Appendix B
Alternatives Documentation

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NEC FUTURE

A Rail Investment Plan for the Northeast Corridor

No Action Alternative Report

April 2015

U.S. Department of Transportation

Federal Railroad Administration

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1. Introduction

NEC FUTURE is a comprehensive planning study being led by the Federal Railroad Administration (FRA) to define, evaluate, and prioritize future investments in the Northeast Corridor (NEC). The NEC is defined as the existing rail transportation spine of the Northeast region, which is anchored by Washington Union Station in the south, Penn Station New York in the center, and Boston South Station in the north. As the rail transportation spine of the Northeast region, the NEC is a key component of the region's transportation system and is vital to its economy. As part of NEC FUTURE, the FRA is preparing a Tier 1 Environmental Impact Statement (EIS) to assess the potential effects of the Tier 1 EIS Action Alternatives (Action Alternatives) on the built and natural environment.

This report describes the No Action Alternative for the Tier 1 EIS. The National Environmental Policy Act (NEPA) requires that the lead federal agency define a No Action Alternative, or the conditions that will exist in an analysis year if a proposed action is not implemented. Under NEPA, the No Action Alternative is sometimes referred to as the No Build condition. For the Tier 1 EIS, the FRA has defined the No Action Alternative as the condition of the Northeast region's multi-modal transportation system in 2040. The FRA will use the No Action Alternative as a baseline against which the FRA will compare the effects of each of the Action Alternatives.

For this Tier 1 EIS, the No Action Alternative is not a "do nothing" alternative. Instead, it assumes that sufficient capital investment is available to keep the NEC's systems and infrastructure functioning properly to support existing services levels. However, if continued capital investments are not implemented the NEC's reliability, capacity, and services levels would decline. Forecasting the implications of insufficient funding on the performance of the eight commuter railroads and Amtrak would be difficult and would be somewhat subjective. This is due to the uncertainty of what improvements might or might not be funded and what their performance implications might be. Therefore, the FRA decided to evaluate a No Action Alternative separate from the discussion of historic or future funding trends and to qualitatively discuss the implications of insufficient funding (see Section 3.2, Disinvestment Scenario).

Transportation projects included in the No Action Alternative generally fall into one of the following three categories: 1) funded projects or projects with approved funding plans (e.g., federal or state committed funding); 2) funded or unfunded mandates; and 3) unfunded projects necessary to keep the railroad running. Although the No Action Alternative identifies the magnitude and type of work required to keep the NEC operating, it does not assign responsibility for specific projects with regard to funding or implementation.

The No Action Alternative in the Tier 1 EIS represents a "snapshot in time." The FRA developed it using current information regarding which projects are funded. This approach avoids being speculative since there is uncertainty in economic conditions, available funding, and political support for transportation projects. As the development of the Tier 1 EIS progresses, assumptions regarding which projects are included as part of the No Action Alternative could be revised based upon available funding, urgency of needs, and changes or updates to the region's transportation plans. The No Action Alternative generally does not achieve a state of good repair nor does it result in additional capacity or changes in functionality of the NEC. However, there are exceptions (e.g., small capacity improvements resulting from projects such as the "Raceway Project" in New Jersey, which is underway).

2. NEC FUTURE Background

First established 150 years ago, the existing NEC is inadequate to meet the region's current and future needs. By 2040, continued population and employment growth in the Northeast is expected to create increasing demand for travel options across the passenger transportation system—rail, air, highway, transit, and intercity bus. Yet today, the aging infrastructure and capacity limitations of the NEC already result in congestion and delays for daily commuters and for regional and intercity travelers. The functional obsolescence of critical infrastructure also affects the performance of daily operations, resulting in service disruptions. For example, every time the Portal Bridge fails to close, thousands of New York metro travelers are inconvenienced; beyond the New York metro area, the ripple effect of the resulting delays on the NEC are felt by travelers from Washington, D.C., to Boston, MA.

Forecast growth in population and employment in the Study Area[1] will put increasing pressures on this already constrained NEC rail network. As such, reliance on this aging and obsolete infrastructure and its inadequate performance inhibit the Study Area's opportunities for realizing its full potential for economic growth. These trends—along with changes in technology, business practices, and lifestyles—will continue to influence future travel needs and opportunities for new types of service on the NEC and its connecting corridors.[2]

Capacity constraints at major hub stations along the NEC—from Washington Union Station to New York Penn Station to Boston South Station—further compromise the ability of the NEC to handle regional travel demands now and into the future. Additionally, these station capacity limitations, particularly in Washington, D.C., limit the opportunities to grow services on connecting corridors. With real capacity constraints, NEC service priorities will continue to focus on high volume services between Washington D.C. and Boston, MA, further limiting opportunities for service to markets to the north and south.

Through NEC FUTURE, the FRA is defining a long-term vision to improve passenger rail service on the NEC in a manner that will enhance mobility options and expand passenger rail service in support of future population and employment growth in the NEC FUTURE Study Area (Study Area). The Study Area extends from the Washington, D.C., metropolitan area to the Boston, MA, metropolitan area (Figure 1). The purpose of NEC FUTURE is to upgrade aging infrastructure and to improve the reliability, capacity, connectivity, performance, and resiliency of future passenger rail service on the NEC for both intercity and regional trips, while promoting environmental sustainability and economic growth.

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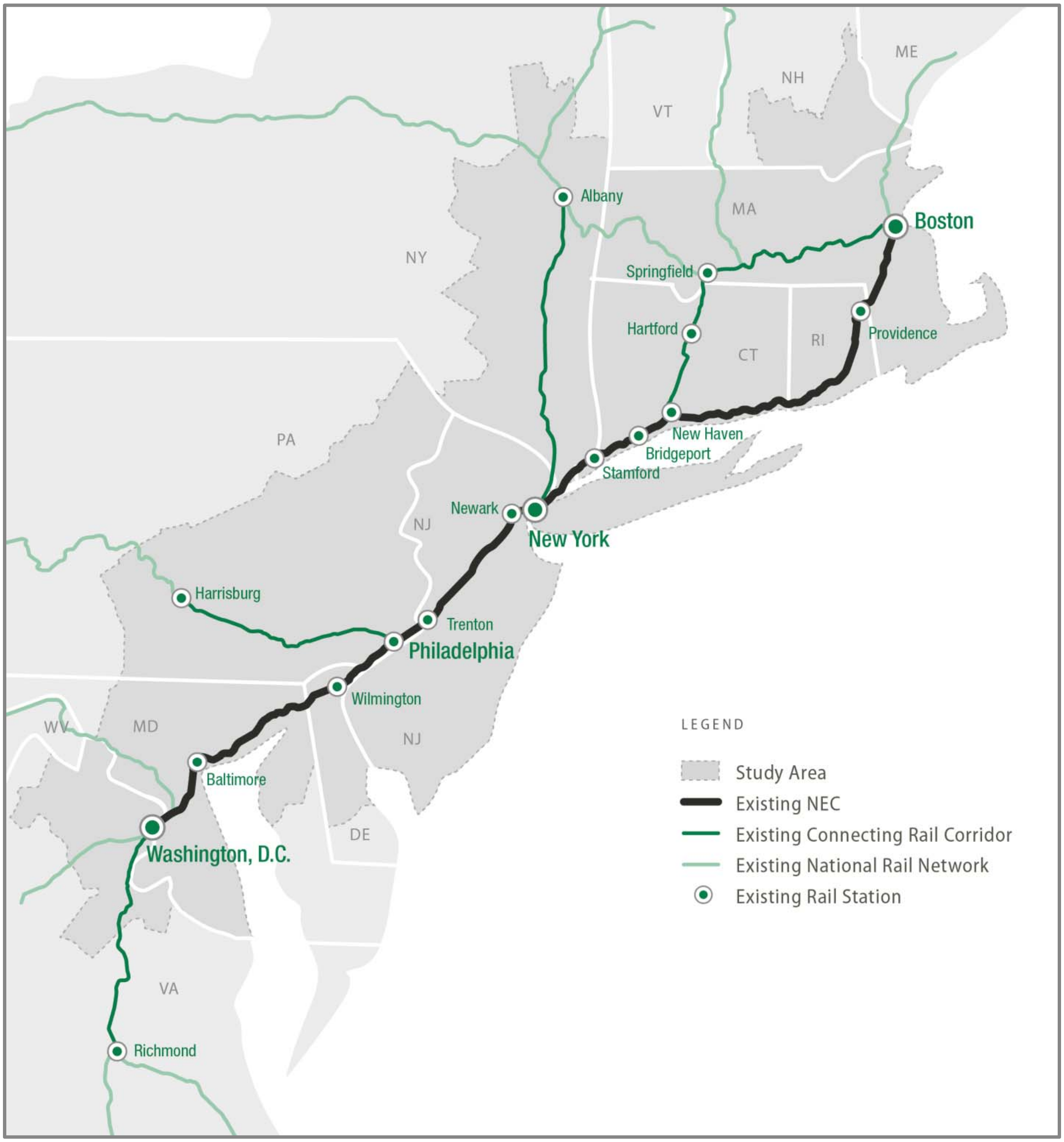
[1] The Study Area includes a broad geographic area, stretching 457 miles from Washington, D.C., in the south to Boston, Massachusetts, in the north, and covering over 50,000 square miles.

[2] Connecting corridors are those travel corridors that connect directly to a station on the NEC. They include (1) corridor service south of Washington Union Station in Washington, D.C., to markets in Virginia and North Carolina, including Lynchburg, VA, Richmond, VA, Newport News, VA, Norfolk, VA, and Charlotte, NC; (2) Keystone corridor service, which connects to Philadelphia 30th Street Station; (3) Empire corridor service, which connects to Penn Station New York); and (4) New Haven-Hartford-Springfield service, which connects to New Haven Union Station.

Figure 1: NEC FUTURE Study Area



The FRA is preparing a Tier 1 EIS that will examine, at a broad programmatic level, environmental, socioeconomic, and transportation impacts of a range of Action Alternatives, each comprising a different long-term vision for the NEC. The Tier 1 EIS will compare the environmental impacts of the Action Alternatives against a No Action Alternative, assuming the full implementation and build out of each Action Alternative by 2040. Although the FRA selected 2040 as the analysis year for evaluating the alternatives in the Tier 1 EIS, the investments proposed in NEC FUTURE are likely to include infrastructure improvements expected to last well beyond 2040 and into the next century. Therefore, the FRA is considering future needs of the NEC beyond 2040 in the alternatives development process.

The FRA will identify a Preferred Alternative in the Tier 1 Final EIS. Following the issuance of the Record of Decision (ROD), the FRA will prepare a Service Development Plan (SDP). The SDP will describe a phased implementation plan that details operational, network, and financial aspects of the Selected Alternative.

3. Approach to No Action Alternative

3.1 METHODOLOGY FOR SELECTING NO ACTION ALTERNATIVE PROJECTS

The No Action Alternative assumes completion of planned and programmed improvements to highway, freight rail, transit, air, and maritime modes by 2040. Interregional and regional travel demand is affected by the availability, price, and reliability of all transportation modes. Therefore, inclusion of improvements of these other modes is necessary to represent the reasonably foreseeable future transportation conditions in the Study Area. The No Action Alternative will serve as a baseline for the purpose of comparing the outcomes of the Action Alternatives on ridership, revenue, cost, and train operations.

The FRA selected the projects included as part of the No Action Alternative using current information compiled from federal, state, and regional transportation planning documents. As the development of the Tier 1 EIS progresses, the FRA may revise or revisit assumptions regarding the projects it includes in the No Action Alternative based upon levels of available funding, urgency of needs, and changes or updates to the region's transportation plans.

The FRA used the following categories in selecting projects to include for the No Action Alternative:

- Funded projects or projects with approved funding plans (e.g., federal or state committed funding)
- Funded or unfunded mandates
- Unfunded projects necessary to keep the railroad running

Beyond specific named projects, the No Action Alternative assumes that individual railroad operators will continue to maintain the NEC through their annual capital investment programs. It also assumes some additional level of investment, beyond currently expected funding levels, as required for normal replacement of track, signals and communications, structures, and electrical infrastructure as well as funded fleet replacement or expansion programs. This includes some—but only a modest proportion—of the significant backlog of work associated with bringing the NEC to a state of good repair.[3]

Appendix A contains the methodology for reviewing projects and developing the No Action Alternative.

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[3] State of good repair is a condition in which the existing physical assets, both individually and as a system, (a) are functioning as designed within their "useful lives," and (b) are sustained through regular maintenance and replacement programs; state of good repair represents just one element of a comprehensive capital investment program that also addresses system capacity and performance. (U.S. Secretary of Transportation M.E. Peters, "State of Good Repair" on the Northeast Corridor [July 2008]).

3.2 DISINVESTMENT SCENARIO

The FRA assumes that funding through 2040 for No Action Alternative projects will be sufficient to maintain existing service levels along the NEC. However, the funding levels necessary to support this assumption exceed historical levels of capital funding from federal, state, and local sources made available to the owners/operators on the NEC. Historical funding levels have averaged approximately $600 million per year over the last 10 years.[4] It remains uncertain if sufficient funding will be provided to sustain the increasing level of investment necessary to support the No Action Alternative. If sufficient funding is not made available, the NEC's reliability, capacity, and service levels would continue to degrade with the possible following repercussions:

- Reliability would decline, resulting in more frequent and longer delays and reduced on-time performance of train service. This reduction in reliability would result from unscheduled delays, as well as "scheduled" delays required periodically (and randomly) to allow engineering crews to access the railroad to make remedial repairs.
- Scheduled trip times would increase as the deteriorating condition of NEC infrastructure—particularly rail, bridge, and subgrade—would require trains to operate slower on some portions of the railroad to ensure safety.
- Operating costs for infrastructure maintenance would rise in response to the need for more frequent maintenance and unscheduled and sometimes substantial repairs.
- Costs for train operations would increase as longer cycle times for equipment would require greater fleet sizes and more crew time and overtime.
- Ridership would decline in response to the reduced level and performance of passenger rail service, leading to declines in revenue and greater operating losses.

As mentioned in the introduction to this report, forecasting the implications of insufficient funding on the performance of the eight commuter railroads and Amtrak is subjective given the uncertainty of what improvements might be funded and what their performance implications might be. Therefore, the FRA has decided that to compare against the Action Alternatives, the No Action Alternative will assume sufficient funding to maintain current service levels. In this way, the FRA can separate the discussion of historic or future funding trends from the Action Alternatives' positive and negative impacts.

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[4] Northeast Corridor Infrastructure and Operations Advisory Commission. (2014). *Northeast Corridor Five-Year Capital Needs Assessment: Fiscal Years 2015 to 2019*.

4. No Action Alternative

The No Action Alternative, including transportation conditions and types of investment projects, is summarized below.

4.1 TRAIN SERVICE

The No Action Alternative represents an NEC that maintains today's service levels, which is defined as the number of trains per hour by operator[5] and types of service. The No Action Alternative does not increase or significantly change capacity, speeds, or the markets served. Instead, it makes annual investments in the state-of-good-repair backlog that is necessary to maintain today's general service characteristics.

Given the growing population and economy of the Northeast region, operating the NEC at these current service levels in the year 2040 would mean more people riding the same number of trains, resulting in overcrowded trains and stations, a general worsening of train performance, and more people turning to other modes of transportation, thus reducing rail's share of total trips across the Study Area. In addition, maintaining the railroad to simply support today's level of service would require continued capital investments, such as those necessary to keep the NEC's structures and systems functioning properly; therefore, it is not a "do nothing" alternative, but rather what is necessary to maintain operations.

Within the Study Area, interregional travel includes trips that start and end in different metropolitan areas (e.g., New York City and Baltimore). Amtrak (the intercity rail operator) primarily serves these trips. Regional travel includes traditional commuter rail trips starting and ending in the same metropolitan areas, such as journey-to-work trips. One of the eight commuter rail operators on the NEC (e.g., NJ TRANSIT or Massachusetts Bay Transportation Authority [MBTA]) primarily serves these trips. Regional rail generally connects cities and towns within one state or on the border of two states (e.g., NJ TRANSIT service within New Jersey, which connects to New York City).

The FRA assumes the following for the No Action Alternative:

- Passenger rail service on the NEC would operate similarly to and at the same approximate level as today's service in the peak hours.
- Amtrak would provide the same types of intercity services, including Intercity Express (Acela), Intercity Corridor (regional),[6] and connecting corridors (i.e., Springfield, Keystone, and Empire).
- The following eight commuter railroads operating on the NEC would continue to provide the same regional services: MBTA, ConnDOT, MTA-Metro-North Railroad, MTA-Long Island Rail Road (LIRR), NJ TRANSIT, SEPTA, MARC, and Virginia Railway Express (VRE).

As noted earlier, while the type of service would generally be operating with equipment similar to that used today, greater demand could affect overall performance.

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[5] Current operators on the NEC include interregional services operated by Amtrak and regional services operated by eight individual commuter railroads within the Study Area.

[6] Amtrak's intercity corridor service is called "Regional Train Service" and should not be confused with the definition of regional rail or traditional commuter rail trips that start and end in the same metropolitan areas (e.g., SEPTA or MARC)

The No Action Alternative would serve the same stations and market areas along the NEC as are served today with one exception: East Side Access, a project currently under construction and thus part of the No Action Alternative, includes new MTA-LIRR service into Grand Central Terminal in New York City. No Action Alternative intercity service would be unchanged from existing intercity service. Table 1 identifies the existing NEC stations that would be served under the No Action Alternative.

Table 1: Existing NEC Stations (excluding Connecting Corridors) Served under the No Action Alternative

State	Total	NEC Stations (excluding connecting corridors)
Washington, D.C.	1	Washington Union Station
Maryland	12	New Carrollton, Seabrook, Bowie State, Odenton, BWI Airport, Halethorpe, West Baltimore, Baltimore Penn Station, Martin Airport, Edgewood, Aberdeen, Perryville
Delaware	4	Newark, DE, Churchman's Crossing, Wilmington Station, Claymont
Pennsylvania	25	Marcus Hook, Highland Ave, Chester, Eddystone, Crum Lynne, Ridley Park, Prospect Park, Norwood, Glenolden, Folcroft, Sharon Hill, Curtis Park, Darby, Philadelphia 30th St, North Philadelphia, Bridesburg, Wissinoming, Tacony, Holmesburg Junction, Torresdale, Cornwells Heights, Eddington, Croydon, Bristol, Levittown
New Jersey	15	Trenton, Hamilton, Princeton Junction, Jersey Avenue, New Brunswick, Edison, Metuchen, Metropark, Rahway, Linden, Elizabeth, North Elizabeth, Newark Airport, Newark Penn Station, Secaucus
New York	7	Penn Station New York, New Rochelle, Larchmont, Mamaroneck, Harrison, Rye, Port Chester
Connecticut	29	Greenwich, Cos Cob, Riverside, Old Greenwich, Stamford, Noroton Heights, Darien, Rowayton, South Norwalk, East Norwalk, Westport, Green's Farms, Southport, Fairfield, Fairfield Metro, Bridgeport, Stratford, Milford, West Haven, New Haven Union Station, New Haven State Street, Branford, Guilford, Madison, Clinton, Westbrook, Old Saybrook, New London, Mystic
Rhode Island	5	Westerly, Kingston, Wickford Junction, TF Green, Providence Station
Massachusetts	12	South Attleboro, Attleboro, Mansfield, Sharon, Canton Junction, Route 128, Readville, Hyde Park, Forest Hills, Ruggles, Back Bay, Boston South Station

Source: NEC FUTURE team, 2015

Table 2 describes the service under the No Action Alternative by type and levels of passenger rail service at selected screenlines along the NEC. Screenlines are lines across a particular geography along a rail right-of-way that serve as specific locations where the frequency and type of rail service are measured, evaluated, and compared as trains pass by the screenlines. They will be used to capture the volume of passenger rail traffic at key locations along the NEC, particularly where capacity or utilization might change. The volume of passenger rail traffic is expressed as trains per hour, by service type at the following points (i.e., screenlines) along the NEC: Washington, D.C., Philadelphia, PA, the Hudson River and East River in the New York metropolitan region, New Rochelle, NY, and Boston, MA. Each type of service is captured. The No Action Alternative service levels for the peak hour, in the peak direction[7] are the same as existing (2012 for the purposes of this analysis) service levels as shown in Table 2.

[7] "Peak hour refers to when demand for transportation services is greatest. Peak direction refers to the direction of travel within the peak hour. In the morning, the peak direction is often toward metropolitan centers. In the evening, the peak direction is often away from metropolitan centers. Transit Cooperative Research Program. (2003). *TCRP Report 100, Transit Capacity and Quality of Service Manual*. Washington, D.C.: Transportation Research Board.

Table 2: No Action Alternative – Peak-Hour Trains, Peak Direction (2040)

Screenline	Existing	No Action Alternative
Washington, D.C., Screenline *North of Washington at Anacostia River*		
Intercity Express	1	1
Intercity Corridor	1	1
Connecting Corridor*	Included above as part of Intercity Express and Intercity Corridor	Included above as part of Intercity Express and Intercity Corridor
Regional Rail	4	4
Philadelphia Screenline *Chester Pennsylvania*		
Intercity Express	1	1
Intercity Corridor	1	1
Connecting Corridor*	0	0
Regional Rail	3	3
Hudson River Screenline		
Intercity Express	1	1
Intercity Corridor	1	1
Connecting Corridor*	1	1
Regional Rail	21	21
East River Screenline		
Intercity Express	1	1
Intercity Corridor	1	1
Connecting Corridor*	2	2
Regional Rail**	36	36
New Rochelle Screenline *Between Shell Junction and New Rochelle Station*		
Intercity Express	1	1
Intercity Corridor	1	1
Connecting Corridor*	Included above as part of Intercity Express and Intercity Corridor	Included above as part of Intercity Express and Intercity Corridor
Regional Rail	21	21
Boston Screenline *South of Back Bay Station*		
Intercity Express	1	1
Intercity Corridor	1	1
Connecting Corridor*	0	0
Regional Rail	6	6

Source: NEC FUTURE team, 2015

* Connecting Corridors include Springfield, Empire, Keystone and Virginia Service south of Washington Union Station

** Only includes service to stations on the existing NEC; excludes new MTA-LIRR service to Grand Central Terminal with the East Side Access project.

4.2 NO ACTION ALTERNATIVE RAIL PROJECTS

As described in Section 3.1, the passenger rail projects included within the No Action Alternative fall generally within three categories: 1) funded projects or projects with approved funding plans (e.g., federal or state committed funding), 2) funded or unfunded mandates, and 3) unfunded projects necessary to keep the railroad running. Due to the geographic scale of the Study Area, only representative examples of types of No Action Alternative projects that fall under these categories are provided below. Appendix A contains the methodology for selecting projects that are included in the No Action Alternative. Appendix B includes a more detailed list of all No Action Alternative projects.

4.2.1 FUNDED PROJECTS OR PROJECTS WITH APPROVED FUNDING PLANS (CATEGORY 1)

These types of projects include normal replacement or routine maintenance at currently expected funding levels such as track, electrification, communications, and facility upgrades to keep the NEC operating. Also included in this category are projects that represent a one-time investment in new or replacement fleet or other projects to increase capacity, upgrade stations, and/or implement new technology.

Please see **Appendix B** for a complete list of projects.

4.2.2 FUNDED OR UNFUNDED MANDATES (CATEGORY 2)

Projects within this category typically include projects responsive to federal or state mandates such Americans with Disabilities Act (ADA) station improvements and/or Positive Train Control (PTC).

Please see **Appendix B** for a complete list of projects.

4.2.3 UNFUNDED PROJECTS NECESSARY TO KEEP THE RAILROAD RUNNING (CATEGORY 3)

These projects typically include minor repairs as necessary to sustain operations, such as normal replacement of track, signals, communications, structures, stations, and electrical infrastructure through the capital programs of various railroads operating on the NEC. It assumes some additional level of investment, beyond currently expected funding levels. Also included in this category are fleet replacement projects and upgrades to existing infrastructure necessary to sustain existing service levels.

This category of projects includes the repairs of major bridges and tunnels to keep them maintained and in operating condition (e.g., Hudson River Tunnels and New Haven Line Bridges). The No Action Alternative does not include the full cost to replace or rehabilitate those structures if those larger efforts do not have project funding in place. These unfunded “Major Backlog” projects, while not included as part of the No Action Alternative, are included within the Tier 1 EIS as “Related Projects” since they may have received some funding for pre-construction activities (see Section 6 for more detail in how Related Projects will be considered). Examples of these include the Susquehanna River Bridge and Baltimore & Potomac Tunnel NEPA/PE projects (see Section 5).

It should be noted that continually repairing aging infrastructure would result in higher costs over time than actually rehabbing or replacing the structure. Repairs to the busy NEC are generally limited to weekends due to heavy train traffic during the week and therefore take longer and cost more than making repairs to an out-of-service railroad where service can be re-routed to a parallel or alternate route. In addition, continually repairing and maintaining the existing infrastructure without adding new capacity to support increased demand for additional service will result in reduced reliability.

Please see **Appendix B** for a complete list of projects.

4.3 COST OF THE NO ACTION ALTERNATIVE

The Tier 1 EIS will identify the capital cost of the No Action Alternative. The capital cost of the No Action Alternative is required to evaluate the incremental effects of the Action Alternatives. The capital cost estimate for the No Action Alternative assumes the estimated costs for projects in each of the three categories: funded projects, funded or unfunded mandates, and unfunded projects necessary to keep the railroad operating.

4.3.1 CATEGORY 1: FUNDED PROJECTS

Estimated capital costs for funded projects (see Appendix B) are based on estimates available from individual project sponsors. These capital costs reflect different assumptions—some are presented in current dollars, others are not. For the purpose of estimating an order-of-magnitude cost for the No Action Alternative, the FRA did not attempt to normalize these numbers.

4.3.2 CATEGORY 2: FUNDED AND UNFUNDED MANDATES

Estimated capital costs for funded and unfunded mandates are based on historic funding trends. The dominant contributing factor is the cost of implementing Positive Train Control (PTC) and compliance with the Americans with Disabilities Act.

4.3.3 CATEGORY 3: UNFUNDED PROJECTS NECESSARY TO KEEP THE RAILROAD OPERATING

Projects necessary to keep the railroad operating include regular ongoing capital maintenance and improvements to basic infrastructure, as well as critical repairs to major backlog projects that are currently unfunded. An estimate for critical repairs is included for those unfunded major backlog projects, such as Susquehanna River Bridge, B&P Tunnels, and the Connecticut River Movable Bridges (see Appendix B Category 3), to keep those assets operating in lieu of replacement or major rehabilitation.

The cost for unfunded annual, normal replacement is based on forecast needs as documented in the Northeast Corridor Commission's Northeast Corridor Five-Year Capital Needs Assessment.[8] Annualized expenditures to repair track, bridges and structures, systems (electric traction, communications, catenary, and signals), fleet replacement programs, and other investments necessary to maintain operations will be estimated to 2040. Similarly, the FRA will estimate the cost over the next 25 years for critical repairs to those major backlog projects currently unfunded, but in need of replacement.

5. Related Projects

There are several ongoing independent rail projects located within the Study Area that are not included in the No Action Alternative project list. Instead, these projects are referred to as "Related Projects" since they generally fall within one of the following three categories:

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[8] Northeast Corridor Infrastructure and Operations Advisory Commission, Northeast Corridor Five-Year Capital Plan, Fiscal Years 2016 – 2020, April 2015.

- Fully or partially funded projects located in a connecting corridor and not on the NEC
- Unfunded projects along the NEC with ongoing or completed NEPA/PE
- Fully or partially funded transit (e.g., NJ TRANSIT, MTA-LIRR) or freight projects located off of but connecting to the NEC

These Related Projects have independent utility and many are currently undergoing their own separate NEPA processes, such as the Southeast High Speed Rail Corridor – Washington, D.C., to Richmond, VA. Others are intended to address some of the NEC's most pressing reliability, safety and capacity needs, such as Boston South Station expansion, Portal Bridge replacement, and the B&P Tunnel replacement. The full-scale rehabilitation and/or replacement of bridges and tunnels identified as Major Backlog assets (e.g., New Haven Line Bridges and Hudson River Tunnels), are also included in this category of Related Projects since their construction is currently unfunded.

Given the significance of some of these Related Projects, as well as their current stages of development, it is likely that the FRA may incorporate some of these projects or their components into an Action Alternative. However, because of the lengthy planning process associated with them, and the large scope of NEC FUTURE, the FRA is studying these Related Projects in separate but concurrent NEPA processes (e.g., B&P Tunnel Project). The FRA will continue to coordinate the technical analyses for each of these Related Projects with the NEC FUTURE analysis and will consider these reasonably foreseeable projects as part of the cumulative impact analysis in the NEC FUTURE Tier 1 EIS.

The FRA will continue to work with project sponsors to ensure that those projects remain compatible with and do not preclude the future design and construction of the NEC FUTURE No Action Alternative and Action Alternatives.

Similar to the development of the No Action Alternative, the FRA selected the projects included as part of the Related Projects through coordination with stakeholders and from current information compiled from federal, state, and regional transportation planning documents. As the development of the Tier 1 EIS progresses, the FRA will revise and update the projects it includes in the Related Projects list based upon levels of available funding, urgency of needs, and changes or updates to the region's transportation plans.

Please see **Appendix C** for a complete list of Related Projects.

6. No Action Alternative Projects of Other Transportation Modes

In the No Action Alternative, the FRA assumes that the capacity of other transportation modes within the Study Area will grow as defined in federal, state and regional transportation planning documents that were reviewed to identify the list of No Action Alternative projects (**Appendix A**). A brief description of these other modes and examples of specific projects is provided below. Figure 2 identifies the existing transportation network in the Northeast.

6.1 TRANSIT PROJECTS

The No Action Alternative includes the existing transit systems such as bus or light rail that serve the Study Area as well as funded and programmed improvements based on financially constrained regional transportation plans (RTP) that were developed by regional transportation planning agencies. The improvements consist primarily of new transit services, rehabilitation of stations, and reconstruction of rail bridges. Specific examples of these types of projects include the Purple Line in Maryland and the Hartford-New Britain Busway. (See **Appendix B** for a complete list of projects.)

Figure 2: Transportation Network in the Northeast Region of the United States

6.2 HIGHWAY PROJECTS

The No Action Alternative includes the highway system that currently serves the Study Area. The No Action Alternative includes this existing highway system as well as funded and programmed improvements on the highway network based on financially constrained RTPs developed by regional transportation planning agencies. Highway improvements included as part of the No Action Alternative include infrastructure projects, as well as intelligent transportation system and other potential system improvements programmed to be in operation by 2040. The No Action Alternative does not include major new highways. Improvements consist primarily of individual interchange improvements and roadway widening on limited segments of the highway network, as well as bridge rehabilitation or replacement projects. Specific examples of these types of projects include I-95 John F. Kennedy Memorial Highway – MD 24 Interchange Improvements, Scudder Falls Bridge (I-95) Reconstruction and Widening in Pennsylvania and New Jersey, and the Nassau County Incident Management System in New York. (See **Appendix B** for a complete list of projects.)

6.3 FREIGHT RAIL PROJECTS

The No Action Alternative includes the existing freight rail system that serves the Study Area as well as funded and programmed improvements based on financially constrained RTPs developed by regional transportation planning agencies. The improvements consist primarily of individual track improvements, rehabilitation of grade crossing and reconstruction of rail bridges. Specific examples of these types of projects include JD to Jones Hill Double Track Project in Maryland, Hunts Point Freight Rail Improvements Project in New York, and Fast Track New Bedford, Massachusetts. (See **Appendix B** for a complete list of projects.)

6.4 AVIATION PROJECTS

In the No Action Alternative, the FRA considered the 15 airports that provide commercial service in the Study Area. The No Action Alternative includes funded and programmed improvements identified in state aviation capital planning documents and airport authority capital programs. The No Action Alternative includes no new airports. The aviation-related improvements consist primarily of terminal modernization and expansion projects as well as new runway or existing runway extension projects. Specific examples of these types of projects include Dulles International Airport Terminal Expansion and Fifth Runway in Washington, D.C.; LaGuardia Airport Central Terminal B Modernization in New York City; and Bradley International Airport Terminal Expansion in Connecticut. (See **Appendix B** for a complete list of projects.)

6.5 MARITIME PROJECTS

In the No Action Alternative, the FRA evaluated maritime projects consisting of six major ports within the Study Area. The No Action Alternative includes funded and programmed improvements identified in port planning documents and port authority capital programs. The port-related improvements consist primarily of access improvements and terminal rehabilitation and construction projects. Specific examples of these types of projects include Dundalk Marine Terminal Rehabilitation in Baltimore, MD, South Philadelphia Port Relocation and Conley Terminal Access Road in Philadelphia, PA. (See **Appendix B** for a complete list of projects.)

7. Approach to Analyzing the No Action Alternative in the Tier 1 EIS

The No Action Alternative incorporates programmatic improvements such as track and signal upgrades within the existing NEC right-of-way. It also includes bridge and station rehabilitation or expansion projects that may extend beyond the existing right-of-way. Each of the Action Alternatives includes the improvements that would be undertaken as part of the No Action Alternative.

There are two aspects to the analysis of these improvements in the Tier 1 EIS: service related and "footprint" related.

For service-related analysis, such as ridership, the FRA will generate quantitative data for the No Action Alternative and use the data to compare and evaluate against the Action Alternatives. The No Action Alternative service data are based on existing and planned rail-related improvements between Washington, D.C., and Boston, MA, for the Tier 1 EIS analysis year 2040. It incorporates data collected from commuter railroads, Amtrak, state departments of transportation, and freight operators. The service data include quantifiable timetable-related data such as scheduled trains by time of day, stopping patterns and travel times as well as equipment types. These data establish a baseline of service for comparison with and evaluation of the Action Alternatives.

"Footprint" related analyses for resources such as land cover, parklands, and wetlands are based on a Representative Route, which is defined as the vertical and horizontal alignment for each of the alternatives. The Representative Routes of the Action Alternatives incorporate the footprint of the existing NEC. Many, but not all, of the projects included in the No Action Alternative would likely occur within the limits of the existing NEC right-of-way. However, given the uncertainty of scope or timing for projects included in the No Action Alternative, it is impractical to calculate footprint-related effects associated with those projects. Therefore, for purposes of this Tier 1 EIS, the No Action Alternative will not include the quantification of footprint effects.

The FRA will provide a qualitative discussion of potential footprint effects of the No Action Alternative for resources such as land cover, parklands, and wetlands. This approach is consistent with:

- The programmatic level of detail across both the No Action Alternative and Action Alternatives, and thus, avoiding the need to distinguish footprint-related effects of the No Action Alternative from those of the Action Alternatives.
- NEPA practice, particularly where the projects included as part of the No Action Alternative are an integral component of proposed Action Alternatives (for example, this approach was used on the Maryland MTA's Purple Line project's Final EIS, August 2013).

The FRA will evaluate the effects of changes in service proposed as part of the Action Alternatives and compare the effects of the proposed service levels in the Action Alternatives to the proposed service for the No Action Alternative. The Tier 1 EIS will quantify and provide these service-related effects assessments.

The FRA will use the qualitative assessment of the No Action Alternative to understand and assess the Action Alternatives' potential contributions to cumulative effects on resources identified. The cumulative effects analysis will also include effects of those separate but related major projects (listed in Appendix C and discussed in Section 5) that are currently underway and not included in the No Action Alternative.

APPENDIX A
NO ACTION ALTERNATIVE METHODOLOGY

1. Introduction

The No Action Alternative, as required under the National Environmental Policy Act (NEPA), provides a basis for comparing and contrasting the impacts of the Tier 1 Environmental Impact Statement (EIS) Action Alternatives (Action Alternatives) with those that would result if future investments were not made. For NEC FUTURE, the No Action Alternative defines the infrastructure and projected service levels that would result from expected investments in the NEC by 2040 in the absence of improvements resulting from implementation of the Action Alternatives being considered.

Developing a No Action Alternative for the NEC FUTURE presents several challenges. There is uncertainty in economic conditions, available funding, and political support for transportation projects among all modes, and this is exacerbated by the long planning horizon. In addition, Intercity rail initiatives are not included in state or regional fiscally constrained transportation plans, making it difficult to establish a basis for including projects in the passenger rail portion of the No Action Alternative. Therefore, this document proposes a methodology to identify and select projects for the No Action Alternative.

The No Action Alternative includes planned improvements and related service changes reasonably expected to be implemented by 2040 for which sufficient progress toward implementation and funding has been made or is expected. Where it is clear that a project is funded, it would be included in the No Action Alternative. Where clear information does not exist on funding status, projects would include planned infrastructure investments that are federally mandated, required for safety, and/or necessary to preserve existing passenger and freight rail, aviation, maritime, highway and other transportation services in the NEC FUTURE Study Area (Study Area).[1]

Transportation service improvements resulting from both public and private investment are included in the No Action Alternative.

Since intercity travel demand is affected by other modes, the No Action Alternative is comprehensive in its structure so as to understand the comparative outcomes of ridership, revenue, cost, and operations modeling. However, the Action Alternatives will not include improvements to modes other than rail.

[1] The FRA anticipates that the cost of rail projects included in the No Action Alternative would fall within historic funding levels for general maintenance.

2. Potential Candidates for Inclusion in the No Action Alternative

Generating of a list of potential projects was the first step in developing the No Action Alternative. The list of candidate projects to include in the No Action Alternative came from available federal, state, and local capital planning documents and operating agency capital plans. The FRA reviewed these plans in consultation with representatives of those agencies and organizations as required to ensure that all applicable projects were included and that the NEC FUTURE team obtained all available studies and information on the nature, extent, timing, and likely impacts of these projects, as well as identifying challenges to their implementation. As the Tier 1 EIS progresses, the FRA may revise or revisit assumptions regarding which projects to include in the No Action Alternative based upon changes or updates to available funding, urgency of needs, and regional transportation plans.

The No Action Alternative includes identified projects and service improvements organized by project type (highway, commuter rail, intercity passenger rail, port, etc.). The FRA obtained information about passenger and freight rail, transit, highway, aviation, maritime/ports, and other transportation projects to potentially include in the 2040 No Action Alternative from available fiscally constrained state and regional capital planning documents, from fiscally unconstrained planning documents, and from the private sector where applicable (e.g., rail freight operators). Projects included in the No Action Alternative comprise infrastructure projects as well as planning for service changes.[2] Table 1 provides an initial list of potential sources of this information.

Table 1: No Action Alternative Sources of Information

Mode	Sources of Information*
Commuter and Intercity Passenger Rail	**Amtrak** ■ The Amtrak Vision for the Northeast Corridor: 2012 Update Report ■ Amtrak Capital Plan (including elements funded by States and/or commuter railroads) **Federal and/or Multi-State** ■ Federal-level grant agreements ■ Federal, state, and regional planning documents ■ Tier 1 and Project-level EISs ■ Northeast Corridor Infrastructure Master Plan Program Summary by Segment ■ Commuter Rail Agency Capital Plans **State** ■ State capital plans (STIPs) ■ State Rail Plans **Regional/Metropolitan** ■ Capital plans (TIPs) ■ Regional transportation plans

[2] For passenger rail, it is assumed that service types will remain the same as they are today. Service levels (that is, the quality and quantity of service) could be affected by the infrastructure improvements in the project lists.

Table 1: No Action Alternative Sources of Information (continued)

Mode	Sources of Information*
Highway	**Federal and/or Multi-State** ■ Federal-level grant agreements ■ Federal, state, and regional planning documents ■ Tier 1 and Project-level EISs ■ Agency plans **State** ■ State capital plans (STIPs) **Regional/Metropolitan** ■ Regional planning documents ■ Regional capital plans (TIPs) ■ Agency plans
Freight Rail	**Federal and/or Multi-State** ■ Federal-level grant agreements **State** ■ State rail plans **Other** ■ Discussions with freight rail operators and owners about planned private investment included in an approved planning document or identified as funded
Aviation	**Federal and/or Multi-State** ■ Tier 1 and Project-Level EISs **State** ■ State aviation capital planning documents **Regional/Metropolitan** ■ Federal-level grant agreements ■ Discussions with airport operators and planning authorities ■ Port authorities' capital programs
Maritime/Ports	**Federal and/or Multi-State** ■ Federal-level grant agreements ■ Tier 1 and Project-Level EISs **Regional/Metropolitan** ■ Regional/local port planning documents ■ Port authorities' capital programs **Other** ■ Discussions with operators about planned private investment included in an approved planning document or identified as funded
Other Transit	**Federal and/or Multi-State** ■ Federal-level grant agreements ■ Project-level EISs **State** ■ State capital plans (incl. STIPs, TIPs) **Regional/Metropolitan** ■ Metropolitan capital plans (incl. STIPs, TIPs) ■ Regional planning documents

*These sources of information will be reviewed simply to identify candidate projects and their status. The entirety of each source will not necessarily be reviewed.

After reviewing these plans and sources, the FRA compiled an initial long list of candidate projects for potential inclusion in the No Action Alternative, organized by mode, and geography (e.g., state).

3. Selecting Candidates for Inclusion in the No Action Alternative

3.1 METHODOLOGY FOR SELECTING NO ACTION ALTERNATIVE PROJECTS

Once the list of candidate projects was generated, the FRA evaluated each project for appropriateness to include it in the No Action Alternative. Many of the projects considered—particularly those funded from states and/or federal sources or likely planned for implementation in the long-term—were subject to uncertainty in terms of (1) the exact scope and resulting service level impact of those projects as eventually approved and (2) the availability of funding and financing. The final inclusion of projects in the No Action Alternative was therefore subject to reasonable planning judgment by the FRA in collaboration with NEC stakeholders.

The following proposed categories for selecting projects comprise the No Action Alternative:

- Funded projects or projects with approved funding plans (e.g., federal or state committed funding) – These types of projects include normalized replacement or routine maintenance at currently expected funding levels such as track, electrification, communications and facility upgrades to keep the NEC operating. Also included in this category are one-time investments or other projects to increase capacity, upgrade stations, and/or implement new technology that are currently funded.
- Funded or unfunded mandates – Projects within the category typically include Americans with Disabilities (ADA) station improvements and/or positive train control.
- Unfunded but necessary to keep the railroad running – These projects typically include “minor repair” as necessary to sustain operations, such as normalized maintenance and replacement of track, signal and communications, structures and maintenance facilities through the capital maintenance programs of various railroads within the NEC. The No Action Alternative for this category does not include the full-scale rehabilitation and/or replacement of major bridges or tunnels (a.k.a. the “Major Backlog” assets) since their construction is currently unfunded. The No Action Alternative includes only the “repairs” of major bridges and tunnels that are necessary to keep the railroad running.

3.2 REVIEW AND FINALIZE NO ACTION ALTERNATIVE PROJECT LISTS

The following actions resulted in a final definition of the No Action Alternative project lists for each mode:

- Conferred with the following regarding recommended projects for inclusion and the assumed nature, funding, and timing of those projects:

- U.S. Department of Transportation (U.S. DOT) modal agencies (Federal Transit Administration, Federal Highway Administration, Federal Aviation Administration, and Maritime Administration)
- Corridor-wide stakeholders (e.g., Northeast Corridor Commission [including the states and freight operators], I-95 Coalition)
- Implementing agencies (commuter railroads, Amtrak, freight railroads).

- Revised final No Action Alternative project list to reflect U.S. DOT and stakeholder feedback

This final list of infrastructure and service-related projects define the No Action Alternative. The last step before modeling evaluated the alternatives to summarize the characteristics of the No Action Alternative, as follows:

- Define and Summarize the Operations, Service, and Infrastructure Characteristics of the No Action Alternative – Once the FRA finalized and approved the project lists for the No Action Alternative, the FRA then determined the operating, service, and infrastructure conditions that resulted from the projects to define the No Action Alternative.
  - In order to establish the conditions of the No Action Alternative, the FRA applied these operating and service assumptions to its operations, travel demand/ridership and revenue, and capital costing models. The results of the modeling will then be compared to the Action Alternatives. (Note: assumptions on modes other than rail will only be included in travel demand/ridership and revenue modeling.)

APPENDIX B
NO ACTION ALTERNATIVE PROJECTS LIST

State	Name	Description
Category 1 Funded Projects/Projects with Approved Funding Plans		
MD	Fleet Acquisition/Overhaul	Purchasing 54 new MARC bi-level coaches and overhauling 63 MARC III coaches
DE	Third Track Expansion, Ragan to Brandy and Mill Creek Bridge Rehabilitation	Install 1.5 miles of a high-speed third track on the Northeast Corridor near Wilmington, DE, including Mill Creek Bridge rehabilitation and replacement to relieve a chokepoint, add capacity for intercity passenger rail service, and improve on-time performance while increasing flexibility for dispatching
DE	Newark Delaware Regional Transportation Center Phase 1	Construct new train station and transit center in conjunction with transit-oriented development of the adjacent property, the former Chrysler plant now owned by University of Delaware. Consists of two new high-level platforms, a new station building, realignment of nearby Norfolk Southern yard tracks, construction of a new rail track at the north end of the rail yard, and new turnouts accessing the rail yard track
PA	Levittown Intermodal Facility Improvements	This project provides for improvements to Levittown Station on the Trenton Regional Rail Line. Levittown Station improvements consist of new high level platforms with canopies, replacement of the station building, parking improvements, storm water management, ADA accessibility improvements, new signage, lighting and passenger amenities. There will also be a new pedestrian overpass to replace the old tunnel, bus shelters and bus loops to promote intermodal access, improved traffic flow and safety for motorists and pedestrians.
PA	Fleet Acquisition/Overhaul	Regional Rail Silverliner IV Replacement, Regional Rail Bi-Level Car & Locomotive Acquisition and Vehicle Overhaul Program which provides replacement or upgrade of rolling stock
NJ	Elizabeth Intermodal Station Reconstruction	The reconstruction of the passenger platforms and station building at Elizabeth Rail Station, including new elevators and stairs, ticket and operational office space, and retail space
NJ	County Yard and Delco Lead Safe Haven Storage and Re-Inspection Facility Project	Reconfiguration and expansion of the existing County Yard. The new facility will provide additional storage during extreme flooding events as well as additional service and a train inspection facility
NJ	Mid-Line Loop	Elimination of the at-grade crossing conflict that exists on the Northeast Corridor in the vicinity of Mile Post (MP) 32 at the Jersey Avenue Station/County Yard facility. Construction of a new station at North Brunswick, NJ.
NJ	Fleet Acquisition	Rail rolling stock acquisition
NJ	NJ TransitGrid	Creation of a natural gas/solar power generation and distribution system as backup to regional power network, allowing transit systems to function in the event of a blackout caused by a disaster. This project will directly benefit NJ TRANSIT and Amtrak.

State	Name	Description
NJ	NJ High-Speed Rail Improvement Project (NJ-HSRIP; aka Raceway project) Amtrak's High Speed Intercity Passenger Rail (HSIPR) Program; also known as "Raceway"	Upgrade or replace catenary, power, track, and signal systems between New Brunswick, NJ and Trenton, NJ to improve operations, speeds, and reliability along the Northeast Corridor
NJ	NEC Newark Intermodal	Includes structural rehabilitation and lighting improvements, customer facility improvements, pedestrian and traffic circulation improvements, and any related track and rail infrastructure work. Improvements to the Newark Light Rail are also included.
NJ/NY	New York Penn Station Improvements	Amtrak, NJ TRANSIT, MTA/LIRR ongoing station upgrades
NY	Fleet Acquisition	Acquisition of 164 M-9 electric cars to replace LIRR's aging M-3 fleet
NY	NHL NY - Ongoing normnalized replacement programs (New Rochelle to NY/CT State Line)	C&S Program (CP 216 - NYS/CT State Line), Bridge Program, Track Program (CP 216 - NYS/CT State Line), Catenary Power Program, Miscellaneous Safety/Administration (CP 216 - NYS/CT State Line) (e.g., environmental abatement/remediation, security initiatives, program administration, insurance), Stations Program.
NY	River to River Resiliency for LIRR and Amtrak	Construction of flood protections at multiple tunnel portals used by the Long Island Rail Road and Amtrak.
NY	LIRR Fire & Life Safety - ERT and PSNY Complex	Long-term work to replace and/or restore various systems within the East River tunnels to address safety and prolong the life of the structures.
NY	LIRR - PSNY Improvements	Investments in support of LIRR's busiest station, and the busiest train station on the North American continent, focus on customer improvements, including the replacement of two-decade old elevators and escalators in the LIRR area of the station, along with rehabilitation of stairs, platform lighting and other station components. The Penn Station Complex Improvements project will advance early initiatives identified as part of the Penn Station Visioning effort. The Vision project recommended enhancements to corridors, access points, lighting, signage and wayfinding and a general improving of the space available for passenger circulation.
NY	Penn Station Access Improvements	Initial phase includes proposed improvements to link Metro-North commuter railroad directly to Penn Station and construction of four new stations in the Bronx. Project includes planning, design, construction, reconstruction, replacement, reconditioning, rehabilitation/preservation, and acquisition of real property interests required for commuter railroad facilities and related equipment.
NY	East Side Access	Construction of new tunnels, rail system elements and a new station on Manhattan's east side for Long Island Rail Road

State	Name	Description
NY	Penn-Moynihan Station Complex Train-shed Hardening Project	The Port Authority of New York and New Jersey will receive funding to make flood protections within the Penn-Moynihan Station Complex to protect existing transit facilities from damage during heavy rains.
NY	Harold Interlocking NEC Congestion Relief Project	Construct conflict-free, grade-separated route through the heavily-congested Harold Interlocking railroad junction in Queens, New York, streamlining passenger rail traffic into New York City from along the Northeast Corridor
NY	Moynihan Station Phase 1	Construct Phase 1 of the Moynihan Station project, which includes below-grade transportation improvements providing increased access points to the western portions of the Penn Station platforms, above and below grade, expanded concourses and a new emergency ventilation system
CT	Shoreline East Stations - High Level Platforms/Pedestrian Overpasses	Improve high level platforms and pedestrian overpass
CT	Stamford Intermodal Access	Construct two pedestrian bridges over the train tracks, pedestrian ramps, and train platform Weather shelters at the Stamford Transit Center (STC) Enclose an outdoor area on the north end of the station in order to increase the station’s overall capacity Widen station’s passenger drop-off area and sidewalks. Construct new bike lanes on approaching roads along with safety improvements.
CT	Shore Line East New London Track 6 Catenary Improvements	The installation of catenary and related improvements on Track 6 at New London Station, accommodating the electrification of Shore Line East service and reducing conflicts between Amtrak and commuter service at the station.
CT	Shore Line East Power Supply Upgrade	Improvements to NEC power supply system, as agreed upon by Amtrak and Connecticut DOT, to support the eventual introduction of electric train service on Shore Line East.
CT	New Haven Line Undergrade Bridges	Multi-year program to replace the existing undergrade bridges of the New Haven Line.
CT	CDOT/New Haven Line - Catenary Replacement - Segment C1A and C2	Replace the original "fixed termination" catenary with a state of the art constant tension system that better accommodates temperature extremes in project segments C1A (East Norwalk to Green's Farms) and C2 (Bridgeport to Milford) - the last two segments of project.
CT	Norwalk River Bridge Replacement	Full replacement of the existing bridge to improve reliability and decrease congestion on the New Haven Line. Proposed work includes rehabilitation of the tracks approaching the bridge, structural repairs to the bridge itself, and upgrades to the bridge’s mechanical and electrical systems.
CT	NHL CT - Ongoing normal replacement programs (NY/CT State Line to New Haven)	C Program (Track Program), S Program (Bridge Steel & Timber Program), Interlocking & Drainage Program, Bridge Design, Annual communications & signals maintenance and repair program, Annual investments and New Haven Line stations

State	Name	Description
CT	New Haven Yard Master Complex - Phase 1	Expand and improve New Haven Rail facilities to support the maintenance, repair, and storage of CDOT's proposed expanded fleet. Add new series of self-propelled electric passenger cars, or M-8 cars
CT	NHL Signal System Replacement Phases 1-3	Resignal the CT portion the New Haven Line (CP233 west) with higher capacity five-aspect cab/no wayside signal system
CT	Shore Line East Guilford & Old Saybrook Sidings	Improve track and catenary to facilitate easier freight and commuter movements at Old Saybrook and Guilford stations
CT NY	Fleet Acquisition	Acquire M8 cars to replace existing EMU west of New Haven and existing diesel powered trains on Shore Line East
RI	Kingston Station Track and Capacity Improvements	Final design and construction of an additional 1.5 miles of third track at the Kingston Station, construction of a high-speed interlocking, and construction of two high-level platforms and increased connections to local transit services.
MA	Ruggles Street Station	The modernization of the Ruggles Station will include the construction of a new 797-foot long, 12-foot wide high-level passenger platform between the Ruggles Station headhouse and Northeastern University's Columbus Avenue parking garage.
MA	Fleet Acquisition/Overhaul	Acquisition/overhaul of locomotives and coaches
Multi	Amtrak NEC - Ongoing normal replacement programs (Washington to New Rochelle; New Haven to Boston)	Normal replacement programs related to four major disciplines: Track, Structures, C&S, ET
Multi	Amtrak - Fleet Acquisition	New equipment including the delivery of ACS-64 locomotives and Tier III Next Generation Trainsets for the Acela Express service

Category 2 Funded or Unfunded Mandates

NY	NHL NY - PTC Installation (New Rochelle to the NY/CT State Line)	Install positive train control safety system to meet 2008 federal rail safety law that requires installation by 2015 and avoid four specific events: train to train collisions, over speed derailments, incursions into established work zones, and the movement through a switch left in the wrong position
NY	New York Penn Station - Service Plant Upgrade and Tunnel Emergency	Ongoing north and east river tunnel life safely improvements
CT	NHL CT - PTC (NY/CT State Line to New Haven)	Upgrade signal system along the New Haven Line to meet 2008 federal rail safety law that requires installation of Positive Train Control by 2015
Multi	ADA STATION IMPROVEMENTS	Improve stations to meet ADA and SGR requirements to facilitate ease of travel, encourage intermodalism
Multi	Amtrak NEC - Positive Stop Train Control (Washington to New Rochelle; New Haven to Boston)	Install ACSES wayside transponders incorporating positive stop and civil speed control in areas of the corridor where ACSES is not currently installed as mandated by the Federal Rail Safety Improvement Act of 2008

State	Name	Description
Category 3 Unfunded Projects Necessary to Keep the Railroad Running		
MD	Susquehanna River Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
MD	Gunpowder River Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
MD	Bush River Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
MD	B&P Tunnels Repairs	Critical repairs necessary to maintain tunnels in operating condition
NJ	Portal Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
NJ	Dock Bridge	Mechanical and electrical improvements, shared use with NEC and PATH
NJ/NY	Hudson River Tunnels Repairs	Critical repairs necessary to maintain tunnels in operating condition
NY	Pelham Bay Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
NY	NHL NY - Addititional investment in basic infrastructure (New Rochelle to NY/CT State Line)	Additional investment in basic infrastructure beyond current funding levels for ongoing normal replacement programs
CT	New Haven Yard Master Complex - Phase 2	Projects in Design **(Funded)**: Central distribution warehouse, MoW facility, Yard Power Upgrade, Pedestrian Bridge Projects in Planning **(Not funded)**: Transportation Building, New S&I facility, East End Yard, Car Washer, Diesel Shop Expansion
CT	Saugatuck Bridge Movable Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
CT	Devon Movable Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
CT	Cos Cob Movable Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
CT	Connecticut River Movable Bridge Repairs	Critical repairs necessary to maintain bridge in operating condition
CT	NHL CT - Addititional investment in basic infrastructure (NY/CT State Line to New Haven)	Additional investment in basic infrastructure beyond current funding levels for ongoing normal replacement programs
Multi	Amtrak NEC - Additional investment in basic infrastructure (Washignton to New Rochelle; New Haven to Boston)	Additional investment in basic infrastructure systems, beyond currently funded levels for ongoing normal replacement, in basic infrastructure systems, particularly systems in high need of replacement: overhead catenary system and undergrade bridges

State	Name	Description
DC VA	Metrorail Extension to Dulles	Construct 23-mile extension of the existing Metrorail system, which will be operated by WMATA from East Falls Church to Washington Dulles International Airport west to Ashburn Serve Tysons Corner, Virginia's largest employment center and the Reston Herndon area, the state's second largest employment concentration Provide a one seat ride from Dulles International Airport to downtown Washington
DC, MD, VA	Priority Bus Transit in the National Capital Region	Provide more efficient bus service along 13 transit corridors in Maryland, Virginia, and Washington, D.C., by investing in a bus transitway, bus-only lanes, transit signal priority, traffic signal management, real-time arrival technology and other enhancements TIGER funds to construct a new transit center at the intersection of University Boulevard and New Hampshire Avenue on the border of Montgomery and Prince George’s Counties in Maryland to consolidate scattered bus stops at a heavily used bus transfer point into one facility. TIGER funds will also provide station improvements (bus bays, real time bus information and other improvements) supporting bus priority on the I-95/395 corridor
DC	DC Streetcar - Phase I	Link neighborhoods with a modern and convenient transportation alternative with alignments from Bolling Air Force base to the Anacostia Metrorail Station in Phase 1, Union Station area to Benning Road Metrorail Station in Phase II
MD	Baltimore Redline	Improve transit mobility in an east-west corridor of the Baltimore region to address traffic congestion, provide better connectivity to existing transit service, support new and future transit-oriented economic development and revitalization efforts and address regional air quality issues Connect to MARC, Light Rail, Metro Subway, and MTA services
MD	Corridor Cities Transitway	The CCT is a 15 mile project in Montgomery County, Maryland from the COMSAT facility near Clarksburg, Maryland to the Shady Grove Metro Station. The project has two phases. Phase I is 9 miles from Metropolitan Grove to Shady Grove. This Phase is actively underway and is currently proceeding with engineering and environmental analysis and is funded for formal environmental documentation, final design, and right-of-way acquisition. Phase II would be a future extension from Metropolitan Grove to the COMSAT facility near Clarksburg, and would be developed as land use matures and additional transportation funding becomes available.
MD	U.S. 301/MD 5 Corridor Mass Transitway	Transitway along the 18-mile corridor from Waldorf-White Plains to the Branch Avenue Metrorail Station aling Route MD 5/US 301 in Prince George's and Charles Counties Mode of either LRT or BRT has yet to be selected
MD DC	Purple Line	Light Rail project located in Montgomery and Prince Georges County MD to connect Metrorail stations on the Green Line at College Park, the Orange Line at New Carrollton, and the Red Line at Bethesda and Silver Spring.

State	Name	Description
DE NJ PA	SEPTA PTC Installation	Superimpose PTC system atop the ATC on all Regional Rail lines to meet federal mandate
PA	SEPTA Fare Collection System/New Payment Technologies	Modernize and improve SEPTA's current fare payment and collection system by offering riders a variety of payment choices to suit their travel needs
PA	SEPTA - Multiple Resiliency Projects	SEPTA Ancillary Control Project Center; SEPTA Railroad Embankment & Slope Stabilziation Project; SEPTA Sharon Hil lLine Flood Mitigation Project; SEPTA Railroad Signal Power Reinforcement Project; SEPTA Jenkintown Area Flood Mitigation Project; SEPTA Manayunk/Norristown Line Shoreline Stabilziation Project.
NJ PA	Philadelphia Area Pedestrian & Bicycle Network	Repair, reconstruct, and improve 16.3 miles of pedestrian and bicycle facilities that will complete a 128-mile regional network in six counties around Philadelphia and Southern New Jersey
NJ NY	NJ TRANSIT Positive Train Control Installation	Install positive train control safety system to meet 2008 Federal rail safety law that requires installation by 2015 and avoid four specific events: train to train collisions, over speed derailments, incursions into established work zones, and the movement through a switch left in the wrong position
NY	Fordham Transit Plaza (Bronx) NY Reconstruction	Reconstruct Fordham Transit Plaza, a key intermodal facility serving 41,000 daily bus users and providing connections to 11,000 daily regional (Metro North) rail users Reconstruct street-level plaza and replace the existing plaza structures; reconfigure the circulation of buses through the plaza to create a more usable, contiguous public space; build a bus-only transit mall to maximize transit efficiency; and make design and safety improvements to the surrounding streets to alleviate traffic congestion and increase pedestrian safety
NY	Second Avenue Subway Phase I	Construct 2.3 miles of new subway on Manhattan's East Side from 96th Street to 63rd Street, connecting with the existing Broadway Line at the 63rd Street Station, including: Construction of three new stations at 96th, 86th, and 72nd Streets Modification of the existing 63rd Street station New tunnels from 92nd to 63rd Streets Station/ancillary facilities Track, signal, and power systems Procurement of 68 rail cars
NY	LIRR Positive Train Control Installation	Install a PTC system throughout LIRR territory in New York State (in coordination with MNR) to increase safety and comply with federal mandates Install Automatic Speed Control (ASC) signal system from Speonk to Montauk to facilitate compliance with PTC
CT	Hartford-New Britain Busway	Construct New Britain - Hartford Busway (Busway), a priority project designed to allow for connections to some rail stations Provide direct linkage shuttle bus to Bradley Airport and over the long term, the feasibility of creating a rail connection to the terminal will be assessed

State	Name	Description
MA	MBTA Green Line Extension (GLX) Phase 1	Extend MBTA Green Line from a relocated Lechmere Station in East Cambridge to Union Square in Somerville and College Avenue in Medford Phase 1 will rely on the traditional Design-Bid-Build approach to deliver a fully state-funded contract widening of the Harvard Street and Medford Street railroad bridges and demolition of 21 Water Street)
MA	MBTA Commuter Rail PTC	Install positive train control (PTC) safety system to meet 2008 Federal rail safety law that requires installation by 2015 and avoid four specific events: train to train collisions, over speed derailments, incursions into established work zones, and the movement through a switch left in the wrong position

State	Name	Description
MD	Freight Line Grade Crossing Rehabilitation	Rehabilitate grade crossing to enhance safety and maintain a smooth traffic flow at freight railroad crossings throughout the State
MD	National Gateway Freight Rail Corridor	Package of rail infrastructure and intermodal terminal projects that will enhance transportation service options along three major freight rail corridors owned and operated by CSX through the Midwest and along the Atlantic coast Improvements will allow trains to carry double-stacked containers, increase freight capacity and make the corridor more marketable to major East Coast ports and shippers TIGER funds will help complete the first corridor project, from Northwest Ohio to Chambersburg, Pennsylvania, through West Virginia and Maryland
DE	Rail Program Autoport	Address capacity improvements for handling railroad cars at Port of Wilmington Sidings will be constructed on Autoport, Inc. and NS Railway right-of-way to increase capacity from 60 to 90 railcars New connections to the NS main track will be provided to eliminate the conflict with highway traffic at Terminal Avenue Part of a public-private project with NS putting up 70% of the cost and FHWA 30%
PA	Central Pennsylvania Rail and Road Expansion	Numerous system-wide improvements to the safety and efficiency of freight movement for the 200 miles of track owned by the SEDA-Council of Governments Joint Rail Authority. Add 9.2 miles of track on existing roadbed, rehabilitate 7.5 miles of railway. Provide new installation of over 36,000 feet of sidings to increase capacity and points of distribution for well service companies Additional infrastructure improvements on five rail lines across the region, improvements to railway bridges, and the opening of a closed rail line to provide access to an existing industrial park that will support a major new tenant when rail access is restored Features new and innovative track occupancy warning system near the airport and will build a new airport access road
PA	CSX Trenton Line Clearance Project	Clearance project that covers the CSX Trenton line, from Park Junction to the Delaware River at Yardley, via West Falls, Newtown Junction, and Woodbourne
PA	Southern Chester County Rail Corridor Improvements (Q26)	Install additional track to facilitate the safe and efficient movement of freight cars to and from Wilmington, DE and points north and west and eliminate a rail switching operation over US 1 and reduce the conflict between vehicular and rail traffic
PA	Rutherford Intermodal Facility Expansion	Expand Rutherford Intermodal Facility to accommodate an additional 125,000 lifts per year and enable the facility to keep pace with growing freight traffic demand in the Harrisburg area and reduce highway truck traffic along the Crescent Corridor that moves freight from cities in 12 states, including Chicago, Memphis, and Atlanta Includes track work, expansion of parking access, and the construction of cranes to increase capacity
NJ	Control Point Trent Improvements	Replace Crossover Switch at CP Trent

State	Name	Description
NJ	Midway Interlocking Reconfiguration	Replace signal system replacement and interlocking upgrades to permit higher speeds while increasing capacity throughout the segment
NJ	South Jersey Port Rail Improvements	The Delaware River Rail/Port Improvement Project is divided into three components, starting with Conrail's Delair Bridge approach rehabilitation. The Salem County component is comprised of two projects: the Oldmans Trestle Rail Bridge replacement and the Salem Running Track rehabilitation. The SJPC component is the Paulsboro At-Grade Rail Infrastructure. This component leverages the ongoing construction of the new Paulsboro Marine Terminal, which will have on-dock rail capability to service ships with rail service directly.
NJ	Track Improvements - Hack to Kearny	Double track P&H Branch segment (1.8 miles) Extend 3 yard tracks. Add 1 yard track
NJ	Track Improvements - Manville to Phillipsburg	Improve track, bridge rehabilitation, crossovers, etc. on Lehigh Line
NJ/NY	Cross Harbor Freight Movement Program	Rehabilitation/Modernization of rail car float fixed and mobile assets to support scheduled service between Greenville, Jersey City and Brooklyn, NY
NY	Hunts Point Freight Rail Improvement Project	Freight rail improvements at the Hunts Point Terminal Produce Market to modernize current infrastructure and create new circulation areas, reduce truck traffic and congestion, and improve air quality in the community. Community will benefit from a reduction in traffic accidents and improved connectivity
MA	Fast Track New Bedford	Reconstruct deteriorated rail bridges, which were constructed in 1907

State	Name	Description
MD	I-95 Fort McHenry Tunnel - Moravia Road to the Tunnel Modifications	Provide a continuous southbound lane from the southern limits of the Express Toll Lanes to the tunnel
MD	I-95 John F. Kennedy Memorial Highway - Express Toll Lanes	Construct two Express Toll Lanes in each direction from I-895 North to north of MD 43 and improve the interchanges with I-895, I-695, and MD 43
MD	I-95 John F. Kennedy Memorial Highway - MD 24 Interchange Improvements (Phase I)	Provide improved capacity, operation, and safety for the I-95/MD 24 interchange and the MD 24/MD 924/Tollgate Road intersection, which is in close proximity and integral to the I-95/MD 24 interchange operation
MD	I-95 John F. Kennedy Memorial Highway - Underwater repairs at Tydings Bridge	Rehabilitate pier foundations and provide pier scour protection to extend useful life of foundations
MD	I-95 New Interchange at MD 198	Construct new interchange with collector-distributer roads at I-95 and Contee Road Relocated to relieve congestion on the mainline of I-95 and improve traffic flow at the I-95/MD 198 interchange
MD	MD 4, Pennsylvania Avenue Upgrade	Upgrade existing MD 4 to a multi-lane freeway from MD 223 to I-95/I-49 to relieve congestion during peak hours
MD	MD 5, Branch Avenue Upgrade	Study to upgrade existing MD 5 to multi-lane freeway from US 301 interchange at T.B. to north of I-95/I-495 Capital Beltway
MD	US 1, Baltimore Avenue Reconstruction	Reconstruct US 1 from College Avenue to I-95 to address major congestion experienced along this segment of US 1 and improve traffic operations, pedestrian circulation, and safety
MD	US 40, Pulaski Highway	Improvements along US 40 from Middle River Road to MD 43 consistent with local corridor plans that promote mixed-used development along US 40 within White Marsh/Nottingham area of Baltimore County
MD	Virginia Manor Road Relocated, Old Gunpowder Road to the Intercounty Connector	Construct critical roadway connection to the (No Suggestions) Connector and I-95/Contee Road Interchange to enhance the supporting roadway network east and west of I-95 in the area that is planned for significant growth and development
DE	Bridge 1-501 Rehabilitation	Rehabilitate bridge and viaduct along SR 141 from the I-95 /141 interchange to Burnside Boulevard Total length of the project is 6,000 feet including the 2,000 foot long Newport Viaduct over the Christina River, Amtrak, and SR4

State	Name	Description
DE	I-295 Improvements Third Lane	Add a third lane from SR 141 to SR 9 to address peak periods when the current two-lane configuration is not adequate Project extends from I-95/SR 141 interchange to 2,400 feet west of US 13
DE	I-295 Improvements Weave Elimination	Remove current ramps from SB US 13 to the EB bridge and construct a collector/distributor ramp and barrier to preclude the weave problem from southbound I-95 to eastbound I-295 to southbound US 13 and offer optional routes to replace the moves eliminated by the barrier New access will require motorist to travel further south on US 13, and then make a cross traffic turn to get onto the Delaware Memorial Bridge
DE	I-95 & US 202 Interchange in Wilmington, Delaware	Widen existing ramp from NB I-95 to NB US202 in the I-95/US202 interchange from one to two lanes Additional ramp improvements will address weaving problems and develop US 202 gateway into the City of Wilmington
DE	I-95 Turnpike Toll Plaza Rehab High Speed E-ZPass	Build two Highway Speed EZ Pass lanes through the I-95 Newark Toll Plaza
DE	SR 1 / I-95 / Christiana Mall Rd Bridge Interchange	Construct new multiple-lane interchange to reduce traffic weaving and separate out local traffic movements from high speed movements
DE	SR 141/I-95 Interchange	Improvements focused along SR141 and ramps leading to and from the interstate, with minor improvements taking place on northbound I-95
DE	US 301 New Toll Road	Construct limited access tolled US 301 with 4-lanes (2 lanes in each direction), from Maryland Line to SR1, south of the C&D Canal (14 miles)
PA	30th Street Bridges (6) Over Amtrak's Northeast Corridor Rail Lines	Rehabilitate 6 roadway structures and pedestrian improvements located around the Philadelphia 30th Street Station area and over Amtrak’s Northeast Corridor rail lines
PA	41st Street Bridge Over Amtrak's Harrisburg Line	Reconstruct 3 span, concrete encased steel thru girder bridge over Amtrak's Harrisburg line and Norfolk Southern RR Utility, railroad electrification, approach paving, and miscellaneous work
PA	Allen's Lane Bridge Over SEPTA R8 Rail Line SR:4003	Replace existing Allens Lane bridge carrying two lanes of north/south traffic of S.R. 4003 over two tracks of SEPTA’s Chestnut Hill West (R8) Regional Rail Line

State	Name	Description
PA	Baltimore Pike Signals	Upgrade and interconnection of 16 signalized intersections along a 3.2-mile multi-lane state route to enhance motor vehicle flow along the corridor Modernize intersection signalization equipment Remove existing equipment and replace with new equipment including signal supports, traffic controllers, signal heads, and all electrical equipment including wires and conduit
PA	Boot Road Extension Bridge Over Brandywine Creek	Construct new bridge over the Brandywine Creek with one travel lane in each direction and sidewalks to provide a more direct connection to the Downingtown Amtrak/SEPTA Train Station and regional bicycle and pedestrian facilities, including PA Bicycle Route L
PA	Bristol Road Intersection Improvements	Reconstruct and widen Bristol Road (SR 2025, Section 001) to accommodate a center left-turn lane from Segment 0332 Offset 0643 north of Old Lincoln Highway to Segment 0372 Offset 1015 at the Pasqualone Boulevard intersection Replace six (6) existing signals along Bristol Road Approximately 2.3 mile section of SR 2025 (Bristol Road) and typical section will include two 11 foot travel lanes an 11 foot center left-turn lane and 2 foot full depth installation shoulders
PA	Bristol Road/Butler Avenue SEPTA Railroad Crossing	Improve pedestrian arm railroad crossing gate for sidewalk at the SEPTA Railroad Crossing at Butler Avenue (Route 202) and Bristol Road
PA	Byberry Road Bridge Replacement	Replace the Bridge at Byberry Road over CSX Rail Line Breakout of MPMS# 88706 for Bridge Rehabilitation
PA	Chestnut Street Bridge Over Amtrak/SEPTA R5 Rail Line SR:7205	Replace 4-span steel girder bridge, with minimal shoulders and minor improvement to the vertical crest, which spans over active AMTRAK, CSX and Norfolk Southern rail lines in East Caln Twp. & the Borough of Downingtown, Chester County, PA
PA	Chestnut Street Bridges at 30th Street	Rehabilitate Chestnut Street (PA 3) bridges spanning the Northeast Corridor, I-76, Schuylkill River, CSX Railroad, and 24th Street to maintain mobility within the project area Bridges are structurally deficient: steel portions have severe rust and advanced section loss and brick and concrete components have mortar loss and spalling respectively
PA	Church Road Bridge Over Norristown High Speed Line (CB) SR:7220	Replace of the Church Road Bridge and approaches over the SEPTA Route 100 rail line (Norristown High Speed Line) in Upper Merion Township
PA	Concord Road Bridge Over SEPTA Chester Creek Branch Line SR:3004	Remove existing multi-span concrete bridge and replace with either a new bridge of similar type and size, earth fill, and a pedestrian box culvert to potentially accommodate a rail-trail or a prefabricated concrete arch

State	Name	Description
PA	Elm Street Bridge Over Plymouth Creek	Replace bridge running east-west on Elm Street over Plymouth Creek and the abandoned Reading Railroad Existing structure is 145 ft. long, and is a steel thru-girder with floorbeam system
PA	Folcroft Avenue Bridge Over Amtrak/SEPTA R2 Rail Line SR:7410	Replace existing one lane bridge with 5' sidewalks on both sides, which is currently closed to traffic, to a new bridge with two lanes, 5' sidewalks on both sides, and corrected vertical geometry to provide better sight distance Incorporate bicycle and pedestrian checklists
PA	French Creek Parkway - Phase 1	1st phase of the design and construction of French Creek Parkway to provide a roadway connection between Main St. and Taylor Alley in the Borough of Phoenixville, including a new traffic signal, new bridge over French Creek, and 0.4 miles of new collector roadway and sidewalk network to support the redevelopment of a 120-acre brownfield site into a mixed use development with office, retail, and residential uses New Functional Classification will need to be established for the roadway
PA	Grays Ferry Avenue Bridge Over Schuylkill River	Rehabilitate pier caps on the bridge that crosses the Schuylkill River and Amtrak railway tracks
PA	Greenwood Avenue Bridge Over SEPTA Mainline Commuter Rail	Replace existing bridge over SEPTA's R2, R3 & R5 mainlines, due to structural deficiencies Complete replacement of the Greenwood Ave. Bridge over SEPTA, three lane bridge with sidewalk on one side, and tie into adjacent intersection and SEPTA driveways
PA	Henry Ave. Bridge over SEPTA SR:4001	Rehabilitate bridge, which crosses an unnamed tributary of the Schuylkill River and active CSX and SEPTA rail lines
PA	Hulmeville Avenue Bridge Over Conrail	Replace existing Hulmeville Avenue bridge that carries two lanes of traffic over three tracks of the former Reading Railroad that is now operated by CSX Span arrangement may be revised during the detailed design phase based on discussions between CSX and SEPTA to provide four (4) tracks throughout the project area An understanding between the parties is that any overhead bridge replacement must accommodate an additional track
PA	I-476, MacDade Boulevard Ramp Improvements	Channelize & signalize shopping center entrance and reconfigure NB I-476 / EB MacDade Boulevard off ramp to improve traffic safety (Former uncontrolled median opening at the shopping center entrance was closed due to excessive accidents)

State	Name	Description
PA	I-476, PA Turnpike Northeast Extension/PA 309 Corridor Incident Traffic Management	Implement a Unified Traffic Management and Signal Coordination Plan within the Pennsylvania Turnpike Northeast Extension (I-476)/PA 309 Corridor, including video cameras, variable message signs, interconnected signal systems and trail blazer signage, to handle both routine traffic conditions and diversions from the Turnpike Part of the DVRPC FY06 Work Program
PA	I-95 Allegheny Ave Interchange	Remove NB off-ramp at Westmoreland Street Add NB off-ramp at Castor Avenue Widen and reconstruct I-95 between Ann Street and Tioga Street Reconstruct or redeck bridge over Allegheny Avenue and the Westmoreland Viaduct (Westmoreland Street to Tioga Street) Street to Tioga Street
PA	I-95, Ann Street to Wheatsheaf Lane (AFC)	Reconstruct 10 bridges and 0.9 miles of I-95 Consolidate existing disjointed interchanges at Allegheny Avenue, Westmoreland Street, and Castor Avenue into two half interchanges: half diamond interchange at Allegheny Avenue for Southbound I-95 and a partial clover interchange at Castor Avenue for Northbound I-95 Remove existing off-ramp at Westmoreland Street, leaving a half-diamond interchange at Allegheny Avenue for I-95 Southbound Add a new northbound on-ramp at Castor Avenue to create a partial-clover interchange for I-95 Northbound Split existing loop-ramp to provide both access to I-95 Northbound and the Betsy Ross Bridge
PA	I-95, Betsy Ross Bridge Ramps Construction (BR0) (IMP)	Reconstruct several Betsy Ross Bridge/Aramingo interchange ramps Construct Adams Avenue Connector

State	Name	Description
PA	I-95, Betsy Ross Interchange (BRI) - Design(IMP)	Reconstruct 1.1 miles of the SR 0095 mainline roadway starting from south side of the Wheatsheaf Lane crossing, adjoining Section AFC, and ending north of Orthodox Street at the south side of the Margaret Street/Lefevre Street crossing, adjoining Section BSR (SR 0095 mainline will have four lanes in each direction from Wheatsheaf Lane to Orthodox Street/Pearce Street crossing) Eliminate lane drops (from 3 to 4) from the Betsy Ross Interchange crossing to the Margaret Street/Lefevre Street crossing Demolish and remove Ramp X SB on ramp and Ramp Y NB on ramp, within the NB and SB collector-distributor roads Reconstruct three dual structures (the dual structures over Frankford Creek; the dual viaduct structures over the Earth Fill area from the Betsy Ross Interchange to south of Orthodox Street crossing; and the dual structures over Orthodox and Pearce Streets) Rehabilitate (minor) Conrail Shared Assets railroad bridges crossing SR 0095 and Ramps A and C
PA	I-95, Columbia Street to Ann Street (GR1)	Relocate major utilities and a majority of the surface street reconstruction and relocation work between Berks Street and Ann Street
PA	I-95, Cottman-Princeton Main Line and Ramps (CP2) (IMP)	Reconstruct and widen I-95 between Levick Street and Bleigh Avenue, including upgrades to several ramps Demolish and replace of seven bridges Relocate Wissinoming Street between Princeton Avenue and Wellington Street Relocate approximately 1500 feet of Philadelphia Water Department trunk line water and sewer Construct six new storm drainage pipes from I-95 to the Delaware River Reconstruct I-95 from Levick Street to Bleigh Avenue to provide four lanes in each direction Improve short existing sections of three lanes in each direction between the off and on-ramps that create the existing bottleneck by adding a fourth lane Upgrade existing SB off-ramp at Bleigh Avenue (Ramp D) and NB off-ramp at Cottman Avenue (Ramp B) Construct new SB on-ramp at Cottman Avenue (Ramp F)

State	Name	Description
PA	I-95, North of Bridge Street Interchange Construction	Widen and reconstruct SR 0095 from the relocated Carver Street Bridge to Levick Street: Construct the new SB off-ramp to Tacony Street and Arsenal Business Cente Remove the existing SB off-ramp to James Street Remove the existing Carver Street Bridge Reconstruct Tacony St. north of Bridge Street Replace Carver, Van Kirk & Comly Street bridges Install new traffic signal at the intersection of Carver Street and Tacony Street Utility impacts under I-95 are anticipated
PA	I-95, Orthodox Street to Levick Street (BSR) - Design(IMP)	Design of I-95 reconstruction SR 0095 Section BSR, also known as the Bridge Street Ramps Section, to eliminate the lane drop at the James St. Ramp in the SB direction and the add lane at the Bridge St Acceleration Ramp in the NB direction Four lanes in each direction from Orthodox St. to Levick St. with exclusive acceleration/ deceleration lanes at the interchanges, six dual structures, and the Bridge Street Acceleration Ramp Bridge Reconstruct retaining walls supporting SR 0095 to support new widened roadway and ramps Reconstruct and realign 1.7 miles along SR 0095, 0.7 miles along Tacony Street from Aramingo Ave. to the west to just prior to Van Kirk St. to the east, and 1.2 miles along Aramingo Ave. from Frankford Creek to the south to the Amtrak Railroad Bridge to the north Widen a portion of Aramingo Ave. from Frankford Creek to the south to the Amtrak Railroad Bridge to the north
PA	I-95, PA Turnpike Interchange (TPK) - State 1	Connect I-95 and I-276 in Pennsylvania, facilitate a revised routing of I-95 in PA and NJ, and make I-95 continuous along the east coast from Florida to Maine Construct I-95 mainline flyovers of the interchange between I-95 and the PA Turnpike, a new mainline toll plaza west of this interchange Replace existing River Bridge toll plaza with an all-electronic (AET) on road toll facility in the westbound direction Remove of existing US13 interchange toll facility Integral to the Delaware Valley Freight Corridors Initiative
PA	I-95, Shackamaxon Street to Ann Street (GIR) - Design	Widen and reconstruct I-95 to eliminate the lane drop (from 4 to 3) in both directions at the Girard Avenue Interchange by providing 4 continuous thru lanes in each direction (Construction Sections GR0 thru GR4) Provide an auxiliary lane in each direction to connect the ramps between adjacent interchanges at Vine St and Allegheny Ave

State	Name	Description
PA	I-95, Shackamaxon Street to Columbia Avenue	Close and remove existing I-95 north bound off ramp (Ramp E) Reconstruct and widen I-95 between Shackamaxon St. and Columbia Ave. Reconstruct Delaware Ave. between Columbia and Montgomery Aves. Replace I-95 structures over Shackamaxon St. Marlborough St., and Columbia Ave. Associated retaining and sound barrier wall construction
PA	I-95: Allegheny Ave Interchange	Reconstruct I-95 from Tioga Street to the railroad bridge (south of Frankford Creek), including reconstruction of the NB off-ramp to the Betsy Ross Bridge over Castor Avenue Reconstruct the NB on-ramp from Castor Avenue I-95 traffic will be maintained on 3 lanes NB and 3 lanes SB during peak hours
PA	I-95: Race - Shackamaxon (GR5)	Reconstruct, rehabilitate, and widen I-95 between Race St. and Shackamaxon St. Reconstruct northern Vine St. interchange ramp connections with I-95 Rehabilitate, replace deck, demolish, and replace eight bridges
PA	I-95N: Betsy Ross Inter (BR2)	Reconstruct 1.1 miles of the NB SR 0095 mainline roadway starting from north side of Wheatsheaf Lane crossing, adjoining Section AFC, and ending north of Orthodox Street at the south side of the Margaret Street/Lefevre Street crossing, adjoining Section BSR
PA	I-95N: Columbia-Ann St N (GR3)	Reconstruct and widen I-95 NB from Columbia Ave. to north of Ann St. Reconstruct NB Girard Ave. interchange ramps Demolish and replace five bridges
PA	I-95S: Betsy Ross Inter (BR3)	Reconstruct 1.1 miles of the SB SR 0095 mainline roadway starting from north side of Wheatsheaf Lane crossing, adjoining Section AFC, and ending north of Orthodox Street at the south side of the Margaret Street/Lefevre Street crossing, adjoining Section BSR
PA	I-95S: Bridge Street Interchange	Eliminate the SB lane drop at the James Street Ramp Eliminate the NB add lane at Bridge Street Widen I-95 to four lanes in each direction from Orthodox Street to Levick Street Add exclusive acceleration/ deceleration lanes at the interchanges Replace six dual, mainline bridges and one ramp bridge Widen one mainline structure Line 1-(5 with long retaining walls through much of this section Construct two sound barriers
PA	I-95S: Columbia-Ann St N (GR4)	Reconstruct and widen I-95 SB from Columbia Ave. to north of Ann St. Reconstruct SB Girard Ave. interchange ramps Demolish and replace nine bridges

State	Name	Description
PA	Lafayette Street Extension (MG1)	Extend Lafayette Street past its current terminus at Ford Street to Conshohocken Road Build slip-ramps at to connect Lafayette Street with the Pennsylvania Turnpike Realign existing Schuylkill River bike/pedestrian trail as a multi-purpose trail for public access and recreational use as part of the project Long term goal: construct an interchange at the Dannehower Bridge/Lafayette Street intersection
PA	Lafayette Street Extension (MGL)	Improve roads around the new Lafayette Street/I-276 turnpike EZ Pass-only interchange Replace NS rail bridge
PA	Lafayette Street Extension (MGL)	Improve roadways around the new Lafayette Street/I-276 turnpike EZ Pass-only interchange Replace NS rail bridge
PA	Lafayette Street, Barbados Street to Ford Street Widening (MGN)	Reconstruct and widen existing Lafayette Street from 2 to 4 lanes between Barbados and Ford Streets, as well as provide turn lanes and upgrade signals
PA	Lafayette Street, Ford Street to Conshohocken Road Extension (MGP)	Extend Lafayette Street as a four lane roadway on a new alignment to tie into a new PA Turnpike interchange and provide turn lanes onto Conshohocken Road
PA	Lloyd Street Bridge Over Amtrak/SEPTA R2 Rail Line	Replace Lloyd Street bridge, which was constructed by the railroad in 1899, due to structural defects Pedestrian walkways have been closed due to holes in the decking
PA	Main St over SEPTA (Bridge)	Rehab /replace state bridge over the Over Septa rail line on Main Street between Cahill Road and 9th Street in Sellersville Borough Structurally Deficient bridge breakout project from MPMS #88706.
PA	Montgomery Avenue Bridge over Amtrak at 30th Street	Reconstruct 5 span, concrete encased steel thru girder bridge over Amtrak's Northeast Corridor along with historically sensitive approach paving restoration with a 3 span steel girder bridge founded atop new reinforced concrete piers and integral abutments Utility and railroad electrification work

State	Name	Description
PA	North Delaware Avenue Extension	First of a multi-phased project to construct a "River Road" along the north Delaware Riverfront amidst planned residential and recreational facilities Construct new roadway and a new bridge across Frankford Creek Extend road between Lewis Street where it currently ends, further north approximately a mile and 1/2 to Buckius Street Roadway planned with wide shoulders for bike use, sidewalks, and will serve as an alternative to the North Delaware Greenway Trail while some portions are under construction, and as an alternate route for local truck traffic in order to get that traffic off of narrow Richmond Street
PA	Oxford Valley Road/Lincoln Highway Intersection Improvements	Add turn lanes from Oxford Valley Road onto Route 1 Realign Levittown Parkway
PA	PA 100, Shoen Road to Gordon Drive (02L)	Reconfigure existing 2-12’ lanes and 10’ shoulders to 3- 11’ lanes and 4’ shoulders Remove inefficient jug handles and install dedicated left and right turn lanes Storm water collection and management system Add sidewalk from Ship Road to Sharp Lane to connect existing Uwchlan Trail System Upgrade traffic signals from Gordon Drive/Rutgers Drive to Shoen Road, including new supports, signal heads, actuation, emergency pre-emption, and all electrical components Retain the closed-loop system footprint between the intersections and the municipal building
PA	PA 23/Valley Forge Road and North Gulph Road Relocation (2NG) - Part 1 of River Crossing Complex	Relocate PA 23 and North Gulph Road in the vicinity of the PA 23/US 422 interchange to improve operations and reduce traffic impacts within Valley Forge National Historic Park with full mitigation buffer zone and provide the opportunity for a new “gateway” for the Valley Forge National Historic Park Move roadway approximately 300 feet to the east of the park entrance Part (1) of the "River Crossing Complex," which is a complex area of roadways, interchanges, intersections, and bridges in and around the Valley Forge National Historic Park
PA	PA 252 Underpass/US 30 Intersection	Component of the Paoli Transportation Center Road Improvements project (MPMS #47979) and implements some of the short term solutions recommended by the Feasibility Study for the PA 252 Underpass and US 30 Intersection undertaken using DEMO funds for that location Includes improvements that will help to reduce congestion and increase safety near the intersection of PA 252 and US 30 and include upgrades to the traffic signal to provide a left turn phase, signal timing, pedestrian improvements, lane reconfigurations, and striping

State	Name	Description
PA	PA 29, Main Street Bridge Over Reading Railroad Tracks Removal	Remove narrow and unnecessary bridge to improve traffic and sight distance constraints on Route 29 Fill overpass and connect with wider road section
PA	PA 313/US 202, East State Street to Mechanics Road Intersection Improvements	Realign US 202 at E. State St. to a "T" intersection Extend the PA 313 left turn lanes at US 202 Widen US 202 from PA 313 to Mechanicsville Road to accommodate a center left turn lane at the US 202/PA 313 intersection Add pedestrian and bicycle access
PA	PA 41 Study	Preliminary engineering and environmental studies to identify transportation improvements for the PA 41 Corridor Current alternatives include widening and limited realignment Actual cost estimates for construction will be determined with the completion of the Environmental Impact Statement
PA	PA 452, Market Street Bridge Over Amtrak/SEPTA R-2 Rail Line SR:0452	Replace existing two lane bridge (built in 1925) with shoulders and 8’ sidewalks for inclusion in the Delaware County Bicycle Plan
PA	PA 611, Old York Road Over SEPTA R3 SR:0611	Replace Old York Road bridge with a new three span, concrete-encased, I-beam structure supported by reinforced concrete abutments and column pier bents
PA	Paoli Transportation Center Road Improvements	Improvements to roadways around Paoli Intermodal Transportation Center, focused on roadways around the new transportation center including US 30 (Lancaster Avenue), North Valley Road, and Central Avenue (See MPMS #60574 for the transit components of the Intermodal Center. Study underway)
PA	Pennswood Road Bridge Over Amtrak/SEPTA R5 Rail Lines SR:7104	Replace existing structure carrying Pennswood Road over Amtrak.
PA	Ridge Pike / Two RR Bridges	Reconstruct and widen two bridges carrying Ridge Pike, a Montgomery County owned arterial, over Norfolk Southern railroad tracks in Plymouth Township between Manor Avenue and Carland Road Construct new pedestrian bridge over Norfolk Southern immediately adjacent to the highway bridges to provide a sidewalk on Ridge Pike Both existing bridges over the railroad are structurally deficient

State	Name	Description
PA	Rt. 322/Comm Barry Bridge/I-95 2nd St. Interchange	Widen (partially) Commodore Barry associated with the construction of a new on ramp and a new off ramp from the Commodore Barry Bridge/US 322 to S.R. 0291, Second Street, in the City of Chester to improve access to and from the City of Chester and the waterfront area from I-95 and the Commodore Barry Bridge/US 322 Add new westbound on ramp from the intersection of S.R. 0291 & Tilghman Street to the Commodore Barry Bridge/US 322 and new eastbound off ramp from the Commodore Barry Bridge/US 322 to S.R. 0291 & Jeffrey Street Construct full depth joint replacements and bearing replacements on the bridge through the limits of the bridge widening Safety and drainage improvements, ramp lighting, guide signing upgrades, and new traffic signals at the ramp termini with S.R. 0291 Amtrak involvement in the project due to the partial widening of the Commodore Barry Bridge includes relocation of two catenary structures and the jacking of a new DRPA storm drain pipe under the railroad
PA	Sellers Avenue Bridge Over Amtrak and SEPTA R2 Rail Line SR:2031	Replace superstructure of the Sellers Avenue Bridge over Amtrak while reusing existing stone abutments
PA	US 1, Baltimore Pike Interchange Improvements SR:0352	Preliminary engineering for the reconstruction of this cloverleaf interchange, originally built in 1939 Roadway is included in the Delaware County Bicycle Plan
PA	US 1, Baltimore Pike Widening	Widen from two lanes in each direction to three lanes in each direction Relocate the School House Rd. intersection Add left turn lanes on US 1 at School House Rd Install new traffic signals
PA	US 1, Township Line Road Bridge Over SEPTA Route 100 Rail Line SR:0001	Rehabilitate bridge carrying S.R. 0001 (Township Line Road) over the SEPTA Norristown High Speed Line
PA	US 202 and US 1 Loops Roads	Completes the loop roads on the southeast and southwest corners, connecting Applied Card Way to Hillman Drive at the existing Route 202/Hillman Drive signalized intersection in the southeast quadrant, and connecting Hillman Drive to Painters Crossing/Brandywine Drive in the southwest quadrant to divert traffic from the Route 202/US 1 intersection Northeast and northwest quadrants have the existing completed loop roads, State Farm Drive and Brandywine Drive, respectively Add turning movements at the intersections (i.e., no jug handles) for the proposed loop road connections

State	Name	Description
PA	US 202, 5-Points Intersection Improvements (71A)	Modify intersection of SR 0202 (Doylestown Road) with SR 0309 (Bethlehem Pike) and SR 0463 (Horsham/Cowpath Road) in Montgomery Township, Montgomery County, Pennsylvania, including the installation of additional thru lanes and minor widening on several legs, as well as the retiming of the existing traffic signal Modify existing drainage system Replace existing traffic signal support structures, adjusting several existing driveways to accommodate additional lanes, and upgrading the signing and pavement marking Replace both signal support structures
PA	US 202, Exton Bypass to Route 29	Reconstruct and widen approximately 2.5 miles of Limited Access Highway from the SR 0030 (Exton Bypass) to the Valley Creek Bridge Widen SR 401 between the ramp intersections, along with the installation of traffic signals at the ramps. Add additional lane and shoulder in each direction within the existing grass median along the mainline Widen SR 401 between ramps. Add left and right turn lanes along SR 401 to accommodate ramp turning movements
PA	US 202, Johnson Highway to Township Line Road (61S)	Widen US 202 approximately 1.8 miles from two lanes to five lanes including a center turn lane in this section of US 202 between Johnson Highway and Township Line Road in Norristown Borough, East Norriton & Whitpain Twps Replace one bridge and one culvert in this portion of Section 600 Replace traffic signal equipment at the intersections with Johnson Highway, Germantown Pike and Township Line Road Includes ITS Designed under Section 610
PA	US 202, Markley Street Improvements (Section 510)	Reconstruct Route US 202, from Main Street from Harding Blvd. from existing four-lane cross-section Replace existing “Bailey Bridge” carrying the NB lanes over Stony Creek Rehabilitate box beam structure carrying the SB lanes over Stony Creek Rehabilitate Main Street arch bridge over Stony Creek Roadway reconstruction to take place within the existing roadway footprint or involve minor widening; more significant widening to provide two NB left turn lanes from Markley Street to Main Street Total pavement reconstruction anticipated Corridor-wide improvements include traffic signal upgrades at the six signalized intersections, highway lighting, and pedestrian accommodations (including pedestrian signals, sidewalks, crosswalks, and bump outs)

State	Name	Description
PA	US 202, Markley Street Improvements (Section 520)	Reconstruct Route US 202, from Harding Blvd to Johnson Highway from a two-lane to three-lane roadway, with one northbound lane, one southbound lane, and one two-way left turn lane Improve signals Widen roadway following the existing alignment Pavement reconstruction is anticipated
PA	US 202, Markley Street Southbound (Section 500)	Pre-construction phases of the Markley Street rehabilitation project for Section 500 of US 202 (SR 3020 and Norristown Borough Street) from approximately 700 feet south of Main Street (local street) to Johnson Highway (SR 3017) for a total length of approximately 8,500 linear feet, and on Johnson Highway (SR 3017) from Markley Street to Powell Street (local street) for a total length of approximately 2,200 feet Incorporate all pre-construction phases (UTL and ROW) for MPMS# 80021 (Section 510) and 80022 (Section 520), which will be used for the respective construction contracts
PA	US 202, Morris Road to Swedesford Road (65S)	Widen US 202 from 2 lanes to 5 lanes in this 2.6 mile section Add a center turn lane where required and a new bridge over the Wissahickon Creek with a wider single-span structure and equestrian path beneath the roadway Improve intersections at Morris Rd., Sumneytown Pk., and Swedesford Rd Integrate a coordinated ITS and traffic signal operating system Designed under section 650 (section 600 was designed in two sections, 610 and 650, and will be built in four sections: Johnson Highway to Township Line Road; Township Line Road to Morris Road; Morris Rd. to Swedesford; Swedesford Road to PA 309
PA	US 202, Swedesford Road to PA 29	Reconstruct and widen US 202 on existing alignment for approximately 4.2 miles of limited access highway between Valley Creek Bridge (between Route 29 and Route 401 interchanges) and North Valley Road to add two additional travel lanes and provide a total of three 12' travel lanes in each direction and wider shoulders that improve safety Modify Route 29 interchange Improvements will help to accommodate pedestrians and bicyclists using the future Chester Valley Trail and other municipal trails Construct SWM basins and installation of sound barrier walls

State	Name	Description
PA	US 202, Township Line Road to Morris Road (61N)	Widen US 202 approximately 2.3 miles from two lanes to five lanes including a center turn lane in this section of US 202 between Township Line Road and Morris Road In East Norriton & Whitpain Twps Improve intersections along the project by adding lanes where necessary on both the mainline and side roads to provide adequate intersection capacities Install new traffic signals Integrate coordinated ITS and traffic signal operating system Takes place at two offline intersections, North Wales Rd./Township Line Rd. and Arch Rd/Township Line Rd. to improve traffic flow through the area during construction Designed under Section 610
PA	US 322 Final Design	Serves as the final design phase for corridor improvements to Route 322/Conchester Road Options being considered would enable US 322 to meet future traffic needs and include widening the road to four lanes, the construction of jughandles, and the installation of median barriers
PA	US 322, Featherbed Lane to I-95	Widen and improve SR 322 to a four lane typical section with a median barrier from east of Mattson Road/Featherbed Lane near Clayton Park and the Concord Township/Bethel Township line, through Bethel Township, to just west of the CSX Bridge in Upper Chichester Township Widened existing two lane section of SR 322 to 4 or 5 lanes with jughandles or exclusive left turn lanes to accommodate left turns at intersections Add a fifth lane between Chelsea Parkway and Cherry Tree Road to accommodate left turns into and out of the adjacent commercial properties
PA	US 322, US 1 to Featherbed Lane	Widen SR 322 (currently two lanes) to a four lane typical section with a median barrier from US Route 1 in Concord Township to east of Mattson Road/Featherbed Lane near Clayton Park and the Bethel Township line
PA	US 422 Expressway Reconstruction, Chester and Montgomery (M1A)	Reconstruct approximately one mile of expressway on both existing and new alignment meeting current design standards for horizontal radii, shoulder widths, and vertical clearance with a 9 foot left shoulder, 2-12 foot lanes, and a 12 foot right shoulder in each direction of travel Reconstruct three (3) bridges carrying SR 0422 over the Schuylkill River, Norfolk Southern Railroad Spur, and Norfolk Southern Railroad Mainline (24.0 Sufficiency Rating), and one (1) bridge carrying Armand Hammer Blvd. over SR 0422 providing 16'-6" of vertical clearance

State	Name	Description
PA	US 422, (New) Expressway Bridge Over Schuylkill River (SRB) - Part 3 of River Crossing Complex	Construct new US 422 bridge structure over the Schuylkill River for westbound traffic Replace existing US 422 structure over the Schuylkill River (sufficiency rating 44.1) for eastbound traffic Replace US 422 structure over Indian Lane (sufficiency rating 69.1) Replace US 422 structure over the Schuylkill River Trail (sufficiency rating 62.5) Replacement PA 23 structure over US 422 (sufficiency rating 24.8) Construct new flyover ramp from US 422 eastbound to PA 23 (See MPMS #16489 for the Old Betzwood Bridge)
PA	US 422, Schuylkill River Bridge Over Schuylkill River (M2A-Stowe)	Reconstruct bridge carrying SR 0422 over Schuylkill River to repair the fracture crack that was found in 2003 and required closure of the bridge followed by the emergency repair work New structure will have a multi-girder superstructure Structural improvements also include the replacement and extension of two (2) culverts
PA	US 422/PA 363 Interchange Reconstruction (4TR) - Part 2 of River Crossing Complex	Part (2) of the "River Crossing Complex," which is a complex area of roadways, interchanges, intersections, and bridges in and around the Valley Forge National Historic Park Environmental clearance for various components undertaken through MPMS #46954 PA 23/US 422 Interchange and North Gulph Road Improvements (MPMS #66952) US 422/PA 363 Interchange, including providing movements to/from the west (MPMS #64796) along with the Adams Ave west-bound off ramp and west-bound on-ramp from PA 363 Trooper Road and west-bound off-ramp to Adams Avenue US 422 Exwy Bridge over the Schuylkill River, replacement of the existing bridge (MPMS #70197), and new parallel four (4) lane bridge US 422 Widening for 1.8 miles from PA-363 interchange to the US-202 interchange Rebuild Old Betzwood Bridge Bike/Pedestrian Trail as a bike/pedestrian bridge only (MPMS# 16703) Early action interim project to provide timely and effective relief to WB afternoon congestion until the long range projects can fully advance (MPMS #74648)
PA	W Girard Ave O/CSX (Bridge)	Rehab/replace state bridge over the CSX rail line on US 30 (W Girard Avenue) between Parkside Avenue and the Schuylkill Expressway in Philadelphia Structurally Deficient bridge breakout project from MPMS #88706

State	Name	Description
PA	Woodbourne Road/Lincoln Highway Intersection Improvements	Add through lanes, right turn lanes, and left turn lanes along Woodbourne Road from Terrace Road to First Street Modify traffic signal for intersections of Old Lincoln Highway and Lincoln Highway with Woodbourne Road Add right turn lanes and lengthen existing left turn lanes
NJ	Atlantic City Expressway Widening	Widen from 5 lanes to 6 lanes from Route 73 to Atlantic County
NJ	Delancy Street, Avenue I to Avenue P	1.1 miles improvements to reduce flooding, raise level of service, for passenger and freight traffic near Routes 1&9
NJ	Garden State Parkway Interchange 91 improvements	Add complete set of on/off ramps to the GSP at exit 91 to increase access to highway, reduce detour driving
NJ	Garden State Parkway Interchange Improvements in Cape May	Improve intersections to address grade-separated interchanges at Shell Bay Ave, Stone Harbor Boulevard, and Crest Haven Road
NJ	Garden State Parkway Widening exits 63-80	Widen Garden State Parkway exits 63-80
NJ	I-295 / NJ 42 / I-76 Connection	Eliminate shared road portion of I-295 and NJ 42 to improve freight flow and relieve congestion
NJ	I-295 at NJ 38	Add missing movement to interchange at NJ 38
NJ	NJ 42 Freeways	Reconstruct NJ 42 from I-295 to AC Expressway
NJ	NJ Turnpike Widening from Exit 6 through Exit 9	Continue separated highway to Exit 6 for PA turnpike to add needed passenger and freight capacity on the highway and improve connection to PA Turnpike
NJ	NJ Turnpike Widening from the Delaware Memorial Bridge to Exit 4	Add one lane in each direction to complete a minimum of three lanes in each direction for the length of the NJ Turnpike
NJ	Garden State Parkway Interchange 125 (Phase 1)	Parkway Interchange 125 (Phase 1)
NJ	Garden State Parkway Interchange 142 Improvements	Parkway Interchange 142 Improvements
NJ	Portway, Passaic River Crossing - freight	Portway, Passaic River Crossing - freight

State	Name	Description
NJ	Route 295/42/I-76 Direct Connection	Construct direct connection between 295 and 42 and 76 Widen I-76
NJ	Route 295/42/I-76 Direct Connection ITS	Integrate ITS with 295/42/76 interchanges for congestion relief
NJ	Route 78 PA State Line to NJ Turnpike ITS Improvements	Route 78 PA State Line to NJ Turnpike ITS Improvements
NJ	Route 78, Pittstown Road (Exit 15) Interchange Improvements	Improve intersections to relieve on/off ramp congestion and queuing traffic
NJ	Route 80, route 46 to West of Change Bridge Road, ITS Improvements	Route 80, route 46 to West of Change Bridge Road, ITS Improvements
NJ	Route 80-Route 15 Interchange	Connect missing links to allow all movements
NJ	Scudder Falls Bridge (I-95) Reconstruction and Widening	Widen bridge to 3 lanes in each direction, make improvements to interchange with NJ 29
NJ/NY	Goethals Bridge Replacement Project	Replace functionally obsolete crossing; the bridge carries I-278 and connects directly with I-95/NJ Turnpike
NY	River Parkway at Gun Hill Road Realignment	Realign Bronx River Parkway Mainline to Gun Hill Rd exit Construct deceleration lane in NB direction Widen existing ramps to two lanes Install concrete median barrier to reduce accidents and improve safety
NY	Atlantic Avenue Extension	Design and construct Atlantic Ave extension to improve access to Jamaica Station Transit Hub at Sutphin Blvd, from VWE Extend Atlantic Ave through an existing mapped ROW
NY	Elm Street Bypass: Colonie	Construct new two-lane road from NY32 to Lansing Lane, Maplewood, Town of Colonie, Albany County
NY	I-87 Exit3-4 Improvement - Part 1	Reconstruct Exit 4 to improve access to Wolf RD/Airport and address operational issues
NY	I-90 Exist 8 Connector Phase 2 ITS Demonstration	Install ITS Currently estimated to cost $750M Additional funding dependent on identifying another fund source

State	Name	Description
NY	Kew Gardens / VWE Interchange Improvements	Rehabilitate bridges Widen Van Wyck Expressway for operational and safety improvements in Queens County
NY	Nassau County Incident Management	Install incident management system to maximize efficiency of traffic flow along major arterials
NY	Route 17 Upgrade to I-86: Exit 130A to Exit 131	Add ramp from Route 32 SB to Route 17 EB
MA	Bridge Street in Salem	Widen Bridge Street (Route 1A) from Flint Street to Washington Street to two lanes in each direction
MA	I-93/I-95 Interchange in Reading, Stoneham, Wakefield, & Woburn	Improve safety at the junction of Interstate 93 and Interstate 95, through multiple highway and transit improvements that brings infrastructure renewal and adds local transit capacity
MA	I-93/I-95 Interchange in Canton	Replace and construct ramps Construction connection road between I-95 and I-93 Widen Dedham St. to 4 and 5 lanes
MA	I-93/Route 3 Interchange in Braintree	Addresses mobility and safety issues of the Braintree Split
MA	I-95 Northbound/ Dedham St. Ramp/ Dedham St. Corridor in Canton	Construct a new ramp from Interstate 95 northbound to Dedham Street in Canton
MA	Interchanges at I-495/I-90 and I-495/Route 9	Interchanges at Interstate 495/Interstate 90 and Interstate 495/Route 9 will be improved to address existing and future safety and capacity deficiencies.
MA	Lowell Junction Interchange	Construct a new highway interchange on Interstate 93 between Exit 42 (Dascomb Road) and Exit 41 (Route 125) to provide improved access from Interstate 93 to the industrial and office properties in the Lowell Junction area (at the Tewksbury-Wilmington border)
MA	Middlesex Turnpike Improvements, Phase III in Bedford, Burlington, & Billerica	Widen Middlesex Turnpike from 800 feet north of Plank Street to 900 feet north of Manning Road to provide two lanes in each direction, making it a four-lane highway with a median
MA	Montvale Avenue in Woburn	Arterial and intersection improvement project along Montvale Avenue from Central Street to east of Washington Street in the City of Woburn

State	Name	Description
MA	Needham St./ Highland Ave./ Winchester Steet Newton & Needham	Needham Street will remain a three-lane cross-section from the Needham Street/ Winchester Street/Dedham Street intersection in Newton to the bridge over the Charles River at the Needham town line
MA	Route 1 Improvements in Malden, Revere, Saugus	Widen Route 1 from four to six lanes between Copeland Circle (Route 60) and Route 99
MA	Route 126/Route 135 Grade Separation in Framingham	Construct a 700-foot, below-grade underpass (one travel lane in each direction) from Park Street to Irving Street, allowing through traffic on Route 126 (Concord Street) to pass underneath Route 135 (Waverly Street) and the railroad tracks
MA	Route 18 Capacity Improvements in Weymouth	Widen Route 18 to two continuous lanes in each direction (with four-foot shoulders) between Highland Place/Charmada Road (south of Middle/West Street) in Weymouth and Route 139 in Abington
MA	Route 53 Final Phase in Hanover	Widen Route 53 from two to four lanes in Hanover between Route 3 and Route 123, a distance of 0.26 mile
MA	Sullivan Sq./ Rutherford Avenue in Boston	Transform the corridor’s highway-like design into a multimodal urban boulevard Rutherford Avenue corridor in the Charlestown neighborhood of Boston extends about 1.5 miles from the North Washington Street Bridge to the Sullivan Square MBTA Orange Line station
MA	Trapelo Road in Belmont	Reconstruct Trapelo Road from the Cambridge city line to Waverly Oaks Road (Route 60), a length of 2.5 miles to provide traffic signal, sidewalk, bicycle, and streetscape improvements

State	Name	Description
PA	Philadelphia International Airport Capacity Enhancement Program Automated people mover	Construct new Automated People Mover for transport between terminals and parking facilities
PA	Philadelphia International Airport Capacity Enhancement Program Enlargement of existing parking garages A, C, and D	Enlarge existing parking garages A, C, and D Reconfigure economy parking lot Construct new centralized ground transportation center Consolidate rental car facilities
PA	Philadelphia International Airport Capacity Enhancement Program New Runway 9R-27L	Construct new Runway 9R-27L, 1,600 feet south of renamed Runway 9C-27C 9,103 feet long and 150 feet wide Engineered Materials Arresting System (EMAS) at west end to reduce impacts to the Delaware River Associated taxiway improvements Runway lighting
PA	Philadelphia International Airport Capacity Enhancement Program New Runway and Extensions to Existing Runway 8-26	Extend Runway 8-26 by 2,000 feet to the east, for a total length of 7,000 feet Engineered Materials Arresting System (EMAS) at east end Associated taxiway improvements Relocate approach lighting system on runway end
PA	Philadelphia International Airport Capacity Enhancement Program New Runway and Extensions to Existing Runway 9R-27L	Extend Runway 9R-27L (to be renamed Runway 9C-27C) to the east by 1,500 feet, to a total length of 12,000 feet Associated taxiway improvements Relocate approach lighting system on runway end
PA	Philadelphia International Airport Capacity Enhancement Program Upgrade and Reconfigure Existing Terminal Complex	Expand Terminal D-E Expand Terminal F Construct new Terminal G and Commuter Terminal
NJ	Newark Airport Terminal A Modernization, Expansion, & Structural Parking	Modernize and expand Terminal A Add structural parking
NJ	AirTrain/Newark Replacement	Replace existing on-airport automated people mover Enhance system capacity Coordinate w/ on-airport improvements and planning for PATH-EWR/RLS extension
NY	LaGuardia Airport Central Terminal B (CTB) Modernization	Modernize the Central Terminal Building at LGA
CT	Bradley International Airport CONRAC (Consolidated Rental Car facility)	35% Design of CONRAC/Garage at BDL
CT	Bradley International Airport Terminal Expansion	Construct 11 new gates at BDL

State	Name	Description
CT	Bradley International Closure of Cross-Runway	Close cross-runway 119 to eliminate crossing at BDL
RI	T.F. Green Airport	Extend Runway 5-23 Expand Runway 16-34 Runway Safety Area Relocate Taxiway C farther from Runway 16-34 Construct up to 7 new gates
VA	Dulles International Airport Fifth Runway (Runway 12R-30L)	Construct fifth runway parallel to existing runway 12-30 along the south side of Dulles Airport property roughly parallel to U.S. 50, west of Chantilly ~10,500 feet long and 150 feet wide named Runway 12R-30L (existing parallel runway will be renamed 12L-30R)

State	Name	Description
MD	Dundalk Marine Terminal, Phase 1 Rehabilitation	Rehabilitate berths 1-6, which are essential to the Port because they handle a variety of cargoes, i.e. automobiles, forest products, roll-on, roll-off and other break-bulk (van-packs)
MD	Masonville Berth Construction	Construct new structure to replace Fairfield Marine Terminal Pier 4, a deficient pier of World War II vintage that is currently at the end of its useful life and the sole MPA berth for two large auto terminals (146 acres) Baltimore is expected to finish calendar year 2011 as #1 in the nation for auto exports, and within 20 years of the Masonville Vessel Berth construction, auto movements over the Berth is predicted to grow from 120,000 to 230,000 units Convert Masonville DCMF into a marine terminal
PA	South Philadelphia Port Relocation	Assist in the relocation of the Packer Avenue Marine Terminal Gate in order to remove conflicting traffic movements on Delaware Avenue, enhance safety, enhance security, and reduce confusion PRPA is currently reviewing options such as the partial or full closure of the east-side service road, commonly called 'Old Delaware Avenue', south of Oregon Avenue, and the location of gatehouses/checkpoints on currently-unused roadways and/or parcels are being explored
NJ	Delaware River Deepening	Deepen river to allow larger ships to access Ports in PA and NJ
NJ	Port Jersey Intermodal (Rail) Access	This project continues the Port Authority's intermodal rail initiative by providing an intermodal container transfer facility in support of the terminal operations at the Port Jersey Marine Terminal.
MA	Conley Terminal Access Road	Construct new terminal access road that will remove container truck traffic from residential East First Street and portions of Summer Street in South Boston
MA	New Russia Wharf Ferry Terminal and Route in Boston	Implement new ferry route in Boston Inner Harbor, from the existing terminal at the Charlestown Navy Yard to a new terminal at Russia Wharf, which is located in Fort Point Channel at Congress Street

APPENDIX C
NO ACTION ALTERNATIVE RELATED PROJECTS LIST

State	Name	Description
Fully or Partially Funded Projects Located in a Connecting Corridor and Not on the NEC		
Connecting Corridor - Springfield Line		
CT	New Haven-Hartford-Springfield Rail Program Phases 1, 2 and 3A	Construction of 10 miles of second track in between New Haven and Meriden, CT, to increase capacity and improve performance on the New Haven-Springfield corridor.
MA	Springfield MA Union Station Project	Integrate multiple transit modes (bus, Amtrak, commuter rail, taxi, bicycle, and pedestrian) Restore Terminal Building and its central concourse. Remove Baggage Building and construct a 24-bay bus terminal and a 146-space parking garage, with 4 additional bus bays on adjacent site. Reopen and restore passenger tunnel linking the terminal building to rail boarding platforms and pedestrian access to the downtown Provide new stair and elevator access from re-opened passenger tunnel leading to passenger rail boarding platforms
Connecting Corridor - Keystone		
PA	Keystone Corridor - Grade Crossing Elimination	Final design and construction for the elimination of four public, at-grade crossings on the Philadelphia-Harrisburg Keystone Corridor to improve speed, reliability, and safety.
PA	Keystone Corridor- Interlocking Design	Engineering and environmental analysis for the replacement and reconfiguration of tracks and improvements to signal and train control along the Philadelphia-Harrisburg Keystone Corridor to improve speed, reliability, and on-time performance.
PA	Keystone Corridor - State Interlocking Improvements	The final design and construction of an upgraded "State" interlcoking near Harrisburg, PA. New interlocking will further decrease trip time on the corridor, increase on-time performance, and improve service reliability.
PA	Keystone Corridor - Automatic Block Signaling/Central Control	Preliminary engineering and project-level NEPA (environmental) work for the installation of Automatic Block Signaling and Centralized Traffic Control on a segment of the Philadelphia-Harrisburg Keystone Corridor to improve speed, reliability, and on-time performance.
PA	Paoli Transportation Center	Develop, engineer, and construct new multi-modal transportation center in Paoli, Chester County, located on the Paoli/Thorndale Line serving SEPTA and Amtrak trains. Phase I will make the existing station ADA accessible and includes a pedestrian overpass, three elevators, and a new high level center platform. Phase II includes an intermodal station complex complete with an additional high-level platform on the outbound side, waiting area and passenger amenities; enhanced bus facilities; and a 600-plus space commuter parking garage.

State	Name	Description
PA	Ardmore Transportation Center	The Ardmore Station improvement project will be completed in two phases. Phase I (funded) includes construction of high level boarding platforms, tunnel ADA improvements, elevators, stairs, and ramps to access the platforms; canopies and shelters; passenger amenities; improved lighting; landscaping and site improvements; new signage and paving; and new underground stormwater system in the existing Township parking lot. Demolition of the existing Amtrak station building to facilitate the installation of high level platforms. Phase II (unfunded) will include the construction of an ADA accessible, multi-level parking garage with approximately 300-500 spaces and an enclosed space for ticketing and passenger waiting.
PA	Exton Station	Construction of high-level platforms, a station building, bus circulation loops,and a multi-level parking garage at Exton Station on the Paoli-Thorndale Regional Rail Line. Phase 1 (funded) will make the station ADA compliant and include the construction of high-level platforms with canopies and wind screens, a station building, and new lighting, signage, security features, and passenger amenities. Phase 2 (partially funded) includes a fully accessible, multi-level, parking garage with pathways to the station platforms and bus circulation loops with shelters.
PA	Villanova Intermodal Station	Modernization of Villanova station. Phase 1 (funded) includes the constructio of pedestrian underpass, ramps, stairs, and storm water management. Phase 2 (partially funded) will make the station fully ADA accessible and includes the construction of high-level platforms with canopies, building exterior improvements, new signage, lighting, passenger amenities, and landscaping.
PA	Middletown Station	Construction of new Amtrak station at Middletown to replace the existing station on a site west of the current station. Project will include new straight, high-level platforms.
PA	Mt. Joy Station	Construction of a new Mount Joy Train Station located in Mount Joy, PA. This station will replace the existing station and include high-level platforms and ADA accessibility.
PA	Coatesville Train Station Rehabilitation	Rehabilitate existing Amtrak train station as part of the Transportation Enhancements program and $1 million specially earmarked FTA funds

Connecting Corridor - Empire

NY	Empire Corridor Planning	Engineering and environmental analysis to support improved passenger rail service between Albany and Penn Station NY (Empire South), Albany and Niagara Falls, NY (Empire West), and from east of Buffalo-Exchange Street Station to Niagara Falls (Niagara Branch). The program of high speed rail improvements include increased speeds and reduced trip times.
NY	Albany-Rensselaear Station 4th Track and Related Improvements (NY-ESC-HP - Empire Corridor Capacity Improvement - Section 1)	This project will construct a 4th passenger loading track, extending both loading tracks to two platforms, and by realigning existing tracks, turnouts and the signal system along the 1 mile of the track network at the Station. This project will also remove the 30 mph speed restriction in the vicinity of the station.

State	Name	Description
NY	Hudson Subdivision Signal Reliability Improvements (All Phases)	The existing signal system is nearly 30 years old, and frequent outages occur during inclement weather affecting all trains between Albany and NYC. This project will increase reliability of signal system by replacing signals and burying the signal cable between Poughkeepsie and Red Hook. The project will be constructed in phases; Phase 1 replaces 19 miles in the Towns of Poughkeepsie, Hyde Park, Rhinebeck and Red Hook (Barrytown). The final phase will replace the final 44 miles of the Hudson Line signal system beginning in the town of Redhook (Barrytown), Dutchess County N.Y. and extends to the Village of Castleton-On-Hudson, Rensselaer County, N.Y.
NY	Highway/Rail Grade Crossing Improvements (ESC3)	This project will upgrade and/or install warning devices at thirteen highway-rail at grade crossings (defined in the Construction Information page), to include 12" LED flashers, gates and motors, and electronic bells. In some locations, new circuitry will be installed, and minor adjacent highway improvements will be made.
NY	Albany to Schenectady 2nd Main Track (ESC10)	This project will reduce delay and improve reliability for passenger rail on the Empire Corridor.The project consists of constructing a second main track between Schenectady and the west end of the Livingston Ave Bridge in Albany, upgrading existing grade crossings and warning device systems.
NY	Schenectady Station 2nd Track & Platform Improvements (NY-ESC-HP - Empire Corridor Capacity Improvement - Section 3)	The Schenectady Train station was built in 1970 by the New York State Department of Transportation. This project will replace the existing Schenectady station with a new station, station tracks and platform, including repairing structural and track deterioratiation, addressing state of good repair, and ensuring ADA compliance.
NY	Empire Corridor - Ongoing Normal Replacement	The normal replacement rate is the annual funding needed to keep existing assets maintained and replaced within their useful life. The normal replacement rate is a sufficient level of investment only if all assets start in a state of good repair.
NY	Livingston Avenue Bridge (ESC15)	Preliminary engineering for the eventual replacement of Livingston Avenue bridge, crossing the Hudson River between Rensselaer and Albany Built more than 100 years ago, the bridge does not meet current railroad bridge design standards.The deterioration of the bridge limits trains to crossing one at a time at 15 mph. The swing span mechanism, which allows taller ships to pass, is unpredictable and continues to deteriorate, leading to increased delays to both rail and marine traffic. (Funded through preliminary engineering only.)

Connecting Corridor - MTA - Metro-North Hudson Line

NY	Metro-North Railroad Power and Signals Resiliency	The New York Metropolitan Transportation Authority (MTA) will receive funding to make flood protections for the Metro-North Railroad Hudson River Line and other facilities.
NY	Metro-North Hudson Line - Ongoing Normal Replacement	C&S Program, Track Program, Stations Program, Tunnel Program, Yard Track Program, Bridge Program, Miscellaneous Safety/Administration (e.g., environmental batement/remediation, security initiatives, program administration, insurance).

State	Name	Description
NY	Metro-North Hudson Line High-Capacity Signal System Replacement (Harmon to Poughkeepsie)	Replace present signal system, from Croton-Harmon to Poughkeepsie, with new high-capacity and performance signal system providing additional signal aspects
NY	Hudson Line - Positive Train Control (Wayside) - CP 12-MP 75.76 (MTA Owned)	Upgrade signal system along the Metro-North Hudson Line to meet 2008 federal rail safety law that requires installation of Positive Train Control.
NY	Hudson Line - Harmon Shop & Yard Upgrade - Phase V, Stage 2	Construction of the new Running Repair and Support Shop facility (Phase V; Stage 2) will complete the replacement of the functionally and physically obsolete existing facility. This will modernize the 100+ year-old Harmon Electric shop and yard complex to support an expanded fleet of electric and diesel hauled rail cars.
NY	Hudson Line - Upper Hudson Line Stations Improvements	Component-based renewal work at multiple stations on the Metro-North Hudson Line.

Connecting Corridor - DC - Richmond VA

State	Name	Description
DC/VA	Long Bridge Preliminary Engineering-NEPA Study	Engineering and environmental analysis for the replacement and/or rehabilitation of the CSX-owned Long Bridge between Washington, DC and Arlington, VA, potentially incorporating multimodal uses. Rehab of existing 2-track bridge assumed in Alternative 1; replacement with 4-track corridor between CP Virginia and AF Interlocking assumed in Alternatives 2 and 3
VA	Southeast High-Speed Rail (SEHSR) Corridor	Engineering and environmental analysis for the development of the Southeast High-Speed Rail Corridor between Washington, D.C. and Richmond, VA
VA	Positive Train Control - Washington to Richmond	Install positive train control to meet federal mandate
VA	Arkendale to Powell's Creek Third Tracl	Final design and construction of 11.4 miles of third track from Arekndal to Powell's Creek on the Washington to Richmond segment of the Southeast HSR Corridor.
VA	CSX RF&P Rail Corridor Rail Corridor Third Track - Phase 2	Track, signal and switch work and second platforms at Leeland Road and Brooke Stations, which will support capacity expansion, operational flexibility and service expansion related to the construction of the new VRE Potomac Shores Station.
VA	VRE - Stations and Facilities	Involves the addition of second platforms, canopy and platform extensions, replacement of signage and other related improvements at various VRE stations in order to keep the stations in good repair. This work will be done at various stations including Fredericksburg, Leeland Road, Brooke, Manassas, Manassas Park, Woodbridge, Rippon, Rolling Road, Broad Run, Burke and other stations to be determined.

State	Name	Description
VA	VRE - Tracks & Storage Yards	As additional cars are added to accommodate ridership demand, storage yards and maintenance facilities must be obtained and/or upgraded. Improvements to the yards and maintenance facilities will allow additional maintenance to be performed by VRE contractors and additional vehicles to be stored.
VA	VRE - Track Lease Improvements	Provides capitalized access fees in the form of long term and related capital improvements on the railroad systems that VRE operates on railroad systems owned by Amtrak, CSX, and Norfolk Southern.
VA	VRE - Potomac Shores Station	Design and construction of a new station to suport a new Transit Oriented Development at Potomac Shores, VA.

Unfunded Projects along the NEC with Ongoing or Completed NEPA/PE

State	Name	Description
DC	Washington Union Station Master Plan	The Union Station Master Plan sets out a framework for rebuilding and expanding the station over the next 20 years. It provides a long-term, multi-phased vision for increased capacity with additional tracks and wider all high-level platforms; new amenities for passengers including sweeping modern concourses and retail spaces; and large-scale real estate development above the station’s tracks.
MD	Amtrak B&P Tunnel Rehabilitation/Replacement	Replacement and/or rehabilitation of the Baltimore & Potomac (B&P) Tunnel in Baltimore, MD, on the Northeast Corridor. (ARRA/HSIPR Program currently funding preliminary engineering and environmental analysis.)
MD	Susquehanna Bridge Rehabilitation/Replacement	Replacement and/or rehabilitation of the Susquehanna River Bridge in Maryland, a chokepoint that precludes capacity increases on the Northeast Corridor. Engineering and environmental analysis is currently funded.
MD	BWI Thurgood Marshall Airport Station - New Station Building and Fourth Track	Construct new station building to meet ADA/SGR requirements and engineering and environmental analysis to study the construction of an additional track to approximately nine miles of existing tracks surrounding the BWI station, and station expansion.
NJ	Hunter Flyover	Construction of a grade-separated crossing of the Raritan Valley Line trains that would allow RVL to cross NEC tracks without interfering with any trains on Tracks 4, 3 and 2. It would permit trains to operate at faster speeds and provide substantial additional capacity, which could be used to support increased train volumes when required. (Engineering and design is currently funded.)
NJ/NJ	Gateway Program - ROW Preservation	Construction of concrete casing beneath the Hudson Yards to preserve the right of way for future Gateway tunnels (trans-Hudson tunnels)

State	Name	Description
NJ/NY	Portal Bridge Replacement	Replacement of the existing swing-bridge over the Hackensack River with a fixed-span bridge, plus track reconfiguration on either end of the bridge where a choke point exists on the busiest portion (Newark, NJ to New York, NY) of the Northeast Corridor. ARRA/HSIPR program funded final design. NJT is funding early-action activities.
NY/NJ	Gateway Program - Tunnel Resiliency	Two new tunnels under the Hudson River connecting Allied Junction to A Yard at Penn Station New York (PSNY) to replace the existing North River Tunnels which are in need of repair.
NY/NJ	Gateway Program - Capacity Improvements	Restores service service to the original North River tunnels to create four tracks into PSNY; adds capacity at PSNY to accommodate additional trains; adds capacity from Allied Junction as far west as Elizabeth, NJ
NY	Pelham Bay Bridge Replacement	Replacement of existing, movable bridge with with a new high-level fixed bridge that will offer enough clearance for boats to pass below. A new fixed bridge will increase reliability and may offer opportunities to increase capacity for Amtrak and proposed Metro-North service
NY	Moynihan Phase 2	The Farley Post Office will be converted into a full-scale, intercity passenger rail terminal, including the construction of ticketing facilities, waiting areas, retail amenities, and access points to tracks and platforms.
NY	Sunnyside Yard Facility Upgrade	Upgrade Sunnyside Yard to improve the efficiency of this major shared use facility for NJT and Amtrak, while building space to accommodate a proposed lengthening of Acela trains
NY	Penn Station Access Improvements	The proposed Capital Program includes design and construction of new infrastructure and completion of specifications for rolling stock to operate Metro-North Railroad service on the New Haven Line into Penn Station NY via Amtrak's Hell Gate Line
CT	New Haven Line Bridge Replacement Projects	Replacement of New Haven Line Bridges (Devon, Cos Cob, and Saugatuck)
RI	Providence Station Improvement Project PE/NEPA	Engineering and environmental analysis for rehabilitation of the intercity rail station to improve passenger accessibility on the Northeast Corridor
RI	Pawtucket/Central Falls Commuter Rail Station	The Rhode Island Department of Transportation (RIDOT), in cooperation with the City of Pawtucket, is considering alternatives to reintroduce commuter rail service into Pawtucket. The potential station would be located on Amtrak's Northeast Corridor (NEC) and the Massachusetts Bay Transportation Authority's (MBTA's) Providence commuter rail line.
MA	Boston South Station Expansion and Layover Facility Project	Expansion of station and storage capacity in Boston, MA, to address anticipated capacity needs for intercity rail operations in a facility shared with commuter rail traffic. (ARRA/HSIPR program funding engineering and environmental analysis)

State	Name	Description
Fully or Partially Funded Transit/Freight Projects Located Off of or Connecting to the NEC		
PA	Levittown Intermodal Facility Improvements	Phase 1 of the project includes construction of intersection improvements at Levittown Parkway and Rt. 13 and relocation of utilities. Construction of the southern portion of the inbound parking lot and new entrance driveway and reconfiguration of the existing outbound parking lot
NJ	NJT - Multiple Resiliency Projects in Response to Hurricane Sandy	Hoboken Long Slip Flood Protection; NJ TRANSIT Raritan River Drawbridge Replacement Project; and Train Controls - Wayside Signals, Power & Communication Resiliency Project.
NJ	Lackawanna Cutoff Minimal Operating Segment (MOS) Project	Reconstruct line including track and signal improvements to approximately 88 miles of right of way, new stations, parking facilities, a train storage yard, and additional rail rolling stock. The first phase of the project (also known as the Minimal Operating Segment, MOS) is a 7.3 mile segment from Port Morris Yard to a new passenger station at Andover, NJ.
NJ	PATH Extension to Newark Liberty International Airport Rail Link Station	Proposed extension of PATH from its present terminus at Newark Penn Station to Newark Liberty International Airport's Rail Link Station (RLS) to enhance airport access for communities served by PATH. The project concept includes construction of new platforms and associated station passenger infrastructure with potential multimodal transit connections adjacent to the existing RLS, relocation of a rail storage yard in the vicinity of the RLS, and modifications at Newark Penn Station to accommodate bidirectional passenger flow as well as limited vertical circulation improvements. The proposed alignment utilizes a portion of the NEC ROW, requires planning coordination with potential Amtrak fifth-track project.
NJ/NY	Cross Harbor Freight Program Tier 1 EIS	NEPA Analysis to evaluate alternatives to improve the movement of freight across New York harbor between the east-of-Hudson and west-of-Hudson regions, including No Action, Waterborne, and Rail Tunnel Alternatives
NY	Flood Resiliency for Long Island City Yard (LIRR)	Construction of flood protections for the Long Island Rail Road Long Island City yard, which is located within the 100-year flood hazard area. This yard serves diesel and electric trains, adding to resilience.
CT	New England Central Railroad Freight Rail Project	The project will complete state of good repair improvements and the upgrade of rail and track infrastructure to accommodate national standard 286,000-pound (286K) gross weight rail freight cars on the 55 miles of track running through the municipalities of New London, Waterford, Montville, Norwich, Franklin, Lebanon, Windham, Mansfield, Willington, and Stafford in eastern Connecticut.

State	Name	Description
MA	Merrimack River Bridge Rehabilitation	Rehabilitation of three bridges that provide an integral connection from Boston to Haverhill and other northern locations, carry two railroad tracks over the Merrimack River in the city of Haverhill, and serve as an important corridor for passenger service, including the MBTA Commuter Rail - Haverhill Line and Amtrak's "Downeaster" train and Pan Am freight service
MA	South Coast Rail	The plan provides resources for continued design, permitting as well as "early action" improvements to rail ties, existing signal systems, crossings and several bridges in the South Coast Region. These early action investments will improve the reliability of existing freight service in the South Coast while contributing to future passenger rail service.
MA	Fairmount Line Improvement Project	Rehabilitate existing Uphams Corner and Morton Street stations Construct four new stations—Newmarket, Four Corners, Talbot Avenue, and Blue Hill Avenue Reconstruct six existing railroad bridges (located over Columbia Road, Quincy Street, Massachusetts Avenue, Talbot Avenue, Woodrow Avenue, and the Neponset River) Construct new interlocking and an upgraded signal system (required to advance the bridge reconstruction work) Upgrades will enhance future service, allowing for increased frequency on the line
MA	MBTA Worcester Line Improvements/Service Expansion	Increase commuter rail service on the Framingham/Worcester line between Boston and Worcester with the addition of three new inbound and three new outbound trains between the two cities for a total of 31 stops arriving or departing Worcester station Agreement between CSX and the Commonwealth provides the Commonwealth ownership of the rail tracks and control of operations along the Framingham/Worcester line, allowing greater opportunities for MassDOT to not only improve service, but also increase service between Boston and Worcester

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Initial Alternatives Report

March 22, 2013
Final

Submitted by:

PARSONS BRINCKERHOFF AECOM
A JOINT VENTURE

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1 Introduction

1.1 PURPOSE OF THE NEC FUTURE PROGRAM

The Northeast region has one of the most extensive multimodal passenger and freight transportation systems in the world—highways, airports, ports, intercity and commuter rail, and public transit serving all major cities and many intermediate markets. However, despite significant investment over decades in all modes, the region still faces major congestion and capacity constraints. These constraints, if not addressed, have the potential to curtail future mobility and economic growth and place the Northeast at a competitive disadvantage to other regions of the U.S. and the world.

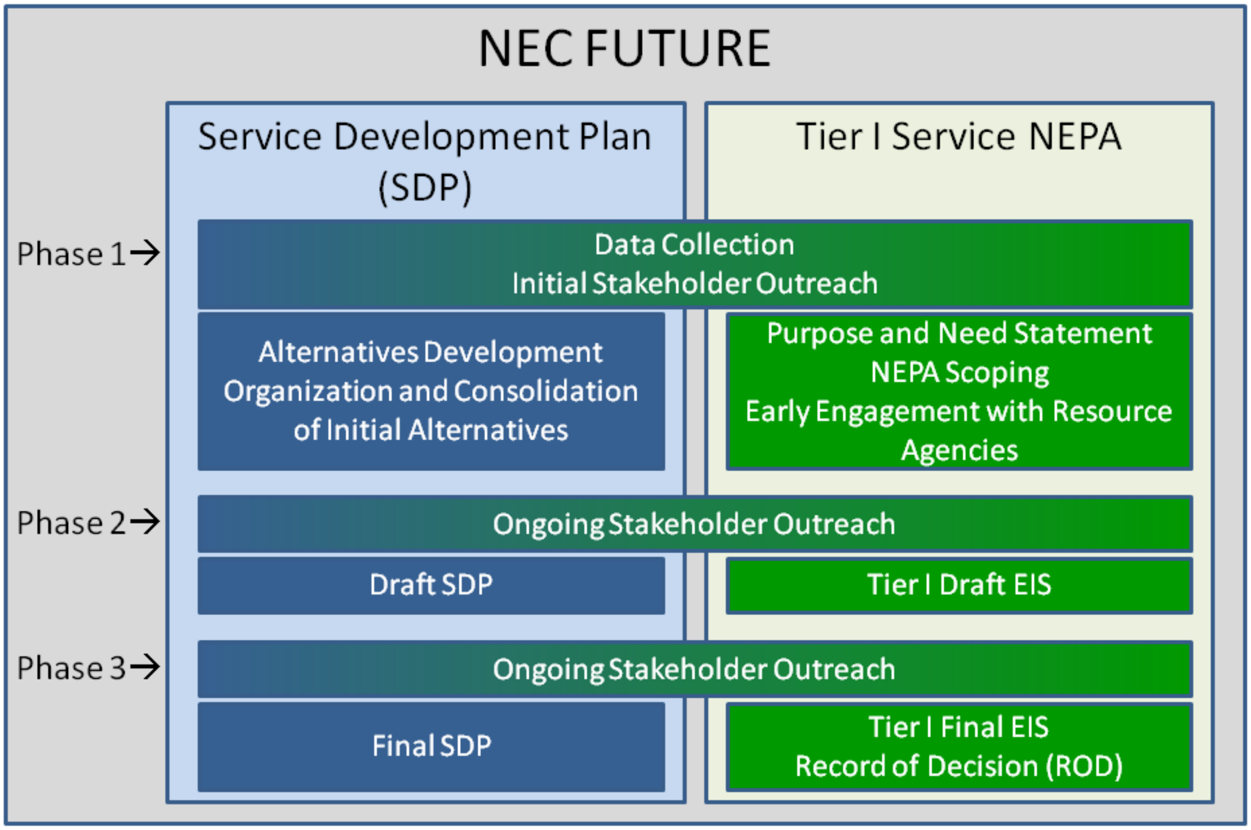
The goal of the NEC FUTURE Program is to prepare a Passenger Rail Corridor Investment Plan (PRCIP) for the Washington, D.C.–Boston Northeast Corridor. The PRCIP, consisting of a Service Development Plan (SDP) that articulates the overall scope and approach for proposed service and Tier 1 Environmental Impact Statement (EIS), will define an integrated, comprehensive passenger rail transportation solution for the Northeast. The purpose of this solution is to improve mobility, effectively serve travel demand due to population and jobs growth, support economic development, reduce growth in carbon emissions and dependence on foreign oil, and contribute to improved land utilization and investment in both urban and non-urban communities in the region.

1.2 OVERALL PLANNING AND ENVIRONMENTAL DOCUMENTATION PROCESS

The Federal Railroad Administration (FRA) is the designated Lead Agency for this project. The project has been divided into three phases, as shown in Figure 1-1:

- **Phase 1** involves the early service planning and alternatives development and evaluation. Technical work to be completed in Phase 1 includes: data collection, development of the project's Purpose and Need, preparation of a Public/Stakeholder Involvement Plan, analysis of existing and future ridership forecasts, operations analysis, service identification and evaluation, identification of infrastructure requirements and alternatives development, and the initiation of Early Engagement with Resource Agencies and National Environmental Policy Act (NEPA) Scoping process. The alternatives development process (which is the subject of this Initial Alternatives Report), will also include a high-level, coarse screening which will result in the advancement of a set of Preliminary Alternatives to be refined and evaluated in Phase 2.
- **Phase 2** will involve further refinement of the alternatives and the preparation of the Draft Tier 1 EIS.
- **Phase 3** will result in the preparation of the Final Tier 1 EIS and Record of Decision, as well as the draft and final SDP.

Figure 1-1: Project Structure



The complexity of a major capital investment initiative such as the one contemplated for the Northeast region necessitates extensive pre-construction preparation, including service planning, environmental review, design and conceptual engineering efforts. The NEC FUTURE represents the up-front planning effort that is necessary to determine the most appropriate level and type of investment. The NEC FUTURE program provides sufficient information to support an FRA decision to fund and implement major investment in a passenger rail corridor.

The scope of the NEC FUTURE program for the Northeast region includes the economic, financial, and environmental analyses necessary for implementing high-speed intercity, and commuter passenger rail as a core component of a better integrated, more efficient, safer, and higher-capacity Northeast regional multimodal transportation network that provides redundant and secure travel options.

1.3 PURPOSE OF THIS DOCUMENT

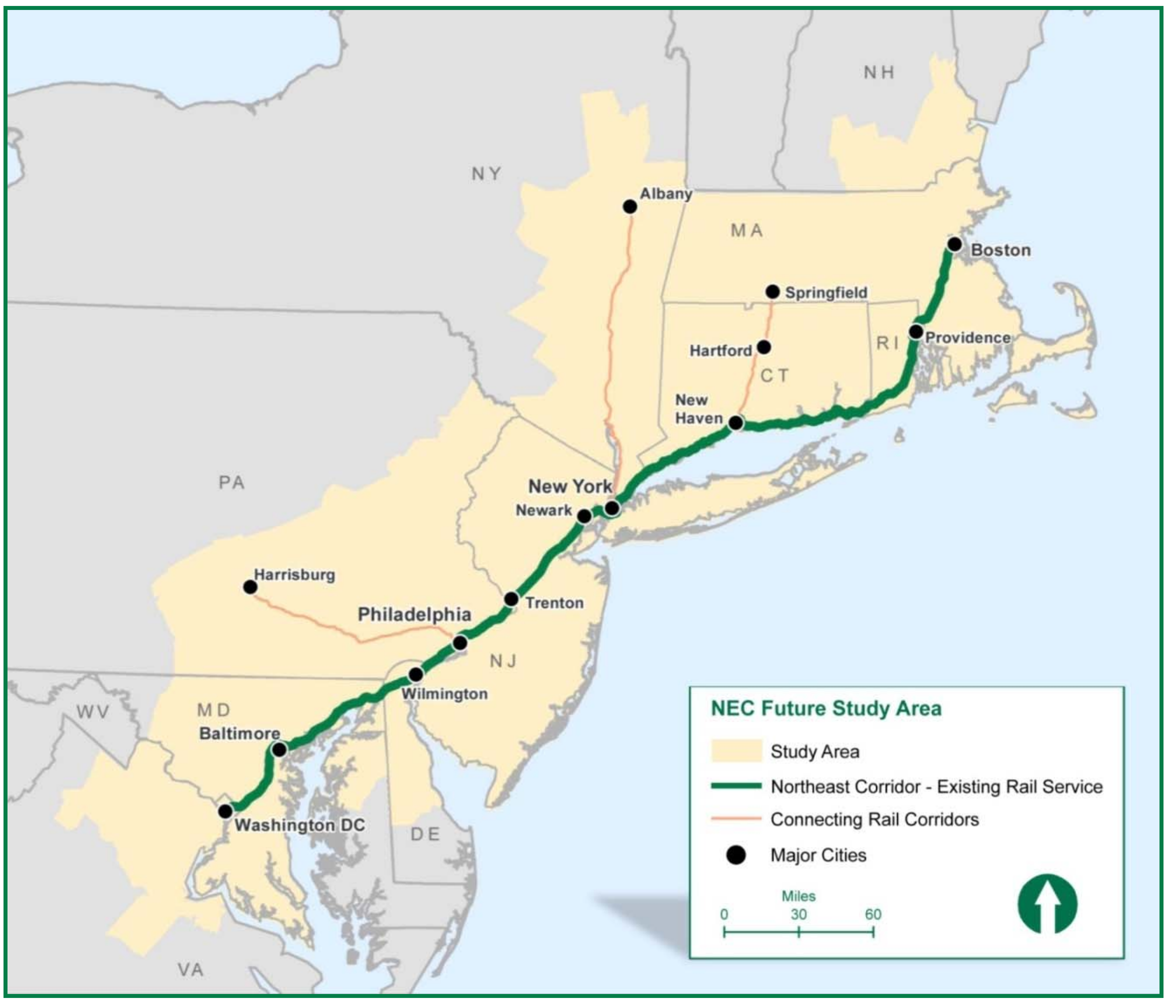
This Initial Alternatives Report documents the background and process for developing the set of Initial Alternatives that will be evaluated and advanced through the alternatives process. As the program advances, the number of alternatives will be reduced as the result of screening and technical analyses, resulting in a set of Preliminary Alternatives and then Reasonable Alternatives, culminating with a recommended Preferred Investment Program.

1.4 STUDY AND MARKETS AREA

For purposes of the Phase 1 early service planning effort, the Northeast Region is defined to encompass Greater Washington, D.C., Greater Boston, MA, and points in between. The existing rail transportation spine of the Northeast region is a linear corridor linking Washington Union Station, Pennsylvania Station New York, and Boston South Station, known as the Northeast Corridor (NEC).

Figure 1-2 shows the existing passenger rail network that comprises the NEC spine, existing connecting services, and other major rail and highway links and airports. The Study Area encompasses the region served by the NEC spine, plus those areas that can be reached directly by train or via a single transfer to connecting corridors from the NEC spine, as well other areas considered part of the overall market area for these services. The Study Area definition will be refined as the alternatives development and EIS processes advances.

Figure 1-2: Study Area



2 Purpose & Need for Rail Improvements

The Purpose & Need for investment in the NEC passenger rail network is detailed in the NEC FUTURE Purpose & Need Statement, which is included as Appendix A. The NEC connects four of the nation's 10 largest metropolitan areas,[1] making the corridor an economic anchor for the nation with a population density triple the national average[2] and a $3 trillion economy.[3] Projections show that over the next 20 to 30 years there will be continued strong population,[4] economic,[5] and travel demand growth in the Northeast Corridor.[6]

The NEC and its connecting corridors (New Haven-Hartford-Springfield [NHHS], Empire, and Keystone) are among the most heavily utilized rail networks in the world and are shared by intercity, commuter and freight operations. The NEC moves more than 259 million (and growing) passengers every year[7] on Amtrak and eight commuter rail agencies, and approximately 370,000 tons of freight per year[8] on four freight carriers.

Maintaining the region's competitiveness for jobs and quality of life will depend in large part on the ability of its transportation system to accommodate growth, in terms of the ability to move both people and freight. Without improvements to and expansion of existing infrastructure, the predicted future growth of population and economy will result in travel gridlock[9] and lost economic growth potential. Rail freight movement on the NEC has already reached the levels forecast for 2030 in the NEC Infrastructure Master Plan, growing from 50 to 72 trains a day.[10]

Highways in the region are already congested,[11] and even with improvements, they will not be able to absorb future demand. The region's airports are facing similar capacity constraints and continual growing demand.[12]

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[1] U.S. Census Bureau, "Population Distribution and Change: 2000 to 2010, 2010 Census Briefs" (March 2011), Table 3, http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf.

[2] CONEG, "Regional Context."

[3] U.S. Dept. of Commerce, Bureau of Economic Analysis, Regional Economic Accounts (September 2012). [MSA estimates within study area are for 2010.]

[4] Moody's Analytics, Inc., 2012 data retrieved from Forecast and historical Databases, http://www.economy.com/home/products/databases.asp?src=left-nav.

[5] Moody's Analytics, Inc., 2012.

[6] The NEC Master Plan Working Group, The Northeast Corridor Infrastructure Master Plan (May 2010).

[7] The NEC Master Plan Working Group, Infrastructure Master Plan.

[8] NEC Commission Freight Committee, "Current and Future Freight Use of the NEC" (March 2012).

[9] National Capital Regional Transportation Planning Board, Metropolitan Washington Council of Governments, "Constrained Long-Range Plan, 2010 Congestion Management Process (CMP) Technical Report," (2010) accessed October 2012, http://www.mwcog.org/clrp/elements/cmp/files/CMP_Tech_Report_2010%20FINAL_09032010.pdf.

[10] NEC Commission Freight Committee, "Current and Future Freight."

[11] I-95 Corridor Coalition, A 2040 Vision for the I-95 Coalition Region: Supporting Economic Growth in a Carbon-Constrained Environment (December 2008), http://www.i95coalition.org/i95/Portals/0/Public_Files/pm/reports/2040%20Vision%20for%20I-95%20Region_Full%20Report.pdf.

Projected regional trip growth is expected to add millions of trips to the NEC's commuter rail carriers in the next 20 years, and intercity travel demand is expected to grow by as much as 45 percent.[13] Both commuter and intercity services on the NEC already face major challenges that limit current service and will further constrain their ability to meet future passenger rail demand, including capacity constraints and chokepoints, reliability problems due to aging infrastructure, and the operational and engineering challenges of introducing high-speed train service.

Addressing the capacity, frequency, travel-time needs, and reliability of transportation with market-competitive passenger rail service along the NEC will be critical to providing the mobility that will allow the future population, employment, freight, and economic growth of the Northeast to reach its potential.

[12] Transportation Research Board Airport Cooperative Research Program (ACRP) Report 31 Sponsored by the Federal Aviation Administration: innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions, Accessed October 2012, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_031.pdf
[13] Moody's Analytics, Inc., 2010.

3 NEC Overview

3.1 INTRODUCTION

The 457-mile-long NEC rail infrastructure is owned by several entities:

- Amtrak (Washington, D.C., to New Rochelle, NY, and New Haven, CT, to the Rhode Island-Massachusetts border)
- New York Metropolitan Transportation Authority (MTA) (New Rochelle to the New York-Connecticut border)
- State of Connecticut (from the New York-Connecticut border to New Haven)
- Massachusetts Bay Transportation Authority (MBTA) (from the Rhode Island-Massachusetts border to Boston South Station)

This complex ownership and operational structure of the NEC is a result of the history of passenger and freight operations in the Northeast, which includes consolidations, bankruptcies, creation of a variety of public transit agencies and Amtrak, and record-breaking ridership and service expansion.

3.2 NEC RAIL SERVICE/ROLLING STOCK

The NEC supports commuter, intercity, and freight operations by over a dozen operators. These services use a wide variety of passenger and freight rolling stock.

- **Commuter:** Commuter rail, as defined by the Code of Federal Regulations (CFR), is “service within an urban, suburban, or metropolitan area.” The commuter rail agencies operate 2,200 weekday trains along the NEC carrying 246 million passengers annually over the respective systems. Although the majority of these trips are traditional journey-to-work trips, many of these commuter railroads provide larger regional mobility options and have the potential to offer more in the future. Commuter rail agencies provide commuter and regional trips within metro areas, connecting travelers within the Washington, D.C., Baltimore, Wilmington, Philadelphia, Trenton, Newark, New York City, New Haven, Providence, and Boston areas. Operators include the following: Massachusetts Bay Transportation Authority (MBTA); Rhode Island Department of Transportation (RI DOT); Shoreline East (SLE); Metro-North Commuter Railroad (MNR); Long Island Rail Road (LIRR); New Jersey Transit (NJ TRANSIT); Southeast Pennsylvania Transportation Authority (SEPTA); Maryland Department of Transportation (MARC); and Virginia Railway Express (VRE).

  SLE and SEPTA operate along the spine of the NEC, and they offer service to NEC stations that are not served by Amtrak. VRE and LIRR offer exclusively branch services that are not on the NEC spine, but they interact with the NEC at major stations. The remaining five carriers (MBTA, RI DOT, MNR, NJ TRANSIT, and MARC) offer trains that operate both on the NEC spine and on branches off of the spine, connecting millions of people directly to downtown rail/transit and Amtrak facilities.

- **Intercity:** Intercity rail is an express passenger rail service that provides transportation between cities at speeds and distances greater than that of commuter rail. High-speed rail is a type of intercity rail that covers large distances at speeds significantly faster than traditional passenger rail traffic. Currently, Amtrak offers 154 daily intercity trains along the NEC providing service to 29 NEC stations, and serving the four largest metropolitan areas on the NEC: New York City, Philadelphia, Washington, D.C., and Boston. Amtrak service on the NEC spine and connecting trains from the Keystone, Springfield, and Newport News/Richmond corridors carried 12.6 million passengers in 2011.
- **Freight:** Freight operation constitutes the movement of goods and cargo in purpose-built freight rolling stock (e.g., boxcars, flatcars, etc.), which are hauled by diesel-powered locomotives. Some 72 daily freight trains currently operate on portions of the NEC, carrying local and long-haul commodities and products to shippers and ports. Major carriers include Norfolk Southern (NS), CSX, Providence & Worcester Railroad, Conrail Shared Assets, and the Connecticut Southern Railroad.

The FRA defines speed limits for passenger equipment based on tiers. Rolling stock meeting Tier I and Tier II standards are permitted to travel up to maximum speeds of 125 mph and 150 mph, respectively. Currently, the only operation in the United States that meets Tier II is the Amtrak Acela Express service. FRA will be introducing a new tier for all operations above 125 mph and up to 220 mph that runs on dedicated corridors, and meet the equivalent safety standards of Tier I on shared corridors. This new tier is expected to be designated Tier III. The NEC FUTURE team will work closely with FRA's Office of Safety as they continue to develop the passenger equipment safety standards in order to develop sound assumptions about future equipment and operations in the NEC study area.

3.3 GROWING DEMAND FOR NEC RAIL SERVICE

As detailed in the NEC FUTURE Purpose & Need Statement, travel demand on the NEC is expected to grow significantly in the future as the result of growing population and employment. Population along the NEC from 2010 to 2040 is expected to grow 6.7 million (or 13 percent), and employment is expected to grow by 5.5 million (or 23 percent). Nearly all of the commuter rail agencies have set new rail ridership records within the past five years, and the LIRR saw its best rail ridership since 1949.[14]

[14] Sources by Transit Agency:
VRE: Washington Examiner, Accessed September 5, 2012, http://washingtonexaminer.com/vre-ridership-soars-again/article/2503157#.UEezvrLN9kl
MARC: MTA, Accessed September 5, 2012, http://mta.maryland.gov/mta-sets-new-ridership-record
SEPTA: NBC Philadelphia, Accessed September 5, 2012, http://www.nbcphiladelphia.com/traffic/transit/SEPTAs-Ridership-Highest-in-22-Years-126346128.html
NJ TRANSIT: NJ TRANSIT Accessed September 5, 2012, http://www.njtransit.com/pdf/NJTRANSIT_2011_Annual_Report.pdf
LIRR: MTA, Accessed September 5, 2012, http://www.mta.info/lirr/News/2008/RecordRidershipAndOntimePerformance.htm
MNR: MTA, Accessed September 5, 2012, http://www.mta.info/mta/news/releases/?en=120123-MNR5

Amtrak set both national and NEC ridership records in 2011, and this trend has continued into 2012. The Keystone and Empire corridor trains accommodate more than a million riders each every year and the New Haven-Hartford-Springfield corridor has grown 18 percent since 2007.

Growing regional travel demand and rising fares, combined with peak-hour congestion, has led to growing off-peak demand on commuter rail, particularly around New York City.[15] By 2030, commuter rail demand is projected to grow by 58 percent and intercity rail demand by 76 percent. By that same time, the number of segments on the NEC that will not be able to serve demand because of capacity constraints is expected to more than triple without substantial improvements and operational changes.[16]

Freight demand just on I-95 along the NEC is expected to double over the next 30 years,[17] which will continue to increase both passenger and freight congestion on the Interstate.

3.4 EXISTING NEC INFRASTRUCTURE

The configuration of the NEC varies along its length and was originally constructed by a number of different railroads between the 1830s and 1920s.

- **Bridges and Tunnels:** In most locations the railroad was constructed either at the existing grade or on an embankment elevated above the surrounding grade. There are also numerous bridge structures at crossings of water bodies, wetlands, or other transportation infrastructure. These bridge structures vary in configuration, ranging from single short span bridges at local roads, to movable bridges over navigable waters, to multiple span viaduct structures with movable bridge segments such as the Susquehanna Bridge over the Susquehanna River in Maryland. Bridge structures vary in age and design, but the NEC contains hundreds of bridge structures that are approximately 100 years old or older, and numerous bridges that have reached the end of their useful life in terms of structural integrity. Likewise, the NEC contains numerous tunnels that were constructed in either the late 19th or early 20th century, and require either significant rehabilitation or replacement. This includes the historic Baltimore and Potomac Tunnel in Baltimore that was originally opened for service in 1873. Many of these bridges and tunnels cannot accommodate additional train volumes and create significant capacity constraints for NEC operations.
- **Catenary System:** The NEC is electrified and powered through an overhead contact wire between Washington, D.C., and Boston, MA. The catenary system between Washington and New Rochelle dates back to the 1930s. The fixed catenary system on much of the NEC places limits on train speed and is highly susceptible to variations in weather. Amtrak is developing a

SLE: Trainweb.org, Accessed September 5, 2012, http://www.trainweb.org/ct/2010AnnualReport.pdf
MBTA: MBTA, Accessed September 5, 2012, http://www.mbta.com/uploadedfiles/documents/Bluebook%202010.pdf

[15] New York Metropolitan Transportation Council, Hub-Bound Travel, 2011.

[16] The NEC Master Plan Working Group, Infrastructure Master Plan.

[17] NEC Commission Freight Committee, "Current and Future Freight."

project in New Jersey to introduce constant tension catenary on a small portion of the NEC to improve reliability and accommodate higher speeds.

- **Track:** The track configuration typically consists of a two-track section north of New Haven, CT, and two-, three-, and four-track main line sections along the corridor south of New York. From New York to New Haven, the corridor is primarily a four-track railroad with some two-track and three-track sections. At several locations along the corridor, freight sidings without a catenary system also exist. At major stations and terminals, the number of tracks is typically greater; for example, there are 21 tracks in Pennsylvania Station New York.

The aging condition of the NEC infrastructure imposes a significant challenge with respect to maintaining systems and equipment and providing the outages necessary to implement repairs on a heavily utilized railroad. Moreover, there also is a lack of redundancy in facilities and systems that severely undermines reliability in the event of failures or break-downs. Thus, a critical challenge moving forward will be to bring the railroad to a state of good repair, a backlog of essential improvements estimated in 2010 at nearly $9 billion.[18]

These infrastructure challenges affect the quality and reliability of existing intercity and commuter rail service on the NEC and will further constrain the ability to meet future passenger rail demand. These challenges include:

- Severe capacity constraints at critical chokepoints along the corridor limit service expansion and improvement, reduce operational flexibility and efficiency, and increase operating and maintenance costs (see Figure 3-1).
- Reliability and performance problems tied to limited track capacity and aging infrastructure create delays, increase trip times, and degrade service quality.

[18] The NEC Master Plan Working Group, Infrastructure Master Plan.

Figure 3-1: Capacity Constraints on the NEC

4 Level of Detail for the Initial Alternatives

With the goal of developing an overall vision for future rail service on the NEC and a coordinated plan for corridor investments, NEC FUTURE is focused on corridor-wide solutions that address the program's Purpose & Need. The goal is to create a broad blueprint for the NEC, defining capacity, service, relative trip-time, and reliability needs and the general physical and operations improvements required to meet those needs. Accordingly, alternatives developed as part of NEC FUTURE will include only the level of detail required to identify and understand technical and operational feasibility, transportation impacts and relative costs for needed improvements and to evaluate, through a Tier 1 programmatic or corridor-level environmental review, the environmental and operational impacts of those improvements.

The level of detail required for determining the specific alignment, selecting the location and configuration of stations, evaluating alternative construction methods, and preparing engineering design concepts and detailed cost estimates, is greater than what can be addressed in a Tier I EIS. Therefore, determining the exact location-specific solutions will be the subject of future analyses, which will entail a Tier 2 project-level environmental review.

Initial Alternatives represent broad ideas for providing or improving corridor-wide service objectives along the NEC. The Initial Alternatives have been developed to broadly focus on addressing the NEC FUTURE program's Purpose & Need related predominately to market and service concerns.

The description of Initial Alternatives will not include specific physical improvements or service plans. These details will be developed for the smaller set of **Preliminary Alternatives.** Characteristics will be further refined for the **Reasonable Alternatives** that will be eventually selected for full analysis in the Tier 1 EIS.

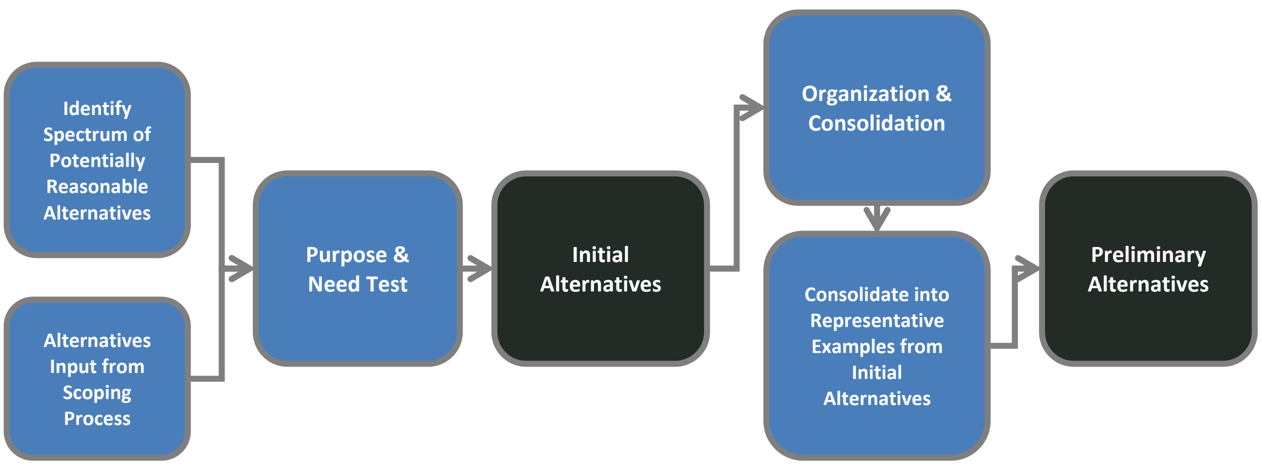
5 Development of Initial Alternatives

5.1 OVERALL PROCESS

The development of alternatives for the NEC FUTURE is a multi-step process that involves a large amount of information, interaction with stakeholders, and analysis. The process is shown in Figure 6-1, starting with identifying the broad spectrum of potentially reasonable alternatives to consider, including any alternatives identified by agencies, stakeholders, and other participants during the NEC FUTURE scoping process. All alternatives must meet an initial threshold test of reasonably addressing one or more of the goals detailed in the Purpose & Need. Those that do are included in the set of "Initial Alternatives." These initial alternatives are subsequently subjected to an organization and consolidation process, resulting in a smaller set of Preliminary Alternatives.

This process is summarized in Figure 6-1.

Figure 5-1: Process to Identify Initial Alternatives and Preliminary Alternatives



5.2 TRAVEL MARKETS

This alternatives analysis focuses on the travel markets and growth forecasts, which allows for the development of more accurate forecast of ridership and other transportation measures, and provides a more direct method of showing how alternatives address the Purpose & Need. Travel markets and associated demand is studied in two categories:

- **Interregional trips**—those that start and end in different metropolitan areas—are currently served primarily by Amtrak.
- **Intraregional trips**—those that start and end within the same metropolitan area—are primarily served by the commuter rail agencies.

Interregional and intraregional trips within the NEC often use the same limited infrastructure but have different travel characteristics and service needs, and currently have different service providers. Understanding the inherent differences between what is required to meet interregional and intraregional travel needs on the NEC is essential to understand the overall service and ultimately the infrastructure needs of the future system.

For the purposes of organizing the list of Initial Alternatives, the alternatives were compiled separately for the "North End" and "South End" of the NEC, with New York City as the North/South dividing line. New York City is selected as the dividing line because it is the dominant market in the Northeast study area—some 60 percent of all current NEC intercity rail trips begin or end in New York. While the NEC operates as a single corridor, the trips taken by a majority of NEC intercity riders began and end either wholly south of New York or north of New York.

5.3 SOURCES FOR NEC FUTURE ALTERNATIVES

5.3.1 Prior Plans, Studies and Reports

A broad data collection effort across the NEC Study Area was conducted. Data collected include capital and operating plans, environmental data and studies, growth and ridership projections, short and long range plans, and other visioning and planning documents such as:

- NEC and connecting corridor rail operators, including commuter authorities, Amtrak and the freight railroads;
- State resource agencies, including transportation, environmental, and economic development agencies and departments;
- Federal modal agencies, including air, highways, transit, rail and waterways within the US Department of Transportation;
- Planning organizations, including Metropolitan Planning Organizations across the corridor; and
- Non-governmental and private organizations that study and otherwise impact the NEC.

5.3.2 Agency and Public Scoping

The Scoping process for the NEC FUTURE program included 18 agency and public meetings across the corridor and one corridor-wide agency webinar. Scoping began June 22, 2012, with a Notice of Intent in the *Federal Register*. Those speaking at the meetings or submitting comments to the FRA and through the project website proposed a number of Ideas for possible future improvements to the NEC, including service to new markets and possible new alignments. The comment period was open through October 19, 2012. For additional information on the scoping process, please refer to the Scoping Summary Report.

Public Scoping meetings were held in the following locations:

- Boston, MA 8/13
- New Haven, CT...................... 8/14

- Baltimore, MD 8/15
- Newark, NJ 8/15
- New York City, NY 8/16
- Wilmington, DE 8/20
- Philadelphia, PA 8/20
- Washington, D.C. 8/21
- Providence, RI 8/22

5.4 GUIDELINES FOR INITIAL ALTERNATIVES DEVELOPMENT

The fundamental guideline used to determine whether an alternative qualifies as an Initial Alternative was: *Would implementation reasonably address one or more goals identified in the Purpose & Need?*

If an alternative does not meet the NEC FUTURE preliminary Purpose & Need (e.g., relating to markets or geography falling outside the Study Area, or would be unlikely to address the markets, service, reliability or capacity needs of the NEC), it was not included in the list of Initial Alternatives. This minimal requirement ensures that a broad range of service and market alternatives is evaluated during the alternatives development process. For example, a route going from New York to Boston via Poughkeepsie and Worcester was not included in the list of Initial Alternatives because it would be circuitous yet serve fewer markets.

5.5 ORGANIZING THE LIST OF INITIAL ALTERNATIVES

The full range of potentially reasonable solutions in the NEC FUTURE Study Area includes various combinations of alternative routes and service types.

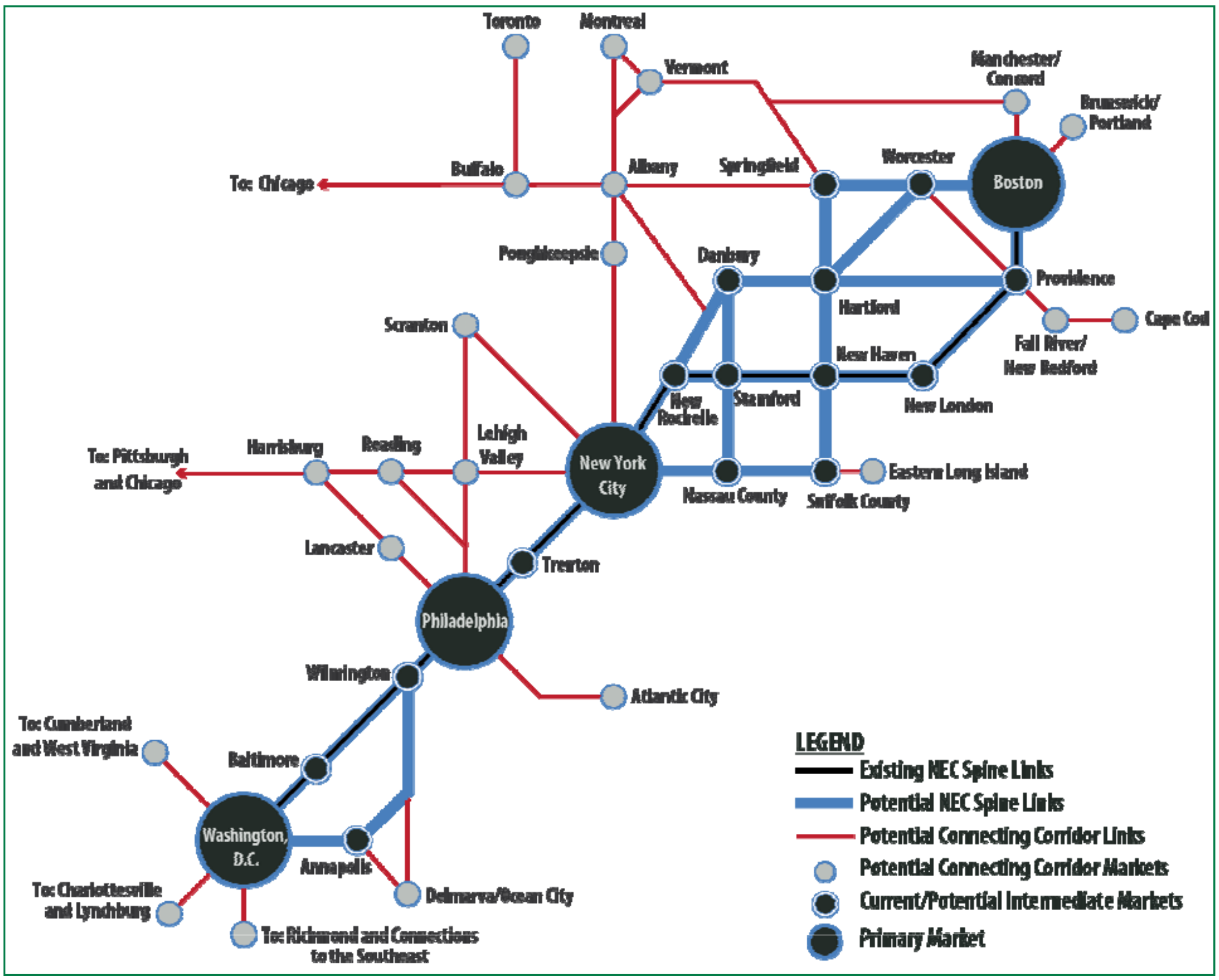
- **South of New York**, these include routing options to Washington via Philadelphia and Baltimore along the existing NEC spine, as well as via the Delmarva Peninsula. Other possible routes for intercity rail service did not meet the Purpose & Need for such reasons, for example, as having routes that were too circuitous or having routes that did not serve the three Primary markets of New York, Philadelphia, and Washington D.C.
- **North of New York**, potentially reasonable route options include several potential routes via Long Island and Central Connecticut. Each of these alternative routes could support varying levels of service, train types and market focus.
- **Connecting Corridors.** In addition to a main NEC spine, there is also a multitude of corridors such as New Haven-Hartford-Springfield or New York-Albany-Montreal that could connect to dozens of other cities within the Northeast region.

Figure 5-2 identifies the linkages between markets under consideration:

- The large circles in Figure 5-2 represent the primary markets. These four primary markets (i.e., Washington, Philadelphia, New York, and Boston) are the source of the majority of the current intercity and commuter rail ridership and are projected to continue to be the dominant drivers of demand in the region through 2040, due to the large trip generation involved. The primary markets must be served by all alternatives.

- The medium circles represent secondary markets (e.g. Baltimore, Wilmington, Stamford, Hartford) that are under consideration for NEC spine alternatives.
- The thick blue lines represent the potential links between markets. Each permutation of nodes and thick blue links connecting the large circles may become an alternative that is considered in the process. (Although every link is in at least one alternative, not every possible path through the links in the network is considered an Initial Alternative.)
- The small circles represent markets on connecting corridors; thin red lines are the links between those corridor markets. Connecting corridors may serve many cities; only the largest markets are marked as nodes.

Figure 5-2: Initial Alternative Routes for NEC Spine and Connecting Corridors



5.5.1 Elements of Initial Alternatives

Each Initial Alternative is defined by four elements:

- The Route for rail service in the study area.
- The potential quantity of service that could be delivered depending on the level of investment.
- The service strategy that will be deployed between markets.
- The type of markets that will be the focus of the service (see Appendix B for more detailed definitions of the elements). This element is useful in organizing the Initial Alternatives will be absorbed into the service strategy during development of the Preliminary Alternatives.

All alternatives include the existing NEC spine route and may include an additional path. Elements of alternatives include:

- **Route (Markets Served)** – Describes a general path for travel between markets. Routes refer to broad corridors and are intended to identify the travel paths and markets served by the alternative. They do not include a specific right-of-way configuration or infrastructure footprint.
- **Program Investment Level** answers the question: How robust a vision for passenger rail is planned and, based on that vision, how much rail service can be provided to serve the markets? The amount of available funding drives the ability to add the capacity to support additional rail operations and service to new markets. The larger the investment in building the capacity of the rail line – its tracks, signal systems, bridges, station platforms and equipment—the more trains that can serve a market.

  NEC FUTURE applied four program levels –a low Baseline level, two medium levels (Baseline Plus and Medium) and High – to broadly test investment options in the NEC over the next 30 years. This results in a range of alternatives from the continuation of today's rail operations at the low end to the ability to provide significantly enhanced and robust service, including service to new markets and high-speed rail options at the high end. The four levels of investment used for the Initial Alternatives are as follows:

  - Baseline: Responds to projected 2040 demand in existing markets using existing infrastructure; achieves State-of-Good-Repair
  - Baseline-Plus: Meets projected 2040 demand in existing markets; includes investments to optimizes the potential of existing NEC spine
  - Medium: Expands capacity to accommodate targeted new service , new markets and additional growth
  - High: Major increase in quantity and type of service on the NEC spine and construction of a new HSR alignment[19]

[19] For simplicity, the nomenclature for the Program Investment Levels will be changed during the development of the Preliminary Alternatives and in the Alternatives Development Report to the following: A (Low); B (Medium-Low); C (Medium-High); and D (High).

- **Service Definition/Operational Environment.** Service definition/operational environment answers the question: what is the best way to provide service based on the markets to be served, level of investment in capacity and the primary emphasis of the service? For the Initial Alternatives, service definition is described in three general categories: current or today's conventional mix of service; and two types of enhanced service—simplified service mix and expanded one-seat ride. These categories encompass a broad range of potential service types for the Study Area. Current Mix forms the baseline for analyzing the impacts of the other service strategies. Enhanced Service include a number of different service patterns such as a simplified service mix or an expanded one-seat ride, and will be used to test the wide range of reasonable enhanced service types. These service strategies are intended to guide the development of potential service types for the alternatives. Their features are not intended to be absolute or exclusive to each service strategy. As the alternatives are refined in future phases of work, features from each of these service strategies may be combined to develop the best service plan for an alternative.

  Various "connection strategies" – such as coordinated transfers or run-through service from connecting corridors – will be applied to each service strategy to ensure that all potential market pairs in the study area are served.

  - **Current Mix**: Includes the current or conventional mix of train types (Acela/Premium High-Speed Rail, Regional/Limited Intercity, commuter, and freight) and institutional arrangements with the number of trains increased as needed to meet future demand. The service would still have a mix of train types, but the proportional mix would be "rebalanced" to respond to market demand.
  - **Enhanced Service Mix**: There are many different ways to operate the corridor. Two enhanced service options that are used in the Initial Alternatives are simplified service and expanded one-seat ride.
    - **Simplified Service**: Provides a limited group of services on a regular, repeating schedule to deliver higher frequency and throughput capacity than service plans with a greater variety of stopping patterns and train types. This may require more transfers and, hence, may not deliver the same trip times to major markets, but overall trip times remain competitive with other service approaches. This service approach provides an opportunity for greater frequencies to secondary markets through highly coordinated schedules and transfers.

      Services include:

      - Limited-stop express service
      - Multi-stop local service
      - Supplemental peak commuter service
      - Convenient transfers from connecting corridors to services on NEC Spine
    - **Expanded One-Seat Ride**: Focuses on maximizing the number of market pairs served with one-seat ride service, particularly for intermediate and connecting corridor markets, through the use of several services. These services include high-speed trains operating exclusively on high-speed or express tracks and other high-performance

services that share high-speed tracks and utilize available capacity on portions of high-speed territory with maximum speeds of 160 mph or less and without intermediate station stops (e.g., on final approach to NYC, Washington and/or Boston).

- **Service Focus** – describes the particular market type that is emphasized in the development of service improvements for those alternatives with an intermediate level of investment, where tradeoffs will need to be made about how various markets utilize the available railroad capacity. As noted, this element will be absorbed into Service Definition as the alternatives are further developed.
  - For the "Baseline," the focus would be on providing a basic level of service for intercity travel and serving projected 2040 regional demand to the extent possible within a relatively limited level of investment.
  - For the Initial Alternatives with Program Investment Levels in the medium range (Baseline Plus and Medium), one of the four customer markets could be the service focus: commuter, intercity primary markets (Washington D.C., Philadelphia, New York, Boston), intercity secondary markets (all other intercity markets) or connecting corridors. Markets that are not the focus for an alternative could receive limited direct benefits but will be served, at a minimum, at the baseline level of service.
  - For the Initial Alternatives with High Program investment Levels, all four customer markets would be enhanced as a result of the improvements to the NEC spine and addition of a new dedicated alignment for high-speed service.

6 Building the Initial Alternatives

6.1 NORTH-END OPTIONS (NEW YORK CITY - BOSTON)

To facilitate the process of developing routes and naming alternatives, the markets between New York and Boston were organized in two groups – New York to New Haven/Hartford and New Haven/Hartford to Boston. The name of each route is described as a set of links between New York and New Haven/Hartford and a set of links between New Haven/Hartford and Boston. For each route, alternatives are included that address different service and market requirements.

The routes within each of the two groups on the North-End include:

- **New York to New Haven/Hartford**
  - New Haven Line: Existing NEC spine between New York and New Haven
  - Central CT: Route between New York and Hartford via New Rochelle, Danbury, and Waterbury
  - Nassau-Suffolk: Route Between New York and New Haven via Nassau Hub and Ronkonkoma
  - Nassau-Stamford: Route between New York and Hartford via Nassau Hub, Stamford, Danbury, and Waterbury
- **New Haven/Hartford to Boston**
  - Shore Line: Existing NEC spine between New Haven and Boston
  - Central CT (or via Providence if south section is Central CT): Route between Hartford and Boston via Providence
  - Via Worcester: Route between Hartford and Boston via Worcester
  - Via Springfield: Route between Hartford and Boston via Springfield and Worcester

By combining routes from each of these two geographic groups, thirteen alternatives were defined north of New York:

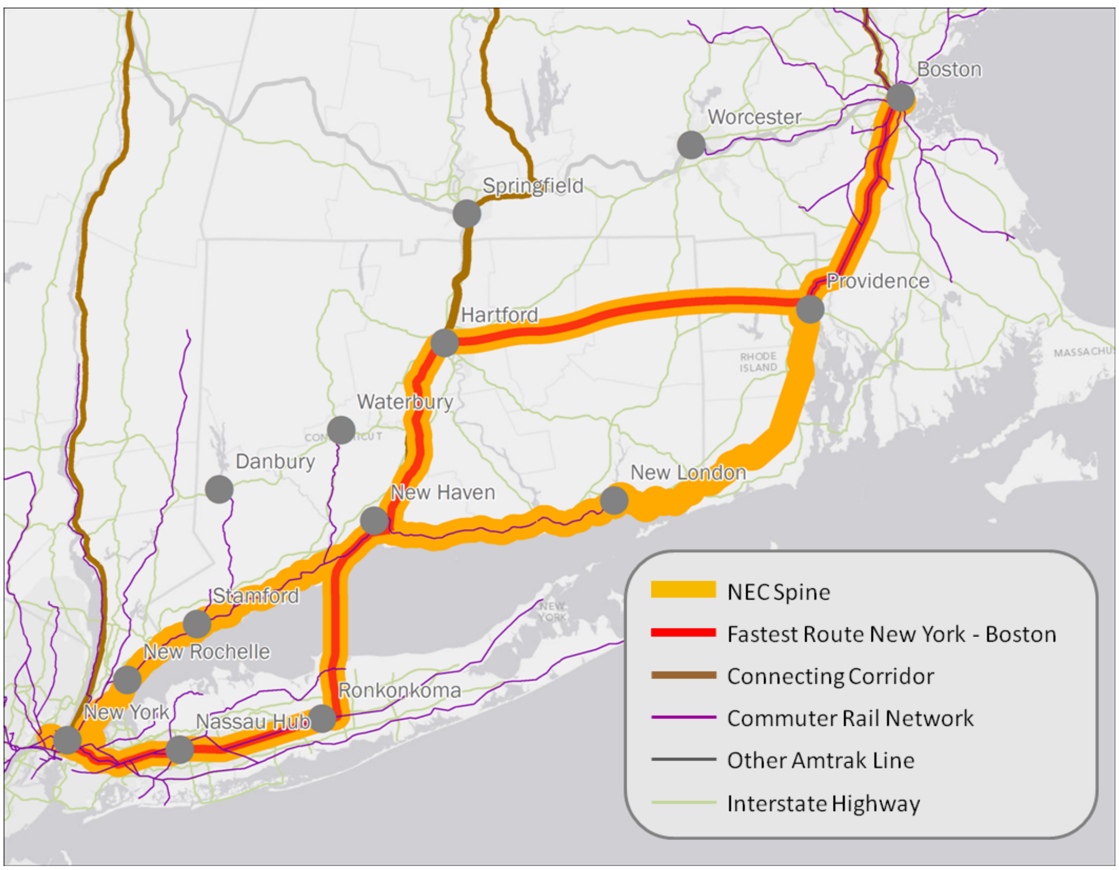
- New Haven Line - Shore Line
- New Haven Line - Central CT
- New Haven Line - via Springfield
- Central CT - via Providence
- Central CT - via Worcester
- Central CT - via Springfield
- Nassau-Suffolk - Shore Line
- Nassau-Suffolk - Central CT

- Nassau-Suffolk - via Worcester
- Nassau-Suffolk - via Springfield
- Nassau-Stamford - Central CT
- Nassau-Stamford - via Worcester
- Nassau-Stamford - via Springfield

While these network combinations cannot serve every market in the Study Area suggested by stakeholders or the public, they would serve all of the strongest markets identified and preserve the ability to serve new regional and intercity rail markets in the future, such as to Cape Cod, between Worcester and Providence, and to the Maryland shore.

Figure 7-1 presents an example of a North-End alternative route.

Figure 6-1: Example of North-End Alternative Route



6.2 SOUTH-END OPTIONS (WASHINGTON, D.C., TO NEW YORK CITY)

Due to the nature of the geography and distribution of markets south of New York, there are fewer alternative geographical routes than north of New York. As a result, alternatives south of New York are more focused on the routing through the major urban areas between Washington and New York.

The alternatives south of New York include:

- **Existing NEC:** A route following the existing Northeast Corridor from New York Penn Station to Washington Union Station via the existing paths through Philadelphia 30th St, Wilmington Station, and Baltimore Penn Station. Alternatives may incorporate slight deviations from the existing alignment to cut out sharp curves or other obstacles to higher speeds but preserves the existing stations.
- **City Center:** A route following the existing NEC for most links with new sections through the cities of Philadelphia, Wilmington and/or Baltimore. Alternatives will consider new paths through city centers, paths that may serve new markets within the city and/or paths that may dramatically increase speed and reduce travel time by developing a straighter alignment. Since the existing rail routes through all three cities currently have curves and alignments that necessitate relatively slow travel speeds, new paths through these cities have the potential to significantly reduce overall travel time.
- **Delmarva:** A route which may adhere to either the Existing NEC or City Center approaches between New York and Philadelphia, but which then alters course south of Wilmington. From Wilmington to Washington, the route turns south via the Delmarva Peninsula and approaches Washington from the east via Annapolis. This route would serve new markets and would connect the state capital of Maryland to major rail service. As in all alternatives planning, this route will only be considered in conjunction with continued upgrades to the existing corridor from Washington, D.C., to Wilmington via Baltimore and the preservation or improvement of existing service types to the Baltimore market.

6.3 COMBINATION OF ELEMENTS TO DEVELOP ALTERNATIVES

For each geographical route, different service scenarios are applied to develop the list of Initial Alternatives. Figure 7-2 illustrates the elements of the alternatives from New York City to Boston.

Each alternative consists of a unique combination of these elements. Figure 6-3 illustrates one unique combination that provides the “Baseline-Plus” quantity of service along the existing NEC with the current mix of services and a focus on the commuter markets.

Figure 6-2: North-End Initial Alternative Elements

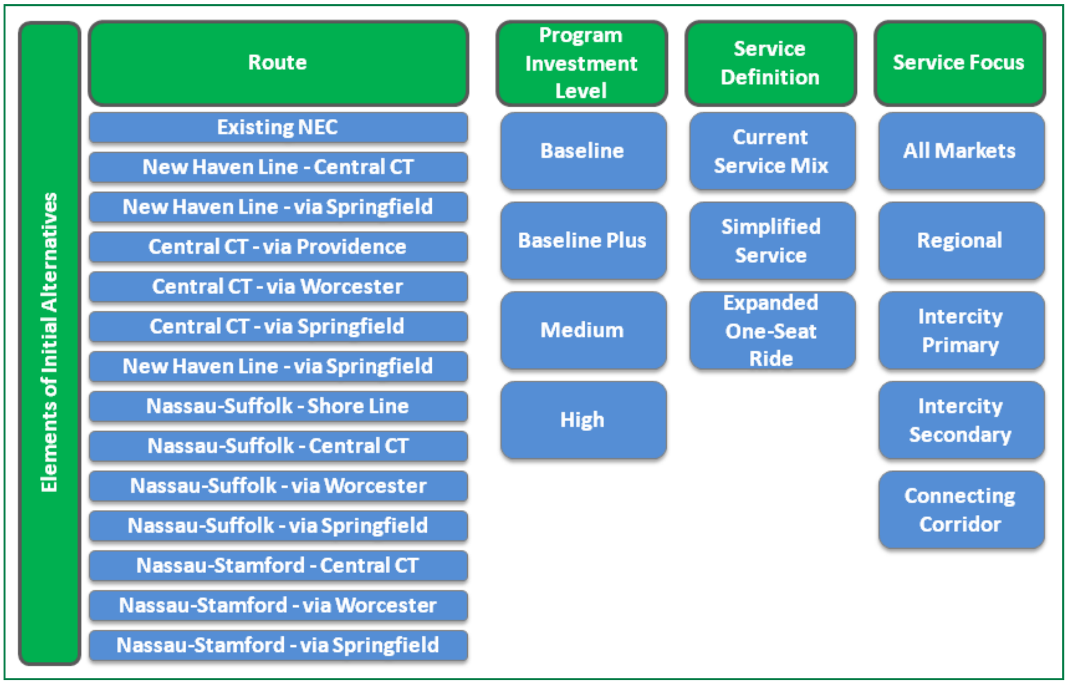
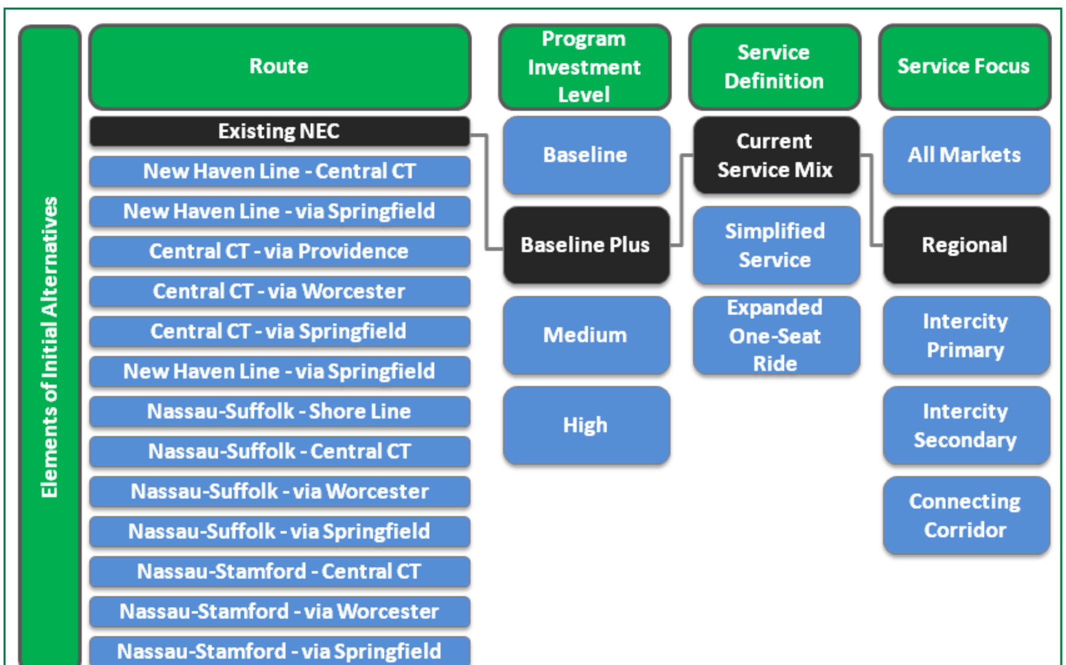


Figure 6-3: Example of a North-End Initial Alternative



Sample: Alternative (North4) Meets growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides current mix of express, regional, and commuter services.

Alternatives serving markets off of the existing NEC spine will require new infrastructure and new alignments. While costly, new alignments provide the ability to deliver substantive service improvements for all users of the rail line. Accordingly, the alternatives that do not follow the existing NEC route are assumed to provide a high quantity of service and to benefit all rail markets served. Forty-two (42) alternatives were defined where a portion of the alignment is off of the existing NEC spine.

In total, 98 separate Initial Alternatives[20] were identified, and they are listed and described in Appendix B. Each alternative represents a unique combination of geographical, market, service and investment needs. These Initial Alternatives incorporate route, service, and market needs identified through the data collection process, and through comments provided to the NEC FUTURE team during the Tier 1 Draft EIS Scoping process that are within the preliminary Study Area and that are consistent with the preliminary Purpose & Need.

[20] 28 North End Alternatives on the NEC spine + 28 South End Alternatives on the NEC spine + 42 off-NEC-spine Alternatives = 98 total alternatives.

7 Next Steps

The next steps in the process of developing NEC FUTURE alternatives are as follows:

- Develop criteria for organizing and consolidating the Initial Alternatives to generate a smaller set of Preliminary Alternatives
- Define Preliminary Alternatives

The goal is to develop a set of Preliminary Alternatives that appropriately encompasses the range of potential rail service solutions for various travel markets that might prove to be successful. These alternatives must be organized in a way that enables the comparative evaluation of alternatives, using both quantitative and qualitative measures, and the mixing and matching of alternative elements into an even smaller number of Reasonable Alternatives as the Phase 2 work effort progresses.

The criteria used to sort the Initial Alternatives and select the combinations of elements that are most appropriate will be mostly qualitative and will be used to eliminate features and elements that are either redundant or that do not serve travel markets as well or as easily as other elements.

The organizing and consolidating process will identify the representative combinations of service types, service quantity, and NEC network configurations that make the most sense to carry forward as Preliminary Alternatives.

Appendix A. Purpose & Need Statement

The following pages are from the final Scoping Package (USDOT FRA, June 2012, http://necfuture.com/pdfs/scoping_package_0612.pdf), excerpting pages 2 through 13.

2. PURPOSE AND NEED

2.1 INTRODUCTION

The Northeast region is facing serious mobility challenges, which, if left unaddressed, will have far reaching repercussions on the regional and national economy. The region is served by an extensive passenger and freight transportation system of highways, airports, ports, and rail. That transportation system has outdated technology and lacks sufficient capacity, connectivity and redundancy to support local and inter-regional mobility needs, resulting in major congestion and delays.

Moreover, regional population and economic growth will require investment in this transportation infrastructure to provide businesses with access to a growing workforce and resources and to provide residents with safe, reliable and convenient travel options. Highway, airport, and rail networks all face substantial challenges to meet their share of growing travel demand and each mode requires investment to address capacity and deteriorating conditions. The Northeast rail system has and will continue to play a critical role in shaping and supporting the development of the Northeast. Upgrades to that system are essential for connecting commuters and travelers with growing downtown business centers. A well defined and planned role for investment in passenger rail is required to improve the region's multimodal transportation network and its ability to support population and economic growth along the NEC.

The purpose of the NEC FUTURE program being led by the FRA is to:

- Define current and future markets for improved rail service and capacity on the NEC.
- Develop an integrated passenger rail transportation solution that:
  - Meets the existing and future service, reliability and capacity needs of the region.
  - Can be implemented incrementally.
  - Considers impacts to the environment and supports reductions in energy use.
  - Reflects the region's freight rail needs.
- Create a regional planning framework to engage stakeholders throughout the Northeast in development of this program.

The Purpose and Need Statement will play a pivotal role in every stage of the NEC FUTURE program. This section of the Scoping Package provides an abridged version of the Purpose and Need Statement. It defines the purpose of the program, the present and future challenges facing the Northeast region, and the need for passenger rail transportation solutions to address these challenges. It also establishes the program's goals and objectives that any actions under consideration must achieve to address identified needs. The statement presents a brief overview of the planning and regulatory environment in which the NEC FUTURE program will be advanced. These planning and regulatory elements are further described in other sections of this Scoping Package.

Numerous recent NEC studies will inform the NEC FUTURE program. These

NEC FUTURE is a roadmap for future investments in an integrated passenger rail transportation system necessary to sustain and advance economic growth.

include (1) FRA's NEC Programmatic Environmental Impact Statement (PEIS) in 1978, evaluating options for investment in the NEC; (2) the *Northeast Corridor Infrastructure Master Plan* (May 2010), a collaborative effort between key NEC stakeholders to define critical NEC investment needs; (3) extensive studies done for the Coalition of Northeastern Governors (CONEG); and (4) Amtrak's *Vision for High-Speed Rail in the NEC* and similar studies of NEC high-speed rail options by the University of Pennsylvania and the Regional Plan Association. These and other regional studies and individual railroad capital programs will be particularly useful in developing reasonable estimates for transportation system capacity, growth and travel demand forecasts.

2.1.1 Study Area

The Northeast region – an area comprising just 2 percent of the nation's land that generates over 20 percent of the nation's Gross Domestic Product (GDP) output[1] – encompasses eight states and the District of Columbia (see **Figure 1**) and is served by an extensive intermodal passenger and freight transportation system of highways, airports, ports, and rail systems linking the major metropolitan areas of Washington D.C., Baltimore, Philadelphia, New York and Boston.

The NEC, the existing rail transportation spine of the Northeast region – anchored by Washington Union Station in the south, Pennsylvania Station New York in the center, and Boston South Station in the north – is a vital component of this regional transportation system, with 80 percent of the region's residents living within 25 miles of an existing or proposed intercity passenger rail service.[2] Like the broader transportation system, the NEC currently faces serious capacity and operational constraints that limit opportunities to expand and improve services to support existing travel demand

Figure 1: Study Area

and projected population and economic growth. Many components of the system are in a state of disrepair or, worse, have reached the point of obsolescence.

For the purposes of defining and analyzing transportation alternatives for NEC FUTURE, the defined program Study Area (see **Figure 1**) encompasses the region served by the NEC, plus those areas that can be reached from the NEC directly by train or via a single transfer to connecting corridors (e.g., the Empire Corridor in New York). The Study Area will be refined as NEC FUTURE progresses and alternatives are identified.

[1] "Regional Economic Accounts," United States Department of Commerce Bureau of Economic Analysis, accessed May 2012, http://www.bea.gov/regional/index.htm.
[2] Council of Northeastern Governors (CONEG) Policy Research Center, Inc., "A Regional Context for Intercity Passenger Rail Improvements in the Northeast" (prepared by Matthew Coogan, Resource Systems Group, Inc. and SmartMobility, Inc., August 24, 2009), http://www.coneg.org/reports/regional_context.pdf.

2.2 NEC FUTURE NEEDS

2.2.1 Introduction

The Northeast region is served by a comprehensive, multimodal transportation network. This rich transportation system supports a population density triple the national average[3] and is the backbone of a $2 trillion economy.[4] However, the limitations of the region's transportation network within all modes will constrain the growth, competitiveness and economic development of the region. These limitations will likely have impacts beyond the Northeast region and could impact how and where future population and business growth takes place in regional, national, and global contexts. The following sections will further describe projected growth in the Northeast, the associated projected increase in travel demand, the challenges the existing transportation network will face and the role that rail will play in meeting those future demands.

Findings presented in this Scoping Package rely on existing reports and datasets, which assume different baseline years, horizon years, and study areas, and present a piecemeal view of the region. The lack of an available, cohesive data set for the NEC FUTURE Study Area demonstrates the need to create a unified representation of the Northeast region as it is currently exists through the horizon year of this program, 2040.[5] This study relies on published 2040 projections for population and employment. For other projections or forecasts related to travel demand, 2040 figures are used where available and 2050 projections, in some instances, are used to interpolate 2040 estimates. Lastly, projections for other years, including 2025 and 2030, are included in this statement to support stated 2040 projections or to provide information where there is none currently available for 2040 or beyond. The available forecasts present a reasonable representation of the Northeast region, suitable for initial development of the program purpose, needs, goals, and objectives. As the NEC FUTURE program advances, a set of forecasts to 2040 will be developed to more consistently evaluate future conditions and to inform subsequent analyses.

2.2.2 Projected Population and Employment Growth

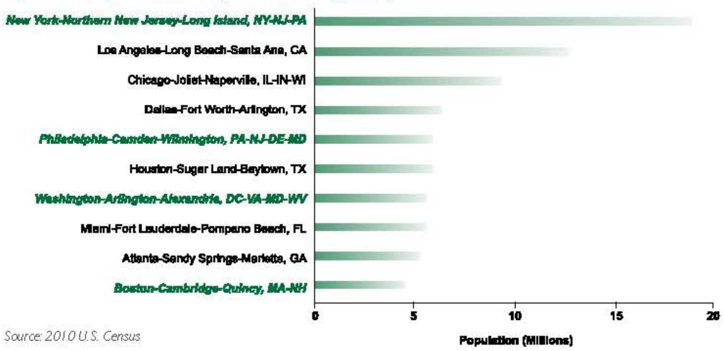
The NEC connects four of the nation's ten largest metropolitan areas (see **Figure 2**), making the corridor an economic anchor for the nation.[6] Projections by MoodysEconomy.com predict that both population and employment growth within the Northeast region will remain strong over the coming decades.

Population and employment in the program Study Area are projected to grow by approximately 6.7 million and 5.5 million, respectively, from 2010 to 2040, representing a 13 percent growth in population and a 23 percent growth in employment.[7] GDP in the Northeast is projected to grow by approximately 75 percent by 2040 (in constant $2010; see **Figure 3**). The four largest metropolitan areas – Boston, New York, Philadelphia and Washington, D.C. – are projected to continue to account for approximately 70 percent of the region's employment and population.[8] Roughly three-fourths of the region's employment growth is projected to occur in these four metropolitan areas.[9]

2.2.3 Projected Growth in Travel Demand

Although population and employment projections developed by public agencies and the private sector differ in certain ways, they are consistent in their forecasts that demographic and economic growth within the Northeast will remain strong over the next 30 to 40 years. This growth will result in travel demand and goods movement increases, which will place increasing pressures on the existing transportation infrastructure in the Northeast region.

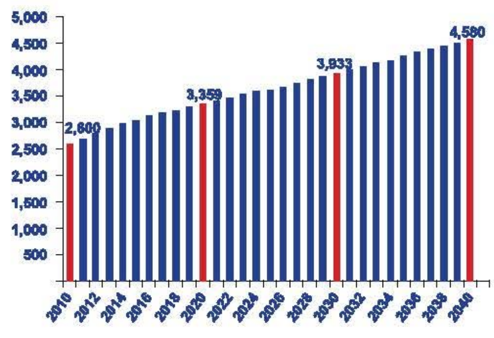
Figure 2: Largest U.S. Metropolitan Areas (2010)



Source: 2010 U.S. Census

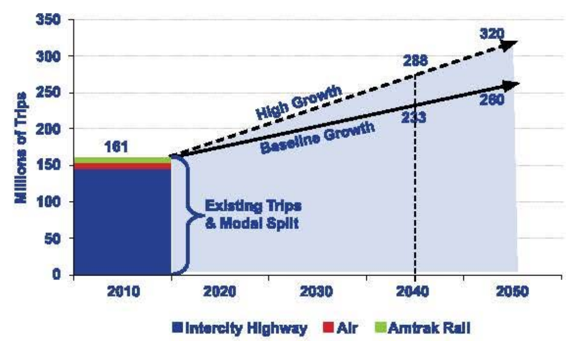
[3] CONEG, "Regional Context."
[4] The NEC Master Plan Working Group, *The Northeast Corridor Infrastructure Master Plan* (May 2010).
[5] 2010 is the baseline year and 2040 is the horizon year. Data used to estimate future population, economic, and travel conditions, however, rely on existing data sources each of which was created at different points in time for different purposes and with different forecast dates.
[6] U.S. Census Bureau, "Population Distribution and Change: 2000 to 2010, 2010 Census Briefs" (March 2011), Table 3, http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf.
[7] Moody's Analytics, Inc., 2012 data retrieved from Forecast and Historical Databases, http://www.economy.com/home/products/databases.asp?src=left-nav.
[8] Moody's Analytics, Inc., 2012.

Figure 3: Projected GDP in Northeast Corridor (Billions $2010)



Source: MoodysEconomy.com (2010)

Figure 4: Annual NEC Corridor Travel Volumes



Source: Amtrak, A Vision for High-Speed Rail in the Northeast Corridor, September 2010

Regional Travel

For regional commuter markets, Metropolitan Planning Organizations (MPO) project substantial trip growth, posing challenges for highway, rail and other transit modes. For example, strong growth in the Manhattan Central Business District (CBD) employment (25 percent from 2005 to 2030)[10] will increase demand for the largest commuter operators in the area – MTA-Long Island Rail Road (LIRR), MTA-Metro-North Railroad (MNR) and New Jersey Transit (NJTRANSIT) – all of which already face significant capacity limitations.[11] Commuter railroad riders today are not just peak-period commuters heading into a region's major CBD. In recent years, commuter railroads have seen significant growth in travel during off-peak periods on weekdays and weekends and in off-peak directions. For example, over the 1990 to 2010 period, off-peak trips into Manhattan on NJTRANSIT trains grew faster than peak-hour volumes, with the off-peak period's share increasing from 48 percent to 58 percent of total daily trips into the city.[12] These patterns demonstrate that difficulties in addressing commuter railroads' present capacity and reliability problems and the challenge of higher future demand will increasingly impact much more than the traditional commuter market. Left unaddressed, the impacts will be noticed in the traditional business sectors as well as the travel and leisure markets. Average weekday travel demand is projected to increase in the New York region by roughly 3.3 million trips from 2005 to 2030, with over 80 percent of those trips absorbed by highways and the balance by transit.[13] The Northeast's other high-growth metropolitan areas face equally pressing challenges; the Washington, D.C., metro area, for example, anticipates severe stop-and-go highway congestion conditions to be prevalent throughout the region by 2040.[14]

Intercity Passenger Travel

According to commercially developed population and economic projections,[15]

[9] Moody's Analytics, Inc., 2012.

[10] Regional Plan Association, *Tomorrow's Transit* (October 2008); Data source: New York Metropolitan Transportation Council Technical Memorandum by Urbanomics June 15, 2005.

[11] The NEC Master Plan Working Group, *The Northeast Corridor Infrastructure Master Plan* (May 2010).

[12] New York Metropolitan Transportation Council, Hub-Bound Travel, 2011.

[13] Regional Plan Association, *Tomorrow's Transit* (October 2008); Data source: Metropolitan Transportation Authority - Regional Transportation Forecast Model - O/D Trip Matrices - 2005/2030 for Autos and Transit Trips.

[14] "Constrained Long-Range Plan, Congestion," Metropolitan Washington Council of Governments, accessed May 2012, http://www.mwcog.org/clrp/performance/congestion.asp.

[15] Moody's Analytics, Inc., 2010 data retrieved from Forecast and Historical Databases, http://www.economy.com/home/products/databases.asp?src=left-nav.

total intercity trips will reach approximately 230 million by 2040, representing about a 45 percent increase from the 161 million trips in 2010[16] (see **Figure 4**). In fact, a study undertaken for the CONEG, a non-partisan association of governors, concluded that by 2025 (about halfway into NEC FUTURE's 2040 planning horizon) travelers in the Northeast region[17] would make over 200 million annual long distance trips to destinations within the region, each of which crossed a state line and was over 100 miles in length.[18]

Goods Movement

In addition to increases in regional and intercity passenger travel demand, overall population and economic growth in the region is expected to generate growth in goods movement. The existing freight demand of 40 tons per capita annually is forecast to increase as the population of the region continues to grow.[19] Estimates from the Federal Highway Administration's (FHWA) Freight Analysis Framework predict that by 2040, freight movement to and from the nine jurisdictions included in the Study Area will increase by 34 percent over 2010 totals, including 31 percent and 26 percent increases in truck and rail freight volumes, respectively. The growth in rail freight tonnage will require additional rail freight traffic along the NEC, increasing the potential for conflicts with projected increases in passenger rail service in the corridor. Growth in truck freight, which will continue to handle the majority of freight in the corridor, will increase congestion on already crowded highways in the Northeast region.

2.2.4 Ability of Transportation Network to Meet Future Demand

The NEC FUTURE Study Area is served by the nation's most comprehensive and complex transportation network, providing a broad range of passenger and

Figure 5: Study Area – North

freight transportation services. **Figures 5 and 6** identify the main highway, commuter and intercity rail networks and airports. The following sections discuss the region's existing highway, air and rail networks and services, the considerable challenges they face in meeting existing demand levels and the even larger challenges predicted when faced with the projected growth in travel demand.

Highway Network and Service Issues

The Northeast is served by a dense network of Interstate and secondary state and federal highways, which collectively handle the bulk of the local, regional and intercity person and goods movement trips, including close to 90 percent of all intercity trips (i.e., those greater than 75 miles) within the Study Area. The Study Area's highway system, especially near

[16] Moody's Analytics, Inc., 2010.
[17] The CONEG study area included Maine to Washington, D.C., but did not include Virginia.
[18] CONEG, "Regional Context."
[19] NEC Commission Freight Committee, "Current and Future Freight Use of the NEC" (March 2012).

the major metropolitan areas served by the NEC, is already heavily congested.[20] The Interstate 95 corridor is the main continuous north-south highway within the market area of the NEC (see **Figures 5 and 6**) and serves the Cross Bronx Expressway, the most congested highway segment in the country.

FHWA studies on the nation's National Highway System[21] indicate that by 2035 many major highway routes in the NEC FUTURE Study Area, especially those near the heavily developed urban areas along the NEC, will be operating above capacity and under congested conditions. A 2040 vision study[22] by the I-95 Corridor Coalition, an alliance of transportation agencies, toll authorities, and related organizations from Maine to Florida, indicates a 70 percent increase in unconstrained demand[23] for roadway travel by 2040, assuming no substantial changes in competing modes. The urban Interstate roadways would be unable to handle the expected growth, resulting in an 84 percent increase in delay. The study's conclusions indicated that other modes would also have to add capacity to maintain their existing share[24] of regional demand. A more sustainable future would require tripling local/commuter transit

Figure 6: Study Area – South

[20] I-95 Corridor Coalition, *A 2040 Vision for the I-95 Coalition Region: Supporting Economic Growth in a Carbon-Constrained Environment* (December 2008), http://www.i95coalition.org/i95/Portals/0/Public_Files/pm/reports/2040%20Vision%20for%20I-95%20Region_Full%20Report.pdf.

[21] "National Statistics and Maps," Federal Highway Administration, accessed April 2012, http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats.

[22] I-95 Corridor Coalition, *2040 Vision*.

[23] Unconstrained demand is not limited by the capacity of the existing system

[24] I-95 Corridor Coalition, *2040 Vision*, ES 4.

ridership and increasing rail passenger ridership eight fold.[25]

Also, the existing highway system faces the challenge of upgrading an Interstate highway network substantially built during the 1950s and 1960s and older parkways and other highways built earlier in the 20th century. Rebuilding these heavily congested roadways under full operation will be challenging, creating substantial disruption and reduced effective capacity during those periods.

Over the past decade, intercity bus operations have responded to increases in travel demand in many markets throughout the country. Since 2006, intercity bus operations have experienced nationwide growth, much of which is attributable to low-cost curbside bus operations in the Northeast. Those operations grew by 23.9 percent[26] between 2009 and 2010 alone, driven largely by new Megabus hubs in Philadelphia and Washington, D.C.[27] Both the larger national bus operators and smaller carriers continue to provide expanded services that will further expand their role in the major Northeast travel markets (e.g., NYC-Boston, NYC-Philadelphia, etc.).[28] Nonetheless, intercity buses are dependent on the regional highway system, which, as noted, already is congested and faces an unsustainable increase in demand in the coming decades.

Table 1: FAA 2010 Annual Boardings and 2040 Forecasts for "Core Airports" in the Corridor (000s)

Airport	2010	2040	Growth
JFK	22,395	64,707	189%
Newark	16,498	34,281	108%
Philadelphia	14,827	30,972	109%
Boston	13,234	24,264	83%
LaGuardia	11,801	16,508	40%
Dulles	11,160	35,676	220%
BWI	10,611	23,321	120%
Reagan National	8,536	11,934	40%
Total Boardings	**109,062**	**241,663**	**122%**

Source FAA, Terminal Area Forecast Summary, Fiscal Years 2011 to 2040, 2012 (data from page 9)

Aviation Network and Service Issues
The region's airports, including some of the nation's largest, serve travel within and outside of the Northeast. **Table 1** shows boardings in 2010 and the FAA's projected growth in air travel at key airports[29] in the Northeast region during the NEC FUTURE planning horizon. As shown, these airports handled over 100 million passengers in 2010, and substantial growth is projected by 2040.[30] However, with capacity constraints on the current aviation infrastructure, the existing air network has been fraught with delay[31] and these airports are already among the nation's most congested.[32] The top four most delay-prone airports in the country are found in the Northeast,[33] with New York metro area airport delays alone accounting for roughly one-third of the air service delays nationwide. These delays spill over into the rest of the nation's air network – resulting in economic and social costs for passengers, airlines and others.[34] The costs attributed to estimated passenger delays and associated higher fares for the major airports of the NEC FUTURE Study Area are expected to increase from over $2.4 billion in 2010 to $7 billion by 2025.[35]

[25] The Coalition's 2040 Vision study used a vision of inter-city rail which had been developed for the National Surface Transportation Policy and Revenue Study Commission to guide its assumptions about passenger rail in the future.
[26] Excludes Chinatown bus operations.
[27] Chaddick Institute for Metropolitan Development, DePaul University, "The Intercity Bus: America's Fastest Growing Transportation Mode 2010 Update on Scheduled Bus Service" (2010), http://las.depaul.edu/chaddick/docs/Docs/Intercity_Bus_2010_Update_Final.pdf
[28] Chaddick Institute for Metropolitan Development, DePaul University, "The Intercity Bus Rolls to Record Expansion: 2011 Update on Scheduled Motor Coach Service in the United States" (2011), http://las.depaul.edu/chaddick/ResearchandPublications/index.asp.
[29] T. G. Green Airport in Rhode Island is not treated as a Core Airport and its forecasts were not included in this FAA source material. This airport has a presently underused station along the NEC rail line.
[30] Federal Aviation Administration (FAA), *Terminal Area Forecast Summary Fiscal Years 2011 to 2040* (2012), http://www.faa.gov/about/office_org/headquarters_offices/apl/aviation_forecasts/taf_reports/media/TAF_summary_report_FY20112040.pdf.
[31] Airport Cooperative Research Program (ACRP), "ACRP Report 31: Innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions," *Transportation Research Board of the National Academy of Sciences* (2010), accessed April 2012, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_031.pdf.
[32] FAA, *Terminal Area Forecast.*
[33] "Chronically Delayed Flights," United States Department of Transportation Bureau of Transportation Statistics, accessed April 2012, http://www.bts.gov/programs/airline_information/chronically_delayed_flights/.
[34] ACRP, "ACRP Report #31."
[35] ACRP, "ACRP Report #31."

Recent studies[36] by the FAA addressing capacity limitations and airports in the Northeast highlight that many airports, even with planned Next Generation (NextGen) air traffic control and airport capacity growth, will be unable to handle the projected air travel demands. These studies further note the need to address both alternative modes for some of these intercity trips and improved transit connections to the airports. Given these limitations, policy analysts at the FAA have highlighted the need to better understand options to meet growing travel demand in high-density travel corridors, including increased high-speed ground transportation.

NEC Rail Network and Service Issues
The NEC and its connecting corridors (New Haven-Hartford-Springfield [NHHS], Empire, and Keystone), shown in **Figures 5 and 6**, are among the most heavily utilized rail networks in the world. Use of the NEC is shared by intercity, commuter and freight operations. The extensive passenger and freight rail system reflects a history of dense development around rail networks. Approximately 80 percent of the region's residents live within 25 miles of an existing or proposed intercity passenger rail service.[37] The NEC moves more than 259 million passengers[38] and approximately 370,000 tons of freight per year.[39]

Amtrak owns 80 percent of the 457-mile NEC, with the balance shared by Connecticut DOT, Massachusetts and MTA Metro-North.[40] There are also several connecting corridors, which have multiple owners including Amtrak, individual states, and freight railroads. This varied network is depicted on **Figures 5 and 6**.

Amtrak operates intercity rail service throughout the NEC and its connecting corridors. Amtrak's Acela Express is its premium service, reaching speeds of 150 mph between Boston and New Haven and 135 mph in segments south of New York City. Amtrak's Northeast Regional service, as well as state corridor services that traverse corridor segments en route to off-corridor destinations (the Vermonter, Ethan Allen, Adirondack, Maple Leaf, Keystone, Pennsylvanian, Amtrak Virginia and Carolinian), operate at speeds of up to 125 mph. These services run between Boston, New York City, Washington, D.C., and intermediate stations. Amtrak also operates Empire service between New York, Albany and Buffalo extending to Toronto, as well as limited Northeast Regional, Vermonter, and Shuttle service on the NHHS Rail Corridor. Near-term plans also call for Boston-Springfield-New Haven service on the Inland Route and the NHHS Rail Corridor. Longer-distance Amtrak trains heading to Chicago, New Orleans, Miami and other locations outside the region also operate over the NEC. Amtrak operates more than 150 daily intercity trains, carrying 13 million passengers annually on the NEC.

The following eight commuter rail systems operate about 2,200 weekday trains transporting 246 million annual passengers on portions of the NEC[41] (see **Figures 5 and 6**):

- Massachusetts Bay Transportation Authority (MBTA)
- Shore Line East (SLE)
- MTA-Metro-North Railroad (MNR)
- MTA-Long Island Rail Road (LIRR)
- New Jersey Transit (NJTRANSIT)
- Southeast Pennsylvania Transportation Authority (SEPTA)
- Maryland Area Regional Commuter (MARC)
- Virginia Railway Express (VRE)

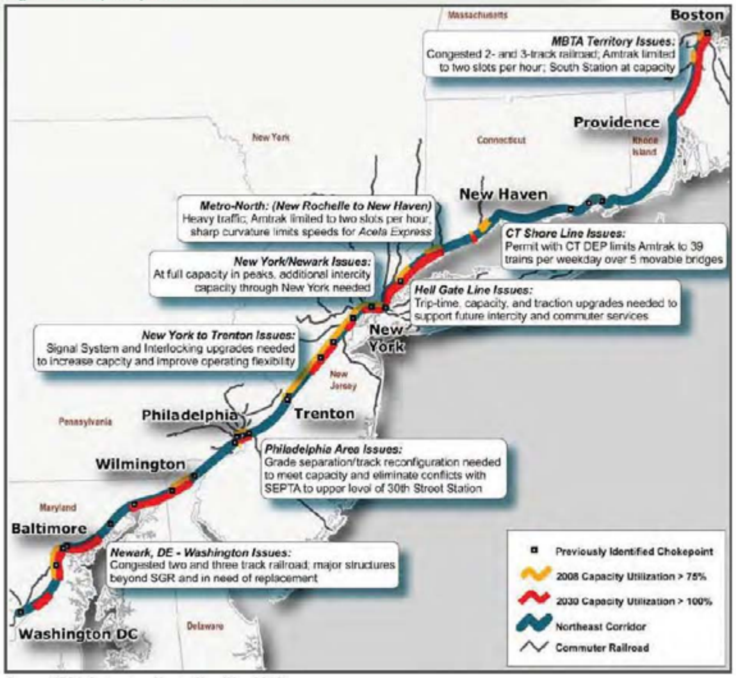
Rhode Island and Delaware support extensions of commuter rail services to their states via MBTA and SEPTA, respectively.

Both commuter and intercity services on the NEC already face major challenges that limit current service and will further constrain their ability to meet future passenger rail demand:

[36] Federal Aviation Administration, *Capacity Needs in the National Airspace System 2007-2025, An Analysis of Airports and Metropolitan Area Demand and Operational Capacity in the Future* (prepared by the MITRE Corporation, May 2007); ACRP, "ACRP Report #31."
[37] CONEG, "Regional Context."
[38] The NEC Master Plan Working Group, *Infrastructure Master Plan.*
[39] NEC Commission Freight Committee, "Current and Future Freight Use of the NEC" (March 2012).
[40] The NEC Master Plan Working Group, *Infrastructure Master Plan.*
[41] The NEC Master Plan Working Group, *Infrastructure Master Plan.*

- Severe capacity constraints at critical chokepoints along the corridor limit service expansion or improvement, reduce operational efficiency, and increase operating and maintenance costs (see **Figure 7**).
- Reliability and performance problems tied to limited track capacity and aging infrastructure create delays, increase trip times, and degrade service quality.
- Speed and travel time performance measures are inconsistent with world-class high-speed passenger service found in other major rail corridors around the world.

Figure 7: Capacity Constraints on the NEC



Source: NEC Infrastructure Master Plan (May 2010)

NEC State-of-Good-Repair Challenge

Generally, the NEC rail network lacks the capacity and overall infrastructure to provide reliable and convenient service in those segments where competing intercity and commuter rail services strain the network's capabilities. These conditions make it difficult to accommodate existing riders or attract new riders, as the functionally obsolescent infrastructure cannot provide the required reliability and quality of service even for today's market. Without actions, these problems will worsen. For example, rail operating statistics collected on a weekday in November 1995 by NJTRANSIT indicate that 14 NJTRANSIT trains heading into PSNY between 7:25 a.m. and 8:50 a.m. were delayed an average of 21 seconds by unanticipated incidents. Data for the same period in 2005 showed 28 trains delayed an average of 6.8 minutes.[42] Conditions creating such delays have only worsened in the subsequent years. Incremental maintenance and repairs to address problems resulting from aging infrastructure will only result in further service disruptions and degradations in service quality during construction. As indicated in the *NEC Infrastructure Master Plan*, a comprehensive effort to address the NEC's substantial state-of-good-repair issues is needed. The corridor railroads need those long-delayed repairs and upgrades to reliably provide the service levels to meet today's demand requirements. These improvements, some of which will likely include some capacity and performance enhancements for affected sections of the NEC, will also provide a solid foundation for the types of more extensive capacity and travel time improvements being considered in NEC FUTURE to meet the future demands faced by the NEC states and passenger railroads.[43]

In the *2010 NEC Infrastructure Master Plan*, commuter rail demand is projected to grow 58 percent by 2030 (from 246 to 389 million annual passengers), requiring a 40 percent increase in commuter trains. Similarly, intercity rail demand over that period will rise by 76 percent (from 13 million riders in 2010 to 23 million by 2030). By that time, the number of over-capacity NEC infrastructure segments will more than triple without substantial improvements and operational changes (see **Figure 7**).[44]

Freight railroads operating on the NEC include Consolidated Rail Corporation (Conrail), Providence and Worcester, Norfolk Southern, and CSX Transportation (CSXT). Generally, freight trains carry a variety of commodities and general merchandise and operate during designated operating windows, often at night or with short-distance daytime runs.[45] Freight traffic includes a variety

[42] NJTRANSIT Rail Operations, 2006.
[43] The NEC Master Plan Working Group, *Infrastructure Master Plan*.
[44] The NEC Master Plan Working Group, *Infrastructure Master Plan*.
[45] NEC Commission Freight Committee, "Current and Future Freight."

of movements along the corridor itself, with local freight serving customers on customers' sidings and branch lines with service provided by shortline railroads.[46] Freight demand along I-95 is projected to more than double over the next 30 years.[47] With over 40 percent of large-truck traffic[48] traveling on the already heavily congested interstate highway system, alternative modes of travel such as rail are an important option for meeting increasing future freight demand, which could put pressure on the already constrained passenger rail network. Rail freight movement on the NEC has already reached the levels forecast for 2030 in the NEC Infrastructure Master Plan, growing from 50 to 72 trains a day.[49]

2.2.5 Institutional and Operating Challenges Constrain the Ability of the Transportation Network to Address Needs

The ability to define a common solution to provide reliable, safe, time-competitive and efficient transportation across the Northeast region has and will continue to be limited by a variety of factors:

- Federal and state policies treat transportation modes differently, depending on funding sources, federal and state law, and infrastructure ownership. This includes separate funding mechanisms for highways, air, transit and Amtrak. Policies also differ based on mode and infrastructure owner.
- Several different owners and operators share responsibility for delivering passenger and freight rail service along the NEC. The different operating requirements for intercity, commuter and freight railroads, in combination with their specific service requirements, impact the mix, capacity and reliability of service overall. Commuters focus most on frequency and reliability; for intercity travelers, trip time is often critical and modal decisions are also often based on price. Over time, service providers have responded to these needs with a variety of transportation options that are often duplicative and consume available transportation infrastructure capacity inefficiently.
- Intensive development along and around transportation corridors and hubs limits the ability to expand facilities or otherwise address congestion and capacity constraints. This impacts rail lines, airports and highways alike, and prevents redistribution of trips to more efficient and travel-appropriate modes.

Equally as important, creating a planning platform to formulate a regional approach to transportation has been a challenge because the Northeast consists of multiple independent states and jurisdictions, each with its own interests and transportation policies. Planning efforts like those undertaken by the I-95 Corridor Coalition and the Coalition of Northeastern Governors have helped to define the Northeast region's transportation needs. However, there has yet to be a regionally-based approach to define and implement a balanced, efficient regional transportation network.

Regional planners and air and highway service interests have called for an increased role for rail modes, but the funding and institutional governance necessary to increase rail capacity have been lacking. The FRA's NEC FUTURE program is a critical initial step to creating the needed regional rail planning platform.

2.2.6 Regional Considerations

Energy and Environmental

The Northeast's overall high-density settlement pattern is a legacy of development that occurred before widespread use of the automobile. It is expected that between 2010 and 2040, population will grow by 13 percent, an increase of approximately 6.7 million people.[50] If this new population is accommodated in the similarly land-intensive manner of recent decades, important rural and open spaces will disappear, putting pressure on ecological and natural systems. Water quality would degrade both by the addition of impervious surface and because natural water recharge systems, such as the Delaware River Basin (which provides drinking water for 15 million people),[51] would be degraded by the pressure of increased land utilization. A passenger rail system would be part of a compact growth solution that concentrates new

[46] NEC Commission Freight Committee, "Current and Future Freight."
[47] NEC Commission Freight Committee, "Current and Future Freight."
[48] I-95 Corridor Coalition, 2040 Vision.
[49] NEC Commission Freight Committee, "Current and Future Freight."
[50] Moody's Analytics, Inc., 2012.
[51] Regional Plan Association, *Northeast Megaregion 2050: A Common Future* (November 2007).

growth and development around stations, thus conserving land and easing pressure on natural resources.

Furthermore, based on national data on passenger travel and energy use, intercity rail is a more energy-efficient mode compared to car or air travel.[52] Rail is 26 percent less energy intensive than travel by car, and 17 percent less energy intensive than air travel. Because carbon emissions are related to energy use, rail has comparably reduced carbon emissions on a per passenger-mile basis versus car travel and air travel.[53]

Economic

The Northeast region already endures costs from delays created by congestion of its transportation network. Various studies have confirmed this:

- Highway congestion and air travel delays together cost the Northeast almost $30 billion a year in lost productivity.[54]
- The Northeast contains three of the seven most congested metropolitan areas, with roughly an additional $1,100 a year in congestion costs[55] incurred per auto commuter.[56]
- The congestion and lack of redundancy of the NEC, highlighted by the recent problem in the NEC's Hudson River tunnels into New York City – a common problem throughout this highly congested and often antiquated corridor – resulted in extensive delays from Boston to Washington.[57]

Future burdens due to reduced mobility and higher congestion would only intensify these pressures and their associated costs will constrain the economic competitiveness of the region. These economic burdens would reduce the attractiveness of the Northeast region's key center city locations, leading to losses to other domestic and international corridors and providing an incentive for less efficient and sustainable growth in suburban and exurban areas.[58] This has particular economic importance given that the NEC's four major "hub" metropolitan areas generate roughly 88 percent of the corridor's GDP.[59] The core cities in these metropolitan areas collectively grew by roughly 8 percent over the 1990-2010 period, although Philadelphia and Washington, D.C. experienced 1 to 4 percent declines in population over this period. While the Northeast is the densest region in the U.S., much of the region's recent growth has occurred outside of core areas, and greater population and employment dispersion has increased travel patterns that overcrowd highways.[60]

Investment in the NEC and similar efficient investments in the other intercity passenger and freight networks to help meet the mobility requirements of a growing corridor is both a transportation and an economic need. The Northeast population and employment projections available from MoodysEconomy.com (and used for this study) assume that infrastructure and services would be improved sufficiently to maintain stable productivity and meet future mobility needs sufficiently to support that productivity. Actions that would worsen passenger and freight mobility would reduce productivity and lower projected growth.[61] These factors collectively confirm that major investments in the NEC and other modes are needed for the Northeast to grow and remain economically competitive in national and international markets.

Environmental, energy, and economic impacts from growth are not only local, but cross jurisdictional boundaries through waterways, air quality and energy consumption, and regional economic development. Only a regional approach to addressing these impacts can result in a comprehensive solution. This emphasizes the need for a collaborative process to understand how local actions can affect larger geographic areas and vice versa. Coordinated improvements to the passenger rail system and other transportation networks can help to alleviate some of the potentially negative effects of growth.

Redundancy

In addition to environmental and economic considerations, transportation redundancy is needed to address safety and security considerations and to support overall improvements to the Northeast's transportation system. Rail network redundancy is critical to safe, efficient and reliable rail operations in the corridor. In the event of the unforeseen loss of essential network links, the availability of redundant components provides the necessary back-up that can maintain the services on which the economies of the larger, more rail-dependent urban areas depend. In addition, redundant network elements greatly facilitate completion of extensive improvements to often 100+ year-old infrastructure (e.g., the North River Tunnels into Manhattan) that would otherwise result in extensive delays and higher costs for these activities.

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[52] Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 27*, ORNL-6981 (prepared for the U.S. Department of Energy, 2008).
[53] Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 27*, ORNL-6981 (prepared for the U.S. Department of Energy, 2008).
[54] Texas Transportation Institute (TTI), *2011 Urban Mobility Report* (September 2012); ACRP, "ACRP Report #31."
[55] Congestion cost is calculated using the value of travel time delay and excess fuel consumption.
[56] TTI, *Urban Mobility Report.*
[57] "Commuter Train Derails under Hudson River in New York City Disrupts Trains Throughout the Northeast," *Washington Post,* August 9, 2011.
[58] Newark Regional Business Partnership, *Northeast Corridor Action Plan: A Call for a New Federal-State Partnership* (prepared by Alan Voorhees Transportation Center of Rutgers and Hamilton, Rabinovitz & Alschuler, Inc.).
[59] Moody's Analytics, Inc., 2010.
[60] I-95 Corridor Coalition, Northeast Rail Operations Study (NEROps) Phase I Final Report (June 2007), http://i95coalition.org/i95/Portals/0/Public_Files/pm/reports/_NEROps-Final-Report_COMPLETE_071607.pdf.
[61] Moody's Analytics, Inc. "Model Methodology: The Moody's Analytics U.S. State Economic Model System" (January 2011).

2.3 PROGRAM GOALS AND OBJECTIVES

The NEC FUTURE Goals and Objectives will form the basis for evaluating and screening alternatives and eventually recommending a Preferred Alternative. As such, the program goals must broadly define those elements that proposed alternatives should possess to best address identified needs and meet the program purpose. In light of the critical role that the NEC and its connecting corridors play in the overall mobility and economic vitality of the Northeast, the program goals must reflect not only a long-term vision and roadmap for future investment, but a phased approach to implementing those more urgent, shorter term improvements necessary to meet current capacity requirements. Similarly, the program goals and objectives must recognize the complex mix of ownership and service provider needs ranging from high-speed intercity travel to daily commuter services and goods movement.

Seven goals and supporting objectives have been developed to address the market growth, transportation network capacity, reliability, connectivity, and other needs of NEC FUTURE articulated in Section 2. While the program goals more broadly define those elements that proposed alternatives should possess, the objectives provide established metrics for fair comparison across the range of alternatives to gauge their potential to meet the purpose of the investment program. These broad goals and specific objectives will continue to be refined through dialogue with the stakeholders, agencies and the public during the program Scoping process to provide the basis for evaluating whether identified alternatives meet the overall purpose and need for the program. The seven goals and objectives of the overall program are to:

- Develop a NEC rail network that is part of an integrated comprehensive passenger rail transportation solution for the Northeast and complements planned investments in other modes serving the region.
- Develop program alternatives that would provide attractive, competitive, high-quality passenger rail service that offers customers:
  - Capacity (frequency, train seating) to meet growing demand
  - Improved connectivity (timed connections, network integration, station design, multimodal access)
  - Competitive travel times
  - High levels of reliability
  - Safe and secure travel
  - Convenient and fare-competitive service
  - A user-friendly system
- Define a network that strengthens intermodal connections between intercity passenger rail modes and corridors, regional and local transit services, and other modes.
- Produce a market-supported intercity rail investment plan that provides near- and long-term solutions to the Northeast region's mobility problems and supports the region's ability to meet expanding freight rail demand.
- Create a phased improvement program that reflects funding and financial limitations as well as the challenges of improving the existing corridor under full operation.
- Establish an intercity rail investment plan that supports the Northeast region's need to reduce environmental impacts and energy use resulting from projected growth in travel demand.
- Produce a cost-effective investment plan that identifies and encourages private sector involvement in future corridor improvements and operations.

2.4 PLANNING CONTEXT

The 2008 Passenger Rail Investment and Improvement Act (PRIIA) and the 2009 American Recovery and Reinvestment Act (ARRA) established guidelines for the funding and development of intercity and high-speed rail corridors in the U.S. On April 1, 2010, the FRA published the FY 2010 Multi-State Planning Proposal Solicitation under the High-Speed Intercity Passenger Rail (HSIPR) Program, inviting proposals for federally-led, multi-state high-speed and intercity passenger rail corridor planning demonstration projects.[62] The FRA received proposals from various groups of states and a proposal submitted collectively by the NEC states was selected by the FRA to fund and advance a PRCIP for the NEC.

[62]In the FY 2010 Department of Transportation Appropriations Act, Congress supported the use of planning funds to facilitate development of a Service Development Plan (SDP) and related Environmental Impact Statement (EIS) for high-speed rail corridors located in multiple states.

Appendix B. List of Initial Alternatives

This Appendix B provides a list of the Initial Alternatives for NEC FUTURE and a description of the terms used to describe the components of each alternative.

B.1 OVERALL APPROACH TO INITIAL ALTERNATIVES

For the purposes of organizing the list of Initial Alternatives, it is convenient to compile the alternatives separately for the "North End" and "South End" of the Northeast Corridor (NEC) with New York City as the North/South dividing line. New York City is the dominant market in the Northeast Megaregion, and will be served with service to and through New York.

At this phase, Initial Alternatives do not include detailed characterizations of the physical and operational aspects of the railroad systems operating within the NEC Study Area, such as detailed alignments, track configurations, specific capital projects, operating plans, train timetables, identification of specific station locations, rolling stock fleet plans, etc. These items may be developed and evaluated in future phases of this or other projects.

Table B-1 lists 98 Initial Alternatives. Each row of the table represents a unique alternative, with the columns of the table representing the components or features of the alternative.

B.2 TERMS USED TO DESCRIBE COMPONENTS OF ALTERNATIVES

Alternatives are described by four components that respond to market demand.

B.2.1 Route (Markets Served)

Describes a general path for the fastest end-to-end route and the markets served by that route. Does NOT refer to any specific alignment or right-of-way configuration. Routes are more general than a specific right-of-way configuration or infrastructure footprint. All alternatives include the existing NEC and may include an additional alignment.

B.2.2 Program Investment Level

Program Investment level answers the question: How robust of vision for passenger rail is planned and, based on that vision, how much rail service can be provided to serve the markets? The amount of available funding drives the ability to add the capacity to support additional rail operations and service to new markets. The larger the investment in building the capacity of the rail line—its tracks, signal systems, bridges, station platforms and equipment—the more trains that can serve a market.

NEC FUTURE applied four program levels—a low Baseline level, two medium levels (Baseline Plus and Medium) and High—to broadly test investment options in the NEC over the next 30 years. This results in a range of alternatives from continuation of today's rail operations at the low end to the ability to provide significantly enhanced and robust service, including service to new markets and high-speed rail options at the high end. The four levels of investment used for the Initial Alternatives were as follows:[1]

- Baseline: Responds to projected 2040 demand in existing markets using existing infrastructure; achieves State-of-Good-Repair
- Baseline-Plus: Meets projected 2040 demand in existing markets; includes investments to optimizes the potential of existing NEC spine
- Medium: Expands capacity to accommodate targeted new service , new markets and additional growth
- High: Major increase in quantity and type of service on the NEC spine and construction of a new HSR alignment

B.2.3 Service Definition/Operational Environment

Describes the type of rail service that is provided, in three general categories: These categories are presented in the Initial Alternatives as distinct options and when combined with the Service Focus element, define the full range of potential service options for the study area. Current Mix forms the baseline for analyzing the impacts of the other service strategies. Simplified Service Mix and Expanded One-Seat Ride will be used to test the wide range of reasonable service options.

These service strategies are intended to guide the development of potential service options for the alternatives. Their features are not intended to be absolute or exclusive to each service strategy. As the alternatives are refined in future phases of work, features from each of these service strategies may be combined to develop the best service plan for an alternative.

Various "connection strategies" – such as coordinated transfers or run-through service from connecting corridors – will be applied to each service strategy to ensure that all potential market pairs in the study area are served.

- **Current Mix:** Includes the current "mix" of train types (Acela/Premium High-Speed Rail, Regional/Limited Intercity, Commuter, Freight) and institutional arrangements with the number of trains increased as needed to meet future demand. The service would still have a mix of train types, but the proportional mix would be "rebalanced" to respond to market demand.
- **Enhanced Service Mix:**
  - Simplified Service :
    - Provides a limited group of services on a regular, repeating schedule to deliver higher frequency and throughput capacity than service plans with a greater variety of stopping patterns and train types.
    - May not deliver same trip times to major markets and may require transfers for passengers in secondary markets, but overall trip times are competitive with other

[1] For simplicity, the nomenclature for the Program Investment Levels will be changed during the development of the Preliminary Alternatives and in the Preliminary Alternatives Report to the following: A (Low); B (Medium-Low); C (Medium-High) ; and D (High).

service approaches with opportunity for greater frequencies to secondary markets through highly coordinated schedules and transfers.

- Services include:
  - Limited-stop express service
  - Multi-stop local service
  - Supplemental peak commuter service
  - Convenient transfers from connecting corridors to and between services on NEC Spine

– Expanded One-Seat Ride: Focuses on maximizing the number of market pairs served with one-seat ride service, particularly for intermediate and connecting corridor markets, through the use of several services. These services include high-speed trains operating exclusively on high-speed or express tracks and other high-performance services that share high-speed tracks and utilize available capacity on portions of high-speed territory with maximum speeds of 160 mph or less and without intermediate station stops (e.g., on final approach to NYC, Washington and/or Boston).

B.2.4 Service Focus

Describes the following types of passenger and/or geographic markets that are the focus of the alternative:

- **Regional markets:** Shorter-distance travel (within a single metropolitan area or to a neighboring metropolitan area) generally on a daily or nearly daily basis
- **Intercity primary markets:** Travel between primary markets (Boston, New York, Philadelphia, and Washington, DC) for any trip purpose
- **Intercity secondary markets:** All other intercity travel between markets located on the existing NEC Spine or on a new route for any trip purpose. (Secondary markets are NEC markets/cities other than the primary markets between Boston, New York, Philadelphia, and Washington DC.)
- **Connecting corridor markets:** Intermediate-distance markets that are not on the NEC Spine but can reach markets on the NEC Spine or new route either directly or by one transfer

As noted in the main report, Service Focus is useful in organizing the Initial Alternatives but will be combined within Service Definition during development of the Preliminary Alternatives.

B.3 COMBINATIONS OF ELEMENTS TO CREATE ALTERNATIVES

B.3.1 Alternatives that Follow the Existing NEC Spine

Using this approach of combining elements to create unique alternatives, 28 alternatives north of New York and 28 alternatives south of New York were defined that follow the existing NEC spine. These consist of combinations of Quantity of Service, Service Strategy, and Service Focus.

B.3.2 Alternatives with a Portion of the Route off the Existing NEC Spine

Alternatives serving markets off of the existing NEC spine will require new infrastructure and new alignments. While very costly, new routes provide the ability to deliver substantive service improvements for all users of the rail line. Accordingly, the alternatives that do not follow the existing NEC route are assumed to provide a high quantity of service and to benefit all rail markets. Forty-two (42) alternatives were defined where a portion of the alignment is off of the existing NEC spine. All of those 42 alternatives still include the existing NEC. .

B.3.3 Summary

In total, 98 separate Initial Alternatives were identified, and they are listed in Table B-1. Each alternative represents a unique combination of geographical, market, service and investment needs. These alternatives include those generated through the data collection process and those raised during scoping that reasonably help to address one or more objectives of the Purpose & Need.

Following Table B-1, a set of fact sheets describes each of the Initial Alternatives in greater detail.

TABLE B-1: INITIAL ALTERNATIVES

Alternative ID	Route	Program Investment Level	Service Definition/Operational Environment	Service Focus
North1	Existing NEC	Baseline	Current Mix	Regional
North2	Existing NEC	Baseline Plus	Current Mix	Intercity Primary
North3	Existing NEC	Baseline Plus	Current Mix	Intercity Secondary
North4	Existing NEC	Baseline Plus	Current Mix	Regional
North5	Existing NEC	Baseline Plus	Current Mix	Connecting
North6	Existing NEC	Baseline Plus	Simplified Service	Intercity Primary
North7	Existing NEC	Baseline Plus	Simplified Service	Intercity Secondary
North8	Existing NEC	Baseline Plus	Simplified Service	Regional
North9	Existing NEC	Baseline Plus	Simplified Service	Connecting
North10	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Intercity Primary
North11	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Intercity Secondary
North12	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Regional
North13	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Connecting
North14	Existing NEC	Medium	Current Mix	Intercity Primary
North15	Existing NEC	Medium	Current Mix	Intercity Secondary
North16	Existing NEC	Medium	Current Mix	Regional
North17	Existing NEC	Medium	Current Mix	Connecting
North18	Existing NEC	Medium	Simplified Service	Intercity Primary
North19	Existing NEC	Medium	Simplified Service	Intercity Secondary
North20	Existing NEC	Medium	Simplified Service	Regional
North21	Existing NEC	Medium	Simplified Service	Connecting
North22	Existing NEC	Medium	Expanded One-Seat Ride	Intercity Primary
North23	Existing NEC	Medium	Expanded One-Seat Ride	Intercity Secondary
North24	Existing NEC	Medium	Expanded One-Seat Ride	Regional
North25	Existing NEC	Medium	Expanded One-Seat Ride	Connecting
North26	Existing NEC	High	Current Mix	All Markets
North27	Existing NEC	High	Simplified Service	All Markets
North28	Existing NEC	High	Expanded One-Seat Ride	All Markets

TABLE B-1: INITIAL ALTERNATIVES (CONTINUED)

Alternative ID	NEC Spine Route	Quantity of Service	Service Strategy	Service Focus
North29	New Haven Line - Central CT	High	Current Mix	All Markets
North30	New Haven Line - Central CT	High	Simplified Service	All Markets
North31	New Haven Line - Central CT	High	Expanded One-Seat Ride	All Markets
North32	New Haven Line - via Springfield	High	Current Mix	All Markets
North33	New Haven Line - via Springfield	High	Simplified Service	All Markets
North34	New Haven Line - via Springfield	High	Expanded One-Seat Ride	All Markets
North35	Central CT - via Providence	High	Current Mix	All Markets
North36	Central CT - via Providence	High	Simplified Service	All Markets
North37	Central CT - via Providence	High	Expanded One-Seat Ride	All Markets
North38	Central CT - via Worcester	High	Current Mix	All Markets
North39	Central CT - via Worcester	High	Simplified Service	All Markets
North40	Central CT - via Worcester	High	Expanded One-Seat Ride	All Markets
North41	Central CT - via Springfield	High	Current Mix	All Markets
North42	Central CT - via Springfield	High	Simplified Service	All Markets
North43	Central CT - via Springfield	High	Expanded One-Seat Ride	All Markets
North44	Nassau-Suffolk - Shore Line	High	Current Mix	All Markets
North45	Nassau-Suffolk - Shore Line	High	Simplified Service	All Markets
North46	Nassau-Suffolk - Shore Line	High	Expanded One-Seat Ride	All Markets
North47	Nassau-Suffolk - Central CT	High	Current Mix	All Markets
North48	Nassau-Suffolk - Central CT	High	Simplified Service	All Markets
North49	Nassau-Suffolk - Central CT	High	Expanded One-Seat Ride	All Markets
North50	Nassau-Suffolk - via Worcester	High	Current Mix	All Markets
North51	Nassau-Suffolk - via Worcester	High	Simplified Service	All Markets
North52	Nassau-Suffolk - via Worcester	High	Expanded One-Seat Ride	All Markets
North53	Nassau-Suffolk - via Springfield	High	Current Mix	All Markets
North54	Nassau-Suffolk - via Springfield	High	Simplified Service	All Markets
North55	Nassau-Suffolk - via Springfield	High	Expanded One-Seat Ride	All Markets
North56	Nassau-Stamford - Central CT	High	Current Mix	All Markets
North57	Nassau-Stamford - Central CT	High	Simplified Service	All Markets

TABLE B-1: INITIAL ALTERNATIVES (CONTINUED)

Alternative ID	NEC Spine Route	Quantity of Service	Service Strategy	Service Focus
North58	Nassau-Stamford - Central CT	High	Expanded One-Seat Ride	All Markets
North59	Nassau-Stamford - via Worcester	High	Current Mix	All Markets
North60	Nassau-Stamford - via Worcester	High	Simplified Service	All Markets
North61	Nassau-Stamford - via Worcester	High	Expanded One-Seat Ride	All Markets
North62	Nassau-Stamford - via Springfield	High	Current Mix	All Markets
North63	Nassau-Stamford - via Springfield	High	Simplified Service	All Markets
North64	Nassau-Stamford - via Springfield	High	Expanded One-Seat Ride	All Markets
South1	Existing NEC	Baseline	Current Mix	Regional
South2	Existing NEC	Baseline Plus	Current Mix	Intercity Primary
South3	Existing NEC	Baseline Plus	Current Mix	Intercity Secondary
South4	Existing NEC	Baseline Plus	Current Mix	Regional
South5	Existing NEC	Baseline Plus	Current Mix	Connecting
South6	Existing NEC	Baseline Plus	Simplified Service	Intercity Primary
South7	Existing NEC	Baseline Plus	Simplified Service	Intercity Secondary
South8	Existing NEC	Baseline Plus	Simplified Service	Regional
South9	Existing NEC	Baseline Plus	Simplified Service	Connecting
South10	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Intercity Primary
South11	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Intercity Secondary
South12	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Regional
South13	Existing NEC	Baseline Plus	Expanded One-Seat Ride	Connecting
South14	Existing NEC	Medium	Current Mix	Intercity Primary
South15	Existing NEC	Medium	Current Mix	Intercity Secondary
South16	Existing NEC	Medium	Current Mix	Regional
South17	Existing NEC	Medium	Current Mix	Connecting
South18	Existing NEC	Medium	Simplified Service	Intercity Primary
South19	Existing NEC	Medium	Simplified Service	Intercity Secondary
South20	Existing NEC	Medium	Simplified Service	Regional
South21	Existing NEC	Medium	Simplified Service	Connecting
South22	Existing NEC	Medium	Expanded One-Seat Ride	Intercity Primary

TABLE B-1: INITIAL ALTERNATIVES (CONTINUED)

Alternative ID	NEC Spine Route	Quantity of Service	Service Strategy	Service Focus
South23	Existing NEC	Medium	Expanded One-Seat Ride	Intercity Secondary
South24	Existing NEC	Medium	Expanded One-Seat Ride	Regional
South25	Existing NEC	Medium	Expanded One-Seat Ride	Connecting
South26	Existing NEC	High	Current Mix	All Markets
South27	Existing NEC	High	Simplified Service	All Markets
South28	Existing NEC	High	Expanded One-Seat Ride	All Markets
South29	Via Downtown Baltimore and Philadelphia	High	Current Mix	All Markets
South30	Via Downtown Baltimore and Philadelphia	High	Simplified Service	All Markets
South31	Via Downtown Baltimore and Philadelphia	High	Expanded One-Seat Ride	All Markets
South32	Delmarva Route via Annapolis	High	Current Mix	All Markets
South33	Delmarva Route via Annapolis	High	Simplified Service	All Markets
South34	Delmarva Route via Annapolis	High	Expanded One-Seat Ride	All Markets

INITIAL ALTERNATIVES FACT SHEETS

Initial Alternative: North1

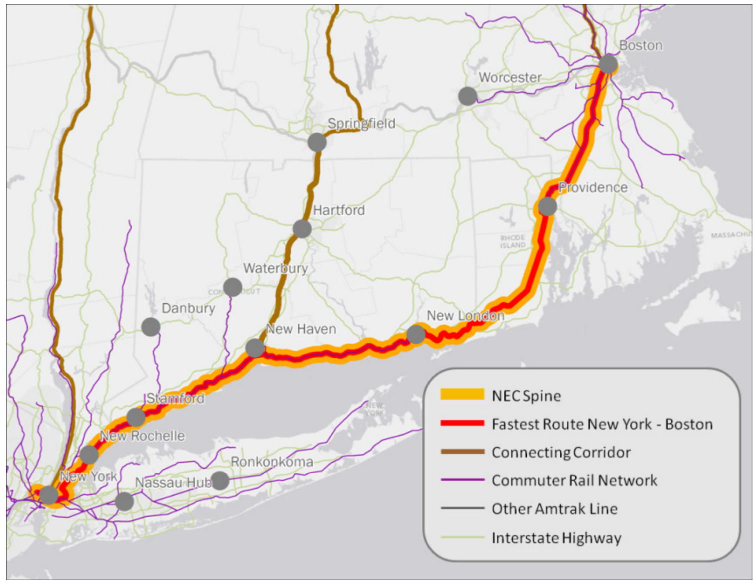
Current Mix of Services with Focus on Regional Service via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline
Service Definition	Current Mix
Service Focus	Regional

Description

Responds to growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: North2

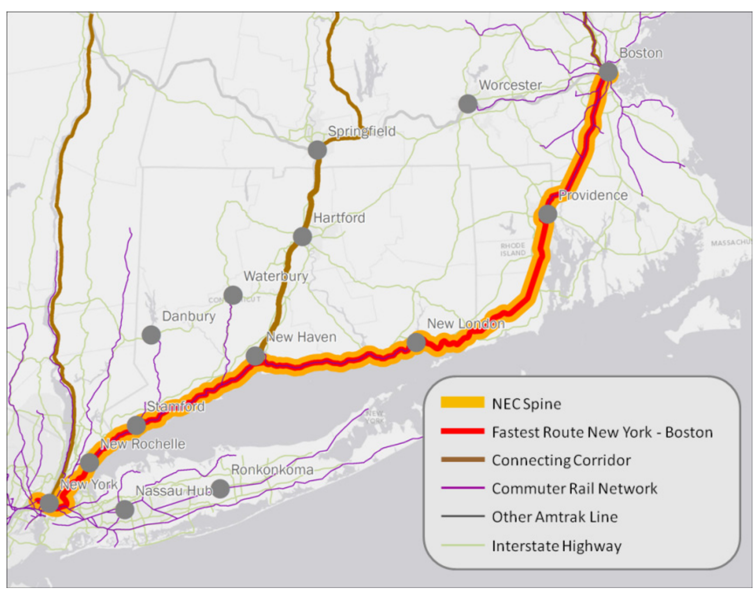
Current Mix of Services with Focus on Primary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Intercity Primary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.

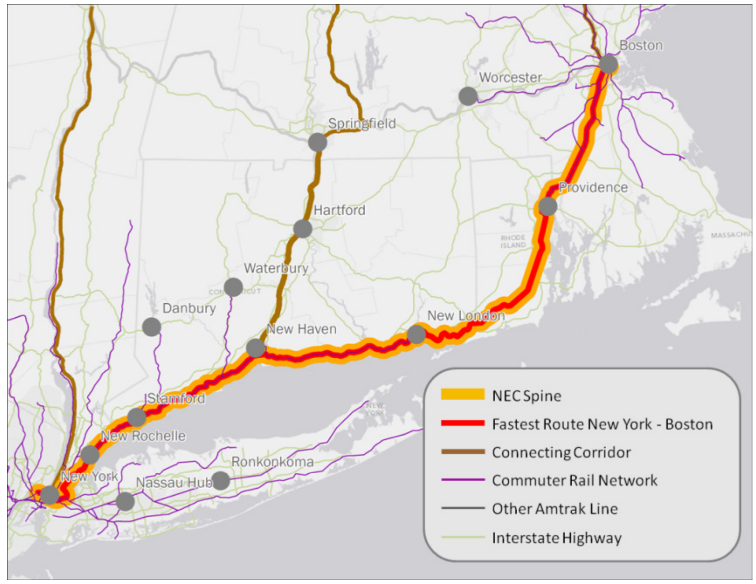


Initial Alternative: North3

Current Mix of Services with Focus on Secondary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Intercity Secondary



Description

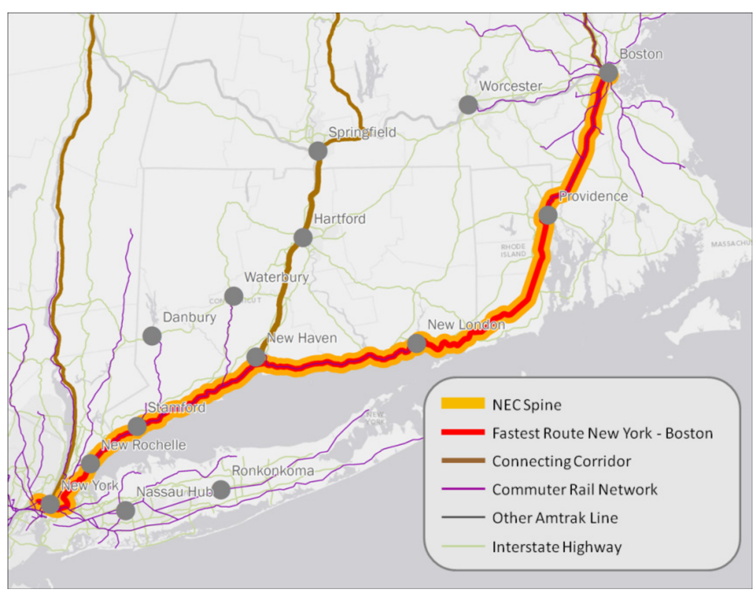
Meets growth in existing markets via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.

Initial Alternative: North4

Current Mix of Services with Focus on Regional Service via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Regional



Description

Meets growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides current mix of express, regional, and commuter services.

Initial Alternative: North5

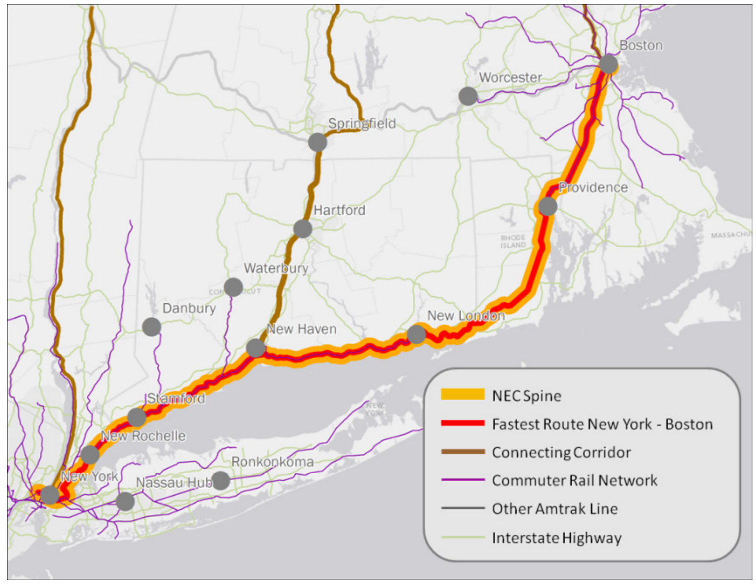
Current Mix of Services with Focus on Connecting Corridors via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Connecting

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: North6

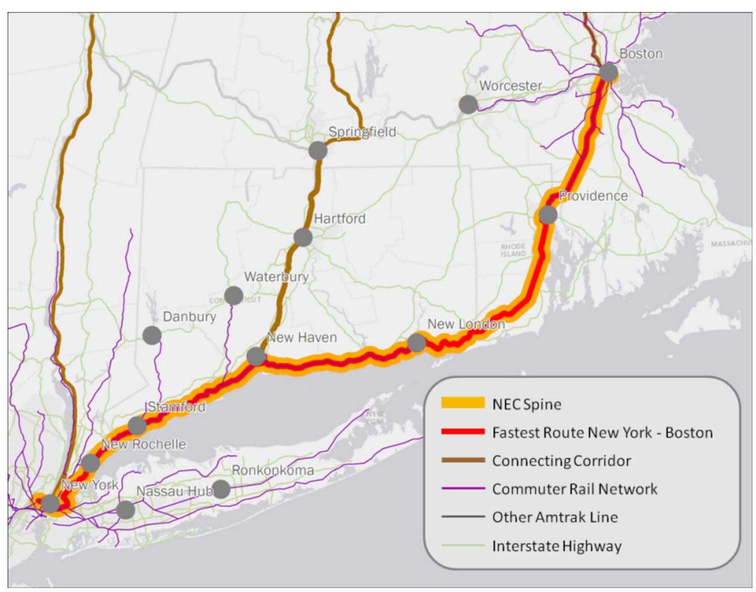
Coordinated, Frequent Service Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Intercity Primary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

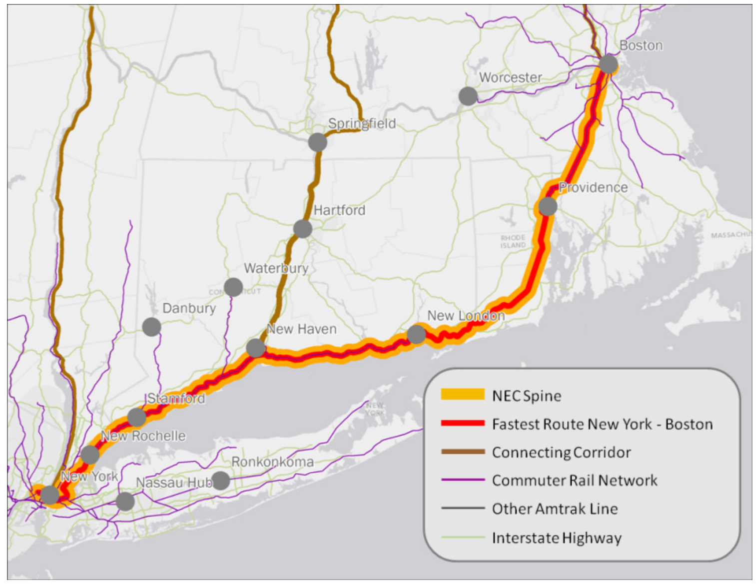


Initial Alternative: North7

Coordinated, Frequent Service Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Intercity Secondary



Description

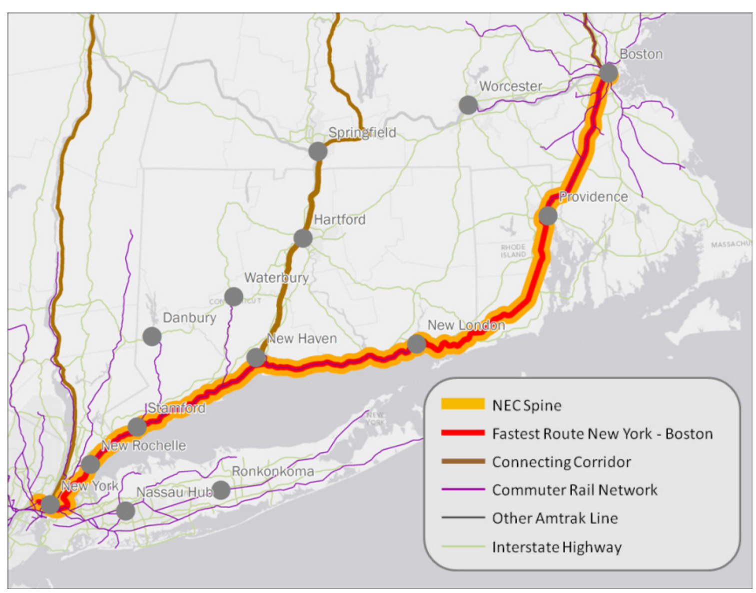
Meets growth in existing markets via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North8

Coordinated, Frequent Service Focused on Regional Service via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Regional



Description

Meets growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North9

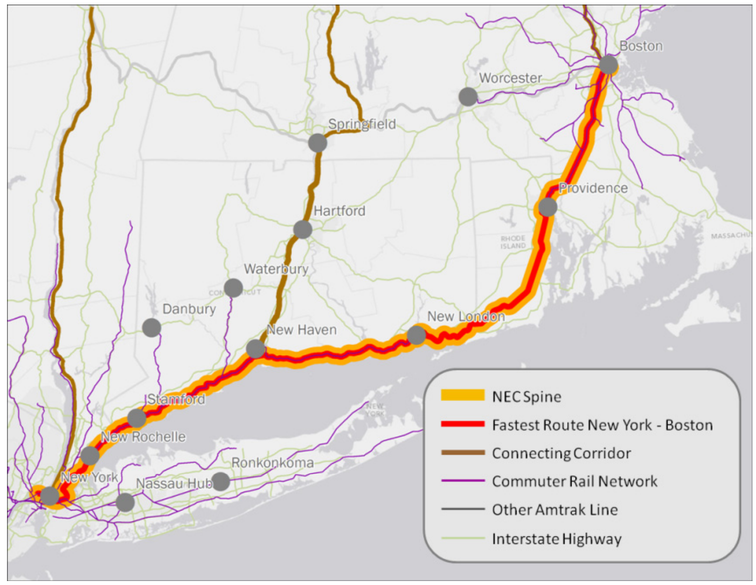
Coordinated, Frequent Service Focused on Connecting Corridors via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Connecting

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: North10

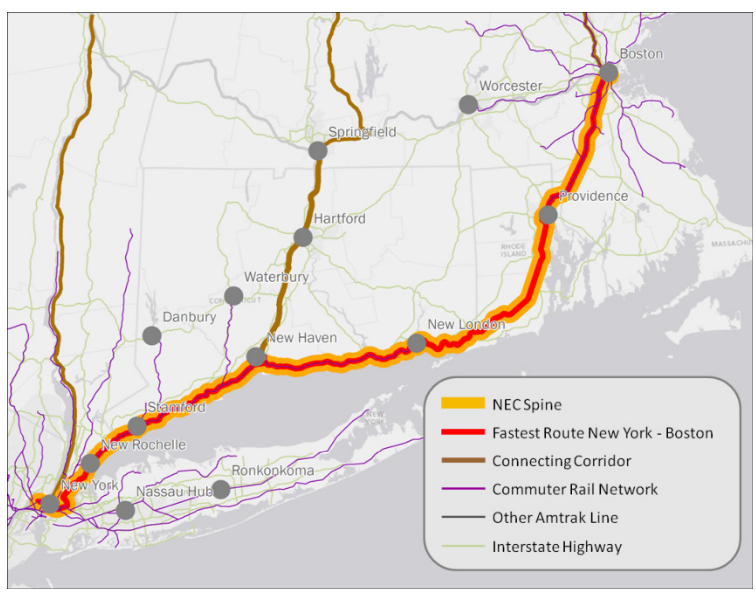
Expanded Mix of Services Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Primary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North11

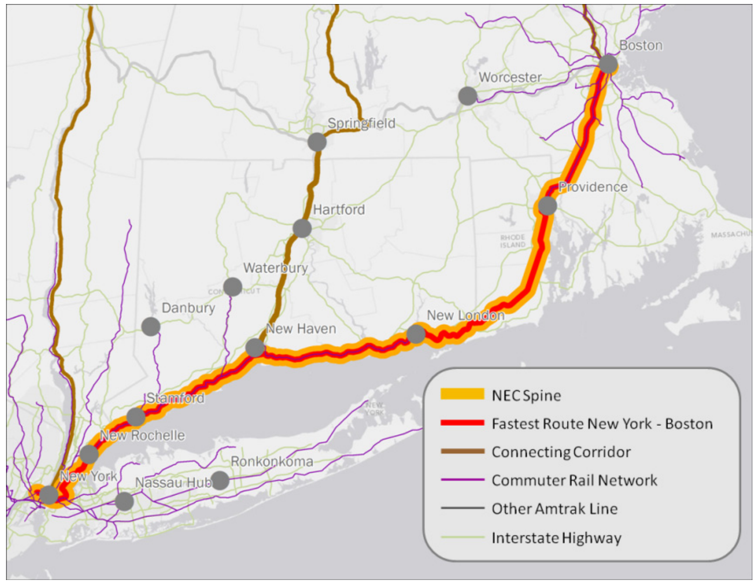
Expanded Mix of Services Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Secondary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North12

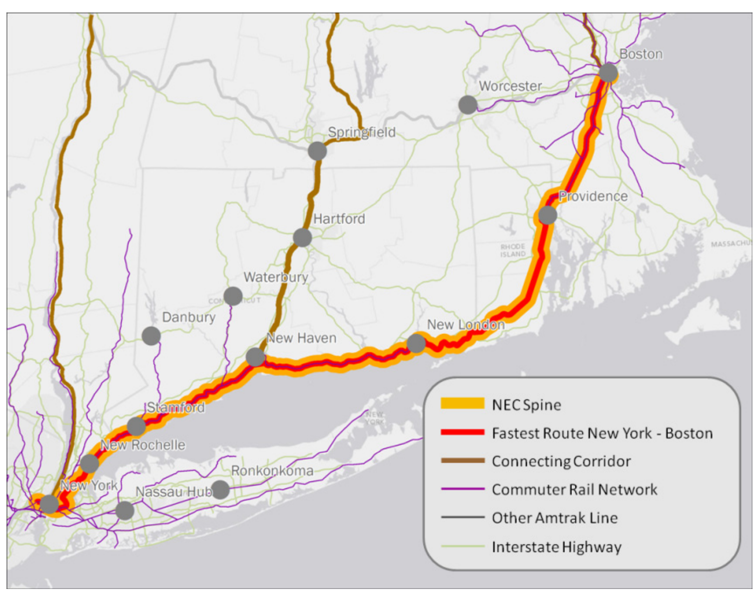
Expanded Mix of Services Focused on Regional Service via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Regional

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North13

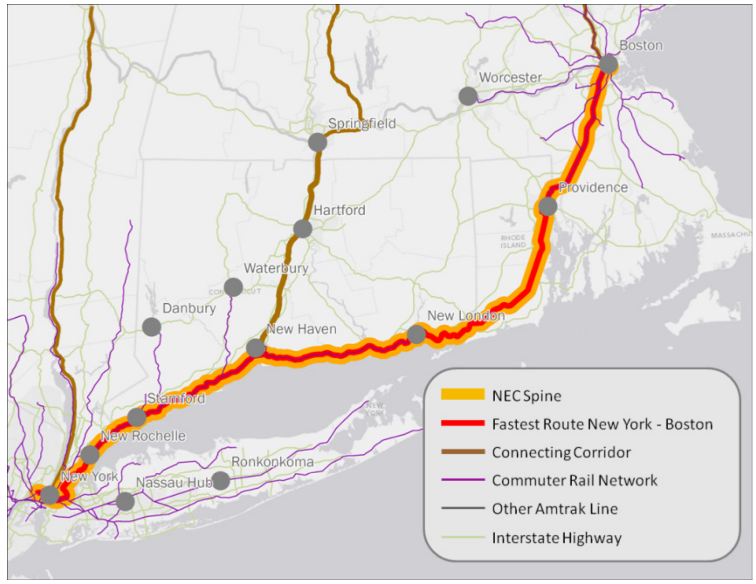
Expanded Mix of Services Focused on Connecting Corridors via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Connecting

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North14

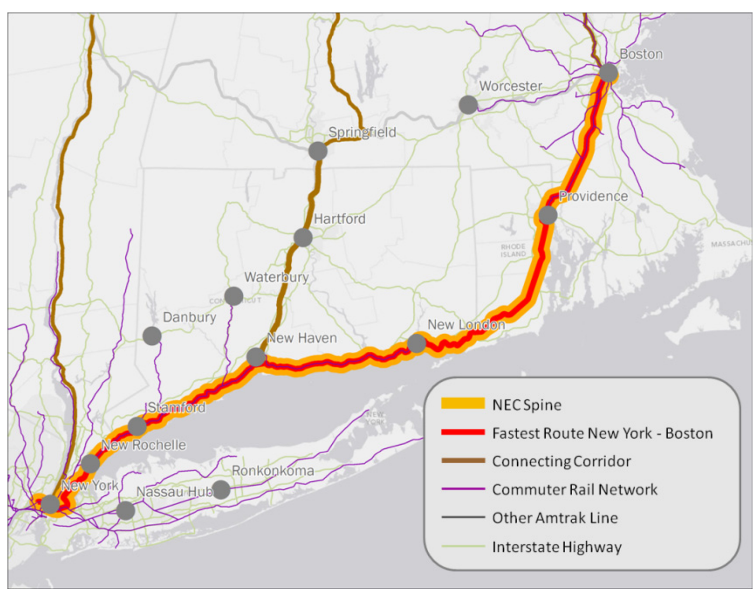
Current Mix of Services with Focus on Primary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Intercity Primary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: North15

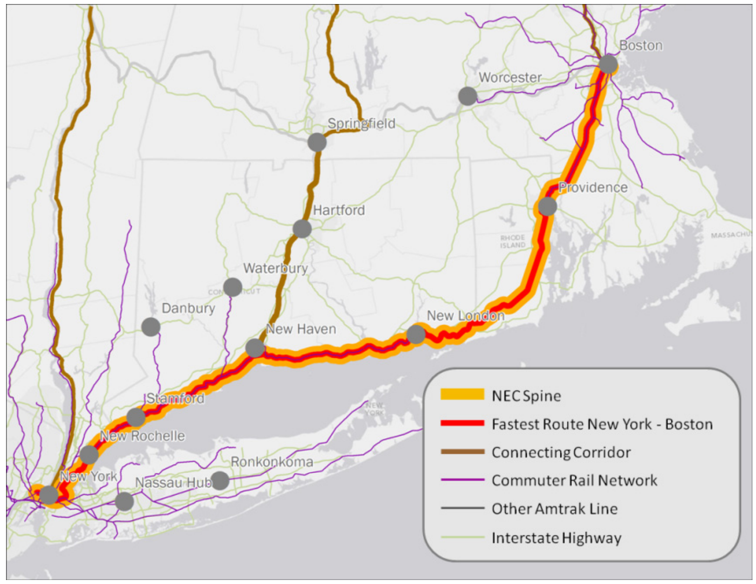
Current Mix of Services with Focus on Secondary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Intercity Secondary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: North16

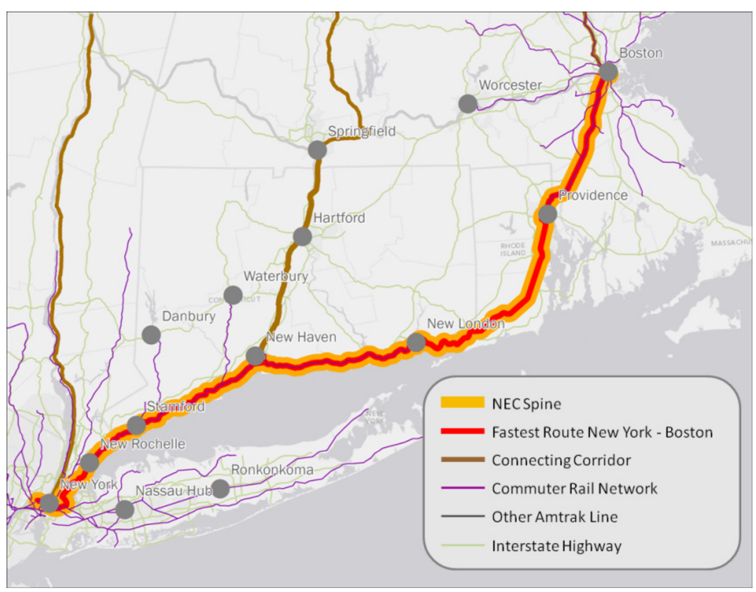
Current Mix of Services with Focus on Regional Service via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Regional

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: North17

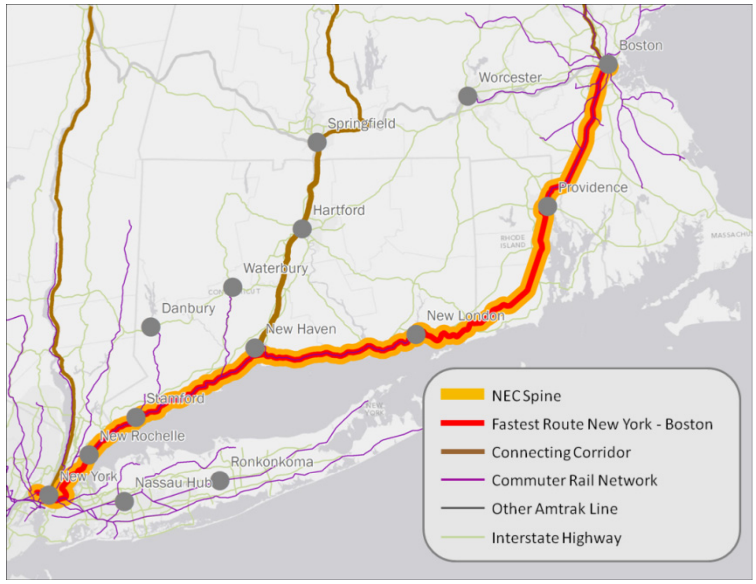
Current Mix of Services with Focus on Connecting Corridors via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Connecting

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: North18

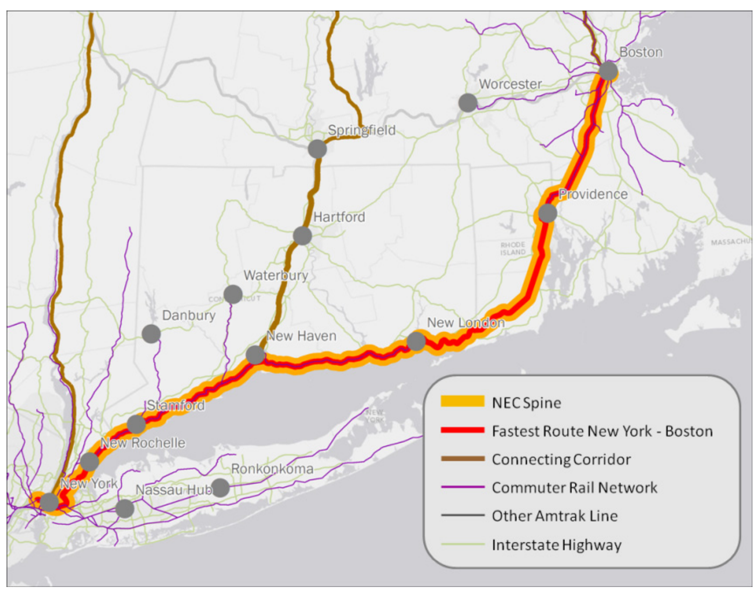
Coordinated, Frequent Service Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Intercity Primary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: North19

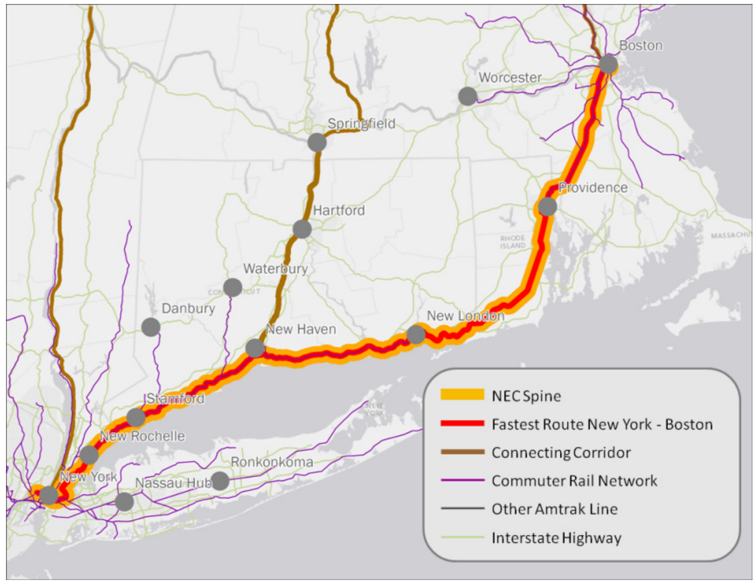
Coordinated, Frequent Service Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Intercity Secondary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: North20

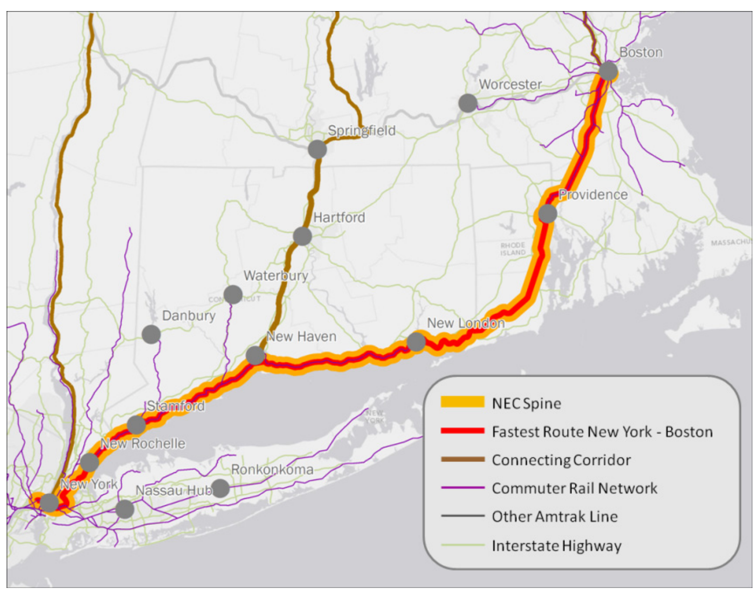
Coordinated, Frequent Service Focused on Regional Service via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Regional

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

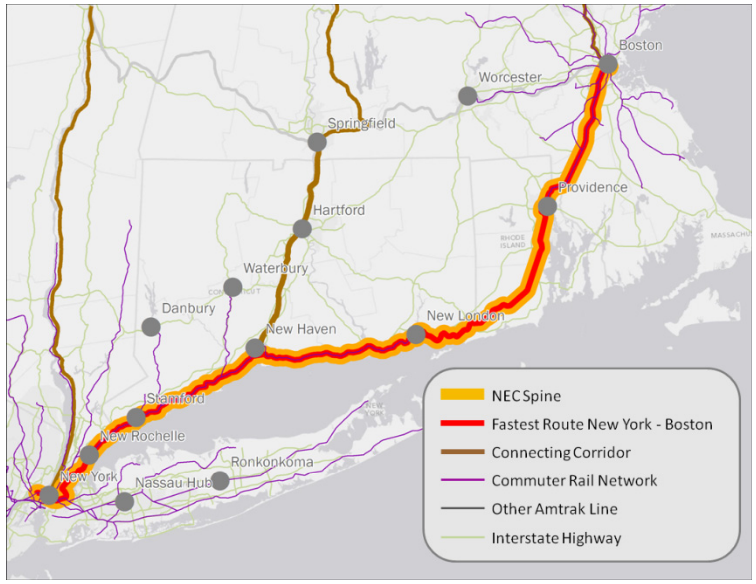


Initial Alternative: North21

Coordinated, Frequent Service Focused on Connecting Corridors via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Connecting



Description

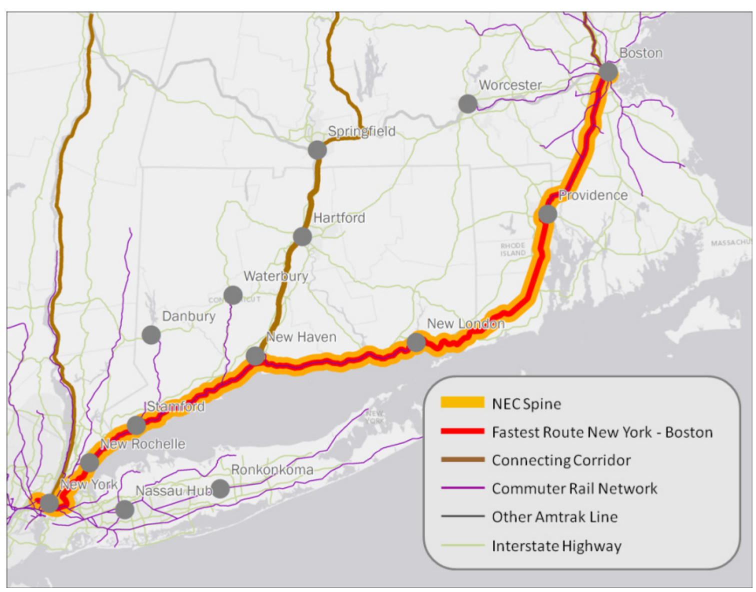
Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North22

Expanded Mix of Services Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Primary



Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North23

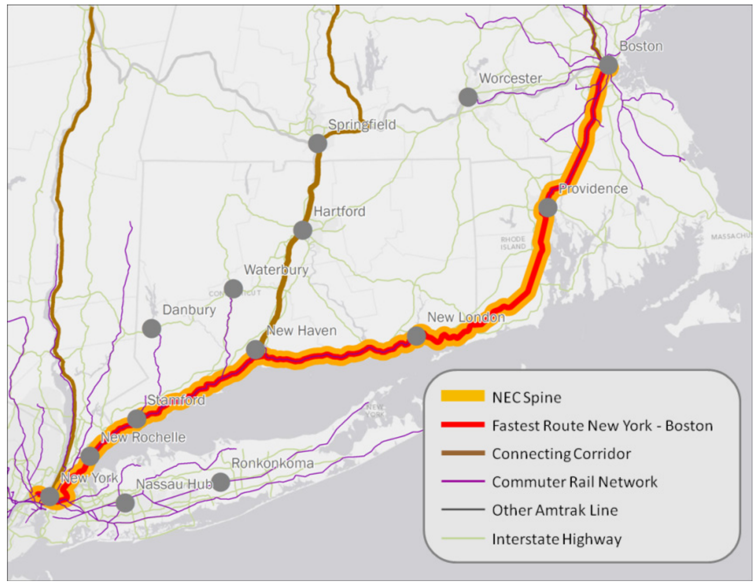
Expanded Mix of Services Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Secondary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North24

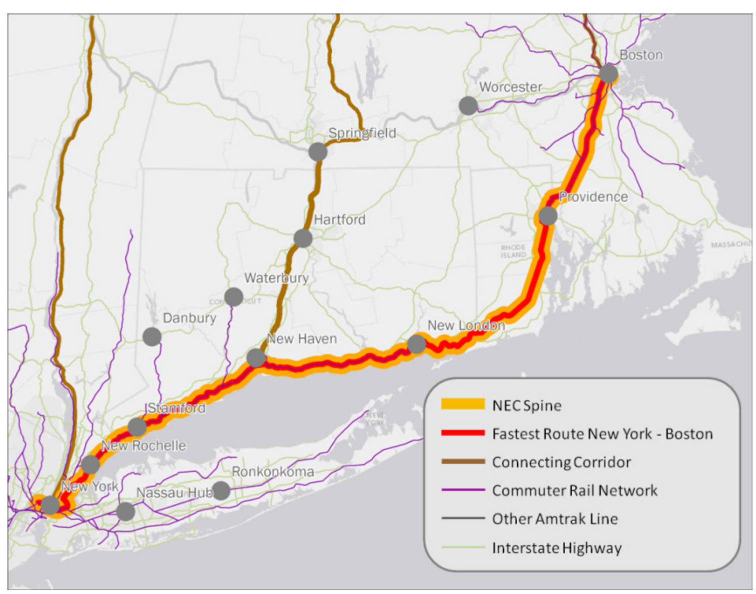
Expanded Mix of Services Focused on Regional Service via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Regional

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North25

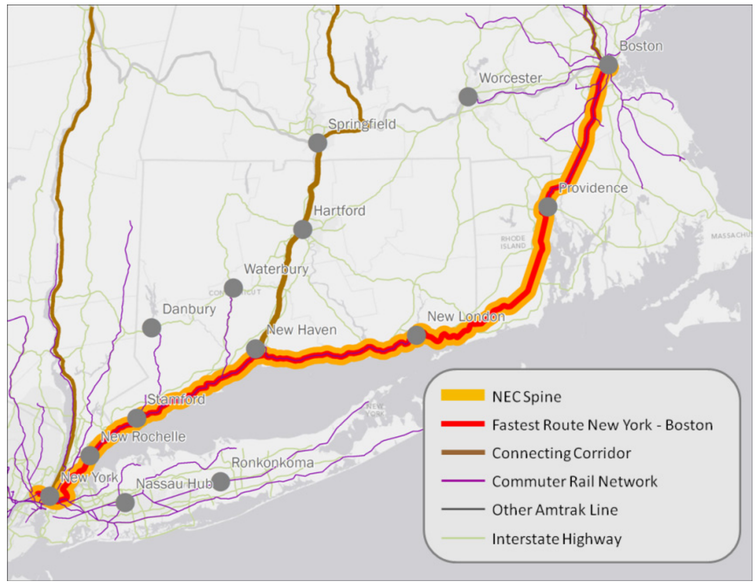
Expanded Mix of Services Focused on Connecting Corridors via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Connecting

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North26

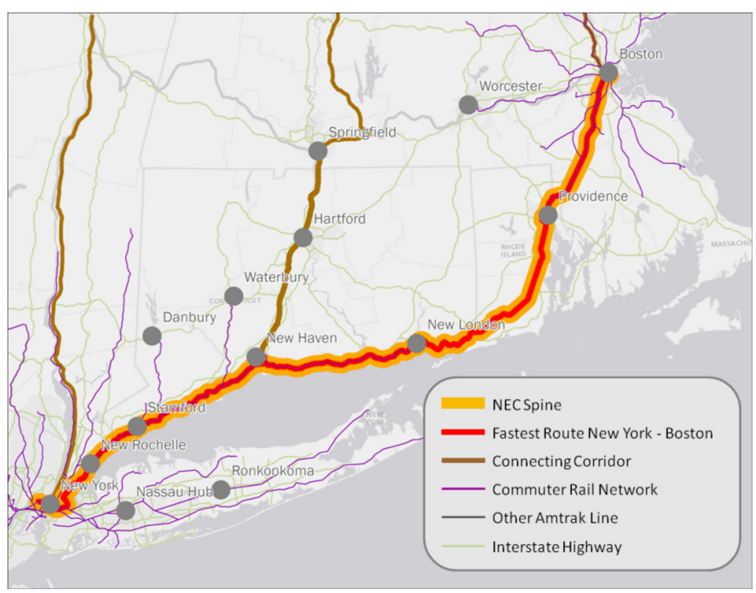
Current Mix of Services with Focus on All Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.



Initial Alternative: North27

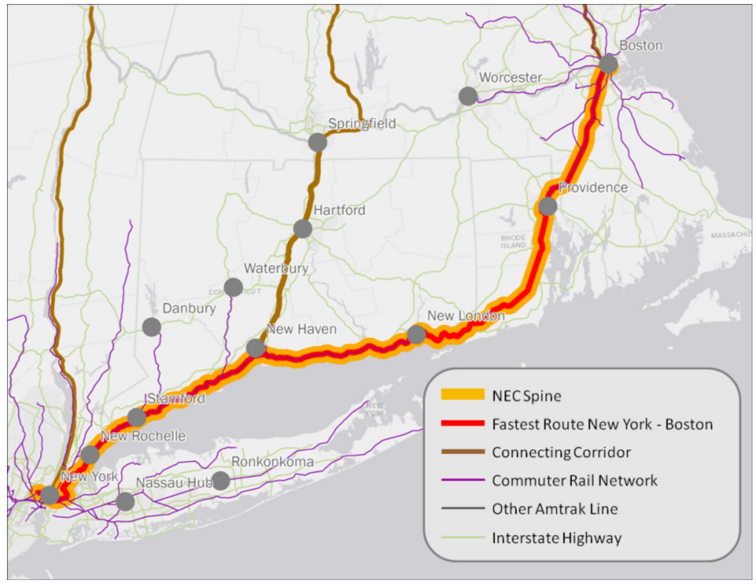
Coordinated, Frequent Service Focused on All Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: North28

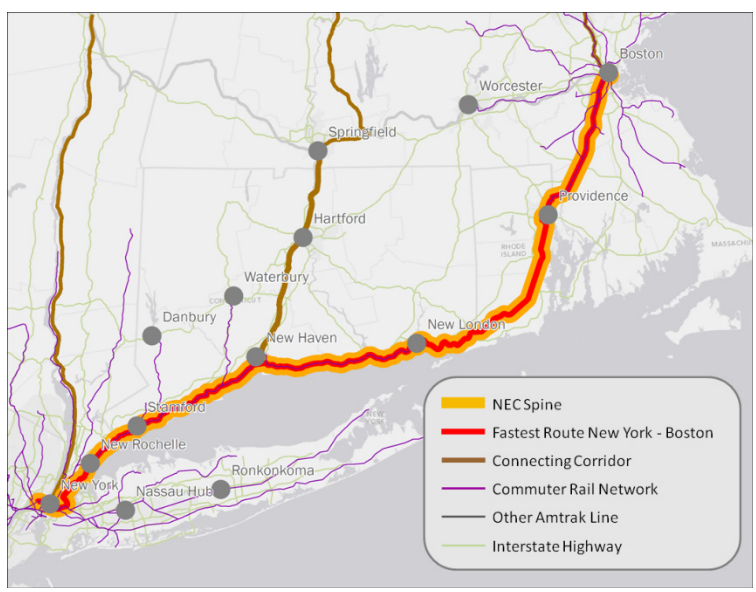
Expanded Mix of Services Focused on All Markets via Existing NEC Alignment between NYC and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

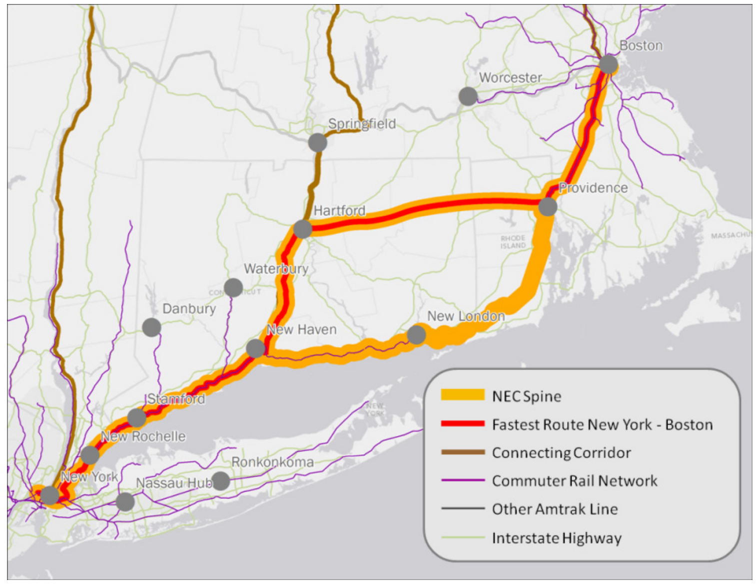


Initial Alternative: North29

Current Mix of Services with Focus on All Markets with New Route Connecting NYC, New Rochelle, New Haven, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets



Description

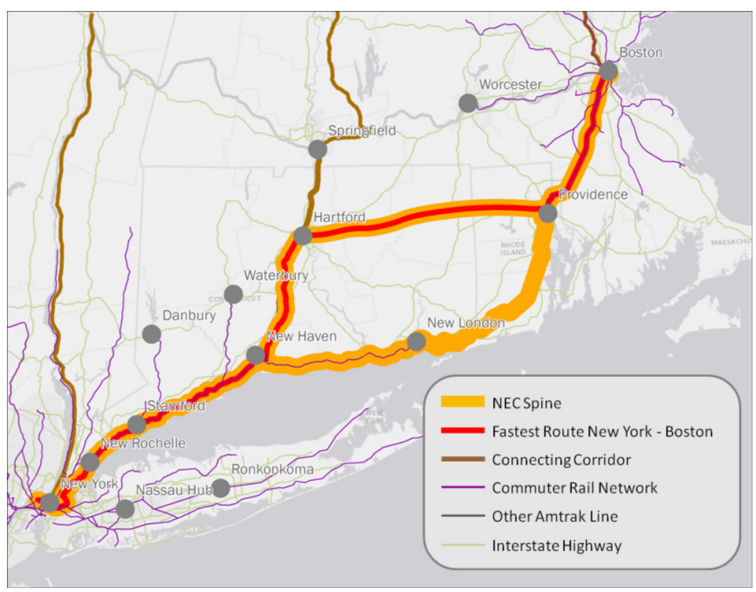
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, New Haven, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

Initial Alternative: North30

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, New Rochelle, New Haven, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, New Haven, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North31

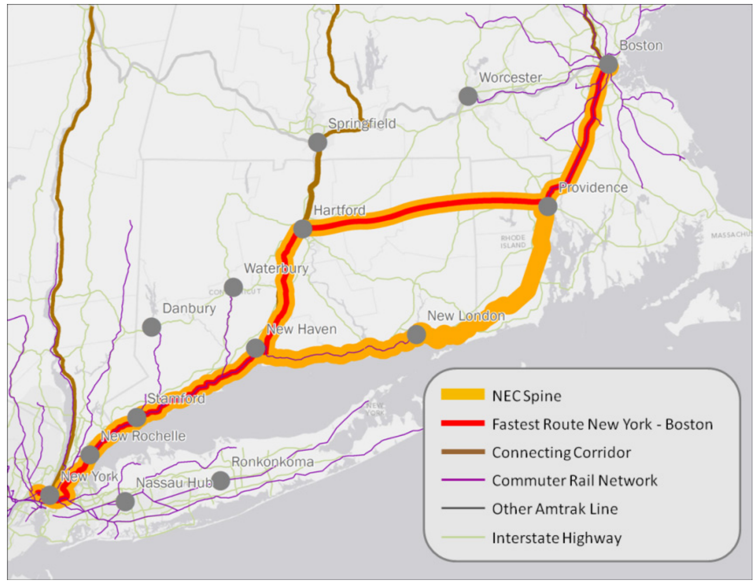
Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, New Rochelle, New Haven, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, New Haven, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North32

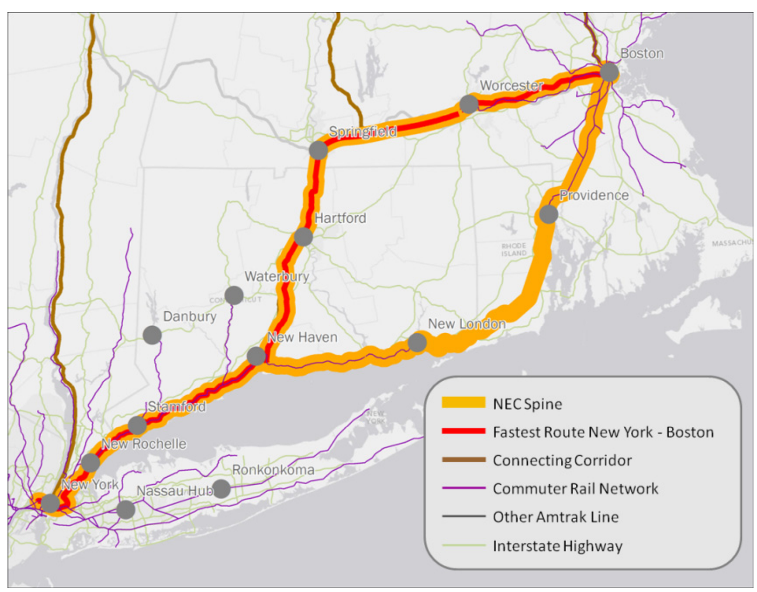
Current Mix of Services with Focus on All Markets with New Route Connecting NYC, New Rochelle, New Haven, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, New Haven, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

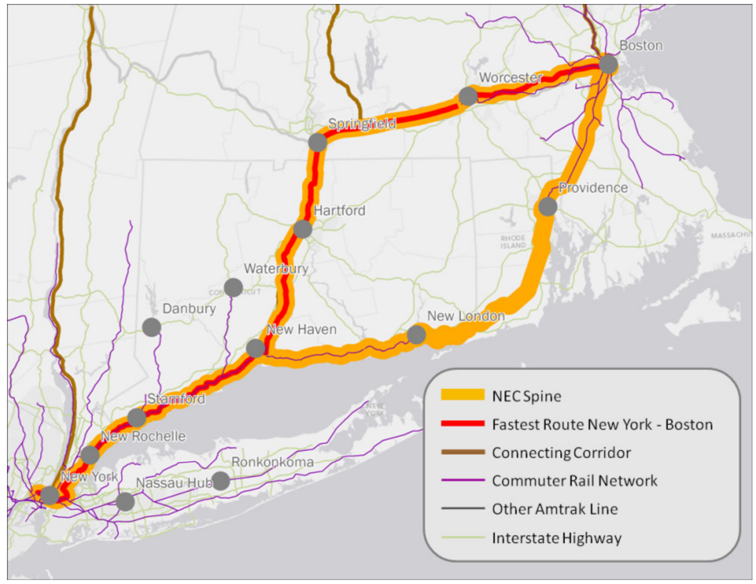


Initial Alternative: North33

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, New Rochelle, New Haven, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

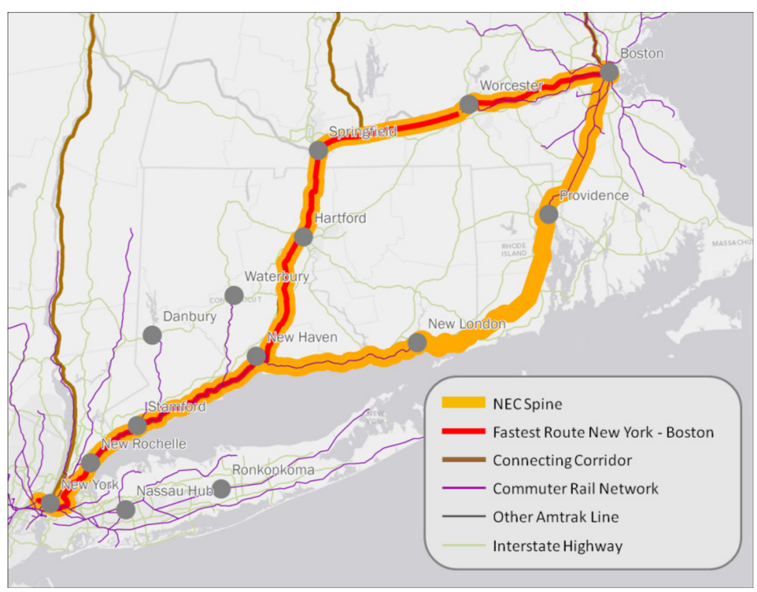
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, New Haven, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North34

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, New Rochelle, New Haven, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, New Haven, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North35

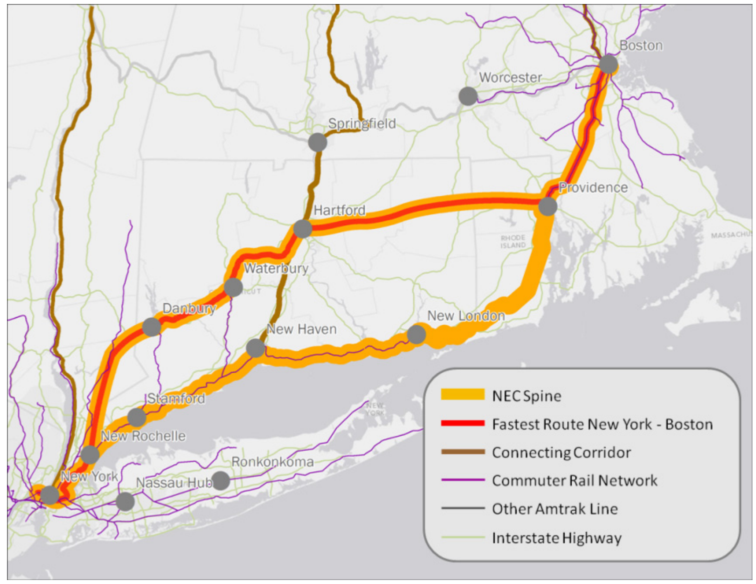
Current Mix of Services with Focus on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.



Initial Alternative: North36

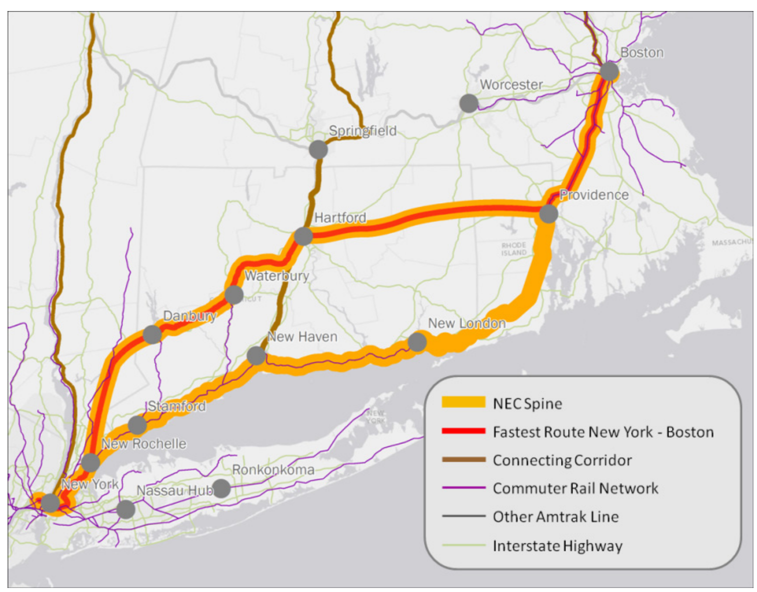
Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

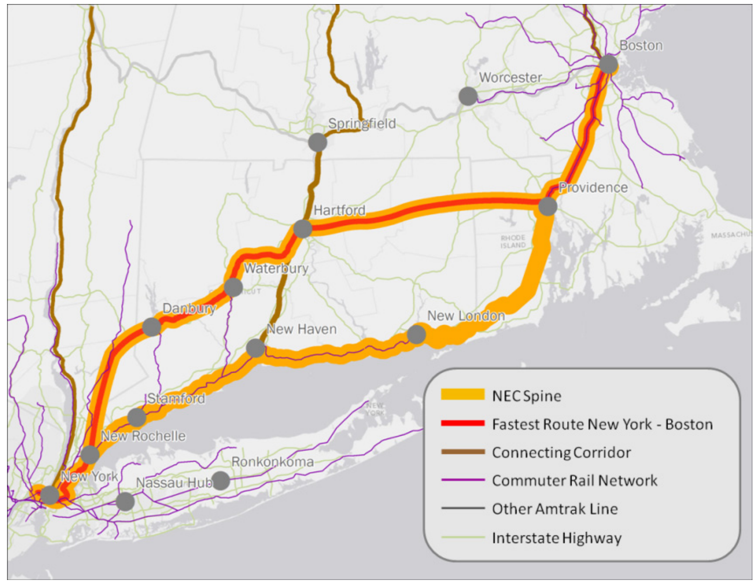


Initial Alternative: North37

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

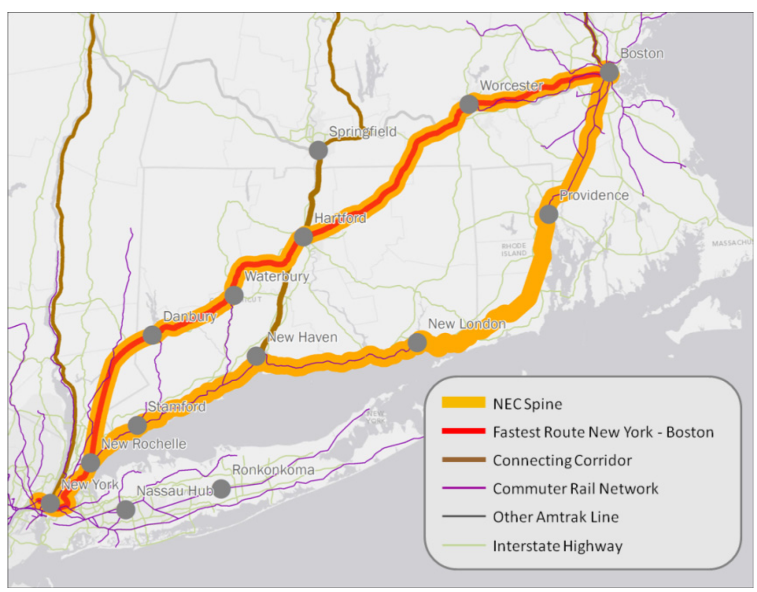
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North38

Current Mix of Services with Focus on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets



Description

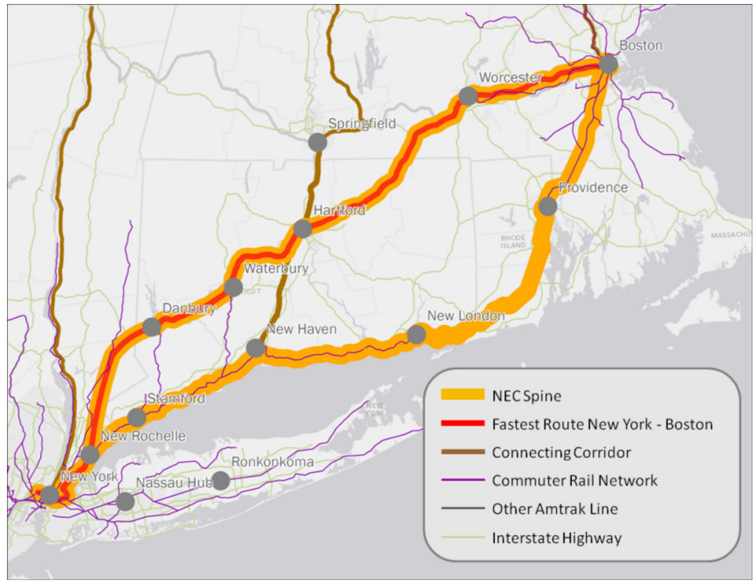
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

Initial Alternative: North39

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

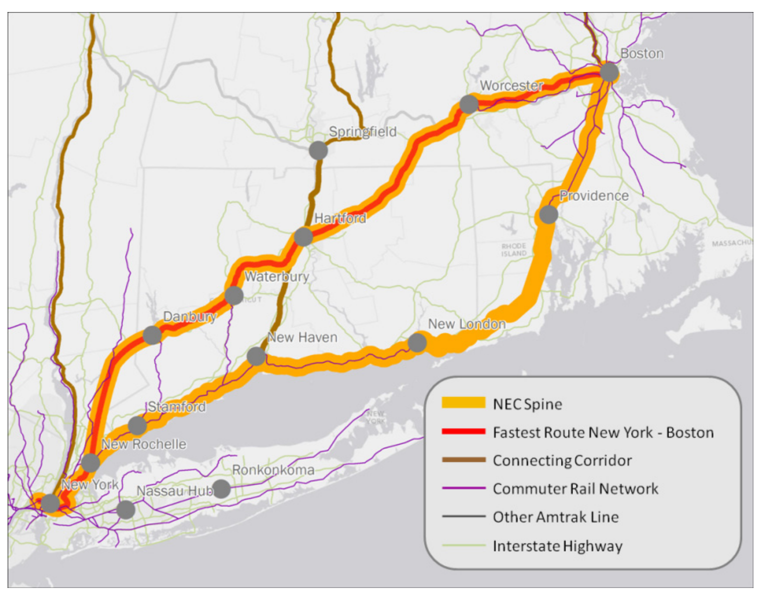
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North40

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North41

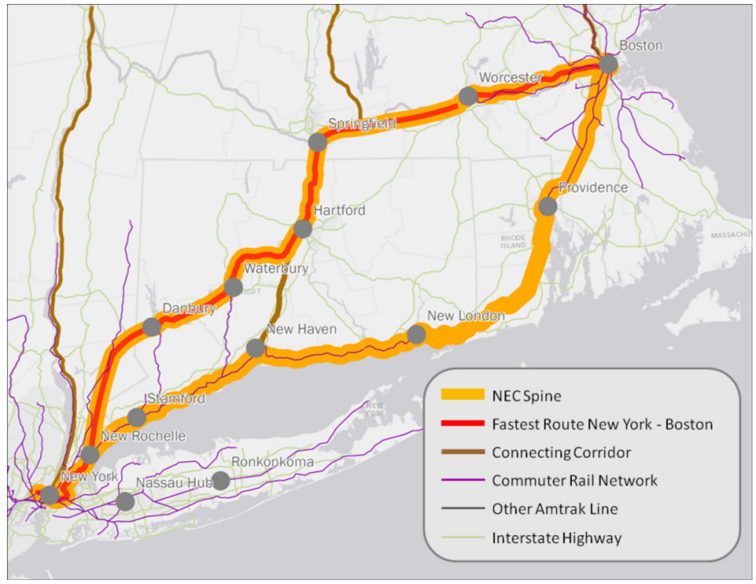
Current Mix of Services with Focus on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.



Initial Alternative: North42

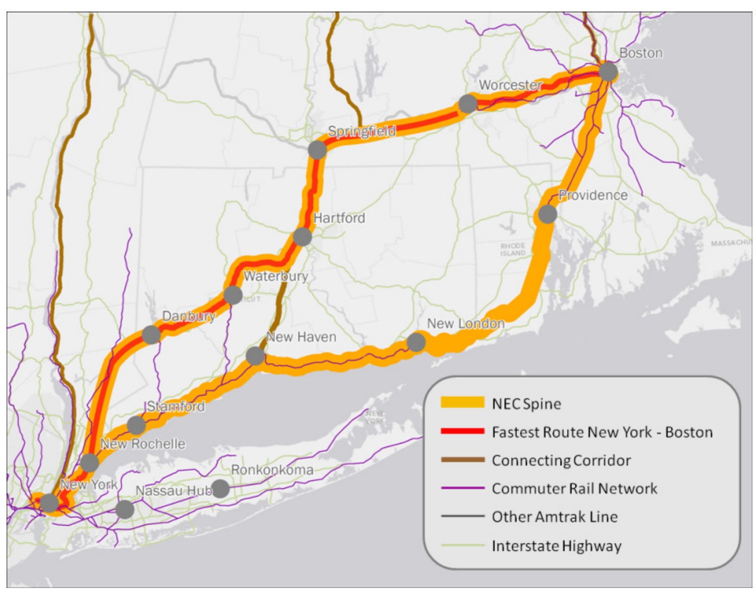
Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: North43

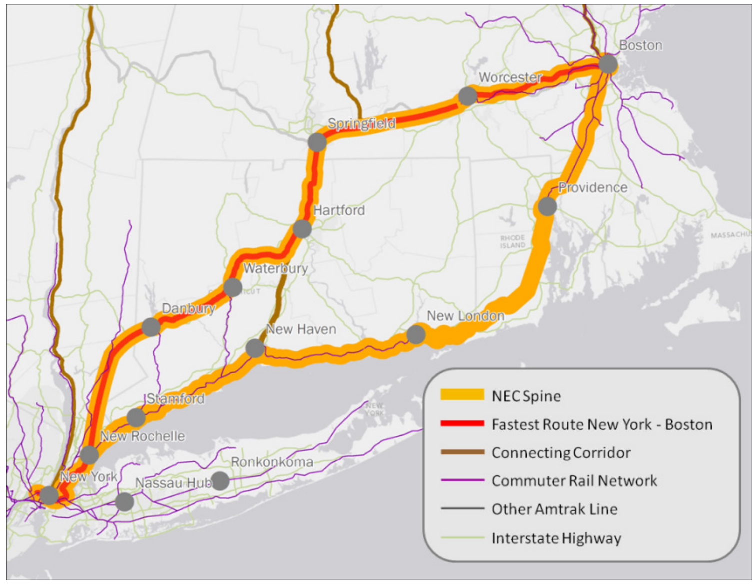
Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, New Rochelle, Danbury, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One Seat Ride
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, New Rochelle, Danbury, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North44

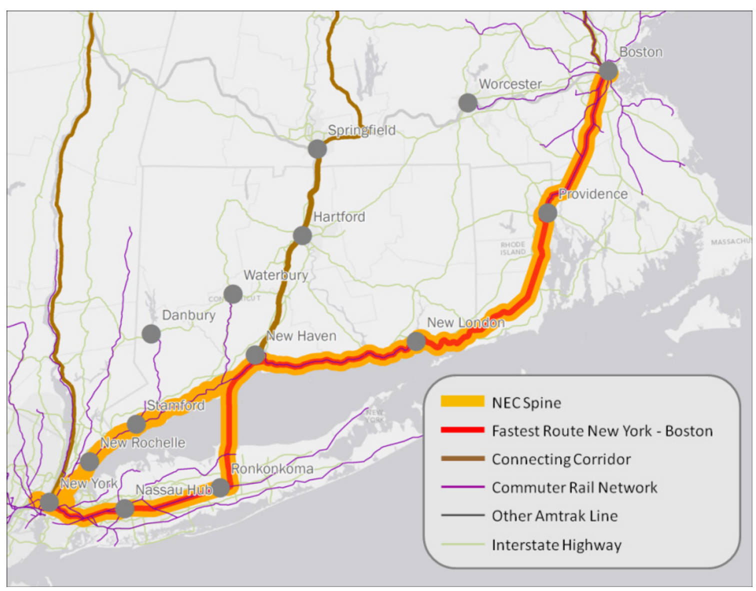
Current Mix of Services with Focus on All Markets with New Route Connecting NYC, Long Island, New Haven, New London, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, New London, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

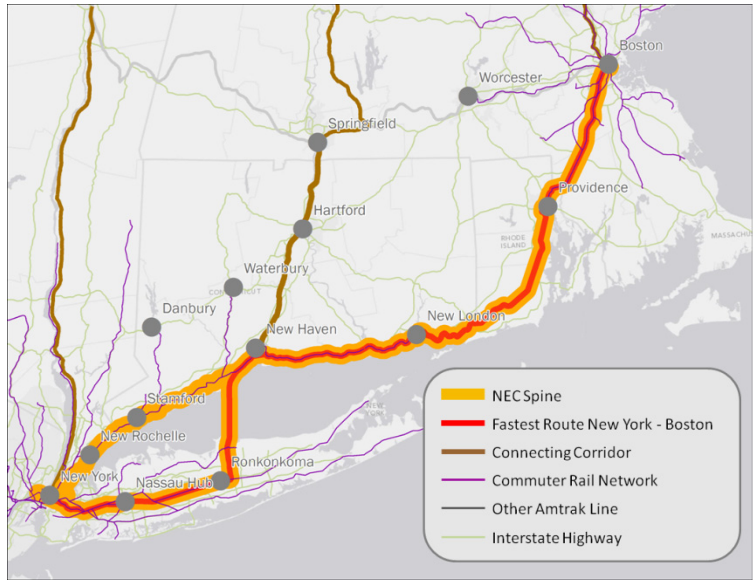


Initial Alternative: North45

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, New London, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

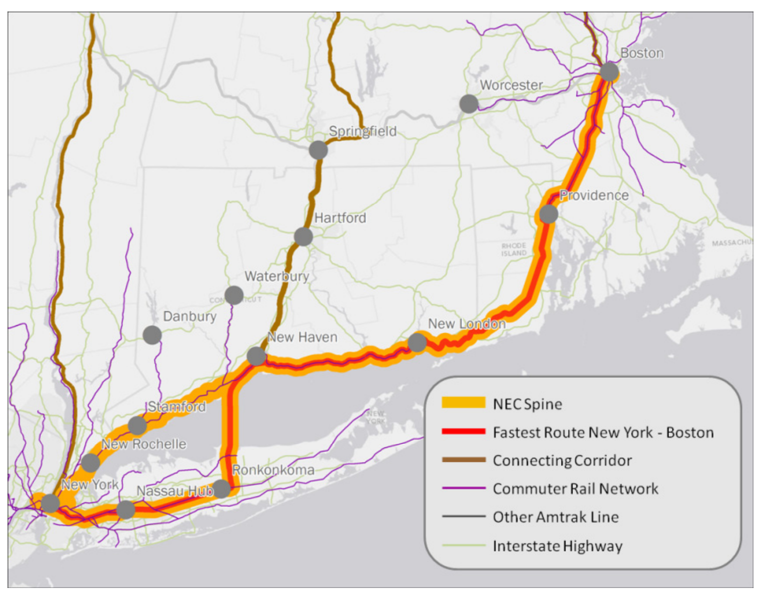
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, New London, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North46

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, New London, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

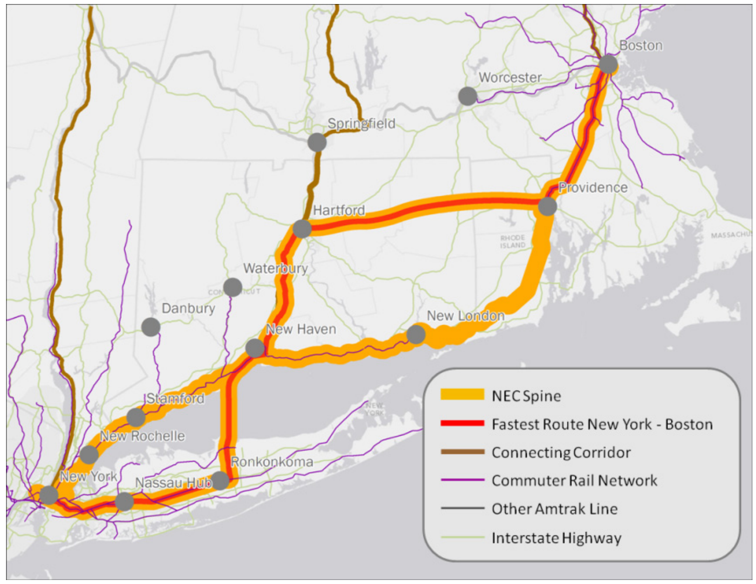
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, New London, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North47

Current Mix of Services with Focus on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets



Description

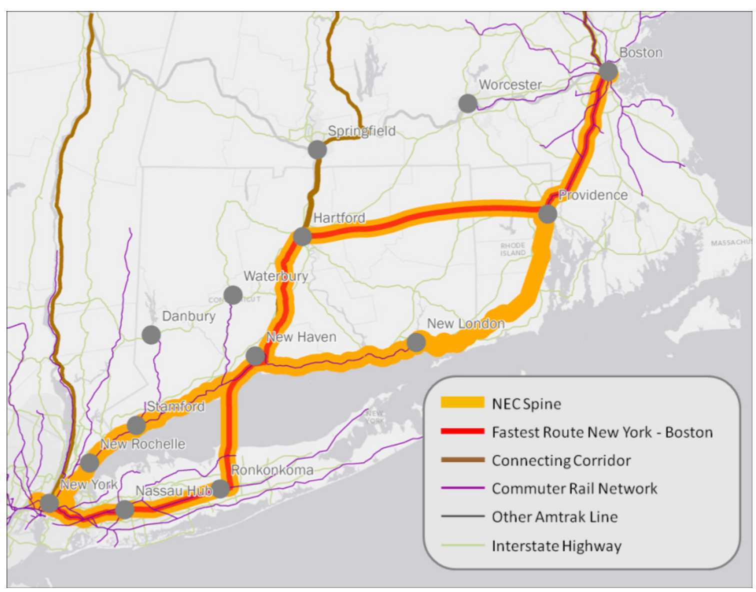
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

Initial Alternative: North48

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North49

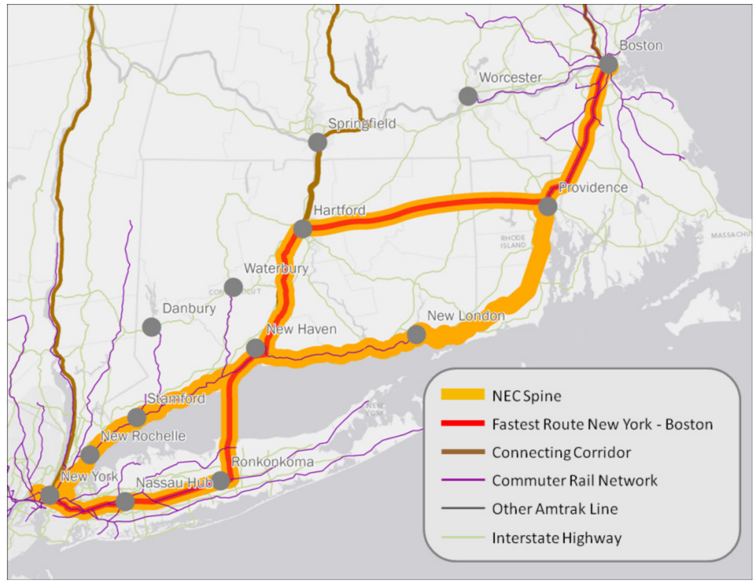
Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North50

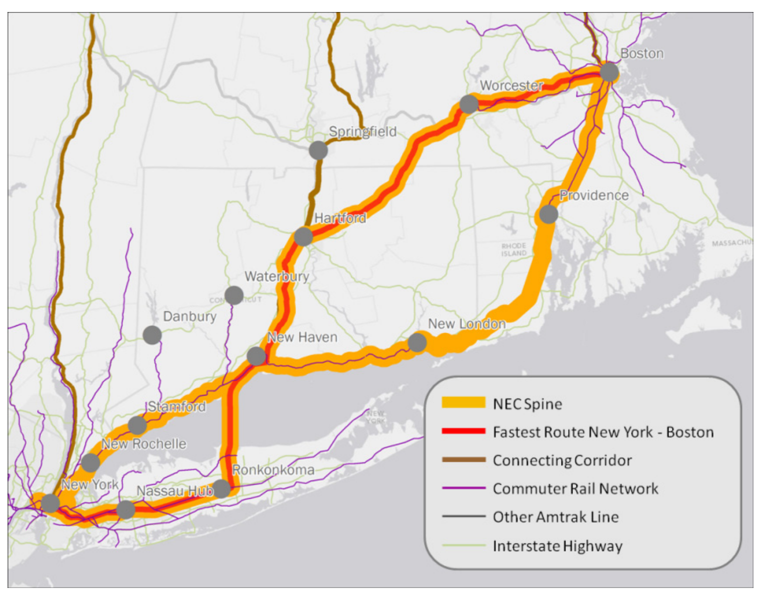
Current Mix of Services with Focus on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

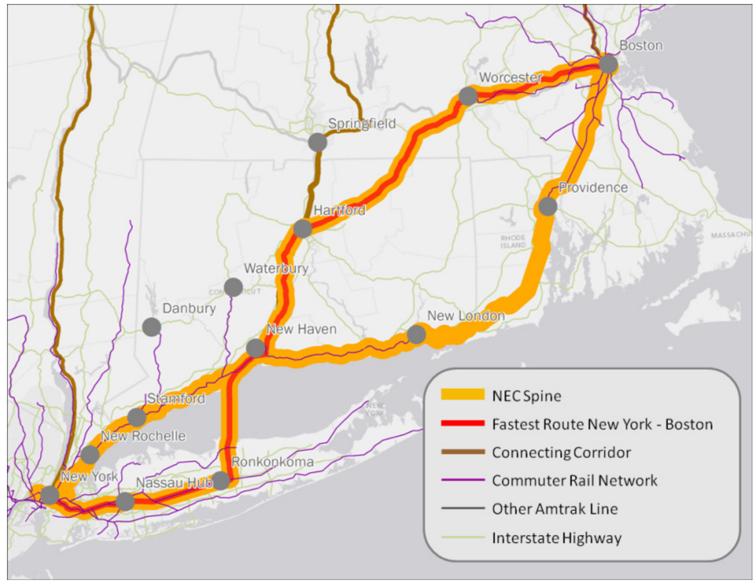


Initial Alternative: North51

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

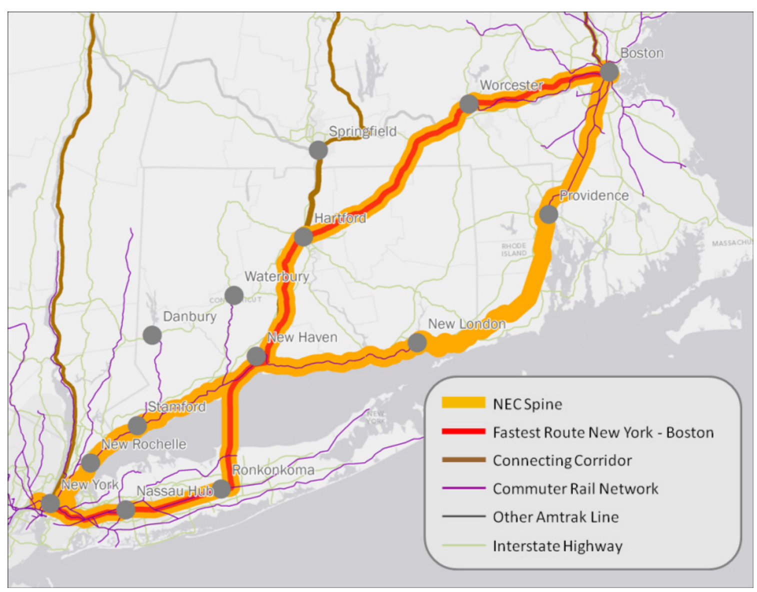
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North52

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

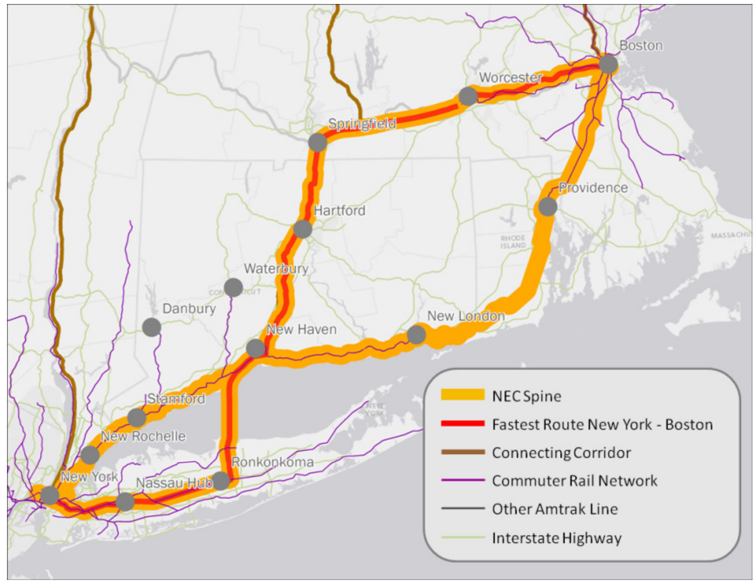
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North53

Current Mix of Services with Focus on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets



Description

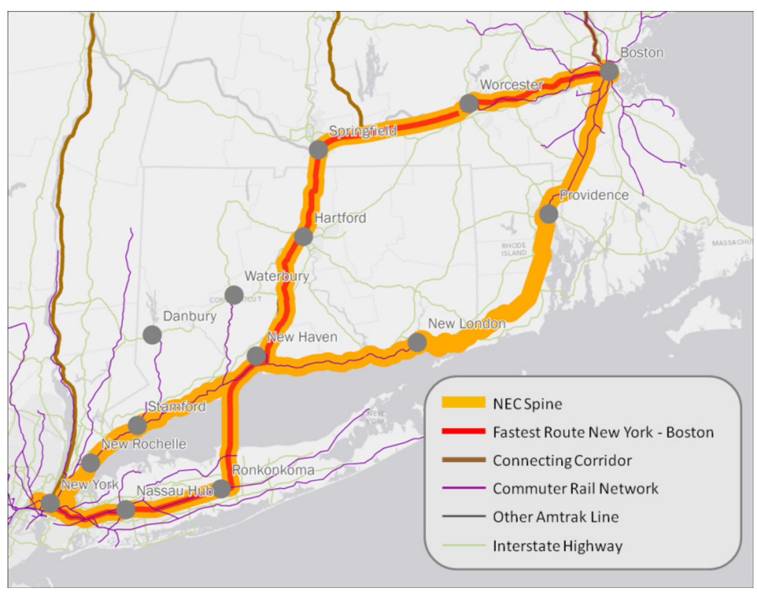
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

Initial Alternative: North54

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North55

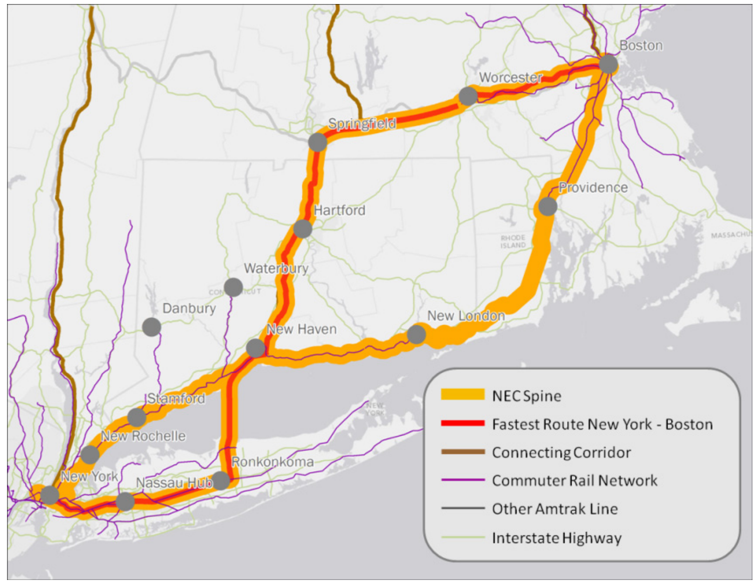
Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, Long Island, New Haven, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Long Island, New Haven, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.



Initial Alternative: North56

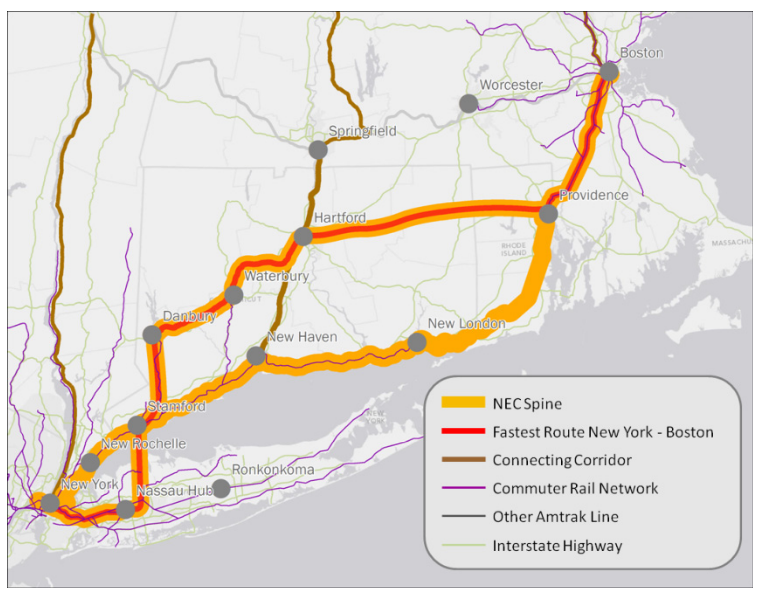
Current Mix of Services with Focus on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

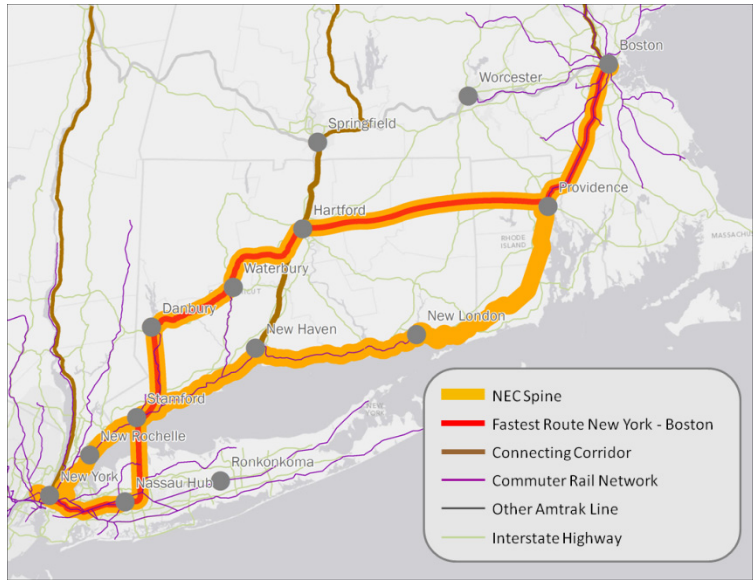


Initial Alternative: North57

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

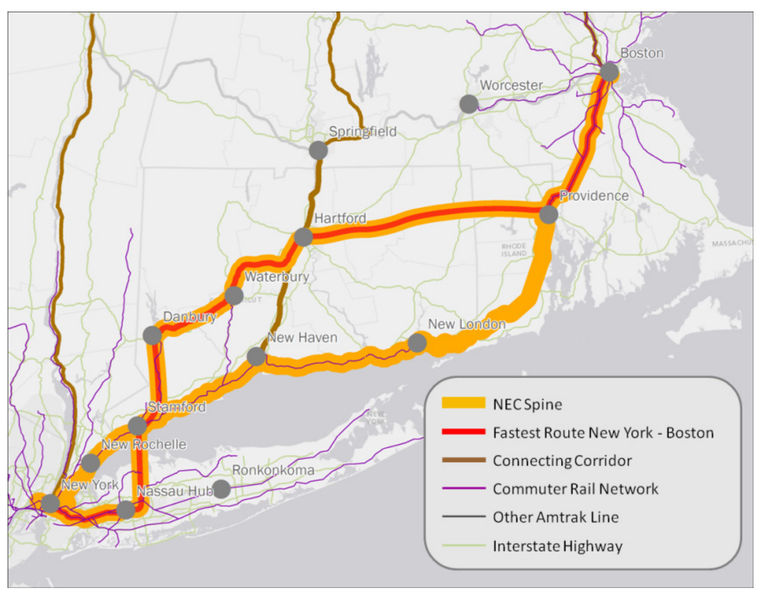
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North58

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Providence, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

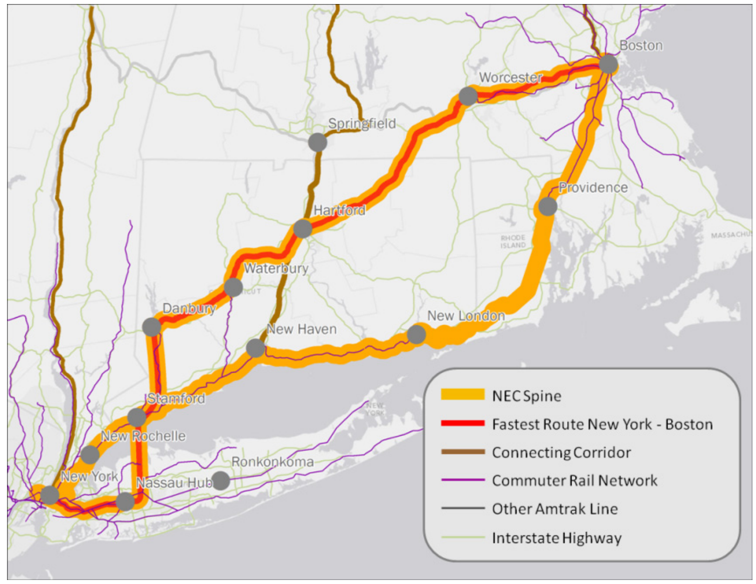
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Providence, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North59

Current Mix of Services with Focus on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets



Description

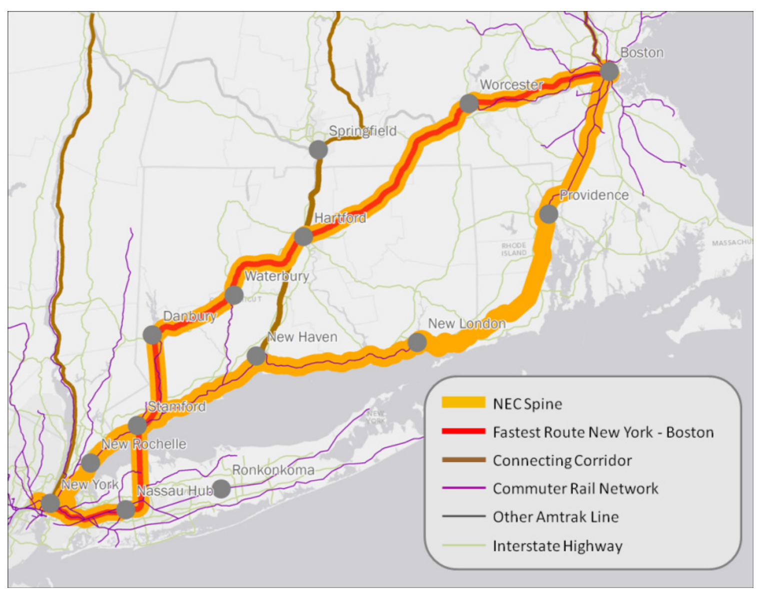
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

Initial Alternative: North60

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

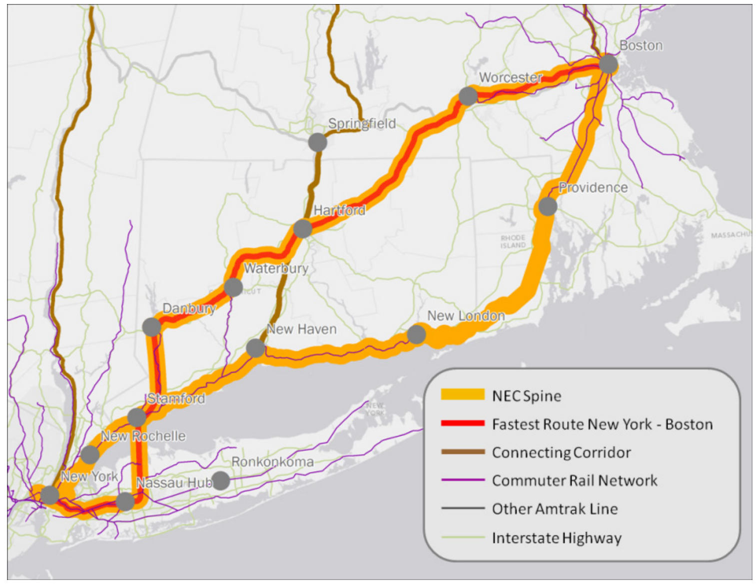
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North61

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Worcester, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

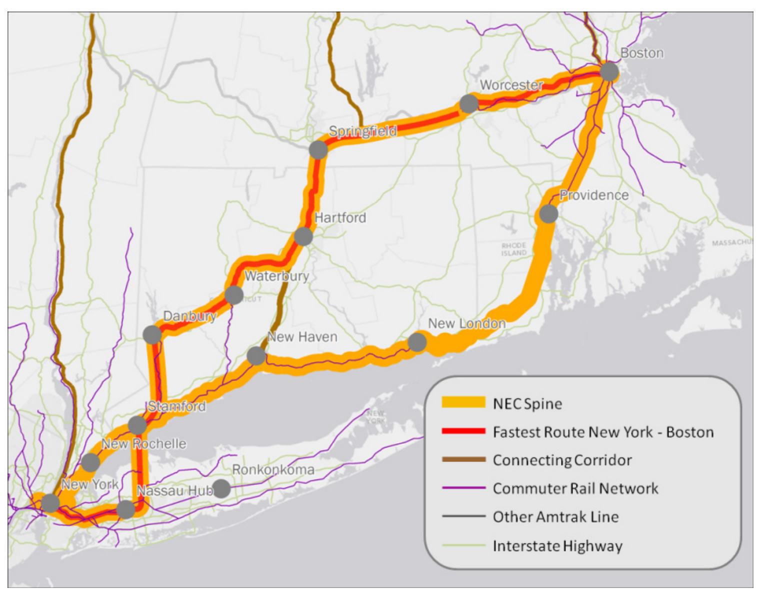
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Worcester, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: North62

Current Mix of Services with Focus on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets



Description

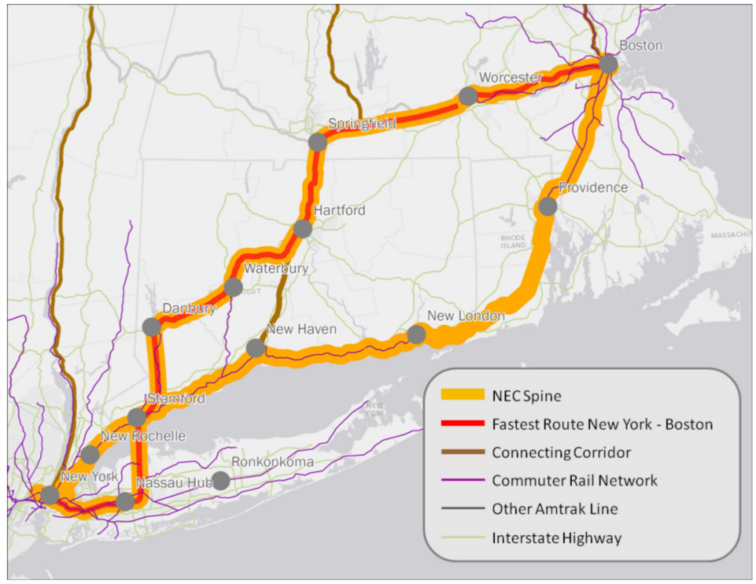
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

Initial Alternative: North63

Coordinated, Frequent Service Focused on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

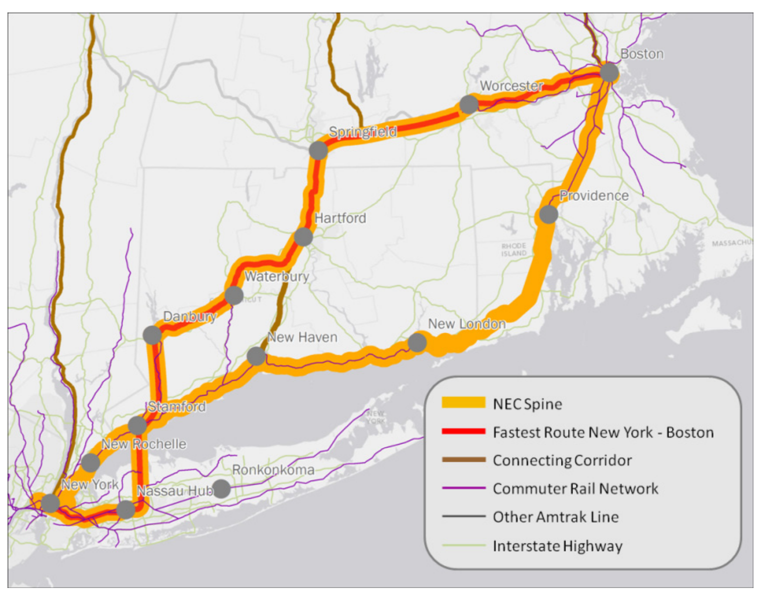
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Springfield, and Boston. Provides enough capacity that all inter-city and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: North64

Expanded Mix of Services Focused on All Markets with New Route Connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Springfield, and Boston

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new route connecting NYC, Nassau, Stamford, Danbury, Waterbury, Hartford, Springfield, and Boston. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: South1

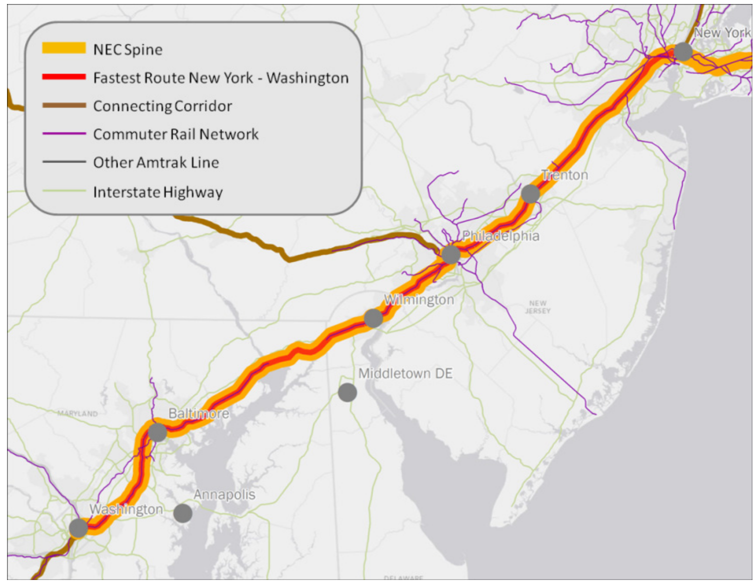
Current Mix of Services with Focus on Regional Service via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline
Service Definition	Current Mix
Service Focus	Regional

Description

Responds to growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South2

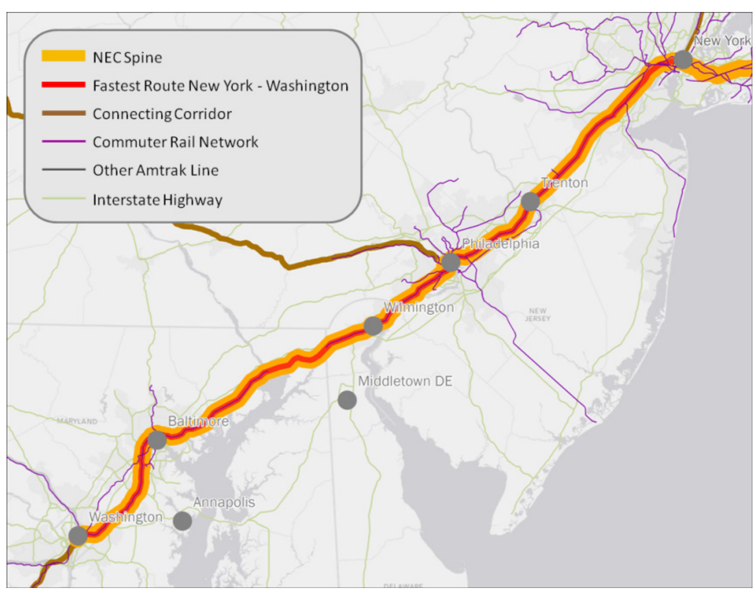
Current Mix of Services with Focus on Primary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Intercity Primary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South3

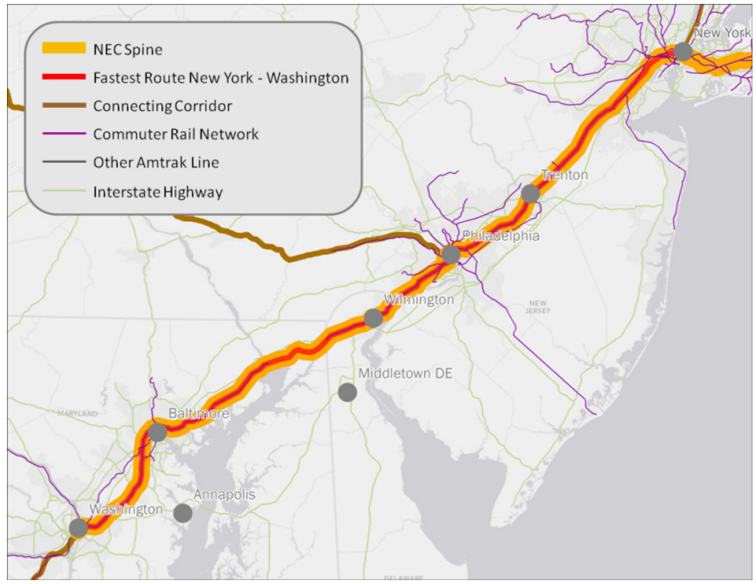
Current Mix of Services with Focus on Secondary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Intercity Secondary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South4

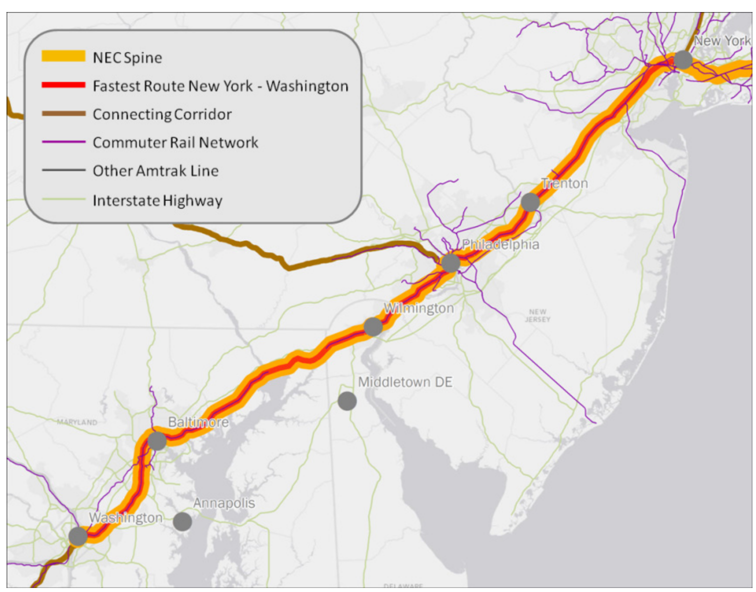
Current Mix of Services with Focus on Regional Service via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Regional

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South5

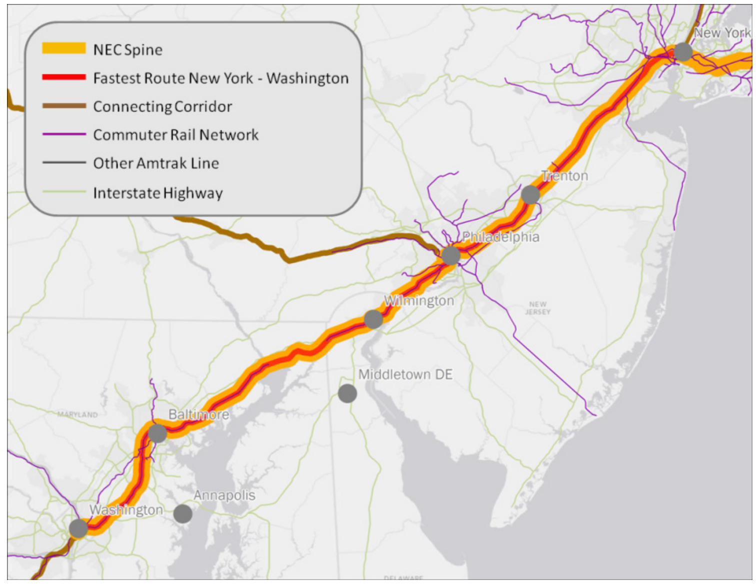
Current Mix of Services with Focus on Connecting Corridors via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Current Mix
Service Focus	Connecting

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South6

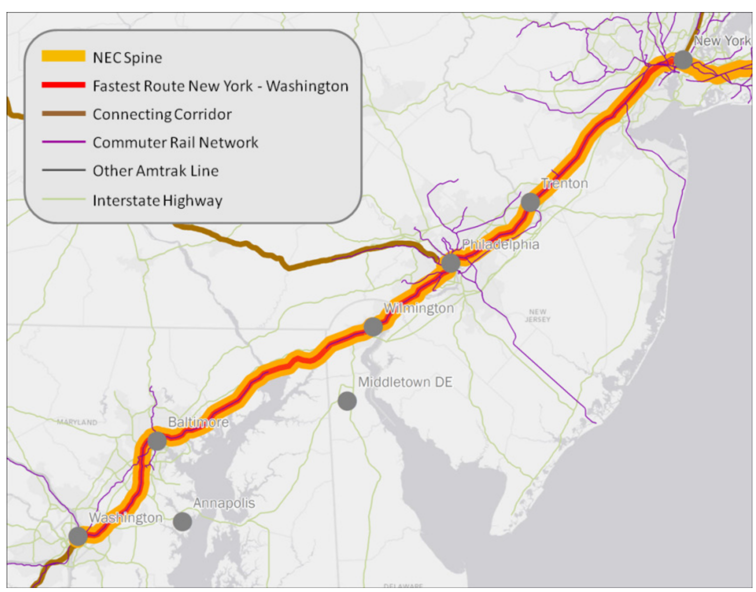
Coordinated, Frequent Service Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Intercity Primary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South7

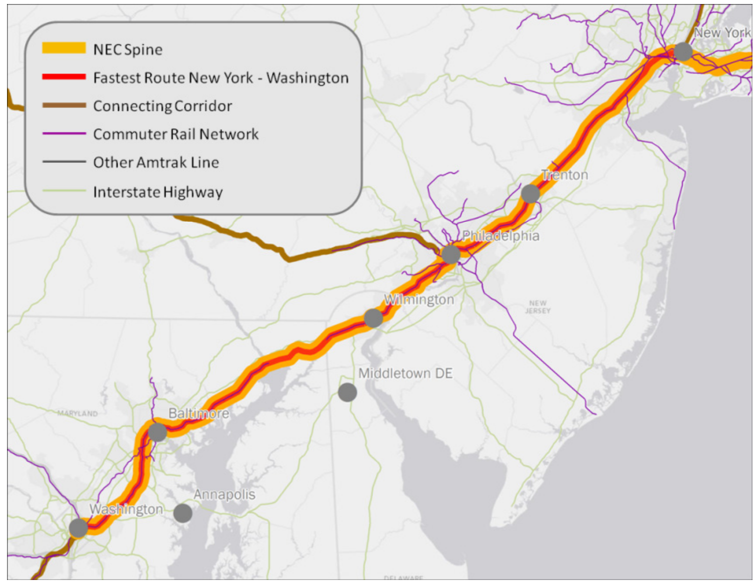
Coordinated, Frequent Service Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Intercity Secondary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South8

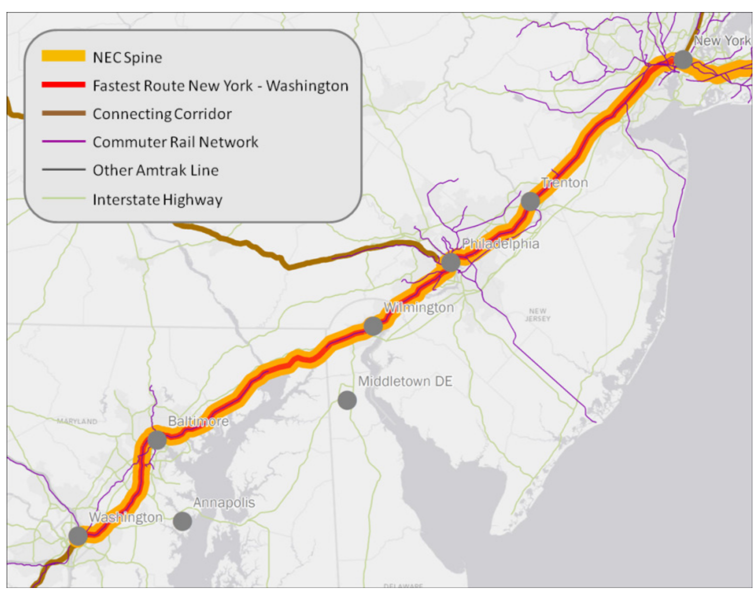
Coordinated, Frequent Service Focused on Regional Service via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Regional

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South9

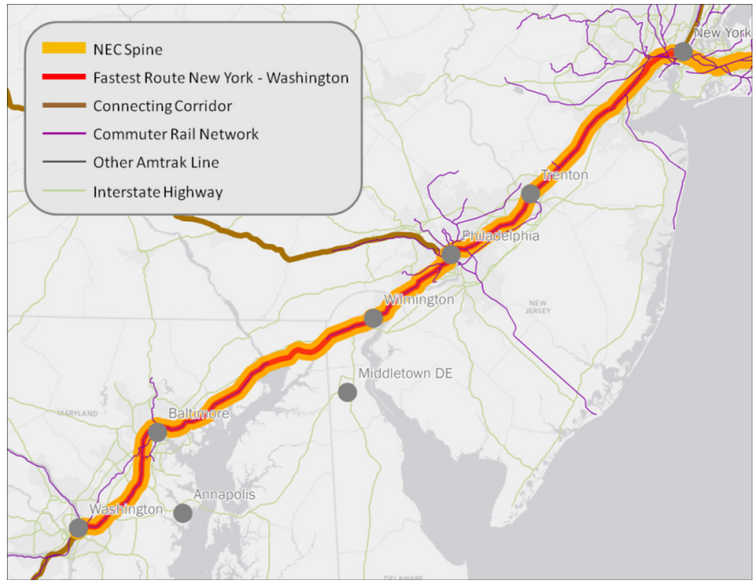
Coordinated, Frequent Service Focused on Connecting Corridors via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Simplified Service
Service Focus	Connecting

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South10

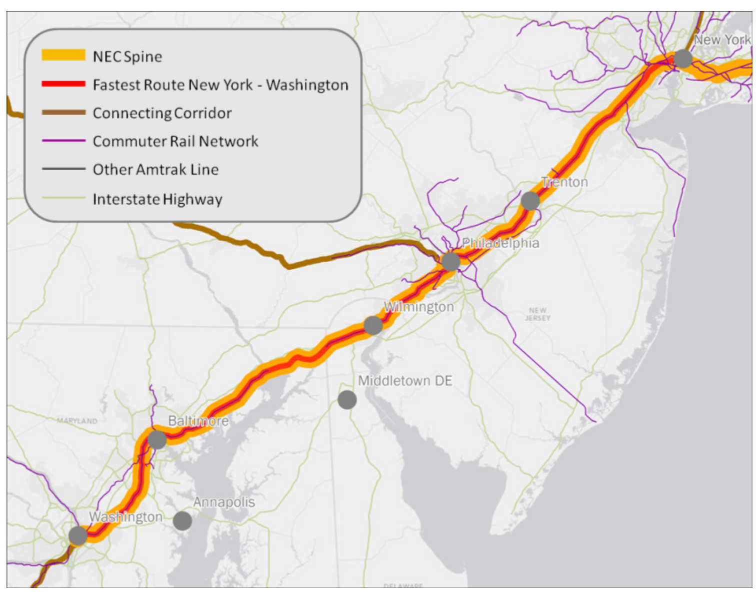
Expanded Mix of Services Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Primary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: South11

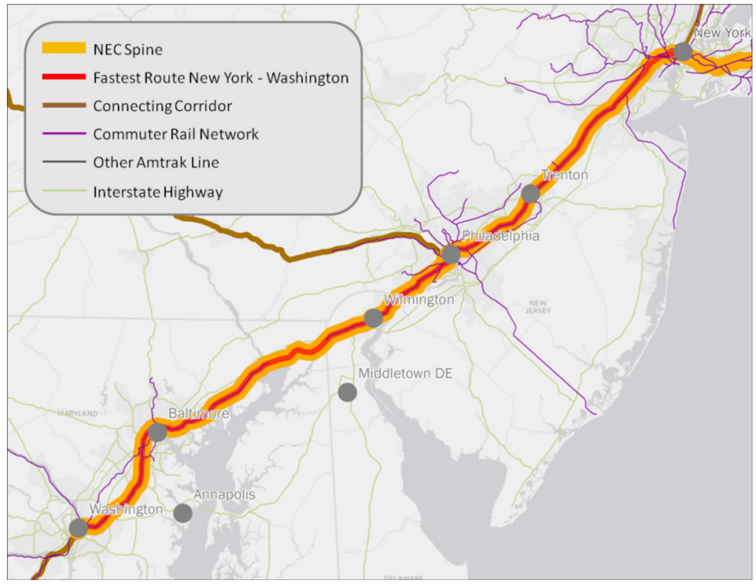
Expanded Mix of Services Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Secondary

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: South12

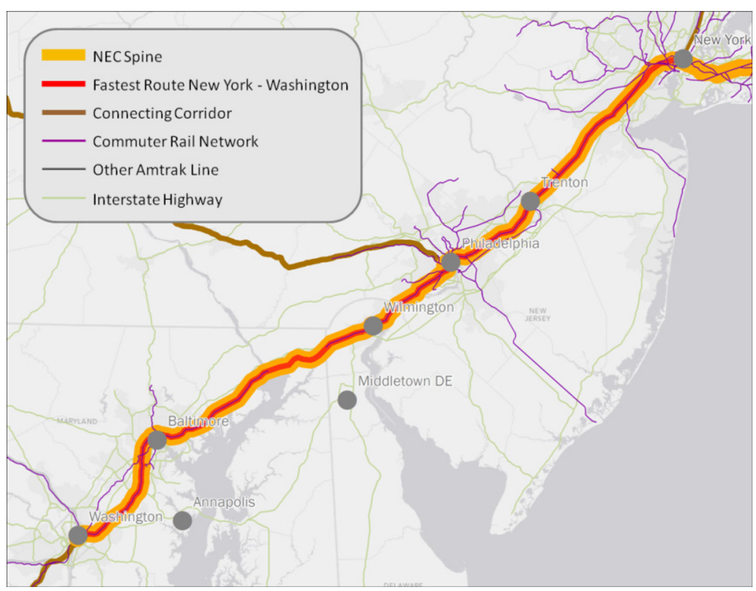
Expanded Mix of Services Focused on Regional Service via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Regional

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: South13

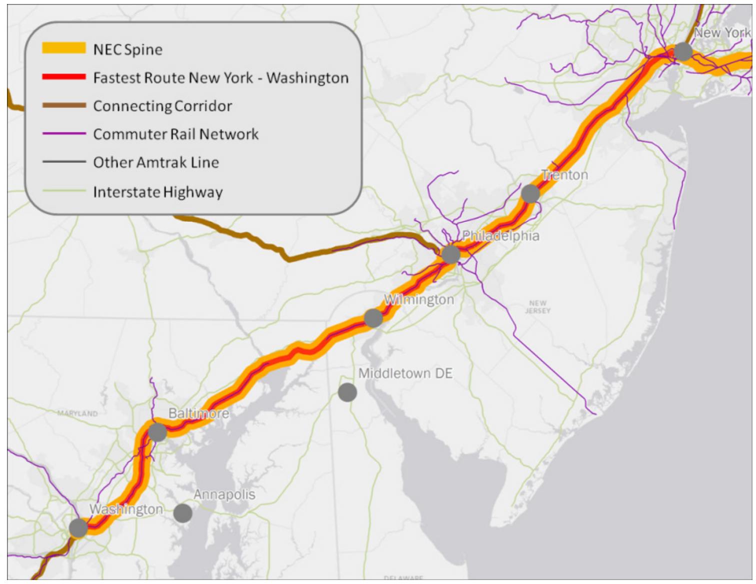
Expanded Mix of Services Focused on Connecting Corridors via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Baseline Plus
Service Definition	Expanded One-Seat Ride
Service Focus	Regional

Description

Meets growth in existing markets via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: South14

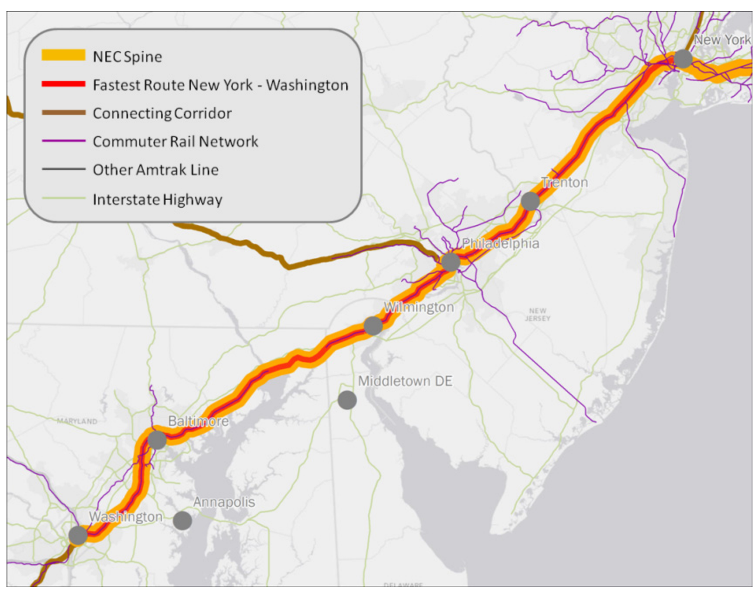
Current Mix of Services with Focus on Primary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Intercity Primary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South15

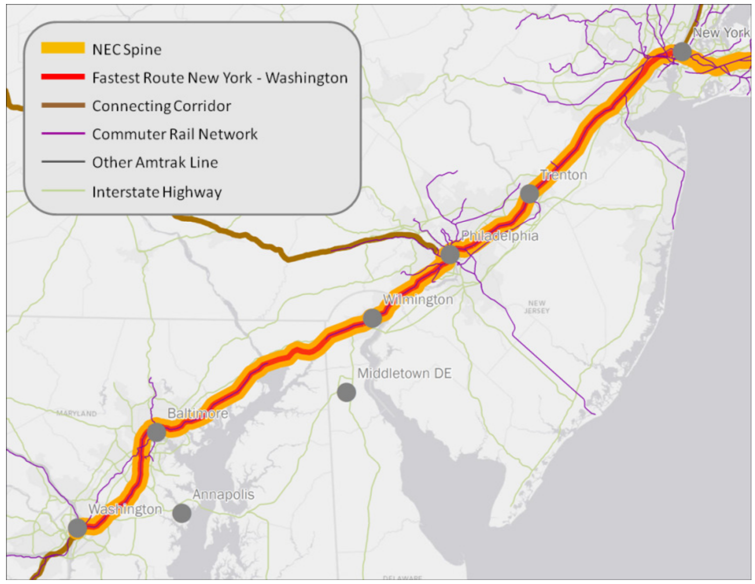
Current Mix of Services with Focus on Secondary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Intercity Secondary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South16

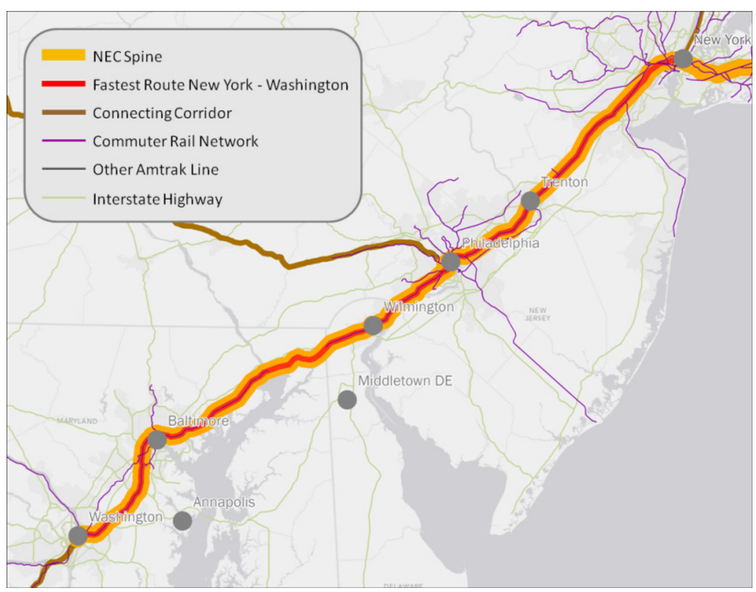
Current Mix of Services with Focus on Regional Service via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Regional

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South17

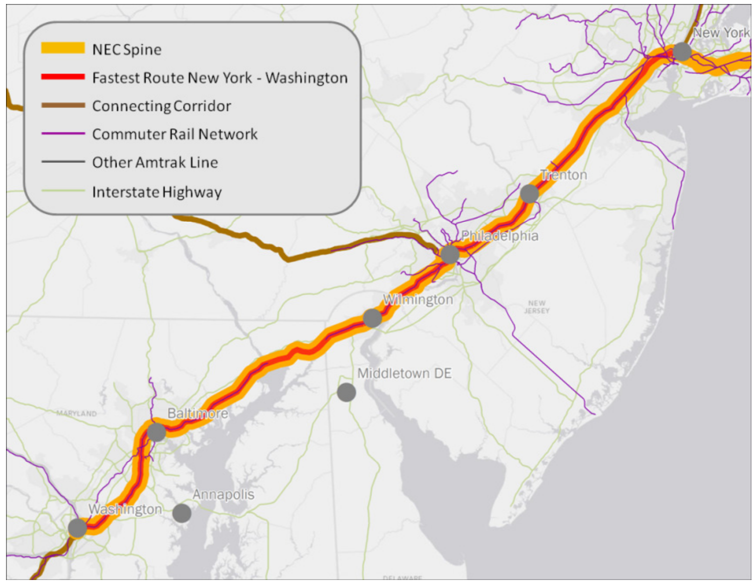
Current Mix of Services with Focus on Connecting Corridors via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Current Mix
Service Focus	Connecting

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides current mix of express, regional, and commuter services.



Initial Alternative: South18

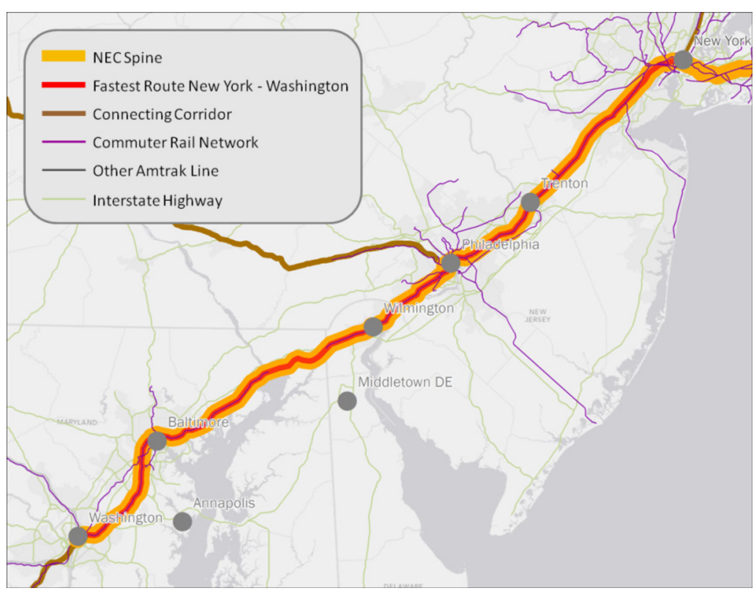
Coordinated, Frequent Service Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Intercity Primary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South19

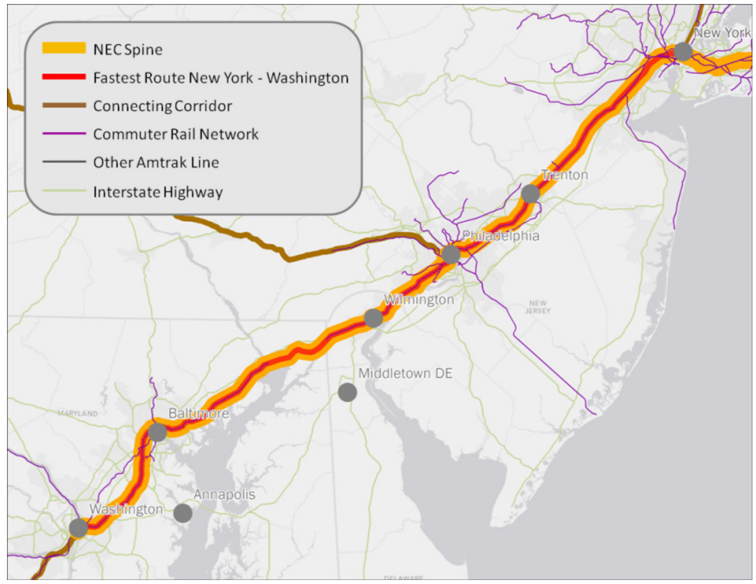
Coordinated, Frequent Service Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Intercity Secondary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South20

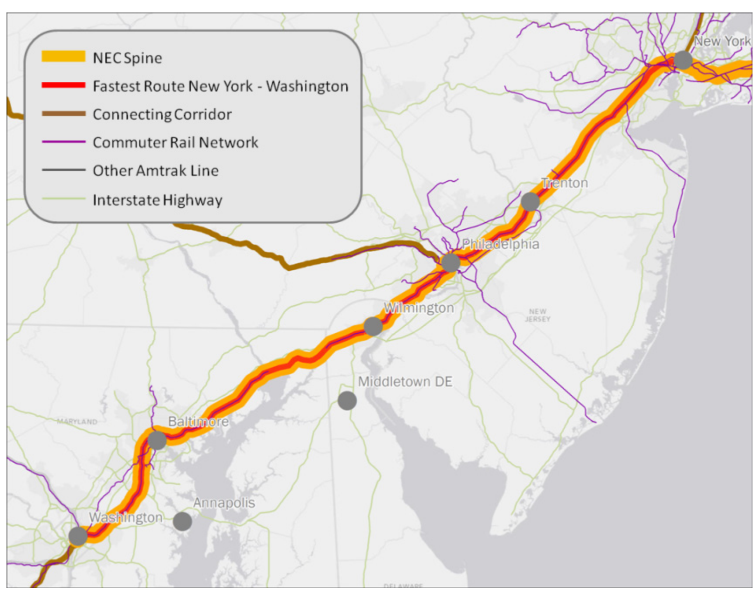
Coordinated, Frequent Service Focused on Regional Service via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Regional

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South21

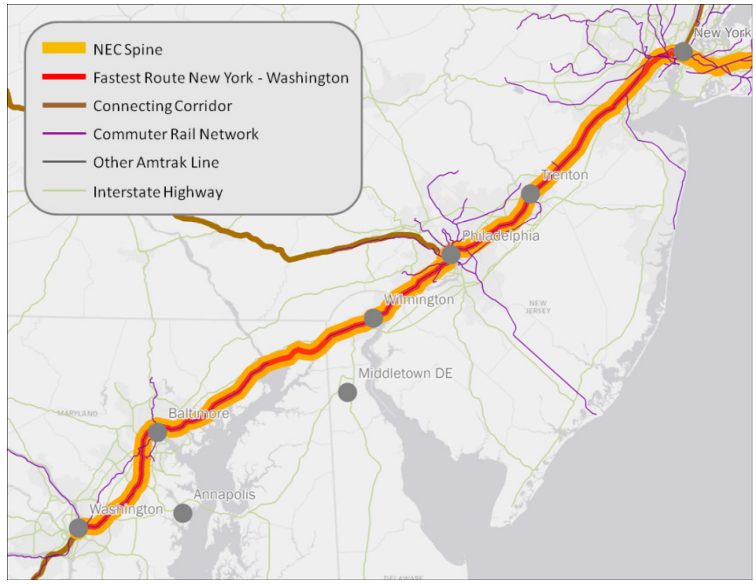
Coordinated, Frequent Service Focused on Connecting Corridors via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Simplified Service
Service Focus	Connecting

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service to connecting corridors with remaining capacity allocated to intercity and regional markets. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South22

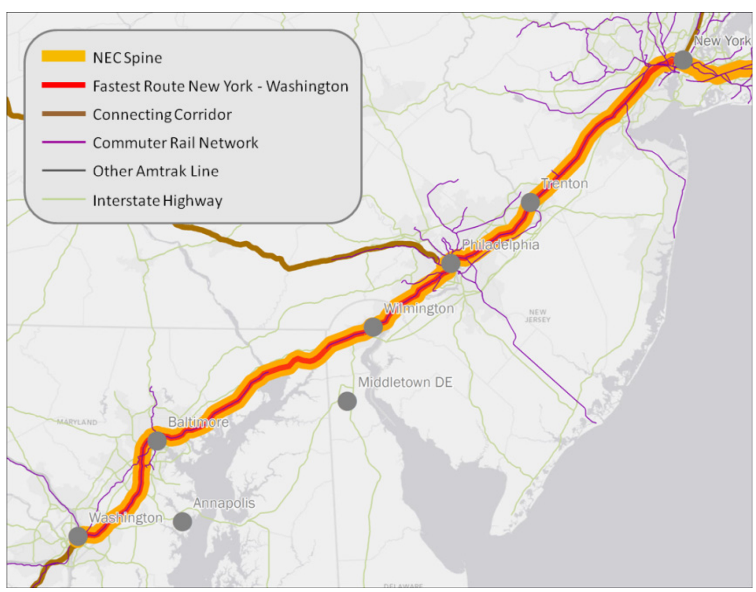
Expanded Mix of Services Focused on Primary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Primary

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes intercity travel between primary markets, with remaining capacity allocated to secondary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.

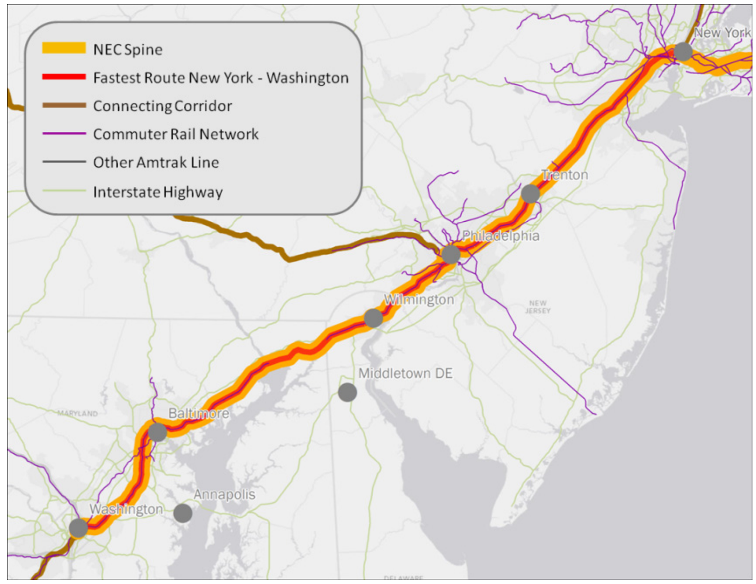


Initial Alternative: South23

Expanded Mix of Services Focused on Secondary Intercity Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Intercity Secondary



Description

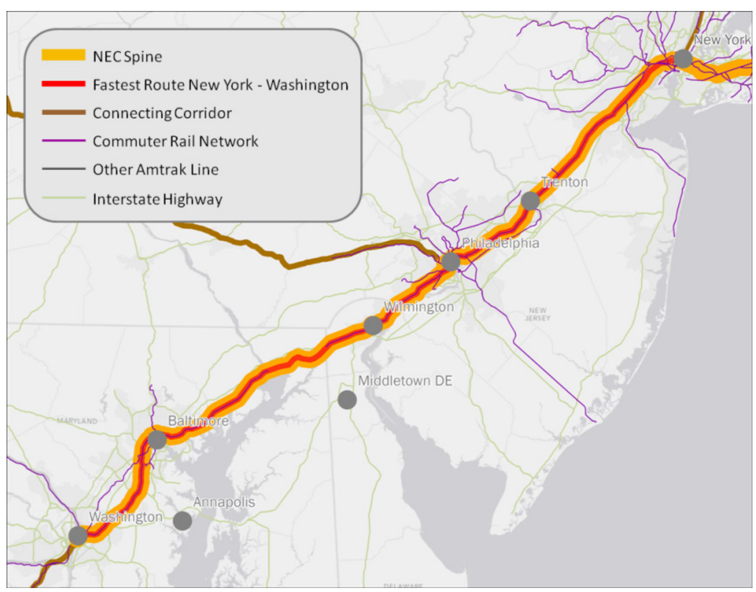
Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service that connects secondary markets with primary markets, with remaining capacity allocated to primary intercity markets and regional markets. Provides a broad range of service types tailored to individual markets.

Initial Alternative: South24

Expanded Mix of Services Focused on Regional Service via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Regional



Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes regional markets with remaining capacity allocated to intercity travel between primary and secondary markets. Provides a broad range of service types tailored to individual markets.

Initial Alternative: South25

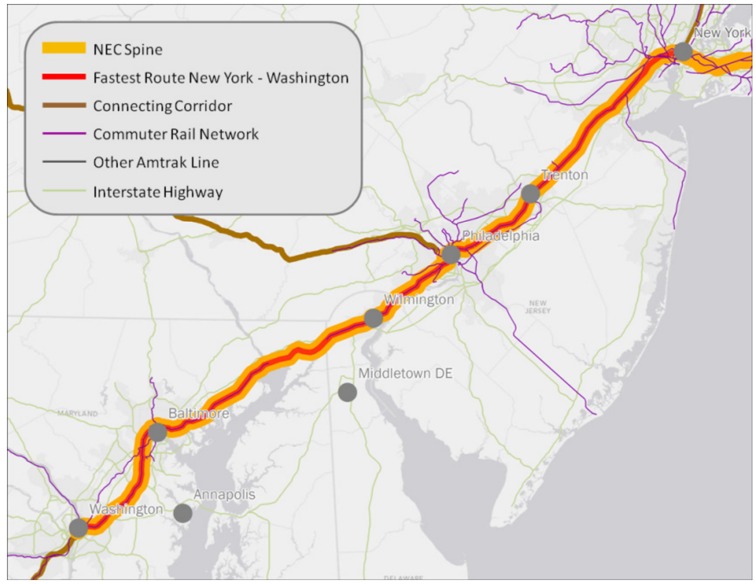
Expanded Mix of Services Focused on Connecting Corridors via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	Medium
Service Definition	Expanded One-Seat Ride
Service Focus	Connecting

Description

Meets growth in existing markets and provides capacity for additional growth via existing NEC alignment. Prioritizes service to connecting corridors, with remaining capacity allocated to intercity and regional markets. Provides a broad range of service types tailored to individual markets.



Initial Alternative: South26

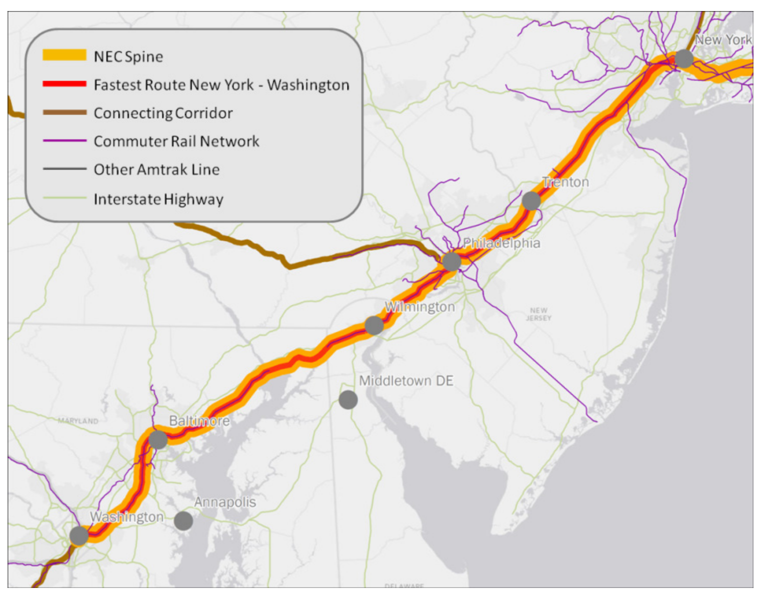
Current Mix of Services with Focus on All Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

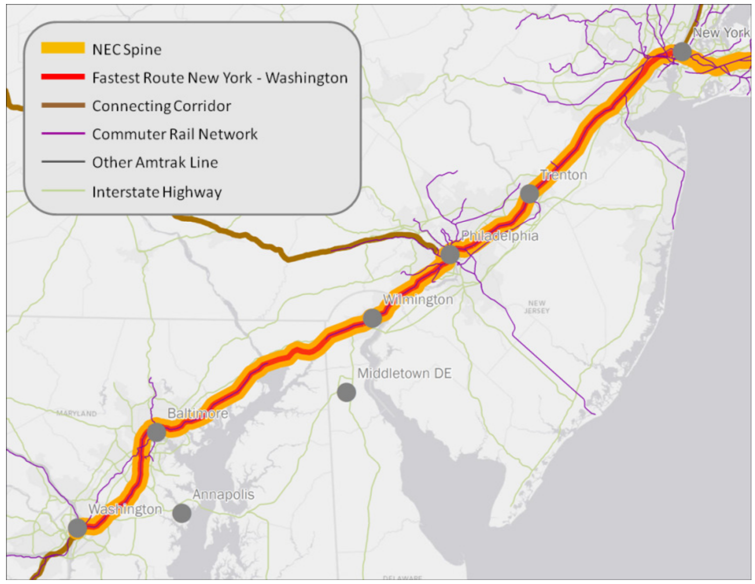


Initial Alternative: South27

Coordinated, Frequent Service Focused on All Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

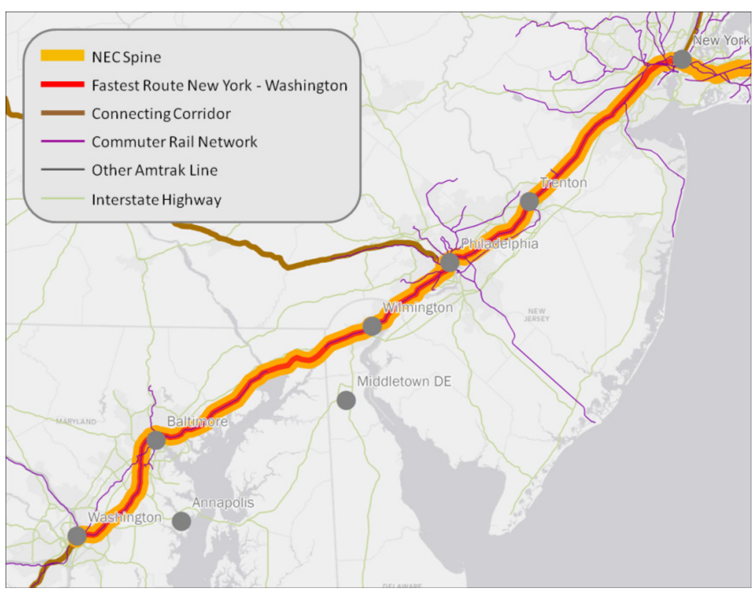
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: South28

Expanded Mix of Services Focused on All Markets via Existing NEC Alignment between NYC and Washington

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

Initial Alternative: South29

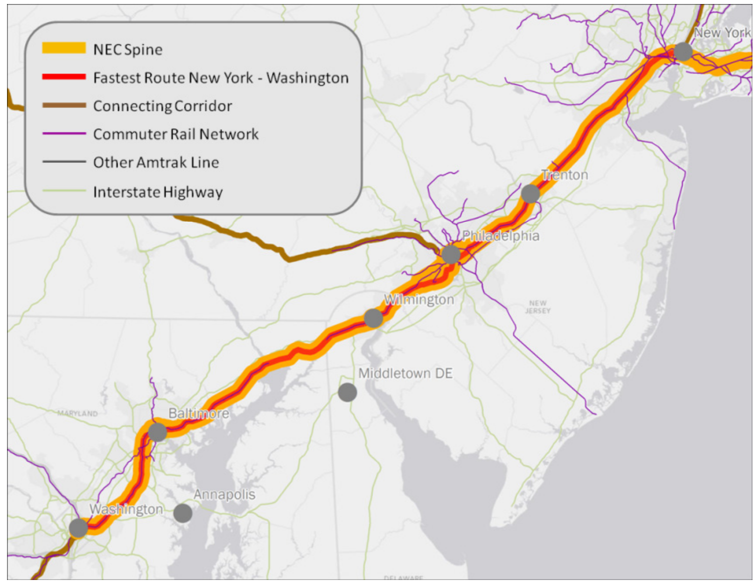
Current Mix of Services with Focus on All Markets with New Route Sections Through Philadelphia, Wilmington, and Baltimore

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new sections through Philadelphia, Wilmington, and Baltimore. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.



Initial Alternative: South30

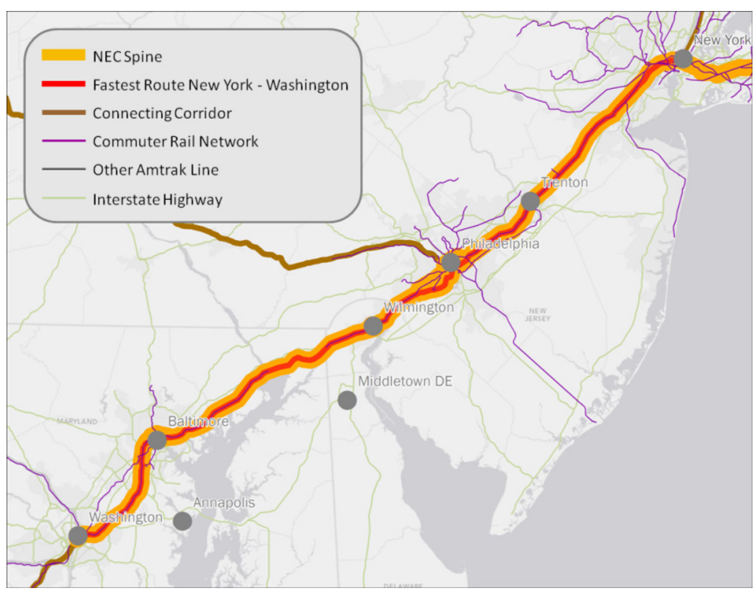
Coordinated, Frequent Service Focused on All Markets with New Route Sections Through Philadelphia, Wilmington, and Baltimore

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new sections through Philadelphia, Wilmington, and Baltimore. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.



Initial Alternative: South31

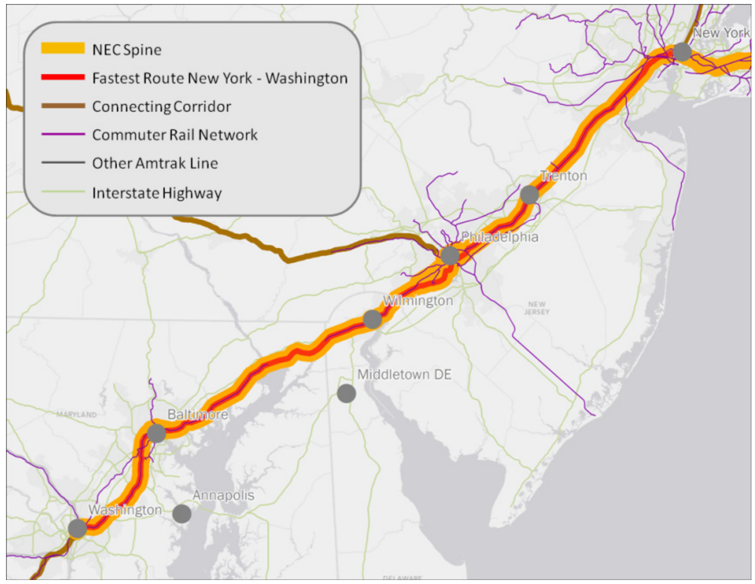
Expanded Mix of Services Focused on All Markets with New Route Sections Through Philadelphia, Wilmington, and Baltimore

Quick Facts

Program Investment Level	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with new sections through Philadelphia, Wilmington, and Baltimore. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.



Initial Alternative: South32

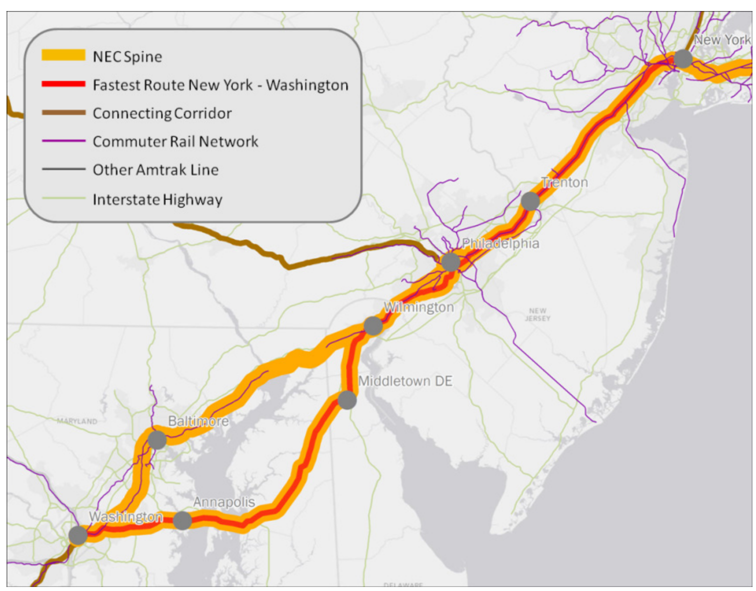
Current Mix of Services with Focus on All Markets with New Route Sections Through Philadelphia and Wilmington, and New Route from Wilmington to Washington via Delmarva Peninsula and Annapolis

Quick Facts

Program Investment Level	High
Service Definition	Current Mix
Service Focus	All Markets

Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with sections through Philadelphia and Wilmington, and new route from Wilmington to Washington via Delmarva Peninsula and Annapolis. Provides enough capacity that all intercity and regional markets can be served. Provides current mix of express, regional, and commuter services.

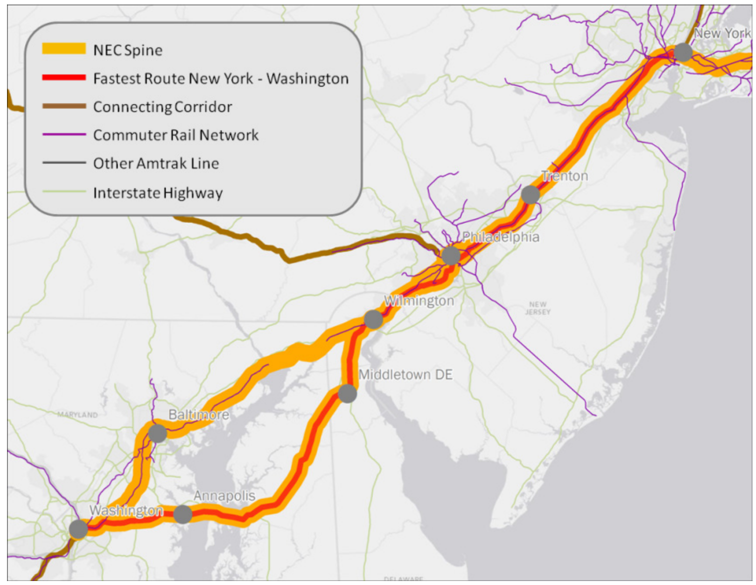


Initial Alternative: South33

Coordinated, Frequent Service Focused on All Markets with New Route Sections Through Philadelphia and Wilmington, and New Route from Wilmington to Washington via Delmarva Peninsula and Annapolis

Quick Facts

Program Investment Level	High
Service Definition	Simplified Service
Service Focus	All Markets



Description

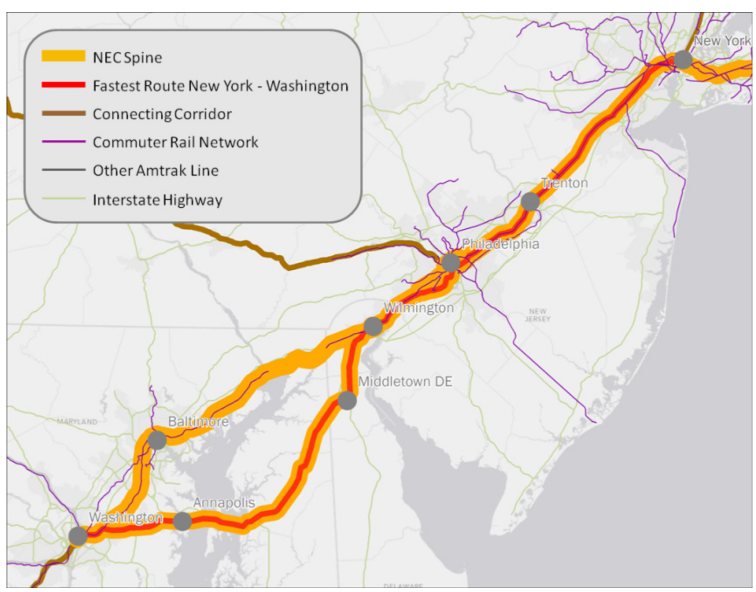
Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with sections through Philadelphia and Wilmington, and new route from Wilmington to Washington via Delmarva Peninsula and Annapolis. Provides enough capacity that all intercity and regional markets can be served. Provides express service between primary markets and coordinates timing of regional and express services to provide frequent service between secondary and primary markets.

Initial Alternative: South34

Expanded Mix of Services Focused on All Markets with New Route Sections Through Philadelphia and Wilmington, and New Route from Wilmington to Washington via Delmarva Peninsula and Annapolis

Quick Facts

High	High
Service Definition	Expanded One-Seat Ride
Service Focus	All Markets



Description

Meets growth in existing markets and provides capacity to meet growth in all markets by improving existing NEC alignment and with sections through Philadelphia and Wilmington, and new route from Wilmington to Washington via Delmarva Peninsula and Annapolis. Provides enough capacity that all intercity and regional markets can be served. Provides a broad range of service types tailored to individual markets.

NEC FUTURE

A Rail Investment Plan for the Northeast Corridor

Preliminary Alternatives Report

April 2013

U.S. Department of Transportation

Federal Railroad Administration

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1. Introduction

The goal of NEC FUTURE is to develop a long-term investment program for improving and growing the Washington, D.C., to Boston, Northeast Corridor (NEC) rail service to accommodate projected year 2040 commuter and intercity rail ridership, as part of the regional transportation system in the Northeast. This Preliminary Alternatives Report summarizes the process by which a large set of Initial Alternatives, which would contribute to achieving this goal, was refined and repackaged into a smaller set of "Preliminary Alternatives." The Preliminary Alternatives, in turn, will be evaluated and narrowed to an even smaller set of "Reasonable Alternatives," and ultimately to a preferred investment program as NEC FUTURE advances. The NEC FUTURE program is being undertaken pursuant to the National Environmental Policy Act (NEPA), which includes preparation of a Tier 1 Environmental Impact Statement (EIS), in which the Reasonable Alternatives will be analyzed and compared based on the environmental, socioeconomic and transportation impacts. The Federal Railroad Administration (FRA), the lead Federal agency, is preparing the EIS and will identify a preferred investment program. At the end of the EIS process FRA will issue a Record of Decision (ROD) selecting an investment program.

The Preliminary Alternatives Report consists of a summary of the alternatives development process through the selection of the Preliminary Alternatives. The Appendix includes Fact Sheets describing each of the Preliminary Alternatives.

The NEC FUTURE project team will prepare an Alternatives Development Report (ADR), which will summarize the processes for evaluation and screening of the Preliminary Alternatives and the identification of the Reasonable Alternatives that will be further evaluated as part of the Tier 1 EIS.

2. Alternatives Development Process

The alternatives development process is directed at defining a broad range of alternatives that address the problems identified in the Purpose and Need Statement, and progressively narrows those alternatives to a reasonable set that can best address those problems. The process is intended to answer several key questions:

- Markets
  - Where are travelers going?
  - Where is population and employment growth occurring?
  - Will rail investment change travel behavior?
- Rail Network
  - How do trains physically access the markets?
- Service Level
  - How much service can be provided to meet demand?
  - What types of rail service are needed to meet demand?

- What are the best ways to provide that service?
- Improvements
  - What improvements are required to provide the service?
  - How can they best be implemented?

As the alternatives progress from Initial to Preliminary, the focus turns from "which markets" are most important to be served, to how best to serve those markets. This requires evaluation using a number of technical tools to assess feasibility, ridership, operational impacts, capital and operating costs, environmental impacts, and benefits. The level of technical scrutiny increases as the alternatives progress from Initial to Preliminary to Reasonable.

A defining aspect of the NEC FUTURE program is that alternatives will only be developed to a programmatic level of detail, consistent with the focus of a corridor-wide Tier 1 EIS. The alternatives are intended to address the broad infrastructure needs and corridor-wide service options required to meet projected growth and demand. More detailed project-level issues relating to design configurations, specific alignments, and engineering solutions for site-specific projects and improvements must be addressed after completion of the Tier 1 EIS through Project (Tier 2) NEPA documents.

2.1 PURPOSE AND NEED

The development of alternatives begins with the Purpose and Need Statement, which defines the problems and challenges experienced by the transportation network in the Northeast generally and by the NEC rail line in particular. To be considered, an alternative must be capable of addressing at least some of the issues identified in the Purpose and Need Statement. A copy of the Purpose and Need Statement is included in the Scoping package accessible on the NEC FUTURE website.

The Purpose and Need Statement identifies that accommodating the 2040 capacity, frequency, reliability and travel-time needs of NEC rail travelers with market-competitive passenger rail service will be critical to providing the mobility that will allow the future population, employment, freight, and economic growth of the Northeast to reach its full potential.

To achieve these results, a set of goals and criteria derived from the Preliminary Purpose and Need were developed to assist in evaluating and organizing proposed alternatives. In general, alternatives must:

- Provide for state-of-good-repair on the NEC.
- Attempt to meet projected 2040 travel demand.
- Improve service reliability and frequency to the primary markets of Washington, Philadelphia, New York, and Boston.
- Include some options for new or improved rail service to intermediate markets with significant ridership potential.
- Support service to and from the connecting corridor markets in addition to the existing NEC Spine, including consideration of both run-through and transfer options.

- Provide equitable and fair levels of service across the Study Area, treat connecting corridors with similar size and market potential in a consistent manner, provide comparable service strategies for the various commuter rail networks focused on Washington, D.C., Philadelphia, New York and Boston, and provide consistent treatment of rail freight along the NEC.
- Support strong intermodal connections between intercity passenger rail modes and corridors, regional and local transit services, and other modes.
- Accommodate freight rail growth by preserving windows for rail freight operations, access to freight customers, and access to rail freight main lines.
- Support the Northeast region's efforts to reduce environmental impacts and energy use resulting from projected growth in travel demand.

In addition, in the case of duplicative and overlapping proposals, alternatives will be dropped that:

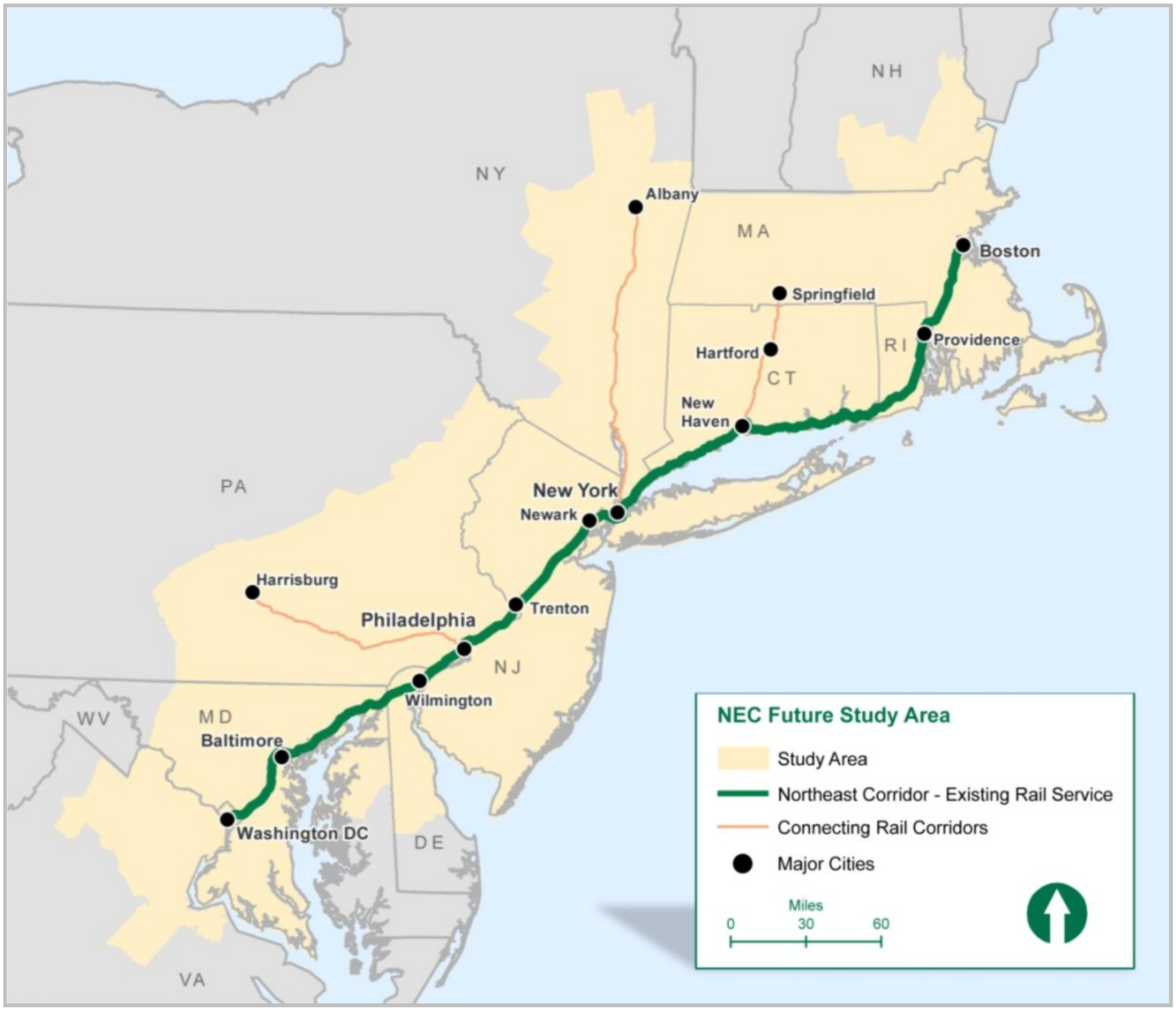
- Are less efficient in serving specific markets (e.g., longer distance, longer travel time) or generate substantially more adverse environmental or transportation impacts compared to other similar service alternatives.
- Provide similar investment levels and performance characteristics, but with a higher implementation risk, or greater impact or clearly higher cost (e.g., significantly longer mileage).

These goals will continue to be refined through dialogue with stakeholders, agencies, and the public to ensure that they provide the basis for evaluating whether identified alternatives meet the needs of the program.

2.2 STUDY AREA

The Purpose and Need identifies transportation challenges in the Northeast generally and along the NEC in particular. For purposes of the early planning effort, the Northeast is defined to encompass the greater Washington, D.C., area, the greater Boston, MA, area, and all points in between. The existing NEC rail transportation spine links Washington Union Station, Pennsylvania Station New York, and Boston South Station. For purposes of defining and analyzing transportation alternatives for NEC FUTURE, the project Study Area encompasses the region served by the NEC spine, plus those areas that can be reached directly by train or via a transfer to connecting rail corridors from the NEC spine. Figure 1 shows a map of the Study Area, indicating the existing passenger rail network that comprises the NEC spine, existing connecting intercity short-distance corridor, and commuter rail corridor connections, other major rail and highway links and major airports. The Tier 1 EIS will be focused on the areas surrounding the NEC spine where impacts from the implementation of improvements are most likely to occur. The Study Area definition will be refined as the alternatives development process advances.

Figure 1: NEC FUTURE Study Area

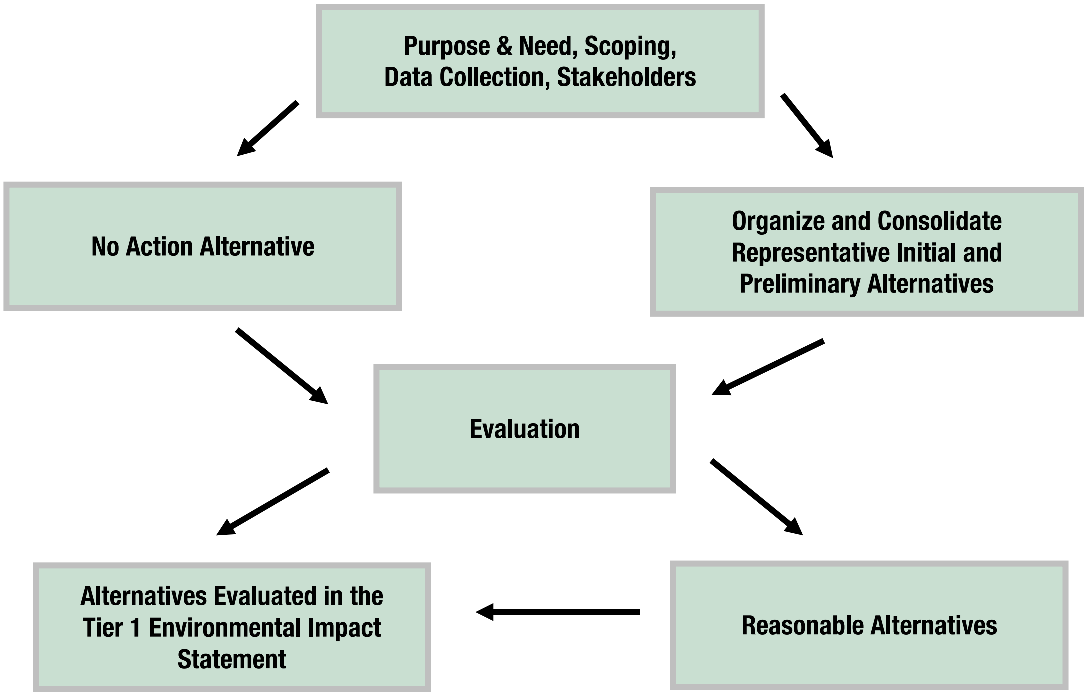


2.3 DEVELOPMENT OF THE ALTERNATIVES

The development of alternatives starts with the No Action Alternative, against which each of the "Build" alternatives must be compared with regard to benefits, costs and impacts. The Build Alternatives consist of combinations of market, route, capacity upgrades and rail service options capable of meeting 2040 ridership demand and addressing other problems identified in the Purpose and Need. They include a broad spectrum of potential service and investment options within the Study Area, including on- and off-corridor routes, service to new markets, different ways of serving markets, and variations in the level of investment in the NEC.

Figure 2 depicts the alternatives development process.

Figure 2: NEC Alternatives Development Process



2.3.1 NO ACTION ALTERNATIVE

All transportation projects evaluated under NEPA must include a No Action (or No Build) Alternative against which all of the build alternatives are compared to assess environmental and transportation benefits and impacts. The No Action Alternative defines the conditions that would prevail if the project or program under consideration was not advanced. For NEC FUTURE, the No Action Alternative describes the NEC as it would be in the year 2040 if no additional improvements beyond those currently planned, programmed, mandated or otherwise expected were implemented across the region's transportation system, including rail, highways, transit and air.

Assembling the No Action Alternative starts with today's Northeast rail, transit, highway (automobile and freight) and air system, and adds the following future improvements:

- Commuter, intercity and freight rail projects and transit, highway and airport projects currently in planning or under design, with an identified or reasonably anticipated funding source, or included in fiscally constrained regional, state and modal planning documents. These would include, for example, electrification upgrades between New Haven and Stamford, CT; construction of the MARC Wedge Yard at Washington Union Station; and implementation of the new FAA New Generation air traffic control system.
- Commuter and intercity rail projects mandated by law, such as Americans with Disabilities Act of 1990, as amended (ADA) station upgrades and Positive Train Control.
- Investments in state-of-good-repair and basic infrastructure renewal as generally required to maintain the operation and safety of the railroad at a level of annual expenditure consistent with the 20-year historical rate of capital investment in the NEC.

Future rail service on the NEC under the No Action Alternative is assumed to remain generally constant, once all currently funded and committed improvements have been implemented. Beyond those projects, capital investment in the No Action Alternative will not make any significant changes to capacity or serve new markets.

2.3.2 SOURCES FOR THE INITIAL ALTERNATIVES

There are two primary sources for the Initial Alternatives: 1) stakeholder input and data, including prior plans, studies and reports; and 2) input from public and agency scoping.

The NEC consists of a very large group of stakeholders:

- NEC and connecting corridor rail operators, including commuter, intercity, and freight railroads
- State resource agencies, including transportation, environmental, and economic development agencies and departments
- Federal modal agencies, including highways, transit, rail and waterways within the U.S. Department of Transportation
- Planning organizations, including Metropolitan Planning Organizations, and academic institutions
- Non-governmental and private organizations that study and otherwise impact the NEC

Over the years, these stakeholders have produced demographic data and growth projections, and prepared a large number of transportation plans and capital investment programs to address specific challenges and to plan future investment in the region's transportation assets. Data collected by NEC FUTURE include the capital and operating plans for Amtrak and each of the commuter and freight operators serving the NEC, upgrade programs prepared by individual railroads or groups of operators, high-speed rail feasibility studies (such as Amtrak's Next Generation program), environmental data and studies, growth and ridership projections, short and long range plans, and other visioning and planning documents. Many of these plans and documents recommend projects and ideas that constitute alternatives that can be used by NEC FUTURE. One major example is the NEC Master Plan, developed by Amtrak and the NEC commuter authorities in 2009. This document recommends a 25-year program of improvements to upgrade and grow the NEC to meet future demand.

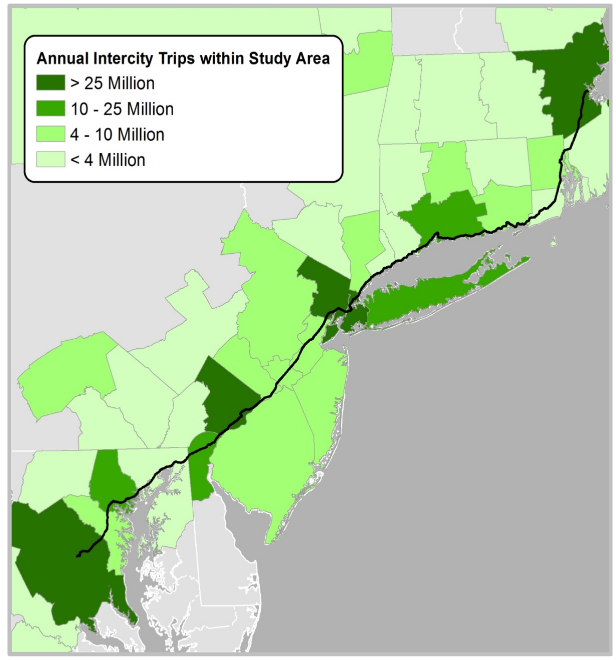
In addition to stakeholder information, a number of important ideas, issues and proposals came from the public and from Federal, state and local agencies through the formal NEC FUTURE Scoping process. Scoping is required under NEPA and provides an opportunity for the public to provide input on publicly funded projects. The NEC FUTURE Scoping process included 18 agency and public meetings across the corridor, as well as one internet-based agency webinar. Scoping began June 22, 2012, and remained open through October 19, 2012. In all, some 700 individuals and 193 public agency staff submitted over 2,300 comments and ideas. These focused on new routes and alignments, specific projects, service issues such as reliability, trip time, and affordability, and the ability to connect to transit at stations, and the importance of high-speed rail on the NEC. One of the most common comments from many members of the public and from agency staff and stakeholders was the importance of addressing deferred maintenance and upgrading the existing NEC spine prior to investments to expand rail service to markets off the NEC spine.

2.3.3 DEVELOPING AND ASSEMBLING THE INITIAL ALTERNATIVES

Developing and assembling the Initial Alternatives begins with analysis of Northeast travel demand and growth data to understand where people are traveling to, where growth in population and employment will occur, and whether travel patterns are likely to change in the coming decades.

NEC FUTURE looked to existing regional and state travel demand and population growth data, ridership projections made by Amtrak and the commuter authorities, data /discussions with states and planning organizations, and public and agency comments made during Scoping to identify current travel patterns and potential new rail markets. These data will be validated in 2013 as results from new NEC FUTURE demand modeling become available. Figure 3 shows the travel demand for all modal trips in the Northeast in 2010. Analysis of regional travel demand, overlaid on population and employment growth projections, helps to identify where people are going and the size of those markets.

Figure 3: Northeast Travel Demand for All Modes



Source: National Transit Database (NTD 2010).

The data underscore the dominance of the four primary markets on the existing NEC spine—Washington, D.C., Philadelphia, Boston and particularly New York. This is reflected by the current pattern of intercity passenger rail service and data:

- South End (Washington-New York)
  - 95 percent of all trips begin or end at Washington, Philadelphia or New York
  - 57 percent of all trips begin and end at Washington, Philadelphia and/or New York
- North End (New York-Boston)
  - 85 percent of all trips begin or end at Boston or New York
  - 27 percent of all trips begin and end at Boston and New York
- Through New York trips
  - Only 9 percent of all trips begin either north or south of New York and end on the other side of New York

The data also show that there are other strong Northeast travel markets, both on and off the existing NEC spine. Those on the spine—such as Baltimore, Wilmington, Newark, Stamford, and New Haven—already receive significant intercity and commuter/regional rail service. Those off the existing spine hold potential as future important rail markets, either via connecting rail service to the NEC spine, or as markets along new NEC alignments, including potential high-speed rail (HSR) routes. These include

Annapolis; Long Island (both Nassau and Suffolk Counties); Hartford; Springfield; and Worcester. The data also support the importance of markets located on connecting rail corridors, including Richmond, Harrisburg, Lancaster, and Albany. Many of these off-corridor markets are under-served by passenger rail. These include the following:

- Long Island to: Washington, Boston, Albany and points in New Jersey
- Hartford to: New York and Boston
- New York to: Albany and Richmond

Regional population and employment growth projections through 2040 support the continued attractiveness and expansion of these primarily urban markets, which will increase demand for both commuter rail and intercity rail services (Figure 4 and Figure 5).

Figure 4: Population Growth (2010-50) by County

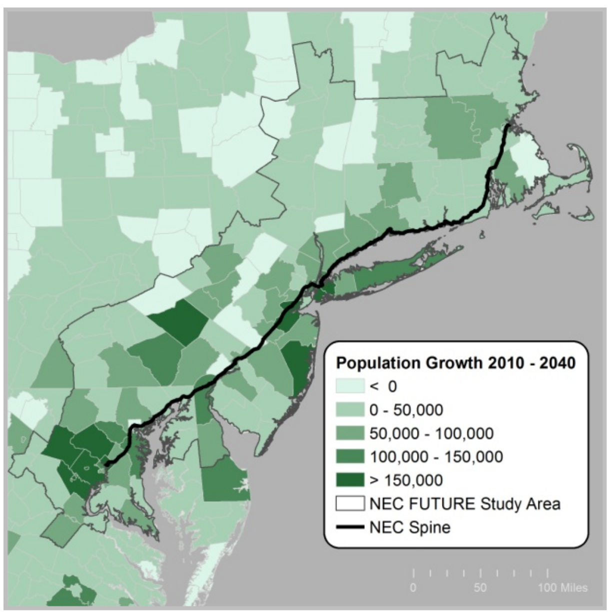
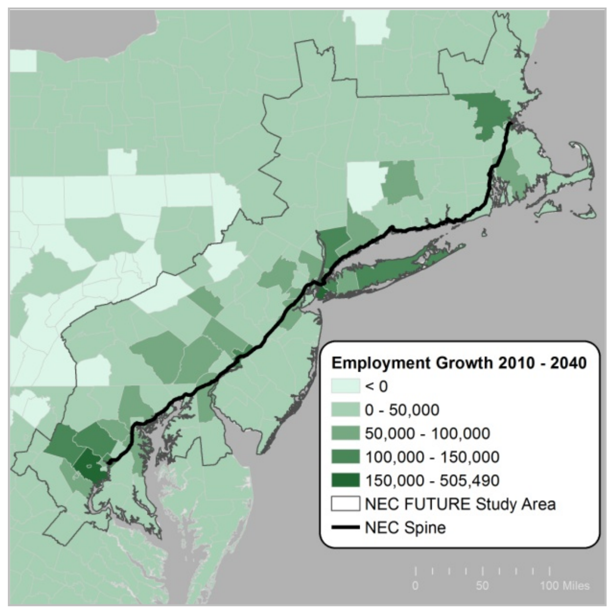


Figure 5: Employment Growth (2010-50) by County



Source: Moody's Analytics

Once the strongest Northeast travel markets have been identified, the many route and service ideas identified through data collection and scoping can be organized by developing combinations of options for serving those markets. These options include how trains will access the markets (route/rail network), how much service to provide to each market (level of service and investment), and the type of service to be provided (service definition and operational environment). Mixing and matching these options provides the basis for testing and comparing multiple market, investment and service proposals. Table 1 describes these three Building Blocks for serving the markets.

Table 1: Initial Alternatives Building Blocks

Building Blocks	Variations
Service/Investment Level ▪ How robust is the program? ▪ How much service can be provided? ▪ Which new markets can we serve?	A (Low): 2040 growth on existing NEC serving existing markets B (Medium low): Additional capacity on existing NEC to add new types of express, regional and connecting corridor services C (Medium high): Targeted expansion of the NEC to serve new off-spine markets and expand service options to NEC and connecting corridor markets D (High): Extensive end-to-end expansion of the NEC to serve new markets and HSR
Network/Route Definition ▪ How do we access the markets by rail?	▪ Existing NEC Spine ▪ Potential second NEC Spine ▪ Potential new right-of-way segments ▪ Potential connecting corridor links
Service Definition/Operational Environment ▪ How can we best serve the market?	▪ Current/Conventional Service Mix ▪ Enhanced Service Mix

The three Building Blocks are detailed below.

Service/Investment Level. Service and investment level answers the question: How robust of a vision for passenger rail is planned? In large part, this relates to the amount of funding available to increase capacity in the NEC, as the ability to increase service and serve new markets depends on such new capacity in terms of tracks, systems, stations and equipment. However, it also is shaped by the focus and objectives of the vision—the types and amount of service that can be provided and the range of markets to be served. Service/Investment Level, when combined with Service Definition, ultimately defines the potential for the investment program alternatives to serve the transportation needs of the region.

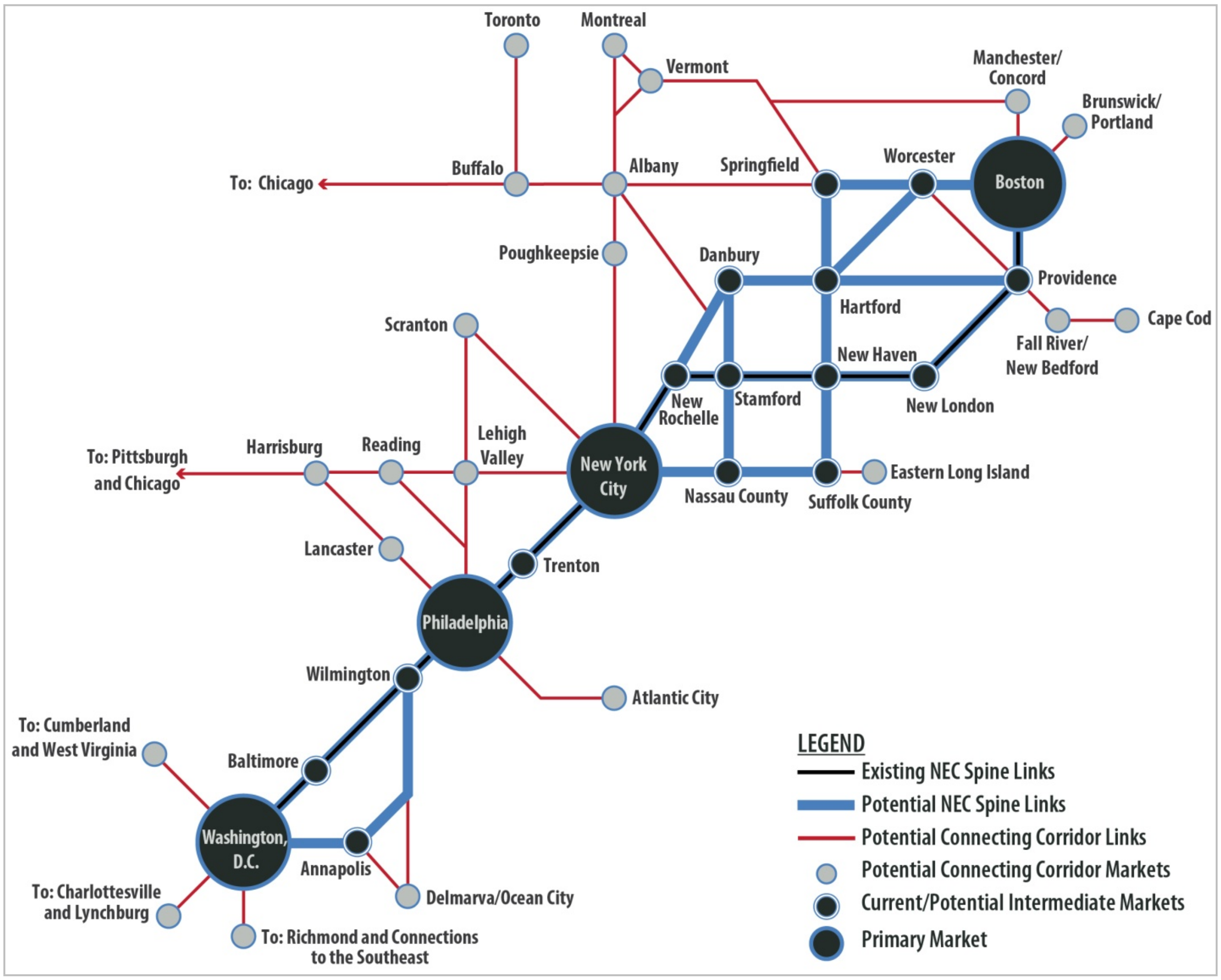
NEC FUTURE applied four incremental investment levels to broadly test investment options in the NEC over the next 30 years. This results in a range of visions for the NEC—from continuation of today's rail operations at the low end to the opportunity to provide significantly different types of service to existing and new markets, including HSR options, at the high end. As the investment level increases, the additional capacity enables carriers to consider a broad assortment of new services and targeted expansion of the rail line to new markets. The nature and extent of these new services and markets will be dynamic as the market for passenger rail on the NEC responds and grows. The four levels of investment—and their predicted outcomes—used for the Initial Alternatives were as follows:

- A (Low): Supports some increase in service and capacity along the existing NEC spine with goal of meeting projected 2040 travel demand; achieves state-of-good-repair. One alternative will represent a fiscally constrained option that represents a minimal level of investment that will not accommodate the full 2040 travel demand.
- B (Medium Low): Supports increased service to existing and connecting rail markets and additional capacity for expanded service types, but assumes no construction of new routes; meets projected 2040 travel demand in all markets on existing NEC spine (maintaining rail mode share).
- C (Medium High): Supports service to new off-spine markets and additional service options to existing NEC spine and connecting corridor markets by adding capacity and/or new rail access in targeted locations and markets.

- D (High): Supports a major increase in the quantity and types of rail services and significantly improved trip time to existing and new markets on and off the NEC through construction of a second NEC main line spine for the entire length of the corridor, which can be combined with increases in capacity along the existing NEC as required to support regional and intercity service operating on the existing spine.

Network/Route Definition. Network definition addresses the question: How do trains physically access markets? Accessing the Northeast markets by rail requires use of existing or new rail alignments and service options, and continued access to the connecting rail corridors. These are illustrated in Figure 6.

Figure 6: Initial Alternatives Networks for NEC Spine and Connecting Corridors



On the basis of these data and input/ideas generated by stakeholders and through scoping, the following route segments and combinations would support passenger rail service to a broad spectrum of Northeast markets, and provide continued access to connecting rail corridors. Accordingly, these were used to define the market networks for the Initial Alternatives:

- NEC mainline/existing spine
- Wilmington-Annapolis-Washington
- New Haven-Long Island-New York
- Hartford-Danbury-New York
- Boston-Providence-Hartford-New Haven
- Boston-Springfield-New Haven

Service Definition/Operational Environment. Service definition/operational environment answers the question: What types of rail service can best serve the markets? This will depend on a number of factors: the long-term vision for the NEC; the capacity available to operate specific types of service; and the markets to be served. For the Initial Alternatives, service definition was described in three general categories: current or today's conventional mix of intercity and commuter rail service; and two types of enhanced service—simplified service mix, which would provide more frequent service to most markets (including via transfer between trains), and expanded one-seat ride service to more markets. These categories encompass a broad range of potential service options for the study area. Current Mix forms the baseline for analyzing the impacts of the other service strategies. Enhanced Service includes a number of different service patterns that extend beyond today's distinct intercity and commuter options to provide broader coverage, faster service and more travel options. These service strategies are intended to guide the development and testing of potential service options for the alternatives. Their features are not intended to be absolute or exclusive to each service strategy, and will change depending on the availability of capacity and as access to new markets expands. As the alternatives are refined in future phases of work, features from each of these service strategies may be combined to develop the best service plan for a given alternative.

Various "connection strategies"—such as coordinated transfers or run-through service from connecting corridors—will be applied to each service strategy to ensure that all potential market pairs in the study area are served.

- **Current Mix:** Includes the current or conventional mix of train types (Acela/Premium High-Speed Rail, Regional/Limited Intercity, commuter, and freight) and institutional arrangements with the number of trains increased as needed to meet future demand. The service would still have a mix of train types, but the proportional mix would be "rebalanced" to respond to market demand.
- **Enhanced Service Mix:**
  - Simplified service that maximizes the number of trains to all markets.
  - Provides a limited group of services on a regular, repeating schedule to deliver higher frequency and throughput capacity than service plans with a greater variety of stopping patterns and train types.

- This high-density service approach provides the opportunity for greater frequencies to secondary markets through highly coordinated schedules and transfers. Total travel times may be slower than other options, and the approach may require transfers for passengers in secondary markets, but overall trip times are competitive with other service approaches and service frequencies are increased.
- Simplified Service Mix could include the following service types:
  - Limited-stop express service
  - Multi-stop local service
  - Supplemental peak commuter service
  - Convenient transfers from connecting corridors to services on NEC Spine
- Expanded one-seat ride: Focuses on maximizing the number of market pairs served with one-seat ride service, particularly for intermediate and connecting corridor markets, through the use of several services. These services include high-speed trains operating exclusively on high-speed or express tracks and other high-performance services that share high-speed tracks and utilize available capacity on portions of high-speed territory with maximum speeds of 160 mph or less and without intermediate station stops (e.g., on final approach to NYC, Washington, and/or Boston).

2.3.4 ASSEMBLING THE INITIAL ALTERNATIVES

Combinations of the three building blocks generated 98 separate Initial Alternatives that cover the spectrum of opportunities to upgrade and expand the NEC, serve existing and new markets both on and off the NEC, provide better connectivity to other rail markets, transit and airports, and develop new high-speed rail service. These include the following, as examples:

- A current/conventional service mix over the existing NEC spine funded at a Low Service/ Investment Level, serving existing NEC markets.
- An enhanced/simplified service mix over the existing spine funded at a Medium-Low Service/Investment Level, serving existing NEC markets with expanded service and additional service to connecting corridors.
- An enhanced/expanded one-seat ride service mix over a new HSR network funded at a High Service/Investment Level, provided new and expanded service both on the existing NEC spine and on a second NEC spine serving the HSR network.
- Some options and ideas were not carried into the Initial Alternatives. These included non-spine market options better served through potential future connecting corridors, such as connections to Ocean City, MD, Lehigh Valley (in Pennsylvania), Cape Cod, MA, Worcester MA (from the NEC mainline in Providence, RI), and Montreal Canada; less efficient spine options, such as New York City to Boston via Albany; and options suggesting specific engineering and alignment solutions that exceed the scope of a corridor-wide Tier 1 Program NEPA document and would be appropriately considered in a subsequent Tier 2 Project NEPA document, such as specific alignments and engineering solutions for trans-Hudson River tunnels and access to downtown Philadelphia.

2.4 DEVELOPMENT AND ORGANIZATION OF THE PRELIMINARY ALTERNATIVES

The Initial Alternatives comprise the spectrum of feasible options for enhancing service on the NEC. At this point in the NEC FUTURE Program, there are insufficient data to comprehensively compare the merits of each Initial Alternative or to select certain concepts while eliminating others. Thus, defining a smaller set of Preliminary Alternatives involved consolidating and reorganizing the Initial Alternatives to facilitate future isolation and testing of incremental service levels and route options. All concepts included in the Initial Alternatives were carried forward into the Preliminary Alternatives through this consolidation process. In addition, the Preliminary Alternatives remain technology neutral. This process of consolidating the Initial Alternatives resulted in 15 Preliminary Alternatives.

As described below, the Preliminary Alternatives were grouped within the four Service/ Investment Levels, as each of these levels presents a different vision for the NEC. Within each Level, capacity is added that permits the testing of a variety of service types and objectives, including minimizing travel time, increasing the density of service, and adding one-seat ride options. In this manner, the operational and ridership impacts of these incremental changes and different service can be isolated, tested and compared. Each Service and Investment Level includes three to four alternatives that test these variables. Level A is a lower cost program. Capacity is increased through operational efficiencies, such as longer, higher-capacity trains, and implementation of the most critical infrastructure upgrades. This would enable operators to accommodate 2040 demand, and, as capacity grows, to begin to implement new enhanced service types, such as regional train service across broad urban areas and better service to connecting rail corridors. In Levels B and C, capacity is sufficiently robust to support specific corridor objectives. These include service options and operational changes focused on three different goals: minimizing travel time; provision of high-density service; and increased one-seat ride options. Level C would also include targeted construction of new tracks to improve service on the existing NEC spine and to serve new off-corridor markets. Program Investment Level D would allow for construction of a second NEC spine that could support significant expansion and improvement of HSR operations and may free up capacity on the existing NEC spine for improved commuter and regional services.

These changes are described below.

2.4.1 SERVICE AND INVESTMENT LEVEL

The four Service/Investment Levels provide a broad range of investment opportunities within which to test various route and service alternatives. As Program Levels increase from A to D, additional capacity is required to support the desired level of service and the ability to serve new markets. Capacity increment levels—ranging from a low of 1 (initial and most pressing capital improvement projects) to 5 (second NEC spine)—were developed to provide a platform for matching capacity with desired levels and types of service. During the technical analysis of the alternatives, the specific capacity improvements required to achieve the service objectives of each alternative can be better defined.

These capacity levels (Table 2) define the types of improvements generally required to address bottlenecks and other constraints and to provide the infrastructure required to serve new markets and support high-speed rail.

Table 2: Capacity Increments Required to Grow the NEC

Capacity Increment Level	Improvements
1	Service and operational efficiencies; high-priority capacity improvement projects with low-to-moderate capital costs
2	Additional cost-effective capacity improvement projects, including high-cost projects with substantial capacity benefits such as tunnel and bridge replacements.
3	Elimination of bottlenecks that constrain throughput capacity, such as at-grade junctions and slow-speed interlockings, and add capacity at major terminals.
4	Targeted construction of limited portions of new railroad right-of-way along and/or connecting to the NEC spine as required for capacity, trip time and/or market access.
5	Construction of a second NEC spine between Boston and Washington and rationalization of service on the existing NEC spine to optimize service objectives.

2.4.2 NETWORK/ROUTE DEFINITION

Route segments from the Initial Alternatives were combined to create three network alternatives south of New York and four network alternatives north of New York. These network alternatives preserve the ability to add future connecting corridor service to various proposed markets such as Cape Cod, Scranton and Ocean City. Most alternatives—those in Service/Investment Levels A, B and C—remain primarily on the existing NEC spine. Alternatives that involve a second NEC spine are limited to Service/Investment Level D. These network alternatives are representative only—specific alignments and station locations along new right-of-way will not be developed until commencement of Tier 2, project-specific environmental processes. The representative network alternatives are illustrated in the NEC Preliminary Alternatives Fact Sheets, included in the Appendix. The rail networks are as follows:

- Existing NEC via Baltimore Penn and Philadelphia 30th Street Stations
- Existing NEC via downtown Baltimore and Center City Philadelphia
- Delmarva Route via Annapolis and Center City Philadelphia
- Existing NEC New Haven Line – Shore Line
- New York-Nassau-Suffolk via Hartford and Worcester
- Central Connecticut via Providence
- New York-Nassau-Stamford via Danbury and Springfield

The performance and impacts of operations over each of these networks—and submarkets/segments within each network—will be evaluated in the next phase of the alternatives development process to determine the best combinations of routes north and south of New York.

2.4.3 SERVICE DEFINITION/OPERATIONAL ENVIRONMENT

Service definition—the various types of service that could be run on the corridor, from today's conventional service to novel enhanced service concepts—saw significant development after completion of the Initial Alternatives. A number of alternate service types were defined and will be developed and tested with both simplified and one-seat-ride strategies to measure their effectiveness at filling market gaps left under-served or unserved by today's conventional mix of services. These variations include the following:

- Super Express: HSR to primary markets only—Washington, D.C., Philadelphia, New York, and Boston
- Premium Express: HSR to primary markets and secondary markets, with multiple stopping patterns
- Limited Express: HSR service expanded to more stations on conventional and HSR tracks
- Limited: Regional service with multiple stopping patterns
- Metropolitan: Limited-stop, run-through service for longer-distance commute trips within broad metro areas
- Regional Zone Express: Mainline and branch express operations, collecting travelers from a specific area and then operating at high speed express trains to major terminals
- Commuter Zone Express: Peak-period trains serving local stops within a zone of stations and otherwise operates non-stop
- Local Commuter: All-stop local service
- Rail Transit Service on NEC right-of-way: Short-distance, short-headways, high-capacity trains within metropolitan core

It should be noted that a number of independent elements must also be considered as they may impact some or all of the alternatives. These include terminal and intermediate station solutions; airport access solutions; and rail freight solutions. As the analytic tools and data become available for evaluation and screening of alternatives, these elements will be analyzed as overlays on the alternatives. This might include, for example, an overlay analysis with respect to the potential options for making rail connections to and between airports, and for configuring the stations, yards, and railroad alignments within the major terminal areas.

2.5 PRELIMINARY ALTERNATIVES

Fifteen Preliminary Alternatives were developed through the combination of different service, capacity and network options under each of the four Service/Investment Levels. These alternatives continue to capture the broad array of options for growing the NEC to accommodate projected 2040 demand and to support the region's transportation needs. Each is sufficiently distinct to permit quantitative evaluation, enabling the analysis of key differentiating variables, including capacity (in terms of train frequency and seat availability), ridership, trip time, operational impacts, network expansion capabilities, connectivity, economic impacts, and costs. The alternatives will be compared with one another and against the No Action Alternative.

The 15 Preliminary Alternatives are described by individual Fact Sheets per alternative (included in the Appendix) and are listed in Table 3.

Table 3: NEC Preliminary Alternatives

Alt	Level	Network	Service Environment
1	A	Some increase in service and capacity along the existing NEC Spine	Conventional intercity/commuter
2			Conventional intercity/commuter
3			Introduce intra-urban metropolitan service
4	B	Increased service to existing and connecting markets along the existing NEC Spine	Conventional intercity/commuter
5			Focus: Maximize train frequency / service
6			Focus: Minimize travel time
7			Focus: Maximize one-seat ride options on and off NEC Spine
8	C	Targeted expansion of the existing NEC Spine to serve new markets, reduce trip time, and introduce robust regional services	Conventional intercity/commuter
9			Focus: Maximize train frequency / service
10			Focus: Minimize travel time
11			Focus: Maximize one-seat ride options on and off NEC Spine
12	D	2nd spine generally parallel to existing NEC	Dedicated high-speed rail; robust intercity and regional services on existing NEC Spine
13		2nd spine via Danbury-Hartford-Providence	
14		2nd spine via Suffolk-Hartford-Worcester	
15		2nd spine via Delmarva and Nassau-Stamford-Danbury-Springfield	

3. Next Steps

In the next phase of the alternatives development process, the Preliminary Alternatives will be comparatively evaluated to understand their transportation and environmental benefits and impacts. Screening criteria will be applied to guide the process for identifying the best service and network options to be used to develop the Reasonable Alternatives, which will then be further evaluated as part of the Tier 1 EIS, ultimately resulting in a preferred investment program.

APPENDIX
NEC PRELIMINARY ALTERNATIVES

Preliminary Alternatives Key

NEC FUTURE

Program Levels

[A] Improve Existing NEC Spine
Some increase in service and capacity with goal of meeting projected 2040 travel demand;
Achieves State of Good Repair

[B] Optimize Existing NEC Spine
Increased service to existing and connecting rail markets, but no construction of new routes;
Meets projected 2040 travel demand in all markets on existing NEC spine (maintaining rail mode share)

[C] Expand NEC and Connections
Service to new markets and additional growth in existing markets by adding capacity/new alignments in targeted locations (e.g., new downtown service in Baltimore and Philadelphia)

[D] Add'l NEC Route (2-Trk. Equiv.)
Major increase in the quantity and types of rail services and significantly improved trip time to existing and new markets on and off the NEC; new main line tracks for the entire length of the corridor; capacity optimized on existing NEC for continuing regional and intercity operations.

Operational Environment

Conventional/Current Service Mix
Existing service types operating over existing railroad; peak trains per hour increased as capacity is made available; selected new connections to connecting corridors (one-seat ride and transfers at hub stations)

Enhanced Options
Introduces new types of express, limited stop and skip-stop service; commuter rail evolves into regional service; endpoints and frequency respond to travel markets and potential operating efficiencies, irrespective of railroad territory; assumes well-coordinated/highly-disciplined operations on the NEC and all connecting corridors feeding into the NEC

Service Types

Premium Express
Super Express: Trains stopping only at Boston, New York, Philadelphia and Washington
Premium Express: High-speed service with few stops to primary & secondary markets; multiple stopping patterns
Limited Express: High-speed service expanded to more stations, operating on both conventional and high-speed express tracks.
Note: these services represent the high-speed rail brand on the Northeast Corridor

Inter-Regional
NEC Inter-Regional: Limited-stop intercity service with multiple stopping patterns serving primary and secondary intercity markets
Connecting Corridor Inter-Regional: Inter-Regional trains also operating off-corridor
Metropolitan: Limited-stop trains serving both intercity and regional/commuter markets within broad metro areas or NEC-wide, with greater frequency, more station stops and lower fares than Inter-Regional service, operating as run-through trains at major terminals

Regional / Urban
Regional Rail (Commuter) Zone Express: Peak period trains serving local stops within a zone of stations and otherwise operating non-stop or with limited stops to a major terminal.
Regional Rail (Commuter) Local: All-stop local service
Zone Express: Commuter Express service – zone express or branch line service with express operations on high-speed express tracks approaching major terminals (HST-type trains)

Urban Rail Transit Service on NEC ROW: short distance, short headways, high-capacity trains within urban core areas

Capacity Improvement Increments
1. Lower-cost incremental improvements
2. Cost-effective higher-cost improvements
3. Elimination or relief of selected choke points, major terminal capacity expansion
4. Portions of new right-of-way parallel to existing NEC
5. New dedicated high-speed route(s)

Trip Time Improvement Increments
1. New high-speed rolling stock (top speed 160 mph)
2. Track realignment (curve mods, terminal areas, turnouts) and widening of track center spacing
3. Bypass tracks at stations
4. New alignments to bypass slow-speed NEC segments
5. New dedicated high-speed right-of-way

Connecting Corridor Service Options
(evaluated as part of Program Level B, C and D Alts)

- High-quality transfer to NEC Spine services at hub stations
- Run-through Inter-Regional service
- Run-through Premium Express service

Rolling Stock Technology
Very-high-speed technology options (e.g., MAGLEV) will be analyzed for the best-performing Program Level D alternatives (which provide new right-of-way between Washington and Boston via New York).

Overlay Analyses
(evaluated in parallel with Prelim Alts)

- Major Terminal Configurations (Bos, NY, Wash)
- Rail Freight Options
- Airport Access Options
- Fare Policy Options

Program Level A – Preliminary Alternative 1

Conventional Operations w/ Lower-Cost Incremental Capacity Improvements

General Characteristics

Relative Magnitude

- Quantity of Service
- Level of Investment
- Operational Environment — ● Conventional ○ Enhanced
- Capacity Improvement
- Trip Time Improvement
- Variety of Service Types
- Level of Service to:
  - Intermediate NEC Markets
  - Existing Connecting Corridors
  - New Connecting Corridors

Capacity improvements (Increment #1):
Relatively low-cost incremental improvements (resource-constrained)

Trip-Time Improvements:
New trainsets for Express service and capital improvements needed to achieve top speed of 160 mph

Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☐ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area

Program Level A – Preliminary Alternative 2

Conventional Operations w/ Cost-Effective Incremental Capacity Improvements

NEC FUTURE

General Characteristics

	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	● Conventional ○ Enhanced
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to: - Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

Capacity improvements (Increment #2):
Cost-effective projects (including high-cost, high-benefit projects) providing increased capacity at choke points.

Trip-Time Improvements:
New trainsets for Express service and capital improvements needed to achieve top speed of 160 mph

Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☐ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area

Program Level A – Preliminary Alternative 3

Enhanced Operations w/ Cost-Effective Incremental Capacity Improvements

NEC FUTURE

General Characteristics

	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	Conventional / **Enhanced**
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to:	
- Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

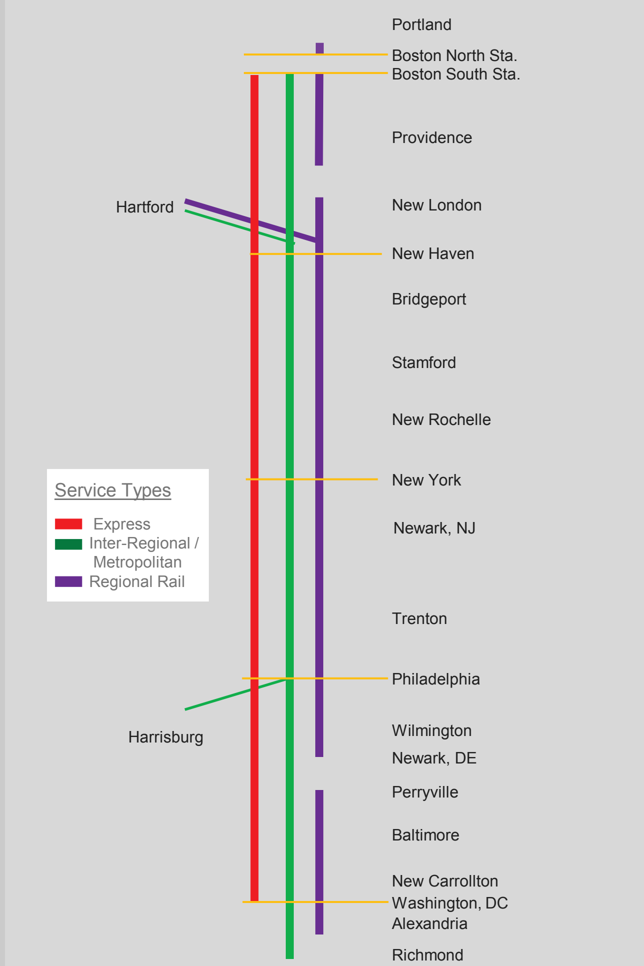
Capacity improvements (Increment #2):
Cost-effective projects (including high-cost, high-benefit projects) providing increased capacity at choke points.

Trip-Time Improvements:
New trainsets for Express service and capital improvements needed to achieve top speed of 160 mph

Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area



Program Level B – Preliminary Alternative 4

Conventional Operations w/ Increased Capacity on Existing NEC Spine

NEC FUTURE

General Characteristics

	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	● Conventional ○ Enhanced
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to: - Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

Capacity improvements (Increment #3):
Increased capacity at all significant choke points; terminal capacity improvements; express bypass tracks at selected stations to facilitate overtakes

Trip-Time Improvements:
Limited to cost-effective projects that also increase capacity.

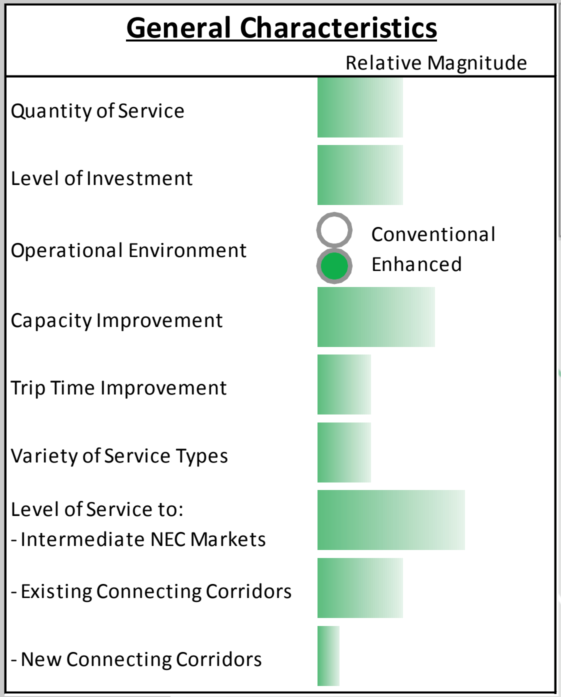
Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☐ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area

Program Level B – Preliminary Alternative 5

Enhanced Operations w/ High-Density Service, Increased Capacity on Existing NEC Spine



Capacity improvements (Increment #3):
Increased capacity at all significant choke points; terminal capacity improvements; express bypass tracks at selected stations; improved track and platform configurations at transfer hubs

Trip-Time Improvements:
Limited to cost-effective projects that also increase capacity.

Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☐ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area

Program Level B – Preliminary Alternative 6

Enhanced Operations w/ Higher-Speed Express Services, Increased Capacity on Existing NEC Spine

General Characteristics

	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	Conventional Enhanced
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to: - Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

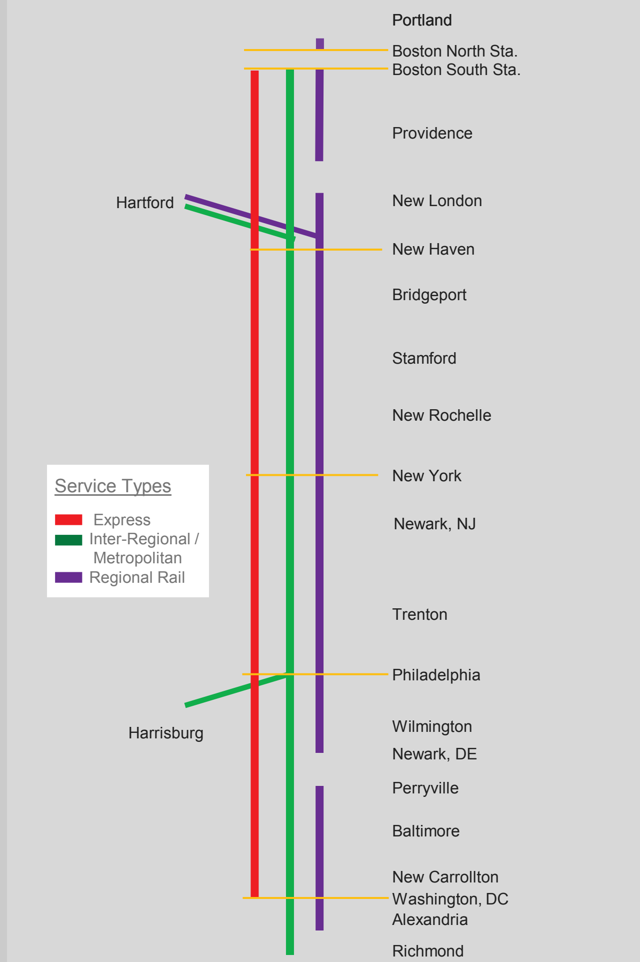
Capacity improvements (Increment #3):
Increased capacity at all significant choke points; terminal capacity improvements; express bypass tracks at selected stations to facilitate overtakes

Trip-Time Improvements:
Realignment of track center spacing, curve modifications and other improvements within existing NEC right-of-way.

Service Types

- ☑ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area



Program Level B – Preliminary Alternative 7

Enhanced Operations w/ Greater Variety of Service Types, Increased Capacity on Existing NEC Spine

NEC FUTURE

General Characteristics

Capacity improvements (Increment #3):
Increased capacity at all significant choke points; terminal capacity improvements; express bypass tracks at selected stations to facilitate overtakes

Trip-Time Improvements:
Limited to cost-effective projects that also increase capacity.

Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

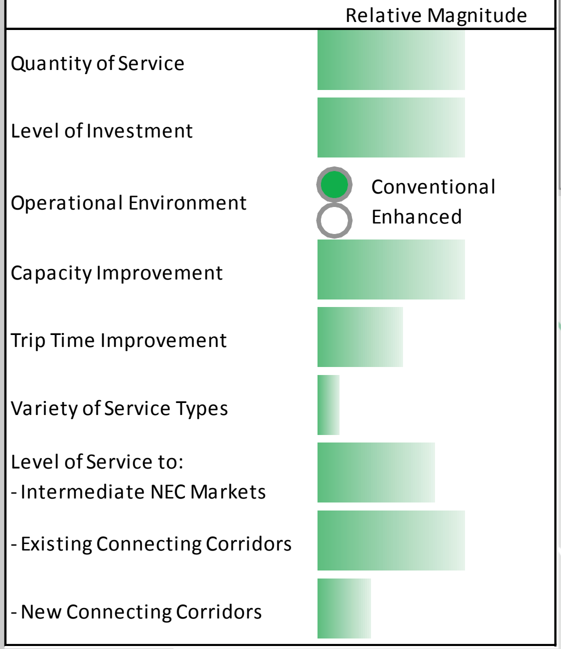
Train Type by Service Area

Program Level C – Preliminary Alternative 8

Conventional Operations w/ Partial New Alignments Parallel to NEC

NEC FUTURE

General Characteristics



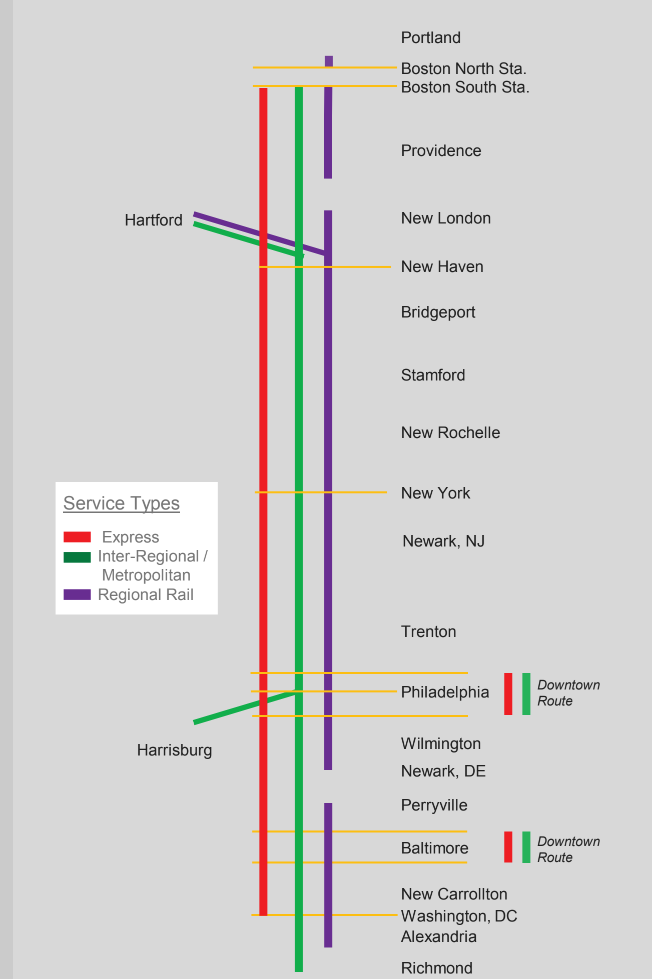
Capacity improvements (Increment #4):
Additional mainline tracks or bypass tracks on new right-of-way at targeted locations along NEC Spine to maximize capacity; terminal capacity improvements, relief of all significant bottlenecks.

Trip-Time Improvements:
Limited to cost-effective projects that also increase capacity.

Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☐ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area



Program Level C – Preliminary Alternative 9

Enhanced Operations w/ High-Density Service, Partial New Alignments Parallel to NEC

NEC FUTURE

General Characteristics

Relative Magnitude

- Quantity of Service
- Level of Investment
- Operational Environment: Conventional / Enhanced (Enhanced)
- Capacity Improvement
- Trip Time Improvement
- Variety of Service Types
- Level of Service to:
  - Intermediate NEC Markets
  - Existing Connecting Corridors
  - New Connecting Corridors

Capacity improvements (Increment #4):
Additional mainline tracks or bypass tracks on new right-of-way at targeted locations along NEC Spine to maximize capacity; terminal capacity improvements, relief of all significant bottlenecks; improved track and platform configurations at transfer hubs.

Trip-Time Improvements:
Limited to cost-effective projects that also increase capacity.

Service Types

- ☐ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area

Program Level C – Preliminary Alternative 10

Enhanced Operations w/ Higher-Speed Express Services, Partial New Alignments Parallel to NEC

NEC FUTURE

General Characteristics

Relative Magnitude

- Quantity of Service
- Level of Investment
- Operational Environment: Conventional / Enhanced (Enhanced selected)
- Capacity Improvement
- Trip Time Improvement
- Variety of Service Types
- Level of Service to:
  - Intermediate NEC Markets
  - Existing Connecting Corridors
  - New Connecting Corridors

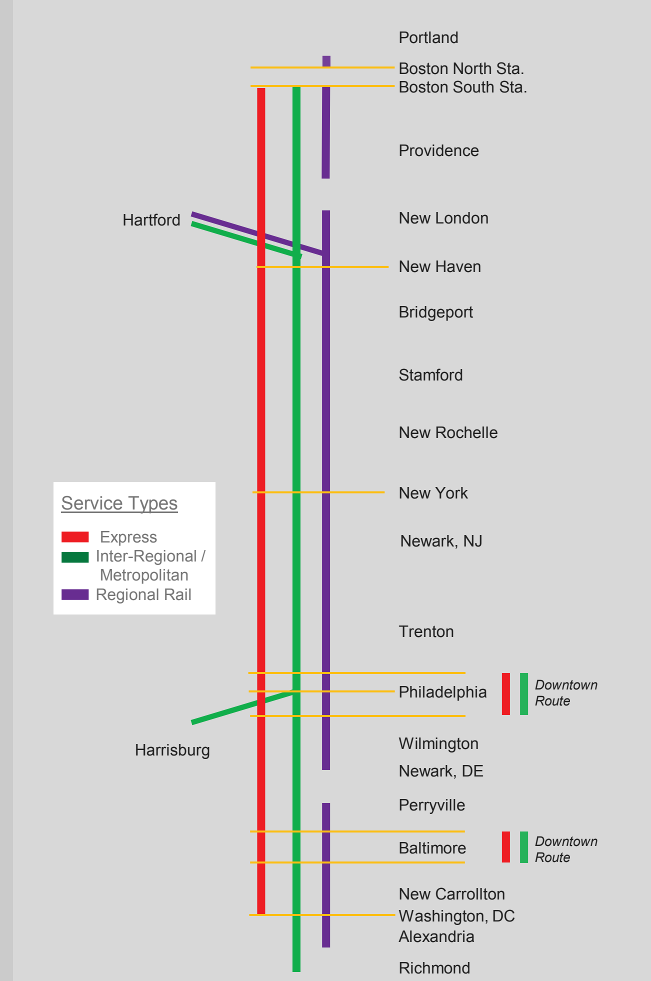
Capacity improvements (Increment #4):
Additional mainline tracks or bypass tracks on new right-of-way at targeted locations along NEC Spine to maximize capacity; terminal capacity improvements, relief of all significant bottlenecks.

Trip-Time Improvements:
New alignments to bypass slow-speed portions of NEC; Realignment of track center spacing, curve modifications on existing NEC right-of-way.

Service Types

- ☑ Super Express
- ☑ Premium Express
- ☐ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☐ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☐ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area



Program Level C – Preliminary Alternative 11

Enhanced Operations w/ Greater Variety of Service Types, Partial New Alignments Parallel to NEC

General Characteristics

	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	Conventional ○ / Enhanced ●
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to: - Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

Capacity improvements (Increment #4):
Additional mainline tracks or bypass tracks on new right-of-way at targeted locations along NEC Spine to maximize capacity; terminal capacity improvements, relief of all significant bottlenecks.

Trip-Time Improvements:
Limited to cost-effective projects that also increase capacity.

Service Types

- ☑ Super Express
- ☑ Premium Express
- ☑ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☑ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☑ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area

Program Level D – Preliminary Alternative 12

Enhanced Operations via New Alignment Parallel to Existing NEC and Improved Existing NEC Route

NEC FUTURE

General Characteristics

General Characteristics	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	Conventional / Enhanced (Enhanced)
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to: - Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

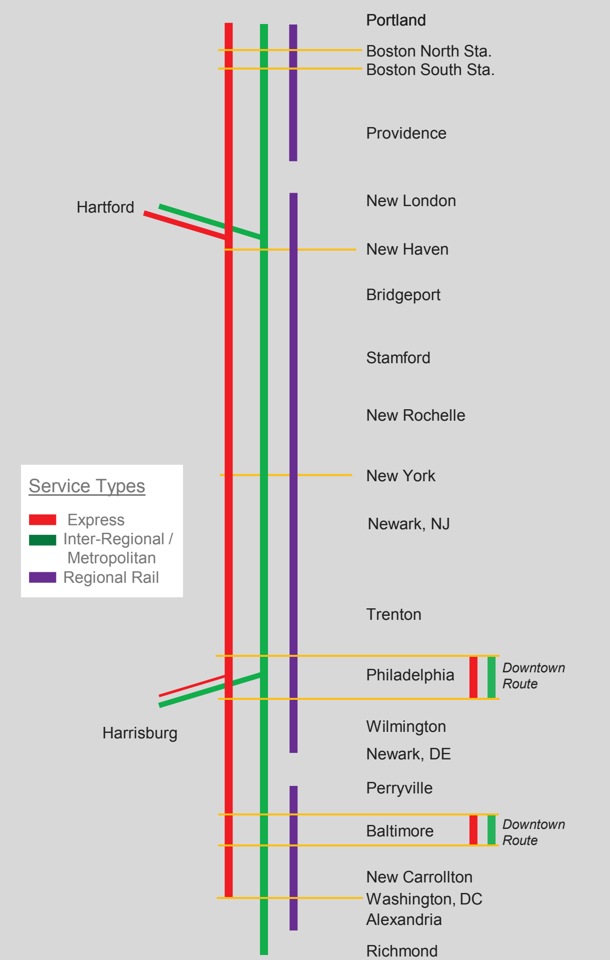
Capacity improvements (Increment #5):
New right-of-way and major increase in capacity, Boston-to-Washington; terminal capacity improvements, relief of bottlenecks and targeted improvements on existing NEC Spine to optimize capacity for continuing operations.

Trip-Time Improvements:
New right-of-way designed for 220 mph top speed; targeted speed and trip-time improvements along existing NEC spine

Service Types

- ☑ Super Express
- ☑ Premium Express
- ☑ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☑ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☑ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area



Program Level D – Preliminary Alternative 13

Enhanced Operations via Danbury-Hartford-Providence and Improved Existing NEC Route

NEC FUTURE

General Characteristics

Relative Magnitude

- Quantity of Service
- Level of Investment
- Operational Environment
  - Conventional
  - Enhanced
- Capacity Improvement
- Trip Time Improvement
- Variety of Service Types
- Level of Service to:
  - Intermediate NEC Markets
  - Existing Connecting Corridors
  - New Connecting Corridors

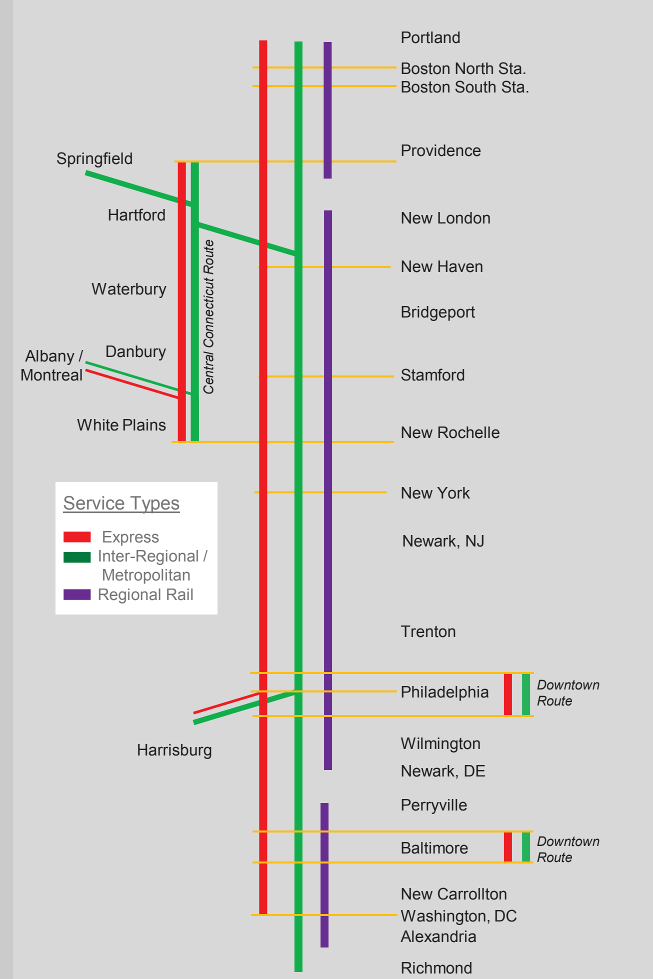
Capacity improvements (Increment #5):
New right-of-way and major increase in capacity, Boston-to-Washington; terminal capacity improvements, relief of bottlenecks and targeted improvements on existing NEC Spine to optimize capacity for continuing operations.

Trip-Time Improvements:
New right-of-way designed for 220 mph top speed; targeted speed and trip-time improvements along existing NEC spine

Service Types

- ☑ Super Express
- ☑ Premium Express
- ☑ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☑ Zone Express
- ☑ Urban Rail Transit (on NEC)
- ☑ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area



Program Level D – Preliminary Alternative 14

Enhanced Operations via Suffolk County-Hartford-Worcester and Improved Existing NEC Route

NEC FUTURE

General Characteristics

	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	Conventional / Enhanced (selected: Enhanced)
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to:	
- Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

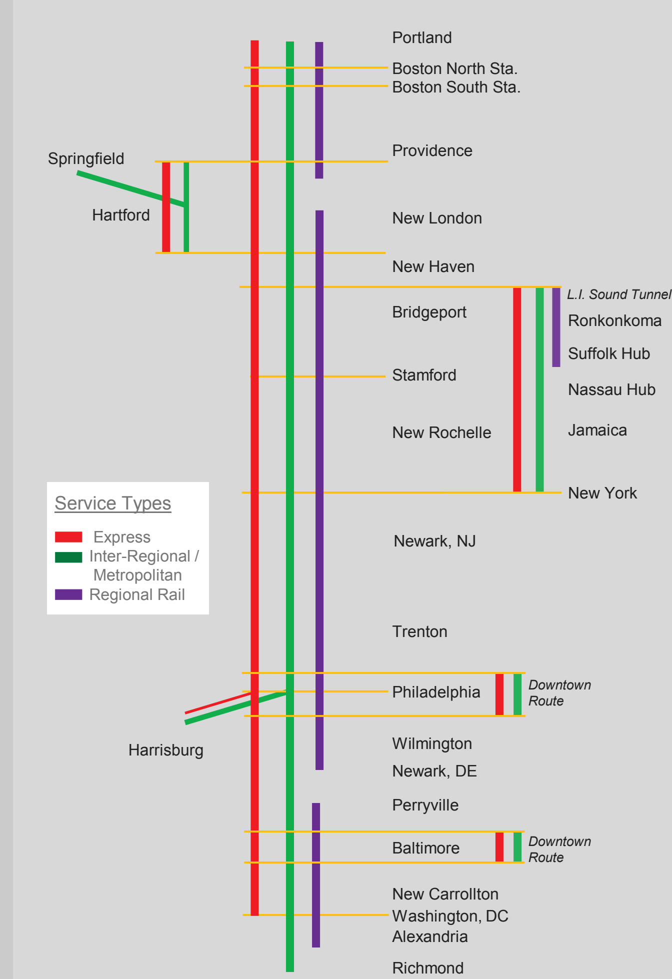
Capacity improvements (Increment #5):
New right-of-way and major increase in capacity, Boston-to-Washington; terminal capacity improvements, relief of bottlenecks and targeted improvements on existing NEC Spine to optimize capacity for continuing operations.

Trip-Time Improvements:
New right-of-way designed for 220 mph top speed; targeted speed and trip-time improvements along existing NEC spine

Service Types

- ☑ Super Express
- ☑ Premium Express
- ☑ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☑ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☑ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional

Train Type by Service Area



Program Level D – Preliminary Alternative 15

Enhanced Operations via Delmarva and Nassau-Stamford-Springfield-Worcester and Improved NEC

NEC FUTURE

General Characteristics

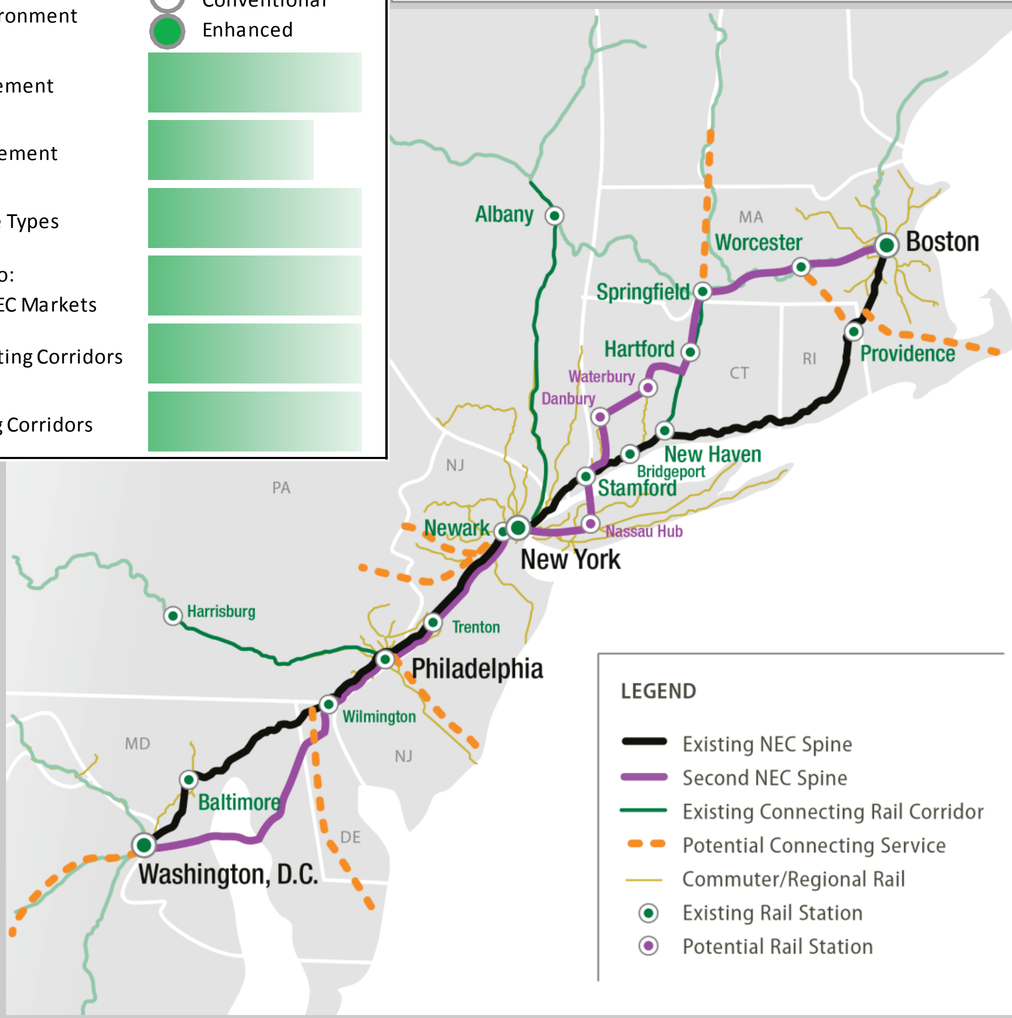
	Relative Magnitude
Quantity of Service	
Level of Investment	
Operational Environment	○ Conventional / ● Enhanced
Capacity Improvement	
Trip Time Improvement	
Variety of Service Types	
Level of Service to:	
- Intermediate NEC Markets	
- Existing Connecting Corridors	
- New Connecting Corridors	

Capacity improvements (Increment #5):
New right-of-way and major increase in capacity, Boston-to-Washington; terminal capacity improvements, relief of bottlenecks and targeted improvements on existing NEC Spine to optimize capacity for continuing operations.

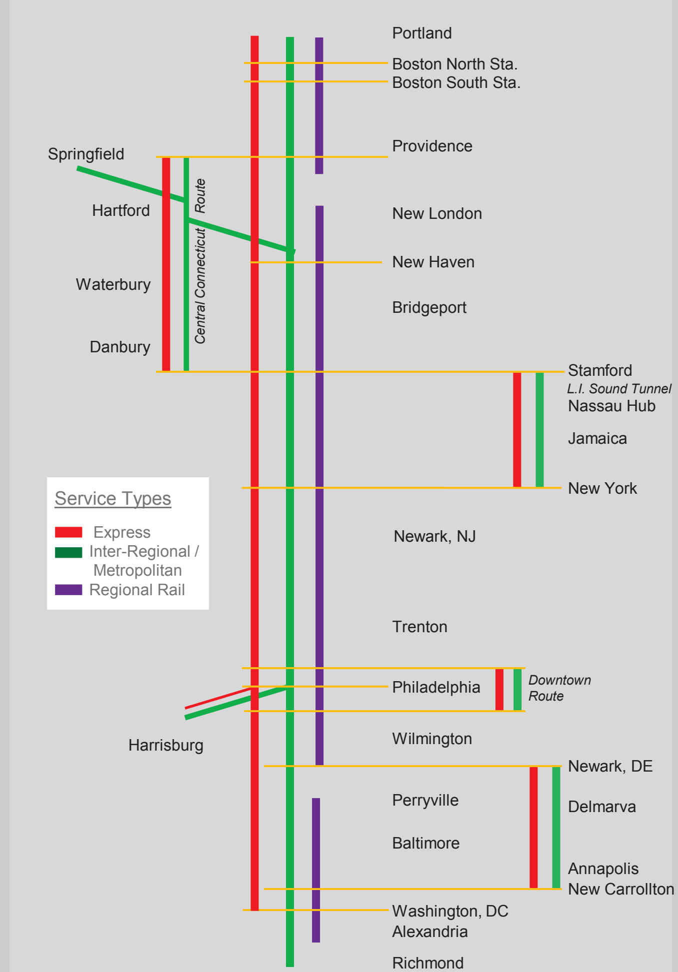
Trip-Time Improvements:
New right-of-way designed for 220 mph top speed; targeted speed and trip-time improvements along existing NEC spine

Service Types

- ☑ Super Express
- ☑ Premium Express
- ☑ Limited Express
- ☑ Inter-Regional (Spine)
- ☑ Metropolitan
- ☑ Regional Rail
- ☑ Zone Express
- ☐ Urban Rail Transit (on NEC)
- ☑ Connecting Corridor Express
- ☑ Connect'g Corr Inter-Regional



Train Type by Service Area



NEC FUTURE

A Rail Investment Plan for the Northeast Corridor

Preliminary Alternatives Evaluation Report

November 2014

U.S. Department of Transportation

Federal Railroad Administration

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TABLES

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1. Alternatives Development Process

NEC FUTURE is a comprehensive planning effort to define, evaluate, and prioritize future investments in the Northeast Corridor (NEC), the rail transportation spine of the Northeast region of the United States. The planning effort will establish an investment plan for NEC, which, if implemented, will improve the capacity and reliability of passenger rail service in the Northeast, for both regional and intercity trips, in a manner that will meet mobility needs as the region's population and employment continue to grow. This plan will strengthen service to existing rail markets and address additional travel markets that rail does not adequately serve today, both on and off the NEC. While the study horizon year for NEC FUTURE is 2040, the vision for rail on the NEC will provide a foundation for growth well beyond 2040. With the alternatives development process, the Federal Railroad Administration (FRA) is evaluating potential options for maintaining or growing the role of rail in the Northeast region. The process includes three stages:

- **Initial Alternatives (July 2012–March 2013):** Through extensive outreach to the region's eight states, the District of Columbia, the NEC's eight regional rail operators, Amtrak, freight railroads, the Northeast Corridor Infrastructure & Operations Advisory Commission (NECC), and the general public (during scoping), a broad range of 98 passenger rail market and service options were assembled and evaluated. These options included specific route recommendations, new service and market options, and a second spine to support 220 mph high-speed rail (HSR) service.
- **Preliminary Alternatives (April 2013–July 2014):** The 98 Initial Alternatives were organized into four distinct program levels, A through D, encompassing the broad spectrum of approaches to serving existing and new markets in the region. Each program level articulates a different vision for the role that rail can play in meeting regional transportation needs.

  Within each program level, separate scenarios were developed to better understand and quantify key rail market and service dynamics, such as the trade-offs between frequency of service, trip time, and the convenience of direct "one-seat" service. Four separate second-spine route alternatives were also developed for Program Level D. A total of 15 alternatives were assembled within the four program levels. Separate service plans and capital investment requirements were created for each alternative. Data were generated using existing ridership, operations simulation, and cost models.
- **Tier 1 Draft Environmental Impact Statement (EIS) Alternatives (August 2014–June 2015):** From the 15 Preliminary Alternatives, a smaller set of alternatives will be developed for full analysis in the Tier 1 Draft EIS. These alternatives will draw from the evaluation of the Preliminary Alternatives and will repackage the best service concepts to provide distinct alternative visions for the role of rail on the NEC. In the Tier 1 Draft EIS, these alternatives will be compared against each other and with the No Action Alternative, using new ridership and operations models now under development.

The Tier 1 Final EIS will identify the FRA's preferred service vision and associated program of investments, including implementation phasing. The FRA will consider the Tier 1 Draft EIS findings and stakeholder input, including comments on the Tier 1 Draft EIS, in identifying a preferred investment program. With the Record of Decision (ROD), the FRA will select the Investment Program and subsequently prepare a Service Development Plan to define how it will be implemented.

Because of the unique geographic, technical, and institutional complexity of the program, the FRA has taken an innovative approach to develop NEC FUTURE alternatives. The alternatives development process being used is iterative, and allows for corridor-wide service plans and infrastructure projects to be developed, tested, refined, recombined, and optimized for different service and geographic markets within the NEC. This modular approach has made it possible to understand how discrete elements perform relative to one another, so that the strongest "package" of separate route, infrastructure, and service options can ultimately be crafted into the alternatives to meet specific market needs within different NEC sub-regions.

With a range of asset owners and service operators that utilize the NEC, the alternatives development process has entailed frequent coordination with state and railroad stakeholders, as well as federal and state environmental, transportation, and non-transportation officials. Additional information on the alternatives development process can be found in the Preliminary Alternatives Report, available on the NEC FUTURE website at necfuture.com.

2. The Preliminary Alternatives

The Preliminary Alternatives were developed by organizing the 98 Initial Alternatives into four program levels that differ by the quantity and types of rail service they provide to the region. The four program levels represent a broad range of options for the role that passenger rail can play in the NEC and across the region, from a lower cost approach focused on the minimum investment required to accommodate future demand to a transformational vision that includes a second spine designed to support HSR service at speeds up to 220 mph. Analysis of these four program levels has enabled FRA to assess the benefits and impacts of different levels of investments in the NEC.

The year 2040 was selected as a reasonable horizon year for ridership demand forecasts based on the availability of data. Many of the regional rail authorities have projected demand through 2030–35, as well as the service levels to support that demand. These projections include both organic growth, based on expected increases in population and employment, and, in some cases, an additional share of the travel market that would shift to rail as other modes become more and more congested. FRA is using these projections to help define demand and capacity needs for the horizon year. Moreover, projecting demand more than 25 years into the future can prove overly speculative.

The following variations were developed within each program level to test key service attributes and dynamics:

- <u>Contrasting Conventional and Enhanced Train Service</u>: Passenger rail service on the NEC today is provided by eight regional rail operators and by Amtrak, which provides intercity service. Regional rail generally connects cities and towns within one state or on the border of two states (e.g., NJ TRANSIT service within New Jersey and connecting to New York City). Each regional rail service operates independently on the NEC and, historically, each regional rail market was geographically distinct, though with the distributed growth of population along the NEC, those distinctions have blurred. Amtrak operates across the full length of the NEC, serving 25 cities with express trains, which offer the fastest trip times and serve fewer cities, and intercity-corridor trains, which stop more often and serve a wider variety of city-pairs. The eight regional rail operators and Amtrak coordinate dispatching of trains and management of track capacity, but there is little integration of service, schedules, or fares across the different NEC markets.

Program Levels A, B, and C include alternatives that contrast today's "conventional" intercity and regional independent operating approach and stopping patterns with an integrated network of "enhanced" services designed to accommodate changing travel patterns along the NEC and provide a more customer-friendly travel experience. These include both new types of train service and changes in the way intercity and regional rail service is operated:

- A new train service, called "metropolitan," would serve both regional and intercity rail stations on the same train. Metropolitan trains would supplement intercity and regional service in the busiest markets during peak periods each day, as well as operate across the NEC to serve a broader mix of stations. These trains would fill the gap between today's intercity and regional rail markets with fares and service amenities that are between those offered by regional and intercity trains.
- Operational improvements would be implemented to better integrate train service across today's separate markets. This would include "through-service" at major stations to reduce the need to transfer between trains; clockwork train departures and standard stopping patterns, to improve travel time and capacity; integrated ticketing and fares across the NEC to reduce passenger inconvenience; and reduced dwell time at stations to reduce travel time. In addition, stations would be enhanced and train schedules integrated across the NEC to provide easier transfers between trains, thereby increasing travel options and frequencies to many stations.

  Program Level A includes a conventional and an enhanced alternative. Program Levels B and C test three different enhanced operating approaches. These operating approaches are designed to quantify the trade-offs between frequency of service, trip time, and the convenience of one-seat service. This test allows for comparison among the operating approaches and between enhanced and conventional operations within each program level. Comparison of conventional and enhanced operations has helped FRA to identify ways to improve service and performance, and to define the most efficient approaches to upgrading the NEC.

- New Markets: Where Program Level A addresses only the minimal additional service and improvements required to meet growing demand for rail service on the existing NEC, Program Levels B, C, and D look to expand rail service off the existing spine and to better integrate with rail service on connecting corridors. Program Level C adds a 60-mile bypass route in southeastern Connecticut and new routes to downtown Baltimore and Philadelphia, and Program Level D adds a second spine to the NEC to serve new markets and support significant new service, including HSR. Program Level D includes four different second-spine route options to quantify differences in ridership, travel time, and connectivity to other markets.

The following Preliminary Alternatives were developed:

- **Program Level A:** Program Level A tests the lower bounds of improvements to attempt to meet the Purpose and Need. This program level generally supports the minimum service levels needed to carry regional travel demand as projected for 2040 (or extrapolated from data provided) by the NEC regional rail operators and/or regional metropolitan planning organizations (MPO). Program Level A would provide only a modest expansion of intercity rail service by increasing the carrying capacity of trains (increasing the number of seats), filling passenger train slots that are currently not filled due to lack of equipment, and expanding the number of stations served. Program Level A does not grow rail's share of the travel market and provides no spare capacity beyond 2040.

Targeted investments address the significant state-of-good-repair backlog and relieve major capacity constraints along the NEC. Investments would include the following:

- Two new tracks under the Hudson River to accommodate additional trains operating to and from New York City. The tracks would stub end at New York Penn Station.
- Expansion of New York Penn Station.
- Additional tracks between: New Carrollton, MD, and Wilmington, DE; New York and Stamford, CT; and Canton, MA, to the Route 128 station. Expansion of the right-of-way to provide bypass routes to avoid choke points at key locations in Maryland, New Jersey, and Connecticut.
- Systemic upgrades to enhance reliability.

Within Program Level A, three alternative scenarios were tested:

- **Alternative A1** serves as a financially constrained alternative. While it includes improvements to the NEC that go beyond the No Action Alternative, it would fail to meet projected growth in demand resulting from population and employment increases, and hence would not meet the Purpose and Need. It was included to help quantify the gap between today's level of service and that required to meet future regional travel demand.
- **Alternative A2** would grow the railroad to attempt to meet regional rail travel demand projected in existing markets for 2040 and provide for a minor expansion of intercity service. It would carry forward the same conventional operating approach and stopping patterns used today by the eight regional rail authorities and Amtrak. It illustrates how the railroad would perform in 2040 if it were modestly improved and operated in the same manner as it operates today.
- **Alternative A3** would grow the railroad to attempt to meet regional rail travel demand projected in existing markets for 2040 and provide for a minor expansion of intercity service. It would also introduce limited metropolitan service, carrying intercity and commuter passengers on the same train, to provide additional train service in the peak periods in the busiest NEC markets, and, where feasible, supplement intercity rail service to support a broader mix of stations. Alternatives A2 and A3 allow comparison of conventional and enhanced operations performance.

- **Program Level B:** Program Level B would provide substantially more rail service by expanding the NEC generally to its full extent within the existing railroad right-of-way. In addition to the upgrades included within Program Level A, all Program Level B alternatives would include the following infrastructure improvements:
  - Expansion of the entire length of the NEC to four tracks, and to as many as six tracks in the busiest sections of New Jersey and Connecticut
  - Expansion of the right-of-way to provide bypass routes to avoid choke points at additional key locations, including Wilmington DE, Trenton NJ and New Rochelle NY

- Expansion of rail passenger facilities at Washington Union Station, New York Penn Station, and Boston South Station to support the increased number of trains and passengers

The added capacity would support expansion of regional rail service to accommodate growth in demand projected in existing markets for 2040. It would also double the number of intercity trains, and modestly improve intercity travel times, providing travelers a broader range of rail service options. This would enable rail to capture a larger share of the travel market. Program Level B was intended to represent the largest role passenger rail can play in the region if investment is predominantly limited to the existing NEC right-of-way.

Program Level B includes four alternatives intended to test different service dynamics:

- **Alternative B4** would grow the railroad to the full extent of its right-of-way, providing the capacity for a substantial growth in rail service. Like Alternative A2, it would carry forward to 2040 the same conventional operating approach and service patterns used today by the eight regional rail authorities and Amtrak, expanded as appropriate to take advantage of the new capacity.
- **Alternative B5** would grow the railroad to the full extent of its right-of-way, providing the capacity for a substantial growth in service. However, the service plan applied to this alternative was designed to maximize the frequency of train service between markets on the NEC. To provide the capacity to maximize train frequencies, there were fewer high-speed intercity-express trains (which consume capacity to pass slower moving trains). In addition, train schedules were integrated across the corridor to support the convenient transfer of passengers from one train to another as well as from one type to the other (e.g., regional rail to intercity) rather than to rely solely on one-seat end-to-end rides to some markets. Thus, for example, service between the Philadelphia and New York City market might be substantially expanded, but passengers arriving from Harrisburg, PA, on the connecting Keystone corridor might be required to transfer to an NEC train at Philadelphia rather than expect a one-seat ride to New York City.
- **Alternative B6** would grow the railroad to the full extent of its right-of-way, providing the capacity for a significant growth in service. However, the service plan applied to this alternative was designed to support the fastest possible intercity-express trip time. This would necessarily reduce the number of trains that can otherwise operate at slower speed on the NEC, providing a direct comparison between frequency of service (Alternative B5) and travel time (Alternative B6) or one-seat ride convenience (B7).
- **Alternative B7** would grow the railroad to the full extent of its right-of-way, providing the capacity for a significant growth in service. However, the service plan applied to this alternative was designed to maximize the number of one-seat rides for both trips starting and ending on the NEC and trips starting or ending at stations on connecting rail corridors, such as Richmond, VA, or Springfield, MA. Maximizing the number of one-seat rides is more convenient for some passengers, but necessarily reduces the total number of trains that can serve a specific station. Alternative B7 (one-seat ride) enabled a direct comparison with frequency of service (Alternative B5) and travel time (Alternative B6).

- **Program Level C**: Program Level C would build on Program Level B to further expand service by adding trains to various new markets in the Northeast. While remaining primarily on the existing

NEC, Program Level C would add portions of a second spine in order to serve new markets and to improve travel time. Anticipated improvements include the following:

- New downtown stations in Baltimore, MD, and Philadelphia, PA, to supplement service to existing stations
- A new 60-mile supplemental two-track route between Old Saybrook, CT, and Kenyon, RI, to address capacity constraints over five movable bridges in southeastern Connecticut along the existing New Haven-Providence shoreline route
- Additional track and right-of-way between New Haven, CT, and New Rochelle, NY, to accommodate additional intercity and regional rail trains in what is the busiest segment of the NEC
- Two additional tracks under the East River in New York to accommodate expanded intercity service and additional regional rail trains at Penn Station New York from Long Island and from New York and Connecticut suburbs north of the city. New stub-end Penn Station tracks included in Program Level A and B from the two additional Hudson River tunnels would extend eastward to the six East River tunnels and connect with the existing NEC tracks near Sunnyside Yard.

Program Level C includes four alternatives intended to test service dynamics similar to Program Level B:

- **Alternative C8** would carry forward to 2040 the same operating approaches and service patterns used today by the eight regional rail operators and Amtrak, expanded as appropriate to take advantage of the new capacity. It illustrates the Program Level C performance if the railroad operates in the same manner as it operates today.
- **Alternative C9** would maximize the frequency of train service between markets on the NEC.
- **Alternative C10** would support the fastest possible intercity-express trip time.
- **Alternative C11** would maximize the number of one-seat rides for both trips starting and ending on the NEC and trips starting or ending at stations on connecting rail corridors, such as Richmond, VA, or Springfield, MA.

- **Program Level D**: Program Level D would transform the role that rail plays on the NEC and in the region by adding a "second spine" from Washington, D.C., to Boston to support significant additional rail service across the region, as well as new air-competitive HSR service between major NEC markets. The addition of a second spine—coupled with improvements to the existing NEC generally equivalent to those included in Program Level B—would support a significant increase in the number of regional rail and intercity trains. Both regional and intercity rail ridership would jump as a result of the significant new capacity, service to new markets, faster trip times, and the opportunity to operate new types of service. In addition, the second spine would allow for implementation of true HSR service on the NEC, operating at speeds up to 220 mph, with the goal of travel times of less than 100 minutes between Washington, D.C., and New York City and between New York City and Boston. The second spine would also be used for new types of regional service, including high-speed zone express service (serving small groups of stations before operating express on the new high-speed tracks), as well as very limited-stop intercity-express service.

South of New York City, the second spine would be built in close proximity to the existing spine and serve existing stations (with the exception of portions of Alternative D15). North of New York, large portions of the second spine would be located to serve new markets, expanding the market reach of the NEC (with the exception of Alternative 12).

Program Level D includes four second-spine route options:

- **Alternative D12** would include a second spine generally parallel to the NEC from Washington, D.C., to Boston, MA
- **Alternative D13** would include a second spine generally parallel to the NEC from Washington, D.C., to New York City, then to Boston, MA, via White Plains, NY, Danbury and Hartford, CT, and Providence, RI
- **Alternative D14** would include a second spine generally parallel to the NEC from Washington, D.C., to New York City, then to Boston, MA, via Ronkonkoma, NY (on Long Island), New Haven and Hartford, CT, and Worcester, MA
- **Alternative D15** would include a second spine serving the Delmarva Peninsula between Washington, D.C., and Wilmington, DE, then generally parallel to the NEC to New York City, then to Boston, MA, via Nassau County (on Long Island), Stamford and Hartford, CT, and Springfield and Worcester, MA.

Table 1 summarizes the Preliminary Alternatives.

As noted, service and route options were separately tested, refined, and optimized for different geographic markets within the NEC in order to be able to develop a range of Tier 1 EIS alternatives. For example, while the fifth and sixth Hudson River tunnels were included and tested only as a component of the most expansive program level, they could be added to a future lower-level investment scenario if needed to meet projected regional and intercity rail demand. Similarly, each major route segment included in the Program Level D alternatives (e.g., Hartford-Worcester-Boston; Hartford-Providence-Boston; and Hartford-Springfield-Boston) was separately tested to enable the possible repackaging of the best-performing segments for analysis in the Tier 1 EIS. This modular approach will be used to craft the strongest “package” of separate route, infrastructure and service options into the alternatives to meet specific market needs within different NEC sub-regions.

Table 1: Summary of Preliminary Alternatives

Service Program	Alternative	Intended Service Outcomes	Service or Route Options
A	1	**Addresses State of Good Repair and Grows Commuter & Intercity Service** ▪ Attempts to meet projected regional rail demand for existing NEC markets ▪ 2 intercity trains/hr each direction	Fiscally Constrained
	2		Conventional Service
	3		Enhanced Service
B	4	**More Capacity on Existing NEC Route** ▪ Meets growth in regional rail demand for existing NEC markets ▪ 4 intercity trains/hr each direction	Conventional Service
	5		Enhanced: High-density service
	6		Enhanced: Fastest Express Service
	7		Enhanced: Most One-Seat Service
C	8	**Targeted Growth to New Markets** ▪ Meets growth in regional rail demand for existing and expanded regional rail markets ▪ 4 intercity trains/hr each direction ▪ Downtown Baltimore and Philadelphia stations	Conventional Service
	9		Enhanced: High-density service
	10		Enhanced: Fastest Express Service
	11		Enhanced: Most One-Seat Service
D	12	**Additional NEC Spine** ▪ Meets and exceeds growth in existing and expanded regional rail markets ▪ 9 intercity trains/hr each direction ▪ Downtown Baltimore and Philadelphia stations ▪ Serves major and intermediate markets along second-spine route	Generally parallel to existing NEC
	13		Via Danbury–Hartford–Providence
	14		Via Suffolk–Hartford–Worcester
	15		Via Delmarva and Nassau–Stamford–Danbury–Springfield

3. Analysis of the Preliminary Alternatives

Evaluation of the four program levels consisted of comparing the 15 Preliminary Alternatives to understand how they meet the purpose of the NEC FUTURE Investment Program and to understand the effect of the different service plans on ridership, travel time and service quality, and, in the case of the different Program Level D second-spine route alternatives, to compare performance and impacts.

Evaluation Criteria: Evaluation criteria and associated performance measures derived from the Purpose and Need were used in the overall alternatives development process. The criteria are based on best practices and models used in transportation investment programs of similar physical and programmatic magnitude at a Tier 1 level of analysis, as well as stakeholder input. The criteria and data used to evaluate the Preliminary Alternatives, such as ridership and travel time, are detailed below. Data supporting other criteria and associated metrics, such as economic impacts, capital and operating costs, and construction phasing, will not be developed until later in the study process and will be used to evaluate the Tier 1 EIS alternatives. Table 2 presents the set of evaluation criteria used to evaluate the Preliminary Alternatives.

Table 2: NEC FUTURE Evaluation Criteria

Evaluation Criteria	Metrics
Accommodate Growth and Expand Capacity	▪ Annual passengers ▪ Annual passenger miles ▪ Peak-hour passengers ▪ Trains per peak-hour
Rebuild Aging Infrastructure	▪ NEC in a state of good repair
Service Effectiveness and Performance	▪ Travel-time savings ▪ Express trip time by segment ▪ Number of hourly corridor-wide intercity train frequencies ▪ Total number of peak-hour trains operating on NEC ▪ Stations and city-pairs served by intercity trains
Connectivity	▪ Stations served by intercity trains ▪ City-pair combinations ▪ Improved air-rail connections ▪ Ability to share existing and future tracks, stations and other railroad infrastructure

The metrics and data for each criterion were used to compare the program levels, as well as to compare the separate alternatives within each program level. This comparison is presented below. In addition, Section 3.6 includes separate ridership and travel-time data for different geographic segments of the Program Level D second-spine alternatives. Separately evaluating the second-spine alternatives by geographic segment will enable the FRA to identify the strongest second-spine route segments and to ultimately assemble the best-performing second-spine route combinations.

3.1 ACCOMMODATE GROWTH AND EXPAND CAPACITY

Ridership is a key measure of the ability to grow the NEC to accommodate future travelers on the rail system. It also reflects the impact of adding new markets and introducing new types of service. Preliminary ridership data were developed from existing models used by Amtrak and the NEC regional rail operators, or were provided directly from the railroads. In the Tier 1 EIS, travel demand and ridership data will be updated using results from a new NEC demand-forecasting model currently under development.

The performance metrics for this criterion include the following:

- Annual passengers
- Annual passenger miles
- Peak-hour passengers
- Peak-hour trains

3.1.1 ANNUAL PASSENGERS/ANNUAL PASSENGER MILES

Table 3 presents preliminary estimates of annual trips and annual passenger miles for the existing condition and the four program levels. Not surprisingly, the data indicate that ridership has a direct relationship with the level of service (and consequently investment). As service increases, projected ridership also increases, indicating that demand for expanded rail service is high.

Table 3: Current and Preliminary Estimates of Future NEC Ridership

	Annual Trips (millions) (average across program level)	Annual Passenger Miles (billions) (average of alternatives within each program level)
Existing (2012)	330	10
Program Level A (2040)	471	15
Program Level B (2040)	495	17
Program Level C (2040)	505	18
Program Level D (2040)	550	24

In addition to comparing annual ridership at the program level, ridership and passenger miles by service type can be compared within each program level to better understand the impacts of service plans designed to emphasize different service attributes. The ridership data in Figures 1 and 2 have been disaggregated to show ridership by service type, as follows:

- **Intercity–express** represents express passenger train service to the largest NEC markets (i.e., today's Acela service operated by Amtrak).
- **Intercity–corridor** represents passenger train service that covers longer distances than commuter or regional trains, but makes more stops compared to intercity-express service. Alternatives A3, B5, B6 and B7, and C9, C10, and C11 include proposed metropolitan service, which would expand the number of stations served by intercity trains well beyond the current 25 Amtrak station stops. While metropolitan trains also carry longer-distance regional rail riders, they are included as intercity-corridor trains in Figures 2 and 3.
- **Regional rail** represents commuter rail service between suburban and urban markets operated today by the eight regional rail operators.

Figure 1: Preliminary Incremental Increase in Annual Passenger Trips (millions)

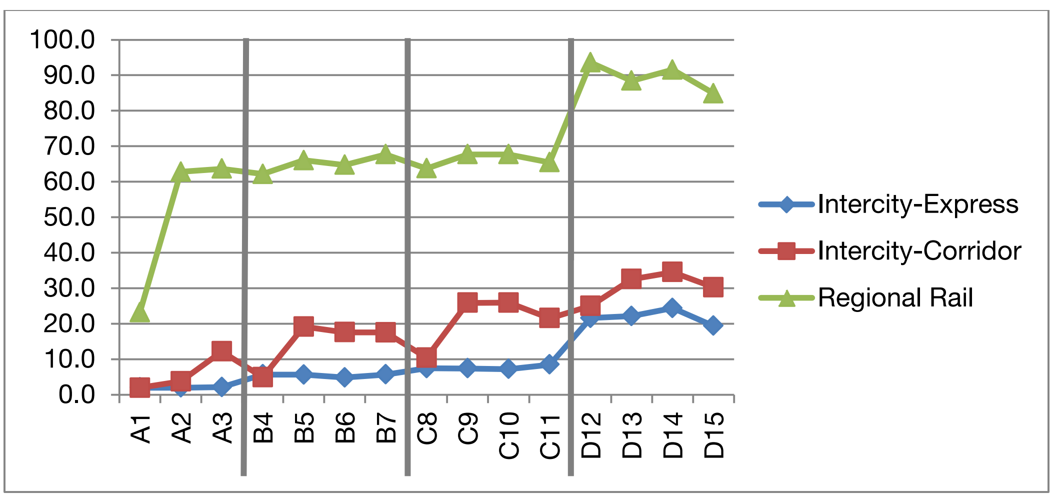
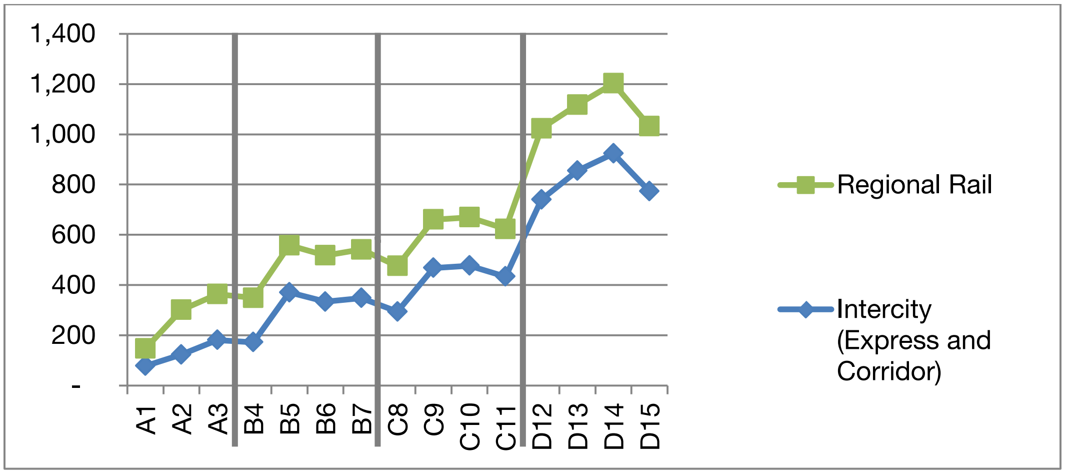


Figure 2: Preliminary Incremental Increase in Annual Passenger Miles (millions)



3.1.2 NEC PEAK-HOUR RIDERSHIP

Peak-hour ridership reflects the highest demand on the rail network during the morning and evening rush hour. Accommodating this level of peak demand drives the need for additional service, which in turn requires changes in operations and additional infrastructure. The easiest metric to illustrate peak-hour demand is the number of people passing a single point or "screen-line location" in the rail system during the rush hour based on the maximum reasonable throughput capacity the railroad infrastructure can support. Screen-line data are provided in Table 4 at the program level for four of the busiest locations on the NEC: Washington, D.C. (between Union Station and New Carrollton station); Philadelphia (between Chester, PA, and 30th Street Station); New York (Hudson River); and Boston (south of Back Bay Station at Forest Hills). The data represent the average for the program level across all alternative service types.

Table 4: Preliminary Peak-Hour Ridership at Major Screen Lines

Program Level	Washington	Philadelphia	New York City (Hudson River)	Boston
A (excluding Alt 1)	8,600	16,200	40,650	10,150
B	10,250	17,150	40,550	11,200
C	10,950	17,750	42,200	11,550
D	13,900	19,200	50,250	13,850

3.1.3 PEAK-HOUR TRAINS

Measurement of peak-hour trains provides a way in which to compare capacity. This is particularly important in the New York City region, which experiences the heaviest peak-hour traffic and suffers from severe train capacity issues. Table 5 provides a preliminary estimate of the number of peak-hour trains for all rail services crossing the Hudson River, the most constrained point on the NEC, for each program level, compared to the maximum number of trains currently projected by the regional rail operators as required to meet future demand (2040). These preliminary projections will be refined for the Tier 1 EIS alternatives later in the study using the new NEC demand-forecasting and operations models.

Table 5: Total Preliminary Peak-Hour Crossings, Hudson River Screen-Line, All Services

Program Level	Maximum Possible Peak-Hour Trains	Maximum Number of Trains Projected for All Services (2040)
Existing (2012)	24	N/A
A (Alts A2 and A3)	44	44–50
B	48	
C	51	
D	70	> 60

Program Levels A, B, and C include construction of two additional trans-Hudson tracks (for a total of four tracks), which permits a doubling of train throughput compared to today's levels. Program Levels B and C also facilitate some through-service for regional trains across Manhattan, providing operational efficiencies that increase throughput under the Hudson River. Program Level D adds a fifth and sixth track across the Hudson River, supporting a large increase in peak-hour crossings.

3.2 REBUILD AGING INFRASTRUCTURE

A primary objective of any long-term investment program on the NEC is to bring the NEC to a "State of Good Repair," where the backlog of infrastructure requiring replacement is eliminated and future capital upgrades are planned and implemented according to a regular replacement cycle. Amtrak has estimated that it will cost in excess of $10 billion to bring the NEC to a state of good repair, in addition to any investments associated with expansion of capacity or improved travel time.

All of the Preliminary Alternatives include and add to the improvements required to achieve a state of good repair.

3.3 SERVICE EFFECTIVENESS AND PERFORMANCE

Service effectiveness measures the adequacy of an alternative to meet key performance standards that influence ridership. This criterion includes various metrics that focus on the passenger experience, such as travel time and frequency of service. Metrics currently available include the following:

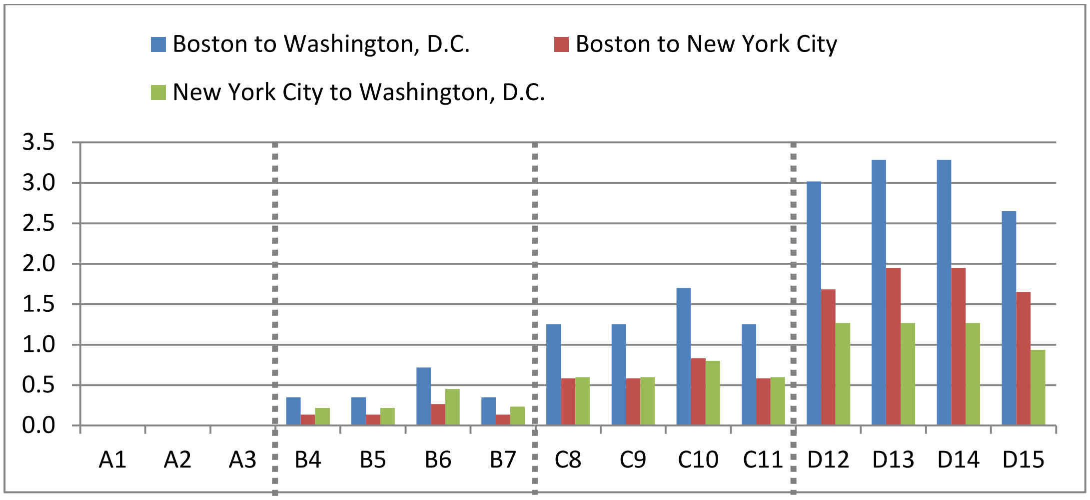
- Express trip times between major cities (New York City to Washington, D.C. and New York City to Boston)
- The number of hourly corridor-wide intercity train frequencies
- The total number of peak-hour trains operating across the NEC
- Stations and station-pairs served by express, intercity-corridor, and metropolitan trains

3.3.1 NEC TRAVEL-TIME SAVINGS

Measurement of express trip time savings is a key measure of service effectiveness. This metric considers how much time can be saved on trips across the existing NEC, and quantifies the trip time benefit of building a second spine specifically designed to support world-class HSR service. Figure 3 presents the preliminary estimates of trip time savings (in hours) for express trips from Boston to

Washington, D.C., Boston to New York City, and New York City to Washington, D.C., compared to today.

Figure 3: Preliminary Incremental Express Trip Time Savings (Hours) Compared to Today



3.3.2 TRAIN FREQUENCIES

Table 6 details the maximum number of peak-hour intercity trains (express, intercity-corridor, and metropolitan trains) that can operate in each direction.

Table 6: Express, Intercity-Corridor, and Metropolitan – Maximum Trains per Hour

Program Level	Maximum Express/Intercity/Metropolitan Trains Per Hour in Each Direction
No Action	4–5
A	6–10
B	10–14
C	10–14
D	23–28

Table 7 details the total number of peak–hour trains operating on the NEC in both intercity and regional rail services.

Table 7: Total (Intercity and Regional Rail) Peak–Hour Trains Operating on the NEC

Program Level	Total Trains Per Peak Hour Operating on the NEC
No Action	174
A	196–236
B	239–241
C	236–244
D	310–320

3.4 CONNECTIVITY

A primary objective of NEC FUTURE is to enhance connectivity between existing NEC markets and the NEC for travelers connecting to it from other rail corridors, such as Southeast HSR Corridor and the Keystone Corridor, or from other modes of transportation, such as airports. Key metrics for measuring the increase in connectivity include the following:

- Stations served by intercity trains
- City-pair combinations
- Improved air-rail connections
- Ability to share existing and future tracks, stations and other railroad infrastructure

3.4.1 NEC STATIONS SERVED

Today's Amtrak intercity trains stop at only 25 of the over 100 intercity and regional rail stations on the NEC, and 61 stations when including the Keystone, Empire, Inland Route and northern Virginia stations. As development patterns have changed over the past 40 years, and as intercity, inter-suburban and regional travel have grown, many smaller markets traditionally served only by regional rail could benefit from inclusion in the broader Northeast rail network. This would support new market connections and increase the number of one-seat rides and other convenient connections available to travelers. Moreover, treating the NEC as an integrated network of rail services to all NEC markets—with coordinated schedules and a common fare system regardless of the operator—would benefit all travelers across the region and likely increase demand for rail.

As noted, Alternatives A3, B5–7, C9–11, and D12–15 include metropolitan trains, which serve a broad mix of intercity and regional rail stations across the NEC and increase the number of city-pair connections. In addition, Program Levels C and D add new markets to the NEC, increasing the number of stations and city-pairs served. The increase in city-pair combinations is reflected on Table 8, which compares the number of stations and station-pairs served by both intercity-corridor and metropolitan trains.

Table 8: Stations Served by Intercity-Corridor and Metropolitan Trains (NEC, Keystone, Empire, Inland Route and northern Virginia)

Alternative	Stations Served	Station-Pairs Served
No Action	61	766
A1	63	825
A2	64	856
A3	71	1,095
B4	62	820
B5	71	1,038
B6	71	1,038
B7	72	1,052
C8	68	981
C9	72	1,116
C10	72	1,149
C11	75	1,171
D12	75	1,242
D13	79	1,306
D14	79	1,411
D15	85	1,446

3.4.2 RAIL-TO-AIRPORT CONNECTIONS

The existing NEC provides direct rail-to-airport connections (via regularly scheduled shuttle service) at three NEC stations:

- Baltimore/Washington International (BWI) Airport near Baltimore
- Newark Liberty International (EWR) Airport in New Jersey
- T.F. Green (PVD) Airport in Providence

Program Levels C and D would expand the number of airport stations (Table 9).

Table 9: Airport Stations

Program Level	Airport Stations	Airports Added
No Action	3	BWI; EWR; PVD
A	3	BWI; EWR; PVD
B	3	BWI; EWR; PVD
C	5	BWI; EWR; PVD; DCA; PHL
D12	5	BWI; EWR; PVD; DCA; PHL
D13	6	BWI; EWR; PVD; DCA; PHL; HPN (White Plains)
D14	7	BWI; EWR; PVD; DCA; PHL; ISL; ORH (Worcester)
D15	8	BWI; EWR; PVD; DCA; PHL; JFK; BDL; ORH

3.5 ENVIRONMENTAL CONSEQUENCES TO NATURAL AND BUILT ENVIRONMENT

Full evaluation of the environmental consequences will occur in the Tier 1 EIS. Nonetheless, it was instructive at this preliminary stage to consider the potential for relatively lesser or greater environmental effects of each of the Preliminary Alternatives. This involved identifying environmentally sensitive areas adjacent to or bisecting the representative route[1] of the Preliminary Alternatives. For example, to measure the environmental sensitivity associated with each of the Preliminary Alternatives, areas of environmental sensitivity were identified along the representative routes for each alternative for five resource categories. Figure 4, Figure 5, and Figure 6 present these areas of environmental sensitivity in the southern, central, and northern regions of the NEC, respectively. They include the following categories:

- Hydrologic Resources (identified in blue)
- Environmental Justice populations (identified in yellow)
- Cultural Resources (identified in pink)
- Parklands and Wild and Scenic Rivers (identified in brown)
- Ecological Resources (identified in green)

[1] Representative route refers to a proposed route or potential alignment for a Preliminary Alternative. The representative route includes the physical footprint of the improvements associated with the Preliminary Alternative. The horizontal and vertical dimensions of the footprint of the representative route are based on prototypical cross-sections for these improvements. The representative route is used as a proxy for estimating the potential effects of a route whose location could shift during further alternatives development and/or subsequent project-level reviews.

Figure 4: Preliminary Areas of Environmental Sensitivity – Southern Region

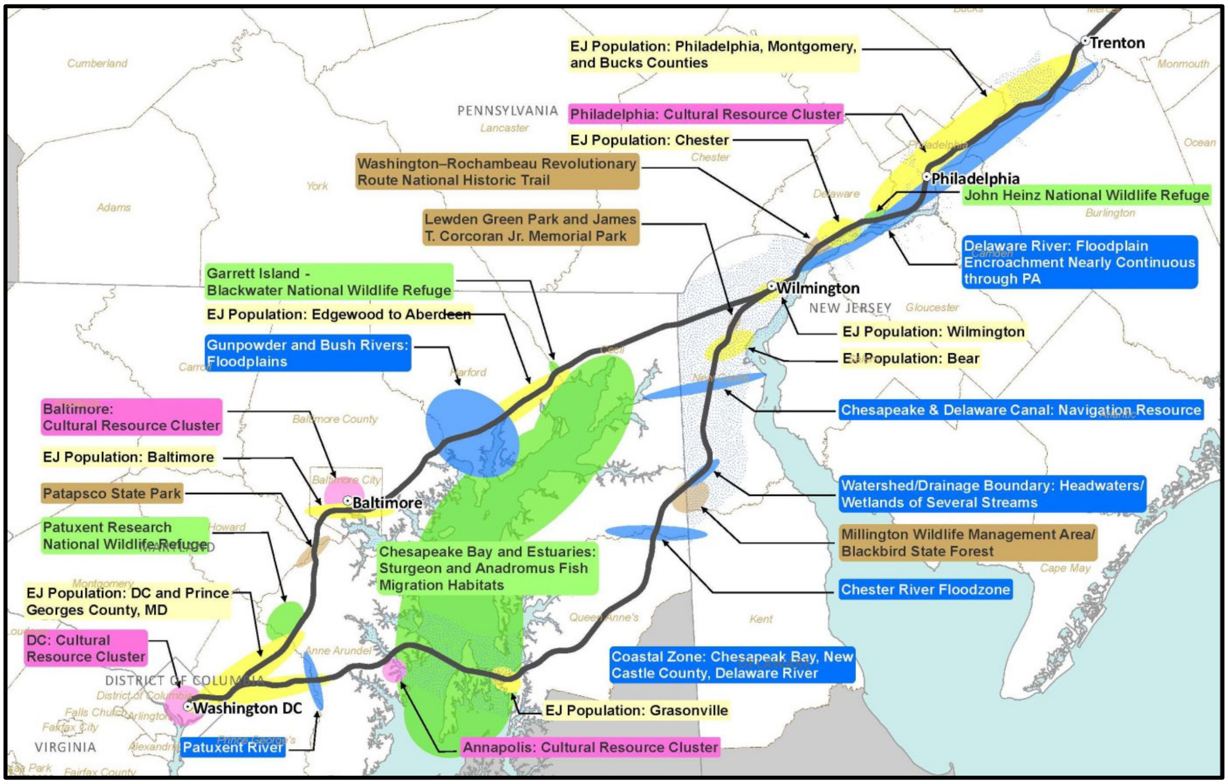


Figure 5: Preliminary Areas of Environmental Sensitivity – Central Region

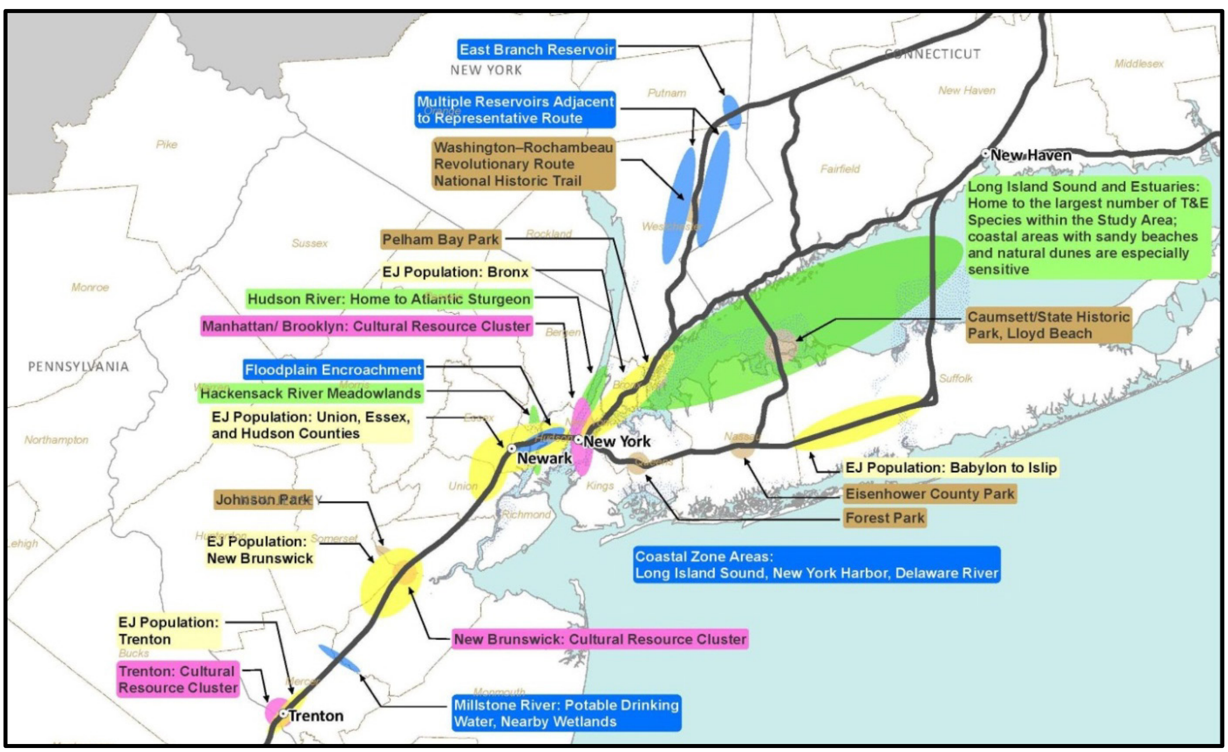
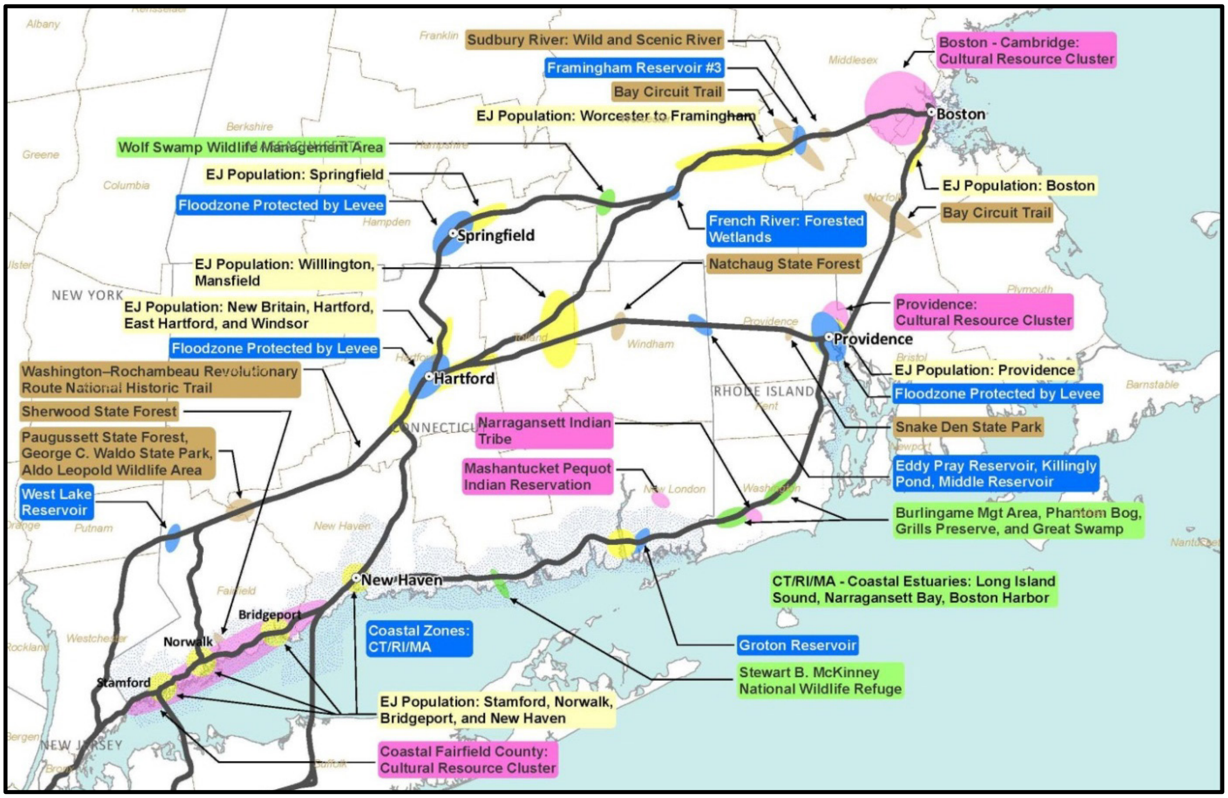


Figure 6: Preliminary Areas of Environmental Sensitivity – Northern Region



The areas of environmental sensitivity are common for all the Preliminary Alternatives along the existing NEC; the only differences between the alternatives are for those portions of the Program Levels B, C, and D alternatives that would add tracks on new rights-of-way off the existing NEC. Potential impacts to multiple resources, each of which is regulated by multiple federal and state agencies, were identified for the following locations and alternatives:

- Chesapeake Bay/Delaware Canal (D15)
- New York City to Danbury to Hartford, Connecticut (D13, D15)
- Long Island Sound (D14, D15)
- New Haven to Providence along NEC (D12)

This early environmental evaluation indicates that each of the alternatives would have environmental effects, some of which would likely require mitigation. At this step of evaluation, however, it does not appear that any single area of environmental sensitivity is a differentiator to recommend dismissing an alternative from further consideration. More-detailed consideration of effects on each of the environmental resource areas and comparison of possible environmental consequences among Tier 1 EIS alternatives will be undertaken in the Tier 1 Draft EIS.

3.6 SECOND-SPINE SEGMENT ANALYSES

The Program Level D second-spine alternatives were designed to permit separate testing of key market segments, such as New York to Hartford and Hartford to Boston. In this way, the best-performing combinations of second-spine route segments could be reassembled for consideration in the Tier 1 EIS. Ridership data for these key segments are presented below. Other data currently under development, including capital and operating costs, constructability, and environmental impacts, will be critical to decisions regarding whether and where to build a second spine. Thus, the evaluation of the second-spine alternatives and the performance of individual route segments within those alternatives will continue as part of the Tier 1 EIS analysis using the new forecasting model and other refined tools.

The preliminary evaluation was conducted for the following second-spine market segments:

- South of New York City: parallel to existing spine versus Delmarva
- North of New York City: New York-Boston; New York-Hartford; and Hartford-Boston

3.6.1 SOUTH OF NEW YORK CITY

The only second-spine alternative south of New York was the Delmarva route option included in D15. Stakeholder feedback indicated that this option conflicts with Maryland state policy of focusing transportation and development along the existing BWI/Baltimore corridor. In addition, it could not be incrementally built and would have limited utility until the entire new route segment is constructed. Ridership compared to the routes parallel to the existing NEC also was modestly lower, as shown in Table 10.

Table 10: Preliminary Intercity Annual Boardings (Express and Corridor) – South of New York City

Annual trips ***South of New York***	**NEC Parallel (D12, D13, D14)**	**Delmarva (D15)**
Total annual trips (millions)	38.0	37.0
Primary markets* (millions)	23.4	21.8
Secondary markets** (millions)	2.6	1.7

* New York City, Philadelphia, Washington, D.C.
** Baltimore, BWI Airport, Middletown/Dover, Annapolis

3.6.2 NORTH OF NEW YORK CITY

Table 11 presents the intercity annual boardings for the north of New York City segment of each of the Program Level D alternatives, which are illustrated in Figure 7.

Table 11: Preliminary Intercity Annual Boardings (Express and Corridor) – North of New York City

Annual Trips ***North of and through New York***	**D12**	**D13**	**D14**	**D15**
Total annual trips (millions)	23.8	28.4	29.7	25.4
Boston / Back Bay to New York City (millions)	7.3	9.9	8.9	7.9

Figure 7: Preliminary Alternatives – North of New York City Segments

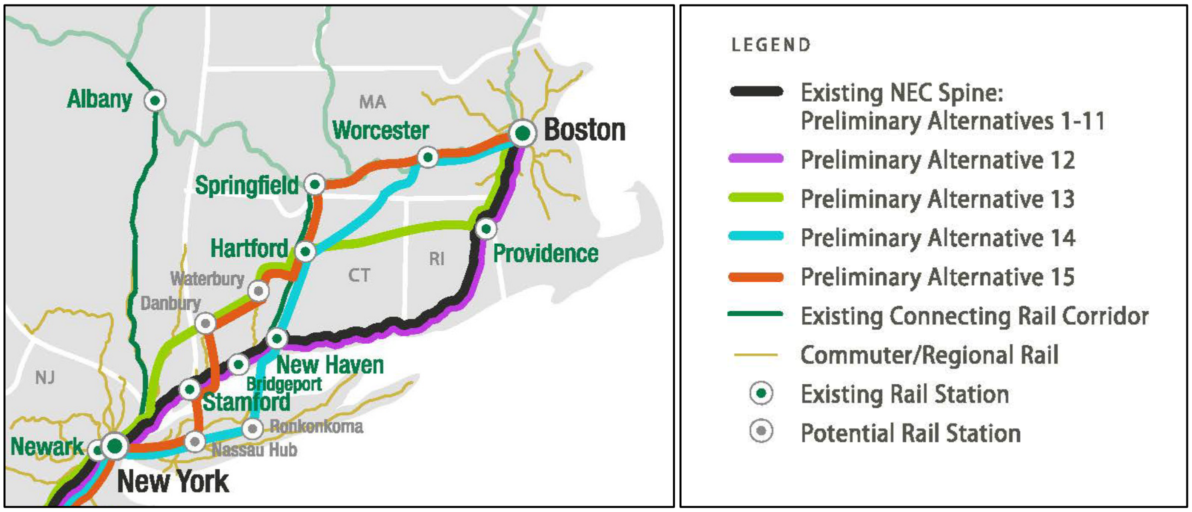


Table 12 presents the intercity annual boardings for the New York City-Hartford segment for Alternatives D13, D14, and D15. The data indicate there are strong markets for new intercity passenger rail service on Long Island and in Central Connecticut.

Table 12: Preliminary Intercity Annual Trips (Express and Corridor) – North of New York City (New York–Hartford)

Annual Trips *North of and through New York*	**Central Connecticut (D13)**	**Nassau-Suffolk-New Haven (D14)**	**Nassau-Stamford-Danbury (D15)**
Total annual trips (millions)	28.1	29.4	25.1
Primary markets* (millions)	26.7	26.4	24.4
Secondary markets** (millions)	3.3	5.3	4.0

* Boston, New York City
** Hartford, New Haven, Stamford, Nassau Hub, Suffolk Hub-Ronkonkoma, Danbury-Waterbury

Table 13 presents the intercity annual boardings for the Hartford-Boston segment options. The data indicate a modestly stronger market potential via Hartford-Providence, as Providence is the largest secondary travel market between New York and Boston.

Table 13: Preliminary Intercity Annual Boardings (Express and Corridor) – North of New York City (Hartford-Boston)

Annual Trips ***North of and through New York***	**Via Providence**	**Via Worcester**	**Via Springfield-Worcester**
Primary markets* (millions)	28.7	28.4	27.7
Secondary markets** (millions)	5.6	5.0	5.3

* Boston, New York City
** Route 128/Riverside, Providence, Hartford, Worcester, Springfield

Review of the second-spine alternatives data indicate that two of the four Program Level D alternatives—D13 (Central Connecticut to Providence) and D14 (Suffolk County to Hartford and Worcester)—generate better ridership and travel-time results. However, as noted, selection of the second-spine route will depend on a broad range of criteria and additional data to be developed using refined tools that will be available in the Tier 1 EIS.

4. Key Findings from Preliminary Alternatives Evaluation

Analysis of the data generated by comparison of the Preliminary Alternatives has helped FRA to develop a smaller set of alternatives for detailed analysis in the Tier 1 EIS. The findings fall into three categories:

- Service dynamics within each of the program levels (i.e., comparison of enhanced and conventional service approaches and differences between service plans optimized for frequency, trip time or one-seat rides). This relates to Program Levels A, B, and C.
- Differences between the program levels in terms of defining the role that rail can play in transporting travelers in the NEC region.
- Comparisons between the different Program Level D route alternatives.

Key findings from the evaluation of the data are discussed below.

4.1 SERVICE DYNAMICS: COMPARING ALTERNATIVES WITHIN EACH PROGRAM LEVEL

Within each program level, studying different enhanced service operating plans allowed for a comparison of rider preferences for frequency of service, trip time, and one-seat-ride service. Each preference also was compared against today's conventional operations service alternative.

Evaluation of the alternatives supports two important conclusions:

- **Enhanced Operations Outperform Conventional Service in All Cases**. Whether optimized for train frequency, trip time, or one-seat rides, the use of service plans that go beyond the bounds of today's conventional approach to service generate more—sometimes significantly more—ridership than simply growing and applying today's operations. This can be seen by comparing ridership for Alternative A3 with A2; Alternatives B5, B6, and B7 with B4; and Alternatives C9, C10 and C11 with C8.

  This result is not surprising, as the markets on the NEC have evolved since the current operating structure—with Amtrak and eight regional rail authorities—was created following the bankruptcy of the Penn Central Railroad some 40 years ago. The geographic boundaries of most urban areas have grown; commuting distances have expanded; many small bedroom communities now are business and travel destinations of their own; and important inter-suburban travel markets that cross regional rail service boundaries have developed. Most important, the Northeast itself has grown into a more contiguous region of more than 42 million people. Enhanced operations treat the NEC as a single network of inter-related rail services. It connects markets more directly, by providing greater frequency of service and more service options (either by reliable timed transfer or one-seat ride), and supports faster trip times. In this way, enhanced operations provides a framework for adapting to changing markets on the NEC and catalyzing a more integrated corridor-wide operating environment.

A key element of enhanced operations is metropolitan service. FRA envisions that metropolitan service would be operated with high-performance equipment and at regular headways either within an extended metropolitan area or over the entire length of the corridor from Boston to Washington. By serving a mix of both intercity and commuter rail markets, and offering a price point between traditional commuter and intercity fares, metropolitan trains can fill gaps that exist in current market coverage by stopping more frequently at a broader mix of stations. Which markets offer the best service and ridership options will have to be tested and validated using the new NEC demand-forecasting model later in 2014.

Table 8 showed the significant increase in number of stations and station-pairs served under the enhanced service alternatives compared to the conventional service alternatives.

- **The Different Enhanced Service Plans Generated Similar Performance**. While enhanced service alternatives consistently outperformed conventional service alternatives, differences in performance between the different enhanced alternatives within each program level were not meaningful at this stage of analysis. In Program Level B, for example, enhanced service designed to accentuate train frequency generated slightly higher ridership than those designed to accentuate the best travel time or one-seat-rides. On the other hand, in Program Level C, the best performer was travel time, but it was only marginally better than the alternative favoring frequency of service. These results underscore the benefits of providing sufficient capacity to permit a broad range of services across the NEC with the flexibility to support future travel needs as they develop. This may mean a different service focus for different portions of the NEC at any given time, or the ability to adapt rail operations across the NEC to changing demographics. The key is providing sufficient capacity to meet market demands, and the flexibility to adapt operations to the changing needs of the market.

4.2 THE ROLE OF RAIL: COMPARING THE PROGRAM LEVELS

The four program levels articulate different visions for the role of rail on the NEC—from the role it plays today, in comparison to other modes, to a much more significant role through creation of a second spine capable of supporting high-speed operations. Given the significant growth in population and employment projected for the region, changing land use patterns that have increased the demand for travel to downtown urban areas, and the severe congestion that already clogs highway and air transportation, it becomes clear that provision of additional rail service nets large numbers of additional rail passengers. While it is essential to validate the preliminary ridership data using the new NEC demand-forecasting model, it appears the maxim “build it and they will come” indeed applies to rail service on the NEC.

A number of findings can be made regarding each of the program levels:

- **Program Level A** would provide the least robust program for upgrading the NEC and fails to meet the Purpose and Need. It would support the immediate growth needs of the regional rail operators, but, as noted below, would facilitate only small increases in intercity rail service. Importantly, it would leave no margin for growth after attempting to meet initial projections of regional travel demand. The capital improvements required to support Program Level A would serve as a building block for other program levels rather than a long-term vision defining the role of rail on the NEC.

- The lack of infrastructure expansion in southeastern Connecticut, and rail congestion between New Rochelle, NY, and New Haven, CT, would prevent the addition of more intercity train service north of New York City. The only increase in intercity rail service would come from expanding train capacity (more seats on existing trains) and filling up all intercity rail slots during non-peak portions of the day.
- Capacity constraints would remain in New York under Program Level A due to the limits on the number of trains that can pass through the additional Hudson River tunnels, which stub end at Penn Station (see Table 5). NJ TRANSIT forecasts maximum train levels in 2040 to Penn Station that may exceed the carrying capacity of the two existing and planned two additional Hudson River tunnel tracks. The number of trains passing through the East River tunnels would also be at capacity, limiting options for additional Long Island Rail Road service and possible Metro-North Railroad service to New York Penn Station.
- Total ridership would increase by 140 million annual trips to 471 million compared to 2012, and annual passenger miles would increase to 15.3 billion, 54 percent more than in 2012. However, 95 percent of the growth in annual trips would be in the regional rail market; continued capacity constraints would strictly limit opportunities for growth in intercity ridership.
- Express travel time would be essentially the same as today.
- No new markets would be added; however, some stations served today only by commuter trains would be served by metropolitan trains in Alternative A3.
- Program Level A would provide little or no capacity for additional growth beyond 2040 and little flexibility to adapt to changing conditions along the NEC.

With these limitations, Program Level A fails to meet the Purpose and Need. It is not so much a vision for the future as an interim step toward a longer-term investment program.

- **Program Level B** would expand the railroad generally to its full extent within the existing right-of-way, with additional capacity for more regional and intercity rail service.
  - Building out a 4–6 track NEC would eliminate many choke points across the NEC and would support reliable and more flexible rail operations.
  - By using metropolitan service to consolidate on one train what would have required both a regional and intercity train slot, capacity issues through the Hudson River tunnels could be eased. Like Program Level A, the number of trains passing under the East River would remain at capacity, limiting options for additional Metro-North and Long Island Rail Road service to New York Penn Station.
  - Total ridership would grow substantially to over 495 million trips per year—24 million more than Program Level A. Passenger miles would grow to 17.5 billion for all modes—a 75 percent increase over 2012 levels and 14 percent more than Program Level A.
  - The number of express, intercity-corridor, and metropolitan trains would double from two trains per hour in each direction to four trains per hour in each direction, with ridership increasing 35 percent compared to Program Level A.

- The fastest Washington–Boston express train would be 20–30 minutes faster than today and the number of intercity stations and city-pairs served would grow appreciably.
- Some stations served today only by regional rail trains would be served by metropolitan trains, increasing the number of city-pairs with direct NEC service.
- Program Level B would provide some room to grow beyond 2040 demand except in the New York area.

Program Level B would support a modest long-term growth vision for the NEC. Like Program Level A, this alternative would eventually face capacity constraints in the New York City area. Program Level C, which would add two additional tracks under the East River, and Program Level D, which would add a fifth and sixth track under the Hudson River, would better accommodate projected New York City demand and hence a larger role for rail in the future. Although Program Level B would add few new markets to the NEC, enhanced operations would create new city-pair opportunities, with both one-seat rides and via more convenient transfers.

- **Program Level C** would open up service to new markets off the NEC, which is an important goal of NEC FUTURE, and would support substantial travel-time reductions for express trains.
  - New markets would be added to the NEC by providing new downtown stations in Baltimore and Philadelphia.
  - Capacity constraints in New York City would be partially addressed by constructing two additional East River tracks. This would support new Long Island Rail Road and Metro-North Railroad service to New York Penn Station, as well as facilitate through-service at New York Penn Station, reducing dwell times in the station and adding to throughput of trains across Manhattan. Tracks under the Hudson River would remain at full capacity.
  - Washington–Boston travel time would be reduced 75–85 minutes compared to today and approximately 50–60 minutes compared to Program Level B due to the Old Saybrook, CT, to Kenyon, RI, bypass; new bypasses between New Rochelle, NY, and New Haven, CT; and the two new downtown stations.
  - Ridership would grow to an average 505 million annual trips. Express, intercity-corridor, and metropolitan trips would grow to some 40 million trips—more than three times today's level. This would account for much of the increase compared to Program Level B. Passenger miles would grow to 18.7 billion per year, nearly 90 percent higher than in 2012 and 7 percent more than in Program Level B.

The primary benefit of Program Level C would be the expansion of the NEC to new downtown business markets in center Baltimore and Philadelphia. These new markets would help to generate an average of 10 million additional trips across the NEC, six million of which would be by express, intercity-corridor, or metropolitan trains. There would be only modest gains in regional rail trips, as Program Level C focuses on existing regional rail markets.

- **Program Level D** would dramatically change the role of rail on the NEC by providing a very significant additional increment in capacity, which would be used to implement new HSR service as well as new types of intercity and regional services that could take advantage of the new high-speed infrastructure. The new NEC demand-forecasting model is expected to quantify the significant increase in mode share with new rail services compared to the highway and air modes, as rail would increasingly fill both intercity and regional travel needs. All four proposed second-spine routes would perform well, with Alternatives D13 (NYP-White Plains-Danbury-Hartford-Providence-BOS) and D14 (NYP-Ronkonkoma-New Haven-Hartford-Worcester-BOS) performing the best through access to new markets on Long Island and in Central New England.

- Ridership would jump to an average 550 million annual trips and 24 billion passenger miles, which would be nearly 70 percent more passengers than are carried by rail today on the NEC. The increment over Program Level C would be significant: 45 million additional annual trips and 4.9 billion additional passenger miles.
- Express travel times would be reduced to less than 100 minutes between Washington and New York City and between New York City and Boston, a more than 60 percent reduction in travel time south of New York and less than half of today's travel time north of New York. A passenger would save more than two and one-half hours in travel time compared to today for a trip from Washington, D.C., to Boston. Rail service across the NEC would be competitive with air, and would have the advantage of serving stations located directly in the downtown business hubs.
- New York City area capacity constraints would be resolved through the addition of two additional tracks under the Hudson River, providing a total of six tracks under the Hudson and East Rivers. With corresponding improvements at New York Penn Station to accommodate HSR, capacity would remain adequate to handle growth in New York City for decades to come.
- Regional rail trains could take advantage of access to the new markets north of New York City with new types of long-commute zone express service that could collect passengers at specific locations and then operate at high-speed on the new second spine to access major city center stations in significantly reduced time.

Program Level D would provide the capacity to operate new types of service and to significantly enhance the travel options available to NEC travelers. As such, it has the potential to transform the way people travel in the Northeast, with train service across the region the mode of choice for many travelers. It should be noted that, as the Tier 1 EIS alternatives are developed, it may be possible to incorporate some of these service options and associated infrastructure improvements into alternatives that do not include a full second spine.

More-detailed data and a broader set of evaluation criteria are required to fully compare the NEC second-spine route options. Environmental impact factors, of less significance for evaluating changes in service on the existing NEC, become paramount when considering a new rail line through highly populated and environmentally sensitive areas. Other factors—such as economic impacts and impacts on other modes—will also be important. At this point, the data are insufficient to select one second-spine route over another. Accordingly, the options for a second spine will be further analyzed in the Tier 1 EIS, using the latest models and tools.

5. Defining the Tier 1 EIS Alternatives

On the basis of the analysis of the Preliminary Alternatives and reflecting extensive discussions with NEC stakeholders, FRA is advancing three distinct alternatives through the Tier 1 EIS analysis in addition to the No Action Alternative. The alternatives will describe unique visions for the role of rail in the NEC and enable a broad analysis of the benefits and impacts in the Tier 1 EIS.

Program Level A is better understood as a building block rather than a distinct vision for the NEC. It would address some of the most pressing regional rail capacity issues on the NEC, but would be inadequate to support a meaningful increase in intercity rail service or to meet the longer-term projected capacity needs for the New York City area. Adding to Program Level A some of the capital improvements included in Program Level B that support expanded intercity service and improve capacity in New York City could result in a "lower-end" vision that meets Purpose and Need. Similarly, combining some elements of Program Level C with Program Level B would further address capacity issues in New York City and would support service to new markets and some new types of service, thereby providing a middle-range alternative. Carrying the second-spine Program Level D alternatives forward would provide a high-end alternative.

The FRA will advance three alternatives into the Tier 1 EIS, in addition to the No Action Alternative.

- **No Action Alternative** does not equate to *no investment*. It represents a substantial increase in maintenance and renewal expenditures from today's level necessary to continue today's service in the corridor through 2040. Nonetheless, it simply maintains today's level and types of service, meaning no increases or significant changes to capacity, speeds, or markets served, but making the annual investments in the state-of-good repair backlog that are necessary to maintain today's general service characteristics. Because of the projected population and employment growth in the region, and the inability to expand service to accommodate growing demand, the No Action Alternative necessarily will undermine the role that plays in the region.
- **Alternative 1** would maintain the role of rail as it is today, keeping pace with the level of rail service required to support the proportional growth in population in the Study Area. To keep pace with growth in population, Alternative 1 would include new rail services and commensurate investment in the NEC to expand capacity, add tracks, and relieve key chokepoints. This would be accomplished by combining the best-performing elements defined within Program Level A and the low end of Program Level B, with sufficient capacity to support balanced increases in regional rail and intercity rail services, facilitating a doubling of intercity train service (and a near tripling of seats) compared to today. It would build off service plans developed by the NEC service operators for 2020–2030 to meet the projected organic increase in travel demand. Alternative 1 would include a significant investment in capacity expansion, adding tracks where required, and would provide solutions for the most pressing choke points, including a bypass between Old Saybrook, CT, and Kenyon, RI, to address movable bridge capacity constraints. It would also include, to the extent possible with available capacity, enhanced operations consisting of metropolitan service to help address capacity constraints through New York City and to broaden the mix of stations pairs served, as well as various best operating practices to provide additional capacity, improve performance and generate operating cost efficiencies.

Capacity would not be provided to accommodate proportional demand beyond 2040 or to meet changing market needs, particularly in the New York metropolitan area. Alternative 1 would not support meaningful travel-time improvements for intercity trains.

- **Alternative 2** would grow the role of rail by expanding rail service at a faster pace than the proportional growth in population in the Study Area. Service and improvements would be focused generally within the existing NEC right-of-way with some route variations, including a new supplemental route between New Haven–Hartford and Providence to improve performance, address capacity constraints, and/or to serve new markets. This alternative would combine the best-performing elements of Program Levels B and C to provide a single intermediate investment alternative that would provide the necessary capacity and faster travel times to grow rail mode share. The railroad would expand to four tracks, with six tracks through portions of New Jersey and southwestern Connecticut, and would include two new East River tracks (in addition to the two additional Hudson River tracks and tunnels included in Alternative 1). Capacity in the New York metropolitan areas would be sufficient to accommodate continued growth, which would eventually overtake full throughput capacity in the absence of more trans-Hudson River tunnels. Alternative 2 would include new service to Philadelphia International Airport, and some regional rail run-through service in New York City and Washington, D.C., to increase terminal throughput.
- **Alternative 3** would transform the role of rail, positioning rail as a dominant mode for intercity travelers and commuters across the NEC. Service and infrastructure improvements would include upgrades on the NEC Spine and the addition of a second spine, which would operate adjacent to the NEC Spine south of New York and expand to reach new markets north of New York. This new second spine would support high-performance rail services between major NEC markets and would provide additional capacity for intercity and regional rail services on both the existing and the new spines. This alternative would increase the level and variety of train service and expand the market reach of the NEC. The FRA will evaluate the four New York City-Boston second-spine route options included in Program Level D.

The alternatives have been defined to provide the FRA, the region, and other stakeholders with a broad range of options and sufficient information to make a reliable, long-term decision about the appropriate role for rail to play within the region's multimodal transportation network. While focused on rail solutions (following the program's Purpose and Need), the alternatives would have different implications for other transportation modes, including the region's airports, highways, and transit networks, and provide important information for policymakers to make decisions with this broader transportation system in mind.

6. Next Steps

The Tier 1 EIS alternatives are being refined and evaluated in the Tier 1 Draft EIS. Refinement will optimize service plans and ensure that capacity and infrastructure improvements are sufficient to reliably deliver proposed service objectives. As was the case in creating the 15 Preliminary Alternatives, this process will involve consultation with railroad operators and other stakeholders. With refinement, the Tier 1 EIS alternatives will be fully evaluated in the Tier 1 Draft EIS.

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Tier 1 EIS Alternatives Report

October 2015

Amended

U.S. Department of Transportation

Federal Railroad Administration

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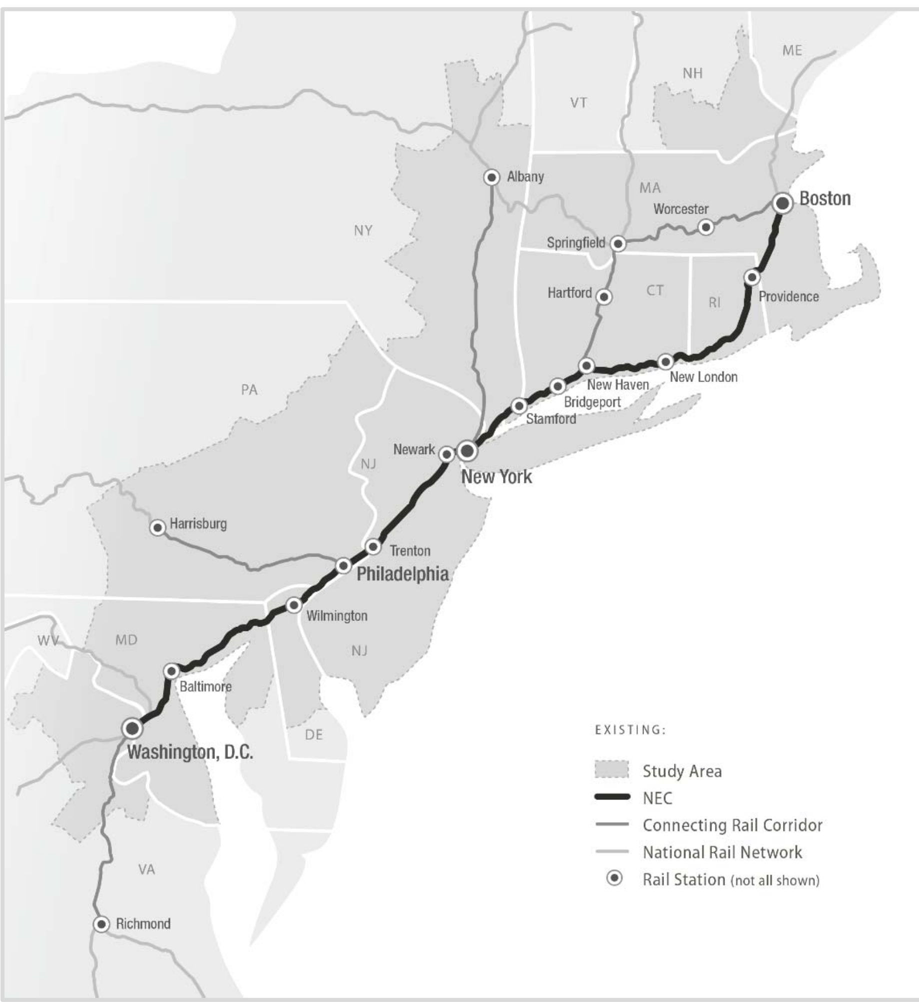
1. Introduction

NEC FUTURE is a comprehensive planning effort to consider the role of passenger rail service on the Northeast Corridor (NEC) within the regional multimodal transportation system and how it can meet current and future demand for Intercity and Regional rail service. As the lead federal agency for this planning effort, the Federal Railroad Administration (FRA) will determine a long-term vision and investment program, through the development of a Tier 1 Environmental Impact Statement (EIS) and Service Development Plan (SDP).

The NEC is the rail transportation spine in the Northeast of the United States and is a key component of the region's overall transportation system. It accommodates the operation of eight commuter-rail authorities and Amtrak—the Intercity rail service provider—as well as four freight railroads. The NEC FUTURE Study Area (Study Area) encompasses eight Northeast states and Washington, D.C., which are served directly by the NEC, plus those areas that can be reached directly by train or via a transfer from the NEC to connecting corridors. Figure 1 shows the Study Area, identifying the existing passenger rail network that comprises the NEC and connecting corridors.

Figure 1: Study Area



1.1 PURPOSE AND NEED

The 457-mile NEC and its connecting rail corridors[1] form the most heavily utilized rail network in the United States. The NEC ranks among the busiest rail corridors in the world, moving more than 750,000 passengers every day[2] on 2,200 trains.[3] Freight operators share the NEC with passenger railroads and move over 350,000 car loads of freight per year[4] on the NEC. This volume of traffic and diversity of service operate with capacity constraints that require scheduled and real-time trade-offs in passenger and freight service frequency, speed, and performance.

The congestion resulting from these capacity constraints, along with the NEC's aging infrastructure, further limit the opportunities to improve or expand passenger rail services. This infrastructure, in many cases built over 100 years ago, also does not provide the resiliency or redundancy necessary to respond to unanticipated natural disasters or other disruptive events. Additional details on the NEC's capacity constraints and aging assets are presented in the NEC FUTURE Scoping package (available on the NEC FUTURE website)[5] as well as the Northeast Corridor Infrastructure & Operations Advisory Commission (NEC Commission) *State of the NEC Region Transportation System* and *NEC Five-Year Capital Plan Fiscal Years 2016-2020*.[6]

An investment program to improve connectivity between passenger and freight rail markets and established and growing Northeast business centers is also critical to the economy. The Northeast is home to more than 51 million people[7] and includes four of the ten largest metropolitan areas in the United States. These major metropolitan areas, Washington, D.C., Philadelphia, New York City, and Boston, are among the top 25 largest metropolitan areas ranked by gross domestic product (GDP) in the world.[8] Approximately 20 percent of the nation's GDP comes from areas within the Study Area,[9] establishing the Northeast as an economic engine for the nation. In fact, if the Study Area were an independent country, it would represent the fifth-largest economy in the world.[10] The effectiveness and efficiency of that transportation system is critical to the continued economic growth and vitality of the Northeast.

As population and employment grow in the Northeast, however, even more demands are made on the existing transportation system. Traffic congestion and delays are routine across the transportation system

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[1] Connecting corridors are those rail corridors that connect directly to a station on the NEC. These include (1) corridor service south of Washington Union Station to markets in Virginia and North Carolina including Lynchburg, Richmond, Newport News, Norfolk, and Charlotte; (2) Keystone (connects to Philadelphia 30th Street Station); (3) Empire (to Penn Station New York); and (4) New Haven-Hartford-Springfield (to New Haven Union Station)

[2] Northeast Corridor Infrastructure and Operations Advisory Commission. (February 2014). *State of the Northeast Corridor Region Transportation System.* State of the Northeast Corridor Region Transportation System.

[3] Amtrak. (2014). *NEC Maps & Data: Growing Demand for Rail Services in the Northeast*. Retrieved January 2015, from Amtrak, The Northeast Corridor: *http://nec.amtrak.com/content/growing-demand-rail-services-northeast*

[4] Northeast Corridor Infrastructure and Operations Advisory Commission. (February 2014). *State of the Northeast Corridor Region Transportation System.*

[5] *www.necfuture.com*

[6] The referenced NEC Commission documents are available at *http://www.nec-commission.com*.

[7] U.S. Census Bureau. 2013. 1970–2012 Population Data. Washington, D.C.

[8] Brookings Institution. *Global MetroMonitor*. 2012. *http://www.brookings.edu/research/interactives/global-metro-monitor-3*

[9] United States Department of Commerce, Bureau of Economic Analysis. (2015). *Regional Economic Accounts*. Retrieved February 2015 from *http://www.bea.gov/regional/index.htm*

[10] Northeast Corridor Infrastructure and Operations Advisory Commission. (April 2014). *The Northeast Corridor and the American Economy.*

for highways and airports. By 2040, the Northeast is expected to add seven million new residents,[11] and no mode has sufficient new capacity to accommodate this growth. As growth continues and transportation demand exceeds the capacity of an already heavily used system, congestion will likely worsen.

Growth in population and employment in the Study Area combined with changes in travel preference will increasingly require a level-of-service and connectivity that is not supported by the existing NEC. Challenges to passenger rail travelers today include poorly coordinated transfers and inconvenient service frequencies, which make other travel choices and modes more attractive. A well-defined and coordinated investment program to support both preservation and enhancement of the NEC is essential to meet the needs of passenger and freight markets in the coming decades.

Moreover, there is national, regional, state, and local interest in how the transportation system, and in particular the rail network, can positively contribute to the overall environmental quality of the Northeast. It is, therefore, critical that improvements also consider environmental sustainability.

The ***purpose*** of the NEC FUTURE program is to upgrade aging infrastructure and to improve the reliability, capacity, connectivity, performance, and resiliency of future passenger rail service on the NEC for both Intercity and Regional rail trips, while promoting environmental sustainability and economic growth.

Overall ***needs*** addressed by the NEC FUTURE program include aging infrastructure, insufficient capacity, gaps in connectivity, compromised performance, lack of resiliency, environmental sustainability, and economic growth (Figure 2).

1.2 GUIDING PRINCIPLES

Given the unique complexities of alternatives development for the NEC, the FRA has drawn on international best practices, lessons learned in the development of the United States rail system, and stakeholder and public feedback to establish a set of “guiding principles” to help structure the planning process. These principles reflect agreed-upon policy objectives for the NEC FUTURE planning study to:

- Consider a Broad Range of Alternatives
- Develop Alternatives that Focus on Efficiency
- Structure Alternatives to Enable Incremental, Flexible Implementation

These principles and the related implications for the alternatives development process are described in the *Preliminary Alternatives Evaluation Report*, available on the NEC FUTURE website.

1.3 DOCUMENT PURPOSE

This Tier 1 EIS Alternatives Report presents the process for developing and refining the Tier 1 EIS Alternatives, which includes the No Action Alternative and Action Alternatives that will be analyzed in the Tier 1 Draft EIS. The alternatives development and refinement process, consists of service planning, ridership modeling, capital and operations and maintenance cost estimating, as well as stakeholder and

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[11] Northeast Corridor Master Plan Working Group. (2010). *Northeast Corridor Infrastructure Master Plan*

public input. Furthermore, this document provides the complete definition and description of each alternative that will be presented in the Tier 1 Draft EIS.

Figure 2: NEC FUTURE Program Needs

State of Good Repair

Service quality currently falls short, due to the aging and obsolete infrastructure that has resulted from insufficient investment in maintaining a state of good repair on the existing NEC. Achieving and maintaining a state of good repair is needed to improve service.

Connectivity

The reach and effectiveness of the passenger rail network are limited by gaps in connectivity among transportation modes and between different rail services.

Capacity

Severe capacity constraints at critical infrastructure chokepoints limit service expansion and improvement, making it difficult to accommodate existing riders and growth in ridership.

Performance

In many markets, the trip times on passenger rail within the Study Area are not competitive with travel by air or highway. Improvements in travel times, frequency, or hours of service are needed to make passenger rail competitive with other modes.

Systemwide Resiliency

The NEC is vulnerable to the effect of severe storms. A more resilient and redundant passenger rail network is needed to enhance safety and the reliability of the region's transportation system.

Environmental Sustainability

Throughout the Study Area, energy use and emissions associated with transportation affect the built and natural environment. Passenger rail can help meet the region's mobility needs with fewer environmental impacts.

Economic Growth

A transportation system that provides options for reliable, efficient, and cost-effective movement of passengers and goods is needed for continued economic growth in the Northeast. The region's knowledge-based economic sector, including academic research and medical facilities, is especially reliant on access to convenient, reliable, and frequent rail service.

2. Alternatives Development Process Overview

There are many possible futures for the NEC. Some involve significant changes in the way passenger service is provided, while others focus on modifications to the existing system, keeping service much as it is today. Some options focus improvements only on the existing NEC, while others include service to new locations or different types of service. The FRA designed the NEC FUTURE alternatives development process to consider a broad array of distinct alternatives that address the program's Purpose and Need. With a set of guiding principles in mind (as listed in Section 1.2), the FRA progressively narrowed those alternatives to a smaller set that address the identified needs to varying degrees.

Because of the unique geographic, technical, and institutional complexity of the program, the FRA took an innovative approach developing the NEC FUTURE alternatives, organizing the process into three steps (Figure 3). The three-step process allowed for the preparation of corridor-wide service plans and infrastructure projects, and subsequent testing, refining, and optimizing of different service and geographic markets within the NEC. This process also provided the FRA with an understanding of how discrete elements perform relative to one another so that the strongest "package" of separate service, infrastructure, and route options could be crafted into different alternatives that meet the needs of various markets along the NEC.

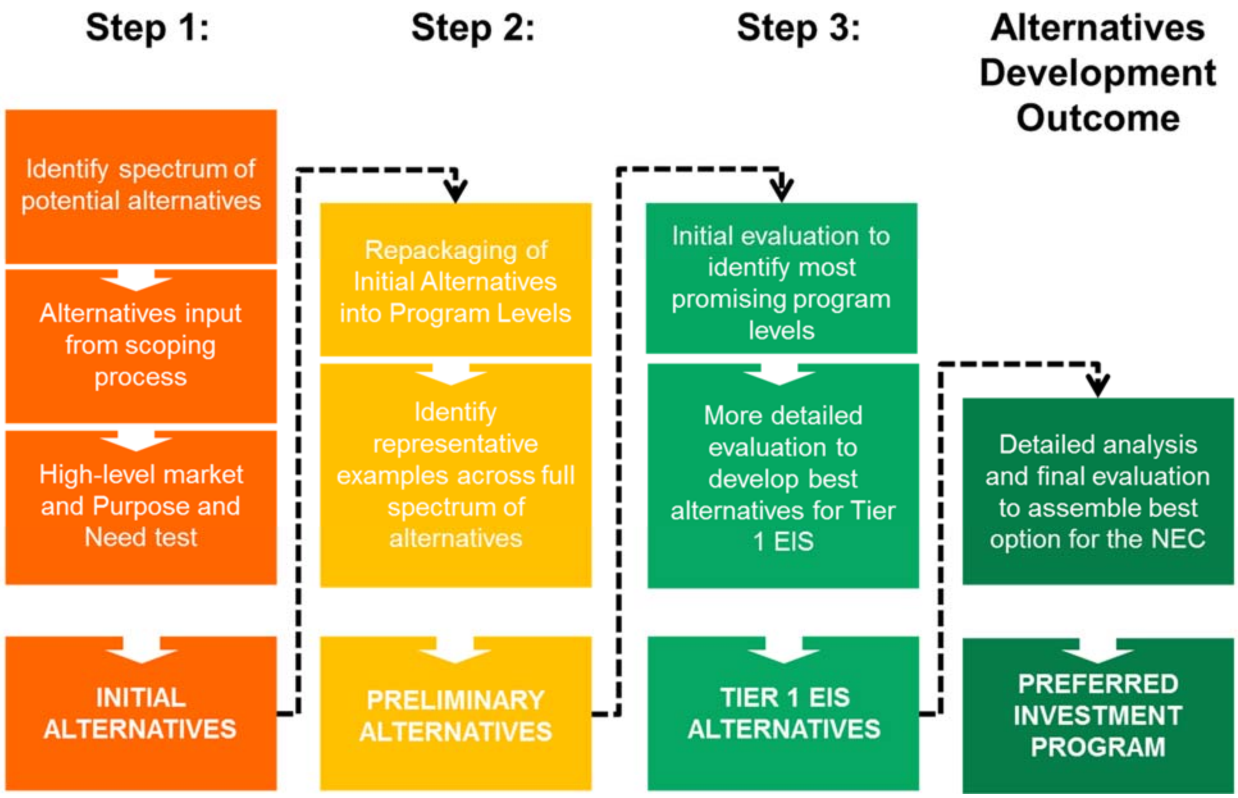
Decisions about the future of the NEC affect a wide range of stakeholders, from rail passengers, agencies, and service operators on the NEC to the residents, travelers, businesses, and communities potentially affected by the outcomes of NEC FUTURE. The FRA has been committed to an open and transparent engagement that involves these stakeholders in the alternatives development process. This engagement has entailed frequent coordination with state and railroad stakeholders, as well as federal and state environmental, transportation, and non-transportation officials. In addition, the FRA has conducted extensive public involvement and agency consultation activities including Scoping, consultation meetings, briefings, workshops, and presentations.

Each level of alternatives development is tied directly to the program's Purpose and Need and reflects the available level of detail from the supporting technical analysis. Similarly, alternatives and service concepts not meeting and addressing the Purpose and Need (Section 1.1) for NEC FUTURE were dismissed from further consideration.

In evaluating the alternatives, the FRA used a number of technical tools (as described in Section 4) to assess engineering feasibility, ridership, operational impacts, capital and operating costs, environmental impacts, and public benefits. The level of technical analysis and associated tools to develop applicable data becomes more detailed as the alternatives advance through the process. This approach was designed to allow for the refinement and the recombination of components of alternatives leading to FRA's identification of the Action Alternatives to be further analyzed and compared to a No Action Alternative in the Tier 1 Draft EIS.

The FRA defined and developed the Action Alternatives to a programmatic level, to focus on corridor-wide solutions within the Tier 1 Draft EIS. These alternatives establish a comprehensive, long-term vision for the corridor's future development and are defined by (1) a range of corridor-wide service options (Service Plans) required to meet varying degrees of projected growth and demand and (2) broad infrastructure needs to accommodate the service. Assumptions made at the Tier 1 level are representative and illustrative, to support analysis in both the alternatives development process and the Tier 1 Draft EIS. These service and infrastructure assumptions are not intended to be specific or prescriptive.

Figure 3: Alternatives Development Process



Source: NEC FUTURE team, 2015

The Action Alternatives provide the FRA and other stakeholders with a range of options and information over the No Action Alternative to determine the appropriate role of rail within the region's future transportation network. While focused on rail solutions (addressing the Purpose and Need), the alternatives have different implications for other transportation modes, including the region's airports, highways, and transit networks. In this way, they provide important information for policymakers to make decisions with this broader transportation system in mind.

The visions articulated by the Action Alternatives will take decades to fully implement. Additionally, improvements are likely to be implemented by multiple stakeholders across the NEC over many years, with specific timing dictated in part by availability of funding, local needs, and construction considerations.

As such, a key element of the NEC FUTURE planning process is to ensure improvements to the NEC are prioritized, integrated, and packaged for optimal service benefits across the entire rail network. The FRA developed the alternatives with the intent that they could be implemented in phases. Prioritization will be accomplished through phasing plans that define the necessary infrastructure and operational enhancements required to support various increments of new corridor-wide service. This phased implementation is described in Section 11.

2.1 INITIAL ALTERNATIVES

Developing a list of "Initial Alternatives" was the first step in the alternatives development process. To develop these alternatives, the FRA began with an analysis of Study Area travel demand and growth data to understand where people are traveling, where growth in population and employment is forecast to occur, and how travel patterns are likely to change in the coming decades. In addition, numerous route and service concepts were identified through input and data collected during Scoping. The FRA organized these ideas into a combination of "building blocks," including how trains will potentially access the markets (network/route), the amount of service to provide to each market (investment level), and the type of service to be provided (service). Mixing and matching these building blocks provided the basis for testing and comparing multiple market, investment, and service options. Table 1 describes these three building blocks.

Table 1: Initial Alternatives Building Blocks

Building Blocks	Variations
Network/Route ▪ How can markets be accessed by rail?	▪ Existing NEC ▪ Potential second-spine ▪ Potential new right-of-way segments ▪ Potential connecting corridor links
Investment Level ▪ How robust is the program? ▪ How much service can be provided? ▪ Which new markets can be served?	▪ Low (A): 2040 growth on existing NEC serving existing markets ▪ Medium-low (B): Additional capacity on existing NEC to add new types of express, regional, and connecting corridor services ▪ Medium-high (C): Targeted expansion of the NEC to serve new off-corridor markets and expand service options to NEC and connecting corridor markets ▪ High (D): Extensive end-to-end expansion of the NEC to serve new markets and high-speed rail service
Service ▪ How can markets be best served?	▪ Standard service mix (services similar to today) ▪ Enhanced service mix (new types of service and operations)

Source: NEC FUTURE team, 2015

Using these three building blocks, the FRA identified approximately 100 Initial Alternatives to address a broad spectrum of opportunities to upgrade and expand the NEC, serve existing and new markets both on and off the corridor, provide better connectivity to other rail markets, transit, and airports, and develop new high-speed rail service.[12] Some of the initial ideas proposed, such as modifying the existing NEC to serve markets off of the existing spine when those markets could be better served through existing and/or future connecting corridors did not advance. The FRA also dismissed less efficient routing options, such as New York City to Boston via Albany. (See the *Preliminary Alternatives Report* available on the NEC FUTURE website for a full description of the process.)

In December 2012, the FRA hosted a set of regional workshops.[13] These December Dialogues presented the market-based approach underpinning the alternatives development process, the results of Scoping, and the framework used to generate the Initial Alternatives. The feedback from participants at the December Dialogues underscored the importance of providing a range of investment scenarios for the NEC, as well

[12] The definition of high-speed rail varies depending on context and purpose. For NEC FUTURE, high-speed rail consists of service provided by Intercity-Express trains operating at a range of speeds from 150 to 220 mph.
[13] A summary of this meeting is available on the NEC FUTURE website: *http://necfuture.com/get_involved/public_meetings.aspx*

as a flexible approach for the use of additional railroad capacity, allowing operators to respond to changing needs.

2.2 PRELIMINARY ALTERNATIVES

For the next step of the alternatives development process, the FRA organized the Initial Alternatives into four program levels to facilitate a comparison of the benefits and impacts of distinct levels of investment in the NEC. Some Initial Alternatives were not advanced into Preliminary Alternatives, particularly those alternatives that included specific engineering and alignment solutions not germane to a corridor-wide, Tier 1 NEPA planning process. These options can be appropriately considered in a project-level, Tier 2 NEPA process.

The four program levels (Table 2) differ by the level and types of rail service they provide to the region and support a broad range of options for the "role" that passenger rail can play on the NEC and in the Study Area, from upgrading the existing NEC to building a second-spine to support high-speed rail operations for existing and future markets. As program levels increase from A to D, larger investments in service and infrastructure are required.

Table 2: Preliminary Alternatives

Program Level	Alt.	Service Objective	Possible Service Option
A	1	Addresses state of good repair[14] and provides some increase in service and capacity along existing NEC	Standard (financially constrained)
	2		Standard
	3		Enhanced (mixture of services)
B	4	Substantially increases service to existing and connecting markets along existing NEC with high capacity operations	Standard
	5		Enhanced: Maximum frequency of trains
	6		Enhanced: Maximum trip time savings
	7		Enhanced: Maximum service to connecting corridors
C	8	Targeted expansion of existing NEC to serve new markets, reduce trip time, and introduce robust Regional rail service	Standard
	9		Enhanced: Maximum frequency of trains
	10		Enhanced: Maximum trip time savings
	11		Enhanced: Maximum service to connecting corridors
D	12	Achieves world-class high-speed rail potential through the addition of new spine	Second-spine generally parallel to existing NEC
	13		Second-spine via Danbury-Hartford-Providence
	14		Second-spine via Ronkonkoma-Hartford-Worcester
	15		Second-spine via Delmarva and Nassau County-Stamford-Danbury-Springfield

Source: NEC FUTURE team, 2015

[14] The condition in which the existing physical assets, both individually and as a system (a) are functioning as designed within their "useful lives," and (b) are sustained through regular maintenance and replacement programs; state of good repair represents just one element of a comprehensive capital investment program that also addresses system capacity and performance.

Within each program level, the FRA developed multiple alternatives to better understand and quantify key market and service dynamics, such as the trade-offs between frequency of service, trip time, and the convenience of one-seat end-to-end service. This allowed the FRA to test and compare different operating scenarios, or, in the case of the second-spine, different route options. In all, the FRA defined 15 Preliminary Alternatives (Table 2). Within Program Levels A, B, and C, the FRA developed two different service scenarios for testing and comparison:

- **Standard service** serves markets in much the same manner as they are served today, with Intercity trains stopping at major stations along the corridor and commuter trains taking passengers from suburban markets into urban centers.
- **Enhanced service** involves the evaluation and testing of new operating approaches and services that allow for more intensive use of existing or new infrastructure.

Because enhanced service, as defined, encompasses a broad range of potential new service options, the FRA developed separate alternatives in Program Levels B and C to focus on three different enhanced service objectives: maximizing the frequency of trains; providing the fastest express trip time; or maximizing service to connecting corridors. (Additional information about the Preliminary Alternatives can be found in the *Preliminary Alternatives Report* available on the NEC FUTURE website.)

In April 2013, the FRA hosted a second set of regional workshops to present the Preliminary Alternatives to the general public.[15] The feedback from participants at the April Dialogues confirmed the importance of preserving a range of program levels in the Tier 1 Draft EIS to reflect different visions for the future of the NEC. Participant feedback also highlighted the importance of evaluating multiple route options.

2.3 NO ACTION ALTERNATIVE AND ACTION ALTERNATIVES

In the final step of the alternatives development process, the FRA evaluated the 15 Preliminary Alternatives by comparing them to understand whether and how each met the Purpose and Need (Section 1.1), and analyzing their benefits in terms of ridership, travel time, and service quality. Similarly, among the different Program Level D second-spine route alternatives, the FRA compared performance (in terms of service and ridership) and environmental impacts.

To conduct the analyses of the 15 Preliminary Alternatives, the FRA developed evaluation criteria and associated performance measures derived from the Purpose and Need. This set of evaluation criteria are based on (i) best practices; (ii) results from models used in transportation investment programs of similar physical and programmatic magnitude, (iii) available data; and (iv) stakeholder input. Table 3 details the criteria and data used to evaluate the Preliminary Alternatives.

The FRA used the metrics and data for each criterion to compare Program Levels A through D, as well as to compare the separate alternatives within each program level. After evaluating the environmental impacts of the Preliminary Alternatives, the FRA determined that each was likely to result in environmental effects. Based on feedback received during the April Dialogues, the FRA dismissed the Delmarva routing in

[15] A summary of this meeting is available on the NEC FUTURE website: *http://necfuture.com/get_involved/public_meetings.aspx*

Preliminary Alternative 15, because of public concerns that the route was not viable for a variety of reasons, including the potential for environmental impacts as well as from a growth and market perspective.

Table 3: Preliminary Alternatives Evaluation Criteria

Evaluation Criteria	Metrics
Growth and Capacity Expansion	▪ Annual trips ▪ Annual passenger miles ▪ Peak-hour passengers at major screenlines* ▪ Peak-hour trains, Hudson River screenline
Aging Infrastructure	▪ NEC in a state of good repair
Service Effectiveness and Performance	▪ Express trip time savings ▪ Maximum trains per hour ▪ Peak-hour trains operating on NEC
Connectivity	▪ Stations served by Intercity trains ▪ Station-pairs served by Intercity trains ▪ Airport stations
Environmental Consequences	▪ Acres of environmental sensitivity

Source: NEC FUTURE team, 2015

* A screenline is an imaginary line used to count rail traffic at a specific location in the Study Area (e.g., the Hudson River, recognizing the capacity restrictions of the tunnels and/or to analyze certain defined types of service/markets).

The FRA's key findings during this stage of the alternatives development process were related to 1) defining service dynamics—evaluating passenger preferences for frequency of service, trip time, and one-seat-ride services; and 2) defining the role that rail can play in transporting travelers across the NEC region. Additional details on this process can be found in the *Preliminary Alternatives Evaluation Report* available on the NEC FUTURE website.

The FRA used this evaluation to repackage the Preliminary Alternatives into three distinct Action Alternatives that meet the Purpose and Need. The FRA also defined a No Action Alternative to establish a baseline for comparative purposes. Each alternative consists of 1) a set of geographic markets to be served by passenger rail; 2) a Representative Route (or footprint) that connects these markets; 3) assumptions about the level of passenger rail service that will be provided to these markets; and 4) infrastructure improvements that support this level-of-service.

The FRA further refined the No Action and Action Alternatives by adjusting and refining service and infrastructure needs based on input gained from over 200 meetings with stakeholders, including the NEC railroads; federal, state, and regional agencies; and other interested organizations and individuals. This refinement process is described in more detail in Section 0.

The following are brief descriptions of the No Action and Action Alternatives. A detailed definition for each alternative is provided in Sections 7, 8, 9, and 10.

- **No Action Alternative** is represented by the existing NEC[16] and maintains today's service levels, defined as the number of trains per hour by operator and existing types of service. It does not increase capacity, address gaps in connectivity, expand service to new markets, or achieve a state of good repair.

[16] Including initiatives currently under construction or funded (e.g., LIRR East Side Access).

- **Alternative 1** maintains the role of rail within the transportation system of the Northeast as it is today, keeping pace with the level of rail service and investment required to support proportional growth in population and employment. For this alternative, the FRA used the projected service plans of NEC service operators as a starting point, and made adjustments to meet projected increases in travel demand. To keep pace with demand, Alternative 1 includes new rail services and investment to expand capacity, add tracks, and relieve key chokepoints, particularly through New Jersey, New York, and Connecticut. Intercity service grows south of New York City through the addition of one Intercity-Express train and one Intercity-Corridor train during periods of peak demand. North of New York City, the Intercity schedule is expanded to include one Intercity-Express train and one Intercity-Corridor train operating hourly in each direction. The capacity of Regional rail service is increased by a combination of lengthening existing peak trains, and adding trains in the peak period where growth is strong and line capacity is limited, especially on the lines feeding New York City.
- **Alternative 2** grows the role of rail, expanding rail service at a faster pace than the proportional growth in regional population and employment. South of New Haven, CT, service and infrastructure improvements are focused generally on the existing NEC, and north of New Haven, a new supplemental two-track route is added between New Haven and Hartford, CT, and Providence, RI, to increase resiliency, serve new markets, reduce trip time, and address capacity constraints. The existing NEC expands in most areas to four tracks, with six tracks through portions of New Jersey and southwestern Connecticut. Alternative 2 includes a new rail route to serve Philadelphia International Airport, and some Regional rail run-through service in New York City and Washington, D.C., to increase terminal throughput.
- **Alternative 3** transforms the role of rail, positioning rail as a dominant mode for Intercity travelers and commuters. Service and infrastructure improvements include upgrades on the NEC and the addition of a two-track second-spine that operates adjacent to the NEC south of New York City and extends the reach of NEC rail to new markets north of New York City. This new spine supports high-speed rail services between major markets and provides additional capacity for Intercity and Regional rail services on both the existing NEC and new spine. Alternative 3 supports a wide variety of new Intercity and Regional rail services, tailored to the needs of specific markets, including non-stop express trains, high-speed zone express trains serving the long-distance commute market, and new service to markets off the existing NEC.

  Alternative 3 includes new high-speed service between Washington, D.C., and Boston. From Washington, D.C., to New York City, this service mostly runs on a route closely parallel to the existing NEC, but it deviates from the existing route to shorten trip times and serve new stations in downtown Baltimore, Philadelphia International Airport, and downtown Philadelphia. Between New York City and Boston, in addition to the existing NEC, Alternative 3 includes several new route options that provide shorter trip times than the existing NEC. Each route option serves different intermediate markets in central Connecticut and on Long Island. These north end route options are described in Section 5. The Service Plans developed to analyze Alternative 3 assume that some Intercity trains operate end-to-end over the new route between Washington, D.C. and Boston, while other Intercity trains, as well as Regional rail trains, operate interchangeably over portions of the new route and the existing NEC.

3. Technology

In defining a long-term vision for the role of passenger rail on the NEC, FRA has actively sought stakeholder and public input via an early and proactive outreach process. The overwhelming message received is that the users of the NEC are seeking reliable, integrated, and expanded train service to meet both Intercity and Regional rail travel needs. Considering that over 90 percent of the users of the NEC are Regional rail customers, it is clear that near-term investments that prioritize responding to the interconnected travel needs of existing rail passengers have great public and institutional support.

The FRA developed the NEC FUTURE Purpose and Need (Section 1.1) to reflect key deficiencies in today's NEC, and subsequently focused on Action Alternatives that best meet that Purpose and Need by improving steel-wheel passenger train technology that is used today by all the railroads sharing the NEC, including both Intercity and Regional rail operations, as well as freight service. The FRA considered proven technological advances, and, where appropriate, incorporated use of international best practices that are compatible with existing steel-wheel train technology for the following reasons:

- **Aging Infrastructure**: The quality of rail service on the NEC – reliability, travel time, and ride quality – currently falls short due to aging and obsolete infrastructure. This is the result of insufficient investment in the rail line to maintain its infrastructure in a state of good repair. Aging infrastructure also increases the cost and complexity of continuing railroad operations. Focusing first on the renewal of existing rail lines using steel wheel technology will yield a significant positive return on transportation investment by improving the reliability and overall quality of current Intercity and Regional rail service for the more than 700,000 daily users of the NEC.
- **Gaps in Connectivity**: Expanding travel connections across the NEC, and making those connections easier and more seamless for the hundreds of millions of people riding Intercity and Regional rail trains each year is fundamental to achieving the purpose of NEC FUTURE. The Northeast is steadily transforming from multiple separate markets to a single region. Essential to this transformation is an integrated network of passenger rail service that connects Intercity and Regional rail markets across the NEC, meets diverse trip origins and destinations of the traveling public, and accommodates projected growth in regional population and employment. Today's NEC passenger rail network is limited by gaps in connectivity among transportation modes and between different rail services. Even with compatible rail technology, today's rail service between stations often requires lengthy layovers or difficult transfers, limiting mobility options for passengers. Expansion of service that incorporates interoperable steel wheel rail technologies within the existing infrastructure will offer travelers a wider choice of city-pair combinations and travel options. It also offers better connectivity through shared station infrastructure and easier cross-platform transfers between Intercity and Regional rail trains.
- **Insufficient Capacity**: Severe capacity constraints at critical infrastructure chokepoints limit service expansion and compromise the ability to recover from service disruptions, making it difficult to offer reliable service and accommodate growth in ridership. Given the broad range of Intercity and Regional rail services provided on the NEC, and the significant cost for adding capacity, the NEC FUTURE Action Alternatives are intended to maximize the transportation benefits of investments in additional capacity, both on the existing NEC and for new routes connecting to or supplementing the existing NEC. The use of interoperable train technology in the Action Alternatives facilitates the incremental expansion of

service across the corridor to address immediate needs on the NEC, keeping up with underlying growth in transportation demand while leveraging individual projects on the NEC to maximize the regional benefits of investments in service and infrastructure.

Given the accelerating pace of change in consumer technology, business practices and transportation patterns, application of future emerging and new technologies may help to support rail service on the NEC and meet other transportation needs across the region. These might include new information systems and services, new train propulsion and guideway systems, fare collection innovations, and safety enhancements. The FRA plays an important role in bringing new rail transportation approaches and technologies to market and demonstrating their specific capabilities and role in the broader transportation system. For example, the FRA has sponsored development of next-generation propulsion systems for locomotives and has explored the potential for use of magnetic levitation train technology.

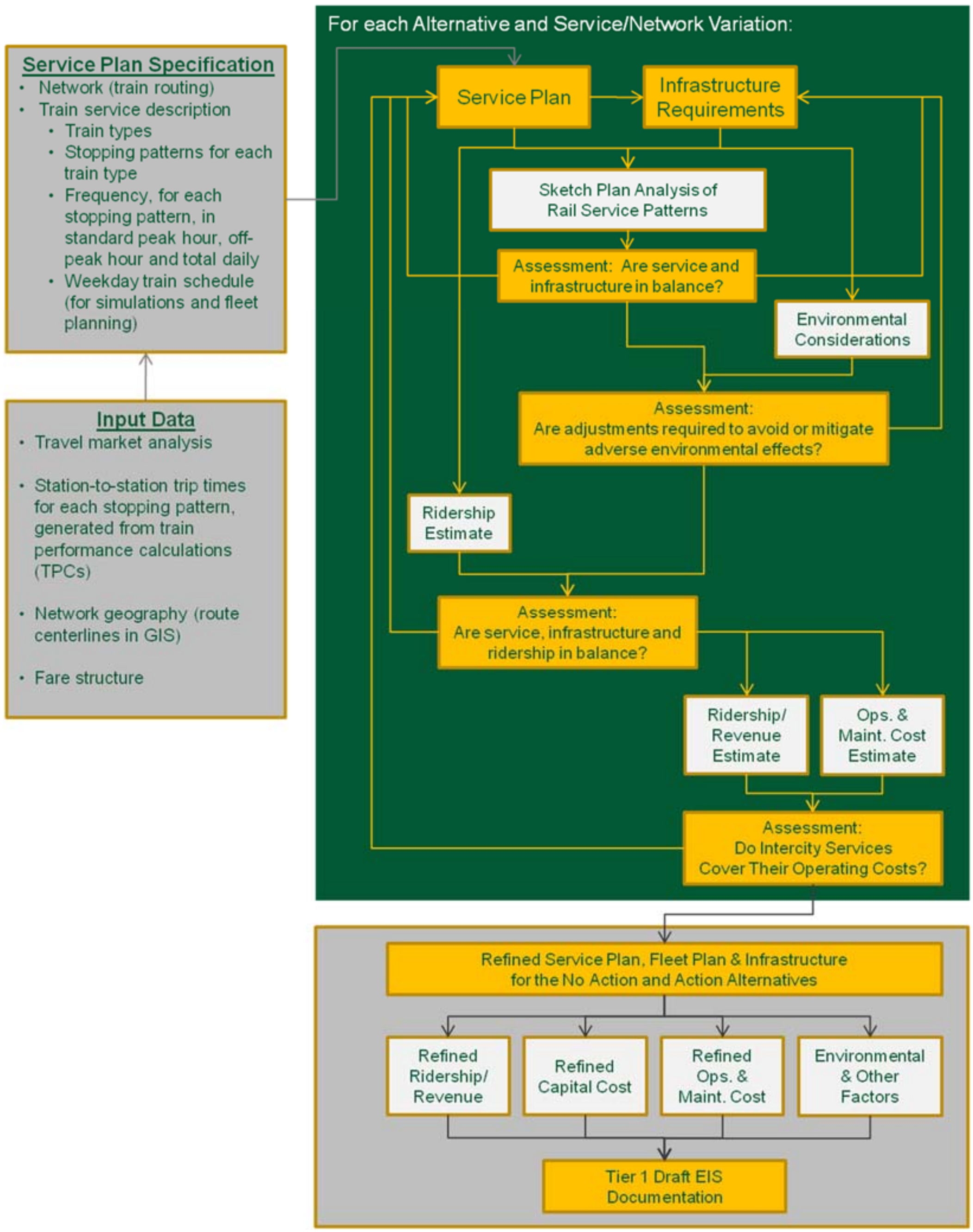
An advanced guideway system, such as magnetic levitation technology, could possibly be used to develop a second-spine or portions thereof as envisioned in Alternative 3. This would require separate stations, could not support run-through trains from connecting corridors, and does not offer proven integration efficiencies with today's NEC infrastructure and operators. However, because advanced guideway technologies remain under development they are not incorporated in the Action Alternatives.

Such technologies could be studied separately, and are not precluded as a future transformative investment in the regional transportation system. Other potential applications of new technology transportation systems could support the NEC passenger rail network by connecting off-corridor markets to the NEC, or a major market to the NEC. This might include a connection between a specific airport (such as JFK International Airport) or other activity center to a downtown center located on the NEC, or connecting the NEC to Pittsburgh, PA or Richmond, VA (e.g., Long Island or parts of northern Virginia).

4. Alternatives Refinement

The FRA refined the Action Alternatives through a phased and iterative process that drew from multiple sources and types of information and work products. Figure 4 summarizes this process in a flow diagram. The refinement of the No Action Alternative also followed this process; however, the process did not require multiple iterations.

Figure 4: Alternatives Refinement Process



Source: NEC FUTURE team, 2015

While the FRA was developing analytic models for estimating ridership, capital costs, and annual operations and maintenance costs, the FRA developed the specific elements of the representative Service Plans – service frequencies, stopping patterns, train routings, and rolling stock characteristics for each service type – to identify their ability to achieve efficient use of rail infrastructure capacity and serve the NEC's rail travel markets. The Service Plans are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assessment of the environmental impacts associated with planned improvements. The Service Plans are not intended in any way to be prescriptive regarding how service should be operated in the future. In addition, the Service Plans are not intended to predict future operating patterns of the NEC operators. The FRA then refined the Service Plans in two broad steps as described below. Throughout this effort, the representative Service Plans remained consistent with the overall role of rail as defined for each of the Action Alternatives.

- The FRA modified the Service Plans to incorporate feedback and input from stakeholders and output from the initial ridership model. Additional refinements were made to balance the rail infrastructure associated with each Action Alternative and provide flexibility for the Regional rail operators, with an emphasis on the areas in and around major terminals.

- The FRA further refined the Service Plans using iterative work with the service planning, ridership, and cost modeling efforts. Interim conservative estimates of service levels were prepared and confirmed the reasonableness of the Representative Route[17] for each Action Alternative. The FRA compared results from the Interregional Model (Section 4.2) with the service levels, and subsequently adjusted the Service Plans to confirm that (1) capacity is reasonably in line with estimated ridership; and (2) the Intercity-Express and Metropolitan services, as defined in Section 4.1.2, generate revenues in excess of operations and maintenance costs in 2040.

For the No Action Alternative, the FRA developed a Service Plan identical to the existing service levels on the NEC, with one exception. The Long Island Rail Road East Side Access Project in New York City, which currently is under construction and therefore included within the No Action Alternative, will change the number of Regional rail trains and their service patterns crossing the East River between Manhattan and Queens, New York. As a result, the FRA incorporated future Regional rail service from Long Island to Manhattan identified in the East Side Access project's Record of Decision into the Service Plan for the No Action Alternative. Intercity service levels are assumed to remain the same as existing levels today.

4.1 SERVICE PLANNING

The FRA developed a sketch planning process for creating and analyzing the representative Service Plans to enable the efficient testing of multiple service scenarios, encompassing:

- Train types, routings, service levels and stopping patterns (peak and off-peak)

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[17] A Representative Route refers to a proposed route or potential alignment for an Action Alternative. It includes horizontal and vertical dimensions, which are based on prototypical cross sections and define its footprint. Prototypical cross sections identify construction methods (tunnel, viaduct, bridge, fly-over, bypass, track type, etc.) and right-of-way requirements for tracks, structures, ancillary facilities, and stations associated with each Action Alternative. (See Section 6.2.) The Representative Route is limited to the NEC Spine; and therefore, excludes connecting corridors and branch lines.

- Scenarios covering the range of service levels and types being considered for each of the Action Alternatives
- Service pattern analysis – balancing service needs and infrastructure requirements.

The FRA performed early rounds of analysis working with ranges of service levels. Service Plan scenarios were developed for the NEC network as a whole and also for key segments of the corridor. These scenarios were developed from a set of planning objectives directly related to the three visions (maintain, grow, transform) of the Action Alternatives.

In each representative Service Plan, the FRA considered:

- A mix of service types, including Intercity-Express, Intercity-Corridor (Metropolitan and Intercity-Corridor-Other), Long Distance, and Regional rail service (as defined in Section 4.1.2)
- Specific stopping patterns and rolling stock for each type of train service
- The calculation of trip times over the rail network for each train type and stopping pattern, based on train performance calculations, with reasoned assumptions about station dwell times, terminal layover time and overall schedule recovery time built into the scheduled trip times
- Future Regional rail frequency targets for each service type and stopping pattern:
  - Peak, at each station (e.g., provide slots for 2, 3, or 4 trains per hour [tph])
  - Off-Peak (e.g., provide slots for 1–2 tph)
- Infrastructure assumptions, including number of main tracks, location and configuration of rail junctions, track and platform configurations at stations, and the locations of train storage yards
- Assignment of trains (by type, stopping pattern and time of day) to available tracks in each segment of the corridor

Using stringline (time-distance) diagrams and train schedule information, the FRA aligned and overlaid a full set of train service patterns. The FRA adjusted train service patterns, schedule times, and track assignments interactively to eliminate operating conflicts. Adjustments to the rail infrastructure configuration were made, where necessary and appropriate to address conflicts that could not be resolved with operational and scheduling adjustments. The end result of this integrated process was a Service Plan and representative train timetable for each Action Alternative that is operationally feasible and fits within the available capacity of the rail infrastructure. This process is described in greater detail in Appendix A, *Service Plans and Train Equipment Options Technical Memorandum.* As noted, the Service Plans are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assess environmental impacts, and are not intended in any way to be prescriptive regarding how service should be operated in the future. In addition, the Service Plans do not predict future operating patterns of the NEC operators.

4.1.1 SERVICE PLANS

The FRA developed Service Plans for the No Action and Action Alternatives to describe the types and levels of passenger train service operating on the NEC in 2040. These Service Plans are a representative train schedule for a typical future weekday, and include the train stops by station for both peak and non-peak periods. The Service Plans are operator-neutral and provide a technical basis that allows the FRA to estimate future ridership and capital investment needs and costs, as well as assess the environmental impacts associated with planned construction and future operations.

The FRA developed the Service Plans as a planning tool. They are not for purposes of actual implementation and are distinct from full detailed operating plans. The Service Plans do not include yarding and crewing assumptions, or specific track assignments at major stations and terminals. They are grounded in reasonable operational assumptions, driven by rigorous train performance calculations and informed by capacity analysis, supported by operations-related analysis at a level sufficient for the plan to be considered operationally feasible. Subsequent investment-grade simulation analyses generally will be required to support detailed decision-making and the development of actual operating plans and timetables.

4.1.2 SERVICE TYPES

For NEC FUTURE, the FRA organized the various types of passenger rail service into categories, based on travel distance, travel market, trip purpose, where and how the trains operate, and the service characteristics and amenities offered to passengers. The categories are used to represent the rail service that is provided in the No Action Alternative and Action Alternatives and correspond with the travel market definitions used for ridership estimating. These categories are aimed at best describing the full range of services provided in the Action Alternatives.

The top level categories are **Intercity** and **Regional rail.** Intercity service provides transportation between cities or metropolitan areas at speeds and distances greater than that of most Regional rail trips. Regional rail generally provides transportation within a single metropolitan region and serves more local markets. Regional rail service currently focuses largely, though not exclusively, on journey-to-work travel to the major central business districts within the Study Area. However, an increasing share of Regional rail trips are attributable to non-traditional commutes and non-work trip purposes. Moreover, reverse-peak and off-peak travel generally is growing at a faster rate than traditional commuting.

Intercity

For purposes of the travel demand analysis and ridership estimating, Intercity service is classified by market segment into two service types: **Intercity-Express** (serving the premium travel market composed largely of business travelers) and **Intercity-Corridor** (serving a broad market segment that includes a mix of business, personal, and leisure trips). Today's Amtrak's Acela Express and Northeast Regional services fit into these two service types, respectively. Ridership estimates were produced for these service types, as described in Section 4.1.2. These service types are described in greater detail in the *Service Plans and Train Equipment Options Technical Memorandum*.

- **Intercity-Express** – the future premium Intercity high-speed rail service offered on the NEC, making limited stops along the NEC and only serving the largest markets. Amtrak's Acela Express currently provides such service on the NEC between Washington, D.C. and Boston, MA. For the Action Alternatives, this category of service is envisioned as analogous to the state of the art high-speed rail services currently operating in Europe and Asia. Intercity-Express service offers the shortest travel times for Intercity trips, with a higher quality of on board amenities, at a premium price, using state of the art high-speed trainsets, with top speeds in the range of 160 mph to 220 mph.
- **Intercity-Corridor** – the Intercity services that operate *both* on the NEC and on connecting corridors that reach markets beyond the NEC. Whereas Intercity-Express service is aimed at the business travel

market, Intercity-Corridor trains serve the more price-sensitive end of the Intercity rail travel market, carrying both leisure and business travelers and stopping at a greater number of intermediate stations, compared with Intercity-Express trains.

- **Metropolitan** – the future primary Intercity rail service on the NEC, a subset of Intercity-Corridor service, and the successor to the existing Amtrak Northeast Regional Service. Whereas Intercity-Express service is aimed at the business travel market, Metropolitan trains serve both leisure and business travelers who are more price-sensitive. The FRA has chosen a new name for this service to emphasize its distinct characteristics and higher level of performance. Metropolitan trains use electric high-performance train equipment intended to operate at speeds up to 160 mph. They operate on regular schedules with high frequency (2-4 trains per hour) and are able to stop at more stations than the current Amtrak Northeast Regional service (including some stations that are only served today by Regional rail trains), due to faster speeds and high-performance operating characteristics. This allows Metropolitan trains to maintain competitive trip time while increasing the number of direct station-pair connections served by Intercity-Corridor trains. Metropolitan service also provides a travel choice for longer-distance commuters at stations served by both Metropolitan and Regional rail trains. In addition to providing service on the NEC Spine, Metropolitan trains provide service on the electrified Keystone Corridor in all three Action Alternatives and on the Hartford Line in the alternatives where this line is electrified (Alternatives 2 and 3).
- **Intercity-Corridor-Other** – Since Metropolitan service utilizes trainsets that can only operate in electrified territory, a separate Intercity-Corridor service is needed to provide connectivity and direct one-seat service between non-electrified connecting corridors and the large and mid-size markets on the NEC. These trains, along with the Metropolitans, are classified as Intercity-Corridor trains for purposes of ridership analysis, and they cater to similar market for Intercity service. These trains are assumed to have operating characteristics similar to today's Amtrak Northeast Regional trains, which will be dual-mode in the future – with top speeds of 125 mph on the NEC and up to 110 mph off of the NEC. The most prominent off-corridor routes served by these trains include Washington, D.C., to various points in Virginia and North Carolina, the Empire Corridor serving Upstate New York, the Knowledge Corridor serving central Massachusetts and Vermont, and the Inland Route corridor between Springfield, MA, and Boston.

- **Long Distance** – Intercity trains connecting the Study Area with other parts of the United States, generally entailing overnight travel with sleeping car and dining car service and handling checked baggage. This category includes existing Amtrak service to Florida, New Orleans, and Chicago. Since these trains operate over longer distances, they are subject to greater delays when operating off-corridor. As such, these trains are scheduled to operate on the NEC during off-peak periods. For NEC FUTURE, the FRA assumes that the level of long-distance train service on the NEC will remain constant through the 2040 horizon period—five round trips per day on the NEC between New York and Washington, D.C., and points south[18] plus the Capitol Limited and Lake Shore Limited, which connect with NEC services at Washington, D.C., New York City, and Boston.

[18] Represented by four existing overnight services (Silver Star, Silver Meteor, Crescent and Cardinal), plus the same-day Palmetto service to Savannah, GA.

Regional Rail

Regional rail encompasses all rail services that are concentrated within a single metropolitan region. Regional rail trains provide local and commuter-focused service characterized by relatively low fares and a high percentage of regular travelers. Regional rail includes the current services provided by Virginia Railway Express (VRE), Maryland Area Regional Commuter (MARC), Southeastern Pennsylvania Transportation Authority (SEPTA), NJ TRANSIT, Metropolitan Transportation Authority (MTA)-Long Island Rail Road (LIRR), MTA-Metro-North Railroad (MNR), Shore Line East, and Massachusetts Bay Transportation Authority (MBTA). None of these railroads, with the exception of Shore Line East, operates exclusively on the NEC. Most include relatively extensive networks of multiple branch lines, which feed one or more major terminal stations. As a result, the NEC does not operate in a vacuum, but rather as a key element within a complex and interconnected rail transportation system. Regional rail services have multiple stopping patterns, which vary by location and among the Action Alternatives: all-stop local service, zone express service (typically a weekday peak service that stops at a group of adjacent stations and then operates express to the main terminal), and limited-stop service focusing on selected key stations.

4.1.3 ROLLING STOCK

The FRA made assumptions in the Service Plans about combinations of various types and configurations of rolling stock and associated traction power. In the Action Alternatives, passenger trains on the NEC comprise both integrated trainsets and locomotive-hauled coaches. Integrated trainsets are represented by electric multiple-unit trains operated by some Regional rail providers, as well as the high-speed trainsets that are used for both Intercity-Express and Metropolitan service. On the NEC, integrated trainsets operate on electric power drawn from the overhead catenary system. Locomotive-hauled trains are categorized by the traction capabilities of the locomotive, which can either be electric (also drawing power from the catenary), diesel, or dual-mode (with the ability to operate under electric or diesel power). Locomotive-hauled trains are used for Intercity-Corridor-Other and Regional rail service.

The Service Plans for the Action Alternatives are based on the use of electric traction by all passenger trains operating on the NEC– using intact trainsets, electric locomotives or high-performance dual-mode locomotives – since these equipment types provide the most consistent top speeds and accelerating and braking performance, which allows for the highest utilization of available capacity. Specific assumptions regarding Regional rail service and rolling stock vary among the Action Alternatives. The ultimate decisions about rolling stock procurement, including the configuration and maximum speed of trainsets, will be made subsequent to the completion of the programmatic Tier 1 EIS.

4.1.4 ENHANCED SERVICE CONCEPTS

In addition to identifying requirements for rail infrastructure investments in capacity needed to accommodate increased levels of train service, FRA also examined the potential to improve passenger rail operations through the adoption of enhanced service and precision operations concepts to fully understand the dynamic operating environment in which passenger rail service on the NEC functions. These enhanced operating concepts represent national and international best practices, and are aimed at enhancing the attractiveness and convenience of train services, increasing the efficiency of operations, lowering the cost per capita of delivering rail service, and making the most efficient use of investments in new rail infrastructure. The FRA's focus in the development of the Action Alternatives was on concepts that take advantage of the elimination of chokepoints, the expansion of capacity and the standardization of rolling stock, so that the benefits of capital investment are maximized. Enhanced service concepts reach markets that are underserved or not served by existing service, while providing the rail operators the flexibility to deliver service that best meets the needs of the market in 2040. The new service concepts that the FRA applied and tested are discussed in the following sections, along with how and where these concepts are embedded within the representative Service Plans of the Action Alternatives.

Regular Clockface Headways

Service Plans for the three Action Alternatives provide for regular schedules for all train services operating on the NEC. Train schedules are headway-driven rather than load driven, as is the case today. In the Action Alternatives, virtually all NEC services operate at regular 15-, 30-, or 60-minute intervals, with local stations generally receiving 2 to 4 tph during peak periods and major stations often receiving more service. Peak shoulder hour, reverse-peak, and off-peak schedules retain the same operating patterns, but with a reduced number of trains per hour to match expected passenger demand. Individual service patterns repeat every hour (e.g., the local train stops each hour at 18 minutes and 48 minutes past the hour), though some patterns may only exist during peak periods.

An additional benefit of regular clockface headways is that they make it easy for passengers to make connections between rail and local transit services. For example, a bus route that runs on a regular clockface headway can be timed to meet connecting trains at a hub station[19]. This coordination increases ridership on both rail and other public transit services by reducing transfer time between modes. Additionally, a bus that is timed to meet the train can serve double duty – bringing passengers to the train as well as carrying passengers from the train on its onward journey. Transit agencies all along the NEC can choose to re-structure routes and schedules to take advantage of the regular clockface headway operation on the railroad.

Metropolitan Service

As described in Section 4.1.2, today's non-premium Intercity-Corridor service evolves into Metropolitan service, a new Intercity-Corridor service that provides frequent, regular service catering to the non-premium intercity market as well as the time-sensitive regional rail market. In all three Action Alternatives, Metropolitan service becomes the primary non-express Intercity service option for trips that begin and end on the NEC. A separate Intercity-Corridor-Other service remains to provide one-seat rides from NEC stations to markets beyond the NEC, including Virginia, North Carolina, and Vermont.

All of the Action Alternatives introduce Metropolitan service, although the level-of-service and the performance characteristics of the service varies among the alternatives. This variance is based on the railroad infrastructure and capacity that are provided in each alternative. In Alternative 1, Metropolitan trains share NEC slots with Intercity-Corridor-Other trains, operate mostly over existing NEC tracks, and service is limited to no more than two trains per hour in the peak periods. Metropolitan service is introduced to additional stations on the NEC, but the overall performance of Metropolitan and Intercity-Corridor-Other services is similar, and the principal travel benefits are derived from the improvement in the frequency of these combined services within the Intercity-Corridor category.

[19] Hub stations include smaller intermediate Intercity stations and key Regional rail stations, as well as new stations that have the potential to fill connectivity gaps, serve special trip generators, and/or provide important inter-modal connections. These stations are served by some Intercity service, although Intercity-Express service is more limited than the service levels offered at Major Hub stations. See Section 6.1.1.

In Alternative 2, Metropolitan service effectively replaces the existing Northeast Regional service for the low or economy end of the Intercity travel market for trips within the NEC territory. The service utilizes the high-speed tracks that are built at various locations along the NEC, and it provides four trains per hour, at regular 15-minute intervals at all locations and in all time periods on the NEC where there is demand to support the service. Intercity-Corridor-Other trains supplement the Metropolitans, further increasing the effective service frequency for travel within the NEC.

Alternative 3 provides two different sets of Metropolitan services, each operating with four trains per hour in peak travel periods. One service operates via downtown Philadelphia and the second-spine between New York City and Boston, and the other service operates on the existing NEC between Philadelphia and New Haven, with extensions of service to Harrisburg, PA via the Keystone Corridor, to Boston, MA via the Shore Line, and to Springfield, MA via the Hartford Line.

Run-Through Service at Major Stations/Terminals

In Boston, New York City, and Washington, D.C., the various Regional rail operators terminate service at the major rail stations in the central business district (CBD). Philadelphia is the exception on the NEC where Regional rail currently operates through Center City Philadelphia with branch lines on one side linked with different branch lines on the other side.

Regional rail run-through service, particularly applicable to Washington, D.C., and New York City, links branch lines from the different service operators and provides continuous revenue service on both sides of the metropolitan region through the CBD. For example, a peak-direction Regional rail train that originates in New Jersey operates into Penn Station New York, then continues eastward in revenue service and offers reverse-peak service to Long Island. Based on early market analysis performed during the alternative development process, demand for this through-service is modest relative to the demand for service to the CBD, and run-through demand is unlikely to be the driver for the investment in infrastructure required to support such operations. However, with considerable investment in the major terminals and coordinated improvements to train fleets, run-through service has the potential to provide operational efficiencies and reduce train interference conflicts, thereby unlocking additional capacity at these congested stations.

Alternative 1, which maintains the role of rail as it is today, retains the existing Regional rail operations with terminating services at Washington, D.C., New York City, and Boston, although the volume of train movement activity increases over existing and No Action Alternative levels. Intercity trains remain the principal through-running trains at Washington, D.C., and New York City.

Alternative 2 requires capital investment at Washington, D.C., and New York City to facilitate the through running of both Intercity and Regional rail trains, including the widening of station platforms and the creation of storage yard facilities on the far side of the terminal for originating and terminating Regional rail services. Through running is assumed to occur at both Washington, D.C., and New York City in this alternative – supporting frequent Metropolitan service as well as high-density Regional rail service. Through running capability and associated capacity projects permit Metropolitan service to be extended through Washington, D.C., to northern Virginia. Similarly, expanded Regional rail services at both Washington, D.C., and New York City are assumed to operate through the Major Hub stations, feeding yard facilities on the far side of the hub station and also enabling (but not requiring) revenue run-through service between suburban branch lines on opposite sides of the region.

Alternative 3 similarly supports through-running operations, which permit the most efficient use of platform and track capacity at the Major Hub stations and enable the dramatic increases in total train volumes that are possible in this alternative.

Intercity-Corridor and Regional Rail Express Service using New High-Speed Tracks

In Alternative 3, the new dedicated high-speed tracks for Intercity-Express and Metropolitan service provide an opportunity to increase the utilization of this infrastructure through urban areas with select Regional rail trains taking advantage of available slots not used by intercity trains. Intercity-Express and these select Regional rail trains operate with high-performance trainsets capable of operating in blended service with high-speed express trains. They supplement or replace the outer zone express service in the major metro regions, or could be used to extend Regional rail service beyond the existing service territories. For example, in New Jersey, this service could replace the current Trenton-Hamilton-Princeton Junction zone express trains, providing significant trip time improvement for these trips. This service could also be used to extend the service territory south to Philadelphia, providing high-quality express Regional rail service between Philadelphia and Bucks County to New York City.

This enhanced service concept is a significant feature of Alternative 3, offering substantially faster commute times for longer-distance commute trips from the outer suburbs. Maryland outer zone Regional rail trains can use the high-speed tracks between Baltimore and Washington, D.C. Similarly, outer zone Regional rail trains in New Jersey can use the high-speed tracks on final approach to New York City to reduce trip times and relieve congestion on the local tracks. Alternative 3 also provide opportunities for up to six or eight commuter express trains per hour from either Long Island or the Upper Harlem Line to Penn Station New York, depending upon the route option.

Simplified Operations

The simplified operations category encompasses a range of possible concepts for operating passenger service on a multi-track rail line. Service concepts include normalizing stopping patterns (with fewer but more regular and better coordinated patterns), as opposed to having a lot of unique individual patterns, less switching of trains between tracks in multi-track territory, fewer branch lines feeding the NEC Spine, timed transfers for branch line passengers at main line hub stations, and/or higher and more regular service frequencies for the stopping patterns that remain on the existing NEC. The primary benefit of a simplified Service Plan is that it brings more predictability to both train operators and passengers.

For train operators, simplifying the train schedule and adopting regular, repeating and well-integrated train stopping patterns can allow the railroad to be run more automatically, without the variability and potential human error introduced by a system that generates a wide range of unique conflicts that require frequent dispatcher decisions and unique solutions. The system remains too complex for completely automated operation, and train dispatchers are still needed to monitor and resolve conflicts and errors that do occur. However, simplified operations can reduce the number and type of train interference conflicts that arise for train dispatchers and allow them to better respond to conflicts when they occur, and respond in a way that is more predictable. Consequently, simplified options should improve the overall reliability of the railroad as well as minimize the amount of redundant and parallel rail infrastructure necessary to support a more complex Service Plan.

For passengers, the regularity of a simplified plan makes planning trips easier, increasing the attractiveness of rail versus other modes. More reliable service and better connections with other rail services and transit modes are benefits that attract additional ridership. Drawbacks of this type of plan may include serving fewer markets with one-seat-rides and increased trip times for express trains between major markets.

Both Intercity and Regional rail stopping patterns in all three Action Alternatives are simpler and more regular than in the current operating plans. These modifications, along with the elimination of chokepoints and the restoration of the railroad to a state of good repair, result in more reliable service and more efficient use of infrastructure. The most dramatic application of simplified operations occurs in Alternative 1 on the New Haven Line. A transit-style service with a simpler system of express and skip-stop local services replaces the current complex overlay of multiple stopping patterns. This service concept delivers greater throughput capacity without major additions of new track.

Coordinated Endpoint and Branch Line Connections

Coordinated scheduling of Regional rail trains on systems that have multiple branch lines or multiple terminals, or where the outer ends of two regional systems meet at a common station (defined as endpoints), can provide for convenient passenger connections, extending the reach of the existing systems, substituting for costly extensions for one-seat-ride service, and providing a much more convenient transfer experience for rail travelers. More precise schedule coordination becomes easier to accomplish with clockface scheduling, simplified operations, and elimination of the chokepoints that contribute to train delays—all of which are characteristics of the Action Alternatives. Convenient transfer connections depend on train schedules that allow enough, but not too much, time for passengers to change trains. Convenience also is enhanced with cross-platform or same-platform transfers, and the integration of timetable and real-time train information, particularly where more than one operating authority is involved. Trenton, NJ, is an example of a location where endpoint connections currently are provided between SEPTA and NJ TRANSIT Regional rail trains.

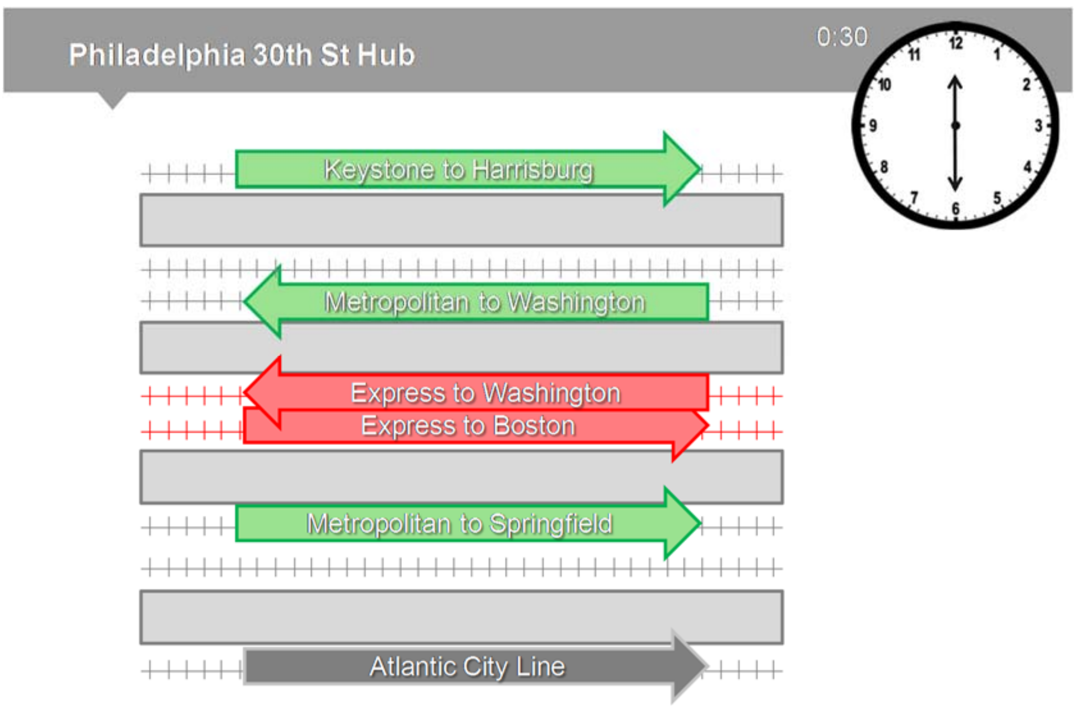
With clockface scheduling and regular, repeating service intervals, Alternatives 1, 2, and 3 take advantage of opportunities for better connected Regional rail service at several locations on the NEC, effectively closing the gaps that now exist in Regional rail connectivity from one system to another. As Maryland Regional rail service is extended to Newark, DE, schedules are coordinated with those of the Regional rail service to Philadelphia, enabling convenient passenger transfers. Modification of the track configuration near Trenton, NJ, allows timed cross-platform transfers between New Jersey and Philadelphia Regional rail trains in both directions. Also, the integration of Shore Line and Hartford Line Regional rail trains with New Haven Line service provides convenient cross-platform transfers at New Haven.

The Action Alternatives also improve connectivity between main line and branch line services at multiple locations. Intercity services can be better coordinated with Regional rail services at Philadelphia 30th Street with the normalization of train schedules. Similarly, NEC services can be better coordinated with train services to and from Hoboken, NJ, at the transfer station in Secaucus, NJ. The timing of Empire train arrivals and departures at Penn Station New York can be coordinated with Intercity-Express, Metropolitan, and Regional rail service on the NEC. And, in cases where simplified operations may reduce the number or frequency of direct train services from the NEC Spine to branch lines, shuttle services on the branch lines can be timed with convenient connections to and from NEC trains. This offers greater overall service frequency on the branch line, and a trip that remains convenient and time-competitive for the passenger making the transfer. The same principles apply to connecting transit services at hub stations. Regular clockface scheduling of rail services, coupled with reliable operating performance, allows local transit service providers to customize the arrival and departure timing connecting and feeder services to match the train schedules.

Pulse-Hub Operations

A pulse-hub is a special application of service coordination, where multiple trains converge on a single hub station concurrently or in close succession, dwell simultaneously for a period of time while passengers transfer from one service to another, and then depart toward their various destinations. A pulse-hub operation can be a key component in a simplified operation, but could also be featured in Service Plans with a wider variety of service offerings. Figure 5 illustrates one example of a pulse-hub operation at 30th Street Philadelphia. Several trains of different types and with various destinations have coordinated arrival and departure times, facilitating convenient transfers.

Figure 5: Philadelphia Pulse-Hub



Source: NEC FUTURE team, 2015

A pulse-hub operation offers opportunities to provide high-quality service to smaller markets that do not warrant one-seat-rides to a major market. For this system to work adequately, significant amounts of built infrastructure are needed at hub stations to facilitate the simultaneous movement of multiple trains through the station as well as the efficient movement of passengers between trains. Investment in station and rail infrastructure to enable easy passenger transfers is a prominent feature of pulse-hub operations. Investment in stations to facilitate high-quality passenger transfers, however, can also be a feature of Service Plans that do not rely exclusively on this type of operation, but selectively employ it at key stations on the network. Similarly, as with coordinated endpoint connections, this service enhancement works only if a transfer passenger can change trains without queuing and with the common practice of staging passengers on platforms.

The Service Plans for Alternatives 2 and 3 provide for pulse-hub operations on the lower level of Philadelphia 30th Street Station with Intercity-Express, Metropolitan, Keystone Corridor, and Atlantic City trains all connecting with universal transfer opportunities every 30 minutes during the peak periods. The Alternative 3 route option from Long Island through New Haven, CT, to Hartford, CT, also provides a timed pulse-hub at New Haven.

4.1.5 FREIGHT RAIL

While the purpose of NEC FUTURE focuses on passenger rail service, the NEC FUTURE Scoping process, along with input received from freight rail operators and state and regional stakeholders, identified the preservation of freight rail as an important objective. NEC FUTURE Service Plans for each of the Action Alternatives preserve freight access on the NEC and do not preclude future growth opportunities. The FRA relied on specific assumptions for the mixed operations of freight and passenger traffic on the same tracks and in the same right-of-way, consistent with the current FRA regulatory framework:

- Freight will not operate on high-speed tracks in mixed traffic with Intercity-Express passenger trains operating above 160 mph—this includes all new segments included in Alternative 3.
- Mixing of different types of passenger trains, including Intercity-Express and Metropolitan service using new high-performance equipment, are assumed to be permissible in the future on the existing NEC with passenger train speeds up to 160 mph—this applies mostly to the express tracks on the NEC where there are more than two main tracks, in all three Action Alternatives.
- New tracks generally will be built with sufficient separation from parallel tracks used by freight trains to permit simultaneous operation of freight and passenger traffic; however, temporal separation of freight traffic may be required for some portions of the NEC where existing express tracks are used by high-speed trainsets and are closely parallel to the existing local tracks, such as in Pennsylvania, New Jersey, and Massachusetts.[20]

4.2 RIDERSHIP

The NEC FUTURE ridership and revenue forecasting approach included two major components to address the most significant travel markets relevant to the NEC. These two components are listed below and described in the next sections:

- A new Interregional Model, which addressed travel between metropolitan market areas in the NEC, developed primarily from a new NEC household survey
- Existing regional models, which addressed travel within metropolitan market areas in the NEC (e.g., Washington, D.C., Baltimore, Philadelphia, New York City, Boston, etc.)

4.2.1 INTEGRATION OF THE INTERREGIONAL AND REGIONAL FORECASTS

The FRA estimated interregional and regional ridership forecasts in parallel processes using separate forecasting models. These forecasts were then combined to form overall ridership forecasts for the No

[20] Railroad operating characteristics and limitations on permissible maximum speeds and the mixing of freight and passenger traffic are described more fully in Appendix A, *Service Plans and Train Equipment Options Technical Memorandum*.

Action Alternative and Action Alternatives. Combining the forecasts involved the identification and application of the appropriate "model of record" for each rail market. Table 4 summarizes the forecasting models used to evaluate the No Action Alternative and Action Alternatives for each region pair within the Study Area. Within the metropolitan regions (on the diagonal of the table), the appropriate regional models were used. Trips between regions were estimated using the new Interregional Model, for almost all pairs of regions. For the final rail results, there were very few interregional commuter-rail trips that were not captured using the regional models. Since the regional models were more robust in estimating commuter trips, as well as to avoid double-counting trips, the Regional rail ridership numbers were taken solely from the regional models as opposed to the Interregional Model commuter ridership.

Table 4: Models Used to Evaluate NEC FUTURE Rail Markets

From/ To	Market Area	Boundaries	A	B	C	D	E	F	G–L
A	Washington Metro	Northern Virginia to Pautuxent River	R1	IR	IR	IR	IR	IR	IR
B	Baltimore Metro	Susquehanna River to Pautuxent River	IR	R2	IR	IR	IR	IR	IR
C	Wilmington/ Philadelphia Metro	Susquehanna River to Trenton	IR	IR	R3	IR	IR	IR	IR
D	NY Metro, West of Hudson	Trenton to New York City	IR	IR	IR	R4	IR	IR	IR
E	NY Metro, East of Hudson	New York City, Long Island & Coastal Connecticut	IR	IR	IR	IR	R5	IR	IR
F	Providence/Boston Metro	Rhode Island to SE New Hampshire	IR	IR	IR	IR	IR	R6	IR
G	Empire Corridor	New York City to Albany	IR	IR	IR	IR	IR	IR	IR
H	Inland Connecticut, Massachusetts	New Haven to Springfield	IR	IR	IR	IR	IR	IR	IR
I	Virginia	Richmond to Washington D.C.	IR	IR	IR	IR	IR	IR	IR
J	Keystone	Philadelphia to Harrisburg	IR	IR	IR	IR	IR	IR	IR
K	Vermont	Vermont to Springfield	IR	IR	IR	IR	IR	IR	IR
L	Maine	Maine-New Hampshire	IR	IR	IR	IR	IR	IR	IR

Tools:

IR	NEC FUTURE Interregional Model
R1	Enhanced Washington Metropolitan Area Transit Authority Transit Post Processor of Metropolitan Washington Council of Governments Model
R2	Simplified Trips on Project Software (STOPS) Application for Baltimore Metropolitan Area
R3	Delaware Valley Regional Planning Commission Regional Forecasting Model
R4	NJ TRANSIT North Jersey Travel Demand Forecasting Model
R5	Metropolitan Transportation Authority Regional Transit Forecasting Model
R6	STOPS Application for Boston Metro/Rhode Island Area

Source: NEC FUTURE team, 2015

4.2.2 INTERREGIONAL MARKETS

The FRA's travel demand modeling and forecasting approach for interregional travel consisted of the development and application of a two-stage model system. The first stage modeled total interregional travel volume by origin-destination (OD) pair. The second stage predicted the share of intercity passengers expected to use each of the available intercity travel modes using a nested logit specification.

The two-stage model system was applied in reverse order (i.e., mode share before total travel demand) to allow mode share model results to be incorporated within the total demand model structure. This linkage provides the total travel model with sensitivity to changes in the level-of-service provided by all modes, allowing for the total number of trips to increase due to overall improvement in travel conditions.

Household Travel Survey

The development of the Interregional Model system was informed by the results of an extensive household survey conducted within the Study Area. Although existing survey data were available, the data were generally tied to specific existing models or forecasts focused exclusively on either interregional or certain regional sub-markets within the NEC. Moreover, these existing data sets and models did not provide a consistent integrated analysis and forecasting basis throughout the NEC. As such, the FRA conducted the NEC FUTURE Survey of Northeast Regional and Intercity Household Travel Attitudes and Behavior (Household Travel Survey) to provide data on travel patterns and mode choice within the Study Area for use in the mode choice models.

The new Household Travel Survey included only respondents who had made interregional trips between the respondent's home and eligible out-of-state locations were considered as qualifying trips. If a respondent took multiple qualifying trips, one was randomly selected to be the "reference trip" for the respondent. The actual mode chosen for the reference trip forms the basis for the revealed preference (RP) portion of the survey response. Respondents were then asked additional questions about this trip about attributes such as type of train service used, mode of access/egress, fare, estimated one-way travel time and cost, as well as trip purpose.

Six stated preference (SP) choice exercises represented the "core" of the survey and provided the primary basis for estimating the new mode-choice model. These SP questions asked respondents to think about the context of their reference trip and then choose from among three modes of travel with characteristics specified by the survey. These characteristics varied across the questions, according to an experimental design that minimized correlations among variables.

The specific SP trade-off questions reflected an experimental design to address an appropriate cross section of all the potential mode availability and service characteristic combinations. The detailed trip information obtained before the trade-off questions provided the context for the respondent's travel choices and a basis for defining trip-relevant service characteristics in the trade-off questions. The responses to the survey questions provided the basis for estimating key sensitivities to changes in the service characteristics, by market segment, for the new model. In addition to the SP questions, all qualifying respondents were asked demographic questions at the end of the survey.

Total Travel Demand Model

In the two-stage travel demand modeling approach, total travel demand models (one for each trip purpose) were required in conjunction with the mode share models (also one for each trip purpose). Total travel demand forecasts define the total market size to which the mode shares are applied to produce ridership forecasts by mode. In general, there are two major influences on the total travel demand between any two geographic areas; population and economic activity growth, and changes in the modal levels of service provided. The impact of population and economic activity contributes to organic growth, in that an increase in those measures will naturally generate more travel. The change of modal levels of service creates induced demand, as opposed to organic growth. Induced demand creates additional trips because overall travel between origins and destinations become more attractive, due to better travel conditions (such as reduced travel time or cost).

The FRA estimated total travel demand model using cross-sectional data that estimates the relationship between current levels of population, income, employment, and level-of-service and current observed demand. The modeling process then applies the observed relationships to forecasts of growth in population, income, employment, and changes in level-of-service.

Multimodal interregional passenger market data for the Study Area were assembled from a number of different sources. The sources are as follows:

- Auto market: NEC Automobile OD Study (2014), prepared by RSG for the NEC Commission
- Air market:
  - Air Carrier Statistics database (T-100 Domestic Market), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from *http://www.transtats.bts.gov/Fields.asp?Table_ID=258*
  - Airline Origin and Destination Survey (DB1B), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from *http://www.transtats.bts.gov/Fields.asp?Table_ID=247*
- Rail market: Amtrak Ridership and Ticket Revenue Data (FY 2013), provided by the Market Research and Analysis Department, Amtrak
- Bus market: Northeast Corridor Bus Schedule and Ridership Data (2014), prepared by RSG for the NEC Commission
- Demographic Data: Demographic Growth Forecasts provided by Moody's Economy.com (annual for years 2010 through 2040)

Using the data sources listed above, the FRA developed annual trip tables for each of the modes. Once the total trips were determined, the FRA then segmented them by purpose using the trip purpose percentage share calculated from the NEC FUTURE Household Travel Survey, segmented by mode and trip length. Table 5 presents the trips by mode and purpose, which shows that 70 percent of trips in the NEC market area are for non-business purpose. The final base trip table used in the Interregional Model was the total trips for each zone pair segmented by trip purpose.

Table 5: Summary of Existing (2013) Annual Person Intercity Trips by Mode and Purpose

Purpose	Auto	Air	Intercity-Express Rail	Intercity-Corridor Rail	Intercity Bus	Total
Business	63,195,000	8,717,000	1,725,000	2,698,000	1,031,000	77,366,000
Non-Business	274,272,000	7,951,000	1,423,000	7,126,000	6,991,000	297,763,000
Commute	47,150,000	0	192,000	1,598,000	1,562,000	50,502,000

Source: NEC FUTURE team, 2015

Mode-Choice Model

The mode share models estimate the share of total person travel by mode. This model component addressed travel by the following modes:

- Auto (passenger car/truck/van)
- Air
- Intercity bus
- Train, addressing the following types of train service separately:
  - Intercity-Express
  - Intercity-Corridor rail
  - Regional rail
  - Metropolitan

Model Structure

The new model estimated shares among these as a function of the following key independent variables describing the service characteristics:

- Travel time
- Travel cost or fare, taking account of the cost implications of travel by group and individuals and also including parking charges
- Schedule of service provided by air, rail, and bus
- Alternative-specific constants reflecting the differences between modes not directly measured by other independent variables in the model (factors and traveler perceptions such as the comfort and convenience provided by each mode would be reflected here)

The FRA estimated three separate mode share models, to reflect trip purpose market segmentation (business, non-business/non-work, and commute). To reflect the differential substitution that exists between different modes of travel, the FRA used a nested logit (NL) structure. Using the NL model structure allows the modes in a common nest to exhibit a higher degree of similarity and competitiveness than modes outside of the nest.

Models of modal travel choice can be based on RP or SP data. Each type of data provides certain advantages over the other. RP data reflect actual behavior and take account of the real world conditions that respondents face. SP data takes account of a wider range of potential choices and attributes. The SP data reflect an experimental design that provides for explanatory variables that have a larger range of variability within and between alternatives and break the correlation between explanatory variables within each alternative. While models can be estimated with each type of data separately, the most robust models combine RP and SP data in order to take advantage of the unique characteristics of each type. Combining the two sets of data to estimate a single model can produce a model that retains the advantages of both RP and SP models and eliminate or dramatically reduce the disadvantages of each. The NEC FUTURE

Household Travel Survey collected both types of data so for use in studying Intercity travel patterns and travel behavior along the NEC.

Modeling Metropolitan Trains

The SP questions in the Household Travel Survey presented four types of rail to respondents:

- High Speed Train (i.e., Intercity-Express)
- Regional Train (i.e., Intercity-Corridor)
- Commuter Train (i.e., Regional rail)
- Metropolitan Train (a new service)

At the time the survey was developed, Metropolitan service was envisioned as a mode that would be a level above the Regional rail services, but below the Intercity-Corridor rail, in terms of service quality. It would be moderately slower and cheaper than the Intercity-Corridor rail, while not having reserved seats (so potentially some riders may need to stand), and no amenities such as restrooms or food service. As the FRA developed the Service Plans for the No Action and Action Alternatives, Metropolitan service evolved to become similar to the Intercity-Corridor trains in terms of frequency and stopping patterns. In addition, the new equipment envisioned for use by the Metropolitan service allows for faster travel times for some Action Alternatives.

To include a new mode in a logit model, the modeler must assert that the new mode is independent from the other modes included in the model so that it does violate the independence from irrelevant alternatives (IIA) property of the model. While using an NL lessens the stringency of the IIA requirement, it does not eliminate it. Given that the more developed concept of Metropolitan service was similar to the existing Intercity-Corridor service in terms of speed, time, and cost parameters, the FRA decided to combine the Metropolitan with Intercity-Corridor for modeling purposes. The decision to estimate Metropolitan and Intercity-Corridor-Other service as a single rail mode does not mean that these services are identical, as there could be significant differences in on board amenities, reservations policy, and actual pricing. The combined service retained the label Intercity-Corridor. The daily frequencies for Metropolitan and Intercity-Corridor-Other were summed together and the travel times were averaged for each station-pair to account for any differences in the service.

As the naming convention of the rail modes differs across sections of the document, Table 6 provides a correspondence between the mode names.

Table 6: Intercity Rail Mode Naming Convention

Existing Name	Survey Name	Model Estimation Name	Model Application Name
Acela Express	High Speed Train	Intercity-Express Rail	Intercity-Express
Northeast Regional	Regional Train	Intercity-Corridor Rail	Intercity-Corridor
N.A.	Metropolitan Train	Metropolitan Rail	Intercity-Corridor

Source: NEC FUTURE team, 2015

Key Service Variable Sensitivities

The most important service variables in the mode-choice model include travel time, travel cost, and frequency of service. Travel time and travel cost typically have an inverse relationship, and can be used to calculate the Value of Time (VOT), or how much respondents are willing to pay to save additional travel time. The business and commute models had VOTs, which were similar to others seen in the corridor or for similar models, but the non-business model had much lower values of time, ranging from around $6 to around $20 (allowed to vary by total cost of the trip). These are lower values than have been seen in the Study Area in the past, and indicate that price is becoming a particularly important piece of the mode-choice decision, especially given that approximately 70 percent of travel in the Study Area is currently non-business. One reason for this shift in cost sensitivity could be the increased prevalence of low-cost intercity bus service that has occurred over the past several years, making travelers more aware of cheaper options in the interregional market. The market for Intercity-Express continues to appeal to business travelers who value time and are willing to pay for the service/time savings, but business travelers are only 18 percent of the total.

In all three mode choices of the Interregional Model (business, non-business, and commute), the FRA used a dampened function of frequency. This specification accounts for the expectation that additional departure options impact choice up until a certain saturation level, at which point travelers have enough options, and more frequency will not increase the utility of the mode. This saturation point in the models is around 50 trains per day, which indicates that once the trains are less than 30 minutes apart, the importance of frequency drops off.

4.2.3 **REGIONAL MARKETS**

The FRA conducted the regional forecasting process largely using existing ridership tools developed by the operators or the metropolitan planning organizations, with some modifications to accommodate the NEC FUTURE forecasting approach. Many of these tools have been used by Regional rail operators or other regional transit operators to plan Federal Transit Administration (FTA) New Starts investments and evaluate the implications of service and policy changes. By using existing tools to the maximum extent possible the NEC FUTURE team maintained consistency with local and future planning efforts, and ridership and growth estimates.

Shorter distance, regional travel markets that lie within a specific major region were addressed by the available regional models. Where local models were not available, the FRA used the FTA Simplified Trips on Project Software (STOPS)[21] module to estimate ridership demand.

The following lists the models used in the analysis of regional trip making:

- Washington: Metropolitan Washington Council of Governments/Washington Metropolitan Area Transit Authority Forecasting Model

[21] STOPS is the FTA's national forecasting model, which relies on a combination of national experience and local market-based information to estimate transit project ridership. STOPS is a series of programs designed to estimate transit project ridership using a streamlined set of procedures that bypass the time-consuming process of developing and applying a regional travel demand forecasting model. It is quite similar in structure to regional models and includes many of the same computations of transit level-of-service and market share found in model sets maintained by metropolitan planning organizations and transit agencies.

- Baltimore: FTA STOPS implemented for the Baltimore metropolitan region
- Philadelphia: Delaware Valley Regional Planning Commission Model
- New Jersey: NJ TRANSIT North Jersey Travel Demand Forecasting Model
- New York: LIRR/MNR/Shore Line East: MTA Regional Transit Forecasting Model
- Boston: FTA STOPS implemented for Boston metropolitan region

4.2.4 MODEL INPUTS AND ASSUMPTIONS

For analysis purposes, the FRA used a forecast year of 2040 for the No Action Alternative and Action Alternatives. Travel demand forecasts are driven by demographics and service levels.

Demographic Forecasts

The fundamental driver of growth in total trip making in the Study Area comes from forecasted growth in population, employment, and income. Forecasts used as the basis for growth were extracted from Moody's Analytics June 2013 "base" demographic forecasts. These forecasts were obtained on a county-level basis for the Study Area.

Table 7 and Table 8 present the population and employment projections, and percentage change for the major NEC metropolitan areas as contained in Moody's Analytics June 2013 forecasts. Three forecasts were supplied by Moody's. They include "low", "base" and "high" conditions. All of the forecasted results use the "base" (or most likely) condition.

Table 7: NEC Population Forecasts

	Population				Percentage Change vs 2013		
Market	2013	2040 (Low)	2040 (Base)	2040 (High)	2040 (Low)	2040 (Base)	2040 (High)
Washington, D.C.	5,930,000	7,127,000	7,655,000	8,238,000	21%	29%	39%
Baltimore	2,774,000	3,000,000	3,145,000	3,299,000	8%	13%	19%
Philadelphia	6,600,000	6,874,000	7,108,000	7,352,000	4%	8%	11%
New York City	22,210,000	23,276,000	24,306,000	25,393,000	5%	9%	14%
Providence	970,000	982,000	1,036,000	1,094,000	1%	7%	13%
Hartford/Springfield	1,794,000	1,876,000	1,905,000	1,935,000	5%	6%	8%
Boston	6,450,000	6,602,000	6,888,000	7,188,000	3%	7%	11%

Source: NEC FUTURE team, 2015

Table 8: NEC Employment Forecasts

Market	Employment				Percentage Change vs 2013		
	2013	2040 (Low)	2040 (Base)	2040 (High)	2040 (Low)	2040 (Base)	2040 (High)
Washington, D.C.	3,104,000	2,781,000	3,858,000	4,801,000	-3%	24%	62%
Baltimore	1,363,000	1,279,000	1,679,000	2,023,000	2%	23%	55%
Philadelphia	3,007,000	2,680,000	3,576,000	4,323,000	-4%	19%	50%
New York City	10,077,000	8,810,000	11,827,000	14,660,000	-6%	17%	51%
Providence	426,000	352,000	476,000	560,000	-10%	12%	39%
Hartford/Springfield	873,000	729,000	963,000	1,145,000	-10%	10%	37%
Boston	3,275,000	2,756,000	3,736,000	4,599,000	-9%	14%	48%

Source: NEC FUTURE team, 2015

Table 7 shows that the populations in the major metropolitan markets are projected to grow between 6.2 percent (Hartford) to 29 percent (Washington, D.C.). The low-high bounds are also fairly tightly bound to the “base” condition, generally plus or minus 5 percent points of the base forecast.

Table 8 presents the employment forecasts. While the “base” forecasts shows employment growing slightly faster than population, the low-high bounds are much wider for employment. This is an important element of the demographic forecasts, as Moody’s forecast suggests larger uncertainty associated with future NEC employment. Their “low” scenario includes a contraction of the overall job market (as compared to today), while their “high” scenario includes a full boom in economic activity with large scale growth in employment. This suggests that one of the significant risks to the forecasts is the strength of the regional employment market, as Moody’s has placed a wide band on these forecasts.

Service Characteristics

The primary mode-choice input for both the Interregional Model and regional models were the service characteristics of all available modes

For the Interregional Model, the relevant service characteristics included travel time (access/egress and line haul), cost, and frequency of service. For the non-rail modes (auto, air and intercity bus), the service characteristics were held constant across all alternatives and were based on existing service, with the exception of introducing highway congestion into the auto and intercity bus travel times. The rail service travel times and frequencies were determined from the service planning process. The non-rail modes were assumed to be unconstrained with respect to their capacity to accommodate future growth.

For the rail fares in the Interregional Model, the FRA initially assumed the current pricing. Later, as described in Section 4.3, the FRA evaluated the impact of lower fares on resulting rail demand to establish the model’s sensitivity to pricing and understand the impacts on ridership demand and operating costs. The FRA found that the operating costs associated with the Action Alternatives were lower than the associated passenger fare revenues, which indicates the flexibility for an operator to discount fares and still cover operating expenses.

While there were six separate regional forecasting models applied to evaluate the No Action Alternative and Action Alternatives, the key attributes that drove the magnitude of the ridership results included travel time (line haul and access/egress), number of transfers, frequency, and total cost. For the Regional models, the service characteristics for the non-rail modes were dealt with in the same manner as for the Interregional Model, by holding them constant across the No Action and Action Alternatives. The rail frequencies and travel times were similarly calculated from the potential service plans developed as part of the alternatives development process. The FRA held Regional rail pricing constant through the analysis in real dollars, meaning Regional rail fares were assumed to grow with inflation.

4.2.5 MODEL OUTPUTS

As described earlier in Section 4, for the alternatives refinement process the FRA ran both the interregional and regional models with numerous intermediate Service Plans. The resulting ridership projections were then compared with the volume of service provided at key locations along the corridor to estimate the extent to which seats on board trains would be filled during peak periods. Service levels then were adjusted either upward or downward as necessary to balance the provided service with the forecasted demand. The Interregional model provided ridership information at screenlines north of Washington, D.C., at the Hudson River and East River, at approaching Boston South Station. The initial ridership results from the Regional model included daily and peak passenger volumes at screenlines in the following locations:

- Potomac River South of Washington Union Station
- North of Washington Union Station
- Susquehanna River
- Keystone West of Philadelphia 30th Street Station
- North of Philadelphia (between Cornwells Heights and Trenton)
- Hudson River
- East River
- Harlem River/Empire Corridor
- South of Boston South Station

The FRA utilized these screenlines by comparing the peak-hour, peak-direction ridership with the available capacity, and adjusting service where there were large discrepancies. The goal was to provide an adequate amount of service to allow for growth, but not to provide excessive capacity.

The primary output of the model was trips by mode for each zonal pair, which can be formatted in multiple ways to support alternatives evaluation. The FRA used the following model outputs (from both the interregional and regional models):

- Annual trips by mode for two levels of geographic aggregation:
  - Metropolitan statistical areas (collectively do not cover entire Study Area)
  - Greater metropolitan area (collectively covers the entire Study Area)
- Annual rail passenger miles
- Annual and average weekday passengers at two levels:

– Station boardings

– Station-to-station ridership

The year 2040 ridership forecasts were constrained to the available seated capacity where forecasted demand exceeded available seats. Specifically, the FRA applied capacity constraints at specific locations and to specific train services where demand was projected to exceed seating capacity. In the No Action Alternative, Intercity-Express, Intercity-Corridor, and New Jersey Regional rail service is capacity-constrained crossing the Trans-Hudson River screenline. In Alternative 1, New Jersey Regional rail crossing the Trans-Hudson screenline is capacity-constrained, but Intercity services have sufficient capacity to accommodate projected ridership. Alternatives 2 and 3 required no adjustments for capacity constraints, meaning that forecasted demand is accommodated by the amount of service offered by each alternative.

4.3 OPERATIONS AND MAINTENANCE COSTS

The FRA prepared operations and maintenance (O&M) cost estimates to provide representative estimates of the costs to operate and maintain the proposed Service Plans for the No Action and Action Alternatives. The methodology produced high-level, order-of-magnitude estimates for O&M costs appropriate for a Tier 1 EIS level of review. In conjunction with the capital cost estimates (Section 4.4), these O&M estimates facilitate comparative cost analysis between the No Action Alternative and each Action Alternative, and, for Intercity services, help the FRA to assess whether the Service Plans are likely to generate an operating surplus, where revenues exceed costs.

Where available, the FRA used data on recent actual Intercity and Regional rail O&M costs as a starting point for the analysis. The availability of this information varied across the service types and cost categories, and the FRA supplemented it with additional cost estimates where needed to provide a more comprehensive data set. The FRA combined these data, which were also generalized across the corridor, to facilitate consistent application of cost estimates across the Service Plans, based on key assumptions about the characteristics of the service types (Section 4.1.2). The FRA then applied these unit O&M costs to projected level-of-service and physical characteristics information to produce O&M cost forecasts for the alternatives for each of the service types.

The FRA calibrated the ridership model for 2013 base trips using current fares to accurately match existing ridership. For the Action Alternatives that include new markets, the FRA calculated distance-based fare equations based on current fares for three types of rail trips: trips entirely south of New York City, trips north of New York City, and trips through New York City, to reflect market-based differences in the pricing structures for these trips today. The O&M costs associated with these existing fare scenarios were substantially lower than the associated revenues. Therefore, the FRA tested multiple fare discounts for the Intercity-Corridor service, while keeping the Intercity-Express fares at the existing level. For each Action Alternative, the FRA reduced the Intercity-Corridor fares by 30 percent compared to today. This reduction is neither fare-maximizing nor ridership-maximizing analysis; rather, it is intended only to demonstrate that the Service Plans operate profitably over multiple fare structures.

4.4 **CAPITAL COSTS**

The FRA developed a capital cost model to provide conceptual cost estimates for each Action Alternative commensurate with the level of detail necessary to provide for an accurate, well-documented cost comparison between the No Action and Action Alternatives. The FRA calculated the No Action Alternative cost by summing the total cost of the No Action Alternative Project List (see *No Action Alternative Report*). While the goal of the model is to reflect a conceptual level of detail, the model is based on a validated methodology that relies on data from actual construction projects. The model is sufficient to reasonably estimate the costs for end-to-end Action Alternatives from Washington, D.C., to Boston, MA. The model is not intended to estimate the costs of specific smaller scale projects or programs separately from the end-to-end routes of the Action Alternatives, such as individual bridge replacements, individual tunnel construction projects, or individual station projects. These detailed project-level cost estimates would be developed in later planning, engineering, and design states as the NEC FUTURE program is implemented.

To develop the cost model, the FRA completed more detailed analysis for typical right-of-way sections, station configurations, track configurations, rolling stock requirements, and maintenance and operations costs. The estimates address all major capital cost elements such as station development, grade crossing eliminations, vehicle and maintenance shop needs, supporting systems, right-of-way acquisition, and costs of linear or area-based infrastructure elements such as tunnel or aerial sections or embankment or retained fill areas.

4.4.1 **LINEAR ELEMENTS**

Linear element costs represent those costs that are measured by linear attributes, such as route-feet or track-feet. The FRA calculated these costs by multiplying lengths by a unit cost per route-foot. There are three types of linear elements that describe capital investment in rail infrastructure and which translate into capital cost line items for the Action Alternatives:

- **Curve Modification**: a shift or straightening of existing NEC track alignments to improve speeds, including straightening a curve or eliminating the curve entirely. Curve modifications address the compromised performance of the existing NEC by reducing, or eliminating speed restrictions at certain locations along the NEC.
- **New Track**: improvements that increase capacity or improve trip times, generally contained within the right-of-way of the existing NEC; typical upgrade projects include:
  - Signal system upgrade
  - Catenary and electrification system upgrade
  - One or two new tracks constructed within existing right-of-way—includes new track as well as all associated construction to enable new tracks to be utilized, including new or modified catenary, signaling, interlockings and civil and structural work
- **New Segment:** New-track construction on new right-of-way that does not follow the existing NEC. New segments diverge from and reconnect to the existing NEC, which expand the capacity of the railroad and/or relieve chokepoints.

Linear elements are mapped along the Representative Route of each alternative. The FRA estimated the capital costs of linear improvements by developing a unit cost of construction per linear mile or foot, and multiplying this unit cost by the length of the route segment over which the given set of linear element improvements are expected. Contingencies and other cost factors were added to the individual line items or totals as appropriate.

Two sets of right-of-way characteristics, which also are mapped along the Representative Route of each alternative, are used to develop the unit cost of construction and to understand the magnitude of potential environmental impacts associated with construction. These right-of-way characteristics are referred to as the ***construction type*** and the ***typical cross section***.

- **Construction Type** identifies the vertical profile characteristics of the existing or proposed new right-of-way, which is a function of the terrain through which the route passes and the extent to which natural features, land development, or highway/waterway/railroad crossings drive the need to change the grade of the railroad. All existing and proposed route segments are assigned one of the following construction types:
  - ***Tunnel*** is typically applied where the Representative Route is beneath a large body of water, such as the Hudson River; the topography is too steep to meet high-speed performance criteria, as is the case in northern Connecticut; and in densely developed areas where there is no room for above ground segments, as is the case in Baltimore, New York City, and Providence.
  - ***Trench*** is generally applied prior to and following a tunnel, where a tunnel transitions to at-grade or embankment construction types, and where local conditions permit the construction of an open trench to provide grade separation of the railroad and crossing roadways.
  - ***At-grade*** is generally applied where local vertical grade changes permit construction at-grade and where existing highway/roadway rights-of-way are grade separated on aerial structures. At-grade segments are common south of New York City where the topography is relatively flat. It is less common north of New York City where changes in topography occur more frequently.
  - ***Embankment*** is generally applied following an aerial structure construction type, indicating where the aerial structure returns to grade, and where local vertical grade changes do not permit construction at-grade. Embankments are common south of New York City where the topography is relatively flat.
  - ***Aerial Structure*** is generally applied in heavily urbanized areas where land available at-grade is scarce and requires an aerial structure above existing rail or roadway rights-of-way, and at river crossings, wetland areas, valleys, or crossings over existing highways/roadways where vertical grade changes below top of rail vertical alignment and/or where potential for significant environmental impacts do not permit construction at-grade.
  - ***Major Bridge*** is generally applied at river crossings, wetland areas, valleys, or crossings over existing highways/roadways where vertical grade changes do not permit construction at-grade. The major bridge construction type generally is associated with long-span aerial structures and with movable bridges.
- **Typical Cross Section** for construction on new track and new segments, the FRA developed representative typical cross sections that identify construction methods and right-of-way configurations for track and track structures. The purpose of these typical cross sections is to aid in the development

and calculation of construction line-item quantities in the model. The typical cross sections define the requirements for major infrastructure components and provide for a quality control review of these quantities and a documentation source for how quantities were developed. The FRA developed quantities by calculating construction line items as they are depicted in the typical cross sections per route-foot. Each construction line item was assigned a unit cost, which was then multiplied by the quantity and summed to a total cost per route-foot for each typical cross section. There are 47 different typical cross sections, organized by interchangeability with the existing NEC, based on the number of total tracks in the right-of-way, the horizontal and vertical location of the new tracks relative to existing tracks, the maximum speed of the route segment, and the construction type. A unique unit cost of construction was developed for each typical cross section.

4.4.2 SUPPORTING INFRASTRUCTURE

In addition to the linear elements, there are several types of rail infrastructure that are location-specific and are best represented in the cost estimate by a single location or point along the Representative Route. These supporting infrastructure costs are generally applied as a single discrete cost per facility or bundle of track work. The discrete cost includes any route-foot or track-foot elements needed to construct the facility or track work.

For purposes of environmental impact assessment, every location-specific element has a defined area of potential impact associated with it. The size and shape of the polygon defining this area of potential impact varies according to the type of element. Construction costs were estimated for location-specific projects based on a unit cost per element and a count of the number of elements constructed at a given location or along a segment of the route. Supporting Infrastructure fall into the following categories:

- **Stations and Station Areas**: station buildings, waiting areas, parking, and ancillary buildings. Existing local stations that are not slated for expansion or upgrading were omitted from the list of location-specific line items, since there are no incremental capital costs associated with these locations.
- **Junctions:** the construction of major track connections or interlockings[22] at points where tracks converge or diverge allowing trains to switch from one set of tracks to another. Junctions are identified at every point where a new route segment connects with the existing NEC, and at locations where grade-separated track connections provide relief to existing chokepoints. This category also includes the additional railroad infrastructure to provide station sidings at new or upgraded stations where stopping trains need to use platform tracks separate from the through tracks used by non-stop express trains. The footprint for these junctions or major connections can extend beyond the existing NEC rights-of-way (but stay within the Representative Route) to accommodate grade-separated, conflict-free movement between tracks or between the NEC and connecting corridors, Regional rail branch lines, and storage yards.
- **Storage and Maintenance Facilities**: support fleet requirements of NEC FUTURE. Horizontal dimensions could extend beyond the limits of the footprint defined for new segments, new tracks, or curve modifications. Right-of-way requirements for these facilities would be evaluated as more details

[22] Interlockings are locations on multi-track rail lines where lines join together or where crossovers between tracks are placed to permit trains to change from one track to another. They are part of the signaling and train control system and are centrally controlled by train dispatchers on the NEC.

become available, during the planning, engineering, and design stages when NEC FUTURE is implemented.

4.5 STAKEHOLDER AND PUBLIC OUTREACH

Throughout NEC FUTURE, the FRA has engaged numerous agencies and operators within the Study Area. This engagement has occurred as part of a Council on Environmental Quality Pilot Program,[23] Scoping, Section 106 consultation, as well as various key program milestones in the alternatives development process (Section 2), to promote transparency and facilitate an informed, efficient, and compliant planning and environmental review process. The knowledge, data, and input these agencies and organizations provided have been valuable to the NEC FUTURE planning process.

- **Federal and State Departments of Transportation** includes administrations within the U.S. DOT and state agencies that plan for and provide transportation infrastructure and/or services within the Study Area. Coordination with federal and state departments of transportation, including with the NEC Commission, comprising voting members from each of the NEC state departments of transportation, Amtrak, and the U.S. DOT is necessary to keep them informed about FRA transportation planning efforts. The FTA is a cooperating agency on the Tier 1 Draft EIS.
- **Other State Agencies** includes other select state agencies within the Study Area, such as planning and economic development agencies, as well as bi-state or multi-state agencies.
- **Railroad and Transit Operators** includes agencies that operate railroad and transit services along the NEC and its connecting corridors, as well as freight rail operators.
- **Metropolitan Planning Organizations (MPO)** within the Study Area play a prominent role in transportation planning throughout their respective regions and serve as representatives of their member municipalities and counties.
- **Tribal Nations:** The FRA coordinating with tribal governments with lands and/or resources in the Study Area as part of the consultation process for Section 106 of the National Historic Preservation Act of 1966.
- **Local Agencies** includes select counties and local agencies within the Study Area.
- **Technical Working Groups (TWG)** were created by the FRA to provide technical guidance in the service planning and environmental review processes. The TWGs include Alternatives Development, Environmental, Engineering and Capital Cost, Operations, and Ridership and Revenue. The TWGs include FRA representatives, as well as members from the stakeholder community to leverage their considerable past work and expertise, as well as add to the general soundness and credibility of the analytical results.

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[23] In January 2012, CEQ and FRA announced the selection of the NEC FUTURE Tier 1 Environmental Impact Statement (EIS) as a pilot project to promote early collaboration with federal and state environmental agencies for efficient environmental decision-making. The pilot was designed to help avoid the conflicts and delays often found in complex, multi-state transportation projects by engaging environmental resource and regulatory agencies early in the environmental review and assessment process.

4.5.1 STATE TRANSPORTATION AGENCIES AND RAILROAD OPERATORS

Throughout refinement of the Action Alternatives, the FRA held a variety of meetings and briefings with state transportation agencies and railroad operators to provide a dialogue and timely exchange of information. The meetings created opportunities to share information on the No Action and Action Alternatives and obtain input and feedback toward improving the NEC FUTURE process and integrity of findings.

4.5.2 PUBLIC OPEN HOUSES

The FRA hosted a series of public open house meetings in November 2014. The purpose of these meetings was to introduce the No Action and Action Alternatives developed for evaluation in the Tier 1 Draft EIS, and provide an informal opportunity for the public to learn about NEC FUTURE, ask questions, and provide comments. A related objective was to provide participants with a better understanding of what to expect from a Tier 1 level of analysis.

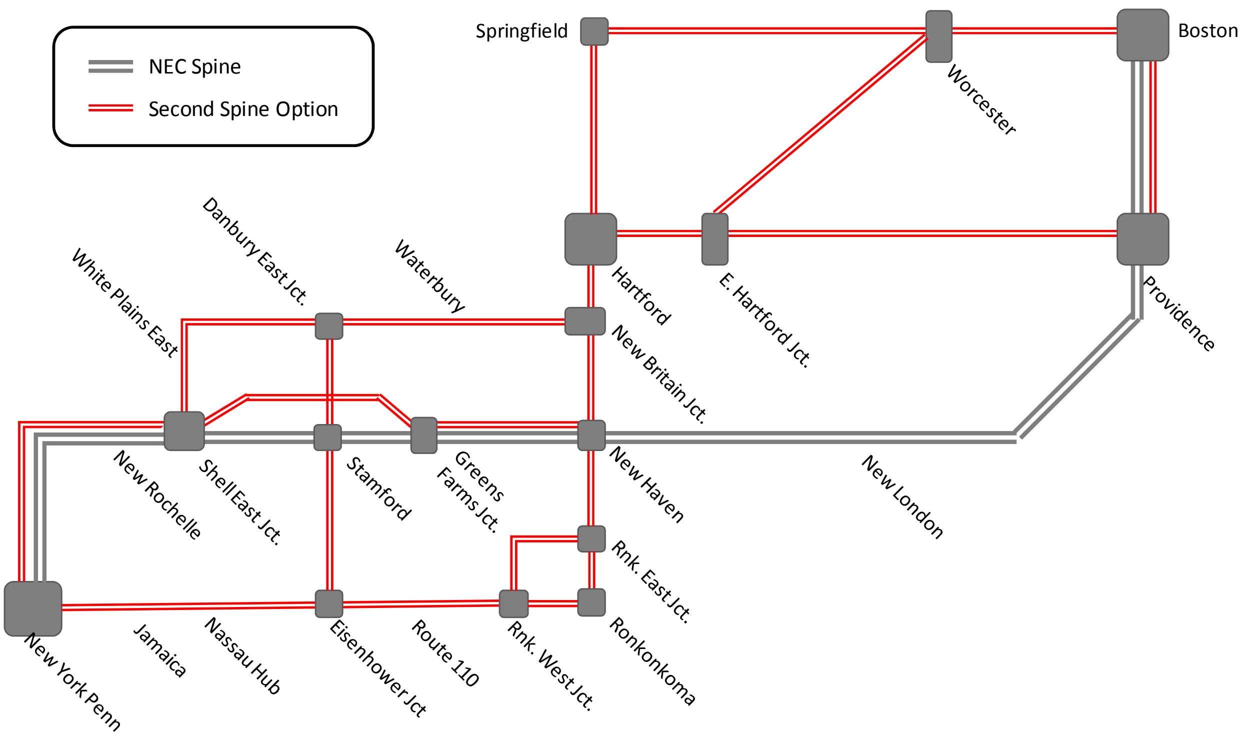
An open house meeting was held in each of the eight NEC states and Washington, D.C. A total of 377 participants attended the nine meetings. Discussion topics varied by location; however, some common themes included:

- The need to fix the existing NEC before expanding
- Importance of freight
- Questions about the feasibility of a Long Island route ("Could you really build it?")
- Relationship of NEC FUTURE to specific projects including Baltimore and Potomac (B&P) Tunnel, Gateway, New Haven-Hartford-Springfield Corridor; and overlap with plans for the Washington-Richmond corridor
- Cost of improvements
- Phasing – what improvements would be done when
- Continued questions about Tier 1 versus Tier 2
- Ability to mix and match alternatives
- Airport connections
- Fare prices, affordability compared to bus
- Climate change
- Importance to economy
- Potential for transit oriented development
- Importance of station areas and stations as destinations
- Seamless ticketing
- Need to accommodate bikes on board
- Millennials less likely to own cars; more will arrive to station by bike, walk, transit modes

5. North End Route Options Evaluation

The refinement of Alternative 3 included an examination of the range of potential options for establishing a new high-speed second-spine route to complement the existing NEC to provide rail service between New York City and Boston. The FRA identified several second-spine route options with potential to attract significant ridership and serve new markets – characteristics considered by the FRA to be essential for transforming the role of rail. Figure 6 shows diagrammatically the segments that comprise these route options. All of these route options deviate from the existing NEC at one or more points, providing direct Intercity service to new intermediate markets between New York City and Boston. Several of these route options touch the NEC only at the endpoints or for short distances. Other options run immediately parallel to or use portions of the existing NEC. Combining the various segments yields a total of 20 possible routing options between New York City and Boston. These options are arrayed in Table 9.

Figure 6: Segments Comprising the North End Route Options



Source: NEC FUTURE team, 2015

Table 9: Full Set of North End Route Options

<table>
<tr><th>No.</th><th colspan="6">North End Route Option</th></tr>
<tr><td>1</td><td rowspan="6">[NEC] New York City-New Rochelle-Stamford</td><td colspan="2" rowspan="3">[NEC] Stamford-New Haven</td><td rowspan="3">New Haven-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>2</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>3</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>4</td><td colspan="2" rowspan="3">Stamford-Danbury</td><td rowspan="3">Danbury-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>5</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>6</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>7</td><td rowspan="3">New York City-New Rochelle-Danbury</td><td colspan="3" rowspan="3">Danbury-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>8</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>9</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>10</td><td rowspan="11">New York City-Nassau Hub</td><td colspan="2" rowspan="4">Nassau Hub-Ronkonkoma-New Haven</td><td colspan="2">[NEC] New Haven-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>11</td><td rowspan="3">New Haven-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>12</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>13</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>14</td><td rowspan="7">Nassau Hub-Stamford</td><td rowspan="4">[NEC] Stamford-New Haven</td><td colspan="2">[NEC] New Haven-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>15</td><td rowspan="3">New Haven-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>16</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>17</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>18</td><td rowspan="3">Stamford-Danbury</td><td rowspan="3">Danbury-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>19</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>20</td><td>Hartford-Springfield-Worcester</td></tr>
</table>

Source: NEC FUTURE team, 2015

Option number 1 in Table 9 was evaluated as Preliminary Alternative 12, which represented a second-spine parallel to the existing NEC from end-to-end. Following the development of the Preliminary Alternatives, the FRA dismissed Alternative 12 from further consideration for service, cost, constructability, and environmental sensitivity-related reasons, as follows:

- **Service**: the alternative provides no new markets north of New York City; and therefore, it performs the weakest in terms of ridership compared to other North End route options
- **Cost**: initial cost estimates indicated that this alternative accounts for the highest cost, as compared to the other second-spine route options
- **Constructability**: North of New York City, construction of a new two-track high-speed line adjacent to the existing NEC is challenging due to proximity to an operating railroad, dense populations, the existing capacity constraints, and bottlenecks across the numerous rivers in Connecticut
- **Environmental sensitivity**: the alternative has a greater proportion of the new right-of-way through environmentally-sensitive areas or through areas with greater environmental sensitivity, and through portions vulnerable to storm surge

In addition, Preliminary Alternative 12 largely overlaps with elements of other alternatives, including improvements between New York City and Hartford, new high-speed tracks between Old Saybrook and Kenyon, and new high-speed tracks between Providence and Boston.

The remaining combinations of route options all pass through Hartford CT. This provided the opportunity to split the analysis into two steps to first analyze and compare six route options for the territory between New York City and Hartford, and then analyze the three potential route options between Hartford and Boston. Figure 6 shows the six route options between New York City and Hartford and the three route options between Hartford and Boston.

5.1 METHODOLOGY

The FRA compared the service and ridership potential of sets of options north and south of Hartford. The objective of the analysis was to identify route options that best meet the NEC FUTURE Purpose and Need (Section 1.1) that can be further evaluated as Alternative 3.

In each step of the analytical process, the FRA prepared quantitative information about trip time, ridership, and capital cost, as well as information on distinguishing environmental factors, development and property impact, other local considerations, and the effects on transportation system connectivity. These characteristics were incorporated into evaluation matrices and used to compare the route options and identify those with greater potential to achieve the vision of Alternative 3.

The specific elements of the two-step process included:

- Step 1 – Assess New York City-Hartford route options [6 options]
  - Identify a limited number of representative New York City-to-Hartford route options with the potential to transform the role of rail, considering both New York City-to-Boston and intermediate markets, in terms of ridership potential, magnitude of expected capital cost, potential environmental effects, and extent of local support.

- – Eliminate from further consideration those route options with lower ridership potential, higher cost, greater potential negative impacts, and/or less potential for transformational benefits.

- Step 2 – Assess Hartford-Boston route options [3 options]
  - – Start with the selected representative New York City-to-Hartford route that offers the highest ridership potential.
  - – Compare Providence, Worcester, and Springfield route options between Hartford and Boston.
  - – Consider ridership effects of the full network, including dual spines (existing and a second-spine dedicated to high-speed rail) and connecting corridor service, as opposed to consideration of service on the second-spine route only.
    - Include Springfield, Knowledge Corridor, and Inland Route (Section 4.1.2)
    - Include Shore Line/Providence improvements in Worcester route options
  - – Compare ridership potential, magnitude of expected capital cost, potential environmental effects and extent of local support, and identify representative New York City-to-Hartford route options with the greatest potential to transform the role of rail.
  - – Eliminate from further consideration route options with lower ridership potential, higher cost, greater potential negative impacts, and/or less potential for transformational benefits.
  - – Combine representative south-of-Hartford and north-of-Hartford route options, plus the Representative Route for a second-spine between Washington, D.C., and New York City, to create Representative Routes for Alternative 3 that span the full length of the NEC.

5.2 ROUTE OPTIONS BETWEEN NEW YORK CITY AND HARTFORD

The first step in the evaluation process considered the six route options between New York City and Hartford as follows:

- New York City-Nassau Hub-Ronkonkoma-New Haven-Hartford
- New York City-Nassau Hub-Stamford-Danbury-Hartford
- New York City-Nassau Hub-Stamford-New Haven-Hartford
- New York City-New Rochelle-Stamford-Danbury-Hartford
- New York City-New Rochelle-Stamford-New Haven-Hartford
- New York City-New Rochelle-White Plains-Danbury- Hartford

The FRA calculated trip times between New York City and various other stations for each of these route options, for both Intercity-Express and Intercity-Corridor service (Table 10 and Table 11). For comparative purposes in conducting this initial step of analysis, which analyzed the New York City-to-Hartford route options, all of these route options were assumed to reach Boston from Hartford via a new route through Providence. The best Intercity-Express trip times were achieved in options 1 and 6, the two options that build a dedicated new high-speed line all the way between New York City and Hartford and avoid the existing New Haven Line. Ridership potential (Table 12) is greatest for the routes via Long Island (route options 1, 2, and 3).

Table 10: Trip Times for Selected Intercity-Express Markets – New York City-to-Hartford

Trip Times by Option

Penn Station New York	Existing	Limited-stop Intercity-Express					
	Acela	Run 1: PSNY>RNK> HFD>PVD> BOS	Run 2: PSNY>NAS> STM>DAN> HFD>PVD> BOS	Run 3: PSNY>NAS> STM>NHV> HFD>PVD> BOS	Run 4: PSNY>NRO> STM>DAN> HFD>PVD> BOS	Run 5: PSNY>NRO> STM>NHV> HFD>PVD> BOS	Run 6: PSNY>WHP > DAN>HFD> PVD>BOS
Boston South Station	3:40	1:37	1:46	1:52	1:55	2:00	1:32
Penn Station New York	**Existing**	**Express**					
Boston South Station	3:40	1:55	2:02	2:10	2:11	2:17	1:51
Providence Station	2:45	1:31	1:38	1:46	1:47	1:53	1:27
Hartford	--	1:04	1:11	1:19	1:20	1:27	1:00
New Haven Station	1:30	0:45	0:59	1:00	1:08	1:08	1:08
Stamford	0:45	0:38	0:29	0:29	0:38	0:38	0:38
Waterbury South	--	--	1:00	--	1:09	--	0:49
Danbury	--	--	0:51	--	1:00	--	0:41
Ronkonkoma	--	0:28	--	--	--	--	--
Nassau Hub	--	0:13	0:13	0:13	--	--	--
White Plains East	--	--	--	--	--	--	0:21

PSNY- New York Penn Station; NAS - Nassau Hub, RNK - Ronkonkoma; WHP - White Plains STM Stamford; NHV - New Haven; NRO - New Rochelle; DAN - Danbury; HFD - Hartford; PVD - Providence; BOS - Boston

Source: NEC FUTURE team, 2015

Table 11: Trip Times for Selected Intercity-Corridor Markets – New York City-to-Hartford

Trip Times by Option

Penn Station New York	Existing	Metropolitan					
	Regional	Run 1: PSNY>RNK> HFD>PVD> BOS	Run 2: PSNY>NAS> STM>DAN> HFD>PVD> BOS	Run 3: PSNY>NAS> STM>NHV> HFD>PVD> BOS	Run 4: PSNY>NRO> STM>DAN> HFD>PVD> BOS	Run 5: PSNY>NRO> STM>NHV> HFD>PVD> BOS	Run 6: PSNY>WHP > DAN>HFD> PVD>BOS
Boston South Station	4:10	2:13	2:18	2:28	2:27	2:35	2:10
Providence Station	3:20	1:46	1:51	2:01	2:00	2:08	1:43
Hartford	2:50	1:15	1:20	1:30	1:29	1:37	1:12
New Haven Station	1:40	0:52	1:12	1:07	1:21	1:14	1:14
Stamford	0:50	0:45	0:33	0:33	0:41	0:41	0:45
Waterbury South	--	--	1:07	--	1:16	--	0:59
Danbury	--	--	0:56	--	1:05	--	0:48
Ronkonkoma	--	0:34	--	--	--	--	--
Nassau Hub	--	0:15	0:15	0:15	--	--	--
White Plains East	--	--	--	--	--	--	0:23

PSNY - New York Penn Station; NAS - Nassau Hub, RNK - Ronkonkoma; WHP - White Plains STM Stamford; NHV - New Haven; NRO - New Rochelle; DAN - Danbury; HFD - Hartford; PVD - Providence; BOS - Boston

Source: NEC FUTURE team, 2015

Table 12: Ridership for Intercity markets – New York City-to-Hartford, 2040

Route Option-->	1	2	3	4	5	6
	Nass Ronk NewHvn Hart Prov	Nass Stam Danb Hart Prov	Nass Stam NewHvn Hart Prov	NewRoc Stam Danb Hart Prov	NewRoc Stam NewHvn Hart Prov	NewRoc WhPlns Danb Hart Prov
Total Annual Intercity Trips (M)	1	2	3	4	5	6
Intercity-Express	2.4	2.4	2.4	1.7	1.7	1.9
Intercity-Corridor-Other/Metropolitan	4.2	3.9	3.6	2.7	2.4	3.0
Total Intercity	6.6	6.3	6.0	4.4	4.1	4.9
Common Station Pairs*	1	2	3	4	5	6
Intercity-Express	1.7	1.6	1.8	1.5	1.7	1.5
Intercity-Corridor-Other/Metropolitan	2.6	2.3	2.4	2.2	2.4	2.3
Total Intercity	4.3	3.9	4.2	3.7	4.1	3.8

Millions of annual intercity trips *BSS,RTE,PRV,HFD,NHV,STM,NYP,PHL,BAL,WAS

Top-performing options (green)

Top-performing options not including LI Sound crossing (yellow)

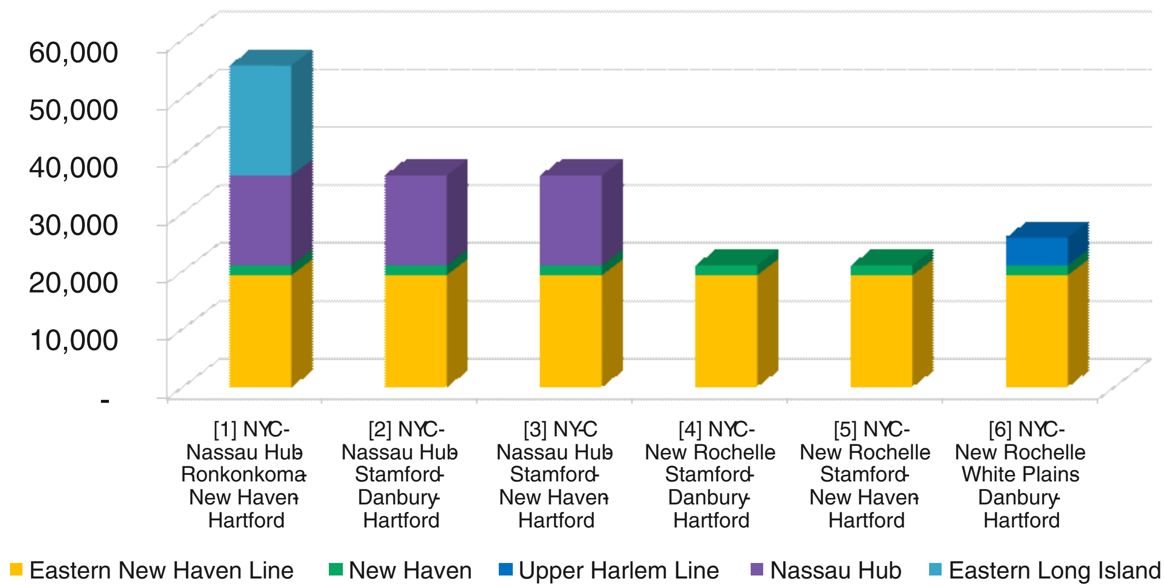
Source: NEC FUTURE team, 2015

A second measure of ridership potential exists in the New York City market. Construction of a new high-speed route via either Long Island, Central Connecticut, or parallel to the New Haven Line significantly decreases trip times for Regional rail services in the outer commuting zones of the New York City market, because these trains could utilize portions of the new high-speed route. Figure 7 presents the relative Regional rail ridership potential of the six New York City-to-Hartford route options. When both Intercity and Regional rail ridership potential are considered together, the New York City-Long Island-New Haven route emerges as the one with the best ridership potential. This is consistent with the Regional rail time savings for outer zone commuting to New York City (Table 13), which also shows the Long Island route to be superior.

Rough order-of-magnitude capital costs for new route construction were estimated for the six route options. Their relative cost and degree of construction difficulty were compared by estimating the extent of the various types of construction needed to create a new two-track right-of-way (Figure 8). The Long Island route is the most expensive, with a long tunnel crossing of Long Island Sound;[24] however, each of the route options have high costs because they require new right-of-way and entail significant amounts of tunneling.

[24] Tunnels were selected over bridges, where possible and appropriate, primarily, because they are easier to align for the straightest possible route (which supports top speeds) and generally because they generate fewer adverse impacts.

Figure 7: Regional Rail AM Peak Ridership for the New York City Market with Improvements to New Haven Line Capacity, 2040



Source: NEC FUTURE team, 2015

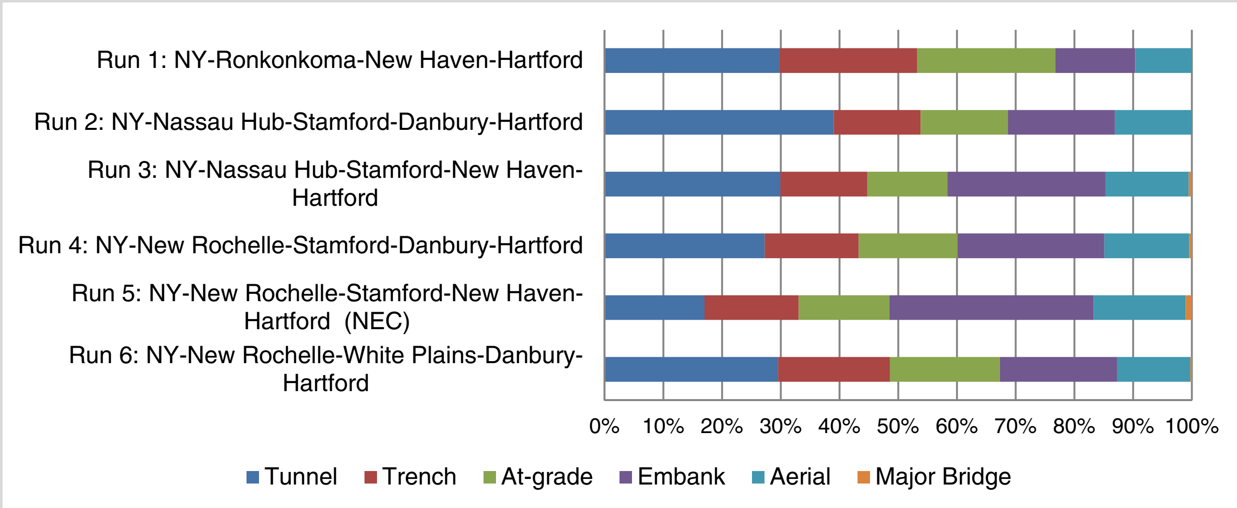
Table 13: Regional Rail AM Peak Period Minutes Saved per Trip for New York City Markets with Outer Zone Express Service Utilizing High-Speed Second-Spine Route –, with Improvements to New Haven Line Capacity, 2040

	New York City-Nassau Hub-Ronkonkoma-New Haven-Hartford	New York City-Nassau Hub-Stamford-Danbury-Hartford	New York City-Nassau Hub-Stamford-New Haven-Hartford	New York City-New Rochelle-Stamford-Danbury-Hartford	New York City-New Rochelle-Stamford-New Haven-Hartford	New York City-New Rochelle-White Plains-Danbury-Hartford
Eastern Long Island	30	—	—	—	—	—
Nassau Hub	25	25	25	—	—	—
Eastern New Haven Line	10	15	15	10	15	10
New Haven	50	25	30	20	25	10
Upper Harlem Line	—	—	—	—	—	20
TOTAL	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Source: NEC FUTURE team, 2015

Note: Column headers refer to the route options between New York City and Hartford, as listed in Table 9.

Figure 8: Relative Construction Type by Route Option, New York City-to-Hartford



Source: NEC FUTURE team, 2015

When all of these factors are considered together, the route options that utilize the relatively low-speed existing New Haven Line, as well as the route from Long Island to Danbury via Stamford, which has significant curvature and relatively lower speeds, do not perform as well as the other options and were eliminated from further consideration as routes for a second-spine. The New York City-Long Island-New Haven route shows the best ridership potential and was retained. Because of the high cost and the risks inherent in the proposed Long Island Sound tunnel crossing, the route option without a Long Island Sound crossing that had the best ridership potential was also retained – the Central Connecticut route via New Rochelle and Danbury.

5.3 ROUTE OPTIONS BETWEEN HARTFORD AND BOSTON

The second step in the evaluation looked at the three route options between Hartford and Boston:

- Hartford-Providence-Boston
- Hartford-Worcester-Boston
- Hartford-Springfield-Worcester-Boston

These route options are designated with letters rather than numbers to distinguish them from the New York City-to-Hartford route options. A complete New York City-to-Boston route option can be represented by the combination of a number and letter (e.g., option 1B for the route that links New York City, Ronkonkoma, New Haven, Hartford, Worcester, and Boston). The FRA compared trip times, ridership, and capital costs for the three route options between Hartford and Boston. Each of these comparisons used option 1 (the Long Island route via Ronkonkoma) as the assumed second-spine between New York City and Hartford, because this route option had the highest level of ridership in the Step 1 comparison, which served to amplify the differences among the Hartford-Boston route options. This was done to provide a basis for comparing the northern route options, and did not represent a preference.

Table 14 compares the relative Intercity-Express and Intercity-Corridor trip times for the resulting three Hartford-to-Boston route options. The Providence (1A) and Worcester (1B) route options produced very similar trip times; the route via Springfield was considerably longer in terms of both distance and time.

Table 14: Trip Times for Selected Intercity Markets – Hartford-to-Boston, 2040

Trip Times by Option

Penn Station New York	Existing	Super Express		
	Acela	**Run 1A:** NYP>RNK> HFD>PVD> BOS	**Run 1B:** NYP>RNK> HFD>WOR> BOS	**Run 1C:** NYP>RNK> HFD>SPG> WOR>BOS
Boston South Station	3:40	1:37	1:37	1:43

Penn Station New York	Existing	Express			Existing	Metropolitan		
	Acela	**1A**	**1B**	**1C**	NE Regional	**1A**	**1B**	**1C**
Boston South Station	3:40	1:55	1:56	2:05	4:10	2:13	2:15	2:27
Providence Station	2:45	1:31	2:13	2:13	3:20	1:46	2:31	2:31
Hartford	--	1:04	1:04	1:04	2:50	1:15	1:15	1:15
New Haven Station	1:30	0:45	0:45	0:45	1:40	0:52	0:52	0:52
Stamford	0:45	0:38	0:38	0:38	0:50	0:41	0:41	0:41
Waterbury South					--	--	--	--
Danbury					--	--	--	--
Ronkonkoma					--	0:34	0:34	0:34
Nassau Hub					--	0:15	0:15	0:15
White Plains East					--	--	--	--

NYP - New York Penn Station; RNK - Ronkonkoma; HFD - Hartford; PVD - Providence; WOR - Worcester; SPG - Springfield; BOS - Boston

Source: NEC FUTURE team, 2015

The FRA compared the ridership potential of these three route options. The comparison yielded little difference in the magnitude of ridership potential (Table 15). The relative size of the Worcester and Providence markets, including the large swath of Boston suburbs lying to the west and south of Boston, is similar for Routes 1A and 1B. The Springfield market compensated for the loss in through ridership to and from Boston resulting from longer trip times. The Springfield route, however, by virtue of its extra length and the difficult topography to be traversed between Springfield and Worcester, requires extensive tunneling and was found to be considerably more costly than the two more direct routes, based on route-level cost estimates and the relative magnitude of the various types of required construction (Figure 9).

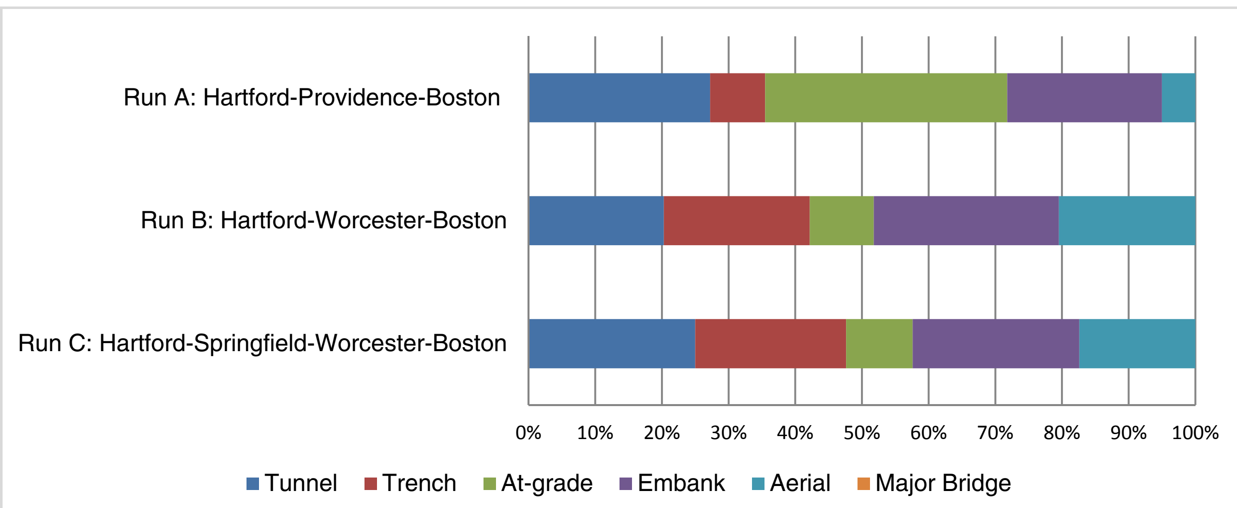
In addition to ridership potential and construction difficulty, the FRA considered the strength of potential connecting corridor service as a third factor to evaluate the route options. Springfield retains rail links to both New York City and Boston even in the options that do not provide direct high-speed service through Springfield – via connections at Hartford. The Hartford Line provides a 25-mile long connection from Springfield to Hartford, where a convenient transfer can be made to either Intercity-Express or Metropolitan trains running on the high-speed second-spine toward either New York City or Boston. The Inland Route, between Springfield, MA and Boston, MA, also offers a direct rail connection between Springfield and Boston that is not high-speed, but which is planned for improvements that offer reasonable service frequencies and trip times.

Table 15: Ridership for Intercity Markets – Hartford-to-Boston, 2040

Route Option-->	1A			1B			1C		
	Hartford-Providence-Boston			Hartford-Worcester-Boston			Hartford-Springfield-Worcester-Boston		
	Express	Corridor/ Metrop	Total	Express	Corridor/ Metrop	Total	Express	Corridor/ Metrop	Total
Total Annual Intercity Trips (M)									
Total North End Trips	3.0	4.2	**7.2**	2.8	4.4	**7.2**	2.9	4.4	**7.3**
Trips Between Common Station Pairs (NEC Spine plus Hartford)	2.5	3.5	**6.0**	2.0	3.4	**5.4**	2.0	3.4	**5.4**
Trips with end points in Greater Boston or New York & South	2.6	3.9	**6.5**	2.5	4.0	**6.5**	2.6	4.0	**6.6**
Percent of total north end trips			***89.7%***			***90.4%***			***90.1%***
Trips between Intermediate Markets	0.4	0.4	**0.8**	0.3	0.4	**0.7**	0.3	0.4	**0.7**
Percent of total north end trips			***10.3%***			***9.6%***			***9.9%***
Total Annual Intercity Trips (000)									
Trips between Greater Boston and New York & South	749	608	**1357**	701	697	**1397**	688	678	**1366**
Percent of total north end trips			***18.7%***			***19.3%***			***18.8%***

Source: NEC FUTURE team, 2015

Figure 9: Relative Construction Type by Route Option, Hartford-to-Boston



Source: NEC FUTURE team, 2015

On the other hand, the same cannot be said for Worcester or Providence, which must be on the high-speed second-spine in order to realize significant trip time and service frequency benefits relative to the No Action Alternative for travel to and through New York City. Without the high-speed second-spine, trip times from Worcester to New York City are significantly longer than via the existing Inland Route. Similarly, if the Providence route option is not selected, Providence retains Intercity-Express and Intercity-Corridor service, but the follows the existing NEC, and trip times to New York City are considerably longer. Moreover, through the various stakeholder and public meetings, the FRA received a greater amount of support for the Providence and Worcester route options, compared with Springfield.

In light of these considerations, the second-spine route option via Springfield was dropped from further consideration, but both of the other more direct route options (via Providence and via Worcester) were retained for further analysis. The service-related negative consequences of eliminating the direct route through Springfield are mitigated by the good connections that available at Hartford to both New York City and Boston with the two route options that are retained.

5.4 FINDINGS

Table 16 summarizes the disposition of the 20 unique north end route options with respect to documentation in the Tier 1 Draft EIS. Eight of the 20 routes are included among the Action Alternatives, either as the NEC or as connecting corridors. The FRA also retained the New Haven Line and Shore Line route as a route for through Intercity trains and Regional rail services in each of the Action Alternatives. In addition, the Stamford-Danbury corridor remains connected to the NEC as a Regional rail branch line. The further analysis and documentation of the Action Alternatives provides additional information on ridership, capital cost, environmental effects and other benefits, that will be used to inform identification of a Preferred Alternative.

The evaluation of the north end route options did not reveal a single superior route. Instead, the FRA identified two viable candidate routes between New York City and Hartford, and two between Hartford and Boston. Consequently, the FRA determined to carry forward the following four potential route options for the second-spine between New York City and Boston in Alternative 3 (Figure 10):

- Alternative 3.1 – Central Connecticut/Providence
- Alternative 3.2 – Long Island/Providence
- Alternative 3.3 – Long Island/Worcester
- Alternative 3.4 – Central Connecticut/Worcester

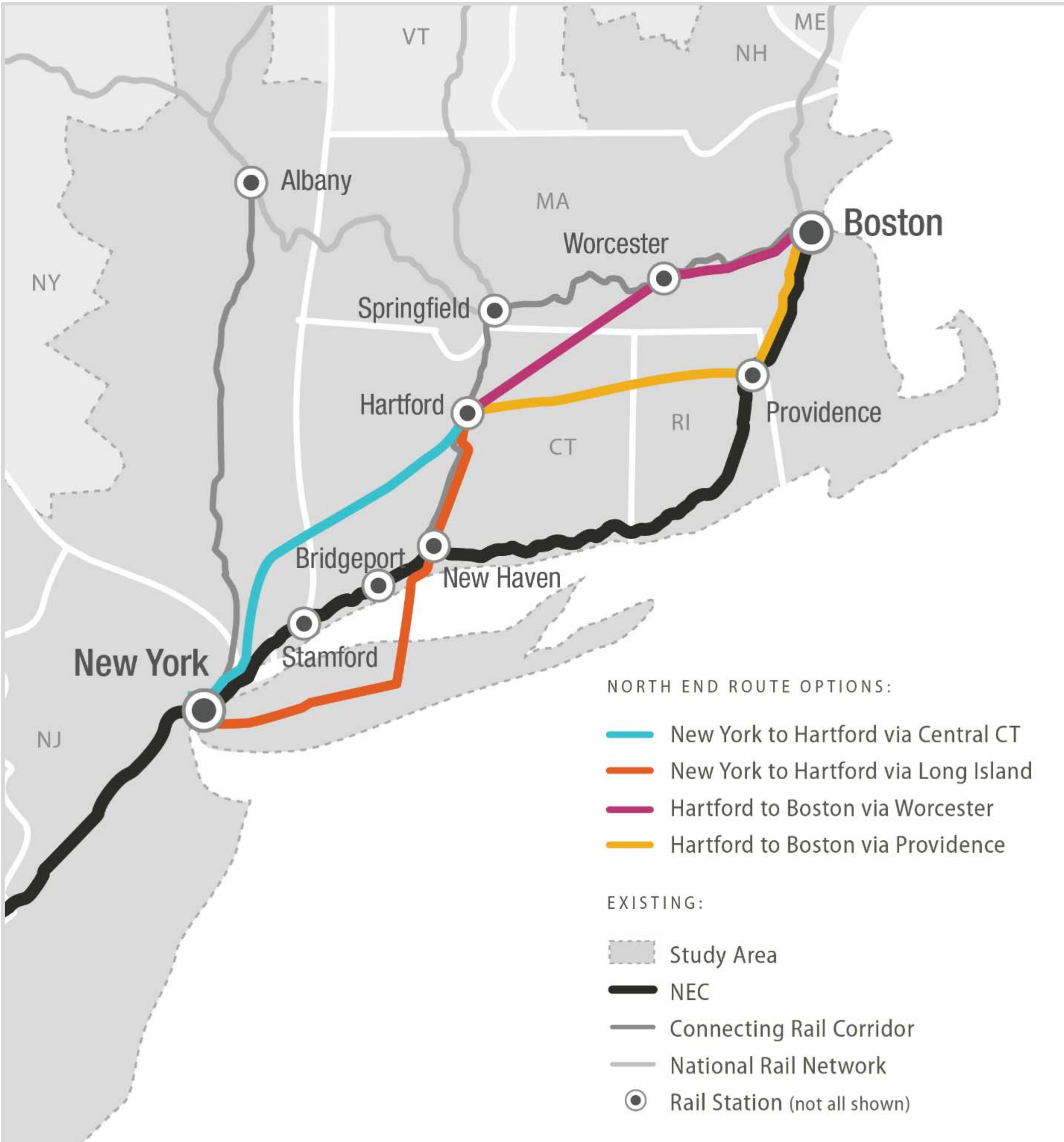
All four route options operate between Washington, D.C., and Boston, and join with common infrastructure improvements and rail services on the south end of the NEC, between Washington, D.C., and New York City. These route options are documented in the Tier 1 Draft EIS as part of Alternative 3.

Table 16: North End Routing Options Evaluation Summary, New York City to Boston

No.	North End Route Option						Dispo-sition
1	[NEC] New York City-New Rochelle-Stamford	[NEC] Stamford-New Haven		New Haven-Hartford	Hartford-Providence	[NEC] Providence-Boston	Alt. 2
2					Hartford-Worcester	Worcester-Boston	X
3					Hartford-Springfield-Worcester		CC
4		Stamford-Danbury		Danbury-Hartford	Hartford-Providence	[NEC] Providence-Boston	X
5					Hartford-Worcester	Worcester-Boston	X
6					Hartford-Springfield-Worcester		X
7	New York City-New Rochelle-Danbury	Danbury-Hartford			Hartford-Providence	[NEC] Providence-Boston	Alt. 3.1
8					Hartford-Worcester	Worcester-Bos	Alt. 3.4
9					Hartford-Springfield-Worcester		CC
10	New York City-Nassau Hub	Nassau Hub-Ronkonkoma-New Haven		[NEC] New Haven-Providence		[NEC] Providence-Boston	X
11				New Haven-Hartford	Hartford-Providence	[NEC] Providence-Boston	Alt. 3.2
12					Hartford-Worcester	Worcester-Boston	Alt. 3.3
13					Hartford-Springfield-Worcester		CC
14		Nassau Hub-Stamford	[NEC] Stamford-New Haven	[NEC] New Haven-Providence		[NEC] Providence-Boston	X
15				New Haven-Hartford	Hartford-Providence	[NEC] Providence-Boston	X
16					Hartford-Worcester	Worcester-Boston	X
17					Hartford-Springfield-Worcester		X
18			Stamford-Danbury	Danbury-Hartford	Hartford-Providence	[NEC] Providence-Boston	X
19					Hartford-Worcester	Worcester-Boston	X
20					Hartford-Springfield-Worcester		X

X = This route was dropped from further consideration as a second-spine for the Action Alternatives.
CC = This route was included as connecting corridor service in various alternatives with second-spine via other route options.

Figure 10: Alternative 3 Route Options



6. Characteristics of the No Action and Action Alternatives

Each Action Alternative represents a unique long-term vision for improving passenger rail service that will enhance mobility options, improve performance, and better serve existing and new markets that support future population and employment growth in the Study Area. All three Action Alternatives provide substantially more and better rail service than the No Action Alternative, along the entire length of the NEC. While the three Action Alternatives are distinct in their service and physical characteristics, they include several common elements. Although the visions are unique, and despite differences in how they achieve that vision, each Action Alternative shares the following attributes:

- Maintains and improves service on the existing NEC.
- Brings the NEC to a state of good repair by replacing or renewing aging infrastructure on the existing NEC and eliminating the backlog of infrastructure requiring replacement, so that future capital upgrades are planned and implemented according to a regular replacement cycle.
- Addresses the most pressing capacity and service chokepoints that constrain capacity on the existing NEC.
- Protects freight rail access and the opportunity for future expansion.
- Incorporates appropriate passenger rail enhanced service concepts and operational “best practices” consistent with integrated service and infrastructure planning to address capacity constraints, broaden the mix of station-pairs served, improve performance, and generate operating cost efficiencies.

The FRA developed a range of Action Alternatives to help better understand and quantify key rail market and service dynamics, such as the trade-offs between frequencies of service, trip time, and the convenience of one-seat service between markets. The Action Alternatives provide the FRA, the region, and other stakeholders with a broad range of options and sufficient information to evaluate future visions and make reliable, long-term decisions about the appropriate role rail plays in the region’s multimodal transportation network. The investment program for each Action Alternative consists of 1) a set of geographic markets to be served by passenger rail; 2) a Representative Route (or footprint) that connects these markets; 3) assumptions about the level of passenger rail service that will be provided to these markets; and 4) infrastructure improvements that support this level-of-service. These characteristics, which are also used to describe the No Action Alternative, are all representative in nature.

6.1 MARKETS

The FRA took a market-based approach to develop Action Alternatives, first identifying current travel patterns, how they have changed over the past three to four decades, and potential new rail markets. The four primary geographic markets on the existing NEC are Washington, D.C., Philadelphia, Boston, and New York City. These four markets are distinguished by existing regional and state travel demand and population growth data, ridership projections made by Amtrak and the commuter-rail operators, data and discussions with states and planning organizations, and public and agency comments made during Scoping and other public meetings.

The data also show that there are other strong Northeast travel markets, both on and off the existing NEC. The Study Area includes a number of smaller intermediate cities and urbanized areas. Some of these are located directly on the NEC, such as Baltimore, Wilmington, and Providence. Others are located away from the NEC, such as Hartford, CT, or Worcester, MA. A significant number of interregional trips[25] include travel from these intermediate cities to the primary metro regions, or between two intermediate cities.

A third category of geographic markets within the NEC Study Area can be characterized as suburban areas, located within the general realm of one or more of the primary regions but without easy access to a large downtown train station. These areas are served by NEC stations with both intercity and commuter trains. For example, the Maryland suburbs of Washington, D.C., and Baltimore are served today by the New Carrollton and BWI Airport stations. A broad swath of New Jersey is linked by highway to the Metropark station. Westchester (NY) and Fairfield (CT) Counties are served today by multiple stations along the New Haven Line, and the southern and western suburbs of Boston have good highway access to the Route 128 station.

6.1.1 STATIONS

For NEC FUTURE, the FRA developed a hierarchy of station types, based on the size of the geographic market and type and quantity of rail service offered. This typology applies to existing stations and future stations included in the No Action and Action Alternatives. Stations are grouped based on similar characteristics into one of three categories:

- **Major Hub stations** serve the largest markets in the Study Area and have the full complement of rail services types. Major Hub stations serve the four primary markets: Washington, D.C., Philadelphia, New York City, and Boston, as well as other major markets within the Study Area, including but not limited to Baltimore, MD; Stamford, CT; and Providence, RI. Major Hub Stations are located in the most populous and densely developed metropolitan areas along the NEC, serving Intercity and Regional rail travel to these major population and employment centers.
- **Hub stations** offer some Intercity service, although the Intercity-Express service is more limited than the service levels offered at Major Hub stations. Hub stations include the existing smaller intermediate Amtrak stations, as well as selected key Regional rail stations and new stations that have the potential to fill connectivity gaps in the existing passenger rail network, serve special trip generators, and/or provide important inter-modal connections.
- **Local stations** are served almost exclusively by Regional rail trains, on the portions of the NEC where Regional rail service is offered. Examples of local stations include Halethorpe, MD; Claymont, DE; Torresdale, PA; Edison, NJ; Larchmont, NY; Westport, CT; Wickford Jct., RI; and Attleboro, MA. There are a limited number of locations on the NEC outside of Regional rail territory where the existing Amtrak stations are best classified as local stations (e.g., Mystic and Westerly stations). Similarly, smaller stations on connecting corridors beyond the NEC are considered local stations (e.g., Ashland, VA; Mt. Joy, PA; Rhinecliff, NY; Wallingford, CT).

[25] Trips that that start and end in different metropolitan areas.

6.2 REPRESENTATIVE ROUTE

The Representative Route refers to the physical path of a proposed Action Alternative, including horizontal and vertical dimensions. The Representative Route is defined by the broad physical limits (or footprint) of an alternative, and is used to assess the potential environmental effects of the Action Alternatives. At the Tier 1 level, the footprint is only representative of where the physical route might be located and are not a prediction of future preferences or decisions. For purposes of footprint-related environmental effects analysis, a relatively wide buffer is drawn around the Representative Route centerline to understand the resources and potential impacts in the general zone within which the actual right-of-way might be located. The width of the buffer area varies by type of construction and is larger for new segments than for new tracks that follow the existing NEC. Recognizing the uncertainty that exists at this early stage of planning, the Representative Routes provide a sound basis for programmatic evaluation of the environmental effects of each Action Alternative.

6.3 SERVICE PLAN

The utility of the current passenger rail network is limited by gaps in connectivity with other transportation modes and minimal coordination between different rail services. Railroads operating on the NEC today share fixed infrastructure but operate separate rail services with different equipment with different performance capabilities. Infrastructure (track configuration, power source) and equipment constraints (diesel, electric) further limit the ability to provide passengers with coordinated and direct service for many city pairs along the existing NEC and connecting corridors.

The representative Service Plans (Section 4.1.1) for the Action Alternatives incorporate operational improvements that better integrate train service across today's separate markets, and explore opportunities free from institutional and jurisdictional operating constraints. The Service Plans are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assessment of environmental impacts, and are not intended in any way to be prescriptive regarding how service should be operated in the future. In addition, the Service Plans do not predict future operating patterns of the NEC operators. These representative improvements (Section 4.1.4) include "through-service" at major stations to provide operational efficiency and improved capacity utilization; clockface (service at regular intervals) train departures and standard stopping patterns to improve efficiency; integrated ticketing and fares across the NEC to improve passenger convenience; and decreased dwell time at stations to reduce travel time. In addition, some stations could be enhanced to accommodate multiple service types, and train schedules could be integrated across the NEC to provide easier transfers between trains, resulting in an increase in travel options and service frequencies to additional markets. Other operational improvements include:

- Development of Regional rail slot catalogues, in which schedule slots are assigned to services where and when demand is greatest and not assigned to a specific operator.
- Scheduling options for accommodating less reliable off-corridor operations to reduce their effect on NEC operations (e.g., extended dwells at NEC entry point, phantom slots, etc.).

6.4 INFRASTRUCTURE ELEMENTS

As described in the Purpose and Need, the Action Alternatives use existing and proposed infrastructure to support the operations necessary to meet market growth and the specific vision of that alternative. All of the Action Alternatives can accommodate different types of trains; however, some route segments in Alternatives 2 and 3 will be dedicated to high-performance trainsets. This integrated approach to operations and train schedules, requires a smaller infrastructure footprint compared to today's independently planned operations.

Individual infrastructure elements make up an Action Alternative's path and describe the type of the physical infrastructure improvement relative to the No Action Alternative. These discrete elements, including both linear elements and supporting infrastructure (Section 4.4), facilitate a modular approach to analyzing the alternatives. Infrastructure Elements that make up the Action Alternatives consist of the following:

- Curve Modification
- New Track
- New Segment
- Station Area
- Junction
- Storage and Maintenance Facility

7. No Action Alternative

The No Action Alternative represents future conditions if no rail investment program is advanced. It assumes planned and programmed improvements to highway, freight rail, transit, air, and maritime modes that will be completed by 2040. Interregional and regional travel demand is affected by the availability, price, and reliability of all transportation modes. Therefore, inclusion of improvements of these other modes is necessary to represent the reasonably foreseeable future transportation conditions in the NEC Study Area. The No Action Alternative serves as a baseline for the purpose of comparing the outcomes of the Action Alternatives in terms of ridership, revenue, cost, and train operations.[26]

The No Action Alternative represents a snapshot in time and has been developed using current information compiled from federal, state, and regional transportation planning documents. As the NEC FUTURE program progresses, assumptions regarding which projects are included as part of the No Action Alternative may be revised based upon available funding, urgency of needs, and changes or updates to the region's transportation plans.

Upon reviewing planning lists of projects across all transportation modes, the FRA used the following methodology for selecting projects for inclusion in the No Action Alternative:

- Funded projects or projects with approved funding plans (e.g., federal or state committed funding)
- Funded or unfunded mandates
- Unfunded projects necessary to keep the railroad running

The FRA assumes that sufficient funding will be made available to maintain current service levels with the No Action Alternative; however, if this is not available, the reliability, capacity, and service quality of the NEC will decline. In fact, historic funding levels are not sufficient to make the improvements and maintain service in the No Action Alternative. Because the implications of continuing current funding levels on service are hard to predict, it is assumed that sufficient funding will be made available for the No Action Alternative. Forecasting the implications of insufficient funding on the performance of the eight commuter railroads and Amtrak would be subjective given the uncertainty of what might or might not be funded and the resulting performance implications. Therefore, the FRA decided to separate evaluation of the No Action Alternative from the discussion of historic or future funding trends and the implications of insufficient funding.

The FRA assumes that the No Action Alternative projects necessary to maintain existing service levels along the NEC will be funded through 2040. However, the funding levels necessary for the No Action Alternative exceeds historic levels of capital funding from federal, state, and local sources made available to all of the owners/operators on the NEC. Historic funding levels have averaged $600 million per year over the last ten years.[27] If sufficient funding to meet the requirements of the No Action Alternative is not made available, the consequence of continuing past patterns of disinvestment in the NEC would be degradation of the reliability, capacity, and quality of service on the NEC with potential outcomes as summarized below.

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[26] For additional information on the No Action Alternative, please see the NEC FUTURE *No Action Alternative Report* on the NEC FUTURE website, *www.necfuture.com*.
[27] NEC Infrastructure and Operations Advisory Commission. *NEC Capital Needs Assessment FY15-19 (September 2014)*

- Reliability would decline, resulting in more frequent and longer delays, and reduced on-time performance of train service. This reduction in reliability would result from unscheduled delays, as well as "scheduled" delays required periodically (and randomly to allow engineering crews to access the railroad to make remedial repairs).
- Scheduled trip times would increase as the deteriorating condition of NEC infrastructure—particularly rail, bridge, and subgrade—would necessitate slow orders to reduce the impact of train operations on sensitive infrastructure and to ensure safety.
- Operating costs for infrastructure maintenance would rise in response to the need for more frequent maintenance and unscheduled and sometimes substantial repairs.
- Costs for train operations would increase as longer cycle times for equipment would require greater fleet sizes and more crew time and overtime.
- Ridership would decline in response to the reduced level and quality of service leading to declines in revenue such that current levels of operating profit for Intercity services would diminish and operating losses would occur.

However, as mentioned earlier, FRA has decided that, for the purposes of providing a baseline for comparison against the Action Alternatives, the FRA presumes sufficient funding to maintain current service levels are made available for the No Action Alternative.

7.1 MARKETS

The No Action Alternative serves existing geographic markets along the NEC. Table 17 identifies the stations served under the No Action Alternative.

7.2 REPRESENTATIVE ROUTE

The Representative Route of the No Action Alternative is the existing NEC between Washington Union Station and Boston South Station. It includes the MTA East Side Access Project currently under construction in New York City.

7.3 SERVICE PLAN

The representative Service Plan under the No Action Alternative is described by type and levels of passenger rail service at selected screenlines along the NEC (Table 18). Screenlines were used to measure the volume of passenger rail traffic at key locations along the NEC, particularly where capacity or utilization might change. Screenlines are drawn across a rail right-of-way usually associated with a particular geography in order to standardize the location at which the frequency and type of rail service are measured, evaluated, and compared. The volume of passenger rail traffic is expressed as trains per hour, per direction, by service type at the following points along the NEC: Washington, D.C.; Philadelphia, PA; the Hudson River and East River in the New York metropolitan region; New Rochelle, NY; and Boston, MA. For comparison purposes, existing (2012) service levels are compared to the No Action Alternative service levels for the peak-hour, peak direction.

Table 17: Existing Stations (excluding Connecting Corridors) Served Under the No Action Alternative

Geography	Total Stations	NEC Stations (excluding Connecting Corridors)
Washington, D.C.	1	Washington Union Station
Maryland	12	New Carrollton, Seabrook, Bowie State, Odenton, BWI Airport, Halethorpe, West Baltimore, Baltimore Penn Station, Martin Airport, Edgewood, Aberdeen, Perryville
Delaware	4	Newark, DE, Churchman's Crossing, Wilmington Station, Claymont
Pennsylvania	25	Marcus Hook, Highland Ave, Chester, Eddystone, Crum Lynne, Ridley Park, Prospect Park, Norwood, Glenolden, Folcroft, Sharon Hill, Curtis Park, Darby, Philadelphia 30th St, North Philadelphia, Bridesburg, Wissinoming, Tacony, Holmesburg Junction, Torresdale, Cornwells Heights, Eddington, Croydon, Bristol, Levittown
New Jersey	15	Trenton, Hamilton, Princeton Junction, Jersey Avenue, New Brunswick, Edison, Metuchen, Metropark, Rahway, Linden, Elizabeth, North Elizabeth, Newark Airport, Newark Penn Station, Secaucus
New York	7	Penn Station New York, New Rochelle, Larchmont, Mamaroneck, Harrison, Rye, Port Chester
Connecticut	29	Greenwich, Cos Cob, Riverside, Old Greenwich, Stamford, Noroton Heights, Darien, Rowayton, South Norwalk, East Norwalk, Westport, Green's Farms, Southport, Fairfield, Fairfield Metro, Bridgeport, Stratford, Milford, West Haven, New Haven Union Station, New Haven State Street, Branford, Guilford, Madison, Clinton, Westbrook, Old Saybrook, New London, Mystic
Rhode Island	5	Westerly, Kingston, Wickford Junction, TF Green, Providence Station
Massachusetts	12	South Attleboro, Attleboro, Mansfield, Sharon, Canton Junction, Route 128, Readville, Hyde Park, Forest Hills, Ruggles, Back Bay, Boston South Station

Source: NEC FUTURE team, 2014

Table 18: Standard Peak-Hour Trains, Peak Direction for the No Action Alternative, 2040

Screenline	No Action
Washington, D.C. Screenline *North of Washington at Anacostia River*	
Intercity-Express	1
Intercity-Corridor	1
Connecting corridor*	Included above as part of Intercity-Express and Intercity-Corridor
Regional rail	4
Philadelphia Screenline *Chester Pennsylvania*	
Intercity-Express	1
Intercity-Corridor	1
Connecting corridor*	0
Regional rail	3
Hudson River Screenline	
Intercity-Express	1
Intercity-Corridor	1
Connecting corridor*	1
Regional rail	21
East River Screenline	
Intercity-Express	1
Intercity-Corridor	1
Connecting corridor*	2
Regional rail**	36
New Rochelle Screenline *Between Shell Junction and New Rochelle Station*	
Intercity-Express	1
Intercity-Corridor	1
Connecting corridor*	Included above as part of Intercity-Express and Intercity-Corridor
Regional rail	21
Boston Screenline *South of Back Bay Station*	
Intercity-Express	1
Intercity-Corridor	1
Connecting corridor*	0
Regional rail	6

Source: NEC FUTURE team, 2015

* Connecting corridors include Springfield, Empire, Keystone and Virginia Service south of Washington Union Station.

** Excludes MTA-Long Island Rail Road access to Grand Central Terminal.

In the No Action Alternative, passenger rail service on the NEC operates similarly to and at the same approximate level as today's services. The No Action Alternative assumes the same types of Amtrak Intercity services, including Intercity-Express (Acela), Intercity-Corridor (Regional), and connecting corridors (i.e., Springfield, Keystone, and Empire). The No Action Alternative also assumes the same types of regional services offered by the eight commuter railroads operating on the NEC: MBTA, Connecticut DOT, MNR, LIRR, NJ TRANSIT, SEPTA, MARC, and VRE. East Side Access, currently under construction and thus part of the No Action Alternative, includes new LIRR service into Grand Central Terminal in New York City. While the types of service are assumed to be similar going forward, greater demand in the future could affect overall performance.

7.4 INFRASTRUCTURE ELEMENTS

The No Action Alternative represents the condition of the Northeast region's multimodal transportation system in 2040 assuming general continuation of infrastructure conditions. The No Action Alternative includes the completion of transportation projects already planned and programmed, or in-progress by 2040. Beyond specific named projects, the No Action Alternative assumes that right-of-way owners individual railroad operators will continue to maintain the NEC through their annual maintenance programs for key elements such as track, signals and communications, and structures, and that the individual railroad operators will continue to maintain their rolling stock and yard facilities. Capital replacement or upgrading of infrastructure assets is assumed be undertaken as necessary to maintain railroad operations at current levels, based on the condition of the assets. This includes some—but only a modest proportion—of the significant backlog of work associated with bringing the NEC to a state of good repair. The No Action Alternative does not bring the NEC to a state of good repair.

8. Alternative 1

Alternative 1 maintains the role of rail, with the level and capacity of rail service to keep pace with proportional growth in population and employment. For this alternative, the FRA used the projected service plans of NEC service operators as a starting point, and made adjustments to meet projected increases in travel demand. Alternative 1 includes new rail services and commensurate investment in the NEC to expand capacity, add tracks, and relieve key chokepoints, particularly through northern New Jersey, New York, and Connecticut (Figure 11). This includes a 60-mile bypass between Old Saybrook, CT, and Kenyon, RI, that adds capacity, improves travel time, and provides an alternative for most intercity trains to avoid five existing movable bridges along Long Island Sound and numerous sharp curves.

8.1 MARKETS

Alternative 1 primarily serves existing regional and interregional NEC travel markets. It also enables expanded service on some Regional rail lines that currently provide direct service to NEC markets. Alternative 1 provides the possibility, with additional investments, for Regional rail lines without such one-seat ride service to connect onto the NEC and offer one-seat ride service to those markets. This includes lines both in New Jersey and Connecticut. Where Metropolitan service is introduced, the accessibility of these areas to NEC Intercity service is significantly improved. The stations with Metropolitan service generally are those with significant local development and economic activity and/or excellent regional highway access.

8.2 REPRESENTATIVE ROUTE

The Representative Route of Alternative 1 closely follows the existing route of the NEC. In all but a few locations, the Representative Route is confined to the existing NEC. Exceptions include locations where infrastructure is added to provide chokepoint relief or add capacity, as described above.

8.3 SERVICE PLAN

The Service Plan for Alternative 1 offers a moderate expansion in service compared to the No Action Alternative, to accommodate underlying growth in both the Intercity and Regional rail markets by 2040. In the standard peak hour, Intercity-Express service increases to two trains per hour, on both the South End and North End. Intercity-Corridor service also increases. In the standard peak hour, two trains per hour operate between Washington, D.C., and New Haven, CT, providing a one-seat ride from the NEC to off-corridor markets on the connecting corridors. In addition to these trains, new Metropolitan service is introduced, with two trains in the standard peak hour running between Washington, D.C., and Boston, and an additional train serving the Keystone Corridor and running on the NEC between Philadelphia and New York City.

Major NEC cities see an increase in total trains per hour in the standard peak hour from combined service of Intercity-Express, Intercity-Corridor, and Metropolitan services:

- Washington, D.C.: 6 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 2 Metropolitan)
- Philadelphia, PA: 7 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 3 Metropolitan)

- Newark, NJ: 7 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 3 Metropolitan)
- New Haven, CT: 6 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 2 Metropolitan)
- Boston, MA: 4-5 tph (2 Intercity-Express, up to 1 Intercity-Corridor-Other[28], and 2 Metropolitan)

Expansion of trainset lengths, where possible, and increases in peak period service frequencies to provide more capacity, enables future Regional rail service to continue to carry its current share of journey-to-work trips to and from the major metropolitan CBDs, such as across the Hudson River screenline. Reverse-peak and off-peak service continues to be operated where it is provided today.

8.4 INFRASTRUCTURE ELEMENTS

Alternative 1 supports increases in Regional rail and Intercity services by bringing the existing NEC to a state of good repair, eliminating key chokepoints along the corridor, and increasing capacity at selected locations by adding additional track within the existing NEC and through new segments parallel to and outside the existing NEC right-of-way.

8.4.1 CHOKEPOINT RELIEF PROJECTS

Alternative 1 includes a set of location-specific capital projects to provide relief of train movement congestion and increase railroad capacity at several existing chokepoints. These projects are spread across the NEC, but are concentrated at locations that are currently congested and where train interference causes delays today—primarily south of New York City and on the New Haven Line in New York City and Connecticut. These chokepoint relief projects are located at stations, branch line junctions, and yard locations where trains lay over and change direction. Implementing these projects may, in some cases be challenging, given existing development and pending plans in project areas. Specific design solutions would be the focus of future Tier 2 studies. The chokepoint relief projects are listed below in geographic order from south to north, and their locations are identified in Figure 11:

- New Carrollton Station, 4 platform tracks, to permit express and local trains to operate on separate tracks
- Newark, DE, station relocation and track reconfiguration, to provide for smoother Intercity, Regional rail and freight train movements
- Holly Interlocking reconfiguration, DE, to separate local and express train traffic
- Philadelphia flyover, to facilitate regional rail local train movements
- Trenton Station and yard access, to facilitate Regional rail terminal operations
- Metropark Station platforms on express tracks, to permit Intercity-Express and Intercity-Corridor trains to stop at this station without switching to the local tracks
- Hunter flyover and Westbound Waterfront Connection, improving access to the NEC from the Raritan Valley Line and from Hoboken Terminal
- New Rochelle (Shell Junction) grade separation, to provide smoother train flows between the Hell Gate Line and New Haven Line
- South Norwalk and Devon junction improvements, to facilitate Danbury and Waterbury Regional rail branch line train movements
- East Bridgeport yard access and turnback track, to facilitate turning of local Regional rail services

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[28] The Intercity-Corridor-Other train at Boston would operate on the Inland Route (via Hartford, Springfield, and Worcester) and would operate at less than hourly service frequencies.

- Canton Jct.-Readville, MA track and junction improvements to facilitate smooth flow of trains

8.4.2 NEW TRACK

New-track projects are identified as linear elements along portions of the existing NEC that include associated junctions and interlockings required to access the new tracks. Six new-track projects are built in Alternative 1. Four are located south of New York City, two of which are in Maryland, which is currently a two- and three-track right-of-way. There are two new-track projects north of New York City. Two tracks are added to the Hell Gate Line in Queens and the Bronx, NYand one or two tracks are added near Route 128 station in Massachusetts. New-track projects are shown on the map in Figure 11 and include the following locations:

- Odenton, MD, to Halethorpe, MD, 4th track
- Bayview, MD, to Newark, DE, additional track(s)
- Elizabeth, NJ, to Newark Airport, NJ, additional track(s)
- Hell Gate Line, Queens and the Bronx, NY, expanded to 4 tracks
- East Greenwich, RI-Warwick, RI, additional track(s)
- Canton Jct., MA, to Westwood/Route 128, MA, additional track(s)

8.4.3 NEW SEGMENT

Alternative 1 adds three new segments,[29] parallel to and outside of the existing NEC right-of-way. Two new segments are located south of New York City: a new tunnel near Baltimore Penn Station and a third and fourth tunnel under the Hudson River between New Jersey and New York. These new segments are listed below (with their approximate length in parentheses) and are also identified on the map in Figure 11:

- Baltimore Tunnel (~2 miles)
- Hudson River third and fourth tunnels and expanded Penn Station New York (~3 miles)
- Old Saybrook, CT-Kenyon, RI (~50 miles)

All of these are locations for new segments are where the railroad is capacity-constrained, where expanding capacity within the existing right-of-way is difficult or impractical, or, in the case of the Baltimore Great Circle Tunnel, where existing facilities require life-cycle replacement.

This alternative also includes one long parallel new segment in southeastern Connecticut, the Saybrook-Kenyon bypass. This new route, approximately 50 miles long, provides a more direct and faster route than the circuitous existing Shore Line, and it circumvents the existing movable bridges over navigable waterways connected to Long Island Sound, over which daily train movements are capped by current agreements and where approval for significant increases in future train traffic will be difficult to obtain. Operating Intercity-Express and Metropolitan service on this bypass route saves approximately 30 minutes of travel time compared with the existing Shore Line route and frees up capacity on the existing route for anticipated growth in Regional rail and freight service. A new station for Intercity-Express and/or Metropolitan services could be built on the bypass route in the New London-Mystic area. The existing stations serving the downtown areas of New London, Mystic and Westerly continue to be served by trains running on the existing Shore Line.

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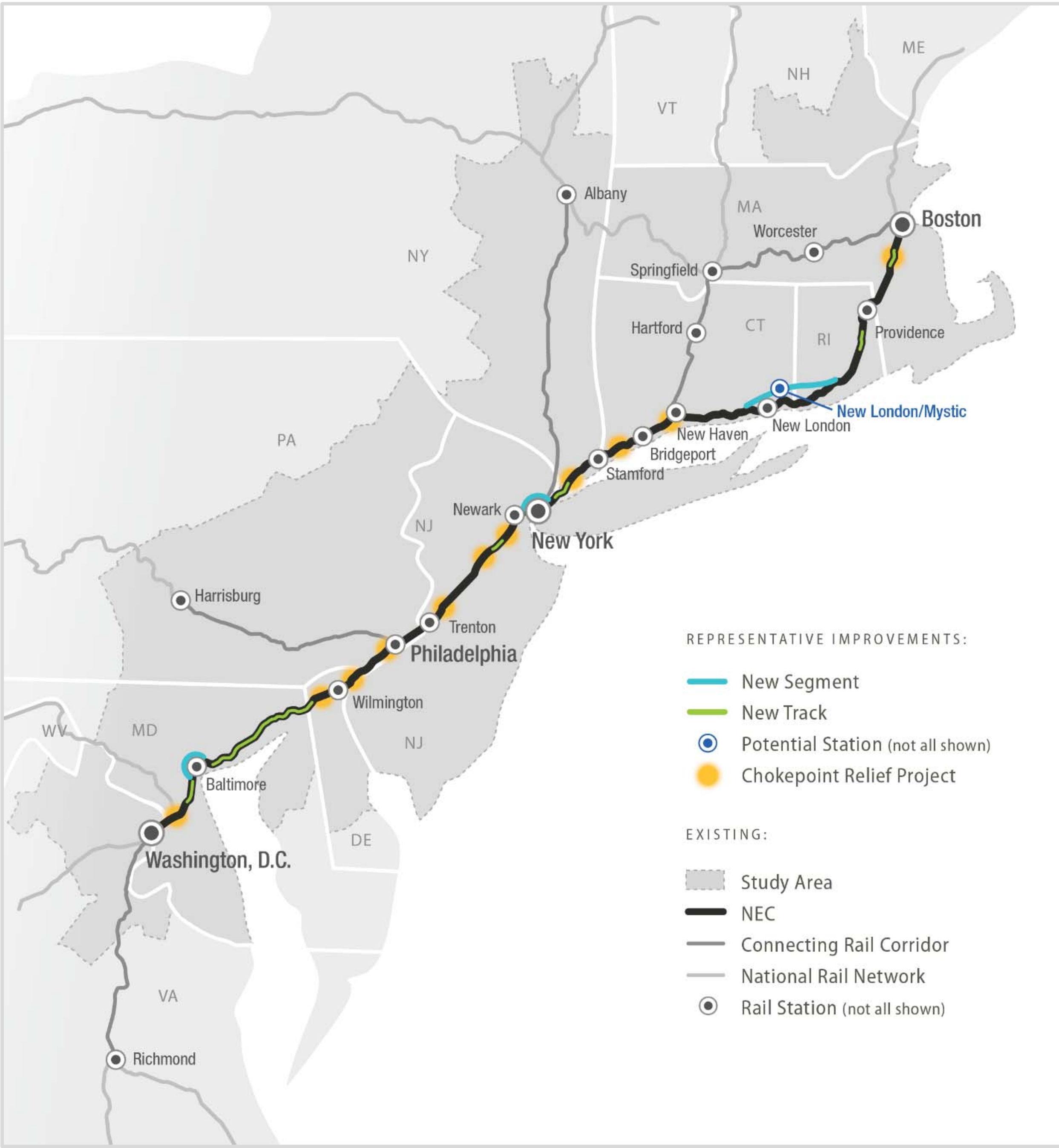
[29] New segments contribute to the Representative Route of an alternative, as described in Section 8.1

Figure 11: Alternative 1



Source: NEC FUTURE team, 2015

9. Alternative 2

Alternative 2 grows the role of rail, expanding rail service at a faster pace than the proportional growth in regional population and employment. During the business travel peak periods, very frequent Intercity-Express service is provided along the entire NEC, with Intercity-Express trains operating at 4 tph. Metropolitan service also is operated on the NEC at a frequency of a train every 15 minutes, providing a level-of-service resembling that of transit. In all regions of the NEC, Regional rail service frequencies also are increased significantly above No Action Alternative levels. As shown in Figure 12, south of New Haven, CT, infrastructure improvements focus on the existing NEC right-of-way with some variations in the route to improve train speeds in areas with speed-limiting curves, address capacity constraints, and serve selected new markets. North of New Haven, Alternative 2 provides a new route segment between New Haven, Hartford, and Providence, improving performance for express trains operating between Boston and New York City while providing better connections for markets in the Connecticut River Valley. Alternative 2 also brings the existing NEC to a state of good repair and implements operational best practices to obtain the highest practical utilization of the infrastructure capacity that is created.

9.1 MARKETS

Alternative 2 greatly improves the level-of-service available to all of the existing NEC markets and selectively taps potential new travel markets that are not served currently or are not well served by the NEC. This includes the New Haven-Hartford-Springfield corridor, now known as the Hartford Line. Hartford becomes a market on the NEC Spine rather than part of a connecting corridor. Other locations along this line have improved trip times and service offerings by virtue of the new high-speed line between New Haven and Hartford featured in this alternative, and the greatly improved accessibility of Providence and Boston by rail.

A second market that receives greatly improved rail service is Philadelphia International Airport, which has a station directly on the NEC in this alternative, with frequent Intercity-Express, Metropolitan, and Regional rail service up and down the NEC as well as to the Keystone Corridor and the rest of the SEPTA Regional rail network.

A third market with significantly increased NEC rail service is located on the south side of Washington, D.C. Improvements to the Long Bridge corridor between Washington, D.C., and Alexandria, VA, coupled with improvements at Washington Union Station, permits Metropolitan service and selected Regional rail trains to run through Union Station, effectively extending the reach of the NEC to this heavily populated part of greater Washington, D.C., and to Ronald Reagan Washington National Airport.

Figure 12: Alternative 2

Source: NEC FUTURE team, 2015

9.2 REPRESENTATIVE ROUTE

Much of the Representative Route of Alternative 2 follows the existing NEC between Washington, D.C., and New Haven, CT, with some exceptions where infrastructure is added or modified to provide chokepoint relief or improve capacity and performance. These infrastructure elements are described Section 9.4. North of New Haven, a new route is provided for Intercity-Express and Metropolitan trains running between New York City and Boston. The new route runs on new tracks between New Haven and Meriden, CT, shares the existing Hartford Line between Newington, CT and Hartford, CT, and runs on new tracks between Hartford, CT and Providence, RI.

9.3 SERVICE PLAN

Alternative 2 significantly grows Intercity service on the NEC through improved service to all existing markets and additional service to selected new markets. In the standard peak-hour, Intercity-Express service increases to four trains per hour compared to the No Action Alternative, where there is never more than one train per hour operating on any segment of the NEC. Intercity-Corridor-Other service increases to 2 tph between Washington, D.C., and New Haven. Metropolitan service provides 4 tph, during peak travel periods, between Washington, D.C. and New Haven.

Major NEC cities see an increase in the total number of Intercity trains in the standard peak hour:

- Washington, D.C.: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other, and 4 Metropolitan)
- Philadelphia, PA: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other, and 4 Metropolitan[30])
- Newark, NJ: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other, and 4 Metropolitan)
- New Haven, CT: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other[31], and 4 Metropolitan[32])
- Boston, MA: 8–9 tph (4 Intercity-Express, up to 1 Intercity-Corridor-Other[33], and 4 Metropolitan)

Regional rail service on the NEC is provided with peak service frequencies at most NEC stations based on 15-mintue headways, which represents an increase in service at a majority of stations, compared with the No Action Alternative. In areas with heavy Regional rail demand, additional service zones are created to increase peak zone express service and reduce average trip times. In addition, service to branch lines is increased where sufficient capacity exists.

9.4 INFRASTRUCTURE ELEMENTS

Alternative 2 maximizes the capacity of the existing NEC, focusing on where future demand is greatest. Alternative 2 includes chokepoint relief projects necessary to provide for smooth-flowing operations, and

[30] Service at 4 tph is provided in the direction of both New York City and Washington, D.C. Metropolitan service in the standard peak hour at Philadelphia consists of 2 trains running between Washington, D.C., and Boston, 2 trains running between Harrisburg and Boston, and 2 trains running between Philadelphia and Washington, D.C.
[31] The Intercity-Corridor-Other trains operate via the Hartford Line to Springfield, with selected trains extended to Vermont via the Knowledge Corridor and to Boston via the Inland Route.
[32] Metropolitan services at 4 tph from New York City splits at New Haven, with 2 tph continuing on the Shore Line to Boston, and 2 tph operating via the new route segment to Boston via Hartford and Providence.
[33] The Intercity-Corridor-Other train at Boston operates on the Inland Route (via Hartford, Springfield and Worcester) and at less than hourly service frequencies.

new-track projects and new segments improve trip times through increases in allowable speeds or bypassing the slowest-speed portions of the existing NEC in and around the major urban areas, on antiquated bridges, and in southeast Connecticut.

9.4.1 CHOKEPOINT RELIEF PROJECTS

Alternative 2 includes capital projects at specific locations to relieve chokepoints on the existing NEC. Most of the chokepoint projects in Alternative 2 are the same as those identified for Alternative 1, addressing chokepoints near stations, at railroad junctions, and at yard locations where trains lay over and change direction. The inclusion of new segments or new tracks at certain locations obviates the need for a separate chokepoint project. The Philadelphia Flyover is one such project, where the new segment via Philadelphia International Airport reduces the severity of train movement conflicts at the location of the potential flyover. As noted, implementing these projects may, in some cases be challenging, given existing development and pending plans in project areas. Specific design would be the focus of future Tier 2 studies. The chokepoint projects identified in Alternative 2 include:

- New Carrollton Station, 4 platform tracks, to permit express and local trains to operate on separate tracks
- Newark, DE, station relocation and track reconfiguration, to provide for smoother intercity, regional rail and freight train movements
- Philadelphia 30th Street – Penn Interlocking – 4-track approaches, to enable the station to operate as a pulse-hub with coordinated transfers between train services at timed intervals
- Trenton Station and yard access, to facilitate regional rail terminal operations
- Metropark Station platforms on express tracks, to enable Intercity-Express and Intercity-Corridor trains, including Metropolitan trains, to stop at this station on the express tracks
- Hunter Flyover and Westbound Waterfront Connection, improving access to the NEC from the Raritan Valley Line and from Hoboken Terminal
- New Rochelle (Shell Junction) grade separation, to provide smoother train flows between the Hell Gate Line and New Haven Line
- New Haven Station, to facilitate the smooth movement of Intercity and Regional rail trains into and out of the station
- Canton Jct.-Readville, MA track and junction improvements to facilitate smooth flow of trains

9.4.2 NEW TRACK

Alternative 2 includes the construction of several new-track projects. Three are located in Maryland where the existing NEC is currently a two- and three-track railroad. Two are located north of New York City, including adding two tracks to the Hell Gate Line in Queens and the Bronx, NY.

- Washington, D.C., to New Carrollton, MD, 3rd Track
- New Carrollton, MD to Halethorpe, MD, 4th Track
- Bayview, MD to Perryville, MD, 4-track railroad
- Hell Gate Line, Queens and the Bronx, NY, expanded to 4 tracks
- Providence, RI to Hyde Park, MA, 4 tracks

9.4.3 NEW SEGMENT

Alternative 2 includes 10 new segments parallel to and outside of the existing NEC right-of-way at the following locations (with the approximate length of the new segments shown in parentheses):

- Baltimore Tunnel (~2 miles)
- Aberdeen, MD, to Newark, DE (~23 miles)
- Wilmington, DE Bypass (~8 miles)
- Baldwin, PA, to Philadelphia 30th Street Station via Philadelphia International Airport (~10 miles)
- Philadelphia 30th Street Station to Bridesburg, PA through North Philadelphia, PA (~8 miles)
- North Brunswick, NJ, to Colonia, NJ (~16 miles)
- Elizabeth, NJ, to Secaucus, NJ (~12 miles)
- Secaucus, NJ, to Hell Gate Viaduct, Queens, NY, via new Hudson and East River Tunnels and expanded Penn Station New York (~8 miles)
- New Rochelle, NY, to Westport, CT (~29 miles)
- Sharon, MA to Canton Jct., MA (~3 miles)

The biggest change in the Representative Route between Alternatives 1 and 2 is in the New Haven-to-Providence territory. Alternative 2 provides new route segment that runs all the way from New Haven to Providence via Hartford. This new route via Hartford is estimated to save an additional 15-20 minutes of run time, compared with service via the New Haven-Saybrook-Kenyon-Providence route in Alternative 1. It removes Intercity-Express trains from 120 miles of the Shore Line route between New Haven (Mill River, CT) and Providence (Hebronville, MA), a route that includes capacity-limited, movable bridges and over which Providence and Worcester freight trains operate in addition to Shore Line East and MBTA Regional rail services.

10. Alternative 3

Alternative 3 is intended to enable transformation of the role of rail within the transportation network, positioning rail as the dominant mode for intercity travel within the NEC and a more competitive mode for all types of tripmaking within the metropolitan regions of the NEC. This alternative provides a major increase in the capacity of the NEC compared with the No Action Alternative and, consequently, offers the potential for considerably more rail service and the introduction of new types of service – both to existing and new markets within the Study Area. Infrastructure improvements include upgrades on the NEC and the addition of a two-track second-spine that operates adjacent to the existing NEC south of New York City and expands the reach of the NEC to new markets north of New York City (Figure 13). This new spine supports high-speed rail services between major NEC markets and provides additional capacity for Intercity and Regional rail services on both the existing NEC and the new spine. The FRA identified several potential routes for the new spine between New York City and Boston (Figure 13).

10.1 MARKETS

The additional NEC rail capacity, coupled with the faster trip times that are possible between the major NEC cities, can be used in this alternative to expand the physical reach of the NEC. The routes that are created parallel to the existing corridor improve the rail system's coverage within the NEC Study Area. Several new geographic markets become part of the NEC and are provided with direct and frequent NEC rail service – including Intercity-Express, Metropolitan and, in some cases, express Regional rail trains:

- Downtown Baltimore
- Downtown Philadelphia
- Central Connecticut Corridor, including White Plains, NY, and Danbury and Waterbury, CT, (Alternatives 3.1 and 3.4 route options)
- Long Island (Nassau and Suffolk Counties) and Jamaica, Queens (Alternatives 3.2 and 3.3 route options)
- Hartford, CT, and Springfield, MA
- The Hartford-Providence Corridor (Alternatives 3.1 and 3.2 route options)
- The Hartford-Worcester-Boston Corridor (Alternatives 3.1 and 3.4 route options)

Figure 13: Alternative 3

Source: NEC FUTURE team, 2015

Alternative 3 provides sufficient capacity to enable Intercity service from connecting corridors onto the NEC to be offered at a volume of up to four trains per hour. This enables an increase in service on existing connecting corridors, as well as the introduction of one-seat ride service onto the NEC from new connecting corridor markets. Capital investment, as well as new railroad access agreements, would be required to implement such connecting service in the future. Opportunities include:

- Washington-Richmond corridor and the Southeast High-Speed Rail corridor (to Richmond, Newport News, Norfolk and Charlotte, NC)
- Washington-Charlottesville-Lynchburg-Roanoke, VA
- Keystone Corridor extended (Philadelphia-Harrisburg-Pittsburgh)
- Empire Corridor extended (New York City-Albany-Buffalo-Cleveland, plus potential links with faster trip times from New York City to Montreal and Toronto)
- Delmarva Peninsula (Newark, DE-Dover-Ocean City, MD)
- Atlantic City (New York City-Atlantic City, Philadelphia-Atlantic City, NJ)
- Lehigh Valley (New York City-Raritan, NJ-Easton-Allentown, PA)
- Scranton (Port Morris, NJ-Scranton, PA)
- Eastern Long Island (New York City-Montauk)
- Knowledge Corridor extended (Springfield-Burlington, VT-Montreal)
- Cape Cod (Attleboro-Fall River-New Bedford-Cape Cod)
- Boston-Concord, NH-Burlington-Montreal
- Downeaster Corridor (Boston-Portland-Brunswick, ME).

Additional capacity exists in this alternative to offer new or improved service to combinations of the above markets while also providing superior service to existing Intercity and Regional rail markets on the NEC. There is not sufficient capacity on the railroad to provide new or greatly improved service to all of these markets simultaneously, even in Alternative 3, requiring trade-off analysis subsequent to NEC FUTURE, to identify which of these corridors, if any, warrant direct service based on their cost-effectiveness or economic benefits. However, slots are provided in Alternative 3 for Intercity-Express and/or Intercity-Corridor trains to operate along portions of the NEC to connect these markets to Boston, New York City, Philadelphia, and/or Washington, D.C. The FRA did not include any particular combination of the above services in the Alternative 3 Service Plan. Rather, the Service Plan provides extra or "phantom" Intercity-Corridor slots on the existing NEC at regular 15-minute intervals. These could be filled by trains serving any combination of these off-corridor markets.

Alternative 3 also provides additional capacity that can be used to offer Regional rail service in new corridors or to offer one-seat ride service to NEC destinations on Regional rail lines that do not currently offer direct service or have only limited direct service. However, considerable investment in railroad infrastructure, stations, fleet and/or yard facilities are required in locations outside the NEC to take advantage of this new service. The scope of NEC FUTURE does not encompass these potential branch line initiatives – either the required investments or their environmental consequences – although the potential benefits of expanding Regional rail network connections to the NEC will be assessed qualitatively. In Alternative 3, the future sponsors and operators of Regional rail and Intercity-Corridor service have great discretion to develop and implement service concepts that meet market demands for rail travel as they emerge. Potential Regional rail concepts are summarized below, without any judgment as to their efficacy or practicality, but as examples of the types of service improvements that could be possible.

There are a number of proposals in New Jersey to extend rail service beyond the current service limits. There are challenges to extending these services, which are not yet resolved, including capital and operating funding. Some of these proposals could advance in the future and support a one-seat ride to Midtown Manhattan.

In Maryland, Alternative 3 presents the potential opportunity for shifting MARC service on the NEC to the new high-speed line along the CSX corridor north of Baltimore, offering station opportunities at Rosedale, White Marsh, and Joppatowne, which are closer to the population centers of Baltimore and Harford Counties than the existing Amtrak line.

In Massachusetts, new rail capacity is needed to meet a level of Intercity service greater than the expanded Boston South Station can accommodate. This might entail the construction of new rail lines and/or new station and rail terminal facilities. There are multiple possibilities for the locations of and connections between these facilities, and some of these options present opportunities for expanding the coverage and connectivity of the Regional rail network serving the greater Boston region.

Finally in Alternative 3, the re-routing of most of the Intercity-Express service to new rail routes through Baltimore, Philadelphia, and New York City presents an opportunity to utilize the capacity freed up on the existing routes within these metropolitan regions to provide short-headway local rail service—effectively creating new rail transit lines. This concept is analogous to the Overground and Thameslink services in London, the RER service in Paris, and the various S-Bahn networks throughout Germany and Switzerland. The NEC route through Baltimore was identified as a potential future transit line in the 2000 Baltimore Region Rail Plan. Offering transit-style service in Hudson and Essex Counties in New Jersey could supplement the capacity provided in Alternative 3 and be complementary to both the Regional rail and rail transit networks.

10.2 **REPRESENTATIVE ROUTE**

The Representative Route of Alternative 3 approximately parallels the existing NEC between Washington, D.C., and New York City. The new high-speed route is closely parallel to the NEC in many locations, but it deviates from the existing corridor in several locations to shorten trip times or service additional travel markets, such as the more direct routes through downtown Baltimore and Philadelphia. North of New York City, the four route options are considered, as described in Section 10.4. In addition, the existing NEC remains as a route for Intercity and Regional rail trains.

10.3 **SERVICE PLAN**

Alternative 3 offers dramatically more Intercity service on the NEC through the construction of dedicated high-speed rail tracks as well as providing new service to new markets within the NEC Study Area. In the standard peak hour, Intercity-Express service increases to six trains per hour compared to the No Action Alternative and includes limited-stop Intercity-Express trains that run between Washington, D.C., and New York City and between New York City and Boston in under 100 minutes. The new Metropolitan service provides four trains between Washington, D.C., and Philadelphia and eight trains between Philadelphia and New York City in the peak hour. North of New York City, four trains per hour Metropolitan service is offered on two different routes – the existing NEC and the new high-speed spine route. An additional four train slots per hour is provided for Intercity-Corridor-Other and Long Distance trains between Washington, D.C., and New Haven. These slots could be filled by new connecting corridor rail services.

Major NEC cities see an increase in the total number of Intercity trains in the standard peak hour:

- Washington, D.C.: 12–14 tph (6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 4 Metropolitan)
- Philadelphia, PA: 16–18 tph[34] (6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 8 Metropolitan)
- Newark, NJ: 16–18 tph (6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 8 Metropolitan)
- New Haven, CT: 8–18 tph[35] (2–6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 4–8 Metropolitan)
- Boston, MA: 12–13 tph (6 Intercity–Express, up to 1 Intercity–Corridor–Other,[36] and 6 Metropolitan)

Regional rail service is increased to fill the capacity made available in this alternative. This includes increasing the quantity of zone express service on NEC Regional rail lines, increasing service to existing branch lines, introducing service on new Regional rail branch lines or existing lines that currently only offer transfer connections to the NEC. In addition, this alternative includes introduction of express Regional rail services that operate from the outer Regional rail service zones and share portions of the new high-speed tracks with intercity trains, offering significantly reduced trip times for long-distance regional commuters.

10.4 INFRASTRUCTURE ELEMENTS

Alternative 3 provides major new rail capacity throughout the entire NEC with two new high-speed tracks between Washington, D.C., and Boston, as well as upgrades to the existing NEC similar to Alternative 1, which brings the existing NEC to a state of good repair and provides capacity and chokepoint relief along the corridor. Alternative 3 provides a new route through New York City with six tunnel tracks beneath the Hudson and East Rivers, along with station facilities for all service types, addressing the most critical capacity issues within the Study Area. Additional infrastructure improvements in Alternative 3 include downtown routing in Baltimore and Philadelphia and terminal capacity expansion in Washington, D.C., New York City, and Boston. New Stations could be built in locations such as downtown Baltimore, Philadelphia International Airport, and Danbury, Connecticut.

Six-track sections, locations where there is a new segment adjacent to the four-track NEC, increase considerably on the south end. Six-track sections extend from Washington, D.C., to Baltimore, and Philadelphia to New York City. Six-track sections are also located in coastal Fairfield County.

10.4.1 CHOKEPOINT RELIEF PROJECTS

Alternative 3 includes capital projects at specific locations to relieve chokepoints on the existing NEC. Most of the chokepoint projects in Alternative 3 are the same as those identified for Alternatives 1 and 2, addressing chokepoints near stations, at railroad junctions, and at yard locations where trains lay over and

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[34] These services are split between 30th Street Station and a new NEC station on the second-spine route at Market East. The six Intercity-Express and four Metropolitan trains serve Market East. The two Intercity-Corridor-Other trains and the other four Metropolitan trains serve 30th Street Station.

[35] The lower totals for Intercity-Express and Metropolitan correspond to the route options via Central Connecticut, which bypass New Haven. The higher totals correspond to the route options via Long Island, which converge with the existing NEC at New Haven.

[36] The Intercity-Corridor-Other train at Boston operates on the Inland Route (via Hartford, Springfield and Worcester) at less than hourly service frequencies.

change direction. The inclusion of new segments or new tracks at certain locations obviates the need for a separate chokepoint project. As noted, implementing these projects may, in some cases be challenging, given existing development and pending plans in project areas. Specific design solutions would be the focus of future Tier 2 studies. Chokepoint relief projects identified in Alternative 3 include:

- New Carrollton Station, 4 platform tracks, to permit express and local trains to operate on separate tracks
- Odenton Station island platforms, to enable Metropolitan trains to stop at this station on the express tracks
- Newark, DE, station relocation and track reconfiguration, to provide for smoother intercity, regional rail and freight train movements
- Philadelphia flyover, to facilitate regional rail local train movements
- Trenton Station and yard access, to facilitate regional rail terminal operations
- Metropark Station platforms on express tracks, to enable Intercity-Express and Intercity-Corridor trains, including Metropolitan trains, to stop at this station on the express tracks
- Hunter Flyover and Westbound Waterfront Connection, improving access to the NEC from the Raritan Valley Line and from Hoboken Terminal
- New Rochelle (Shell Junction) grade separation, to provide smoother train flows between the Hell Gate Line and New Haven Line
- Canton Jct.-Readville, MA track and junction improvements to facilitate smooth flow of trains

10.4.2 NEW TRACK

Alternative 3 includes the construction of fewer new-track projects on the existing NEC, because the need for additional tracks is reduced with the construction of new high-speed tracks along the entire corridor. The locations of the most prominent new-track projects are the following:

- Odenton, MD, to Halethorpe, MD (4th track)
- Bayview, MD, to Perryville, MD (4-track railroad)
- Hell Gate Line, Queens and the Bronx, NY (expanded to 4 tracks)
- Providence, RI, to Hyde Park, MA (4 tracks)

10.4.3 NEW SEGMENT

As shown on Figure 13, Alternative 3 includes multiple new segments parallel to and outside of the existing NEC right-of-way, providing a second-spine route between Washington, D.C. and Boston, MA. This alternative also increases the capacity of the existing NEC with the Baltimore Tunnel and new segments of two track line parallel to the New Haven Line between New Rochelle and Stamford.

11. Phased Implementation

To ensure that incremental capital investment in the NEC will result in benefits for the entire corridor, the FRA anticipates that the Action Alternatives will be implemented in phases consisting of integrated, complementary projects. Such phased implementation of the expanded service envisioned in the Action Alternatives is inevitable due to many factors, including funding, environmental approvals, market growth, and practical constraints relating to construction on a very busy rail corridor. Even as NEC FUTURE uses the year 2040 as a horizon year for planning purposes, the time frame for implementing corridor improvements is likely to extend beyond 2040.

As such, the FRA believes it is important to identify an initial phase of the long-term NEC FUTURE vision that addresses the NEC's most critical near-term needs, provides tangible transportation benefits, and provides a "down-payment" on achieving the long-term vision articulated by each of the alternatives. A Universal First Phase would address the most pressing capacity, chokepoint, and state of good repair needs of the NEC by implementing a set of projects that address these common needs across all the Action Alternatives. In some cases, the specific scope and design of a project in this Universal First Phase may vary across the Action Alternatives to allow for subsequent implementation of the unique characteristics of a specific alternative.

Implementation of this first phase would create a level starting point for further advancing any of the three Action Alternatives. Importantly, implementation of this first phase would enable NEC stakeholders to more quickly realize the benefits of investment in the NEC—increased service, improved reliability and advancing state-of-good-repair priorities—as well as build the stakeholder partnerships required to successfully implement a highly complex, integrated and complementary program of service and infrastructure improvements. Subsequent incremental phases can be developed that build upon the initial investment and ultimately achieve the full long-term vision.

Many factors will ultimately influence the scope of an initial phase of service for each alternative. These include the following:

- Political and governance support for investment to offer enhanced services
- Growth in passenger rail ridership demand
- Availability of public and private funding for capital investment and operating expenses
- Environmental and other regulatory clearances, approvals, and permits
- Workforce and construction industry capacity to undertake and sustain the scope of work
- Impacts on, and constraints imposed, to protect ongoing NEC rail service

The Universal First Phase will be fully described in the Tier 1 Draft EIS. A full phasing plan, including a set of prioritized service objectives and necessary improvements that achieve important regional benefits, for the Selected Alternative will be detailed in the SDP.

12. Next Steps

The Tier 1 Draft EIS will analyze and compare the Action Alternatives outlined in this document to the No Action Alternative. The framework for this evaluation ties directly to the NEC FUTURE Purpose and Need; as such, the FRA identified evaluation metrics to measure, both quantitatively and qualitatively, how well the No Action and Action Alternatives address Study Area needs. The evaluation factors developed for the early screening of Initial and Preliminary Alternatives form the basis for this more detailed evaluation of alternatives. The evaluation framework also considers other factors such as ridership, cost, and constructability.

The FRA established specific metrics to evaluate how the No Action and Action Alternatives address these factors and to compare alternatives. Table 19 presents the evaluation factors and the specific metrics to evaluate them. The transition from an earlier set of less detailed metrics used to screen Initial and Preliminary Alternatives is also presented to show how the metrics have evolved toward increasingly detailed and quantitative analysis.

Table 19: Evaluation Factors and Metrics

Factors	Early Metrics for Screening	Metrics for Evaluation of Alternatives
NEC FUTURE NEEDS		
Aging Infrastructure	■ NEC in a state of good repair	■ NEC in a state of good repair ■ Passenger trips shifted to safer mode of travel
Capacity	■ Peak-hour trains ■ Peak-hour seats/ passengers at major screenlines annual trips ■ Annual passenger miles	■ Peak trains per hour ■ Capacity utilization/available capacity (residual capacity) – train slots/passenger seats ■ Annual trips
Connectivity	■ Stations served by Intercity trains ■ Station-pairs served by Intercity trains ■ Airport stations	■ Service frequency – train volume for key city pairs and key stations ■ Service frequency – train volume for connecting corridors ■ Ridership changes at airport stations (new, existing) ■ Ridership within 10-mile buffer of Representative Route ■ Qualitative assessment of transfers/connections/access at key stations
Performance	■ Express trip time savings ■ Maximum trains per hour ■ Peak-hour trains operating on NEC	■ Travel-time savings (key city-pairs) ■ Average speed (key city-pairs) ■ Top speed by segment ■ Qualitative assessment of on-time-performance/reliability
Resiliency	■ N/A	■ Redundancy for key network links ■ Route miles/passenger miles within or outside areas vulnerable to weather-related events
Environment	■ Areas of environmental sensitivity	■ Rating of magnitude of effects on water resources, ecologically sensitive habitats, air quality/GHG emissions, EJ populations, Section 4(f)/cultural resources and conversion of land cover by type, noise/vibration effects and indirect and cumulative effects
Economic Growth	■ N/A	■ Jobs resulting from construction and/or operations ■ Value of travel-time or cost savings, change in emissions ■ Land premium or agglomeration potential
BENEFITS, COSTS, AND OTHER FACTORS		
Ridership – Interregional and Regional	■ Annual Passengers	■ Annual Passengers ■ Annual Passenger Miles ■ Peak-hour Passengers
Capital/O&M Costs	■ N/A	■ Total capital cost ■ Total O&M cost
Constructability/ Phasing	■ N/A	■ Ridership and service benefits of Initial Phase

Service Plans and Train Equipment Options Technical Memorandum

October 5, 2015
Amended Version

Submitted by:

PARSONS BRINCKERHOFF AECOM
A JOINT VENTURE

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Figures

Tables

1 Introduction

The Federal Railroad Administration (FRA) created this technical memorandum to document the process undertaken to determine Service Plans and train equipment options for the alternatives developed for the Tier 1 Draft Environmental Impact Statement (Tier 1 Draft EIS). The technical data, methodology, and assumptions assembled in this memorandum provide background information and insight into the service planning process for readers of the Tier 1 EIS Alternatives Report.

The NEC FUTURE Service Plans provided a technical basis used in estimating ridership and capital investment needs and costs, and in assessing environmental impacts associated with planned construction and future operations. The operational and maintenance costs of improved service and potential capital improvements to the network were also tested against anticipated ridership increases and revenue streams to validate their usefulness and provide quantitative comparisons between the No Action and Action Alternatives. Service Plans were the mechanisms that made these assessments possible, and thus have been integral to the development and evaluation of the performance of rail scenarios and alternatives.

The creation of Service Plans is a process that uses planning tools, distinct from the development of full-detailed operating plans. The Service Plans are intended to be representational only, required for analysis of capacity, performance and costs, as well as assessment of environmental impacts associated with planned improvements. The Service Plans are not intended in any way to be prescriptive regarding how service should be operated in the future. The Service Plans also are not intended to predict future operating patterns of the railroad operators within the NEC. The FRA grounded the Service Plans with reasonable operational assumptions, and utilized train performance calculations, capacity thresholds, and operations-related analyses with levels of detail sufficient for the resulting Service Plan to be considered operationally feasible. Additional future analyses will be required to support the development of operating plans, timetables, yarding or crewing assumptions, or specific track assignments at major stations or terminals, which are not addressed in the NEC FUTURE Service Plans.

The information in this technical memorandum is organized as follows:

- Section 2 identifies and discusses the key factors—ridership markets, service types, and time periods—that influenced the development of the NEC FUTURE Service Plans.
- Section 3 documents the service planning methodology that was developed specifically by the FRA for NEC FUTURE. The methodology involved a sketch planning approach to approximate various capacity and demand scenarios (which are not prescriptive nor do they represent predict future operations of the railroads on the NEC) followed by a two-step balancing process: (1) to balance the service and the rail infrastructure provided in each alternative; and (2) to balance the service with the estimated level of ridership and to assure that projected Intercity service revenues will exceed costs of operations and maintenance.

- Section 4 describes the results and effects by alternative of the two-step balancing process described in Section 3.
- Section 5 describes relevant operational and service-related best practices of the world-wide rail industry and discusses the assumptions made regarding their application in the Service Plans of the Action Alternatives.
- Section 6 discusses the train-equipment options available to the operators of the Northeast Corridor (NEC) and details the rolling stock assumptions for the No Action and Action Alternatives.
- Section 7 presents the Service Plans and includes tables and diagrams that illustrate the Service Plan attributes and components of the No Action and Action Alternatives.

The appendix to this technical memorandum provides additional background and technical information. Additional information regarding tables and diagrams in support of the NEC FUTURE service planning process will also be included in the Tier 1 Draft EIS.

2 Service Plan Factors and Drivers

Service Plans, while not prescriptive, were developed specifically in response to the travel demand needs of the markets. Service Plans helped to define the investment needed to meet demand within and beyond the current capacity. The definitions of relevant ridership markets, service types, and time periods were all essential to the development of Service Plans for each Action Alternative and are outlined below.

2.1 RIDERSHIP MARKETS

The FRA defines four regions within the NEC Study Area:

- Washington-Baltimore
- Philadelphia-Wilmington
- New York (includes portions of New Jersey and Connecticut)
- Boston

The regions are characterized by the following:

- They have major central business districts (CBD). These CBDs have rail stations or terminals that are hubs for Regional rail service that carry a significant share of work trips from suburban areas to the CBD.
- They include other significant cities within the reach of the Regional rail network.
- They have metropolitan planning organizations (MPO) and extensive travel demand data and models available for travel demand analysis (but not limited to one MPO or data set and model per region).
- They have major air carrier airports with international service.

To improve the analysis of ridership markets, the FRA created two categories of ridership within the Study Area: ***interregional*** and ***regional markets.*** The two categories are differentiated by their geographical zone pairs (origins and destinations of trips). The zone pairs associated with a regional market lie within the same metropolitan area or region. For an interregional market the zone pairs extend beyond the boundaries of a single region.

2.1.1 Interregional Market

The ***interregional*** travel market encompasses travel that extends beyond the boundaries of a single metropolitan region. Most, but not all, trips on Amtrak trains today are interregional trips. NEC FUTURE developed a new interregional travel model to estimate future demand for interregional trip-making. The model[1] is trip-based, similar in structure to other existing models, including Amtrak's NEC model. It estimates the future total travel demand, based on existing and estimated growth from (1) changes in population and economic activity; and (2) changes in the modal levels of service provided. It estimates mode shares among rail, air, intercity bus, and highway auto. Data for the new model are drawn from a new, detailed survey of households in the Study Area. In addition, surveys of automobile travelers and intercity bus riders—sponsored by the Northeast Corridor Infrastructure and Operations Advisory Commission (NEC Commission)—provided data on auto and bus trips. Ticket data from the Federal Aviation Administration were used to provide information on air travel, and rail ridership data were furnished by Amtrak and the Regional rail operators.[2]

The interregional travel model distinguishes among business, non-business, and commuter trip purposes. The model estimates ridership for all varieties of rail service that are available for each zone pair market, including premium rail service (represented by Intercity-Express), non-premium rail service (represented by the Intercity-Corridor services, including both Metropolitan and Intercity-Corridor-Other trains), and Regional rail (represented by commuter rail services if available to serve the zone pair). The riders of the premium service tend to be drawn from the business travel segment and tend to be more responsive to trip time and less sensitive to price, whereas the riders of the non-premium and Regional rail modes tend to be more price-sensitive and include business, non-business, and commuter travel segments.

2.1.2 Regional Market

The ***regional*** markets comprise trip-making that occurs within a metropolitan area. The Study Area contains four major metropolitan areas: Washington-Baltimore, Philadelphia-Wilmington, New York (including portions of New Jersey and Connecticut), and Boston. Each of these metropolitan regions is served by its own network of Regional rail lines and includes one or more major stations on the NEC. A large majority of the Regional rail trips on the NEC have one of these four major markets as one or both endpoints of the trip.

The analysis of the regional markets builds off of existing urban area travel data sets and models from the various MPO and railroad operators in these regions, which are commonly used for urban area travel demand analysis, including the evaluation of Federal Transit Administration (FTA) New Starts program's rail projects. In some cases, the model geography is adjusted to cover the territory served by Regional or commuter rail service, including combining contiguous areas within the same or adjacent regions where needed. The focus of the intraregional data and models remains mostly on journey-to-work commuting—both traditional commuting to the regional CBDs, as well as other more dispersed work trip patterns—but also encompass other trip purposes, which represent a growing share of metropolitan area train travel. By leveraging the existing locally developed forecasting tools, where available, the FRA can avoid costly new model development and provide

[1] The ridership model is documented in the Ridership Technical Memorandum, which will be included as an appendix of the Tier 1 Draft EIS, along with the sources of data, including the methodology and survey of households and travelers within the NEC.

[2] Regional rail ridership data were furnished by Maryland Transit Administration , Southeastern Pennsylvania Transportation Authority, NJ TRANSIT, Metropolitan Transportation Authority (New York), ConnDOT, and Massachusetts Bay Transportation Authority.

analysis results that were consistent with those undertaken by local agencies to develop long-range plans and support programmed projects. Where existing regional models were unavailable, the FTA's Simplified Trips on Project System (STOPS) model and data sets were utilized.

2.2 SERVICE TYPES

The markets described in Section 2.2 can be served by a variety of rail services types. An important step in the development of the visions for the NEC was for the FRA to identify the types of services that best satisfy rail travel demand by offering attractive service characteristics and amenities. The FRA did not limit choices about the types of rail service to be offered and their characteristics to the services that are currently operated on the NEC.

For NEC FUTURE, the FRA organized the various types of NEC passenger rail service into categories, based on travel distance, the travel markets and trip purposes served, where and how the trains operate, and the service characteristics and amenities offered to passengers. The categories are used to represent the rail service that is provided in the No Action Alternative and each of the Action Alternatives and correspond with the travel market definitions used for ridership estimating. These categories describe the full-range future service that is provided in the Action Alternatives, but they also relate to the existing services offered by Amtrak and the Regional rail operators. These rail service types are summarized in the Tier 1 EIS Alternatives Report (Section 4) and are described in greater detail below.

Intercity rail service provides transportation between cities or metropolitan areas at speeds and distances greater than that of most commuter trips. **Regional rail**, by definition, operates within a single metropolitan region and serves more local markets. Regional rail service currently focuses largely though not exclusively on journey-to-work travel to the major central business districts within the NEC study area. However, an increasing share of trips on the regional railroads are attributable to non-traditional commutes and non-work trip purposes, and reverse-peak and off-peak travel generally is growing at a faster rate than traditional commuting. The FRA identified several types of potential rail service within each of these categories. The various service types are described in Sections 2.3.1 and 2.3.2, followed by a table in Section 2.3.3 that relates service types to travel markets and the models used to analyze them.

2.2.1 Intercity

Intercity passenger service on the NEC falls into three basic categories, each having fundamentally different characteristics and targeting different travel markets and trip purposes. The existing services offered by Amtrak fit into these categories. Future service concepts—some of which differ significantly from current service offerings—also fit within these same categories. The primary distinguishing features of these service categories, and their applicability to existing NEC Amtrak service and potential future service, are as follows:

- Intercity-Express
  - Premium high-speed rail service

- Aimed at business travel markets where trips are relatively time-sensitive and price-insensitive
- Serves major cities and Major Hub stations[3]
- Includes existing Amtrak Acela Express service

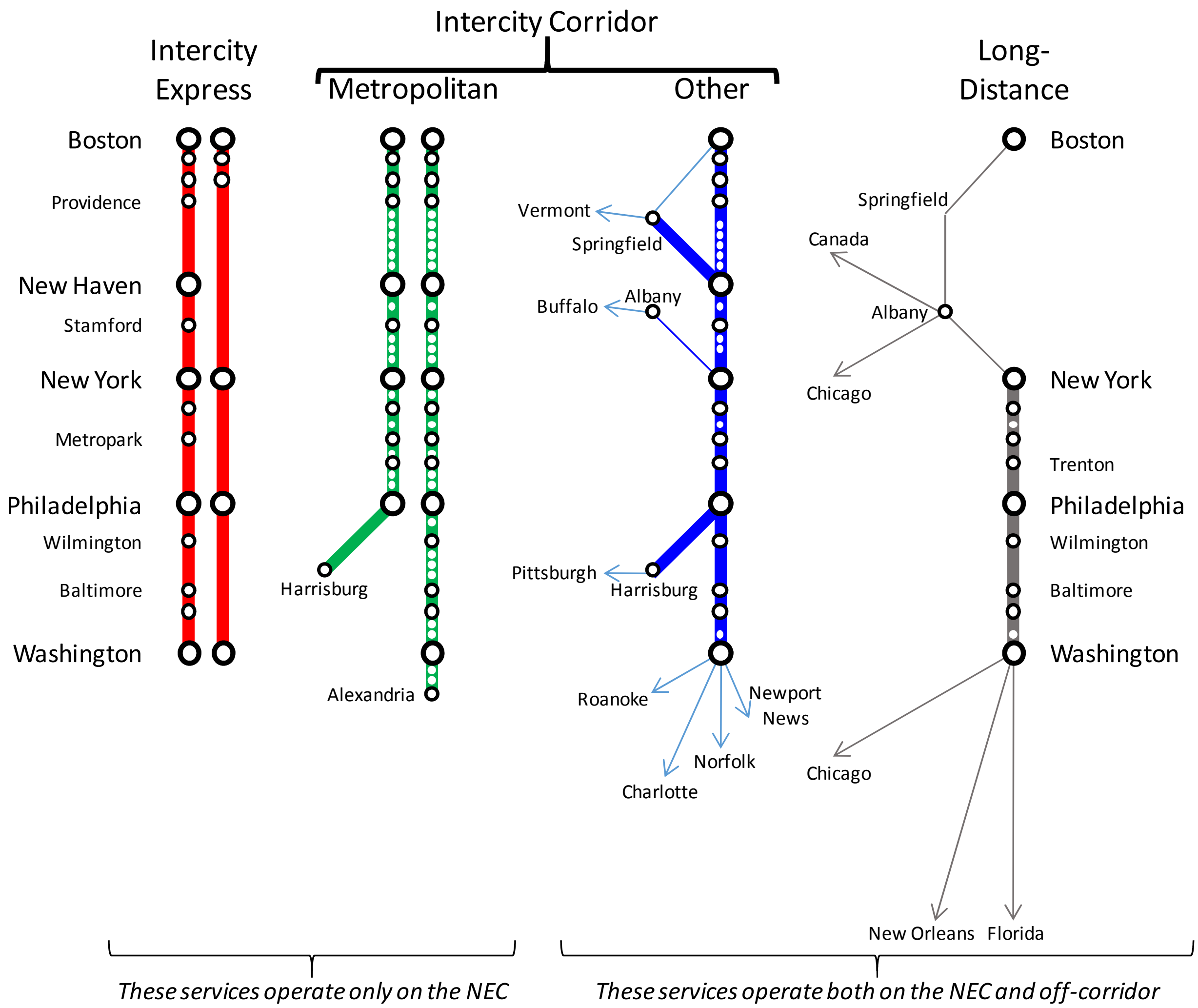
- Intercity-Corridor
  - Regular Intercity passenger service on the NEC
  - Aimed at non-business and price-sensitive travel markets
  - Serves major cities and Major Hub stations, and also serves intermediate travel markets at hub stations not served by Intercity-Express trains
  - Includes trains that operate exclusively within the NEC, as well as trains that operate both on- and off-corridor, serving connecting corridors to the NEC
  - Includes existing Amtrak Northeast Regional service[4]
  - Includes connecting corridor trains from Virginia, North Carolina, Keystone Corridor from central and western Pennsylvania, Vermont, and Empire Service from Upstate New York.
- Long Distance
  - Includes trains that operate overnight with sleeping and dining car service, or to locations remote from the NEC Study Area, which do not carry passengers locally within the NEC
  - Includes international trains to and from Toronto and Montreal
  - Includes existing Amtrak trains to Florida, Georgia, New Orleans, Chicago, and Canada

For purposes of travel demand analysis and ridership estimating, Intercity rail service is classified by market segment into **Intercity-Express** (serving the premium travel market composed largely of business travelers) and **Intercity-Corridor** (serving the regular or "economy" end of the Intercity travel market, serving mostly travelers with non-business trip purposes). Ridership estimates are produced for these two categories of service. Figure 1 depicts schematically the extent of service and NEC station stopping patterns for the various types of Intercity service.

[3] Major Hub stations serve the four primary markets (Washington, D.C., Philadelphia, New York, and Boston), as well as other major markets within the Study Area, and have the full complement of services types. See *Tier 1 Alternatives Report*, Section 6.1.1 (stations).

[4] Northeast Regional service is Amtrak's regular Intercity service currently operating on the NEC Spine and on the connecting corridors feeding the NEC Spine. Some Northeast Regional trains operate exclusively on the NEC Spine between Washington, D.C., and Boston, or Washington, D.C., and New York. Selected Northeast Regional trains continue beyond the NEC Spine. Trains operate with conventional passengers coaches (the "Amfleet"), hauled by either electric or diesel locomotives. For those trains that operate beyond the electrified NEC, there is an engine change required at the points at which these trains enter or leave the NEC Spine.

Figure 1: Intercity Service Types



Source: NEC FUTURE team, 2015
Note: This graphic is intended for illustrative purposes only.

The following summary descriptions of these four intercity service types are organized around the operational and fleet characteristics of the service:

- **Intercity-Express** is the future premium Intercity high-speed rail service offered on the NEC, making limited stops along the NEC and serving only the largest markets. For Action Alternatives, this category of service is envisioned as analogous to the state-of-the-art high-speed rail services currently operating in Europe and Asia. Intercity-Express service offers the shortest travel times for Intercity trips, with a higher quality of onboard amenities, at a premium price, using state-of-the-art high-speed trainsets, with top speeds in the range of 160 mph to 220 mph. In general, these trains make the same station stops as today's Amtrak Acela Express service. In alternatives and time periods where Express service is provided at a level of at least four trains per hour, selected trains are able to operate with fewer stops, improving trip times for the major travel markets. Where new high-speed routes are provided, Express trains stop at Major Hub stations along the new routes.

- **Metropolitan** service utilizes high-speed equipment similar to the trainsets that provide Intercity-Express service. Consequently, these trains operate exclusively on the NEC and in electrified territory connected to the NEC. Metropolitan service is the future primary Intercity rail service on the NEC, a subset of Intercity-Corridor service, and the successor to the existing Amtrak Northeast Regional service. Whereas Intercity-Express service is aimed at the business travel market, Metropolitan trains serve both leisure and business travelers who are more price-sensitive. The FRA has chosen a new name for this service to emphasize its distinct characteristics and higher level of performance. Metropolitan trains operate on regular schedules with high frequency (2-4 trains per hour) and stop at more stations than the current Amtrak Northeast Regional service (including some stations that are only served today by Regional rail trains), thereby increasing the number of direct station-pair connections served by Intercity trains. Metropolitan service also provides a travel choice for longer-distance commuters at stations served by both Metropolitan and Regional rail trains. In addition to providing service on the NEC Spine, Metropolitan trains provide service on electrified Keystone Corridor in all three Action Alternatives and on the Hartford Line in alternatives where this line is electrified (Alternatives 2 and 3).
- **Intercity-Corridor-Other**–Since Metropolitan service utilizes trainsets that can operate only in electrified territory, a separate Intercity-Corridor service provides connectivity and direct one-seat service between non-electrified connecting corridors and the large and mid-size markets on the NEC. These trains, along with the Metropolitan trains, are classified as Intercity-Corridor trains for purposes of ridership analysis, and they cater to the same market for regular Intercity service. They generally stop at the NEC stations currently served by Amtrak Northeast Regional trains. These trains are versatile, operating on the electrified high-speed NEC Spine and on the non-electrified national railroad network on tracks owned by and shared with freight railroads. Off-corridor trains are made up of rail cars pulled by locomotives, as opposed to the specialized trainsets that provide NEC-only service. Intercity-Corridor-Other trains operate at top speeds of 125 mph on the NEC and up to 110 mph off of the NEC. The FRA assumes that by 2040 dual-mode locomotive technology will allow movement along electrified and non-electrified corridors without engine changes for Intercity-Corridor-Other services.[5] The most prominent off-corridor routes served by these trains include the several Virginia corridors south of Washington, D.C.,[6] the Empire Corridor serving Upstate New York,[7] the Knowledge Corridor

[5] Dual mode locomotive technology does not currently exist that meets the top speed and other performance requirements for operations on both the NEC spine and off-corridor on the U.S. freight rail network. Should such technology not become available, the Service Plans for the Action Alternatives remain feasible if engine changes continue to be made at Washington, D.C. and New Haven, CT or Springfield, MA.

[6] Off-Corridor service to and from Virginia covers four different routes: three routes via Richmond, VA, plus a route serving Charlottesville, Lynchburg and Roanoke. The three Washington-to-Richmond routes diverge south of Richmond and include the corridor to Williamsburg and Newport News, the corridor to Norfolk, and the corridor to Raleigh and Charlotte, NC. All services that are part of the Southeast High-Speed Rail (SEHSR) initiative are included within this definition of the Virginia Off-Corridor routes.

serving central Massachusetts and Vermont, and the Inland Route corridor between Springfield, MA, and Boston, MA. This category includes named trains that operate partially on the NEC but also over longer distances on rail lines owned and dispatched by freight railroads, including the Carolinian, Pennsylvanian and Vermonter services.

- **Long-Distance Services** are Intercity trains connecting the Northeast with other parts of the United States that generally entail overnight travel with sleeping car and dining car service and handling checked baggage; this category includes existing Amtrak service to Florida, New Orleans, and Chicago. Generally, these trains are scheduled to operate on the NEC during off-peak periods; since these trains operate over longer distances, they are subject to greater delays when operating off-corridor. They are assumed to operate with electric locomotives on the NEC but with diesel locomotives for the off-corridor portion of the trip, requiring a change of engines at the points at which these trains enter and leave the NEC Spine. For this analysis the FRA assumes that the level of Long-Distance train service on the NEC will remain constant through the 2040 horizon period. Five round trips per day operate over the full length of the NEC between New York and Washington, D.C., on their way to and from and points south.[8] Several other Long-Distance trains serve stations on the NEC and offer connections to other NEC trains, but the trains only operate on short sections of the NEC in proximity to these stations.[9]

2.2.2 Regional Rail

Regional rail encompasses rail services within a single metropolitan region. Regional rail trains provide local and commuter-focused service characterized by relatively low fares and a high percentage of regular travelers. Regional rail includes the current services provided by Virginia Railway Express (VRE), Maryland Area Regional Commuter (MARC), Southeastern Pennsylvania Transportation Authority (SEPTA), NJ TRANSIT, MTA-Long Island Rail Road (LIRR), MTA-Metro-North Railroad (MNR), Shore Line East, and Massachusetts Bay Transportation Authority (MBTA). These railroads, with the exception of Shore Line East, do not operate exclusively on the NEC. Most regional railroads in the Study Area operate relatively extensive networks of multiple branch lines, which feed one or more major terminal stations. The NEC does not operate independently, but rather is the backbone of an extensive and interconnected rail network.

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[7] The Empire Corridor connects New York City with Albany, NY, and extends westward to Buffalo and Niagara Falls, NY. Intercity rail service in the Empire Corridor as envisioned in the Action Alternatives remains independent of NEC Spine service. Empire trains operating within New York State utilize push-pull trainsets powered by dual-mode locomotives, which will be stored and maintained at the Amtrak facility in Rensselaer, NY. Trains using the Empire Corridor to and from Canada and Chicago will continue to operate with conventional equipment outside of the peak periods and as non-revenue trains on the segment between Penn Station New York and Sunnyside Yard in Queens, NY.

[8] Represented by four existing overnight services (Silver Star, Silver Meteor, Crescent, and Cardinal), plus the same-day Palmetto service to Savannah, GA.

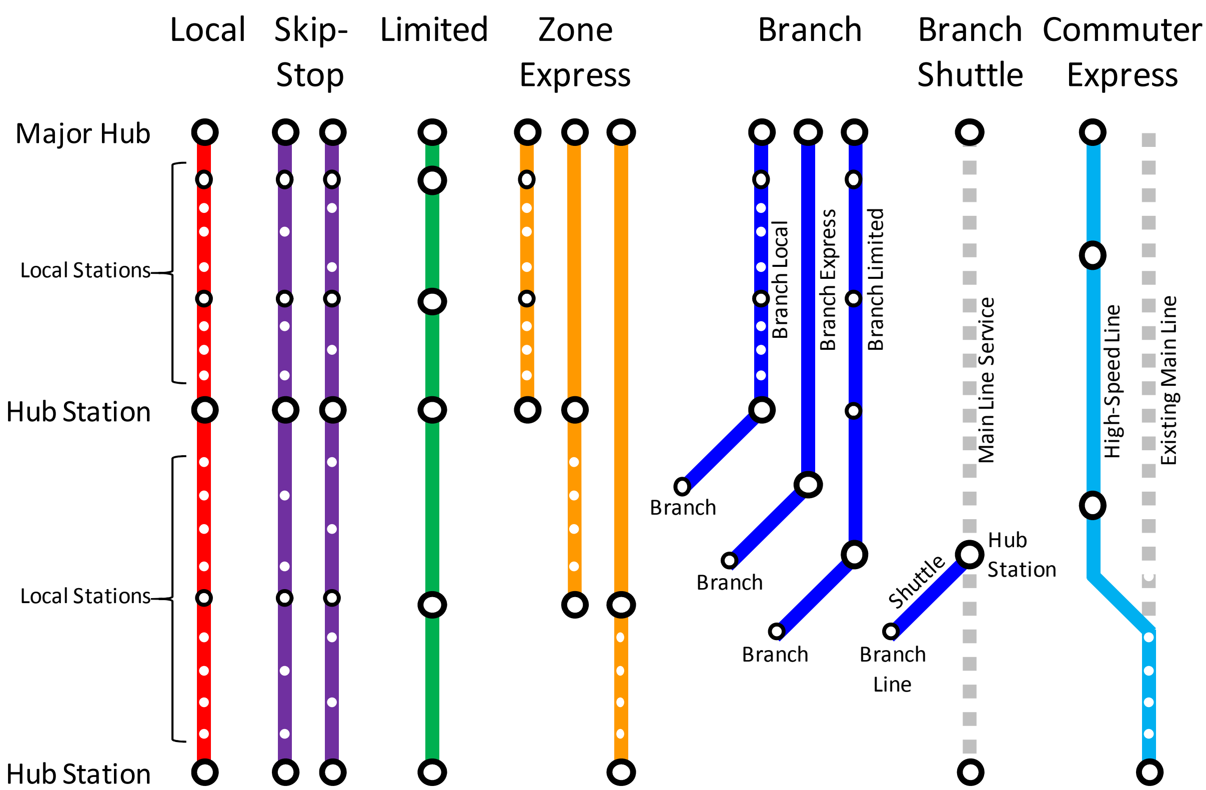
[9] Includes two existing overnight services, the Capitol Limited between Washington and Chicago, and Lake Shore Limited from both New York and Boston to Chicago via the Empire Corridor. Also includes two international trains that operate same-day service on the Empire Corridor from New York to Montreal (Adirondack) and Toronto (Maple Leaf).

The Service Plans for each of the eight Regional railroads have evolved over the last few decades. Faced with the constraints imposed by existing physical assets and jurisdictional boundaries, the railroads have finely tuned their train schedules and stopping patterns to maximize the utilization of scarce capacity during the weekday peak periods. Train schedules and patterns are designed to fill up the trains and can vary considerably throughout the peak period. This has allowed Regional rail operators working within existing capacity constraints to maximize their ridership volumes during the peak periods; but this practice results in uneven headways and makes the establishment of timed multimodal and rail-to-rail connections, especially between different rail providers, difficult. For purposes of NEC FUTURE analysis, the wide array of potential Regional rail stopping patterns on the NEC is organized into the following categories, which are illustrated schematically Figure 2:

- ***Local*** service makes all stops in the territory in which it operates. A local train can operate for the entire length of the service territory or within the "inner zone"—the closest group of stations nearest to the major terminal.
- ***Skip-Stop Local*** service is a variation on local service that operates more than one pattern of service on the local tracks at close headways. Local trains stop at every second or third local station, skipping the other stations. Subsequent trains serve the stations skipped by the initial train. This increases the average speed of local trains by reducing the number of station stops. This type of service is most commonly seen on rail transit lines but is applicable to Regional rail service plans that seek to simplify operations by running independent local and express services. An example of this type of service is described in Section 4.3.6.3 for the New Haven Line in Alternative 1.
- ***Limited*** service stops at select stations only. This train generally operates over the full service territory and serves major stations in that territory. Metropolitan service is a good example of a limited-service pattern, as are the Regional rail trains operating on the express tracks on the New Haven Line in the simplified operations scenario described in Section 4.3.6.3.
- ***Zone express*** service stops at a group of stations in succession within a zone on the NEC Spine and then operates as a non-stop express train the rest of the way to its major city destination. These trains usually run only in the weekday peak periods in the major direction of travel—inbound in the morning and outbound in the evening. The number of zones offering zone-express service within a region depends upon the length of the service territory and the volume of passenger demand.
- ***Branch*** service describes a train that operates on the NEC for a portion of its run and on a branch line for the remainder of the run. On the NEC, these trains can operate as non-stop zone-express trains, as limited trains, or as locals.
- ***Shuttle*** service describes a branch line train that operates exclusively on the branch line, but not on the NEC Spine, or only over a very short distance on the Spine. Shuttle service allows trains on the branch line to be operated independently of the NEC, providing greater scheduling flexibility and the opportunity for increased service frequency in locations where the main line capacity is limited. All passengers on shuttle services must transfer at Hub stations where the branch line meets the NEC to access origins or destinations elsewhere on the NEC.
- ***Commuter Express*** is a new type of service that takes advantage of available capacity on new high-speed tracks. It is a variation on zone-express service, with trains serving the outer zones

on existing Regional rail lines and then switching to the high-speed tracks for the remainder of the trip to the CBD. By utilizing rolling stock with higher top speeds, major trip time savings are possible from these service zones.

Figure 2: Regional Rail Service Types



Note: This graphic is intended for illustrative purposes only.

2.2.3 Correspondence between Markets and Service Types

Generally, ridership for Intercity rail services is drawn from interregional markets and estimated using the interregional model, while ridership for Regional rail trains is drawn from the intraregional markets and estimated from the various MPO regional travel demand models. However, the somewhat artificial geographic boundaries of the regional travel demand models are limiting factors, and these models are unable to estimate the full extent of commuting and travel for other purposes crossing the boundaries of metropolitan regions. As a result, the interregional model is used to estimate commuter travel between adjacent regions by all modes, including commute trips on Intercity trains. In addition, Regional rail provides service for some interregional markets as they are defined for this project. In those instances the interregional model provides an additional source of estimated ridership.

Table 1 indicates the markets served by the various rail services and lists the various rail service types in the first column. The remaining table columns represent the ridership markets as they are analyzed in the travel demand models. The top level breakdown is between the interregional and regional markets. Within the interregional model, trips are defined and then spread among the available rail service types in three categories related to the predominant trip purpose: 1) the market for premium service (which primarily serves business travelers who tend to be more time-sensitive); 2) the market for regular Intercity service (which primarily serves non-business travelers who tend to be more price-sensitive); and 3) the market for journey-to-work trips that happen to cross regional boundaries and are therefore captured in the interregional model data. The table highlights the overlaps between markets and service types, such as the potential for Metropolitan trains to serve both the interregional and regional markets, and the contribution of cross-boundary commute trips from the interregional model to ridership on Regional rail services.

Table 1: Correspondence Between Ridership Markets and Service Types

	Ridership Markets			
	Interregional Markets (by *Trip Purpose Categories)*			
Service Types	***Premium***	***Regular/ Economy***	***Commute Trips Across Regional Boundaries***	**Regional**
Intercity-Express	✓ [IR]			
Intercity-Corridor ▪ Metropolitan ▪ Intercity-Corridor-Other*		✓ [IR] ✓ [IR]**	✓ [IR]	✓ [Reg]
Long-Distance	(Travel market assumed to remain constant and not analyzed explicitly)			
Regional rail			✓ [IR]	✓ [Reg]

Source: NEC FUTURE team, 2015
Notes: Travel Demand Model(s) used to generate ridership estimates:
[IR] New interregional ridership model
[Reg] Regional ridership models based on existing MPO models and regional travel data.
* Includes connecting corridor service that remains mostly or entirely off-corridor but connects with NEC services, such as Empire Service and Hartford Line shuttle service.
** Interregional model is used to estimate ridership for station pairs that are entirely in the NEC FUTURE market area. For any off-corridor city pairs that are not fully within the market area, ridership estimates at a coarse sketch plan level of precision can be obtained by utilizing the FRA's CONNECT model.

2.3 PEAK PERIODS

The unit of analysis for the development of the Service Plans was the ***standard peak hour***. Because the temporal patterns of Intercity and Regional rail service on the NEC do not align perfectly, it was necessary to define a reasonable worst-case condition that simultaneously imposes a maximum level of demand for both service types, in each of the primary markets that comprise the NEC. This condition is not one that exists simultaneously everywhere on the NEC, but it is most representative of conditions in the weekday evening peak period, when Intercity service generally is operating in both directions of travel at maximum levels, at the same time as the evening peak commuter rush hour. In most locations, the morning commuter peak is not as heavily subscribed with Intercity trains, and the Regional rail operators take advantage of the available capacity to run slightly more concentrated service in the morning than in the afternoon, which generally matches the sharper commuter demand peaks in the morning rush. This is expected to continue to be the case in the future; however, the analysis remained conservative by basing estimates of ridership on and developing Service Plans for the standard peak hour.

In support of the daily ridership analysis, the FRA made assumptions in the Service Plans regarding off-peak service levels and patterns, and the peaking of service within peak periods. Full-day Service Plans were developed for selected scenarios and for the No Action Alternative and each Action Alternative in order to develop requirements for fleet and yard facilities, and for the purposes of estimating annual operations and maintenance costs. Infrastructure requirements and capital costs were driven by the capacity needed to serve the weekday peak periods.

Service Plans for the Action Alternatives provide information on train service, by type of train within each service territory, for a typical weekday in the year 2040. ***Intercity service*** specifications include the number of trains per hour in the standard peak hour and the total number of daily trains in each direction, for each type of Intercity service. Regular Intercity service is assumed to operate throughout the day on a repeating clockface schedule, with train departures at evenly spaced intervals for each type of service.[10] Standard peak-hour service includes additional trains needed to satisfy peak demand during the business travel peaks, typically over a three-hour period in morning and again for three hours in the afternoon and evening. Selected trains originate/terminate at intermediate points in the peak shoulder hours and at the beginning and end of the service day.

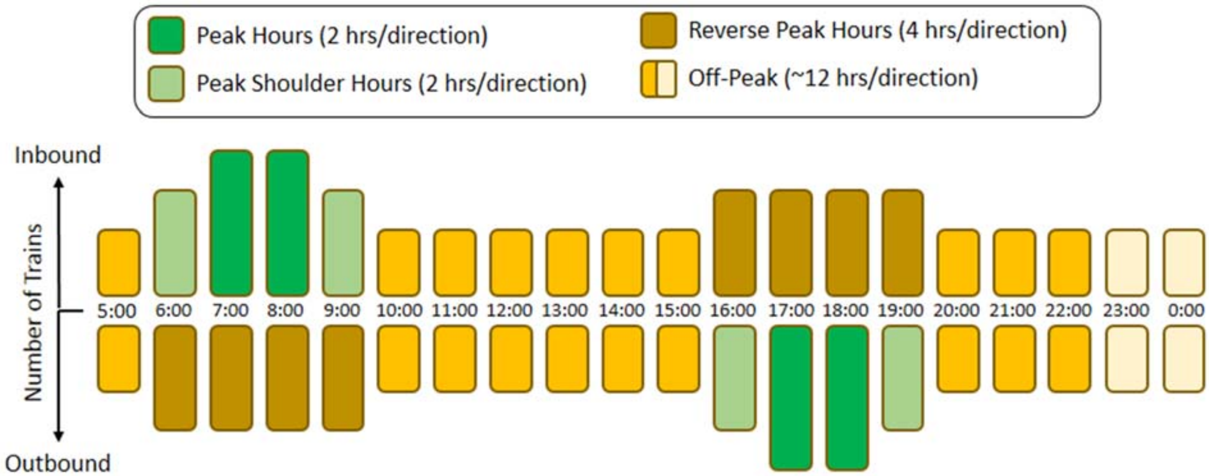
Regional rail service specifications for each NEC region include total daily trains on a typical weekday, broken out into the number of trains per hour for each service pattern in each of four standard time periods:

- Peak hour, peak direction – defined as the *Standard Peak Hour* (assumed to comprise two hours in the morning in the inbound direction of travel and two hours in the evening in the outbound direction)
- Peak shoulder hour, peak direction (the one-hour periods immediately preceding and following the standard peak hour)
- Reverse-peak hour (travel in the direction opposite the peak flow, over the entire four-hour periods – outbound in the morning and inbound in the evening)
- Typical off-peak hour, representing all other hours of the day (the larger Regional rail operators generally provide off-peak service over 12 hours of the day, including midday and late evening/nighttime service; the smaller all-day operations typically provide 10 hours of off-peak service; some operators, and some branch line services, provide peak-only service or have only limited reverse-peak and off-peak service.)

Figure 3 illustrates how the level of Regional rail service is assumed to fluctuate within these hourly time intervals through the course of a typical weekday. This represents an idealized picture of peaking on the Regional railroads, but one that generally reflects observed peaking patterns and is representative of expected future conditions.

[10] The concept of clockface schedules and regular repeating service patterns is described in Section 5.1, which highlights operational best practices that are incorporated into the Action Alternatives.

Figure 3: Standard Temporal Distribution of Regional Rail Service by Time of Day

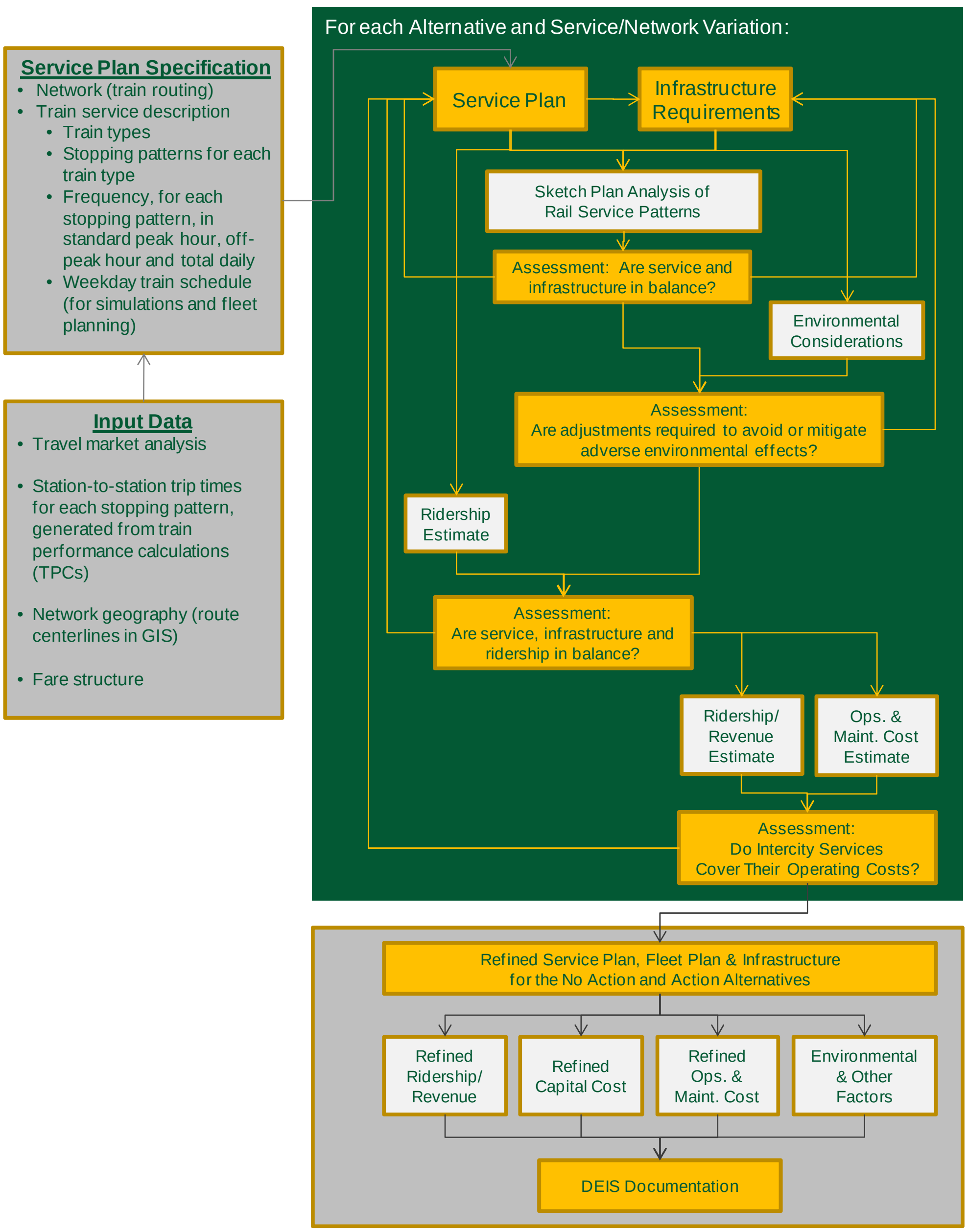


Note: Figure depicts relative volume of train movements in both directions of travel by time period. In every weekday, for Regional rail travel, there are four standard peak hours, four peak shoulder hours, eight reverse-peak hours, and 20-24 off-peak hours (counting both directions of travel).

3 Service Planning Methodology

This section summarizes the various components of a rail service plan and outlines the methodology and interdependent tools used to create Service Plans to assist in the development and the assessment of the Action Alternatives. As shown in Figure 4, the sketch plan analysis of rail service patterns provides an understanding of practical line capacity and terminal capacity at critical locations—measured in trains per hour typically for the standard peak hour.

Figure 4: Alternatives Refinement Process



Source: NEC FUTURE team, 2015

The FRA developed an early series of hypothetical and non-prescriptive Service Plans for each of the Action Alternatives. Based on existing information and projected growth rates, a mix of Intercity-Express, Metropolitan, Intercity-Corridor-Other, and Regional rail services was posited for each ridership market. Plans were developed with regular headways such that each market received two, four, or more trains per hour. These early Service Plans were used to test infrastructure requirements and market response with the detailed cost and ridership models that were being developed in parallel with service planning. After the detailed ridership forecasts were completed and validated, the Service Plans were adjusted to improve the supply-demand balance.. In Alternative 3, for example, the ridership models suggest that reducing the Intercity-Express service and adding Metropolitan trains to serve the low end of the interregional ridership market yields higher ridership and better service utilization. The final Service Plans reflect this adjustment. Across all Action Alternatives, early morning, midday, and late evening services were reduced to better tailor service around travel peaks and reduce unnecessary train miles**.** As noted, the Service Plans are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assessment of environmental impacts, and are not intended in any way to be a prediction of future conditions or prescriptive regarding how service should be operated in the future.

3.1 EARLY ANALYSIS STAGES

The FRA set up the early stages of analysis to encompass a wide range of service levels, ensuring that the objectives of the three visions for rail in the NEC are met. Scenarios were developed for the NEC network and for key segments of the corridor. Service scenarios followed planning guidelines directly related to the overarching vision for each Action Alternative, as summarized in Section 3.4. Each service scenario considered the following:

- A mix of service types, including Intercity-Express, Intercity-Corridor, Intercity off-corridor and Regional rail service
- Specific stopping patterns and rolling stock for each type of train service
- Trip times over the rail network calculated for each train type and stopping pattern, based on train performance calculations, with reasoned assumptions about station dwell times, terminal layover time and overall schedule recovery time built into the scheduled trip times
- Future Intercity and Regional rail frequency targets for each service type and stopping pattern:
  - Peak, at each station – e.g., provide slots[11] for 2, 3, or 4 trains per hour (tph)
  - Off-Peak – e.g., provide slots for 1–2 tph

[11] A slot, for purposes of rail service planning, is defined to be a scheduled opportunity for a train to run. It represents a time window within which a train can run at a specific geographic location, and it also represents a path through the railroad network over a period of time. Slots are defined to be free of train interference conflicts along the route, so any train operating within its slot can operate without delays caused by other trains. A slot can be filled with an actual train, or it can remain empty. The slot is based on specific assumptions about train speeds, equipment performance, station stops and dwell times, so the slot may be usable by only certain types of trains.

- Infrastructure assumptions, including number of main tracks, location and configuration of rail junctions, track and platform configurations at stations, and the locations of train storage yards
- Assignment of trains (by type, stopping pattern and time of day) to available tracks in each segment of the corridor.

3.2 SKETCH PLANNING

For NEC FUTURE, a sketch planning process for creating and analyzing Service Plans was used to facilitate the relatively efficient testing of multiple service scenarios, including:

- Train types, routings, service levels and stopping patterns (peak and off-peak)
- Scenarios covering the range of service levels and types being considered for the Action Alternatives
- Service pattern analysis – balancing service needs and infrastructure requirements

Using stringline (time-distance) diagrams and train schedule information, as described further in Section 3.3, the FRA introduced and aligned individual train service patterns with each other to identify potential train operating conflicts. The train service patterns, schedule times, and track assignments were adjusted interactively to eliminate operating conflicts. Adjustments to the rail infrastructure configuration were made where necessary and appropriate to address conflicts that cannot be resolved with operational and scheduling adjustments. The end result of this process was a hypothetical Service Plan and train timetable that was shown to be operationally feasible and which fit within the available capacity of the rail infrastructure.

The sketch service planning framework for NEC FUTURE was developed at two different scales. Corresponding to the breadth of the NEC, the Service Plans are intended to inform the Tier 1 Draft EIS and support public review and comment on the alternatives, as well as policy discussions and decisions by stakeholders. This broad scale defines the overall vision but does not claim to represent specific physical or operational conditions with accuracy and does not purport to impart information sufficient for final implementation decisions or funding commitments. The service and infrastructure assumptions are representative and illustrative of potential future conditions, not prescriptive, absolute or a prediction of future operating plans for the NEC railroad operators.

At a smaller scale, the Service Plans are a basis for discussions with the railroad operators and transportation agencies. These discussions are more technical in nature and examine the corridor at a more granular level, looking at infrastructure and service on specific line segments or at individual stations and interlockings. This more detailed scale provides for “proof of concept” or confirmation of the operational and physical feasibility of the proposed plans. It also furnishes the data on train movements and operating characteristics that were required for the quantitative analyses that support the Tier 1 Draft EIS, including projections of ridership and revenue, estimates of capital and operating and maintenance costs, operations simulations, and analysis of the environmental effects associated with the volume and type of train movements, such as noise, vibration, air quality and energy consumption. The Service Plans also enabled an equitable comparative evaluation of the performance of train service patterns and infrastructure and for determining the extent to which service and infrastructure were balanced in any given scenario for the Action Alternatives.

3.3 ANALYTIC TOOLKIT

3.3.1 Rail Planning Tools

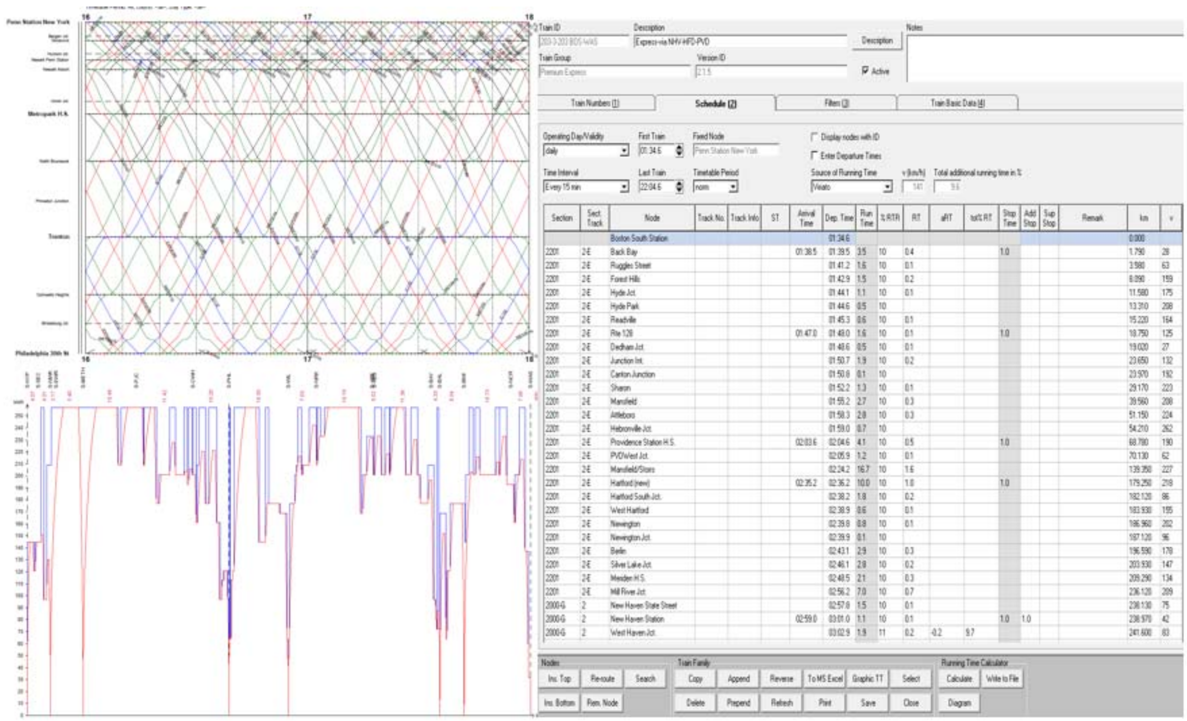
The service planning effort for NEC FUTURE used a combination of spreadsheet-based tools, a detailed simulation model using the Rail Traffic Controller[12] (RTC) software, and several planning-level models developed using the Viriato[13] software package. Viriato aids in the development of railroad Service Plans and associated outputs, including timetables, stringline charts (time-distance diagrams) and cumulative train operating data, at a sketch planning level of detail appropriate to a Tier 1 Draft EIS level of alternatives development and analysis. Viriato, a conceptual planning tool, allows for a rapid assessment of multiple alternatives, providing the rail planner with direct control of the service planning process. Unlike a dynamic simulation tool such as RTC, Viriato is a static planning tool that operates with a customized user interface accessing a database of infrastructure, train performance, and service data. The static nature of this tool allows the user to work with varying levels of specificity in infrastructure and service information, and facilitates the development and assessment of multiple scenarios.

The FRA used RTC to calibrate and validate the train performance calculations (TPC) the FRA developed with Viriato. The FRA coded the rail alignments associated with each of the Representative Routes[14] into Viriato and the RTC model for the production of TPC travel times and speed profiles.

Figure 5 provides an example of the tools available within Viriato including a stringline chart, a speed profile, and a train window. The train window contains all the critical service information to describe a “train family.” A train family is a group of trains that operate on regular headways and share a consistent set of service characteristics such as route, stopping pattern, speed between stations and dwell time at stations. The train window also contains the departure time for the first and last train in the train family and the equipment used to operate that service. The service planning process for NEC FUTURE, including specifications of trains and conflict resolution was performed primarily using the train window and the stringline chart tools in Viriato.

[12] Rail Traffic Controller is a product of Berkeley Simulation Software, Inc.
[13] Viriato is a product of SMA+Partner.
[14] The Representative Route refers to a proposed route or potential alignment for an Action Alternative, including horizontal and vertical dimensions. The Representative Route defines the physical limits or representative footprint for each Action Alternative, and is used to assess the potential effects of the Action Alternatives.

Figure 5: Sample Viriato Stringline, Speed Profile, and Train Window



3.3.2 Initial Train Performance Calculations

The first service planning step was to code single-track alignments for the Action Alternatives into the RTC model to simulate trip times for stopping patterns of selected prototypical trains. These trip times were developed using the following six trainsets that cover the reasonable spectrum of performance on the NEC:

- A high-speed train, capable of 220 mph, similar to the French TGV
- A consist similar in performance to Amtrak's Acela equipment
- A conventional, electric, Intercity locomotive with 8 coaches
- A conventional, electric, commuter locomotive with 10 coaches
- A 10-car Electric Multiple-Unit (EMU) train
- A diesel locomotive with 4 coaches

The FRA used the calibrated, validated performance characteristics of these six trainsets to create a conservative representation of train that could feasibly operate on the NEC. The alignment attributes included the location of proposed stations, the location and speed limit of curves, and the location of concepts for junction points associated with connections to other alignments.

The FRA coded train sets with similar performance characteristics into Viriato for the production of trip times using the TPC in that software platform. The trip times produced by Viriato were calibrated using the simulated trip time results produced from the RTC model, so that the onboard TPC in Viriato could be used "on the fly" as train stopping patterns were changed to resolve conflicts or to test alternative scenarios. This calibration of train performance between the two software platforms provided the confidence to use the trip times from either platform when developing Service Plans.

3.3.3 Schedule Margin

The simulated trip time results produced from RTC and Viriato represent an optimal theoretical trip time. A uniform 10 percent "schedule margin" was added to the pure simulated time for all trains in the network to account for factors that may cause train performance to deviate from ideal conditions, including uncertainty of future alignments, braking and acceleration rates that take into account passenger comfort and energy use, and interactions with other trains in the network. This is common practice among railroad operators in the development of train schedules.

While all train schedules include some schedule margin, there is not a single correct way to apply it, and it can be specific to operating conditions. Schedule margin can be added at the beginning or end of a run, included in the dwell time at major terminals, or spread evenly over the run. The 10 percent schedule margin added for all Action Alternatives was applied evenly across the run of the train to the segment times between every operational node through which the train passes, including stations and junctions (but not to station dwell times). Schedule margin as defined for this analysis is made up of three components: network interaction allowance, civil speed allowance, and alignment uncertainty allowance.

Network Interaction Allowance – This is the additional time in train schedules that accounts for the variability in actual train performance due to day-to-day variability and interactions of trains on the network. It adds a percentage of time to the best possible running times to account for minor delays caused by train interference and other factors, including those caused by conflicting train movements at junctions, yards, terminals and train turning locations. In order to preserve reasonable on-time performance, this allowance needs to increase as the density of traffic approaches the practical capacity of the line and as the complexity of the overall network increases, as measured by the number of branch lines and the number of different equipment types and train stopping patterns served. On actual railroads, this allowance is built into the train timetables and typically is increased in response to network congestion.

Civil Speed Allowance – This factor accounts for the differences between actual train performance and how train performance is simulated in the models used to generate train running times. It helps calibrate the modeled train performance to actual performance and is not an allowance that is built into actual timetables. Civil speed limits are established for a rail line based on the physical characteristics of the line, such as curvature and grade, and are normalized along a line to ensure passenger comfort and avoid unnecessary accelerations and deceleration in territories with frequent curves and changes in physical characteristics. These speed limits are lower than the maximum possible speed in some locations, and this allowance is used to adjust the simulated train performance to match typical operating conditions.

Alignment Uncertainty Allowance – Train speeds and associated trip times on new route segments in the Action Alternatives were developed based on the Representative Routes, which identified railroad alignments only at a highly conceptual level. Once detailed engineering design and environmental analysis is performed for any prospective new route, the actual alignment is likely to be different and might greater curvature and slower speeds to save cost or reduce potential impact. To ensure appropriately conservative train running times for purposes of service planning and ridership analysis, additional trip time was added to the ideal running times to account for this uncertainty with respect to future new route alignments. This alignment uncertainty allowance also is not applicable to existing train timetables.

The No Action Alternative, which is based on existing train schedules, includes only the network interaction allowance, assumed to be four percent for Acela Express and nine percent for Northeast Regional trains. All three allowances were included in the assumed 10 percent schedule margin for each of the Action Alternatives. Each alternative included a civil speed allowance of 2.5 percent. However, the composition of the remaining schedule margin varied from alternative to alternative. The network interaction allowance was 6.5 percent for Alternative 1, 5.5 percent for Alternative 2, and 3.5 percent for Alternative 3. With increasing investment in railroad capacity, redundancy and parallel movement capability, and as train movement conflicts are eliminated and as trains with differing performance characteristics are able to operate on separate tracks, the amount of extra network interaction time built into train schedules to protect against train interference conflicts is expected to decrease. On the other hand, the alignment uncertainty allowance increases as the proportion of total route-miles utilizing new route segments increases. This allowance was set at one percent for Alternative 1, which mostly follows the existing NEC, two percent for Alternative 2, and four percent for Alternative 3, where Express and Metropolitan trains operate mostly on new route segments. The differences in the latter two factors tend to cancel each other out, resulting in the uniform 10 percent schedule margin applied to all trains in the analysis.

3.3.4 Dwell Time

Dwell time is the elapsed time that a train is stopped in the station at a scheduled station stop. Dwell time comprises the entire stopped time of the train, including time required for passenger flow (passenger alighting and boarding) and time in a station before and after the passenger doors open. Dwell times may also include time to service the train at major terminals and may differ based on station configuration and passenger loads. In addition, these times are greater at a major terminal with larger passenger loads.

Dwell times at specific stations on the corridor varied based on conditions such as platform height, platform width, consist composition and passenger loads. Assumptions for dwell times were based on the size and use of stations on the corridor and represented an approximation of “typical” conditions for similar stations.

For most stations the FRA assumed a 1-minute dwell time for Intercity service. This is typical of intermediate station stops for Amtrak Northeast Regional trains, such as New Carrolton, Trenton, and Bridgeport. For the larger intermediate stations and stations where the FRA planned for transfers between services, the FRA assumed a minimum of 2-minute dwells. These stations typically have larger passenger loads that require additional time for alighting and boarding of passengers. Examples included Philadelphia and New Haven. The FRA assumed 30-second to 1-minute dwell times for Regional Service at non-terminal stations.

Dwell time assumptions at Penn Station New York for Intercity trains were assumed to be 8-12 minutes in Alternative 1, which does not require platform widening, and 8 minutes in Alternatives 2 and 3, where platforms are assumed to be widened, providing for more efficient passenger handling.

3.3.5 Practical Line Headways

The FRA developed prototypical trains using a reasonable set of potential stopping patterns within each service type and incorporating the schedule margin and dwell assumptions described above. Once the prototypical trains were specified, they were organized into a service plan. Further assumptions regarding appropriate train spacing governed how these trains were compiled into a coherent and feasible plan. The practical following headway for passenger trains for the Action Alternatives was assumed to be the following:

- 220 mph top speed: 4 minutes
- 160 mph top speed: 3 minutes
- Slower-speed territory, including station approaches with merging and diverging movements: 2 minutes.

These assumptions are consistent with a fixed block (cab, no wayside) signal system and an overlay Positive Train Control system. Shorter block lengths were assumed to provide for higher-density operation at shorter headways than the existing signal system. Moving block technology was *not* assumed for the NEC or connecting corridors in the NEC FUTURE analysis.

3.3.6 Scheduling Trains

The development of Service Plans followed a logical pattern based on priority sequencing of trains into the plan. Service type governed the order in which a train was added to the plan. Intercity-Express trains had the highest priority and thus the FRA added them to the plan first. These trains were routed on the optimal route through the network, operating on express tracks and maintaining the minimum dwell and schedule margin for the entirety of their run.

Intercity-Corridor service (both Metropolitan and Intercity-Corridor-Other trains) received the next highest priority. To the extent possible, these trains were scheduled on the express tracks into slots between the Intercity-Express trains. Where conflicts arose between the faster moving Intercity-Express trains and the slower Intercity-Corridor and Metropolitan trains, the FRA either shifted the Intercity-Corridor trains onto the local or intermediate tracks or extended their station dwell at select stations to facilitate an overtake. In some instances, the FRA added schedule margin to these trains (above the minimum 10 percent) to resolve conflicts.

At key Hub stations along the network, primarily at New Haven and Philadelphia, “scheduled meets” were planned. These meets occur when an Intercity-Express train and Intercity-Corridor train traveling in the same direction are scheduled for a simultaneous stop at a given station. These meets serve two purposes. They provide connectivity between the service types allowing for easy, cross-platform transfers between trains. They also facilitate Intercity-Express trains “overtaking” or passing the slower Intercity-Corridor trains at these stations, allowing for efficient operations of the Intercity-Express trains with minimal added time to the stopping Intercity-Corridor train.

The FRA added Regional rail trains to the schedule after the Intercity pattern was fully planned. Zone Express trains were added first, operating on the local tracks at the extremities of the network, and then shifting to the intermediate or express tracks for the express portion of their run, filling the remaining slots on these tracks into the major terminals. The local train patterns were then added and operated exclusively on the local tracks.

The development of the Service Plans at this stage focused on meeting the peak-hour service levels. Trains were added to the plan using the peak service specification. Only after the all trains in the peak hour were added and fully integrated into the plan with no remaining conflicts, did the FRA adapt the plans for the full-day service. For Regional rail trains, the service levels for the reverse-peak, off-peak and shoulder hours represent a subset of peak service. The FRA adjusted each train pattern or train family to meet the full-day service specification.

For Intercity service, the transition from peak-hour to full-day operations is not achieved by merely adjusting the service frequency or train count for non-peak periods to represent a subset of the peak. Because of their long travel distances and times, most Intercity trains do not fit comfortably into a single time slot along the entire run. A train leaving Washington, D.C., at the height of the evening peak hour, for instance, does not arrive in Boston until late evening. So, the volume of Intercity service was tailored to the business travel peak periods in Washington, D.C., New York, and Boston by originating and terminating selected trains at key intermediate stations. Specifically, this tapering of service was accomplished for both the morning and afternoon service peaks by taking every second train in the peak pattern and introducing it (at the start of the peak period) or cutting it off (toward the end of the peak period) at an intermediate station.

For Intercity-Express service, selected trains were designated to originate in New York in both directions at the start of the business peak periods, as the frequency of service ramped up to its maximum level north and south of New York in the morning and evening peaks. As the service tapered at the ends of the peak periods, selected trains were terminated at New York as well as the endpoints of the NEC. This peaking pattern approximately matched the ridership peaks that currently exist on the NEC. For example, a 6:00 a.m. southbound Intercity-Express train serving the morning business peak between New York and Washington, D.C., needs to originate in Boston before 4:00 a.m. Instead, these trains were designated to originate in New York with the first Boston trains originating after 5:00 a.m. Similar tapering at the end of the service day occurred with late evening southbound trains from Boston, and northbound trains from Washington, D.C., terminating in New York. Similar service breaks were also planned for the beginning and end of the day for Intercity-Corridor trains in New York, and for Metropolitan trains in New Haven, New York, and Philadelphia.

4 Alternatives Refinement

The FRA developed initial Service Plans for each Action Alternative, building from the successful elements of the Preliminary Alternatives that were advanced from the evaluation of the Preliminary Alternatives. As the analytic models for estimating ridership, capital costs and annual operations and maintenance costs were being developed, the specific elements of the Service Plans—service frequencies, stopping patterns, train routings and rolling stock characteristics for each service type—were tested and evaluated for their ability to achieve efficient use of rail infrastructure capacity while meeting the varying service needs of each type of rail service. Service Plans were iteratively refined in two broad steps—first to balance the service and the rail infrastructure provided in each alternative, and second to balance the service with the estimated level of ridership and the ability of Intercity services to cover their projected cost of operations and maintenance. The Service Plans are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assessment of environmental impacts, and are not intended in any way to be prescriptive regarding how service should be operated in the future. In addition, the Service Plans are not intended to be a prediction of future operating patterns of the NEC railroad operators.

The FRA developed a Service Plan for the No Action Alternative, in the same format as for the Action Alternatives, to permit direct comparison. Throughout the NEC, the FRA assumed that service levels for the No Action Alternative are identical to existing service levels, with the exception of the East Side Access project to bring LIRR trains to Grand Central Terminal.[15] Service levels in the No Action Alternative Service Plan were calibrated to existing peak hour and total daily train movements. Within these control totals, the patterns and levels of service during peak-period, peak-shoulder, reverse-peak and off-peak hours were adjusted to fit the NEC FUTURE Service Plan format.

The work effort to refine the Action Alternatives was undertaken 1) based on work that was possible prior to completion of the new ridership models and 2) with work that relied on the initial ridership model results. The service and operating plans were refined to clearly distinguish the characteristics of each of the Action Alternatives. The work effort prior to obtaining initial ridership estimates included the following:

- Analysis of the Action Alternatives
  - Refine Service Plans consistent with the distinct nature of each alternative.
  - Develop service and infrastructure assumptions.

[15] East Side Access is one of the largest transportation infrastructure projects currently underway in the United States. The project encompasses work in multiple locations in the New York City boroughs of Manhattan and Queens and includes more than 11 miles of tunneling. When completed, East Side Access will provide a faster and easier commute from Long Island and Queens to the east side of Manhattan in a new 8-track terminal and concourse below Grand Central Terminal.

  - Perform capacity analysis using sketch operations planning tools to confirm the practical capacity of various critical segments of the corridor.
  - Estimate trip times and relative order-of-magnitude capital costs.
  - Prepare service plan specifications that respond to the objectives of each alternative and fit within the limits of the practical capacity of each segment of the railroad.
  - Test alternative service patterns to determine which patterns best utilize available infrastructure capacity.
  - Identify infrastructure configurations that can support multiple ways of delivering the same level of rail service.
  - Adjust service and/or infrastructure as needed to achieve high levels of capacity utilization during peak periods and balance the supply of and demand for train operating slots on the NEC.
- Conceptual Engineering Analysis
  - Complete development of typical cross-sections and construction types by segment, junction configurations, and station configurations.
- Test enhanced service and precision operations concepts and identify best practices to be applied to the Action Alternatives.
- Develop analytic tools and models, including interregional and intraregional ridership models, capital cost model, operations and maintenance cost model and rail operations simulation model.[16]

Following the receipt of initial Intercity and Regional rail ridership results, the FRA reviewed and refined the Action Alternatives including the performance of the following analyses:

- Refined Service Plans and rail infrastructure configurations based on balancing capacity and demand in:
  - Portions of NEC with four main tracks but demand for additional track capacity
    - Northern New Jersey
    - New Haven Line
  - Portions of NEC with less than four main tracks
    - Maryland and Delaware
    - Hell Gate Line
    - Southeast Connecticut

[16] These tools were developed in parallel with the alternatives refinement process. They were not available at the start of the process and became available for use interactively with servicing planning by the end of the refinement process.

    - Massachusetts

- Validated service pattern assumptions
- Confirmed minimum Regional rail service level assumptions for Alternatives 1, 2, and 3 for visions of the NEC that maintain, grow, or transform the role of rail
- Quantified relative effects of changing frequency, trip time/reliability and fare on Intercity and intraregional ridership
- Quantified ridership performance of Metropolitan service
- Estimated the potential effect on ridership of coordinated/improved rail-rail and multimodal transfers
- Evaluated the range of North End Route Options for a second spine in Alternative 3
- Evaluated 220 mph vs. 160 mph as the top speed for Intercity-Express trains
- Evaluated the relative market and ridership benefits of alternative service patterns for Alternative 3
- Estimated the relative magnitude of connecting corridor ridership markets
- Prepared preliminary estimates of rolling stock fleet and yard facility requirements

4.1 GENERAL SERVICE CHARACTERISTICS

The FRA developed Service Plans following the method outlined in Section 3. The Service Plans and scenarios that the FRA analyzed, accounted for the full mix of Intercity and Regional rail passenger trains operating on the NEC. The FRA first developed Service Plans for the standard peak hour, as defined in the previous section. The operational feasibility of the Service Plans—their ability to fit within the infrastructure provided and operate free of conflicts between train movements of different types—was established for the standard peak hour, which included the maximum number of Intercity and Regional rail trains operating on all portions of the NEC. Service during all other hours of the day was defined as a subset of the standard peak hour and, therefore, was considered to be operationally feasible.

Intercity services were planned so that trains of the same type (and with the same stopping patterns) operate at intervals of exactly 30 minutes, or in some cases 15 minutes. Similarly, Regional rail trains, whether they are all-stop locals, zone-expresses, limited-stop services or branch line trains, were scheduled at regular intervals. For service zones and branch lines with relatively heavy demand or relatively close to the regional central cities, the service objective for 2040 was to operate trains at regular 15-minute intervals at each station. The overall headway at stations served by more than one stopping pattern (e.g., both a local train and a zone-express train) in many cases was less than 15 minutes. Where projected demand was lighter, typically on branch lines or in outer zones on the NEC farthest from the urban centers (such as the MARC outer zone between Perryville and Newark, DE, or the Gladstone Branch in New Jersey or the Waterbury Branch in Connecticut), peak service at regular 30-minute headways was provided.

4.2 INTERCITY SERVICE LEVELS AND PATTERNS

4.2.1 Intercity-Express Service

At the conclusion of the evaluation of the Preliminary Alternatives, the initial service specifications for the three Action Alternatives called for increases in Intercity-Express service from the No Action Alternative and existing levels of service (which are equivalent, with 1 tph south of New York and approximately 1 tph every two hours north of New York) to 2 tph in Alternative 1, 4 tph in Alternative 2, and 8 tph in Alternative 3 during the standard peak hour. This level of service was selected based on the ridership estimates that were prepared for the Preliminary Alternatives, where the market for Intercity-Express service, comprising primarily business travelers, was analyzed separately from other Intercity travel markets.

The new interregional travel demand model considered all interregional travel together and assigned trips by mode and among the service types within the rail mode based on relative cost, frequency and trip time. As ridership numbers became available for the Action Alternatives, it became clear that the increase in demand for Intercity-Express service between Alternatives 2 and 3, and to a lesser extent between Alternatives 1 and 2, was less than originally envisioned. This was due to multiple factors, including the greater sensitivity of the new Intercity model to fares and relatively lower sensitivity to frequency of service and trip time in the selection of mode and service type as compared with previous models. The resulting competitive strength of Metropolitan service, and the estimated ability of the air mode to continue to offer service in the longer-distance NEC travel markets at prices superior to Intercity-Express rail, tended to dampen projected Intercity-Express ridership. As a result of these early findings, the volume of Intercity-Express service in the standard peak hour was reduced from 8 trains to 6 trains in Alternative 3.

With the overall level of Intercity-Express service established for the Action Alternatives, the remainder of the analysis focused on analyzing alternative stopping patterns, which focused on the level of service provided at each station served by Intercity-Express trains, and on the trip times between stations on the NEC. Trip time is relatively more important in the interregional express market, which is largely made up of business travel, than in other Intercity travel markets. Trip time savings can be achieved through a combination of the following:

- Service changes (i.e., reducing the number of intermediate stops and the time spent dwelling at stations)
- Infrastructure improvements (i.e., modifying curves on the existing alignment or constructing new route segments that are more direct and permit higher speeds)
- New rolling stock (capable of higher maximum speeds and with improved acceleration and braking performance)

The options that were considered with respect to infrastructure configuration and rolling stock are addressed in subsequent sections of this technical memorandum. Regarding service, tradeoffs had to be made between the number of markets and stations served by Intercity-Express trains and the trip times offered between the major stations with the largest ridership markets. These tradeoffs, and the resulting decisions made about the types of service that represent each of the Action Alternatives, are described below in the remainder of this section.

4.2.1.1 Intercity-Express Stopping Patterns

Several Service Plan scenarios were analyzed to test the merits of introducing an Intercity-Express service that stop only at the stations serving the major markets: Washington Union Station, Philadelphia, Penn Station New York, Boston Back Bay Station, and Boston South Station. These limited-stop Intercity-Express trains supplement rather than replace the regular Intercity-Express service that continues to serve key intermediate markets such as Baltimore, MD, Wilmington, DE, Stamford, CT and Providence, RI.

Alternative 2 provided a useful framework for analyzing the operational, infrastructure and ridership effects of various Intercity-Express stopping patterns. Four Intercity-Express trains operate in each direction in the standard peak hour in Alternative 2. Many different combinations of stopping patterns for these four Intercity-Express trains are possible, but two scenarios offered a good illustration of the tradeoffs and issues. The analysis started with the most difficult scenario to develop in terms of fitting peak trains onto the railroad without schedule conflicts: the scenario with two different Intercity-Express service patterns, plus Metropolitan service, on top of the Regional Rail rush hour service patterns. Then, a second scenario with four similar Intercity-Express patterns on regular 15-minute headways was developed, with a simpler set of express patterns and similar Metropolitan and Intercity-Corridor-Other patterns.

<u>**Intercity-Express Scenario with Two Different Express Patterns**</u>

This scenario provided a limited-stop Intercity-Express and a regular Intercity-Express service, each operating with 2 tph spaced 30 minutes apart in the standard peak hour. This scenario prioritized the Intercity-Express and Metropolitan trains by developing the schedules for these trains first and creating the best spacing and interaction between these two services. Then in decreasing priority, the Intercity-Corridor and Regional rail trains were scheduled into patterns around these services. This priority order was limited to the pattern development and not the level of service. Both scenarios provided similar levels of service corridor-wide for all types of Intercity and Regional rail trains.

This scenario offered Intercity-Express service among the four major markets with all 4 tph, with two of these trains being the limited-stop Intercity-Express stopping only at Boston, New York, Philadelphia, and Washington, D.C. The remaining intermediate stations were served with the two regular Intercity-Express trains with an “Acela-like” stopping pattern. The total travel time difference between the Intercity-Express and limited-stop Intercity-Express[17] between Boston and Washington, D.C., was 30 minutes – approximately 15 minutes between Boston and New York and 15 minutes between New York and Washington, D.C.

The benefit of the limited-stop Intercity-Express service was that it provided fast, regular service between the four primary markets, which dominate premium express ridership. The tradeoff

[17] A rail service pattern where trains make stops only in primary markets.

introducing this type of service was that it created irregularity in the Service Plan, adding to the complexity of train movements throughout the network and compromising capacity.

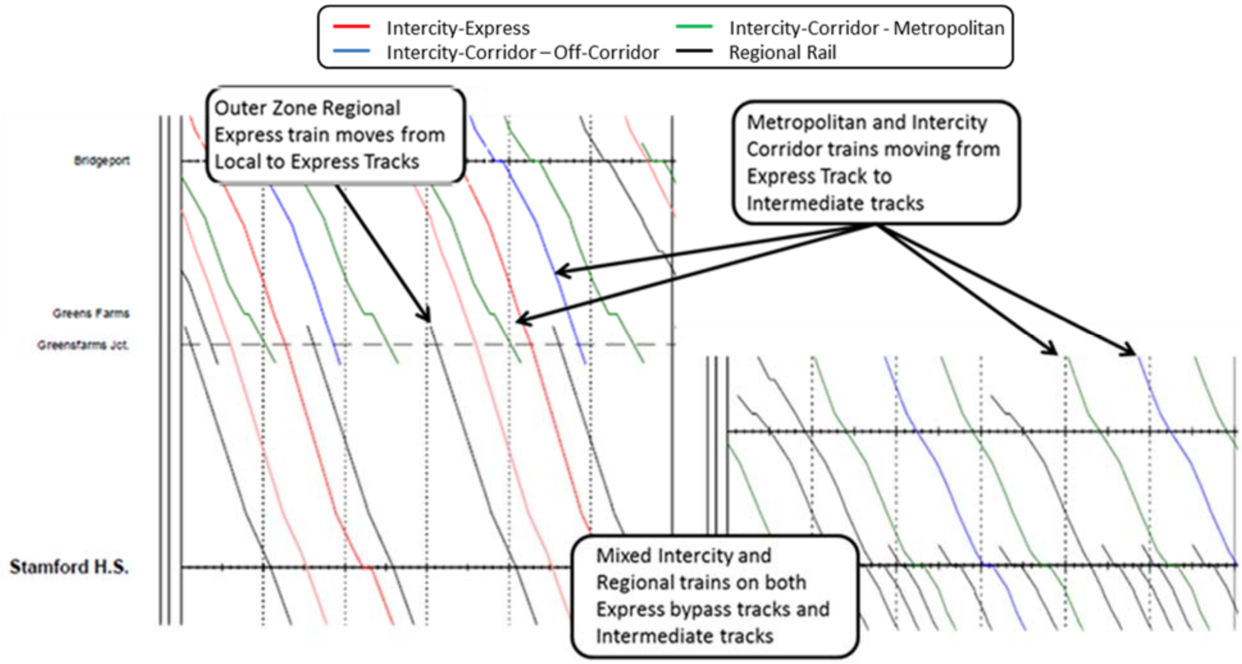
Metropolitan service was offered on the corridor at regular 15-minute headways in the standard peak hour, to provide frequent regular service to intercity markets as well as serve the major regional markets in the large metropolitan regions. In addition, two slots per hour for Intercity-Corridor-Other trains between Washington, D.C., and Boston were provided on 30-minute headways. A good illustration of how this scenario works is provided by the territory in Connecticut on the New Haven Line between Stamford and Bridgeport – looking at Alternative 2 service levels in the standard peak hour and including the construction of two new express tracks parallel to the NEC between Stamford and Westport, CT. In Alternative 2, the express bypass between New Rochelle and the Saugatuck River in Westport, CT results in six tracks in this territory. The existing inside express tracks are referred to as the intermediate tracks as the new bypass becomes the express tracks. North of the Saugatuck River, there are four tracks, with only express and local.

Figure 6 shows the graphic timetables (stringline charts) for the express and intermediate tracks between Bridgeport and Stamford, CT, for this scenario with two different Intercity-Express patterns. North of Westport, CT, only express tracks are shown because no intermediate tracks exist; south of Greens Farms, express tracks are shown on the left, intermediate tracks on the right. Each line represents a single train and is color coded by train type:

- Red = Intercity-Express (limited-Stop Intercity-Express in pink)
- Blue = Intercity-Corridor-Other (Intercity-Off-Corridor)
- Green = Metropolitan
- Black = Regional rail

A one-hour time period is shown in Figure 6, with Intercity and Regional rail service running in mixed service on both the express and intermediate tracks. At Greens Farms Junction, the Intercity-Corridor and Metropolitan trains move from the express tracks to the intermediate tracks to avoid conflicts with the express trains. At the same junction, Regional rail trains (outer zone New Haven express trains) move from the local tracks (not shown) to the express tracks.

Figure 6: Graphic Timetable of Intercity-Express and Intermediate Track between Bridgeport and Stamford – Two-Pattern Scenario



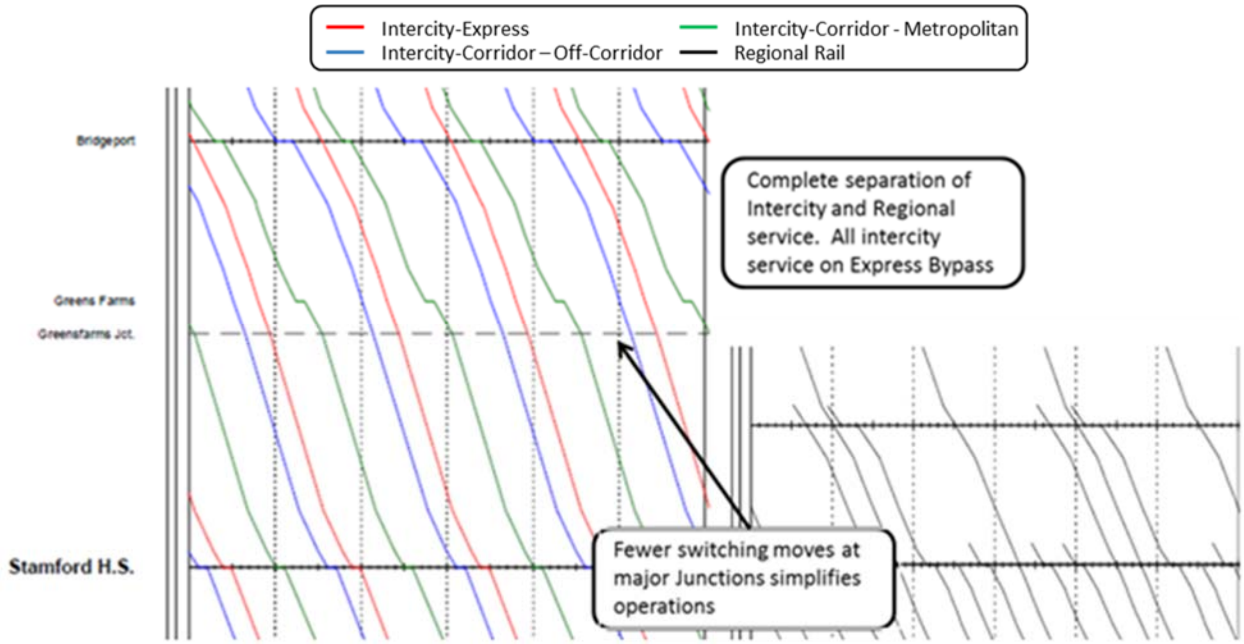
Source: NEC FUTURE team, 2015

This two-pattern Intercity-Express scenario provided an increase in service on the New Haven Line to Grand Central from 21 to 24 tph and introduced Regional rail service to Penn Station New York with 8 tph during the peak period. A mix of outer-zone Intercity-Express trains and inner-zone local trains were scheduled to both terminals, with a similar zone structure as operates today on the New Haven Line.

Express Scenario with Repeating 15-Minute Express Pattern

This scenario provided the same number of Intercity trains as the previous scenario, but included a more regular service plan to maximize slot capacity. To accomplish this, the limited-stop Intercity-Express trains were removed from the Service Plan and replaced with two regular Intercity-Express trains, resulting in a single express pattern that operated at 15-minute headways between Boston and Washington, D.C., during the standard peak hour. Figure 7 shows the graphic timetables (stringline charts) for the express and intermediate tracks in Connecticut for this scenario.

Figure 7: Graphic Timetable of Express and Intermediate Track between Bridgeport and Stamford – Single Pattern Scenario



Source: NEC FUTURE team, 2015

Scenario Comparison

While the two scenarios achieved a similar level of overall service, there were some key differences in terms of complexity of the operations and available capacity in particular parts of the corridor. On the New Haven Line, both scenarios achieved the same level of capacity, but the two-pattern scenario with limited-stop Intercity-Express service resulted in more complex operations with a greater number of instances of trains having to change tracks to enable or avoid being overtaken by other trains. The train movements through Greens Farms Junction, where the railroad expands from four to six tracks, are streamlined in the single-pattern scenario. All Intercity service (Intercity-Express, Intercity-Corridor-Other, and Metropolitan) remain on the express tracks all the way through Stamford to New Rochelle. The Regional rail service is segregated and is left to occupy the intermediate and local tracks. As a result, the only train movement at this junction is a sorting of the Regional rail trains from local tracks north of the junction to local and intermediate tracks south on this junction.

Figure 5 shows that with all three Intercity services operating at regular repeating 15-minute intervals in the single-pattern scenario, there is capacity to accommodate all Intercity trains on the express tracks, avoiding any track switching in this territory and freeing up both the local tracks and intermediate tracks for Regional rail service. This scenario also provides four slots per hour for Intercity-Corridor-Other service instead of the two slots shown in the previous scenario.

In the two-pattern scenario, the difference in run times between the two express patterns did not allow for these four Intercity-Express trains to run in 15-minute intervals everywhere on the corridor. The territory between New York and Philadelphia was prioritized for even headway spacing between these trains to maximize the capacity and plan the Regional rail service in this territory. As a result, the Intercity-Express trains were more closely spaced in the Wilmington-Washington, D.C., territory and the Boston-Stamford territory. Because of this, the New Jersey to New York Regional rail service is essentially the same in both scenarios, and because the Boston and Philadelphia Regional rail service operating on the local tracks was more fully segregated from the express services, these Regional rail services were also essentially the same between the two scenarios. Where these patterns impacted the Regional rail Service was on the New Haven Line and in the Washington, D.C., region.

Table 2 compares the number of standard peak-hour train slots provided at the north-of-Washington screenline under both Intercity-Express service scenarios. It shows the differences in available slots for both Intercity-Corridor-Other and Regional rail service on the NEC at Washington, D.C.

Table 2: Comparison of Intercity-Express Service Scenarios – Alternative 2 – Train Slots in the Standard Peak Hour, Peak Direction at Washington, D.C. Screenline

TRAIN MOVEMENTS IN STANDARD PEAK HOUR, PEAK DIRECTION

	North of Washington, D.C.	
	W/ Limited EXP Stop	15-MIN EXP Pattern
Intercity-Express		
Limited-Stop Express	2	-
Express	2	4
Intercity-Corridor – Metropolitan	4	4
Intercity-Corridor – Other	2	4
Regional Rail	8	12
Total	**18**	**24**

Source: NEC FUTURE team, 2015

In the single-pattern scenario, Intercity-Corridor-Other service is provided with four slots, which is useful for enabling late trains reaching the NEC from the Virginia or Vermont connecting corridors to access an available slot. In addition, the single-pattern scenario allowed for four additional Regional rail train slots in the peak hour from the NEC to Washington, D.C. (12 as opposed to 8). These slots can be used by any type of train, but the specific stopping patterns on which these slots are based are most appropriate for Regional rail. The resulting level of service, with all slots utilized, was more than adequate to meet the capacity necessary to serve the market in this region as indicated by the 2040 demographic forecasts, but the level of service also provided the Regional rail operator with additional operational recovery ability and flexibility for to fill a wider array of slots with trains.

The single-pattern scenario offers two more slots for Intercity trains than the two-pattern scenario, and four more slots for Regional rail service. This is due to the more regular patterns that exist in the single-pattern scenario at Washington, D.C., the southern end of the NEC.

Table 3 compares the two Intercity-Express service scenarios for a set of criteria. Both scenarios are operationally feasible On the basis of most of the criteria, the single-pattern scenario performs better. The principal benefit of the two-pattern scenario is improved trip times on the limited-stop Intercity-Express trains between the major cities on the NEC. Marginally faster trip times increased ridership in the major markets, but the reduction in service frequency at the intermediate Intercity-Express stations had a dampening effect on ridership in the intermediate markets. Absent a strong ridership response to faster express trip times in the premium interregional market, FRA selected the single-pattern scenario with its benefits as the basis for the representative Alternative 2 Service Plan.

Table 3: Comparison of Intercity-Express Service Scenarios – Alternative 2

Criteria	Two Pattern Scenario (Intercity-Express at 2 tph limited-stop Intercity-Express at 2 tph)	Single Pattern Scenario Intercity-Express at 4 tph
Service frequency in standard peak hour	4 tph	4 tph
Service frequency in off-peak hours	2 tph (no limited-stop)	2 tph
Service frequency at intermediate stations (e.g., BWI Airport, Baltimore, Stamford, Providence)	2 tph	4 tph
Trip time between major stations	Limited-stop Intercity-Express offers fastest trip times	All trains have the same trip times
Available capacity for other services on express tracks	Lower capacity – Variable slots at 30-min intervals	Higher capacity – Regular 15-min slots
Operational feasibility – meets service objectives for Alternative 2	Yes	Yes
Operational simplicity – relative number of times non-express trains need to change tracks	More complex – Lower reliability	Simpler – Higher reliability
Ability to support alternative train stops at lower volume intermediate stations (e.g., Metropark and Trenton)	No	Yes
Impact on intermediate overtakes	High	Low
Ridership potential	TBD Better for major markets	TBD Better for intermediate markets
Required infrastructure investment	Potential additional capacity needed to accommodate complex service patterns	Efficient use of railroad capacity

Source: NEC FUTURE team, 2015

Note: Cells with green shading indicate better performance, and cells with red shading indicate worse performance in a relative comparison. No shading indicates lack of a clear preference between the scenarios.

Train Routing

In Alternatives 1 and 2, the Intercity-Express service always follows the fastest NEC route between Washington, D.C., and Boston, to achieve the best possible trip times with the infrastructure available in each alternative. In Alternative 3, Intercity-Express service follows multiple routes. With the increased capacity and routing choices in Alternative 3, many possible combinations of stopping patterns and routes for Intercity-Express were tested, with the intent of finding a representative mix of Intercity-Express service patterns that serves multiple markets and achieve the highest ridership potential. North of New York, Intercity-Express service at a minimum level of 2 tph was provided on the existing NEC between New York and New Haven, ensuring improved Intercity-Express service at Stamford and New Haven; the highest ridership was achieved in Alternative 3 by having all remaining Intercity-Express services follow the fastest route between New York and Boston along the new second spine route. South of New York, in scenarios that included peak Intercity-Express service at 8 tph, the analysis indicated opportunities for splitting the service between existing and new downtown Baltimore and Philadelphia stations to potentially improve access to premium rail service in these cities by offering it at multiple stations. However, at 6 tph, which was the level of traffic supported by the ridership estimates, all trains were routed on the fastest route, through the new downtown stations, to offer the best potential combination of service frequency and fast trip times.

Maximum Speeds

In Alternatives 1 and 2, the top speed for Intercity trains is 160 mph. In Alternative 3, the FRA developed and tested service scenarios with two different maximum speeds for Intercity-Express and Metropolitan trains: 160 mph and 220 mph. Trip times for Alternatives 1 and 2, and for the 160 mph variation of Alternative 3, were estimated based on non-tilting equipment. The impact of reducing the top speed on trip times can be mitigated by utilizing rolling stock with tilting capability, which allows trains to operate around speed-limited curves at higher speeds than is possible with non-tilting equipment.[18]

According to the model, time savings for Intercity-Express services associated with the higher top speed were relatively modest (single-digit minutes between major markets). Limiting top speed to 160 mph reduces the capital cost of new route segments by reducing the amount of tunneling required. The preliminary ridership analysis showed a relatively limited response in the premium and regular intercity markets to improved trip times resulting from increasing the top speed of Intercity-Express and Metropolitan trains from 160 mph to 220 mph. The limited time savings, coupled with modeling assumptions that gave a relatively low benefit to rail time savings relative to trips by other modes, resulted in modest incremental ridership associated with the higher top speed.

However, the FRA determined that the initial results of the ridership and cost analysis were not sufficiently conclusive given the relatively coarse nature of the analysis, which was not able to take into account all of the factors involved in predicting future travel times and costs for all modes of

[18] The decision on the specific type of rolling stock to be used for Intercity-Express service will be made as part of a Tier 2 process subsequent to NEC FUTURE.

Intercity transportation. The FRA decided that the cost-effectiveness of limiting the top speed of Intercity-Express services to 160 mph was not sufficiently proven, and therefore decided to carry both operating speeds forward into the Tier 1 Draft EIS with variations by alternative. The Action Alternatives that maintain or grow the role of rail in the NEC (Alternatives 1 and 2) have the top speed of high-speed passenger trains on the NEC capped at 160 mph. A 220 mph top speed was retained for the second spine routes in Alternative 3, enabling consideration in the Tier 1 Draft EIS of the transformative potential of state-of-the-art high-speed rail to attract ridership by reducing trip times by rail to their practical minimums given current technology and the physical constraints of the corridor.

Full-Day Service Plans

Existing Acela Express service on the NEC is provided at the same level throughout the day. This even or flat level of service is carried forward in the No Action Alternative. With the increases in service included in the Action Alternatives, the opportunity exists to match the supply of service to the variations in demand through the course of the day. Full service (i.e., the level of service specified for the standard peak hour) is provided during weekday morning and afternoon hours when business travel demand is greatest. Service tapers on the shoulders of the peak (i.e., during the hours immediately preceding and following the peak hours). As Intercity ridership results became available from the new Intercity model, the levels of peak service and full-day service and the available train seating capacity provided were compared with ridership, and an exercise was undertaken to balance service with projected 2040 ridership.

Table 4 compares the volume of daily train movements for Intercity-Express service in the No Action and Action Alternatives, for the standard peak hour and for an average weekday. The increases in the magnitude of Intercity-Express service are substantial in the Action Alternatives, compared to the No Action Alternative. For traffic south of New York, the frequency of Intercity-Express service in Alternative 1 is 50 percent higher than in the No Action Alternative, increases by a factor of 2.5 in Alternative 2, and increases almost five-fold in Alternative 3. North of New York, where there is a lower base of existing service, the growth is even more pronounced, with the volume of daily Intercity-Express trains approximately doubling in Alternative 1, quadrupling in Alternative 2, and growing by a factor of 8 in Alternative 3, compared with the No Action Alternative.

Table 4: Intercity-Express Service Specifications

Alternative	Standard Peak Hour Trains/Hour		Average Weekday One Way Trips	
	South of NY	North of NY	South of NY	North of NY
Existing	1	<1	32	18
No Action Alternative	1	<1	32	18
Alternative 1	2	2	48	38
Alternative 2	4	4	82	82
Alternative 3	6	6	146	150

4.2.2 Intercity-Corridor and Intercity-Long Distance Service

For purposes of analysis in NEC FUTURE, all Intercity passenger rail service that is not classified as Intercity-Express falls into the general category of Intercity-Corridor service. Each of the three Action Alternatives includes two different sets of service patterns on the NEC for Intercity-Corridor trains:

- Metropolitan service operates solely within the electrified territory of the NEC (i.e., north of Washington, D.C., south of Boston, and on the Keystone Corridor between Philadelphia and Harrisburg)
- Intercity-Corridor-Other service operates both on and off the NEC, including off-corridor trains that serve connecting corridors as well as Long-Distance trains to and from Florida, New Orleans, Chicago and Canada

The former set of trains is "captive" to the NEC and can take advantage of improved infrastructure and high-performance rolling stock to greatly improve the level and quality of service offered to non-Intercity-Express markets within the corridor. The latter set of trains needs to operate in the Class 1 freight rail environment as well as on the NEC and utilizes traditional trainsets of locomotive-hauled coaches. Different schedule slots were created for these two types of trains, because of their different performance characteristics. However, these two service types serve essentially the same markets within the NEC.

Based on the results of the analysis of the Preliminary Alternatives, where all off-corridor markets generated significantly higher estimated ridership when provided with direct one-seat ride service to New York, it was decided to continue to expand the ability to offer direct service from connecting corridors to New York via the NEC to the extent feasible. As a result, most Keystone Corridor and Hartford Line Intercity trains continue onto the NEC as Intercity-Corridor trains. Since the Keystone Corridor is electrified, this service is operated as a Metropolitan service in all three Action Alternatives. Intercity service between New Haven, CT and Springfield, MA is also operated as Metropolitan service in Alternatives 2 and 3, since the route is electrified. Alternative 1 does not assume electrification of the existing Hartford Line, and, therefore, Intercity-Corridor-Other trains with dual mode locomotives are assumed to provide the intercity service in this corridor.[19]

Each of the Action Alternatives provides slots on the NEC for trains coming from off-corridor. Alternative 1 provides two slots in each direction per hour for these trains. Alternative 2 provides four slots per hour in each direction. Not all of these slots are occupied by trains in the Service Plan. The unused or "phantom" slots are available for the use of Intercity-Corridor-Other trains that may arrive at their entry point to the NEC later than scheduled. Alternative 3 provides for up to four trains per hour in each direction, with the ability to accommodate late trains in additional phantom slots.

[19] Electrification of the Hartford Line between New Haven and Springfield is included in the long-range plan for the New Haven-Hartford-Springfield corridor but is not currently funded or part of the near-term implementation plan.

Trains from Virginia and North Carolina[20] are assumed to operate through Washington, D.C., onto the NEC and utilize these Intercity-Corridor-Other train slots at up to 2 tph. At the other end of the NEC, trains from the Knowledge Corridor, from Montreal via Vermont, and from the Inland Route from Boston via Worcester, all operate via the Hartford Line from Springfield to New Haven and join the NEC at New Haven. As on the south end, these trains utilize slots at up to 2 tph.

These trains continue northward and provide off-NEC connections to the north and east of Springfield, including the Knowledge Corridor and Montreal service via Vermont, and the Inland Route to Boston via Worcester. The slots in the Service Plan run continuously between Virginia and the northern connecting corridors. Actual train schedules may have Montreal trains and Virginia trains that do not occupy these slots from end to end. Empire Service operates to and from Penn Station New York in each of the Action Alternatives, with New York being by far the largest ridership market for Empire Service. All Action Alternatives provide well-coordinated transfer connections to NEC trains in both directions.

Ridership-service balancing was undertaken once ridership results from the new interregional travel demand model became available, similar to the balancing performed for Intercity-Express service. As with Express service, the off-peak service was tapered to a greater extent than originally envisioned, resulting in fewer daily Intercity-Corridor-Other and Metropolitan trains than were in the original service specification.

All three Action Alternatives were developed and analyzed with the same level of service on the connecting corridors – combining to generate Intercity-Corridor-Other service on the NEC Spine at up to two trains per hour in each direction. Initial ridership analysis indicated that this level of service was consistent with the estimated magnitude of demand for rail travel between the connecting corridors and the NEC, which in most cases is most heavily concentrated on the New York region as the primary destination for trips coming from off-corridor markets. Higher than anticipated growth in demand for connecting corridor service is accommodated by increasing the frequency of Intercity-Corridor-Other service. In Alternatives 1 and 2, this additional service comes at the expense of either Metropolitan or Regional rail service, because capacity on all of the NEC main line tracks feeding New York is heavily utilized in these alternatives. With the full second spine in Alternative 3, there is sufficient main line capacity to support an increase in the number of off-corridor trains coming onto the NEC. Therefore, the potential is greatest in Alternative 3 for accommodating either an increase in the volume of service from the existing connecting corridors or the introduction of service to potential new connecting corridors. Conceptual Service Plans for Alternative 3 were identified that provided for increased numbers of Intercity-Corridor-Other trains and potential service to new connecting corridors, but these plans were not analyzed in detail because they entail making assumptions about infrastructure investment and rights of way beyond the limits of the NEC as defined for purposes of this analysis.

Long-distance service was assumed to remain the same in the future as it is today. These trains operate on the NEC generally outside of the business travel peaks and utilize slots allocated to

[20] These trains including Long-Distance trains, Virginia-sponsored Intercity-Corridor trains, and Southeast High Speed Rail corridor trains from Charlotte, NC, and Norfolk, VA.

Intercity-Corridor-Other service. The train equipment used for Long-Distance service, including both locomotives and rail cars, was assumed to be upgraded as needed to be able to perform equivalently to Intercity-Corridor trains in terms of top speed (125 mph on the NEC) and acceleration and braking performance. Extra unused or "phantom" slots were provided in the Service Plans for Alternatives 2 and 3 as a way to mitigate late train arrivals from off-corridor, allowing late Intercity-Corridor-Other or Long-Distance trains to fall back into an available phantom slot for the remainder of its trip on the NEC.

4.2.3 Metropolitan Service

The concept of Metropolitan Service as a new NEC rail service bridging a gap in current service between Intercity and Regional rail, serving both interregional and regional markets, was tested extensively in the development of Service Plans for the Action Alternatives. Metropolitan service emerged from the analysis of Preliminary Alternatives as a service type with strong ridership potential. Multiple service patterns and scenarios were developed and analyzed to better understand how this service operates, and how it can be scheduled on the railroad along with other service types. The best fit with other services was achieved with Metropolitan service utilizing trainsets with the same performance characteristics as the Intercity-Express trainsets, since this allowed these trains to operate at relatively close headways either directly ahead of or behind Intercity-Express trains.

Among the scenarios analyzed were various service frequencies and combinations of stations and stopping patterns. Service frequencies in the standard peak hour of 2, 4, 6, and 8 tph were tested. Ridership as measured in the interregional model increased significantly up to the level of 4 tph on a given route but exhibited diminishing returns as frequency increased above that level. The number of station stops for the Metropolitan service ended up as a combination of three factors: ridership demand, the geography of the NEC network, and the average speed of the trains relative to other train types in the Service Plan. Metropolitan service performed well in terms of ridership demand with stations positioned within the gaps in-between existing Intercity stations and at locations with local employment or activity centers and good highway access. The number and location of station stops also was a factor of how well trains of different types fit together on the same tracks, particularly with respect to Metropolitan and Intercity-Corridor-Other service. This tends to limit the number of stops on Intercity-Corridor-Other trains to the existing Intercity stations with frequent Amtrak service, and provides opportunities to add a reasonable number of Metropolitan stops at logical locations where the average speed of Metropolitan service is matched with that of Intercity-Corridor-Other service, or to facilitate the overtaking of Metropolitan trains by Intercity-Express trains at convenient locations such as Philadelphia 30th Street, Trenton, NJ, or Bridgeport, CT.

Service plan scenarios were developed for Alternatives 1 and 2 both with and without Metropolitan service. In scenarios without Metropolitan service, the non-premium intercity market is served by regular Intercity-Corridor trains with characteristics and stopping patterns similar to current Amtrak Northeast Regional service. In selected other scenarios, Metropolitan service was introduced, catering to both the Regional rail and Intercity markets, and the assumption was made in these cases that the future service targets are met in the major commute markets by substituting four Metropolitan trains for two Regional rail trains in the peak hour, enabling a commensurate reduction in the number of peak hour Regional rail trains, as well as a reduction in allowances for Intercity-Corridor train slots in the standard peak hour.

The initial estimates of ridership with Metropolitan service as a brand distinct from Intercity-Express and Intercity-Corridor-Other service yielded model results that generated substantial swings in ridership based on relatively small changes in frequency, speed and stopping patterns. The analysis results became more stable when Metropolitan and Intercity-Corridor-Other services were considered together as a single service type in the ridership model, so subsequent ridership analyses were based on having two types of Intercity service. Similarly, Metropolitan service was tested as an Intercity-only service and as a service that carries passengers in both the interregional and regional markets. The latter scenarios allow Metropolitan service to achieve higher levels of demand, but remain at levels that were estimated to be within the capacity of trainsets. To a large degree, the extent to which capacity on these trains is allocated among interregional and regional travelers is a function of rail fares, which can be adjusted as needed to regulate demand and distribute passengers between the two train types in a way that balances demand with available seating capacity.

The analysis of these various service scenarios, with initial results from the ridership models, confirmed the effectiveness of Metropolitan service and its potential ability to supplement or replace traditional Intercity-Corridor rail service for trips within the NEC. Initial ridership and service planning analyses also confirmed the success and basic operational feasibility of Metropolitan as a type of service that participates in both travel markets and productively fills the current service gaps that exist at the boundaries between these markets. Consequently, Metropolitan service is featured in all three Action Alternatives. It shares slots with Intercity-Corridor-Other trains in Alternative 1, achieves 15-minute peak headways in Alternative 2 on the NEC, and is deployed on both the existing and new spine routes in Alternative 3.

Metropolitan service, as presented in the Action Alternatives, is illustrative and representative. There are several variables that can be adjusted in the definition of the service, including the specific stations served, the frequency of peak and off-peak service, reservations policy, rolling stock configuration, extent of onboard food service, and fare policy. More information on the characteristics of Metropolitan service and the reasons for its inclusion in the Action Alternatives is provided in the discussion of enhanced service concepts in Section 5.2.

4.3 REGIONAL RAIL SERVICE LEVELS AND PATTERNS

The general guidance that the FRA used to develop NEC FUTURE Regional rail Service Plans related to the visions for the role of rail in each of the three Action Alternatives. For **Alternative 1**, which *maintains* the current role of rail, the FRA increased the level and capacity of Regional rail service in response to projected growth in travel resulting from increasing population and employment, although the FRA did not fundamentally change current Regional rail service patterns. Where projected growth can be accommodated by adding cars to existing peak trains, the FRA avoided or limited increases in service frequencies. Conversely, in areas where existing trains are crowded, where average train lengths cannot be easily increased, and where future growth is projected to be strong, the FRA provided additional train service frequencies to increase peak seating capacity commensurate with projected demand growth, including the introduction of Metropolitan trains serving hub stations. The FRA also identified the infrastructure capacity improvements that are required to support the Service Plan.[21] A focus of the interactive analysis of service options for Alternative 1 was the testing of different mixes of service types, levels of service, and service patterns on segments of railroad and at locations that have constrained capacity and where considerable investment is required to increase capacity.

For **Alternative 2**, which *grows* the role of rail in urban area travel relative to highway and other transit modes, a broader array of improvements were identified, including increasing the frequency of service, extending the duration of the peak periods and operating windows for off-peak service, and reducing trip times through the introduction or expansion of zone-express service. A set of general service standards at Regional rail stations was used to guide the development of future service targets for the *Grow* vision:

- Peak-hour service on lines with relatively heavy ridership demand at 4 tph
- Peak-hour service on lines with relatively less ridership demand, including lighter density branch lines and the portions of the NEC at the extremities of regional commuting territory, at 2 tph, tapering to 1 tph during peak shoulder hours
- Reverse-peak service on all NEC services and branch lines at 2 tph
- Off-peak service at 2 tph on heavily utilized lines and 1 tph on light density lines, coupled with weekend service where practical and appropriate

Where Regional rail service currently is provided only as all-stop local service, service zones comprising groups of adjacent stations were created to enable the introduction of zone-express service at peak periods. Where zone-express service already exists, consideration was given to increasing the number of zones, in order to improve trip times for stations in the outer zones.

Metropolitan service also is introduced along the NEC in Alternative 2 at 4 tph, providing an additional option for limited-stop service at existing and potential Hub stations. Service Plans were tested and ridership estimates obtained for scenarios that both included and excluded Metropolitan service in the regional travel markets. Metropolitan service helps to distribute passenger loads in certain Regional rail markets.

In **Alternative 3**, which seeks to *transform* the role of rail within the NEC Study Area, determining those characteristics of a future Regional Rail service that might be transformative is challenging, since Regional rail service patterns for Alternative 3 bear a strong resemblance to those developed for Alternative 2. Providing service that is frequent, highly reliable and available at all times of day is a prerequisite. Additional benefits offered in Alternative 3 are extensions of Regional rail service territories, expansion of non-journey-to-work trip opportunities, and faster trip times for longer commutes where Regional rail trains can share the new high-speed tracks with Intercity trains.

[21] This memorandum focuses on passenger rail Service Plans. Associated infrastructure requirements are summarized in the *Tier 1 Alternatives Report*.

Some concepts that were tested in Alternative 3 that push the envelope of what Regional rail can do to influence trip-making include:

- Operation of transit-style service on the portions of the railroad network through city centers (i.e., close headways, all-stop local service, and fares comparable to local transit fares), to expand the reach and capacity of urban transit networks and relieve crowding on congested parallel transit lines
- Through-running service at major regional stations/terminals to better connect regional sub-centers
- Operating new Regional rail express services from outer suburban areas to regional centers, using the inner portions of new high-speed rail routes to dramatically shorten commute times for longer-distance work trips
- Significant expansion of off-peak and weekend service to open up rail travel and capture a wider array of trip purposes

Specific issues that were considered and addressed in each of the Regional rail service territories of the NEC as Service Plans were developed and refined are summarized below.

4.3.1 Greater Washington, D.C., and Maryland

MARC and the Virginia Railway Express (VRE) provide Regional rail service to Washington Union Station from five branch lines serving suburban Maryland and northern Virginia. Current service is concentrated during the weekday morning and evening peak periods, with two to three trains per hour serving each branch line. The MARC Penn Line, which operates over the NEC in Maryland, provides hourly service during weekday off-peak hours, and weekend service was initiated on the line in 2014. The No Action Alternative retains the current level of service through 2040.

VRE and the MARC Brunswick and Camden Lines are the only Regional rail services touching the NEC that currently operate with very limited reverse-peak and off-peak service. With high growth in Regional rail travel in the greater Washington, D.C., region projected through 2020, all of the Action Alternatives increase the quantity of service and expand these Regional rail systems to bi-directional rather than peak-focused service and extend service into off-peak periods beyond the commuter rush hours.

Two sources were tapped containing information on potential future Regional rail service in Maryland: the MARC Growth and Investment Plan, with projections of service for 2030 and 2050, and the Washington Union Terminal Master Plan, which included service growth assumptions for 2020, 2025, and 2030. These plans provided a range of Regional rail service levels, which were tested for their ridership potential.

4.3.1.1 Penn Line (NEC Spine)

The No Action Alternative retains the existing Penn Line train schedule. Some peak-period Penn Line trains are at their maximum length given station platform lengths and the hauling capabilities of the MARC diesel locomotives. Other trains can be lengthened to provide capacity for growth, but these opportunities are limited and cannot keep up with the pace of expected demand given projected population and employment growth in the region.

With construction of a fourth main track on the NEC between Odenton and West Baltimore in Alternative 1, MARC is able to run Regional rail service at more regular headways between Baltimore and Washington, D.C. than in the No Action Alternative, where southbound Regional rail trains must be scheduled around Intercity services on a single main track. The fourth track increases the number of slots available for Regional rail trains and provides the Regional rail operator with greater scheduling flexibility. All of the Action Alternatives include the planned extension of MARC service to Elkton and Newark, DE (2 tph during peak period, with a zone-express stopping pattern).

Alternative Service Plans were tested for Maryland Regional rail service on the Penn Line that provide 8, 10, or 12 trains in the weekday peak hour and peak direction. Each plan divides the line into either two or three service zones. In all three scenarios, Regional rail stations between Martin Airport and Washington, D.C., receive peak service with at least 4 tph, and an outer zone-express service operates at 2 tph. Options for the core Baltimore-to-Washington, D.C., service in Alternative 1 includes a Martin Airport-to-Washington, D.C., local train at 4 tph, or a pattern with two inner zones comprising a Baltimore-to-Washington, D.C., local service and a Martin Airport-to-BWI Airport zone-express service each operating at 2 tph. Initial ridership estimates favored the latter scenario, with 6 tph in the peak hour, which was selected by the FRA to represent Alternative 1.

Given the relatively robust growth in Regional rail demand, the Service Plan with three service zones and a total of 10 tph in the peak hour and peak direction at the screenline north of Washington, D.C. was selected by the FRA to represent Alternative 2. In addition, Metropolitan trains provide additional capacity for commuters from Newark, DE and Aberdeen, MD to Baltimore, BWI Airport and Washington, D.C. The relatively fast trip times make these Metropolitan trains attractive for longer-distance commuters. Also, more robust reverse-peak service to both serve the reverse-commute market to strong employment centers near Odenton, BWI Airport, Baltimore and Aberdeen, and to enable cycling of equipment to make additional peak period trips is provided. Off-peak service is increased to 2 tph between Washington, D.C., and Martin Airport, with an outer zone-express train provided at 1 tph serving stations between Baltimore and Newark, DE.

For Alternative 3, the FRA selected a Service Plan providing full Regional rail service on the Penn Line, with three service zones each operating at 15-minute headways (4 tph) in the peak hour and peak direction. This level of service through Baltimore at 5-minute headways during the peak hour effectively provides a new rail transit line through Baltimore[22] on the route of the NEC. Alternative 3 introduces transfers between the Penn Line and the existing Baltimore (MTA Maryland) METRO line[23] and other proposed rail transit lines at multiple locations.

[22] The full ridership effects of transit operations within Baltimore were not modeled. Incremental ridership benefits of such service are assessed qualitatively.

[23] Requires construction of one or two new transfer stations at the point(s) where the METRO and rail lines cross. These new stations are not precluded by Alternative 3, but they are not explicitly included in the definition of

4.3.1.2 Camden and Brunswick Lines

These two MARC Lines operate principally on CSX-owned rail lines and join with the NEC within the limits of Washington Union Terminal. These lines share station platforms and facilities at Washington Union Station with the Penn Line, as well as with Amtrak and VRE.

Alternative 1 includes modest increases in peak and reverse-peak frequency. Off-peak service remains limited, given the difficulty and cost associated with obtaining access to the freight rail lines on which these services operate (1-2 midday roundtrips on each line).

In Alternative 2, Camden Line service increases to 3 tph in the peak hour, 2 tph for reverse-peak and peak shoulder hour service, and bi-hourly off-peak service. Brunswick Line service increases to 6 tph in the peak hour (three services at 2 tph each: Martinsburg zone-express, Brunswick local, and a Frederick limited-stop service – which together provide peak service at 4 tph at all major stations between Brunswick and Silver Spring), with reverse-peak service and bi-hourly off-peak service to Frederick.

Alternative 3 retained the same peak service as in Alternative 2, with reverse-peak service at 2 tph and hourly off-peak service.

4.3.1.3 Virginia Regional Rail

Virginia Railway Express (VRE) currently operates on two lines that converge at Alexandria, VA, and run to Washington, D.C., via the Long Bridge across the Potomac River and the First Street Tunnel, into the lower level platform tracks on the east side of Washington Union Station. The VRE System Plan, updated in 2014, was the principal source of information about future VRE levels of service at Washington Union Station. The System Plan included both medium-term (c.2030) and long-range (c. 2040) Service Plans. The medium-term plan operates 3 tph from each line in the peak hour and peak direction (6 tph total). An extension off the Manassas Line to Gainesville and Haymarket in western Prince William County, VA is included, with relatively limited service. The medium-term plan also includes limited reverse-peak service (bi-hourly), with no off-peak service. A slightly more robust version of this plan included hourly reverse-peak service and bi-hourly off-peak service on each line.

The VRE long-range plan, with a horizon year of 2040, increases peak hour service to 4 tph in the peak direction on each line (8 tph total), include full peak-direction service on the Manassas Line (2 tph from both of the Haymarket and Broad Run branches, with 4 tph at primary stations inboard of Manassas). The long-range plan includes reverse-peak service at 2 tph to both Fredericksburg and Haymarket, as well as off-peak service at 2 tph on both lines.

The No Action Alternative retains the existing VRE train schedule. Alternative 1 is based on the medium-term plan for VRE (6 tph in the peak hour, peak direction at Washington), with the more limited reverse-peak service and no significant off-peak service. Alternatives 2 and 3 include the full

Alternative 3 and will be the subject of subsequent comprehensive local transit planning studies to determine the potential effectiveness of regional transit service on the railroad and associated multimodal network connections.

long-range plan for 8 tph in the peak hour, peak direction. Alternative 2 assumes limited reverse-peak and off-peak service. Alternative 3 assumes the full long-range plan with robust reverse-peak and off-peak service (2 tph on each line) and the introduction of weekend service.[24]

4.3.1.4 Greater Washington, D.C. and Regional Rail Rolling Stock

The FRA based all three Action Alternatives on the same assumptions with respect to train equipment. All services operate with locomotives and coaches in a push-pull configuration (i.e., the trains can be operated with the locomotive at either the front or the rear of the train, with the engineer positioned either in the locomotive or in a cab control car at the opposite end). The Service Plans for Penn Line service on the NEC, selected by the FRA to represent the Action Alternatives, were based on Regional rail trainsets made up of coaches hauled by electric locomotives. The Camden, Brunswick, Fredericksburg and Manassas Lines were assumed to continue to operate with diesel locomotives. Since NEC FUTURE does not prescribe the extent or type of service to be provided by regional operators, the FRA analyzed alternative service plan scenarios for the Penn Line based on the use of diesel locomotive-hauled trains for Regional rail trains, but with the same infrastructure configuration. Because trains with diesel locomotives generally accelerate more slowly than those with electric locomotives, the Regional rail stopping patterns required adjustments to avoid train movement conflicts, particularly during the standard peak hour. In these cases, peak service can be provided at levels that meet the demand for rail service in 2040, but with less regular service patterns and less scheduling flexibility for Regional rail service.

4.3.2 Delaware and Pennsylvania South of Philadelphia

4.3.2.1 Wilmington-Newark Line

The Wilmington-Newark Line of SEPTA currently provides service to Center City Philadelphia from two *de facto* zones, marked by the Delaware-Pennsylvania state line: local service to and from Marcus Hook, the last station in Pennsylvania; and service to Delaware, with some trains turning at Wilmington and others turning at Newark, DE. The latter service is financially supported by the State of Delaware. Most trains operate as all-stop locals, though selected Newark trains in the peak periods make limited stops in Pennsylvania. Ridership demand growth through 2040 is projected to be smaller on this line than in other locations, such as New York or Washington, D.C. The greatest growth is projected from the Delaware markets, and Delaware intends to increase the frequency of service and reduce the number of intermediate stops to improve trip times.

The No Action Alternative retains the existing SEPTA train schedule. Three service concepts were analyzed for this line to represent the Action Alternatives, all of which provide for increased service and improved trip times from the Delaware stations to Philadelphia. The first concept retains the Marcus Hook and Wilmington local services and increases the frequency and expand the time

[24] NEC FUTURE Service Plans were developed for an average weekday. Regional rail ridership also was estimated for an average weekday in 2040. Weekend service was not modeled explicitly. Assumptions about the level of weekend service were embedded in the factors used to convert average weekday ridership into estimated annual ridership, which were based on the historical factors for Regional rail systems in the NEC study area that currently operate weekend service.

windows of the Newark-Philadelphia zone-express service. The second concept creates a clear distinction between the Pennsylvania and Delaware services, creating a grade-separated turnback facility at Marcus Hook for inner zone services, and overlaying Delaware zone-express services from Newark and Wilmington. A third concept was examined that creates three service zones. While not driven by high ridership demand, these zones take maximum advantage of rail infrastructure planned as part of Alternatives 2 and 3 to minimize train operating conflicts at the capacity-constrained Wilmington Station and at locations where inner zone trains lay over and change direction. In this concept, the inner zone for local service ends at a new Regional rail station at Baldwin. A middle zone is created between Baldwin and a planned new station at Edgemoor, DE, just short of the Wilmington Station. Turning Regional rail trains at this location, where the local tracks are side-by-side, reduces the number of trains on the single local track at Wilmington Station and avoid crossing conflicts with trains on the express tracks. The third zone serves the stations between Wilmington and Newark, and provides express service between Wilmington and Philadelphia (including the potential to directly serve the Philadelphia International Airport in Alternative 2).

The capacity for additional service on the Wilmington-Newark Line is available to accommodate long-term growth in the demand for rail service. It also will help mitigate impacts associated with future lane closures on Interstate 95 (I-95) in Delaware County, PA, when it is reconstructed at some point in the future.

4.3.2.2 MARC and SEPTA Service in Delaware

NEC FUTURE considered the potential for integration of MARC and SEPTA Delaware service, creating a single through-running Regional rail line in lieu of two separate services that both terminate at Newark, DE. Service integration is operationally efficient and reduces the physical footprint of the station at Newark and any train storage facilities at Newark. Integration of service, however, raises issues associated with rolling stock compatibility (electric equipment is necessary for operations through the tunnels in Center City Philadelphia), train consists (MARC trains typically have more coaches than SEPTA trains), institutional and contractual requirements, and the inherent reliability of a single Regional rail service that operates over such a long route. The size of the ridership markets in this area are small relative to other service zones along the NEC, so the benefits of integrated operations are marginal from a ridership standpoint. Therefore, the NEC FUTURE Action Alternatives are based on continuation of separate Washington, D.C., and Philadelphia-oriented Regional rail operations and provide for the required terminal facilities at Newark, though there is nothing in the NEC FUTURE service or infrastructure plans that precludes integrated operations, should they be deemed warranted. Metropolitan service provides an additional 2–4 tph, stopping at several stations between Philadelphia and Washington, D.C., to stations that are only served by Regional rail today.

4.3.3 Pennsylvania North of Philadelphia

SEPTA service along the NEC on the north side of Philadelphia includes two branch lines: the Trenton Line, which operates entirely along the NEC, and the Chestnut Hill West line, which branches off the NEC at North Philadelphia. Ridership demand growth is projected to be smaller on these Regional rail lines than in other locations, such as New York or Washington, D.C. Existing trains also are relatively short, and additional cars can be added relatively easily to increase available seating capacity. Nevertheless, NEC FUTURE allows for increases in service frequency on these lines, which can be accommodated on the local tracks of the existing four-track corridor without constraining the projected growth in Intercity service operating on the express tracks. In addition to providing for future demand growth, increased service on the Trenton Line will help mitigate impacts associated with I-95 reconstructions over the next two decades.

The Trenton Line currently operates with all local service, at frequencies of up to 4 tph in the peak hour, with half-hourly reverse-peak and hourly off-peak service. This level of service is retained in the No Action Alternative and in Alternative 1. In Alternatives 2 and 3, consideration was given to introducing inner and outer service zones, to shorten trip times from the outer zone to Philadelphia. This introduces the need to create a grade-separated intermediate turnback location, since one does not currently exist. A better option results in the introduction of a limited-stop train that operate on the local tracks in the slots between the all-stop locals and serve the stations on the line with the highest ridership and greatest parking capacity. Slots were available to run these trains at 4 tph, but demand was estimated to support service at 2 tph, which became the level of service carried forward for Alternatives 2 and 3. These limited-stop slots turned out to have two useful functions. In the peak direction, for Philadelphia commuting (south in the morning, north in the afternoon), these trains run between Trenton and Philadelphia. In the peak direction for New York commuting, these trains originate in Philadelphia in the morning and run through Trenton to serve the outer zone for Regional rail in New Jersey (Trenton through North Brunswick) and then operate express to Penn Station New York. They return to Philadelphia in the evening, providing a one-seat ride Regional rail option for commuters to New York from all of the Regional rail stations on the line in Philadelphia and Bucks County, PA. – not just the two stations served by Metropolitan trains (North Philadelphia and Cornwells Heights). These trains also are needed for the regional travel market in New Jersey, to supplement Regional rail zone-express service to New York stations from the outer zone on the Northeast Corridor Line in New Jersey.

Chestnut Hill West service currently operates at 2 tph in the peak hours. This level of service was retained in the No Action Alternative and Alternative 1, and peak service was increased to 4 tph in Alternatives 2 and 3.

4.3.4 New Jersey and Hudson River Crossing

The capacity of the existing Hudson River tunnels is effectively fully utilized during the weekday peak hours in the peak direction of travel. There is no room to add significant numbers of new trains, and most trains are at or close to their maximum lengths given constraints on station platform lengths, yard space and locomotive hauling capacity. The No Action Alternative, therefore, which retains the existing train schedule, is severely constrained in terms of ridership growth potential, and this alternative is unable to maintain rail's share of trans-Hudson travel in the face of the projected 30- to 40-percent increase in trans-Hudson travel demand projected by 2040.

The Action Alternatives add new tunnel capacity across the Hudson River. Two new tunnel tracks are added in Alternatives 1 and 2, effectively doubling current capacity. Alternative 3 provides an additional pair of rail tunnels from New Jersey to Midtown Manhattan for a total of six. In each of these Action Alternatives, ridership estimates have demonstrated that there is sufficient ridership demand in 2040 to fill all of the peak Regional rail trains that fit within available capacity – and the trans-Hudson bus and PATH services remain oversubscribed. Consequently, service planning for New Jersey Regional rail focused on enabling maximum utilization of the available rail infrastructure capacity, in combination with the growth in Intercity passenger service specified for each alternative. The Alternative 1 Service Plan provides 30 tph in the standard peak hour crossing the Hudson River, an increase of slightly more than 40 percent over the current level of 21 tph. Alternative 2 provides 42 tph at the Hudson River screenline, fully utilizing the two pairs of tunnels and representing a doubling of peak-hour service compared with the No Action Alternative. Alternative 3 provides Regional rail service at up to 54 tph in the standard peak hour and peak direction across the Hudson River, supplemented by Metropolitan service at 8 tph, fully utilizing the three pairs of tunnel tracks from New Jersey to Manhattan that are included in this alternative and allowing for growth in Intercity service. The ridership estimates indicated a high level of utilization of these Regional rail services in the peak periods in all alternatives, along with continued growth in trans-Hudson travel by other modes, reinforcing the decision by FRA to develop Service Plans for Regional rail in Alternatives 2 and 3 that fully utilize the available tunnel and New York terminal capacity.

4.3.4.1 Standard Slots for Local and Express Services

With three distinct Regional rail service zones on the NEC in New Jersey, plus multiple Regional rail branch lines potentially feeding the NEC at various locations, there are many possible service patterns and concepts that can be developed to fit within the available Hudson River tunnel capacity. NJ TRANSIT identified potential future service levels by branch line, and initial travel demand estimates provided a sense of the projected magnitude of travel growth within the catchment areas of the NEC service zones and branch line service territories. These inputs provided guidance for the development by the FRA of representative Regional rail Service Plans for the Action Alternatives. The FRA tested several concepts for operating Intercity and Regional rail service together on the NEC, to find those that were able to use rail infrastructure most efficiently and provide the greatest ridership potential. The most productive concepts utilized regular Regional rail stopping patterns aligned on repeating 15- and 30-minute intervals in the standard peak hour, which can be synchronized with the Intercity patterns that also followed the same repeating intervals. This led to the development of Service Plans that identified an array or catalogue of standard slots on the express and local tracks of the NEC that encompassed all of the stopping patterns necessary to meet the service standards for each service zone or branch, while not dictating the precise mix of patterns and level of service for each of the branch lines. These standard slots repeated at either 15- or 30-minute intervals. Actual trains can occupy either an entire slot or a portion of the slot by joining/leaving the line at an intermediate point. Benefits of developing a service plan based on a standard slot catalogue include the following:

- Scheduling flexibility for the Regional rail operator in the development of branch-specific train schedules
- Maximizes practical capacity by standardizing stopping patterns and operating speeds
- Demonstrates operational feasibility without prescribing a particular configuration and level of branch line service.

The service planning objective was to develop standard slots or train paths over as long a portion of the corridor as practical. After some initial evaluation, it was found that the zone between Newark Liberty Airport and Penn Station New York was the most appropriate territory over which to provide the standard slot catalogue. Specific Service Plans and stopping patterns were developed for the remainder of the NEC in New Jersey, between Newark Liberty Airport and Trenton.

To better understand the impact on capacity through use of a standard slot catalogue, the FRA developed an illustrative Service Plan for the four-track NEC main line in northern New Jersey connecting to the four Hudson River tunnels that are provided in Alternatives 1 and 2. In this example, the express tracks between Newark Airport and the Hudson River connect into the existing Hudson River tunnels, and the local tracks connect into the new third and fourth Hudson River tunnels. [25] This example is not intended to be prescriptive, and other service plans could prove equally or more efficient or offer a better mix of services to the regional travel markets.

For this example, the standard slots on the local tracks followed an identical pattern of stops and were spaced to deliver 28 tph to the new tunnels, which was estimated to be the practical capacity of the tunnel and associated station complex in New York configured for through-running service (as in Alternative 2). Figure 8 shows the catalogue of available slots. All trains in these slots on the local tracks stopped at Newark Airport, Newark Penn Station and Secaucus, enabling trains to be operated at two-minute headways. Figure 9 presents an example of how the local track slots might be utilized in the evening peak service plan for Alternative 2. This is only one of many possible ways in which the standard slots can be utilized, and is presented here for the purpose of explaining the concept of a standard slot catalogue, not to imply any particular preference with respect to actual service patterns. In this sample case, southbound trains were deployed as follows:

- 2 tph – Trenton locals from Penn Station New York
- 4 tph – North Jersey Coast Line locals from Penn Station New York (exiting at Union Junction)
- 6 tph – North Jersey Coast Line zone-expresses from Penn Station New York (2 exiting at Union Junction and 2 shifting to the express tracks at Newark Airport)
- 16 tph – "Standard" local slots for inner branch line services – these can be deployed in multiple ways; one possible allocation is as follows (shown in Figure 8 for purposes of illustration):
  - 5 tph – Main, Bergen and Pascack Valley Line trains from Penn Station New York (exiting the local tracks at Secaucus via the Bergen Loop connection)
  - 8 tph – Morris and Essex Line and Montclair-Boonton Line trains from Penn Station New York (exiting the local tracks at Swift Junction west of Secaucus)

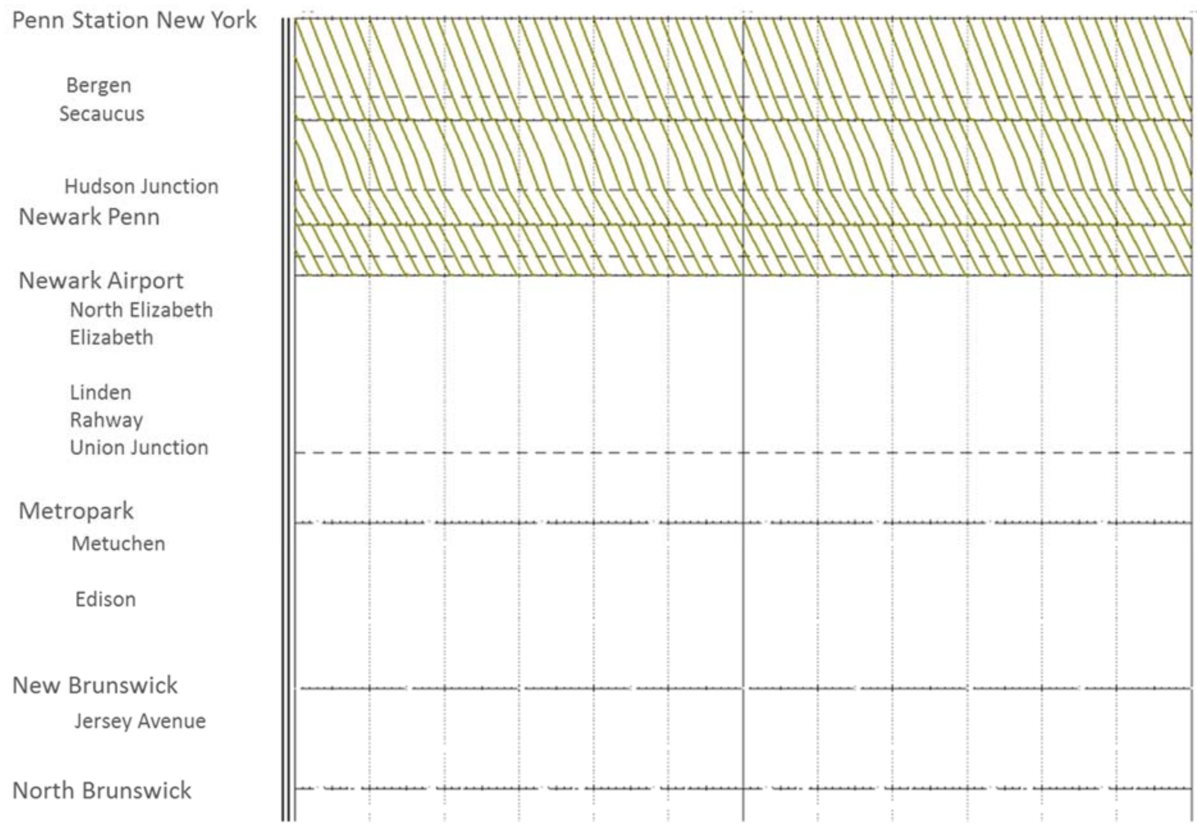
[25] Other feasible scenarios could route Intercity-Express and Metropolitan trains to new tunnel tracks and use the existing tunnels to accommodate Regional rail service growth. NEC FUTURE is not prescriptive with respect to future operating plans for rail traffic through New York, and Tier 2 studies subsequent to NEC FUTURE will determine the specific configuration of tunnels, tracks, station facilities and yard facilities to be provided in the New York area – and how they will be operated.

- 3 tph – Raritan Valley Line trains from Penn Station New York (exiting the local tracks at Hunter Junction west of Newark)
- 3 tph – Raritan Valley Line trains from Hoboken (entering at Hudson Junction in Kearny, NJ and exiting at Hunter Junction – these trains occupy the same slots as Main-Bergen-Pascack or Morris & Essex trains, which vacate the slots prior to Hudson Junction)
- 2 tph – North Jersey Coast Line Bay Head trains from Hoboken (entering the local tracks at Hudson Junction in Kearny, NJ and shifting to the express tracks at Newark Airport – these trains occupy the same slots as two Main-Bergen-Pascack trains, which vacate the slots at Secaucus)

The standard slot patterns for the local trains do not include any extra or ’phantom’ slots to protect late Regional rail trains. However, the hourly throughput of 28 tph represents a conservative estimate of practical capacity. The signal system design accommodates train movements at up to 31–32 tph, with all trains retaining the same standard stopping pattern. As a result, headways can be reduced to accommodate denser train movements when necessary to recover from train delay conditions. This ability to recover from delays, and to operate trains in any sequence with a standard stopping pattern, is a significant benefit associated with the concept of standardized stopping patterns. The provision of phantom slots is a more appropriate concept where stopping patterns are varied.

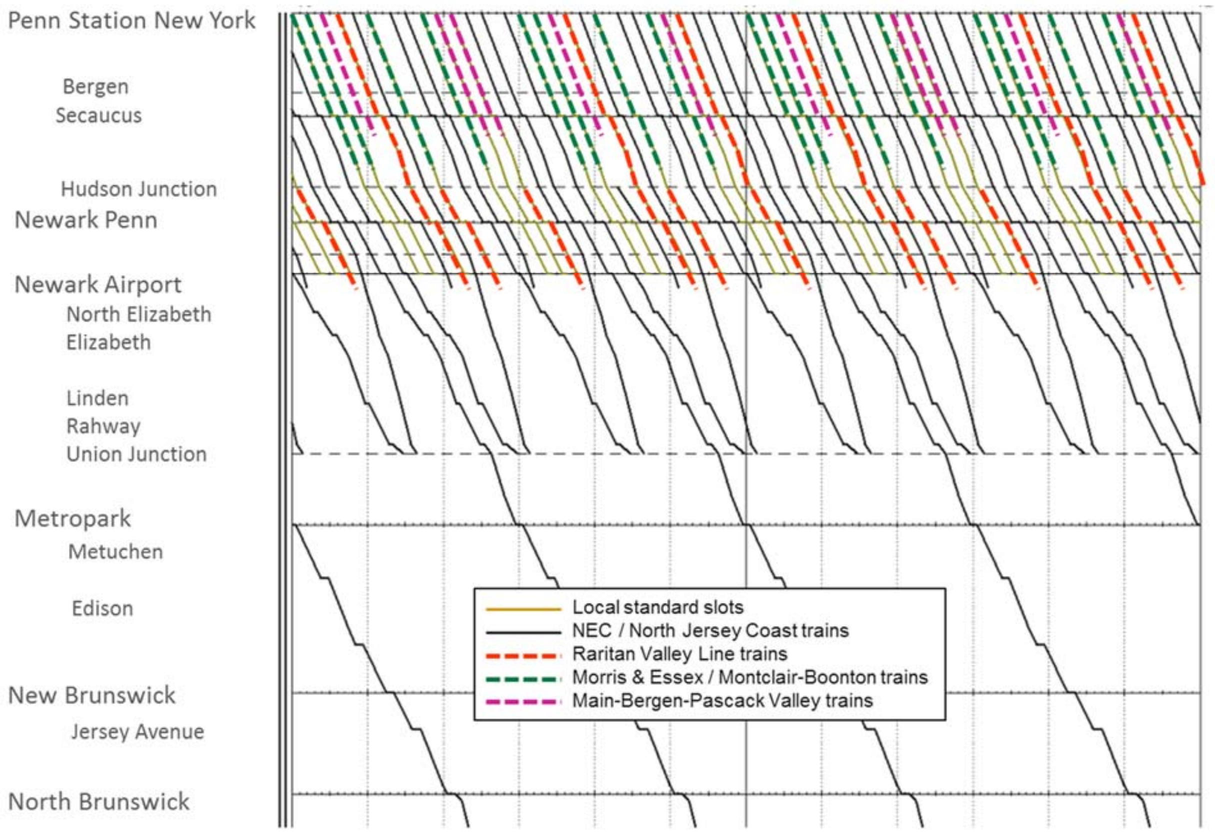
While the example described above illustrates how standard slots can be used in practice, the value of the standard slot catalogue lies in its inherent flexibility—its ability to support any combination of trains using the standard slots that are supported by the railroad infrastructure.

Figure 8: Illustrative Standard Slots on Local Track (New Jersey and Hudson River Crossing)



Source: NEC FUTURE team, 2015

Figure 9: Illustrative Utilization of Local Track Slots (New Jersey and Hudson River Crossing)



Source: NEC FUTURE team, 2015

The standard slots on the express tracks provided three different stopping patterns that were overlaid with each other in an overall pattern that repeated every 15 minutes and provided a total level of service of 26 tph, close to the estimated practical capacity of the existing Hudson River tunnels. Shown in Figure 10, these included the following pattern categories:

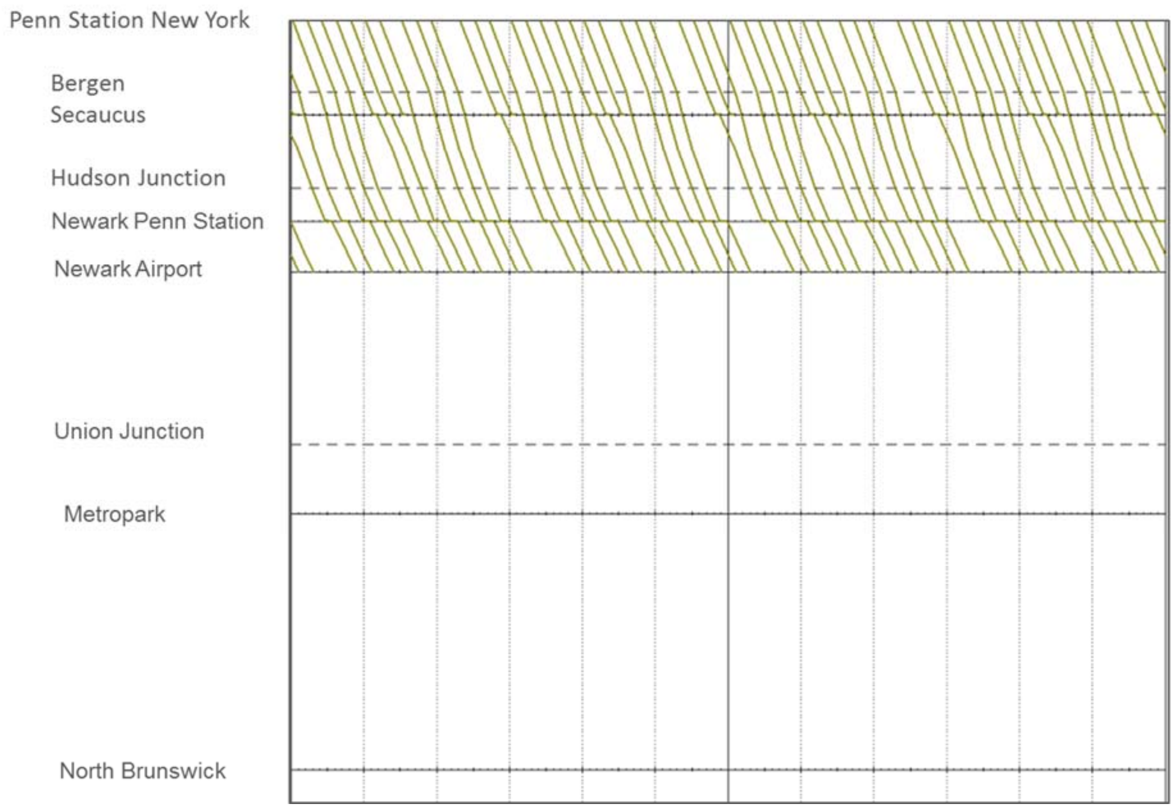
- 12 slots with patterns that stopped only at Newark Penn Station
- 8 slots that included stops at both Secaucus and Newark Penn Station
- 4 slots that existed only between Penn Station New York and Secaucus

Figure 11 illustrates how these slots were deployed for southbound trains in an evening peak-hour service plan for Alternative 2:

- 4 tph, Pattern #1 – Intercity-Express
- 4 tph, Pattern #1 – Metropolitan service

- 4 tph, Pattern #1 – Intercity-Corridor slots for off-corridor trains (two of which are filled with trains, and two of which are "phantom" slots reserved for accommodating late Intercity-Corridor-Other or Long-Distance trains)[26]
- 6 tph (4 tph in Pattern #1, 2 tph in Pattern #2) – Trenton outer zone-expresses
- 4 tph, Pattern #2 – North Brunswick middle zone-expresses
- 4 tph, Pattern #3 – Main, Bergen and Pascack Valley Line to Penn Station New York (exiting at Secaucus)

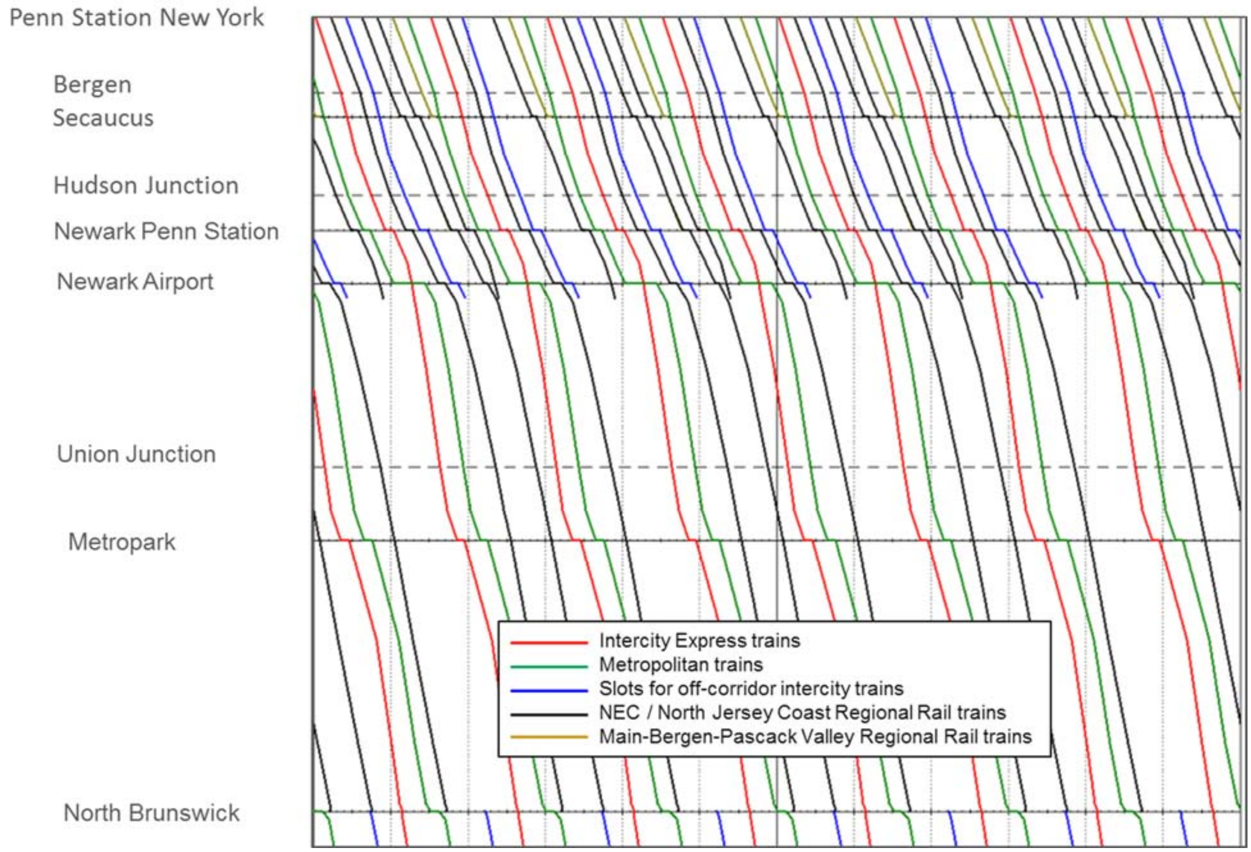
Figure 10: Illustrative Standard Slots on Intercity-Express Tracks (New Jersey and Hudson River Crossing)



Source: NEC FUTURE team, 2015

[26] These trains disappear from the express track stringline diagram south of Newark Airport, because they move to the intermediate tracks on the six-track section of railroad between Elizabeth and Rahway, NJ.

Figure 11: Illustrative Utilization of Intercity-Express Track Slots (New Jersey and Hudson River Crossing)



Source: NEC FUTURE team, 2015

4.3.4.2 Hoboken Service

NEC FUTURE does not explicitly involve developing Service Plans or train schedules for New Jersey Regional rail services to and from Hoboken Terminal that do not travel along any portion of the NEC. For purposes of developing ridership estimates, these Hoboken-oriented services—which operate on the Morris and Essex, Montclair-Boonton, Main, Bergen and Pascack Valley Lines—were assumed to remain similar to current levels of service.

The Service Plans for the No Action and Action Alternatives do include Bay Head trains from the North Jersey Coast Line that serve Hoboken. The Action Alternatives also include trains from the Raritan Valley Line serving Hoboken, taking advantage of the conflict-free track connections at both Hunter and Hudson Interlockings that are provided in all Action Alternatives.

4.3.4.3 Metropark, North Brunswick, Trenton and Philadelphia Service

Early regional travel demand model results indicated very high existing ridership demand and projected growth from this territory, particularly the middle and outer zones between Metropark and Trenton. This is the only territory on the NEC where inherent ridership demand is projected to exceed what can be carried on four full-length trains per hour, with the current configuration of service zones. The Service Plans for each of the Action Alternatives, therefore, provide extra trains in the standard peak hour serving this territory, including middle zone (Metropark-North Brunswick) and outer zone (North Brunswick-Trenton) service at a minimum of 4 tph, an all-stop Trenton local service at 2 tph, and an additional outer-zone express service at 2 tph that originate in Trenton in Alternative 1 or in Philadelphia in Alternatives 2 and 3 to provide a one-seat ride to New York from the relatively small but growing commuter market to New York from Philadelphia and Bucks County, PA. This increased level of traffic depends upon chokepoint relief projects at both North Brunswick (Mid-Line Loop) and Trenton to keep trains running smoothly at higher densities.

4.3.4.4 Bergen and Passaic Service

A strong ridership market has been identified for trans-Hudson trips to Manhattan from Bergen and Passaic Counties in northeastern New Jersey and the New York west-of-Hudson counties of Rockland and Orange. The Bergen Loop project is designed to provide one-seat-ride access to Penn Station New York from the Main, Bergen and Pascack Valley Lines of NJ TRANSIT and the Port Jervis Line (operated by NJ TRANSIT on behalf of the MTA), which serve these growing suburban counties, via a direct track connection at Secaucus. Passengers currently can transfer to Penn Station-bound trains at the Secaucus Junction Station. In Alternative 1, which maintains the current role of rail in the region, the ability to transfer to a wider selection of Penn Station trains is retained, but the direct track connection is not provided. Direct rail service from the northern New Jersey lines via the Bergen Loop is assumed in Alternatives 2 and 3. The capital project to construct the loop connection is identified as a Related Project in the No Action Alternative Report[27] and is not included in the capital cost of rail improvements to the NEC, since it exclusively serves Regional rail branch lines.

4.3.5 Long Island, Queens, Bronx and East River Crossing

The East River screenline is the one location on the NEC that sees a significant increase in service in the No Action Alternative, as compared with existing conditions. This is due to completion of the LIRR East Side Access project, which will open a new tunnel connection from the LIRR to Grand Central Terminal with capacity for an additional 24 tph in the peak hour and peak direction of service. This allows 60 tph in the peak direction for Regional rail service across the East River to or from Penn Station and Grand Central Terminal. As described in the *No Action Alternative Report*, the No Action Alternative does not include the introduction of train service from the New Haven Line and East Bronx to Penn Station. Such service, however, for planning purposes, was incorporated into the operations modeling in each of the Action Alternatives.

4.3.5.1 Standard Slots in the East River Tunnels

The Action Alternatives identify a number of train slots available for Regional rail services in the standard peak hour crossing the East River to and from Penn Station. These include slots for LIRR main line and Port Washington Branch trains serving Penn Station. The MTA has programmed funding for Penn Station Access in its 2015-19 budget, and the Governor of New York State has set aside funding for new stations on the Hell Gate Line as part of the Penn Station Access program.

[27] [Add correct citation for No Action Alternative report]

With these improvements, standard slots could also be provided for Regional rail trains from the Bronx, Westchester, and Connecticut. Slots for non-revenue trains operating without passengers (sometimes referred to as deadhead trains) between Penn Station New York and Sunnyside Yard also are accounted for in the screenline capacity analysis, ensuring that train service remains within available practical capacity. However, tables summarizing the train movements associated with the Service Plans do not include deadhead (non-revenue) trains unless explicitly identified.

Alternatives 2 and 3 include additional rail tunnels beneath the East River and, for planning purposes, provide sufficient capacity to accommodate up to 50 Regional rail trains per hour at Penn Station New York from Long Island and potentially from the New Haven Line and East Bronx.

Alternative 1 is limited to the existing four East River Tunnels, plus the LIRR East Side Access project. The peak-hour, peak-direction capacity of the East River Tunnels in this alternative is assumed to be approximately 48 tph,[28] accommodating Intercity and Regional rail service to Penn Station New York. For planning purposes, six slots per hour are allocated to Intercity trains in the standard peak hour, leaving 42 slots for the regional rail markets.

Alternative 2 adds a fifth and sixth East River tunnel and avoids the need to substantially increase the capacity of the existing tunnels. Overall, East River crossing capacity increases to approximately 68 tph in the peak direction for both Intercity and Regional rail services. For planning purposes, with 10 slots allocated to Intercity services, the remaining 58 slots are sufficient to meet the maximum planned service for Regional rail service, with eight excess slots remaining available for additional new services, if warranted by demand.

Alternative 3 includes the same number of East River tunnel tracks as Alternative 2, but the second spine route north of New York increases the number of Intercity trains to as many as 18 tph in each direction during peak hours. With the same capital improvements to the signal system and interlocking on the existing tunnel routes, total East River crossing capacity to and from Penn Station New York increases to 76 tph, including the same East River tunnel capacity improvements that are included in Alternative 1, and the same overall peak capacity of 58 tph remains available for Regional rail services to Penn Station. As in Alternative 2, for planning purposes up to eight slots per hour are available for additional Regional rail service. In Alternative 3, this additional capacity was allocated to Regional rail service from the outer service zones of the LIRR, but could also be utilized for trains from Metro-North's upper Hudson Line if the New York-Danbury-Hartford route option were selected; these trains fill available capacity on the high-speed second spine into Manhattan and offers substantially reduced trip times to Penn Station New York (Table 5).

[28] This represents an increase in peak capacity through the existing tunnels from the 40 tph that corresponds to existing service and the 2040 No Action Alternative. The increase in capacity is assumed to be achieved through a combination of signaling, track alignment and interlocking improvements within the tunnels, at Penn Station New York and in western Queens.

Table 5: Trip Times for Outer Zone Regional Rail Express Services (existing routes versus new service via high-speed second spine routes (Alt. 3))

Selected Stations	Route	Minimum Trip Time (Hrs:Min)
Ronkonkoma	Existing LIRR to Penn Station New York Via High-Speed Tracks to Penn Station New York	1:09 :56 (zone exp.) :45 (express)
Pt. Jefferson	Existing LIRR to Penn Station New York Via High-Speed Tracks to Penn Station New York	1:36 1:00
Patchogue	Existing LIRR to Penn Station New York Via High-Speed Tracks to Penn Station New York	1:32 1:01
Babylon	Existing LIRR to Penn Station New York Via High-Speed Tracks to Penn Station New York	1:02 :31
Brewster Southeast	Existing MNR to Grand Central Illustrative via High-Speed Tracks to Penn Station New York	1:18 :53*
Wassaic	Existing MNR to Grand Central Illustrative via High-Speed Tracks to Penn Station New York	1:59 1:27*

Source: NEC FUTURE team, 2015

* The trip time shown for the route shown from Brewster Southeast via high-speed tracks to Penn Station New York is illustrative only and intended for planning purposes to identify possibilities. This example is not intended to be prescriptive.

4.3.6 New Haven Line

The No Action Alternative continues current service levels on the New Haven Line and introduces the planned new Barnum station at East Bridgeport. There are limited opportunities to increase the lengths of some peak trains on the New Haven Line, but existing service levels lack the ability to accommodate projected growth in demand.

Service Plans for the Action Alternatives initially were developed based on the assumed rail infrastructure configuration in each alternative. Alternative 1 eliminates the chokepoints at New Rochelle, Harrison and Stamford with new tracks to grade separate Intercity-Express and Regional rail zone-express trains from local Regional rail service. To meet estimated travel demand growth in the corridor, the level of Regional rail service in Alternative 1 was set at 26 tph in the peak direction in the standard peak hour, an increase of 24 percent over the current level of 21 tph in the peak hour. Alternative 2 expands the existing NEC from four to six tracks from New Rochelle to east of Westport, CT. Alternative 3 was developed with the same infrastructure as Alternative 1 on the New Haven Line but rerouted most, but not all, Intercity-Express service to a new second spine route. Intercity-Express service on the New Haven Line was retained at 2 tph in the standard peak hour in Alternative 3, in order to continue to provide Intercity-Express service to Washington, D.C., New York, and Boston from Stamford.

4.3.6.1 Standard Slots on New Haven Line

All Action Alternatives provide slots that could be used for Regional rail trains from the New Haven Line through to Penn Station New York via the Hell Gate Line. Additional track capacity is required on the Hell Gate Line, as are capital improvements to relieve chokepoints at the rail junctions in New Rochelle and in western Queens. Table 6 presents the number of trains operating on the New Haven Line in the weekday peak hour and peak direction of travel at New Rochelle. These trains could be distributed between Grand Central Terminal and Penn Station New York, with the actual split of service to be determined at a future date based on additional analysis and planning.

Table 6: Capacity Slots Available for Regional Rail Trains in the Standard Peak Hour, Peak Direction

Alternative (2040)	New Haven Line at New Rochelle		
No Action	21		
1	26		
2	32		
3	34 + 8*		

* The additional eight slots are on the high-speed second spine route to Penn Station New York, in the variations of Alternative 3 that provide the second spine route via Central Connecticut.

The use of a standard slot catalogue for New Haven Line Regional rail service would have several benefits:

- Provides future scheduling flexibility for New Haven Line service
- Maximizes practical capacity by standardizing stopping patterns and operating speeds
- Demonstrates the operational feasibility of the service plan concepts without specifying a particular level of service to Penn Station New York and Grand Central Terminal.

4.3.6.2 East Bronx Service

For planning purposes, all three Action Alternatives assume the construction of four new stations on the Hell Gate Line in the East Bronx, at Hunt's Point, Parkchester, Morris Park, and Co-Op City, and that these stations are served in the standard peak hour by four local trains in each direction. Bi-directional service could operate between Penn Station New York and points on the New Haven Line. High-Density Transit-Style Service

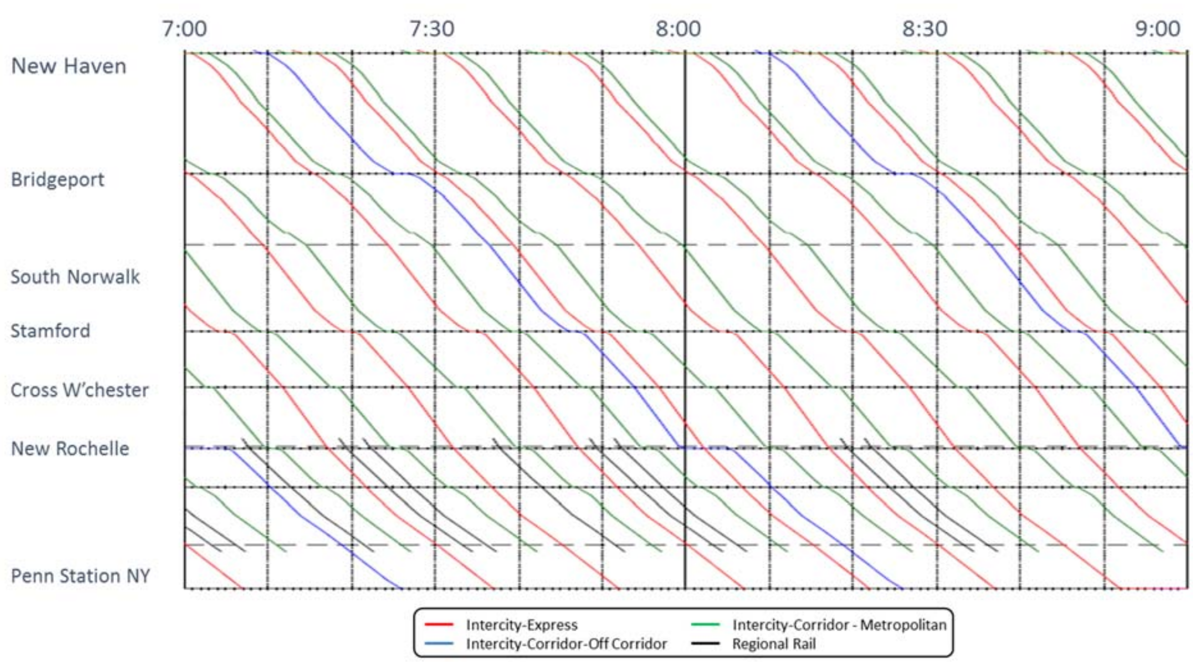
Based on stakeholder feedback and in recognition of the difficulty and high capital cost associated with six-tracking the western half of the New Haven Line, consideration was given to Regional rail service concepts that make more intensive use of existing track capacity and potentially avoid or significantly reduce the need for six-tracking of the line. This approach for more intensive track use is illustrative only and has not been endorsed by the rail operator, nor has it been thoroughly evaluated by the FRA. It was developed to enable a comparison of two very different concepts for operating rail service on the New Haven Line and to illustrate the range of solutions that are possible for accommodating anticipated future growth in demand for rail service. These are based on two different approaches for potentially delivering Regional rail service:

- Traditional zone-express service, where peak trains operate on the outside local track to serve a group of local stations then shift to an inside express track and operate non-stop the rest of the way to the downtown terminal
- Transit-style service, with largely separate limited-stop express services on the inside tracks and local service with skip-stop patterns on the outside tracks

These concepts, as originally analyzed, are independent of the overall vision for rail in the NEC and are potentially applicable to any of the Action Alternatives. The traditional zone-express service concept requires considerable additional rail infrastructure on the New Haven Line as the level of traffic begins to exceed the available capacity, including grade-separated junctions at New Rochelle and locations where branch lines join the corridor, removal of intermediate chokepoints where trains turn or access yards, such as at Harrison and Stamford, and two additional main line tracks (for a total of six) from New Rochelle to east of the Saugatuck River to accommodate the volume of trains and varieties of stopping patterns.

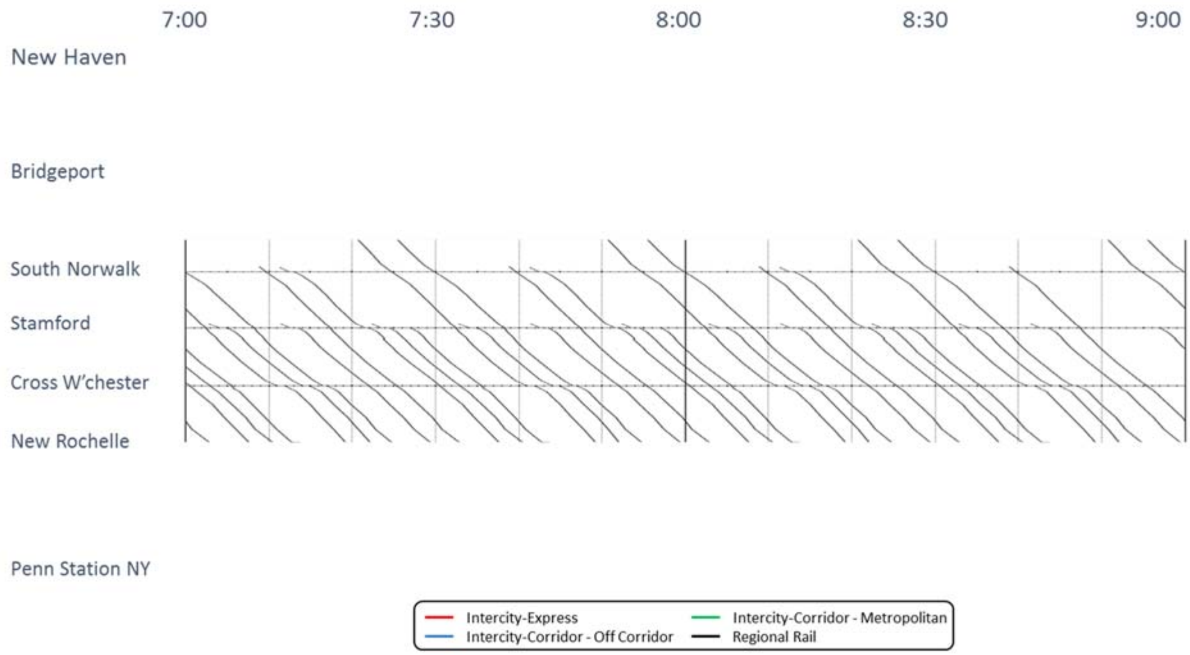
Service characteristics for the traditional concept resemble current service patterns, with zone-express trains operating on local tracks when stopping and on the express tracks the rest of the way to or from Grand Central Terminal and potentially Penn Station New York. The assignment of trains between Grand Central Terminal and Penn Station New York are flexible within available slot capacity. Figure 12 through Figure 14 show in stringline or time-distance diagram format the standard peak hour service patterns for a traditional service plan corresponding to Alternative 2 levels of service—on the express, intermediate and local tracks. Between New Rochelle and the Saugatuck River, the intermediate tracks correspond to the existing inside tracks on the New Haven Line, and the express tracks become the new fifth and sixth main tracks in this territory.

Figure 12: Traditional Zone-Express Service – Alternative 2 – New Haven Line Express Tracks



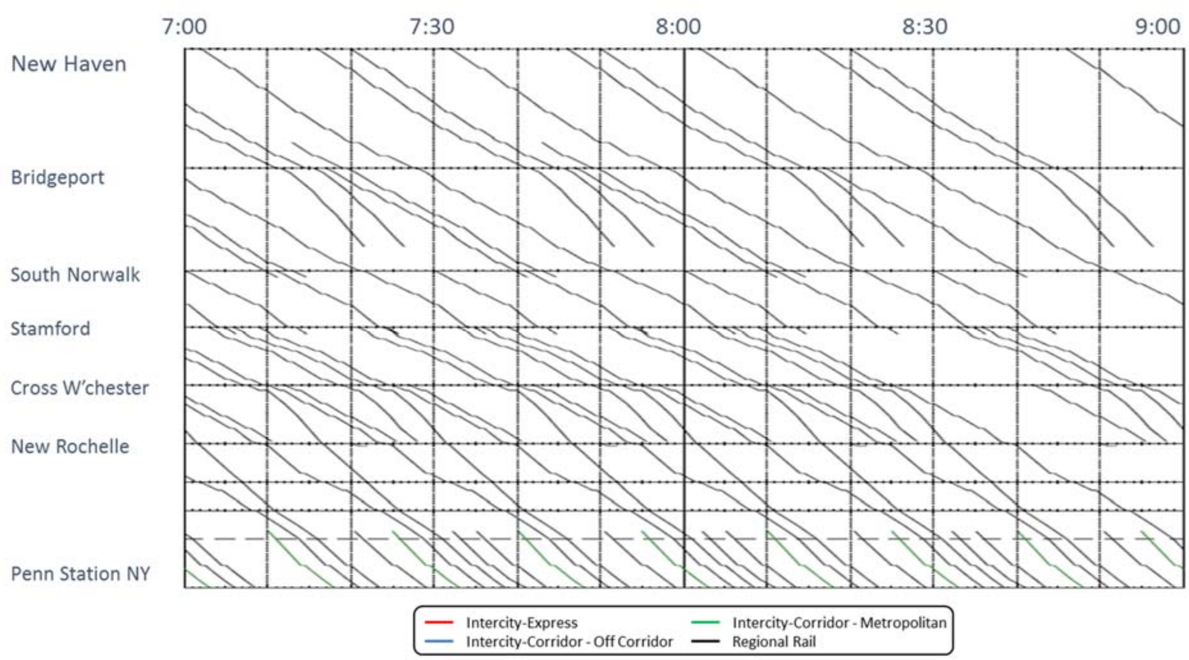
Source: NEC FUTURE team, 2015

Figure 13: Traditional Zone Express Service – Alternative 2 – New Haven Line Intermediate Tracks



Source: NEC FUTURE team, 2015

Figure 14: Traditional Zone Express Service – Alternative 2 – New Haven Line Local Tracks



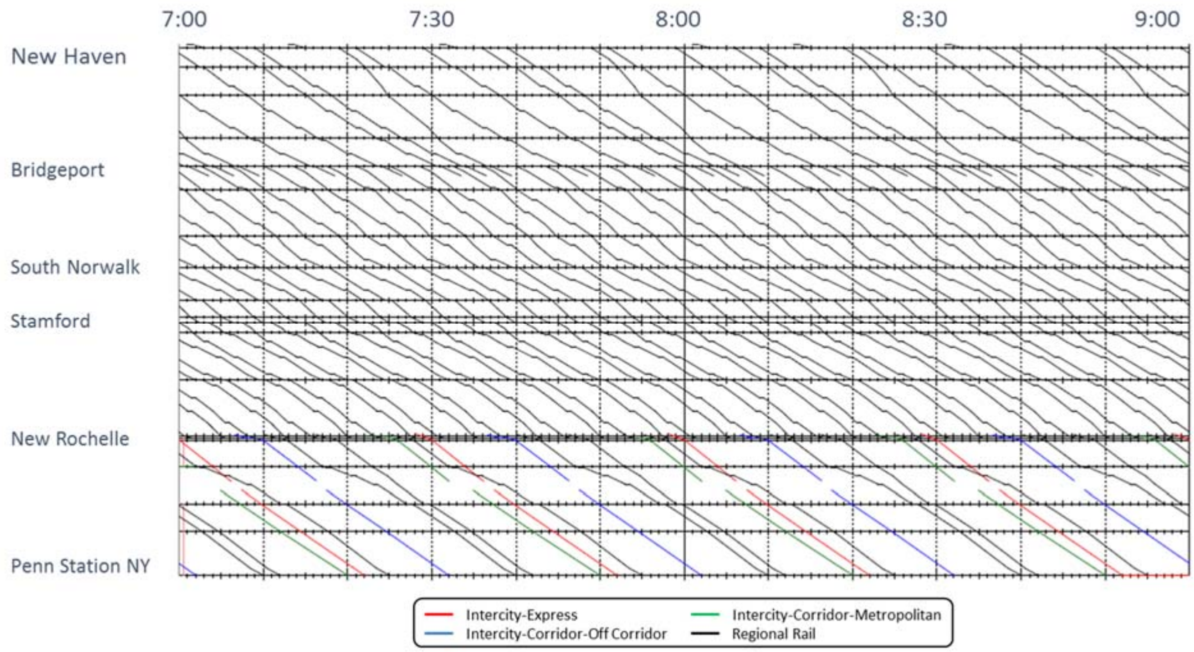
Source: NEC FUTURE team, 2015

Transit-style service offers a simpler array of service patterns, dedicated to and optimized for each main track in the right-of-way. Local trains remain on the local tracks. Because of the high number of local stations on the line, running all-stop locals seriously degrades trip times to New York from stations at the outer end of the line. As a result, the service concept for the local tracks employs a “skip-stop” service concept, which operates trains in groups of two or three, enabling each train to serve selected stops while all operating at approximately the same average speed to preserve relatively short headways. This style of service exists or has been operated in the past on various rail transit lines, notably in Chicago, New York, and Philadelphia.

Trip times to Grand Central Terminal from stations on the New Haven Line, on average, are similar to existing trip times, with some stations seeing slightly higher time and others slightly lower. Even though the skip-stop trains make more total station stops than the traditional zone-expresses, the overall simplicity of the operation and reduced number of train movement conflicts allows for a reduction in the extra time included in train schedules to account for anticipated train delays. These two factors tend to offset each other, resulting in trip times that are not significantly worse than those in a traditional service plan. Some direct service between local intermediate stations is lost in the skip-stop concept, but all local trains stop at the stations that have significant employment or activity centers, and overall connectivity and service is improved to the major destination stations. Service headways also are relatively short and can be sustained over an extended peak period in this concept. The transit-style concept requires an increase in the size of the rolling stock fleet, because all local trains operate over longer distances, with the elimination of “short” inner zones on the line.

Two examples of this type of service are illustrated in the following figures that depict stringlines for the New Haven Line. In the first example, which is consistent with the level of train service in Alternative 1, service on the local tracks operates with an A-B skip-stop pattern with trains operating at 4-minute headways, as shown in Figure 15. Local stations that serve predominantly residential suburbs, designated as either “A” or “B” stations, is served by alternate trains, stopping every eight minutes. More important stations, including those designated as express stations or local stations that also significant employment centers (such as Greenwich and Fairfield, CT) are designated as “A-B” stations, with every local train stopping, providing four minute headways in the peak periods. The local trains in this example operate from an eastern terminal at East Bridgeport yard to Grand Central.

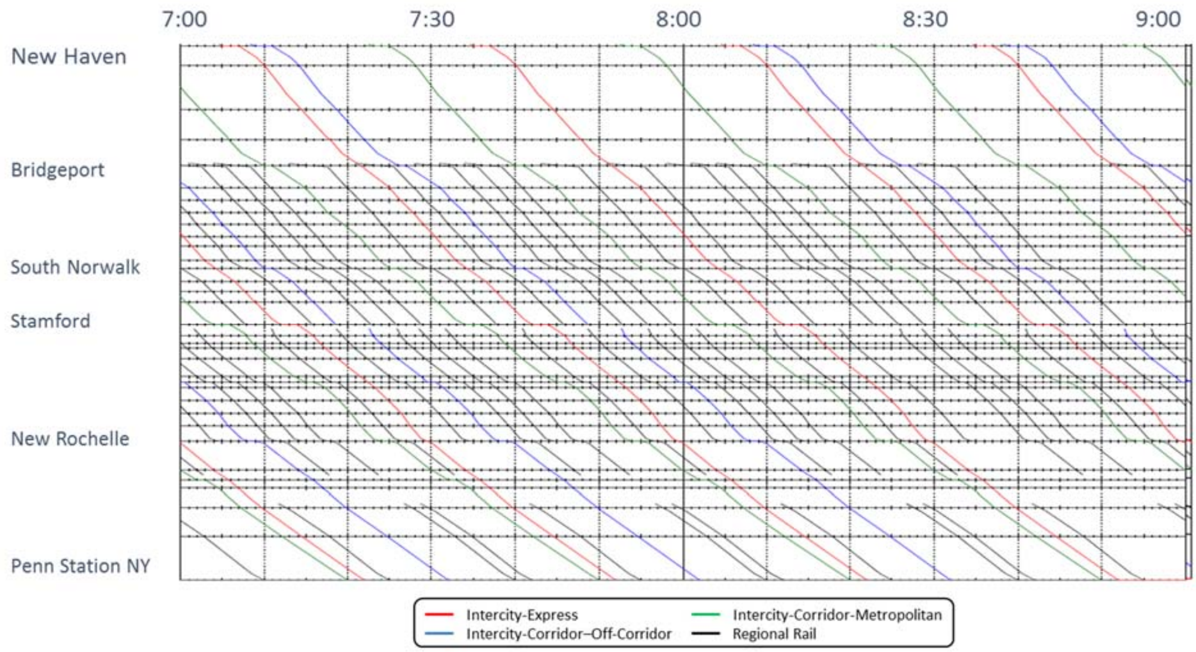
Figure 15: Transit-Style Service – Alternative 1 "A-B" Pattern – New Haven Line Local Tracks



Source: NEC FUTURE team, 2015

Figure 16 shows the services that operate on the express tracks in the same territory. For planning purposes, to slots are designated for two Intercity-Express trains per hour, four Intercity-Corridor (Metropolitan or Intercity-Corridor-Other) trains per hour, and up to 10 Regional rail express trains per hour. All of the Regional rail and Intercity-Corridor trains stop at the express stations, which include East Bridgeport, Bridgeport, South Norwalk, Stamford, Cross-Westchester, and New Rochelle. The existing stations that become express stations, but which only have side platforms on the outside tracks, are reconfigured with two island platforms serving all four main tracks, which entails major construction at these locations. This concept can be implemented with a different mix of express stations based on more detailed subsequent studies. The Intercity-Express trains stop only at the New Haven and Stamford stations in Connecticut. These trains occupy two consecutive slots on the express tracks, enabling these trains to achieve a shorter trip time than the other trains using the express tracks.

Figure 16: Transit-Style Service – Alternative 1 – New Haven Line Express Tracks



Source: NEC FUTURE team, 2015

A second example of transit-style service operates with greater density of traffic and is consistent with the service levels provided in Alternative 2.

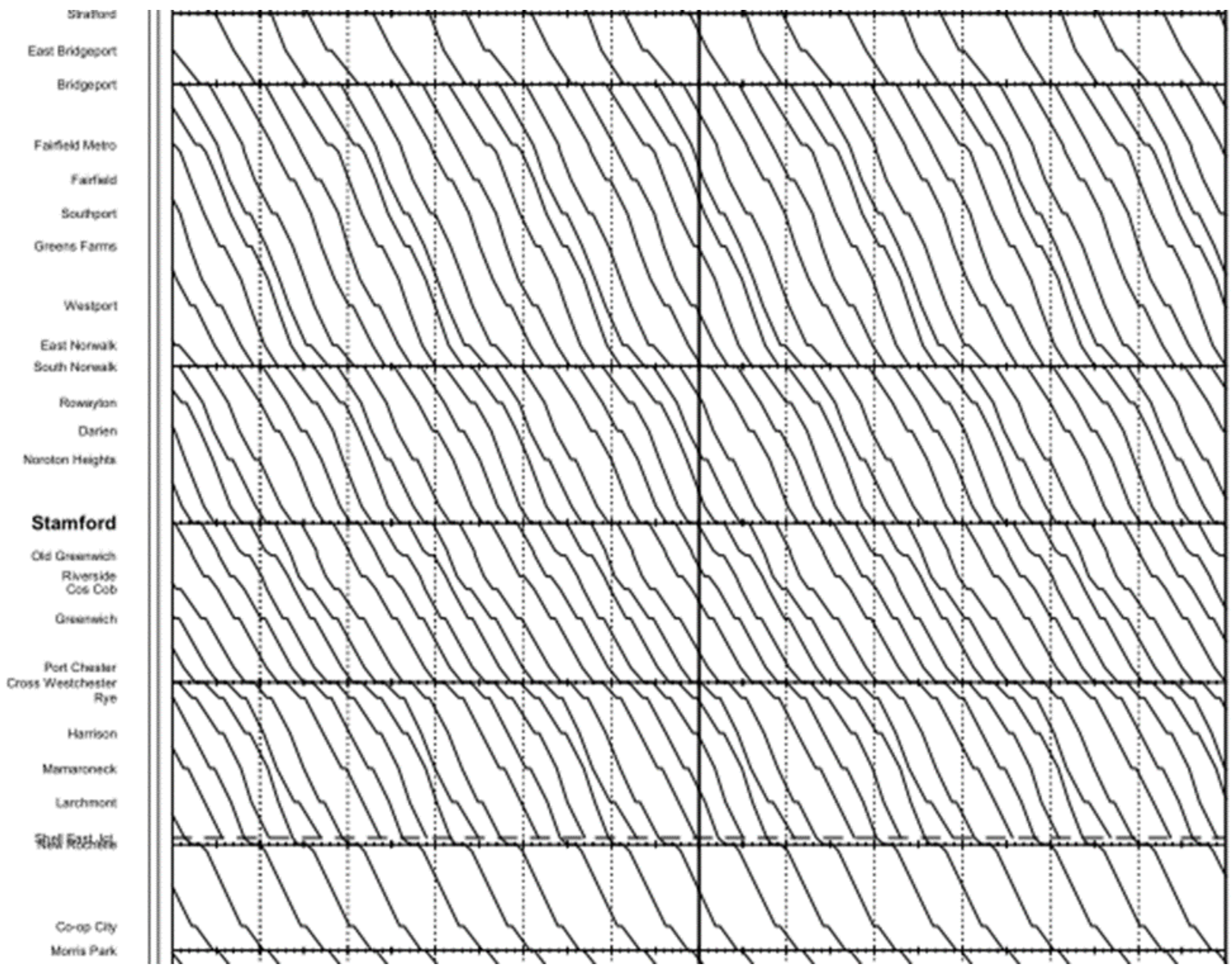
Under this example, local service is provided in an A-B-C skip-stop pattern (Figure 17). Each local pattern operates every 9 minutes. Alternating trains could run to Penn Station New York and Grand Central Terminal, providing local service at 18-minute intervals to each of these two terminals. Overall, local service operates at 3-minute headways on average during the peak periods, and the A-B-C stations are served by local trains every 3 minutes, with Grand Central and Penn Station New York each receiving 10 tph.

Intercity and Regional rail trains could operate on the express tracks at up to 20 tph (an average headway of 3 minutes) under this example. Half of these trains are Regional rail trains, destined for Grand Central Terminal or potentially split between Penn Station New York and Grand Central Terminal. Four Metropolitan trains and four Intercity-Express trains run via Penn Station New York. Essential characteristics of the transit-style A-B-C pattern include the following:

- Efficient use of track capacity and rail infrastructure, with all elements of both existing and new infrastructure highly utilized, major investment limited to chokepoint elimination, island platforms at express stations, and an expanded yard at East Bridgeport, CT
- Service at transit-like headways within the New Haven Line service territory
- Balanced operations in both directions, providing very high-quality reverse-commute service in addition to peak direction service to serve the growing intrastate demand within southwest Connecticut

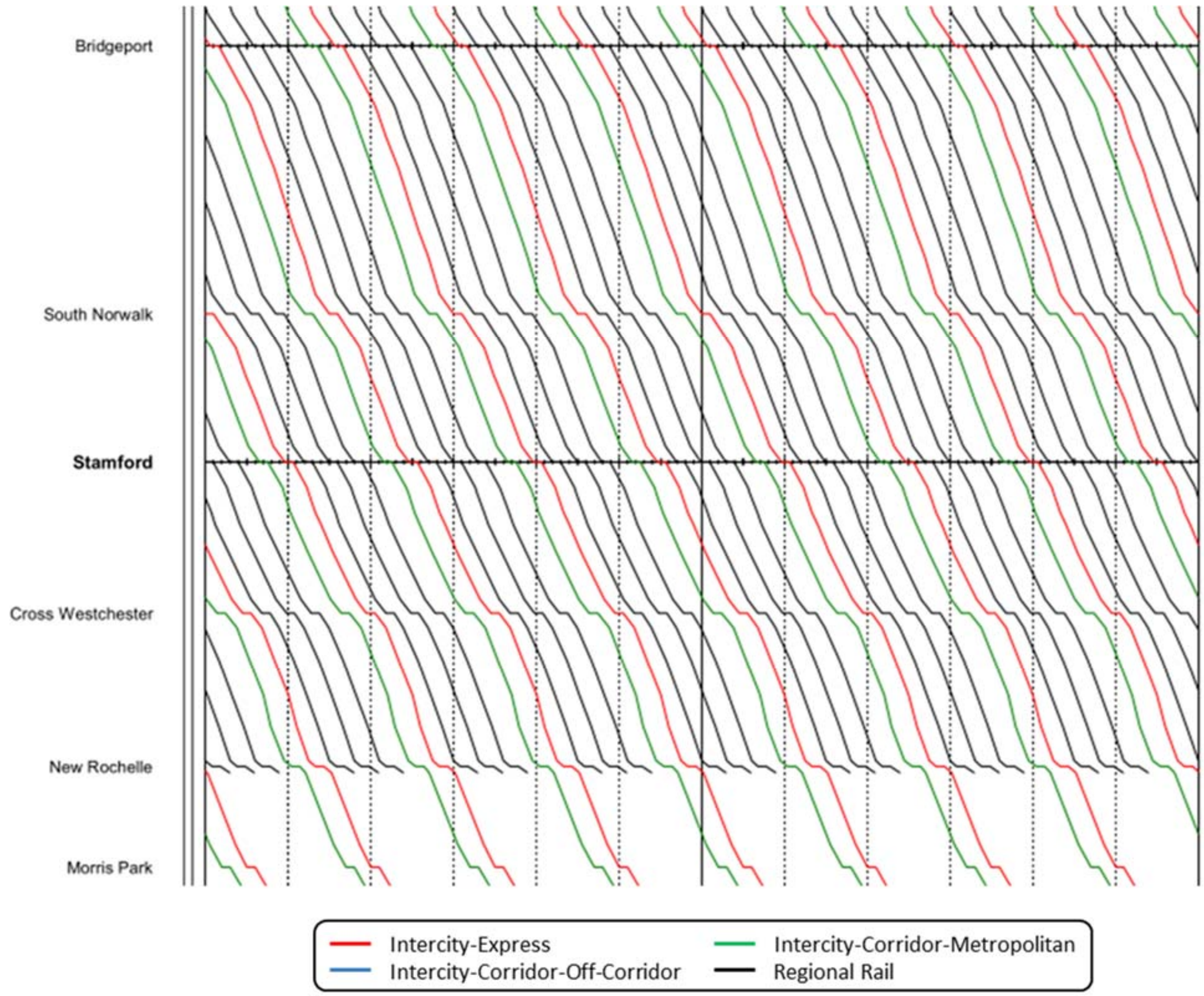
- Operations that can be sustained at peak levels over an extended period of time – the trains keep moving and are not constrained by limited yard capacity at terminals or limited reverse-direction capacity
- Service that tapers during peak shoulder hours and off-peak hours.

Figure 17: Transit-Style Service – Alternative 2 "A-B-C" Pattern – New Haven Line Local Tracks



Source: NEC FUTURE team, 2015

Figure 18: Transit-Style Service – Alternative 2 – New Haven Line Express Tracks



Source: NEC FUTURE team, 2015

Both of these examples of transit-style service are operationally feasible. The first example, with the A-B local pattern and 25 Regional rail trains per hour in the peak hours, was selected to represent Alternative 1 on the New Haven Line, because it meets the service objectives of this alternative at a significantly lower capital cost than a concept that provides the same level of service with traditional zone-express service patterns.

Traditional zone-express service patterns were retained for Alternatives 2 and 3, which have essentially the same service plan for Regional rail. These Action Alternatives increase the capacity of the inner portion of the New Haven Line by expanding it to six tracks. The service concepts in these Action Alternatives deliver the best express trip times and greater scheduling flexibility.

4.3.7 Shore Line East and Hartford Line

The No Action Alternative includes funded and committed service improvements, including the initial phase of service improvements included in the New Haven-Hartford-Springfield corridor plan.

All of the Action Alternatives provide for Regional rail service in the peak hour and peak direction at 15-minute headways on Shore Line East and 30-minute headways on the Hartford Line. This level of service provides ample capacity to accommodate projected 2040 Regional rail ridership to the north and east of New Haven, so the same service levels are provided in all three Action Alternatives.

Hartford Line Regional rail trains are assumed to terminate at New Haven with a transfer to NEC trains. In all three Action Alternatives, this is a coordinated timed transfer, intended to minimize wait times at New Haven and improve the predictability and convenience of rail travel.

As with the existing service, selected Shore Line East trains are extended to Stamford in the No Action Alternative and in Alternatives 2 and 3, to offer one-seat rides between Shore Line East stations and Stamford. Commuters to New York City are able to transfer to New Haven Line Regional rail trains at New Haven or Stamford. With transit-style service, Stamford becomes an inconvenient place to turn trains because of the higher volume of through-train service. Therefore, the Alternative 1 Service Plan terminates all Shore Line East service at New Haven, with coordinated timed transfers to both Intercity-Express and local Regional rail services.

The potential exists to integrate the Shore Line East and Hartford Line into the New Haven Line, and this was considered as a possible service plan variation. There are some concerns, however, that make full integration problematic, even assuming removal of institutional barriers. Issues include differences in train consists (driven by the significantly lighter ridership demand east and north of New Haven compared with the New Haven Line, and affecting station platform lengths and operating costs) and the potential need for electrification of the Hartford Line. The possibility of splitting New Haven Line trains at New Haven was considered, breaking up a single long New Haven train and running separate shorter sections to and from the Hartford-Springfield and Shore Line East routes. This approach requires high-precision operations, which are a basic assumption in Alternatives 2 and 3. It also leads to higher operating costs and has a potential impact on reliability. As a result, the Action Alternatives assume independent operation of these Regional rail services, with coordinated connections at New Haven. Tier 2 studies could examine the potential for more closely integrated Regional rail services within Connecticut, which is not precluded in any of the Action Alternatives.

4.3.8 Rhode Island and Massachusetts South and West of Boston Back Bay Station

The No Action Alternative includes funded and committed service improvements, including those planned for service and stations on the Fairmount Line between Readville and Boston South Station. Otherwise, the No Action Alternative assumes retention of existing levels of Regional rail service. The Action Alternatives include planned service improvements by 2040, including introduction of South Coast service to Fall River and New Bedford via the Stoughton Branch, plus increases in peak period service on all lines feeding Boston South Station.

Alternative 1 accommodates modest growth to these planned increases in service and minimizes the investment in new rail infrastructure capacity within Massachusetts. Schedule patterns are regularized to fit within the regular schedule patterns of the planned Intercity services. Needham Branch service operates at 2 tph in both directions exclusively on the third main track between Forest Hills and South Station so as not to conflict with main line train movements. Franklin Branch trains also operate at 30-minute intervals, sharing the third track with Needham trains in the peak direction, and running over the Dorchester Branch in the reverse-peak direction between Boston and Readville, to avoid the need to construct a fourth main track on the NEC main line inboard of Readville. This represents a slight reduction in Franklin Branch service frequency during the peak hour versus the existing condition and No Action Alternative, but the 30-minute headway service is sustained over a longer period, resulting in an increase in the total number of peak period trains.

Alternative 2 increases service frequencies in the standard peak hour on the NEC and branch lines feeding the NEC. This includes four Providence trains (two of which are extended to Westerly, RI), four Stoughton Line trains (two of which are extended to Fall River and New Bedford), and four Franklin Line trains. The Needham Branch continues to operate as in Alternative 1, with 30-minute headways in both directions. The cumulative total of Regional rail trains on the 3-track NEC between the Forest Hills and Back Bay stations increases to 12 tph in the peak direction of travel. In addition, Metropolitan service is available at Providence, Route 128, Back Bay, and South Station.

Alternative 3 provides Regional rail service on the Providence, Stoughton, Franklin and Needham branches that are equivalent to what is provided in Alternative 2. The variations of Alternative 3 that include two new high-speed tracks parallel to the existing NEC between Providence and Boston support the reduction in trip times from the Providence-Westerly outer zone by operating the zone-express trains on the high-speed tracks for the express portion of their trip. In the variations of Alternative 3 that provide a new high-speed second spine via Worcester, commuter express service can be offered on the Worcester Line.

4.4 CONNECTING CORRIDOR SERVICE

The following connecting corridors currently have train service onto or connecting with the NEC:

- Washington, D.C.-Richmond corridor, with extensions beyond Richmond to Newport News, Norfolk and Charlotte, NC, encompassing the Southeast High-Speed Rail (SEHSR) corridor
- Washington, D.C.-Charlottesville-Lynchburg-Roanoke, VA
- Keystone Corridor extended (Philadelphia-Harrisburg-Pittsburgh)
- Empire Corridor extended (New York-Albany-Buffalo-Cleveland, plus potential links with faster trip times from New York to Montreal and Toronto)
- Knowledge Corridor (Springfield-Burlington, VT), with an extension to Montreal, Quebec
- Inland Route – Springfield-Worcester-Boston
- Downeaster Corridor (Boston-Portland-Brunswick, ME), though serving a different station in Boston than NEC service.

Based on the service and ridership analysis undertaken by the FRA for the Preliminary Alternatives, the FRA determined that demand for direct service to the NEC from the connecting corridors can be accommodated in the standard peak hour on two trains operating in both directions. The FRA also reviewed the most recent plans by the states and railroad operators for service growth on the existing NEC connecting corridors and confirmed that these plans are not expected to generate demand for rail service onto the NEC in excess of 2 tph in any given hour. Therefore, the Action Alternatives reserve a minimum of two slots per hour, spaced 30 minutes apart, along the NEC between Washington, D.C., and New Haven. The two slots continue north of New Haven to both Boston (via the Shore Line) and Springfield. Trains can be routed either way, depending upon demand. The Keystone Corridor is provided with two additional train slots on the NEC between Philadelphia and New York, separate from the slots provided from Washington, D.C., to New Haven. These slots can be configured either for Metropolitan trainsets or traditional Intercity-Corridor-Other trains. Because the Keystone Corridor is electrified to Harrisburg and has physical and operating characteristics similar to the NEC, Metropolitan equipment is planned for in Alternatives 2 and 3. Alternative 1 retains the use of traditional locomotive-hauled coaches, to enable a comparison of relative performance. Empire Corridor service is assumed to continue to originate and terminate at New York, so these trains are not assumed to operate in revenue service on the NEC, although the trains themselves operate at Penn Station New York. The Action Alternatives include two Empire Corridor trains in each direction in the standard peak hour. Empire trains requiring servicing or storage at New York also operate through the East River Tunnels to and from Sunnyside Yard in Queens.

The slots for Intercity-Corridor-Other trains are provided in the service plan throughout the day. However, the service itself is expected to exhibit peaking characteristics similar to other Intercity services. Interregional business and non-business travel, somewhat like commuter travel, has morning and afternoon peaks that occur over about a three-hour period in both mornings and afternoons. However, given the longer trip distances involved in interregional travel, these peaks will not all occur at the same time in all locations on the NEC, so the Intercity service peaking patterns will not be as sharply defined as was shown in Figure 1 in Section 2.4 for Regional rail service. Intercity-Corridor-Other service from the connecting corridors will fill the allotted two slots per hour at certain times of day. At other times of day, fewer trains are operated. As a result, not all slots for Intercity-Corridor-Other trains are filled at non-peak times of day. The initial Service Plans had relatively robust daily services in each of the existing connecting corridors, allowing for peak demand that occurs in different parts of the NEC at different times. Upon review of initial ridership results and Intercity-Corridor-Other plans being prepared by the states and railroad operators, the FRA reduced the level of Intercity-Corridor-Other service outside of the business peak hours for Intercity-Express travel, to reflect an appropriate balance between estimated passenger-miles and the available seat-miles on these Intercity-Corridor-Other trains provided by the Service Plans. With the provision in the Service Plans of regular Intercity-Corridor-Other slots throughout the day, the Action Alternatives all provide the flexibility to grow connecting corridor service in line with passenger demand and investment in these corridors, up to the limit of 2 tph in any given hour. Table 7 summarizes the level of existing service and the range of service levels considered for the Action Alternatives, for the existing connecting corridors that feed the NEC.

Table 7: Connecting Corridor Service Levels

Connecting Corridor	Standard Peak Hour		Daily Round Trips	
	Existing/ No Action	All Action Alts	Existing/ No Action	All Action Alts
Keystone Corridor				
▪ Philadelphia-Harrisburg	1	2	16	16-24
▪ Harrisburg-Pittsburgh			1	1
Hartford Line				
▪ New Haven-Springfield	1	2	6	16-24
▪ Springfield-Boston (Inland Route)			-	12
▪ Springfield-Vermont (Knowledge Corr.)			1	2
Virginia and North Carolina Corridors				
▪ Washington-Richmond	1	2	9	21
▪ Richmond-Newport News			2	3
▪ Richmond-Norfolk			1	6
▪ Richmond-Charlotte			1	5
▪ Washington-Charlottesville			3	6
Empire Corridor				
▪ New York-Albany	1	2	13	23
▪ Albany-Buffalo			4	9
▪ Niagara Falls-Toronto			1	1
▪ Albany-Montreal			1	1
▪ Albany-Rutland			1	1

Note: Includes Long-Distance services and excludes Amtrak Auto Train. Train counts for the individual line items are not additive; they represent total daily Intercity round trips operating in each segment.

The service analysis also considered the introduction of service onto the NEC from potential new connecting corridors, which were identified as part of the Scoping process. Capital investment, as well as new railroad access agreements, would be required to implement such connecting service in the future. Opportunities include the following:

- Delmarva Peninsula and Ocean City, MD
- Atlantic City, NJ
- Lehigh Valley (Allentown and Bethlehem, PA)
- Scranton, PA and Binghamton, NY
- Eastern Long Island
- Montreal, QC [Canada] via several potential new high-speed routes
- Cape Cod, MA
- Providence, RI-Worcester, MA
- Direct linkage from NEC to Downeaster Corridor serving Portland and Brunswick, ME

Capacity is available off-peak to fill unused Intercity-Corridor slots with trains from other corridors. However, new markets are assumed to demand service during peak periods, so it was not considered reasonable to plan additional connecting corridor service that operate only outside of the peak travel periods. Alternatives 1 and 2 concentrate on markets within the NEC and existing connecting corridors. New service only becomes feasible within Alternative 3; therefore, Intercity service in new connecting corridors was considered in the context of Alternative 3 and the transformative vision for the future of the NEC. All of the Action Alternatives support the provision of convenient passenger transfers between new or expanded Intercity-Corridor-Other services and NEC Spine services at the Hub stations where connecting corridors meet the NEC. The ridership potential of these new corridors was not directly estimated, nor was a comparative evaluation or ranking of new connecting corridor services or further enhancements to existing connecting corridor service undertaken as part of NEC FUTURE.

4.5 RAIL INFRASTRUCTURE CONFIGURATION

The configuration of tracks, junctions, station platforms and yards is integrally tied to the rail service plan for each alternative. As was the case with Service Plans, an initial set of assumptions about the configuration of NEC rail infrastructure was made for each Action Alternative. As the FRA tested various hypothetical service concepts and refined the Service Plans, the FRA made corresponding adjustments to the rail infrastructure configurations to ensure that new infrastructure meets the needs of the various rail services and that, in turn, the Service Plans make productive use of the proposed rail infrastructure. This iterative process of refining both the Service Plans and the associated infrastructure configurations maintained an appropriate service and infrastructure balance in each of the Action Alternatives.

Additional infrastructure-related work performed in parallel with the testing of service plan concepts included:

- Confirmation of the location, configuration, and scope of chokepoint relief and bypass projects
- Extent of bypasses and 6-track railroad required for capacity, especially in the territory surrounding New York City
- Identification of opportunities to decrease trip times and increase average speed

4.6 MAJOR STATIONS, TERMINALS AND YARDS

4.6.1 Washington, D.C.

The physical and operational characteristics of the Action Alternatives within the Washington, D.C., terminal area address the needs and requirements identified in the 2012 Washington Union Terminal Master Plan[29] prepared by Amtrak (WUTMP). The levels of rail service in the Action

[29] The Washington Union Terminal Master Plan was completed by Amtrak in 2012. Amtrak and its partners at Washington Union Station are continuing to develop master plan concepts and a phased implementation plan for station and yard improvements at Washington, building upon the 2012 Master Plan. The specific elements of the

Alternatives correspond closely with the major implementation phases established for the WTUMP. Implementation of Phases 1, 2 and 3 of the WUTMP results in the reconfiguration of the track and platform area of Union Station to create a facility that meets modern train movement and passenger handling standards for a high-performing rail terminal. The station includes 12 stub-end platform tracks and eight run-through platform tracks feeding the tunnel leading to the Potomac River and Virginia. This configuration supports the peak and daily traffic levels for Intercity and Regional rail traffic included in Action Alternatives 1 and 2. A fourth phase of the WUTMP further increases the capacity of the Union Station complex by constructing a new lower level of tracks and platforms, connected by new tunnels to the NEC main line and to terminal yard facilities. These facilities are included in Alternative 3. The new lower level station supports future high-density Intercity-Express operations, freeing up capacity on the upper levels for expansion of Regional Rail, through-running Metropolitan service, and Intercity-Corridor-Other traffic.

4.6.1.1 Train Movements

Table 8 presents the standard peak-hour train volumes, by type of service and location within Union Station, for the Action Alternatives. The levels of traffic are comparable to those analyzed in the WUTMP. A significant exception is Metropolitan service (described in Section 2.3), which is a new type of service identified as part of NEC FUTURE and essentially takes the place of the existing Northeast Regional service, on which the WUMTP was based.

Table 8: Washington Union Station – Standard Peak Hour-Peak Direction Revenue Train Movements in 2040

Service Type	Alternative 1	Alternative 2	Alternative 3
Intercity-Express	2	4	6
▪ Originate/Terminate (via West Side stub tracks)	*2*	*4*	—
▪ Originate/Terminate (via new lower level tracks)	—	—	*6*
Intercity-Corridor			
Virginia off-corridor ▪ All trains via East Side	2	2	2–4
Metropolitan	2	4	4
▪ Run-Through (via East Side)	—	*4*	*4*
▪ Originate/Terminate (via West Side stub tracks)	2	—	—
MD Regional rail/Commuter (MARC Penn Line)	6	10	12
▪ Run-Through (via East Side)	—	*4*	*4*
▪ Originate/Terminate (via West Side stub tracks)	*6*	*6*	*8*
VA Regional rail/Commuter (VRE)	6	8	8
▪ All trains via East Side			

Source: NEC FUTURE team, 2015

Table 9 provides a breakdown of the volume and mix of trains projected to be operating on the east side of Union Station in the 2040 horizon year under NEC FUTURE Alternatives 2 and 3, where this

master plan may be revised as a part of this work, which is proceeding in parallel with NEC FUTURE and is being coordinated by the FRA in concert with Amtrak and other stakeholders.

portion of the station complex is estimated to operate at the maximum practical level of capacity utilization :

Table 9: First Street Tunnel – PM Peak Hour Train Movements – Alternatives 2 and 3

Service	PM Peak Hour Southbound	PM Peak Hour Northbound
Intercity-Corridor	2–4	2–4
Metropolitan	4	4
VRE Peak Direction	8	—
VRE Reverse Peak	—	4
MARC Run-Thru	—	4
Total	**14–16**	**14–16**

4.6.1.2 East Side Track and Platform Configuration

The most critical area of the station is the east side, with the tracks that run through to and from Northern Virginia. This is the part of the station that is most physically constrained, in terms of both horizontal and vertical alignment, and it is the part of the station that is expected to see the greatest proportional growth in traffic, especially over the next decade. Consequently, the long-range configuration aims to maximize the capacity of the East Side zone, and to enable smooth through-running operations with dwell times that are as short as practically possible. The WUTMP proposes widening this zone and expanding from six to eight platform tracks. Wider platforms and ample vertical circulation capacity are provided to permit trainloads of boarding passengers to be positioned on the platforms before a through train arrives. Three low platform edges are provided to support VRE operations with low-level boarding Gallery equipment. In addition, there are six platform edges (three island platforms) that permit high-level boarding.

Reconfiguration of this zone was identified in the WUTMP as the highest priority for major investment, which commences in Phase 2 of the WUTMP. Phase 2 also provides space below the track and platform level for future program requirements of vehicle parking, taxis and potentially the bus terminal, so that the existing parking garage structure can be taken down at the start of Phase 3.

The east side tracks are configured to facilitate the continuation of engine changes for Intercity-Corridor and Long-Distance trains that operate through Washington, D.C. The strong preference is to eliminate engine changes altogether with the advent of high-performance dual-mode locomotives that can operate at 125 mph on the NEC and also at up to 100 mph on the Class I freight network – or with the electrification of the main line to the south of Union Station. However, the WUMTP protects the ability to continue engine changes in the short to medium term with shorter station dwells, by configuring the interlocking north and south of the east side platforms to permit engines to be staged and moved in parallel with normal revenue train movements. Full flexibility to simultaneously continue engine changes while increasing the frequency of train movements require reconstruction of the northern portion of the First Street Tunnel (generally in the zone beneath Massachusetts Avenue) to provide an engine pocket track and parallel through-running capability. With either electrification or introduction of dual-mode locomotives, however, the need for this costly tunnel reconfiguration is avoided.

4.6.1.3 Yards and Equipment Maintenance

Requirements, initial options and concepts for increasing train storage and maintenance capacity at Washington, D.C., developed as part of the Washington Union Terminal Master Plan, have been the basis of NEC FUTURE's planning. Amtrak's subsequent Washington Terminal Yard Master Plan, however, represents the most recent and comprehensive source of information and findings from this work effort should supersede the earlier work. There are some key conclusions that still hold and which should guide future planning.

VRE midday storage is most effective if located on the east side of NEC right-of-way, with dedicated track access from the Union Station east side platform tracks, so the VRE trains going to and from the yard are not required to cross the path of NEC trains going to and from the stub-end platform tracks.

Potential run-through service for Maryland Regional rail trains (MARC) and/or Metropolitan trains, with a storage and maintenance facility in Northern Virginia, reduces the requirement for yard expansion on the north side of Washington, D.C., assuming that sufficient capacity is provided for these trains in the Long Bridge corridor.

4.6.2 Philadelphia

30th Street Station retains its track and platform configuration in each of the Action Alternatives. The lower level of 30th Street station, which serves Intercity and NJ TRANSIT Atlantic City trains, has ample capacity and is well configured to accommodate planned growth in service. Alternative 1 requires no significant changes to the infrastructure configuration. Alternative 2 utilizes the existing platform and track configuration at the station, but reconfigures the terminal interlocking and expand the approaches on both the north and south sides of the station from two tracks to four tracks, to facilitate the operation of 30th Street as a hub for convenient transfers between rail services. Alternative 3 provides a new route via downtown Philadelphia for Intercity-Express and selected Metropolitan trains. The Alternative 3 Service Plan, however, is intended to preserve and enhance Intercity service at 30th Street Station, even with the development of a new downtown station at Market East. Metropolitan service at 4 tph operates via 30th Street, along with Intercity-Corridor-Other services and Long-Distance trains. Virtually all Philadelphia Regional rail trains are routed through Center City Philadelphia and serves both 30th Street Station (on the upper level) and Market East. Table 10 summarizes standard peak-hour train movements, by train type, on the NEC north and south of Philadelphia for the No Action and Action Alternatives.

Table 10: Philadelphia Area – Standard Peak Hour-Peak Direction Service in 2040

South Screenline	Existing	No Action	Alt. 1 Maintain	Alt. 2 Grow	Alt. 3 Transform
Number of Tracks	4	4	4	6	6
Standard Peak Hour (Trains/Hour)	7	7	14	20	28-30
Intercity-Express	1	1	2	4	6
Intercity-Corridor	1	1			
Metropolitan			2	4	4
Intercity-Corridor-Other			2	2	2-4
Regional rail Lines					
Wilmington-Newark	3	3	6	8	12
Philadelphia Int'l. Airport	2	2	2	2	8
North Screenline					
Number of Tracks	4	4	4	4	6
Standard Peak Hour (Trains/Hour)	10	10	15	22	28-30
Intercity-Express	1	1	2	4	6
Intercity-Corridor	2	2			
Metropolitan			3	4	8
Intercity-Corridor-Other			2	2	2-4
Regional rail Lines					
Trenton Line	4	4	4	6	6
Chestnut Hill West Line	2	2	2	4	4
Atlantic City	1	1	2	2	2

Source: NEC FUTURE team, 2015

Intercity rail services on the NEC generally operate through Philadelphia, especially in the peak hours. As service builds in the hours prior to the morning and afternoon peak hours, selected Intercity-Express and Metropolitan trains originate at Philadelphia, heading northward toward New York. Similarly, as service tapers in the hours following the peak hours, selected trains from the north terminate at Philadelphia. These originating and terminating trains require yard storage at Philadelphia, assumed to be provided at or in the vicinity of the Coach Yard adjacent to 30th Street Station. Yard storage requirements are a function of the extent of the service tapering.

Keystone Corridor service comprises a combination of trains that continue onto the NEC in the direction of New York, and trains that originate, terminate or turn at Philadelphia 30th Street Station. Keystone service requires yard space for both overnight and midday storage of trains.

In Alternative 2, there are three sets of Metropolitan services at 30th Street Station, each with 2 tph offset at 30-minute intervals. One set operates between Boston and Washington, D.C., on the NEC. A second set operates from Boston and New York on the NEC and serves the Keystone Corridor, with trains changing direction at the lower level platforms as is done today. A third set operates between Philadelphia and Washington, D.C., filling the gaps in the 15-minute Metropolitan headways left by the Keystone trains; this third set of Metropolitan trains, in this alternative, require yard space at Philadelphia for equipment turns and for overnight and midday storage.

4.6.3 New York

Multiple planning initiatives are underway in and around the New York rail terminal, comprising Penn Station New York, the Hudson and East River tunnels and approaches, the New Jersey Meadowlands and western Queens, NY.[30] Since these initiatives are running in parallel with NEC FUTURE, the NEC FUTURE service and infrastructure plans remain generalized so as avoid conflict with more detailed plans that are under development. Service Plans were developed and infrastructure investments identified, based on appropriate assumptions representative of potential future conditions in the New York terminal area, in order to confirm the operational feasibility of Service Plans and estimate potential ridership and the order-of-magnitude capital cost of capacity-related improvements.[31]

4.6.3.1 New York Area Capacity Assumptions

The segment of the NEC which serves the New York region, between northern New Jersey and the New Haven Line in Connecticut, has the heaviest Intercity and Regional rail demand and the greatest densities of train service. Current demand fills the existing available line and terminal capacity to the maximum during the weekday peak periods. Future demand for Regional rail also was estimated to fully utilize the service provided in each of the Action Alternatives. As a result, the FRA confirmed reasonable assumptions for the practical capacity of these portions of the NEC. The FRA used available simulation modeling tools and assumptions about future signal system capabilities and trainset performance to perform a signal wake analysis[32] and determine the maximum practical headways for trains operating on the existing and planned future NEC tracks. The FRA then combined these headways with the stopping patterns for each of the three Alternatives to determine the practical capacity of the line.

In addition, the FRA reviewed prior studies and analyses of the capacity of the Penn Station New York complex to generate reasonable estimates of the incremental station capacity improvements that is accomplished with station expansion. The FRA assumed that minimum practical station dwell times for originating, terminating, turning and through train movements and considered configurations with the existing narrow station platforms and configurations with reconstruction and/or expansion of the station with wider platforms. All of these analyses, taken together, helped the FRA understand the maximum practical capacity of the systems feeding Penn Station New York across both the Hudson and East River screenlines for the No Action Alternative (including completion of the LIRR East Side Access project) and for each of the Action Alternatives. Figure 19

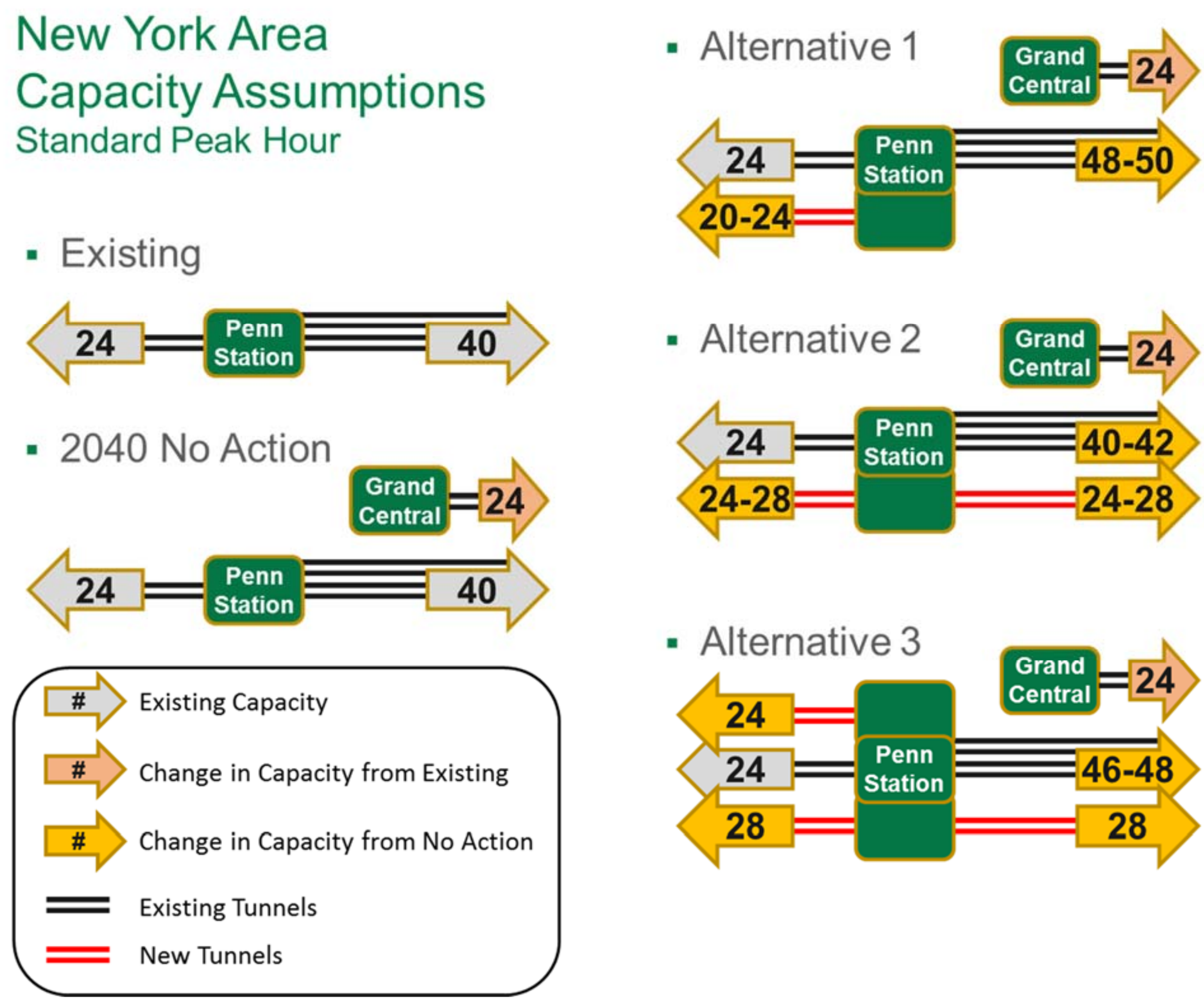
[30] These initiatives include the Moynihan Station redevelopment, vision planning for existing Penn Station New York on the part of the railroads that operate at Penn Station New York, a Master Plan for Sunnyside Yard in Queens, the Metro-North Penn Station Access plan, and the Amtrak Gateway initiative to construct new Hudson River tunnels, expand Penn Station New York and Secaucus Station and replace the Portal movable bridge across the Hackensack River.

[31] NEC FUTURE is not prescriptive with respect to future operating plans for rail traffic through New York, and Tier 2 studies subsequent to NEC FUTURE will determine the specific configuration of tunnels, tracks, station facilities and yard facilities to be provided in the New York area—and how they will be operated.

[32] Signal Wake Analysis is a quantification of line capacity, based on simulated signal clearing time for capacity-critical segments of a rail line, using a computer simulation model of the line's physical characteristics, including the signaling and train control system, and the rail traffic operating over the line.

presents the assumed practical capacities for each alternative. All service plan scenarios tested kept standard peak hour traffic within these limits of practical capacity.

Figure 19: Standard Peak-Hour Practical Capacity at Hudson River and East River Screenlines



Source: NEC FUTURE team, 2015

4.6.3.2 Service Plan Characteristics

Table 11 and Table 12 present the Standard peak-hour train movements in the year 2040 at the Hudson River and East River screenlines, by train type for the No Action and Action Alternatives.

Table 11: Hudson River Screenline – Standard Peak Hour-Peak Direction Service in 2040

	Existing	No Action	Alt. 1 Maintain	Alt. 2 Grow	Alt. 3 Transform
Number of Tracks	2	2	4	4	6
Capacity (Trains/Hour)	24	24	44–48	48–52	76
Standard Peak Hour (Trains/Hour)	24	24	37	52	70
Intercity-Express	1	1	2	4	6
Intercity-Corridor (includes Metropolitan and Intercity-Corridor-Other trains)	2	2	5	6	10
NEC and North Jersey Coast Line	15	15	20	22	24
Other Regional Branch Lines	6	6	10	20	30

Table 12: East River Screenline – Standard Peak Hour-Peak Direction Service in 2040 (Penn Station New York Trains Only)

	Existing	No Action	Alt. 1 Maintain	Alt. 2 Grow	Alt. 3 Transform
Number of Tracks	4	4	4	6	6
Capacity (Trains/Hour)	40	40	48–50	68–70	74–76*
Standard Peak Hour (Trains/Hour)	40	40	48	60	66–74
Intercity-Express	1	1	2	4	6
Intercity-Corridor (includes Metropolitan and Intercity-Corridor-Other trains)	3	3	4	6	10
Regional rail Trains	36	36	42	50	50–58

* The increase in overall peak hour capacity indicated for Alternative 3 reflects capital investment in the capacity of the existing East River Tunnels and Penn Station New York complex, to increase capacity. This work is included in Alternatives 1 and 3. It is not needed to support service levels in Alternative 2 and therefore this capital work and its associated capacity are not included in the plan for Alternative 2.

Current Intercity service on the NEC is heavier to the south of New York than to the north. With improvements in both capacity and trip time on the north end of the NEC, future operations are expected to be more balanced. During peak hours, Intercity trains of all types operate through New York. In Alternative 1, these trains utilize existing tracks and platforms at Penn Station New York, and dwell times of at least 12 minutes are required to ensure that alighting and boarding passenger volumes can be handled safely and that there is sufficient time for train servicing activities and crew changes. In Alternatives 2 and 3, Service Plans are based on Intercity trains utilizing station facilities with platforms and passenger and service circulation facilities that are sufficiently sized to efficiently handle through trains, with minimum dwell times on the order of eight minutes.

Even though Penn Station New York is configured mostly as a through station, current Regional rail operations of the LIRR and NJ TRANSIT use the facility exclusively as a terminal.[33] Both railroads

[33] Metro-North Railroad and NJ TRANSIT currently cooperate to provide a Metro-North service that operates through Penn Station New York from the New Haven Line to Secaucus, NJ, on selected weekends, to carry

utilize yards on the far side of Penn Station New York for storage and equipment turning, which allows for through-running train movements at Penn Station New York, but not run-through revenue operations. These yards, however, have limited capacity and are not easily accessed from all station tracks, so many trains of both railroads turn at the station platforms and often occupy those platforms for extended periods of time. Alternative 1 continues to use Penn Station New York primarily as a terminal station for Regional rail, similar to today's operations. The expanded Penn Station New York, accessible to the new Hudson River tunnel tracks, functions as a stub-end terminal. Alternatives 2 and 3are based on maximizing through-running operations to and from expanded far-side storage yards,[34] also providing connections between Regional rail lines on both sides of New York. Linking Regional rail branch lines with run-through revenue service is possible in these Service Plans, and reduces the number of required train movements, which is important during the commuter peak periods. However, it is not a prerequisite for these Service Plans to be feasible. Although new travel patterns from one side of a metropolitan region to the other benefit from run-through service, ridership potential for trips from one side of the region to the other is estimated to be relatively low, compared with rail ridership to and from the Manhattan CBD. This reflects the relatively low volume of total trips more than any shortcomings related to the level and quality of rail service. Consequently, the principal reasons for through-running operations at Penn Station New York are not market-related but instead derive from the ability to reduce operational conflicts and efficiently utilize the available railroad infrastructure.

Deterministic service planning analyses were undertaken to test a number of potential operating patterns through and at Penn Station New York, based on available data and prior simulation and capacity analyses that have been performed at the station. Additional detailed operations analysis was not undertaken as part of this Tier 1 Draft EIS.

4.6.3.3 Yards and Equipment Maintenance

During the shoulders of the peak periods and at the beginning and end of the service day, selected Intercity trains operating in both directions originate or terminate at New York and require access to storage yard and maintenance facilities, which continues to be concentrated at Sunnyside Yards in Queens.

Expansion of existing yards and/or new facilities in the Meadowlands area of New Jersey and in western Queens are provided as part of the Action Alternatives. Regional rail midday storage requirements increase as the level of peak rail service increases among the Action Alternatives.

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passengers attending sporting events at the Meadowlands sports complex. This is the only example of through-running Regional rail service in New York City. Such service is not provided at present during weekday peak periods.

[34] Sunnyside Yard in Queens, NY, is an example of a far-side yard for NJ TRANSIT. Some morning peak New Jersey Regional rail trains, after discharging passengers at Penn Station New York, continue onward as non-revenue trains (i.e., without passengers) through the East River tunnels to Sunnyside, where they are stored until it is time for their return trip to New Jersey. This mode of operation allows for relatively short dwell times at Penn Station New York and minimizes train interference delays. Alternative 2 expands this concept for New Jersey, Long Island, and New Haven Line Regional rail services, entailing either expansion of existing yards or the construction of new yard facilities in both Queens and on the New Jersey side of the Hudson River tunnels.

4.6.4 Boston Area Capacity Assumptions

Action Alternatives rely on the completion of the Boston South Station Expansion Project being advanced by MassDOT with the support of the FRA, which will expand the platform track capacity at South Station and reconfigure the terminal interlockings, providing space to accommodate a greater number of peak train movements to and from South Station. In Alternatives 1 and 2, the planned South Station expansion is estimated to be sufficient to accommodate the level of Intercity and Regional rail train movements and passenger traffic estimated for 2040. Service specifications for Intercity and Regional rail service on the NEC approach to South Station were shared with MassDOT, and it was agreed that these levels of service were consistent with the level of rail traffic that can be accommodated by the planned expansion project.

In Alternative 3, however, the total level of traffic in the standard peak hour is estimated to exceed the capacity of the South Station complex, even with the planned expansion. New rail terminal facilities, therefore, are assumed to be constructed at some point subsequent to the South Station expansion but prior to 2040, in this alternative. NEC FUTURE does not specify the precise location of these new facilities, the associated changes to the rail network that is needed to take advantage of the increased capacity, or the extent to which improved rail service and access within the greater Boston region affects travel choices and patterns within the region. Additional Boston area capacity takes several forms, including further expanding the capacity of the Boston South Station complex, terminating some service within the Boston region but short of South Station (with transfers to Regional rail or rail transit services), or re-routing some service to other locations within the Boston region. Decisions about the specific future rail network configuration are beyond the scope of NEC FUTURE and will be part of subsequent Tier 2 analyses.

For purposes of ridership estimation, all Intercity rail services are assumed to originate and terminate at Boston South Station in all of the Action Alternatives. Similarly, all Regional rail services on the south side of Boston are assumed to continue to operate to and from South Station. Table 13 presents standard peak-hour train movements, by train type, for trains operating on the NEC to and from Boston, for the No Action and Action Alternatives.

Table 13: Boston South Screenline (South of Back Bay Station) – Standard Peak Hour-Peak Direction Service in 2040

	Existing	No Action	Alt. 1 Maintain	Alt. 2 Grow	Alt. 3 Transform
Number of Tracks	3	3	3	3	5
Standard Peak Hour (Trains/Hour)	10	10	17	22	24–32
Intercity-Express	<1	<1	2	4	2–6
Intercity-Corridor / Metropolitan	<1	<1	3	4	2–6
Regional rail Trains	9	9	12	14	20

Source: NEC FUTURE team, 2015

4.7 FREIGHT RAIL

- The NEC FUTURE Scoping process, along with input received from freight rail operators and state and regional stakeholders identified the preservation and enhancement of freight rail as an important concern, and the identification of opportunities to facilitate improved freight rail service as an important objective of NEC FUTURE. NEC FUTURE Service Plans for each of the Action Alternatives preserve freight access on the NEC and do not preclude future growth opportunities. Specific assumptions were developed for the mixed operations of freight and passenger traffic on the same tracks and in the same right-of-way, consistent with the current FRA regulatory framework: Freight will not operate on high-speed tracks in mixed traffic with Intercity-Express passenger trains operating above 160 mph – this includes all new route segments included in Alternative 3
- Mixing of different types of passenger trains, including Intercity-Express and Metropolitan service using new high-performance equipment, are assumed to be permissible in the future on the existing NEC with passenger train speeds up to 160 mph – this applies mostly to the express tracks on the NEC where there are more than two main tracks, in all three Action Alternatives[35]
- New tracks generally will be built with sufficient separation from parallel tracks used by freight trains to permit simultaneous operation of freight and passenger traffic; however, temporal separation of freight traffic may be required for some portions of the NEC where existing express tracks are used by high-speed trainsets and are closely parallel to the existing local tracks, such as in Pennsylvania, New Jersey and Massachusetts.

As part of NEC FUTURE, locations were identified where freight traffic operates on the NEC. Future freight rail traffic is difficult to forecast, and the freight railroads adjust their business plans year to year as a result of changing market conditions. The FRA, therefore, in lieu of preparing long-range freight forecasts, identified opportunities in all three Action Alternatives to facilitate or allow for increased freight service at selected locations where future demand likely increases. As an example, the portions of the NEC that have overhead[36] freight traffic today that is restricted to nighttime access includes investment in additional track capacity that permits daytime overhead freight operations on the local tracks, while Intercity-Express service is operated on separate express tracks.

In addition to preserving freight rail access to local industries along the NEC and not precluding future expansion of freight rail service, the Action Alternatives were reviewed with respect to their potential effects on four specific potential freight traffic growth opportunities:

- Freight access to Port of Baltimore, Port of Wilmington and Delmarva Peninsula
- Freight access along the NEC in Southeastern Connecticut and Rhode Island

[35] Railroad operating characteristics and limitations on permissible maximum speeds and the mixing of freight and passenger traffic are described more fully in Section 8.1.
[36] Overhead freight trains are defined to be through trains that operate from one end of a segment of railroad to the other, without stopping at intermediate locations. This is distinct from local freight trains, which serve industrial customers or call at yards located within the segment.

- Potential high-capacity, double-stack clearance freight line parallel to NEC between Washington, D.C., and northern New Jersey
- Freight rail access to Long Island and New England

In the Baltimore to Wilmington segment, all Action Alternatives expand the existing NEC to four tracks, replace or expand the two-track Gunpowder, Bush and Susquehanna River crossings to provide four tracks, and provide daytime slots for through-freight trains. Norfolk Southern uses the NEC to access the ports of Baltimore and Wilmington and to serve the Delmarva Peninsula. With a four-track main line, Intercity-Express and Metropolitan services operate on tracks that are separate from Regional rail and freight traffic, and crossings of the express and local tracks are grade-separated to permit access to freight branch lines and port and yard facilities that exist on both side of the right-of-way. Freight trains and Regional rail trains operate in mixed traffic on the local tracks, with commuter traffic dominating during weekday peak periods and freight rail having priority during overnight hours. Regional rail stations will have high platform edges that meet the requirements for level boarding under the Americans with Disabilities Act and enable rapid passenger boarding and alighting. Freight trains need to be dimensioned to be compatible with high platforms, or additional infrastructure will need to be built at stations, such as gauntlet tracks or freight bypass tracks. The formal wide clearance freight route remains on existing NEC express tracks, but will be used only during overnight hours or on a contingency basis.

Similar issues and opportunities exist in the territory where the P&W railroad operates in Southeast Connecticut and Rhode Island:

- All Action Alternatives envision operation of Tier III passenger equipment along the existing Shore Line route.
- Temporal separation of freight traffic on the NEC may be required in certain locations where investment in parallel track capacity is not economically warranted.
- Expansion of track capacity for increased passenger service will need to consider grade separation of key freight moves where warranted (e.g., Quonset, RI).

Conditions vary among the Action Alternatives in this territory:

- Alternative 1 and Alternative 3 variations with the second spine route via Worcester
  - Express service continues to be operated via the Shore Line, at frequencies greater than today.
  - Mixed Tier IIII operations are possible at New Haven-Old Saybrook at speeds less than 125 mph.
  - The Old Saybrook-Kenyon bypass allows for Intercity passenger trains to operate separately from freight trains.
  - Kenyon-Providence: a parallel freight track is provided to permit Tier III passenger operations on express tracks at up to 160 mph.

  - Grade-separated access for freight trains to the Narragansett Bay port facilities at Davisville is provided.
- Alternative 2 and Alternative 3 variations with Intercity-Express service in the Hartford-Providence corridor
  - Express service is provided via the New Haven-Hartford-Providence new route, enabling increased freight use of the Shore Line.
  - Passenger/freight trains are able to operate on the Shore Line route in a Tier I operating environment at passenger speeds up to 125 mph.

Each of the Action Alternatives preserves the future opportunity to create a dedicated north-south high-clearance, high-density freight line, which remains a long-term goal of Northeast transportation planners. Alternative 3 does the most in terms of providing new rail infrastructure that can be used by freight trains in portions of the corridor in Maryland, and freeing up the existing NEC for increased freight service in southeastern Connecticut and Rhode Island. Also, the Action Alternatives remove Intercity-Express trains from local tracks in many areas, creating potential opportunities for increased sharing of these tracks by Regional rail and freight trains during non-peak periods. Freight rail operations are generally incompatible with high-speed passenger operations utilizing Tier III equipment. Therefore, new separate infrastructure for freight will need to be built in most areas to provide a truly independent through-freight line.

Freight access to Long Island and New England is an issue that is beyond the scope of NEC FUTURE to address and resolve. NEC FUTURE will not draw any definitive conclusions about the ability to support significant opportunities for freight rail access as a consequence of the NEC FUTURE investments in and around New York. However, subsequent Tier 2 actions could address the potential for new Hudson River and East River tunnels to carry freight rail during overnight hours and identify the physical and operational requirements, life safety and security issues, and cost impacts.

5 Operations and Service Best Practices

The adoption of enhanced service and precision operations concepts on the NEC becomes possible with investment in the corridor to bring the railroad into a state of good repair, eliminate chokepoints, and expand capacity, which occurs with the Action Alternatives. These enhanced operating concepts represent national and international best practices and are aimed at increasing the efficiency of operations, lowering the cost per capita of delivering rail service, and making the most efficient use of investments in new rail infrastructure by maximizing the utilization of practical system capacity. These enhanced service concepts reach markets that are underserved or not served at all by existing service, while providing the rail operators the flexibility within which to deliver service that best meets the needs of the market in 2040. A discussion of several enhanced service concepts follows, along with a description of how these concepts were applied and tested as the Service Plans for the Action Alternatives were refined.

The analysis of alternatives focused on train operations and service patterns. However, a number of concepts in the customer service realm also are considered best practices that should be applied to future rail service improvements to maximize the benefits of those improvements to rail passengers. Additional features of improved rail service, not explicitly captured in the Service Plans for the Action Alternatives, potentially include the following:

- Fare collection system integration among Regional rail systems and with regional transit systems and Intercity rail
- Multimodal coordination, including improved opportunities for enhanced “first and last mile” links between rail stations and the places where people live and work
- Improved real-time travel information for rail and connecting travel modes.

5.1 REGULAR CLOCKFACE HEADWAYS

The Service Plans developed for the Action Alternatives are based on regular, repeating service patterns, which allow for the efficient scheduling of trains and use of infrastructure. Also, where new capacity infrastructure is needed at junctions and at locations where faster or non-stop trains need to overtake slower or stopping trains, regular repeating patterns tend to result in the most efficient and effective use of this additional infrastructure. Analysis of a wide range of potential service patterns has led to a set of common assumptions among the Action Alternatives to base schedule patterns for virtually all NEC services on trains operating at regular 15-, 30-, or 60-minute intervals, with local stations generally receiving 2-4 tph during peak periods and major stations often receiving more service. Peak shoulder hour, reverse-peak, and off-peak schedules typically can be developed by keeping the same operating patterns and reducing the headways or number of trains per hour associated with each service type and pattern.

An additional benefit of regular clockface headways is that they enable improved connections between rail and local transit services. For example, a bus route that runs on a regular clockface headway can be timed to meet connecting trains at a Hub station. This coordination increases ridership on both transit and rail by reducing transfer time between the modes. Additionally, a bus that is timed to meet the train can serve double duty—bringing passengers to the train as well as carrying passengers from the train on its onward journey. Transit agencies all along the NEC can choose to re-structure routes and schedules to take advantage of the regular clockface headway operation on the railroad.

Figure 20 provides an example of a regular headway pattern from the Alternative 2 service plan. In this example, Intercity-Express trains depart Boston South Station every 15 minutes at regular intervals throughout the AM peak period.

Figure 20: Sample Regular Interval Service – AM Peak Intercity-Express

Boston South Station	6:04	6:19	6:34	6:49	7:04	7:19	7:34	7:49	8:04
Back Bay	6:09	6:24	6:39	6:54	7:09	7:24	7:39	7:54	8:09
RTE 128	6:17	6:32	6:47	7:02	7:17	7:32	7:47	8:02	8:17
Providence Station	6:34	6:49	7:04	7:19	7:34	7:49	8:04	8:19	8:34

Source: NEC FUTURE team, 2015

Train schedules for the Action Alternatives are headway-driven rather than being load driven,[37] as is the case today. Virtually all NEC services operate at regular 15-, 30-, or 60-minute intervals, with local stations generally receiving 2-4 tph during peak periods and major stations often receiving more service. Peak shoulder hour, reverse-peak, and off-peak schedules retain the same operating patterns but reduce the headways or number of trains per hour in line with expected demand. Benefits of regular clockface scheduling include predictability, improved rail-to-rail and multimodal connection possibilities, simplified and therefore more reliable operations, improved convenience for rail travelers, and, as a consequence, increased ridership potential.

The use of standard hour and regular, repeating service patterns somewhat oversimplifies the factors that go into development of actual railroad operating plans and train schedules. However, clockface scheduling facilitates the implementation of pulse hubs and endpoint transfers (described elsewhere in this section), and it allows for more regular service intervals, which are desirable as service-related best practices.

5.2 METROPOLITAN SERVICE

As described in Section 2.3, Metropolitan service is a new Intercity-Corridor service that provides frequent, regular service on the NEC. By catering to the non-premium intercity market and the time-sensitive regional rail market, and offering service to a large set of stations that include both the Major Hubs as well as smaller hubs serving intermediate markets, this service becomes the

[37] Headway-driven schedules provide trains at regular time intervals. Load-driven schedules seek to maximize the number of passengers on trains in response to observed ridership peaking. The time intervals between trains are variable and tend to be shorter for lines or service zones with higher or more highly peaked ridership, and longer for more lightly patronized lines or zones. Load-based schedules are highly customized to the specific ridership markets being served and tend to be employed where overall capacity is severely constrained.

backbone of the NEC and the primary non-express Intercity rail option for trips that begin and end on the NEC.

Currently Amtrak Intercity-Corridor service (Northeast Regional) is not offered uniformly across the corridor, essentially using the same station stops since Amtrak's inception in the 1970s. Some stations are served infrequently, and other relatively important regional stations do not have Intercity service. Regional rail service, on the other hand, is geographically limited to single metropolitan areas and is focused largely on serving CBD commuters. In addition to a service gap, there is a price gap, with large differences between current Intercity and Regional rail fares.

The proposed Metropolitan service covers the entire NEC and includes more stations than currently served by Amtrak trains, providing service to markets that are underserved or not served by Intercity trains today. Stations providing Metropolitan service, in addition to where the existing Intercity-Corridor service stops today, are located at population, employment, and activity centers or at locations with good highway access, parking capacity and local transportation system connections. Examples include the following:

- Odenton, MD, which is adjacent to the major military base and employment center at Fort Meade and offers highway and potential connecting transit access to Annapolis and Columbia, MD
- Aberdeen, MD, adjacent to the military base and employment center at the Aberdeen Proving Ground
- Newark, DE, adjacent to the University of Delaware and at a station site with major development potential
- North Brunswick, NJ, at a potential station location with good highway access and major development potential, strategically located midway between the educational, research and employment centers of Princeton, NJ and New Brunswick, NJ

Despite adding station stops, Metropolitan service remains competitive with the trip times offered by current Amtrak Northeast Regional service, because it uses high-performance trainsets similar to those used for Intercity-Express service, and because it takes advantage of trip time improvements that are possible with the faster routes and improved infrastructure that are provided, to varying degrees, in the Action Alternatives.

While Metropolitan service functions as the future replacement for current corridor service, a separate Intercity-Corridor-Other service is also operated, providing one-seat rides to markets beyond the NEC, including Virginia, North Carolina, and Vermont. These two Intercity-Corridor services combine to provide service frequencies and passenger-carrying capacity on the NEC that are significantly higher in each of the Action Alternatives than is offered in the No Action Alternative. The travel demand analysis using the ridership models developed by the FRA for NEC FUTURE showed the combined Intercity-Corridor service to be successful in capturing a high level of ridership. Metropolitan service, therefore, is introduced in all of the Action Alternatives.

In Alternative 1, Metropolitan trains share NEC slots with Intercity-Corridor-Other trains, and service is limited to no more than 2 tph in the peak periods. As a result, the impact of adding this service is incremental. In Alternative 1, Metropolitan and Intercity-Corridor-Other services follow the same route, trip time performance is similar between the two service offerings, and they combine to offer a frequent and time-competitive service for interregional travelers.

In Alternative 2, Metropolitan service at 4 tph (15-minute regular headways) effectively replaces the existing Amtrak Northeast Regional service for the low or economy end of the Intercity travel market for trips within the NEC territory. The service utilizes the high-speed tracks that are built at various locations along the NEC. Metropolitan service between Washington, D.C., and Boston is operated at regular 30-minute intervals. The Keystone and Hartford Line connecting corridors are served by additional Metropolitan trains, also operated at 30-minute headways. These two sets of trains together provide a regular 15-minute headway between Philadelphia and New Haven. At the Washington, D.C., and Boston ends of the NEC, the headway gaps during peak periods are filled by shorter-haul Metropolitan trains (such as between Washington, D.C. and Wilmington, DE, or between Boston, MA and Providence, RI), as warranted by demand.

In Alternative 3, the Metropolitan service operates over extended distances on the high-speed infrastructure and outperforms the Intercity-Corridor trains for most station-to-station markets, in terms of both trip times and frequency of service. Alternative 3 operates the equivalent level of Metropolitan service as Alternative 2 on the existing NEC and on the Keystone and Hartford Lines. A second set of Metropolitan trains also operating at 15-minute headways is introduced on the second spine route north of New York (via White Plains, NY and Danbury, CT, or via Long Island, depending upon which new route segments are constructed to serve the New York-to-Boston Intercity-Express market). This doubles the number of Metropolitan trains running through New York to as many as 8 tph. In addition, the main line capacity included in this alternative presents the opportunity to introduce new connecting corridor services that have service characteristics similar to Metropolitan service, such as between the Empire Corridor and Long Island, even though different rolling stock is required to operate in non-electrified territory.

5.3 RUN-THROUGH SERVICE AT MAJOR STATIONS/TERMINALS

In Boston, New York, and Washington, D.C., the various Regional rail operators terminate service at the major rail stations in the CBD. Philadelphia is the exception on the NEC where Regional rail currently operates through the CBD with northern branch lines linked with those to the south.

Regional rail run-through service, particularly applicable to Washington, D.C., and New York, links branch lines from the different service carriers and provide continuous revenue service on both sides of the particular metro region through the CBD. For example, a peak-direction Regional rail train that originates in New Jersey operates into Penn Station New York, and then continues in revenue service and offer reverse-peak service on Long Island. Run-through service can provide operational efficiencies and unlock additional station capacity, which can help contain the need for considerable additional investment in the major terminals.

Alternative 1, which is based on retaining current operational environments as much as possible, retains the existing Regional rail terminal operations at Washington, D.C., New York and Boston, although the volume of train movement activity increases over existing and No Action Alternative levels. Alternative 1 intentionally avoids reliance on through-running operations where they do not currently exist to illustrate the limits of current terminal operations. Intercity trains remain the principal through-running trains at Washington, D.C., and New York.

To meet the service scenarios developed for Alternatives 2 and 3 with higher volumes of peak train traffic, run-through Regional rail operations are introduced to illustrate how they can free capacity and support highly reliable operations and maximize the utilization of new railroad infrastructure.

Alternative 2 expands the terminals at Washington, D.C., and New York to facilitate the through-running of both Intercity and Regional rail trains, including the widening of station platforms and the creation of storage yard facilities on the far side of the terminal for originating and terminating regional services. Efficiencies gained with through-running at both Washington, D.C., and New York are assumed in this alternative—supporting frequent Metropolitan service as well as high-density Regional rail service. Through-running capability and associated capacity projects permit Metropolitan service to be extended through Washington, D.C., to Northern Virginia. Similarly, expanded Regional rail services at both Washington, D.C., and New York are assumed to operate through the Major Hub stations, feeding yard facilities on the far side of the Hub station and also enabling (but not requiring) revenue run-through service between suburban branch lines on opposite sides of the region. This concept is not predicated on any particular assumptions with respect to the entity or entities that operate the various services.

Alternative 3 similarly supports through-running operations, which permit the most efficient use of scarce platform and track capacity at the Major Hub stations and enables the dramatic increases in total train volumes that are possible in this alternative.

5.4 REGIONAL RAIL EXPRESS SERVICE USING HIGH-SPEED TRACKS

In Alternative 3, in which new dedicated high-speed tracks are provided for Intercity-Express service, there is an opportunity to use this infrastructure through urban areas for select Regional rail trains by taking advantage of available slots not used by the Intercity-Express service. These select Regional rail trains are operated with high-performance trainsets with top speeds and acceleration and braking rates similar to Intercity-Express and Metropolitan trainsets, making them capable of operating in blended service with high-speed express trains without unduly constraining the capacity of the high-speed tracks. These select Regional rail express trains supplement or replace the outer zone-express service in the major metro regions, or can be used to extend Regional rail service beyond the existing service territories.

There is insufficient capacity in Alternatives 1 and 2 to offer regional express service on the high-speed tracks. However, this is a significant feature of Alternative 3, offering substantially faster commute times for longer-distance commute trips from the outer suburbs.

For example, Maryland outer-zone Regional rail trains can use the high-speed tracks between Baltimore and Washington, D.C. Similarly, this service improves trip times to New York from the outer–zone service serving New Jersey and Bucks County, PA, while relieving congestion on the local tracks. Other opportunities to provide high-speed Regional rail service in Alterative 3 exist in

Long Island and Westchester County, in which Regional rail providers can take advantage of portions of the new high-speed line feeding New York and Boston to dramatically reduce trip times to the outer zone markets. Opportunities exist for 6 to 8 commuter express trains in the peak hour from either Long Island or the Upper Harlem Line to Penn Station New York, if new high-speed lines were built from New York either via the Long Island or Central Connecticut second spine routes.

5.5 SIMPLIFIED OPERATIONS

Simplified operations encompass a range of possible concepts for operating passenger service on a multi-track rail line. All of these concepts share the objectives of maximizing the utilization of infrastructure capacity, increasing the reliability of rail service and the ability of the system to recover when delays occur, and providing customers with a high level of convenience. Service concepts that fall under the heading of simplified operations include the following:

- Normalizing stopping patterns (with fewer but more regular and better coordinated patterns), as opposed to having a lot of unique individual patterns
- Less switching of trains between tracks in multi-track territory
- Fewer branch lines feeding the NEC
- Timed transfers for branch line passengers at main line Hub stations
- Higher and more regular service frequencies for the stopping patterns that remain on the NEC

The primary benefit of a simplified service plan is that it brings more predictability to both train operators and passengers.

For train operators, simplification of the train schedule and adoption of regular, repeating and well-integrated train stopping patterns can allow the railroad to be run more automatically, without the variability and potential human error introduced by a system that generates a wide range of unique conflicts that require frequent dispatcher decisions and unique solutions. The system remains too complex for completely automated operation, and train dispatchers are still needed to monitor and resolve conflicts and errors that do occur. However, simplified operations can reduce the number and type of train interference conflicts that arise for train dispatchers and allow them to better respond to conflicts when they occur, and respond in a way that is more predictable. Consequently, simplified options should improve the overall reliability of the railroad as well as minimize the amount of redundant and parallel rail infrastructure necessary to support a more complex service plan.

For passengers, the regularity of a simplified plan makes planning trips easier, increasing the attractiveness of rail versus other modes. More reliable service and better connections with other rail services and transit modes are benefits that attract additional ridership. Drawbacks of this type of plan may include serving fewer markets with one-seat rides and increased trip times for express trains between major markets.

Several of the scenarios developed for Alternative 2 provide a clear illustration of the differences between a complex and a simplified set of service patterns. Both schemes have advantages and drawbacks relative to the other, and the analysis demonstrates that the rail infrastructure configuration assumed for Alternative 2 accommodates either set of patterns, which enables the specific development of Service Plans and train schedules to be made at a later date as market demands and the needs and priorities of the railroad operators are better known. These scenarios differed in the variations in stopping patterns among the Intercity services and the extent to which Intercity and Regional rail services were segregated onto separate tracks.

Both Intercity and Regional rail stopping patterns for the Action Alternatives are simpler and more regular than in the current operating plans, which, when coupled with the elimination of chokepoints and the restoration of the railroad to a state of good repair, results in highly reliable service and efficient use of infrastructure. The Action Alternatives generally retain the relatively complex network configuration that feed multiple branch lines onto the NEC at various points along the corridor.

The most dramatic application of simplified operations occurs in Alternative 1 on the New Haven Line, where a transit-style service is implemented that replaces the current complex overlay of multiple stopping patterns with a simpler system of express and skip-stop local services that can deliver greater throughput capacity without major new track capacity. Comparison of this alternative with the more conventional zone-express service patterns in Alternatives 2 and 3 enabled the relative merits and challenges of implementing a simplified operating pattern to be better understood.

5.6 COORDINATED ENDPOINT CONNECTIONS

Coordinated scheduling of Regional rail trains—on systems that have multiple branch lines or multiple terminals, or where the outer ends of two regional systems meet at a common station—can provide for convenient passenger connections, extending the reach of the existing systems, substituting for costly extensions one-seat-ride service, and providing a much more convenient transfer experience for rail travelers. More precise schedule coordination becomes easier to accomplish with clockface scheduling, simplified operations and elimination of the chokepoints that contribute to train delays—all of which are characteristics of the Action Alternatives. Convenient transfer connections depend on train schedules that allow enough, but not too much, time for passengers to change trains at the Hub or endpoint station. Convenience also is enhanced with cross-platform or same-platform transfers, and the integration of timetable and real-time train information, particularly where more than one operating authority is involved. Trenton, NJ, is an example of a location where endpoint connections currently are provided between SEPTA and NJ TRANSIT Regional rail trains.

For coordinated endpoint connections to work well, physical and operational barriers to transferring must be reduced. The reduction in physical barriers includes investing in station and line infrastructure to accommodate cross-platform transfers and providing clear and intuitive pathways between platforms. The reduction in operational barriers also includes an integrated ticketing system so that a trip that includes multiple legs across multiple rail operators is easily booked and fully transparent to the passenger and allowing passengers free flowing access to platforms.

With clockface scheduling and regular, repeating service intervals, Alternatives 1, 2, and 3 take advantage of opportunities for better connected Regional rail service at several locations on the NEC, effectively closing the gaps that now exist in Regional rail connectivity from one regional system to another. As Maryland Regional rail service is extended to Newark, DE, schedules are coordinated with those of the Regional rail service to Philadelphia, enabling convenient passenger transfers. Modification of the track configuration in the vicinity of Trenton (or potentially at some other future location in New Jersey) allows timed cross-platform transfers between New Jersey and Philadelphia Regional rail trains in both directions. Also, the integration of Shore Line and Hartford Line Regional rail trains with New Haven Line service provides convenient cross-platform transfers at New Haven.

In the Action Alternatives, opportunities for better connected service are provided at locations such as Newark, DE, New London, CT, Westerly, RI, and Springfield, MA. The full-build plan for a new multimodal Hub station at Newark, DE, facilitates cross-platform transfers between Washington-based (MARC) and Philadelphia-based (SEPTA) Regional rail services, as well as potential new passenger service on the Delmarva Peninsula. Existing stations need to be improved or reconfigured to enable closing of the Regional rail service gap between Shore Line East service to New Haven and MBTA service to Providence and Boston. And at Springfield, convenient timed transfers can be provided between NEC Metropolitan and Intercity-Corridor-Other trains serving the Knowledge Corridor and Inland Route.

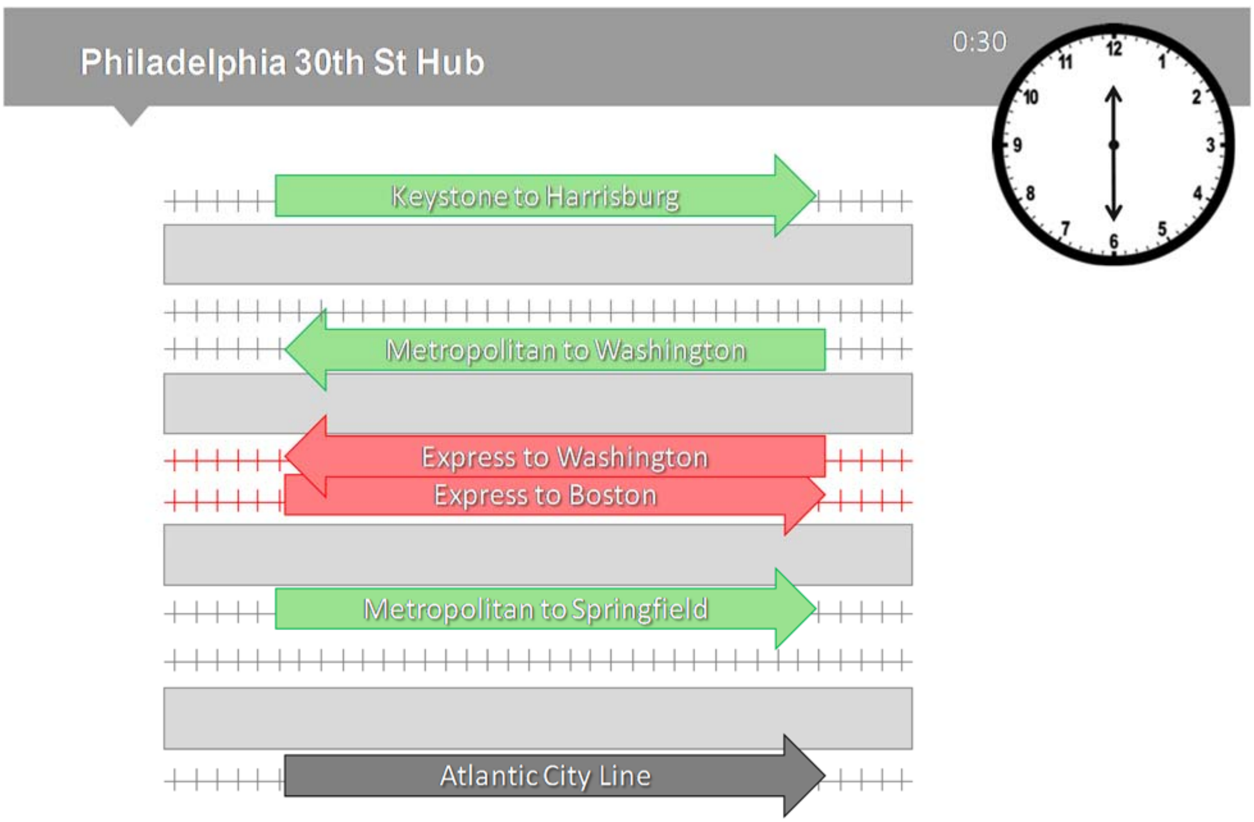
The Action Alternatives also improve connectivity between main line and branch line services at multiple locations. Intercity services can be better coordinated with regional services at Philadelphia 30th Street with the normalization of train schedules. The timing of Empire train arrivals and departures at Penn Station New York can be coordinated with Intercity-Express, Metropolitan, and Regional rail service on the NEC. And in cases where simplified operations may reduce the number or frequency of direct train services from the NEC main line to regional branch lines, shuttle services on the branch lines can be timed with convenient connections to and from NEC trains, offering greater overall service frequency on the branch line and a trip that remains convenient and time-competitive for the passenger making the transfer. The same principles apply to connecting transit services at Hub stations. Regular clockface scheduling of rail services, coupled with reliable operating performance, allows local transit service providers to customize the arrival and departure timing connecting and feeder services to match the train schedules.

5.7 PULSE-HUB OPERATIONS

A pulse-hub operation plays a prominent role in a simplified operation, but can also be a feature of Service Plans with a wider variety of service offerings. In pulse-hub operations, trains from different lines and service tiers arrive at a Hub station concurrently or in close succession. Passengers can then transfer to a range of services during the simultaneous dwell of these multiple trains. Trains then leave the station in close intervals. Figures 20 and 21 illustrate one example of a pulse-hub, at 30th Street Philadelphia, where several trains of different types and with different destinations have coordinated arrival and departure times, facilitating convenient transfers.

A pulse-hub operation offers opportunities to provide high-quality service to smaller markets that do not warrant one-seat-ride to major markets. For this system to work appropriately, significant amounts of infrastructure may be needed at Hub stations to facilitate the simultaneous movement of multiple trains through the station as well as the efficient movement of passengers between trains. Investment in station and rail infrastructure to enable high-quality passenger transfers and elimination of operational barriers including segregated ticketing and limited passenger access to platforms are prominent features of pulse-hub operations. Providing high-quality passenger transfers can also be a feature of Service Plans that do not rely exclusively on this type of operation, but selectively employs it at key stations on the network.

Figure 21: Philadelphia Pulse Hub



Source: NEC FUTURE team, 2015

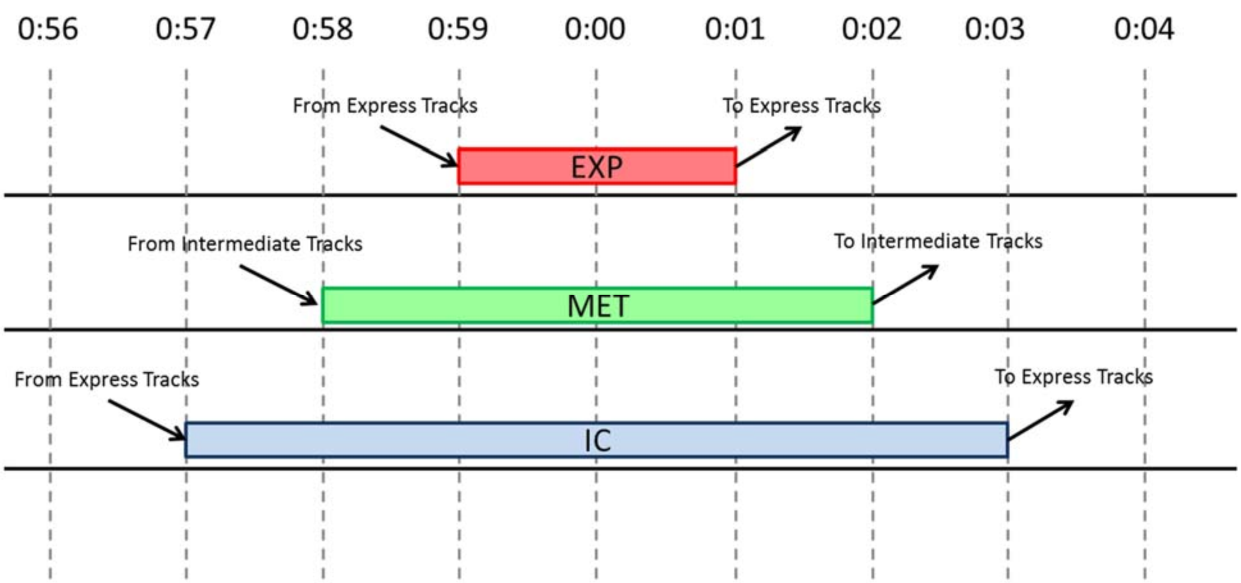
The service scenarios that were developed for Alternative 2 provide a good example of pulse-hub operations at the lower level of Philadelphia 30th Street Station and at New Haven Union Station – both locations where Intercity connecting corridors and multiple Regional rail services come together at a single location. The Service Plans for Alternatives 2 and 3 provide for pulse-hub operations on the lower level of 30th Street Station every 30 minutes, with Intercity-Express, Metropolitan, Keystone and Atlantic City trains all connecting with universal transfer opportunities every 30 minutes during the peak periods. The versions of Alternative 3 that provide for a new route from Long Island through New Haven to Hartford also provide for a timed pulse-hub at New Haven.

Figure 21 shows a simplified schematic of the lower level of track and platforms at 30th Street station in Philadelphia during a pulse in service at the tops of the hour when northbound and southbound Metropolitan and Intercity-Express trains and an Atlantic City-bound train are all in the station simultaneously. In this example, the Intercity-Express trains will depart first, followed closely by the Metropolitan trains and then finally the Atlantic City train.

Two Metropolitan trains are scheduled on 30-minute headways the entire length of the corridor providing the basic all-day Intercity service to markets on the NEC and operate over the express route between Providence and New Haven via Hartford.

These trains re coordinated with the express trains in Philadelphia providing convenient transfers between the Metropolitan and Intercity-Express service twice per hour, allowing the Metropolitan to act as feeder/distributer service for Intercity-Express trains broadening the market reach of express service. This timed transfer opportunity in Philadelphia is also timed to coincide with Intercity-Corridor trains allowing for transfer between all three services. This allows passengers on the Intercity-Corridor trains, particularly those beginning their journey from off-corridor markets south of Washington, D.C. and traveling to Harrisburg, convenient same-platform transfers to both the Intercity-Express and Metropolitan trains, allowing access to more on-corridor markets than are served directly by the Intercity-Corridor train. Figure 22 depicts this Philadelphia concept.

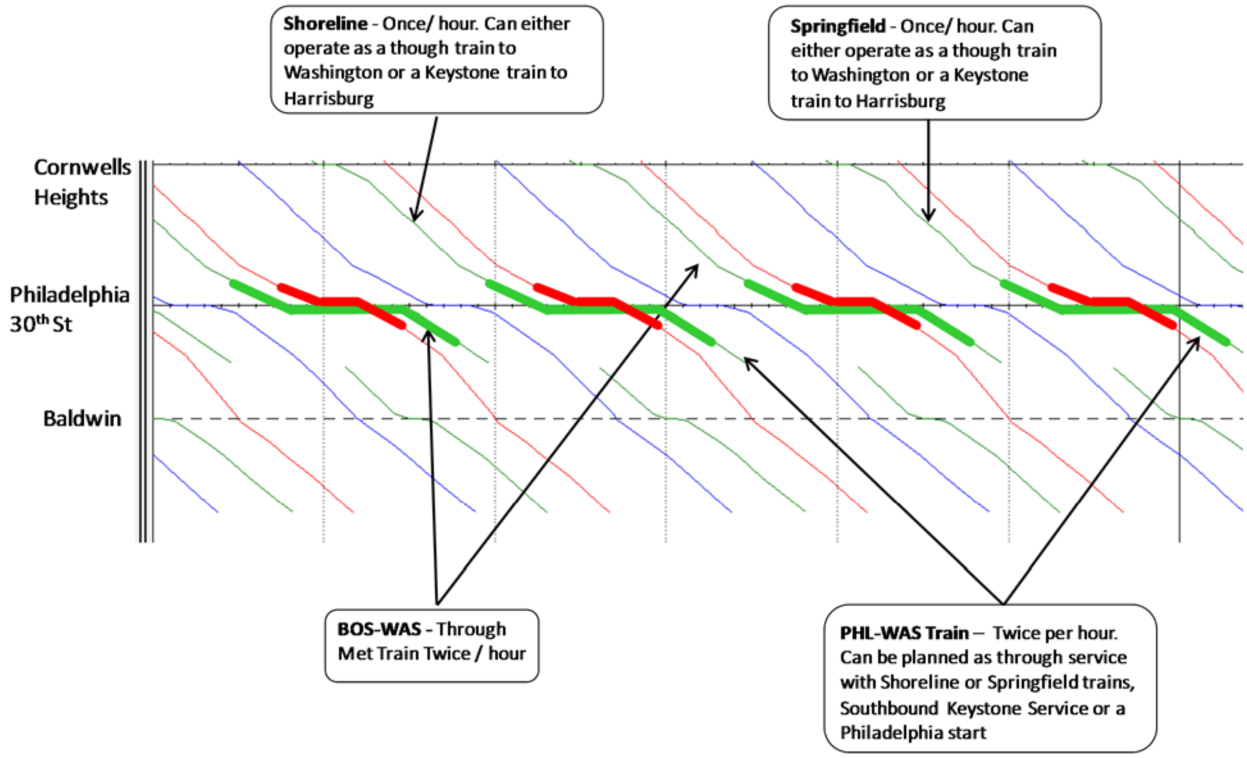
Figure 22: Philadelphia Pulse-Hub Concept



Source: NEC FUTURE team, 2015

A potential Philadelphia pulse-hub with a 15-minute cycle, which can be implemented in Alternative 2 to provide an even greater degree of rail-to-rail connectivity, is shown in the stringline diagram format in Figure 23.

Figure 23: Philadelphia Hub with Intercity-Express and Metropolitan Transfers Every 15 Minutes

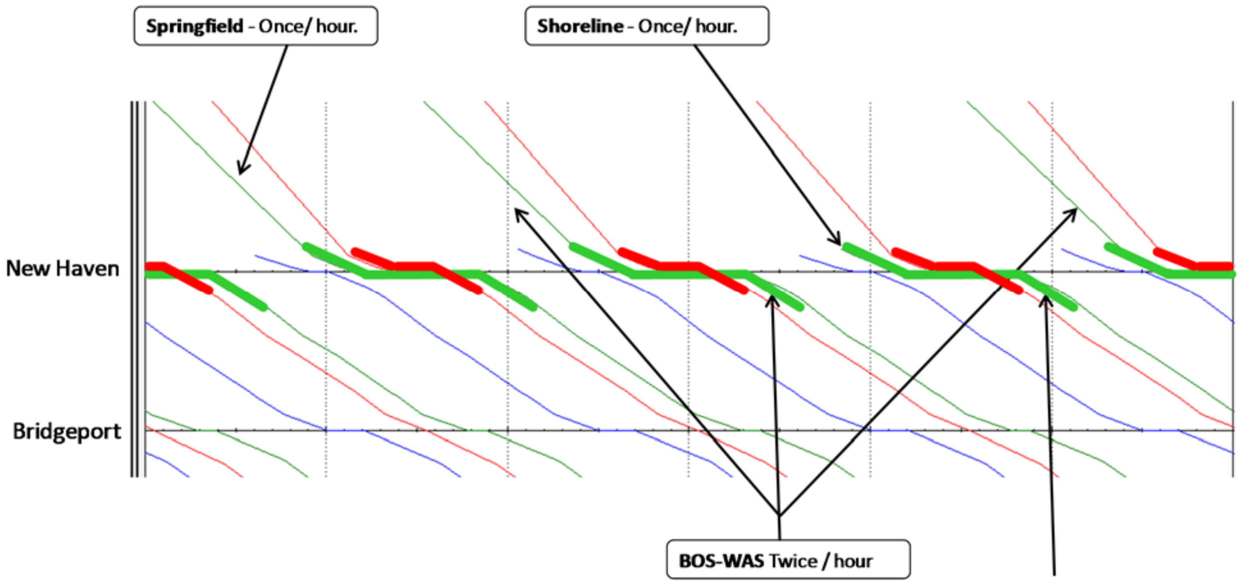


Source: NEC FUTURE team, 2015

A similar pulse-hub operation can be implemented in New Haven in Alternative 2 or 3. The following example illustrates how the pulse-hub concept works in Alternative 2. In New Haven, express trains arrive at the station at 0:59, 0:14, 0:29, and 0:44 past the hour. These trains dwell at the station for two minutes and leave New Haven at 0:01, 0:16, 0:31, and 0:46 past the hour. At the top and bottom of the hour, the Boston to Washington, D.C., Metropolitan trains arrive two minutes before and leaves two minutes after the Intercity-Express train facilitating a cross-platform transfer and providing an opportunity for the Intercity-Express train to overtake or pass the Metropolitan train in the station, as opposed to out on the main line. This happens simultaneously in both directions.

At 15 minutes after the hour, this transfer/overtake occurs between the southbound Shoreline Metropolitan and the northbound Springfield Metropolitan and Intercity-Express in both directions. At 45 minutes after the hour this transfer/overtake occurs between the northbound Shoreline Metropolitan, and the southbound Springfield Metropolitan and Intercity-Express in both directions. Figure 24 shows a diagram of this operation.

Figure 24: New Haven Hub with Intercity-Express and Metropolitan Transfers Every 15 Minutes



Elements of the pulse-hub concept can be adopted at Washington Union Station to coordinate the schedules of Regional rail trains with Intercity train arrivals and departures in both directions of travel. This concept also can be used to enable Intercity passengers from origins south of Washington to have convenient transfers to Intercity-Express trains for faster trip times to points on the NEC such as New York or Boston.

6 Rolling Stock

6.1 TRAIN EQUIPMENT OPTIONS

The FRA considered a range of potential rolling stock types for passenger rail service on the NEC for analysis purposes. Table 14 presents the menu of rolling stock options. The objective of FRA's service planning for NEC FUTURE is to establish a long-term vision and investment plan for the NEC and is not to make decisions about fleet composition and equipment procurement for NEC rail services. Planning goals are to achieve operational efficiencies, maximize capacity utilization, and make the best use of infrastructure investment dollars by making train performance more uniform. These goals are best achieved through the standardization of rolling stock types on the NEC to enable delivery of a consistent and high level of performance. The Action Alternatives, therefore, are based on the use of the same high-speed trainset technology for both Intercity-Express and Metropolitan service, and the use of all-electric equipment for Regional rail service. Ultimate decisions about rolling stock procurement, including the configuration and maximum speed of high-speed trainsets, will be made over time after completion of the Tier 1 EIS. Specific assumptions regarding Regional rail service and rolling stock vary among the Action Alternatives, and consideration is given, particularly in Alternative 1, to continued use of diesel-hauled trains, where a level of service sufficient to meet the objectives of the alternative can be achieved, although some reduction in Regional rail service frequency and scheduling flexibility result, compared with what is possible using all-electric equipment.

6.2 BASIS OF ANALYSIS FOR NO ACTION AND ACTION ALTERNATIVES

This section summarizes the rolling stock characteristics of the No Action Alternative and Action Alternatives for each service type.

6.2.1.1 No Action Alternative

The size of the Intercity-Express fleet is augmented through the procurement of a new fleet of high-speed trainsets, which increases train seating capacity from 305 to 450 and allows for limited expansion of Intercity-Express service on the NEC. Normal life-cycle replacement of the Amfleet Intercity-Corridor equipment occurs over the period through 2040, but the configuration of these trains with electric locomotives and trailer coaches remains the same.

Regional rail service is operated with the future fleet that currently is planned for each of the eight Regional rail systems:

- Boston: diesel locomotives and bi-level coaches
- Shore Line East: EMU trainsets
- Metro-North New Haven Line: EMU trainsets and dual-mode locomotives in a push-pull configuration.
- LIRR: EMU trainsets on electrified lines and dual-mode locomotives and bi-level coaches in a push-pull configuration on trains to Penn Station New York serving non-electrified territory
- NJ TRANSIT: EMU trainsets

- SEPTA: EMU trainsets or electric locomotives and coaches
- MARC: electric or diesel locomotives and bi-level coaches in a push-pull configuration
- VRE: diesel locomotives and Gallery-style coaches (low platform boarding only) in a push-pull configuration

Table 14: Rolling Stock Options for Service Planning Purposes

Equipment Type	Tier	Length [1]	Locomotives	Loco Type / Traction Power Type	Train Length[2] (ft)	Seats/Car	Seats/Train	Operates Off-Corridor	Max. Speed on NEC (mph)	Boarding Platform Level	Remarks
Intercity-Express High-Speed Trainset	III	7–14	0	Concentrated or distributed power w/ Catenary	595–1,190	50–60	350–840	No	220	High only	
Metropolitan or Intercity-Corridor High-Speed Trainset	III	7–14	0	Concentrated or distributed power w/ Catenary	595–1,190	60–70	420–980	No	220	High only	On NEC Spine and branches w/ catenary electrification
	III	12	0	Dual Power/Cat. + 3rd Rail	1,020	60–70	720–840	Yes	160–220[5]	High only	NEC-Long Island run-through services
	III	12	0	High–Performance Dual Mode[3]	1,020	60–70	720–840	Yes	160–220[6]	High or Hi-Lo	Other off-corridor extensions
	III	12	0	Dual Mode/3rd Rail + Diesel	1,020	60–70	720–840	Yes	160–220[6]	High or Hi-Lo	Long Island-Empire run-through services
Intercity-Corridor Train	I	10	1–2	High–Performance Dual Mode[3]	1,000	60–70	600–700	Yes	125	Hi-Lo	New loco type[3]
	I	12	1–2	Diesel loco	1,170	60–70	720–840	Yes	(110)	Hi-Lo	Operates off-corridor only
	I	12	1–2	Electric loco/Catenary	1,170	60–70	720–840	Yes	125	Hi-Lo	On NEC w/ engine change
Regional rail Electric Multiple-Unit (EMU)[4]	I	12	0	EMU/Catenary or 3rd Rail	1,020	105	1,260	Yes	100–125	High or Hi-Lo	Single level fleet, similar to M7, M8, Silverliner V
	I	12	0	EMU/Catenary or 3rd Rail	1,020	135	1,620	Yes	100–125	High or Hi-Lo	New fleet type – Bi-Level or multi-level EMU
Regional rail Push-Pull, Single level or Bi-level[4]	I	10–12	1–2	Electric, Diesel or Dual–Mode loco	1,000	135	1,350–1,620	Yes	125/100	High or Hi-Lo	Includes run-through services
	I	8	1	Electric, Diesel or Dual–Mode loco	755	135	1,080	Yes	125/100	High or Hi-Lo	Includes run-through services
Intercity-Long Distance Train	I	10–12	1–2	Same locomotive options as Intercity–Corridor trains	1,170	n.a.	400	Yes	125	Hi-Lo	Operates on NEC during off-peak hours only

[1] Measured in equivalent 85-foot car lengths. Also can be operated in smaller consists as warranted by demand. High-speed equipment assumed to comprise one or two intact trainset modules.
[2] Based on 85 ft. long passenger cars and 75 ft. long locomotives, or the equivalent length of intact trainset modules.
[3] Assumptions re future high-performance dual-mode locomotive or multiple-unit trainset (technology assumed to exist prior to 2040 horizon year): Catenary on existing NEC; Diesel off-corridor; Top speed off-corridor: 110 mph; Braking rate: 1.6 mph/second; Acceleration: similar to AEM7 (placeholder with middle-of-the-road performance).
[4] Includes through-running services, assuming compatibility with traction power system (if any) on all lines served.
[5] There is currently no high-speed trainset 220 mph-capable that has both overhead electrification and third rail equipment. This trainset will need to be compatible with the three types of AC power present on the existing NEC.
[6] There is currently no trainset 220 mph-capable that is powered by overhead electrification and diesel.

6.2.1.2 Alternative 1

Intercity-Express service operates with Tier III high-speed trainsets, with a top operating speed of 160 mph. The high-speed trainsets may have tilting capability, to permit these trains to operate around existing curves on the existing NEC at a higher speed than currently is permitted for conventional trains. Tilting technology affects vehicle weight and cost and requires minimum track center spacing greater than what exists in some portions of the existing corridor. Tilting capability therefore is not a prerequisite.

Intercity-Corridor service, as well as Intercity-Long Distance service, is operated with trains composed of locomotive-hauled coaches. Metropolitan service is assumed to be operated with Tier III high-speed trainsets with performance characteristics similar to Intercity-Express trains, but with an interior configuration with greater seating capacity and larger vestibule areas to facilitate rapid boarding and alighting at stations.

Service Plans for Regional rail service on the NEC are based on locomotive or trainset performance equivalent to push-pull trains with high-performance electric locomotives. Those systems that operate with lower-performing equipment, such as the diesel locomotives currently operating on the NEC in Maryland, southeastern Connecticut and Massachusetts, upgrade to electric locomotives or equivalent-performing equipment. In this alternative, Regional rail operators are able to operate with lesser-performing equipment—albeit with reduced scheduling flexibility, fewer peak trains, and/or less reliability.

6.2.1.3 Alternative 2

Alternative 2 is based on the same rolling stock performance assumptions as Alternative 1. Intercity-express service is assumed to be operated with Tier III high-speed trainsets, with a top operating speed capped at 160 mph.

Metropolitan service is operated with Tier III high-speed trainsets, with the same performance characteristics as the Intercity-Express trains, allowing them to operate on the high-speed tracks between express trains at minimum headways, in order to maximize the utilization of the line's practical capacity. The interior configuration of the Metropolitan trainsets are different from the express trainsets, since these trains are expected to carry higher passenger loads including both Intercity travelers and commuters, with higher seating capacities, larger vestibules and a greater number of doors to facilitate passenger boarding and alighting.

Intercity-Corridor service, as well as Intercity-Long Distance service is operated with trains composed of electric or dual-mode locomotive-hauled coaches.

Service Plans for Regional rail are based on use of high-performance equipment to maximize capacity utilization. Regional rail operators are able to operate with lesser-performing equipment—albeit with reduced scheduling flexibility, fewer peak trains, and/or less reliability.

6.2.1.4 Alternative 3

Alternative 3, which entails the construction of a second spine on new right-of-way along most of the corridor between Washington, D.C., and Boston, offers the opportunity to develop a dedicated high-speed rail service with top speeds higher than what can be practically achieved on the existing NEC and with significantly improved trip times for both Intercity-Express and Metropolitan services. Compared with Alternative 2, Intercity-Express trains following the second spine route in Alternative 3 makes the trip between Washington, D.C., and New York approximately 48 minutes faster and saves over 60 minutes on the northern portion of the trip between New York and Boston. The analysis was based on the use of a Tier III high-speed trainset with a top speed of 220 mph, equivalent to the current state of the art of European and Asian high-speed rail systems. These trains do not have tilting capability, and therefore, need to operate at lower speeds around existing curves on the NEC and any curves on the new alignment. The same high-speed trainset technology is assumed for all Intercity-Corridor and Metropolitan services operating on the NEC. The trip time performance of these 220 mph trainsets was compared with the performance of the Tier III equipment assumed in Alternatives 1 and 2 (160 mph top speed with tilting capability). The 160 mph tilting equipment generated trip times approximately 8 minutes longer between Washington, D.C., and New York and 13 minutes longer between New York and Boston compared with the use of equipment with a top speed of 220 mph, over the same Alternative 3 second spine route for a typical Intercity-Express train.

Intercity-Corridor rolling stock assumptions are the same in Alternative 3 as in the other Action Alternatives. All Regional rail services are assumed to operate with high-performance equipment on the NEC (i.e., either EMU trainsets or coaches pulled by high-performance electric locomotives in a push-pull configuration).

A new type of Regional rail service also is investigated in this Action Alternative—commuter express service, which operates partly on the existing Regional rail network and partly on the new high-speed lines, taking advantage of available capacity on these lines close to the major regional business districts. These trains must match the performance of the Intercity-Express and Metropolitan trains and, therefore, are assumed to utilize the same trainset technology, with an interior configuration and door spacing similar to the Metropolitan trainset.

7 Service Plans for the No Action and Action Alternatives

This section provides final service plan information for the No Action Alternative and Action Alternatives analyzed in the Tier 1 Draft EIS. For each alternative, the level of peak and daily train service is described, by type of service, with the required capital investments in capacity-related rail infrastructure also identified. The service specifications used to drive the ridership and operations and maintenance cost models, and on which the analysis of service-related environmental effects was based, will be presented in Appendix B of the Tier 1 Draft EIS. The Service Plans are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assessment of environmental impacts, and are not intended in any way to be prescriptive regarding how service should be operated in the future. In addition, they are not intended to predict the future operating patterns of the NEC railroad.

7.1 NO ACTION ALTERNATIVE

The No Action Alternative serves existing markets along the NEC using the existing mix of trains and level of train service. South of New York, there are three Intercity services, each operating with 1 tph in the standard peak hour: an Intercity-Express (Acela Express) train, an Intercity-Corridor (Northeast Regional) train, and a Keystone Corridor train. Intercity-Express and Intercity-Corridor service is operated north of New York to Boston and/or Springfield, at frequencies of approximately one train every two hours each. Empire service operates approximately hourly in the standard peak hour in each direction. Table 15 presents the level of Regional rail service in 2040 included in the No Action Alternative. The only substantive change from existing service levels is the introduction of LIRR service to Grand Central Terminal, which becomes possible with completion of the East Side Access project. A fuller description of the No Action Alternative is contained within the *No Action Alternative Report*[38].

[38] Available on the NEC FUTURE website at www.necfuture.com.

Table 15: 2040 No Action Alternative – Regional Rail Service

REGIONAL TRAINS PER HOUR	Existing / No Action			
	Peak	Shoulder	Reverse Peak	Off Peak
WASHINGTON REGION				
MD Regional Rail (Penn Line)	3	2.5	1.5	1.3
VA Regional Rail	5.5	1	0.2	0.1
PHILADELPHIA REGION				
North Side Regional Rail	7	4	4	2.5
South Side Regional Rail	5	4	3.5	3
NEW YORK REGION				
NJ - NEC / NJCL Trans Hudson	15	8	7	3
NJ - Other Regional Rail Trans Hudson	6	3	3	2
NJ - Standard Inner Branch Slots	-	-	-	-
CT - New Haven Line (PS & GCT)	22	16	12	3
BOSTON REGION				
NEC Regional Rail	9	4	4	2.6
Worcester / Framingham Lines	3	2	1	1

Source: NEC FUTURE team, 2015

Note: Table excludes Long Island Rail Road services. Fractional values represent services that do not operate the same number of trains each hour during the four major time periods. For existing service, these values were derived so that the total daily number of trains in the service specification approximately matches the number of trains actually operated.

7.2 ALTERNATIVE 1

Alternative 1 maintains the role of rail as it is today, with the level and capacity of rail service keeping pace with the projected population and employment within the Study Area. Alternative 1 builds off Service Plans developed by the NEC rail operators to meet the projected organic increase in travel demand. Alternative 1 includes new rail services and commensurate investment in the NEC to bring the railroad to a state of good repair, expand capacity, add tracks, and relieve key chokepoints, particularly through northern New Jersey, New York, and Connecticut.

Alternative 1 is focused on meeting the growth needs of existing NEC rail markets, rather than providing service to new markets. Projected increases in population and employment within the Study Area through 2040 will increase demand for rail in the corridor, requiring commensurate increases in Intercity and Regional rail service on the NEC. Intercity service nearly doubles compared with the No Action Alternative, which alleviates the existing constraints on ridership and accommodates future population and employment growth. Alternative 1 increases available Regional rail capacity by lengthening trains in some locations, mostly outside the New York area, but these opportunities are limited and are not sustainable through 2040 corridor-wide. As a result, Alternative 1 adds train service over and above what is provided in the No Action Alternative, to allow more riders to be carried at peak periods. This, in turn, requires targeted investment in railroad capacity beyond No Action Alternative levels where constraints currently exist—such as at the Hudson River crossing, in Maryland south of Baltimore, on the New Haven Line, and at the major terminals in Washington, D.C., New York and Boston. Taken together, lengthening trains and increasing service frequency enables future Regional rail service to continue to carry its current share of journey-to-work trips to and from the major metropolitan central business districts. Reverse-peak and off-peak service continues to be operated where it is provided today.

In general, Alternative 1:

- Includes the infrastructure investment necessary to meet 2040 Regional rail ridership and service targets, along with moderate expansion of Intercity service
- Focuses investment on eliminating chokepoints and getting the highest practical capacity out of the existing railroad
- Assumes the current institutional structure of rail operators is maintained
- Resembles the future Service Plans proposed by the rail service providers as much as possible
- Incorporates a potential new service concept—Metropolitan service—to the extent possible within available capacity.

Table 16 and Table 17 present the service plan specifications for Intercity and Regional rail service, respectively, showing the levels of rail service provided in Alternative 1.

Table 16: Alternative 1 – Intercity Service in Standard Peak Hour

	Existing	No Action	Alt 1
South End			
Intercity Express	1	1	2
Intercity Corridor			
Wash-Phila	1	1	2
Phila-NY	2	2	2
Metropolitan			
Wash-Phila	--	--	2
Phila-NY	--	--	3
North End			
Intercity Express	<1	<1	2
Intercity Corridor			
NY-New Haven	<1	<1	2
New Haven-Boston (Shore Line)	<1	<1	1
New Haven-Springfield	--	--	1
Metropolitan			
NY-New Haven	--	--	2
New Haven-Boston (OSB-KEN Bypass)	--	--	2
New Haven-Boston (Shore Line)	--	--	--
New Route	--	--	--
Connecting Corridors			
Virginia	<1	<1	2
Empire	1	1	2
Keystone	1	1	1
Springfield	<1	<1	1
Knowledge Corridor	1 tpd	1 tpd	<1
Inland Route	--	<1	<1
Other	--	--	--

Source: NEC FUTURE team, 2015

Table 17: Alternative 1 – Regional Rail Service

REGIONAL TRAINS PER HOUR	Existing / No Action				Alternative 1			
	Peak	Shoulder	Reverse Peak	Off Peak	Peak	Shoulder	Reverse Peak	Off Peak
WASHINGTON REGION								
MD Regional Rail (Penn Line)	3	2.5	1.5	1.3	6	5	3	2
VA Regional Rail	5.5	1	0.2	0.1	6	4	2	0.4
PHILADELPHIA REGION								
North Side Regional Rail	7	4	4	2.5	8	5	5	3
South Side Regional Rail	5	4	3.5	3	6	6	6	3
NEW YORK REGION								
NJ - NEC / NJCL Trans Hudson	15	8	7	3	20	10	7	3
NJ - Other Regional Rail Trans Hudson	6	3	3	2	-	-	-	-
NJ - Standard Inner Branch Slots	-	-	-	-	10	8	6	6
CT - New Haven Line	22	16	12	3	26	20	16	8
BOSTON REGION								
NEC Regional Rail	9	4	4	2.6	12	10	10	4
Worcester / Framingham Lines	3	2	1	1	4	3	1	1

Source: NEC FUTURE team, 2015
Note: Fractional values represent services that do not operate the same number of trains each hour during the four major time periods. For existing service, these values were derived so that the total daily number of trains in the service specification approximately matches the number of trains actually operated.

Alternative 1 invests in capacity sufficient to keep pace with demographic growth, but does not provide additional capacity to support growth beyond 2040 or to meet changing market needs.

Growth in Regional rail service differs by region along the corridor. In the slower growth regions of Boston and Philadelphia, Regional rail frequencies will increase 15 to 20 percent in the peak period with expanded train consists providing additional capacity in both regions. More robust population growth in the Washington, D.C., metro area is expected and Regional rail from both the north and the south will expand at a higher rate—50 percent growth in frequencies from the north and a more than doubling of service from the west/south. With additional trans-Hudson capacity, Regional rail from New Jersey increases 70 percent in the peak hour.

7.2.1 Markets Served

Alternative 1 serves existing NEC travel markets. There are several suburban corridors that potentially could include one-seat ride service to Manhattan in this alternative, such as the Raritan Valley Line corridor in northern New Jersey.. Where Metropolitan service is introduced, the accessibility of these areas to NEC Intercity service is greatly improved. This is due to the criteria that define the Hub stations at which Metropolitan trains stop, which include the presence of substantial local development and economic activity and/or available regional highway access.

7.2.2 Service Levels

Intercity service in Alternative 1 approximately doubles in the standard peak hour, compared with the No Action Alternative. The level of peak hour Intercity service is as follows:

- Intercity-Express: 2 tph, operating between Washington, D.C., and Boston
- Intercity-Corridor-Other: 2 tph, with one Washington, D.C.-Boston train and one Washington, D.C.-Springfield train
- Keystone Corridor: 1 tph, operating Philadelphia to New York
- Empire Corridor: 2 tph to Penn Station New York (remaining separate from NEC)

Selected Intercity-Corridor trains are assumed to extend beyond the NEC (e.g. to Virginia, North Carolina, Vermont and central Massachusetts via Springfield and the Inland Route to Boston). These trains are considered to be Intercity-Corridor-Other trains, utilizing upgraded conventional trainsets of coaches hauled by high-performance dual-mode locomotives. Outside of the standard peak hour, some of these Intercity-Corridor-Other slots are assumed to be available for Long-Distance trains. The remainder of the Intercity-Corridor service (i.e., those trains that operate wholly on the NEC Spine) is assumed to be Metropolitan service, operated with high-performance trainsets, stopping at additional stations designated as hub stations.

One Intercity-Express train per hour will operate between Boston and Washington, D.C., supplemented by a second hourly frequency between New York and Washington, D.C. This service expansion, along with lengthening the trainsets, will more than double the available Intercity-Express seats in the peak hour. Two Intercity-Corridor-Other trains per hour will provide one-seat rides from the markets south of Washington, D.C., (Newport News, Norfolk, Richmond, Lynchburg, and Charlotte) to markets along the NEC. These trains will also provide Intercity service between intermediate markets along the NEC.

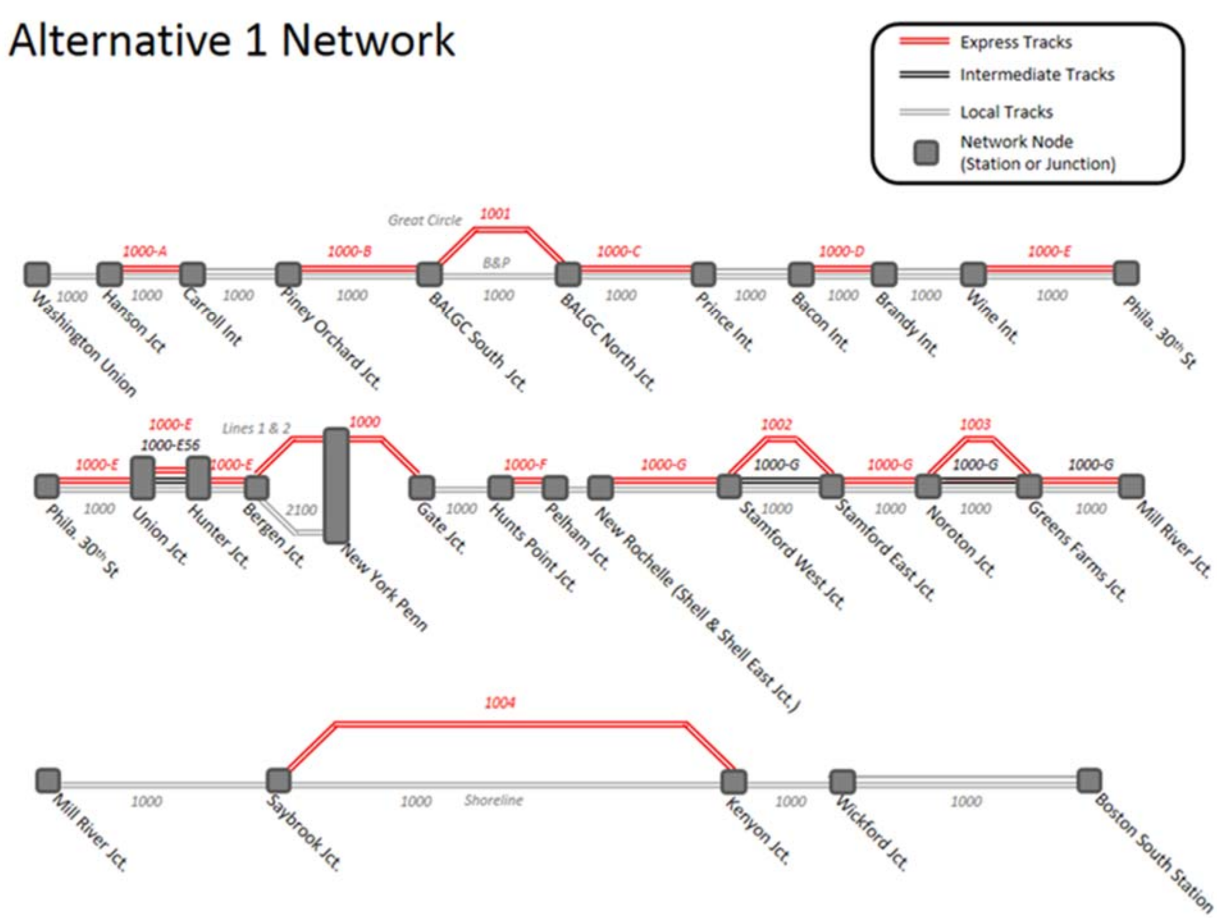
Even with the major expansion in capacity in the New York City region, rail access through New York City remains constrained. Metropolitan service helps to meet the increased demand, by serving both regional and Intercity travelers on the same train. It effectively increases the number of trains in the peak hours available for both interregional and regional riders, since the Metropolitan trains can be counted in each category. Though the physical capacity and total number of slots is the same, the scarce capacity can be more flexibly utilized by rail passengers, since the pricing of Metropolitan service can be used to regulate the level of regional ridership on these trains. One of the Metropolitan trains runs the entire corridor from Boston to New York, serving both Intercity and Regional rail passengers. The other train operates from Boston or New York to Philadelphia and serves the Keystone Corridor to Harrisburg, PA. The combination of Metropolitan and Intercity-Corridor-Other service provides regular service during peak hours at 4 tph in the busiest portion of the NEC between Philadelphia and New Haven, serving all current Intercity stations. The two Metropolitan trains also serve major Regional rail stations in these markets, such as Odenton, MD and North Brunswick, NJ.

7.2.3 Network

The Representative Route for Alternative 1 includes the entire existing NEC main line between Washington, D.C., and Boston. (This is also the case for Alternatives 2 and 3.)

A schematic diagram of the Representative Route for Alternative 1 is shown in Figure 25. This diagram, and the others that depict the available routes for the other Action Alternatives, were developed to help build the analytic model used to analyze and reconcile train movement and station stopping patterns, and show major stations and junctions and the network links that connect them. The horizontal close parallel lines represent the number of NEC main tracks. The other lines that in places deviate from the main horizontal line represent new segments that generally are constructed off the existing NEC right-of-way, either to obtain better speeds and trip times or because of right-of-way constraints on the existing corridor.

Figure 25: Representative Route Schematic – Alternative 1



Source: NEC FUTURE team, 2015

7.3 ALTERNATIVE 2

Alternative 2 is intended to grow the role of rail within the Study Area, expanding rail service at a faster pace than the proportional growth in regional population and employment. As shown in Figure 26, south of New Haven, CT, service and infrastructure improvements are focused generally within the existing NEC; however, north of New Haven, a new supplemental route is added between New Haven, Hartford, and Providence to increase resiliency, serve new markets, reduce trip times, and address capacity constraints. The existing NEC generally expands to four tracks, with six tracks through portions of New Jersey and southwestern Connecticut. Alternative 2 includes new service to Philadelphia International Airport, and some Regional rail run-through service in New York City and Washington, D.C., to increase terminal throughput.

Alternative 2 provides a significant increase in the volume of Intercity service on the NEC compared to the No Action Alternative. With major investment in new railroad capacity between central New Jersey and southwestern Connecticut, this alternative also provides the opportunity for increasing the volume of peak Regional rail service, though the increases in Regional rail are more marginal, as these increases build on the very high base of service specified in the minimum 2040 targets. Alternative 2 can simultaneously accommodate the program for Intercity train service, meet or exceed the 2040 targets for Regional rail service, and provide for 15-minute headway limited-stop Metropolitan service along the entire NEC if it is developed to the high end of the range of capacity. In addition, the infrastructure in Alternative 2 provides reasonable scheduling flexibility for both the Intercity and Regional rail operators, permitting a relatively wide range of possible future schedule and service patterns.

7.3.1 Markets Served

Alternative 2 improves the level of service available to all of the markets served by the No Action Alternative. It also selectively taps a set of potential new travel markets that currently are not served or not well served by the NEC. This includes the New Haven-Hartford-Springfield corridor, now known as the Hartford Line. Hartford becomes a market on the NEC rather than a connecting corridor, and other locations along this line have improved trip times and service offerings by virtue of the new high-speed line between New Haven and Hartford that is part of this alternative, as well as the greatly improved accessibility of Providence and Boston by rail.

A second market that sees greatly improved rail service is Philadelphia International Airport, which also has a station directly on the NEC in this alternative, with frequent Intercity-Express, Metropolitan and Regional rail service up and down the NEC as well as to the Keystone Corridor and the rest of the SEPTA Regional rail network.

A third market with the opportunity for significantly increased NEC rail service in Alternative 2 is located on the south side of Washington, D.C., Improvements to the Long Bridge corridor between Washington, D.C., and Alexandria, VA, coupled with improvements at Washington Union Station, permit Metropolitan service and selected Regional rail trains to run through Union Station, effectively extending the reach of the NEC to this heavily populated part of greater Washington, D.C., as well as to Reagan National Airport.

7.3.2 Service Levels

Intercity service is increased to four Intercity-Express trains per hour in the standard peak hour between Washington and Boston, which represents a four-fold increase in service on the south end and an even greater proportional increase on the north end, compared with the No Action Alternative. This Alternative also seeks to increase the number of train slots reserved for Intercity-Intercity-Corridor-Other trains, including Long-Distance services, to 4 tph in each direction, provided there is sufficient available capacity to accommodate these unoccupied train slots in the peak period.

The levels of Intercity rail service in Alternative 2 in the standard peak hour are as follows:

- Intercity-express: 4 tph, operating between Washington, D.C., and Boston
- Metropolitan service: 4 routes offering 4 tph at all major stations along the spine, with…
  - 2 tph operating between Washington, D.C., and Boston on the express route (via New Haven-Hartford-Providence on the north end and via Philadelphia Airport on the south end)
  - 1 tph operating from the Keystone Corridor to New York, and thence to Boston via the Shore Line
  - 1 tph operating from the Keystone Corridor to Hartford via the express route, and thence to Springfield via the Hartford-Springfield Line
  - 2 tph operating from Washington, D.C., to Philadelphia via Philadelphia Airport, with one or both trains extended westward on the Keystone Corridor as warranted by demand
- Intercity-Corridor-Other service: 2-4 slots per hour, to accommodate up to 2 tph, with one Washington, D.C.-Boston train and one Washington, D.C.-Springfield train
- Empire Corridor: 2 tph to Penn Station New York (remaining separate from NEC), with improved transfers at Penn Station New York.

The level of Intercity-Corridor service running off-corridor remains the same in each of the Action Alternatives, representing an increase in service consistent with the most recent plans developed for this corridor. Alternative 2 provides for 2 tph following the existing NEC route (one Virginia-Washington, D.C.-Boston train via the Shore Line and one Virginia-Washington, D.C.-New Haven-Springfield train heading to either the Knowledge Corridor or Inland Route). These Intercity-Corridor-Other trains serve the Virginia corridors, the SEHSR corridor, the Knowledge Corridor in Massachusetts and Vermont, and the Inland Route between Springfield and Boston. However, the Service Plans in this alternative seek to provide four slots, particularly in the scenarios that represent the high end of the possible range of tunnel capacities into Manhattan. Two of these are empty or "phantom" slots, available for the use of Intercity-Corridor-Other or Long-Distance trains arriving late from off-corridor at their NEC entry point, such as Washington, D.C., or Springfield. These slots also provide an extra margin of reliability and recovery capacity at those times when delays occur on the NEC.

With Metropolitan service provided at 4 tph between New Haven and Philadelphia, Keystone Corridor and Hartford Line service can be provided by Metropolitan trains, and a richer mix of train services becomes available to Intercity travelers in the central portion of the NEC through New York.

Alternative 2 assumes half-hourly pulse-hub operations at the lower level of 30th Street station, with regularly repeating opportunities for coordinated timed transfers among various rail services at repeating 30-minute intervals. In the assumed service plan, Intercity-Express trains overtake Metropolitan trains at 30th Street, with cross-platform transfers between the two trains while dwelling at the platform in Philadelphia. In this same scenario, both Keystone Metropolitan trains and inbound Atlantic City Line trains are timed to arrive just ahead of the Intercity-Express and Metropolitan trains, providing convenient transfers for passengers from these services to northbound Intercity-Express trains, southbound Intercity-Express, and Metropolitan trains.

Regional rail service expands above the minimum levels needed to preserve existing regional rail market share, with increased frequencies of service and increased capacity that enable Regional rail ridership to grow at a greater pace than underlying demographic growth within the regions of the NEC. The largest increase in Regional rail service results from the two new tunnels under the East River on approach to Penn Station New York, which enables an increase in Regional rail service from Connecticut, Long Island and New Jersey to and through New York City.

Further increases in Regional rail service are also planned for in the Philadelphia, Baltimore, and Washington, D.C., regions. Table 18 and Table 19 present the service plan specifications for Intercity and Regional rail service, respectively, showing the levels of rail service provided in Alternative 2.

Table 18: Alternative 2 – Intercity Service in Standard Peak Hour

NEC FUTURE EIS ALTERNATIVES
Standard Peak Hour Trains per Hour

	Existing	No Action	Alt 2
South End			
Intercity Express	1	1	4
Intercity Corridor			
Wash-Phila	1	1	2
Phila-NY	2	2	2
Metropolitan			
Wash-Phila	--	--	4
Phila-NY	--	--	4
North End			
Intercity Express	<1	<1	4
Intercity Corridor			
NY-New Haven	<1	<1	2
New Haven-Boston (Shore Line)	<1	<1	-
New Haven-Springfield	--	--	2
Metropolitan			
NY-New Haven	--	--	4
New Haven-Boston (OSB-KEN Bypass)	--	--	--
New Haven-Boston (Shore Line)	--	--	1
New Route	--	--	4
Connecting Corridors			
Virginia	<1	<1	2
Empire	1	1	2
Keystone	1	1	2
Springfield	<1	<1	2
Knowledge Corridor	1 tpd	1 tpd	1
Inland Route	--	<1	1
Other	--	--	--

Source: NEC FUTURE team, 2015

Table 19: Alternative 2 – Regional Rail Service

REGIONAL TRAINS PER HOUR	Existing / No Action				Alternative 2			
	Peak	Shoulder	Reverse Peak	Off Peak	Peak	Shoulder	Reverse Peak	Off Peak
WASHINGTON REGION								
MD Regional Rail (Penn Line)	3	2.5	1.5	1.3	10	6	5	3
VA Regional Rail	5.5	1	0.2	0.1	8	5	3	3
PHILADELPHIA REGION								
North Side Regional Rail	7	4	4	2.5	12	6	5	4
South Side Regional Rail*	5	4	3.5	3	10	10	12	7
NEW YORK REGION								
NJ - NEC / NJCL Trans Hudson	15	8	7	3	22	14	10	4
NJ - Other Regional Rail Trans Hudson	6	3	3	2	-	-	-	-
NJ - Standard Inner Branch Slots	-	-	-	-	20	14	10	8
CT - New Haven Line	22	16	12	3	32	19	15	6
BOSTON REGION								
NEC Regional Rail	9	4	4	2.6	14	10	10	5
Worcester / Framingham Lines	3	2	1	1	4	3	1	1

Source: NEC FUTURE team, 2015

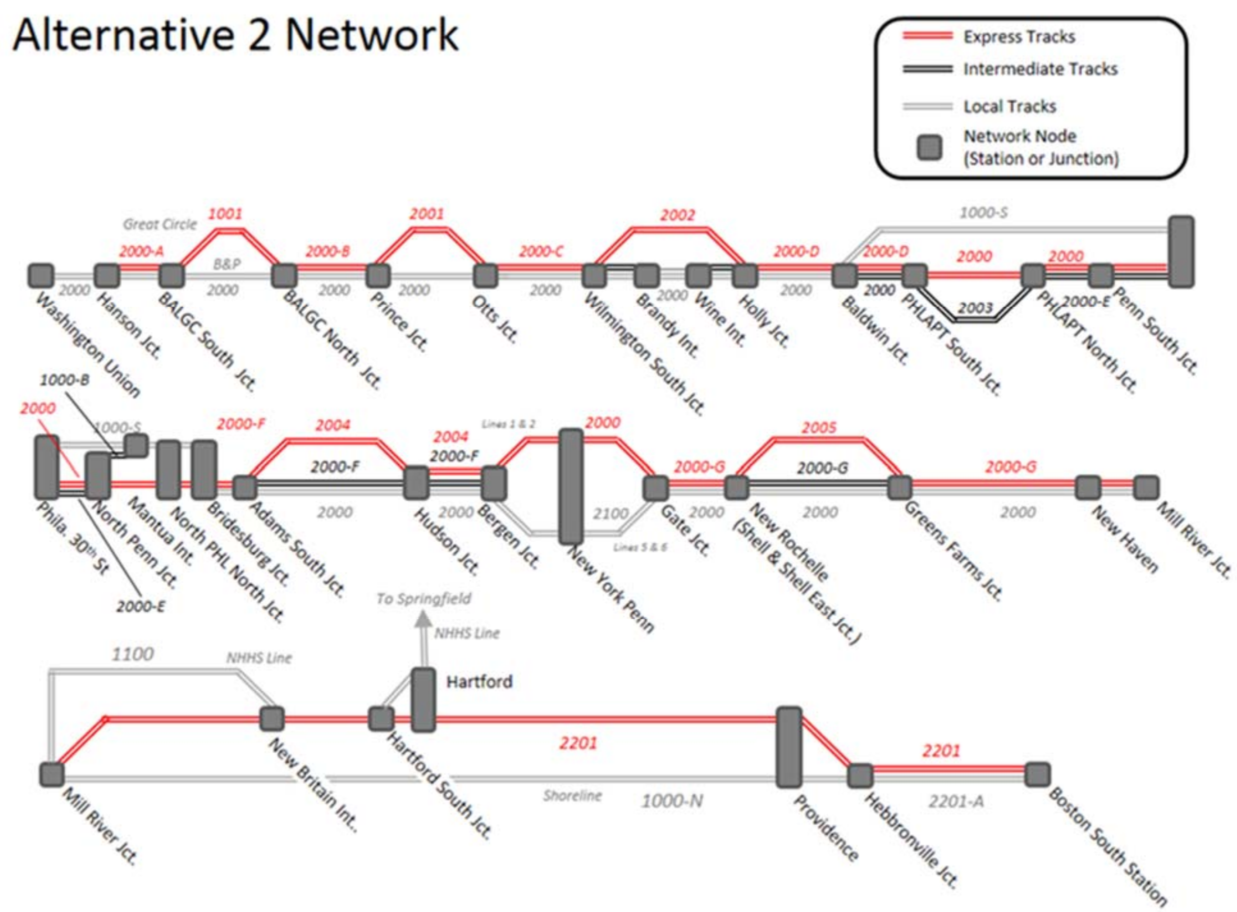
Note: Fractional values represent services that do not operate the same number of trains each hour during the four major time periods. For existing service, these values were derived so that the total daily number of trains in the service specification approximately matches the number of trains actually operated.

* Service Plan includes four additional inner-zone Regional rail trains in the peak hour on the Wilmington Line that are not reflected in the Alternative 2 peak counts.

7.3.3 Network

A schematic diagram of the Representative Route for Alternative 2 is shown in Figure 26.

Figure 26: Representative Route Schematic – Alternative 2



Source: NEC FUTURE team, 2015

7.4 ALTERNATIVE 3

Alternative 3 provides a rail network with much greater capacity and the ability to offer a full array of rail services. Alternative 3 transforms the role of rail within the Study Area, positioning rail as the dominant mode for Intercity travel within the NEC and for journey-to-work travel to the major CBDs of the NEC. This alternative features construction of a new 2-track high-speed rail line for the entire length of the route between Washington, D.C., and Boston. It also includes infrastructure upgrades and service improvements along the existing NEC route.

Service and infrastructure improvements include upgrades on the NEC and the addition of a two-track second spine that operate adjacent to the NEC south of New York and expand the reach of the NEC to new markets north of New York. This new spine supports high-speed rail services between major NEC markets and provides additional capacity for Intercity and Regional rail services on both the existing NEC and new spine.

7.4.1 Routing and Service Options

The two ends of the rail corridor on either side of New York City have different roles and characteristics in Alternative 3. South of New York the route approximately parallels the existing NEC, serving roughly the same travel markets but providing much better service and offering greater service frequency and more service choices at NEC stations, including introducing Intercity service at selected major Regional rail stations. North of New York, Alternative 3 provides a new, second route for high-speed train service, opening up the NEC to new travel markets and creating an expanded network of rail services. Four variations of Alternative 3 are analyzed as Action Alternatives, corresponding to the four North End Route Options that emerged from the comparative evaluation of North End options:

<u>Alternative 3 – North End Route Options for Second Spine Between New York and Boston</u>

- 3.1 – New York-White Plains East-Danbury-Hartford-Providence-Boston
- 3.2 – New York-Long Island-New Haven-Hartford-Providence-Boston
- 3.3 – New York- Long Island-New Haven-Hartford-Worcester-Boston
- 3.4 – New York-White Plains East-Danbury-Hartford-Worcester-Boston

All four of these variations are identical in terms of both service and infrastructure between Washington, D.C., and New York. All four variations include upgrading of the existing NEC Spine and improvements in service on the existing New Haven Line and Shore Line, irrespective of the location of the second spine route. Between New York and Boston, the level of service and mix of rail service types remains constant across the four route variations, although the specific stopping patterns and trip times for services utilizing the second spine route vary somewhat.

The Service Plans for Alternative 3 are intended to provide a quantity of train service significantly higher than the other Action Alternatives, filling the capacity created by the construction of two new high-speed express tracks for the full length of the existing NEC between Washington, D.C., and Boston.

7.4.2 Markets Served

The additional NEC rail capacity, coupled with the faster trip times that are possible to the major NEC cities, can be used in this alternative to expand the physical reach of the NEC. At the same time, the new routes that are created parallel to the existing corridor improve the rail system's coverage within the Study Area. Several new geographic markets become part of the NEC and are provided with direct and frequent NEC rail service – including Intercity-Express, Metropolitan and, in some cases, express commuter trains:

- Downtown Baltimore
- Center City Philadelphia
- Central Connecticut corridor, including White Plains, NY and Danbury and Waterbury, CT (Route Options 3.1 and 3.4 only)

- Long Island (Nassau & Suffolk Counties) and Jamaica, Queens (Route Options 3.2 and 3.3 only), as documented in Section 6 of this memorandum
- Hartford, CT
- The Hartford-Providence corridor (Route Options 3.1 and 3.2 only)
- The Hartford-Worcester-Boston corridor (Route Options 3.1 and 3.4 only)

Potential connecting corridor markets that can be served on an extended NEC or connecting high-speed line, also have the opportunity for new direct Intercity service to the NEC or receive significantly improved service to the NEC where some service now exists.

The coverage of the Regional rail network also can be expanded significantly in Alternative 3. Alternative 3 is expected to generate capacity beyond what will be needed to serve the existing markets. This additional capacity can be used to offer Regional rail service in new corridors or to offer one-seat ride service to NEC destinations on Regional rail lines that do not currently offer direct service or have only limited direct service. In virtually all these examples, considerable investment in railroad infrastructure, stations, fleet and yard facilities are required in locations other than on the NEC. The scope of NEC FUTURE does not encompass these potential branch line initiatives – either the required investments or their environmental consequences – although the potential benefits of expanding Regional rail network connections to the NEC will be assessed qualitatively and taken into consideration in the evaluation of the Action Alternatives. In Alternative 3, the future sponsors and operators of Regional rail and Intercity-Corridor service have great discretion to develop and implement service concepts that meet market demands for rail travel as they emerge.

Finally, the re-routing of most of the Intercity-Express service to new rail routes through Baltimore, Philadelphia and New York in Alternative 3 presents the potential opportunity to utilize the capacity freed up on the existing routes to provide short-headway local rail service within these metropolitan regions – effectively creating new rail transit lines for these cities. This concept is analogous to the Overground and Thames link services in London, the RER service in Paris and the various S-Bahn networks throughout Germany and Switzerland. The NEC route through Baltimore was identified as a potential future transit line in the 2000 Baltimore Region Rail Plan. In the New York area, offering transit-style service on the inner portions of the LIRR network in Queens and in Hudson and Essex Counties in New Jersey is possible with the capacity provided in Alternative 3 and can be complementary to both the Regional rail and rail transit networks.

7.4.3 Service Levels

The Alternative 3 Service Plans provide for more than six times the quantity of Intercity-Express and Metropolitan service compared with the No Action Alternative, in the standard peak hour. It provides for Intercity-Express service at 6 tph in the future standard peak hour, with some operating the full length of the corridor between Boston and Washington, D.C., on the express tracks, others diverging to serve groups of stations along portions of the existing NEC, and still others introducing direct premium service to connecting corridors such as the Keystone and Springfield lines.

The high number of express trains that are possible in this alternative allows for relatively wide variations in stopping patterns, providing dramatic reductions in trip times (90 minutes between Boston and New York and between New York and Washington, D.C., on the Boston-New York-Philadelphia-Washington, D.C., service) while also providing direct premium service to more stations on the NEC. Many stations that currently receive only Regional rail or Amtrak's Northeast Regional Intercity service today, receive regular premium service in Alternative 3. This is one aspect of Alternative 3 that potentially can be transformative in its effect on rail travel within the Northeast U.S.

Metropolitan service is also expanded significantly, since it operates at 4 tph over two separate routes to the north of New York and covers dual routes through Philadelphia and Baltimore. Four to 6 tph operate the full length of the corridor between Washington, D.C., and Boston with additional service supplementing these frequencies with 2 tph between New Haven and Philadelphia. This results in 8 Metropolitan trains per hour through New York. North of New York, four of these trains operate on the existing NEC between New York and New Haven; four operate via the new high-speed route - either Central Connecticut or Long Island. Service through Philadelphia is split between the two stations with 4 tph serving 30th Street Station and 4 tph serving the new Center City station. Two of the four trains that serve 30th Street provide service to Harrisburg on the Keystone Branch, the other six trains (two from 30th Street, four from Center City) continue to Washington, D.C.

Excess capacity on the new high-speed route provides an opportunity to deliver express commuter service operated with high-performance trainsets. This service reduces trip time from outer zone commuter territories, improve the quality of the passenger experience, and potentially expand the existing Regional rail territories beyond their current boundaries.

Two corridor trains per hour will provide one-seat rides from the markets south of Washington (Newport News, Norfolk, Richmond, Lynchburg, and Charlotte) to markets along the NEC. These trains, along with the Intercity-Express and Metropolitan trains will also provide Intercity service between markets along the NEC. An additional two Intercity-Corridor slots is available on the NEC to accommodate various combinations of connecting corridor service from other off-corridor markets.

Table 20 presents the assumed level of Intercity rail service in Alternative 3 for the standard peak hour. The level of Regional rail service is expanded to both respond to identified demand and to fill available capacity on the railroad. Table 21 shows the assumed service levels.

Table 20: Alternative 3 – Intercity Service in Standard Peak Hour

	Existing	No Action	Alt 3
South End			
Intercity Express	1	1	6
Intercity Corridor			
Wash-Phila	1	1	2
Phila-NY	2	2	2
Metropolitan			
Wash-Phila	--	--	4
Phila-NY	--	--	8
North End			
Intercity Express	<1	<1	6
Intercity Corridor			
NY-New Haven	<1	<1	2
New Haven-Boston (Shore Line)	<1	<1	-
New Haven-Springfield	--	--	2
Metropolitan			
NY-New Haven	--	--	4
New Haven-Boston (OSB-KEN Bypass)	--	--	--
New Haven-Boston (Shore Line)	--	--	2
New Route	--	--	4
Connecting Corridors			
Virginia	<1	<1	4
Empire	1	1	2
Keystone	1	1	2
Springfield	<1	<1	2
Knowledge Corridor	1 tpd	1 tpd	1
Inland Route	--	<1	1
Other	--	--	2

Source: NEC FUTURE team, 2015

Table 21: Alternative 3 – Regional Rail Service

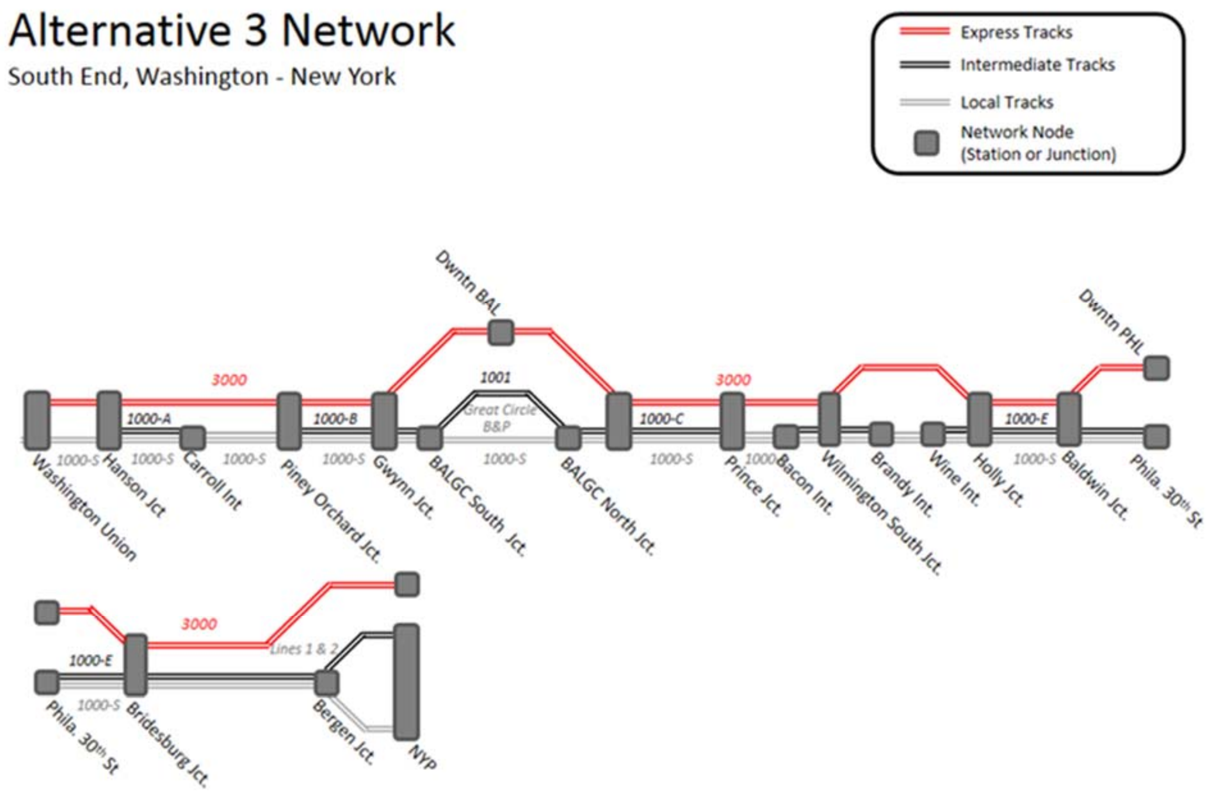
REGIONAL TRAINS PER HOUR	Existing / No Action				Alternative 3			
	Peak	Shoulder	Reverse Peak	Off Peak	Peak	Shoulder	Reverse Peak	Off Peak
WASHINGTON REGION								
MD Regional Rail (Penn Line)	3	2.5	1.5	1.3	12	8	6	3
VA Regional Rail	5.5	1	0.2	0.1	8	6	4	4
PHILADELPHIA REGION								
North Side Regional Rail	7	4	4	2.5	12	7	6	4
South Side Regional Rail*	5	4	3.5	3	16	14	16	11
NEW YORK REGION								
NJ - NEC / NJCL Trans Hudson	15	8	7	3	24	14	10	4
NJ - Other Regional Rail Trans Hudson	6	3	3	2	-	-	-	-
NJ - Standard Inner Branch Slots	-	-	-	-	30	24	20	12
CT - New Haven Line	22	16	12	3	36	19	15	6
BOSTON REGION								
NEC Regional Rail	9	4	4	2.6	20	14	12	9
Worcester / Framingham Lines	3	2	1	1	8	4	2	2

Source: NEC FUTURE team, 2015
Note: Fractional values represent services that do not operate the same number of trains each hour during the four major time periods. For existing service, these values were derived so that the total daily number of trains in the service specification approximately matches the number of trains actually operated.
* Service Plan includes four additional inner-zone Regional rail trains in the peak hour on the Wilmington Line that are not reflected in the Alternative 3 peak counts.

7.4.4 Network

The Representative Route for Alternative 3 generally parallels the existing NEC and serves the same metropolitan regions and markets as the existing corridor on the south end between Washington, D.C., and New York. A new 2-track high-speed line is constructed on new route segments. In most locations, the route is adjacent to the existing NEC. In several places, however, the high-speed line deviates from the existing corridor, most prominently taking more direct routes through downtown Baltimore and Philadelphia. The south end Representative Route, common to all four variations of Alternative 3, is shown schematically in Figure 27.

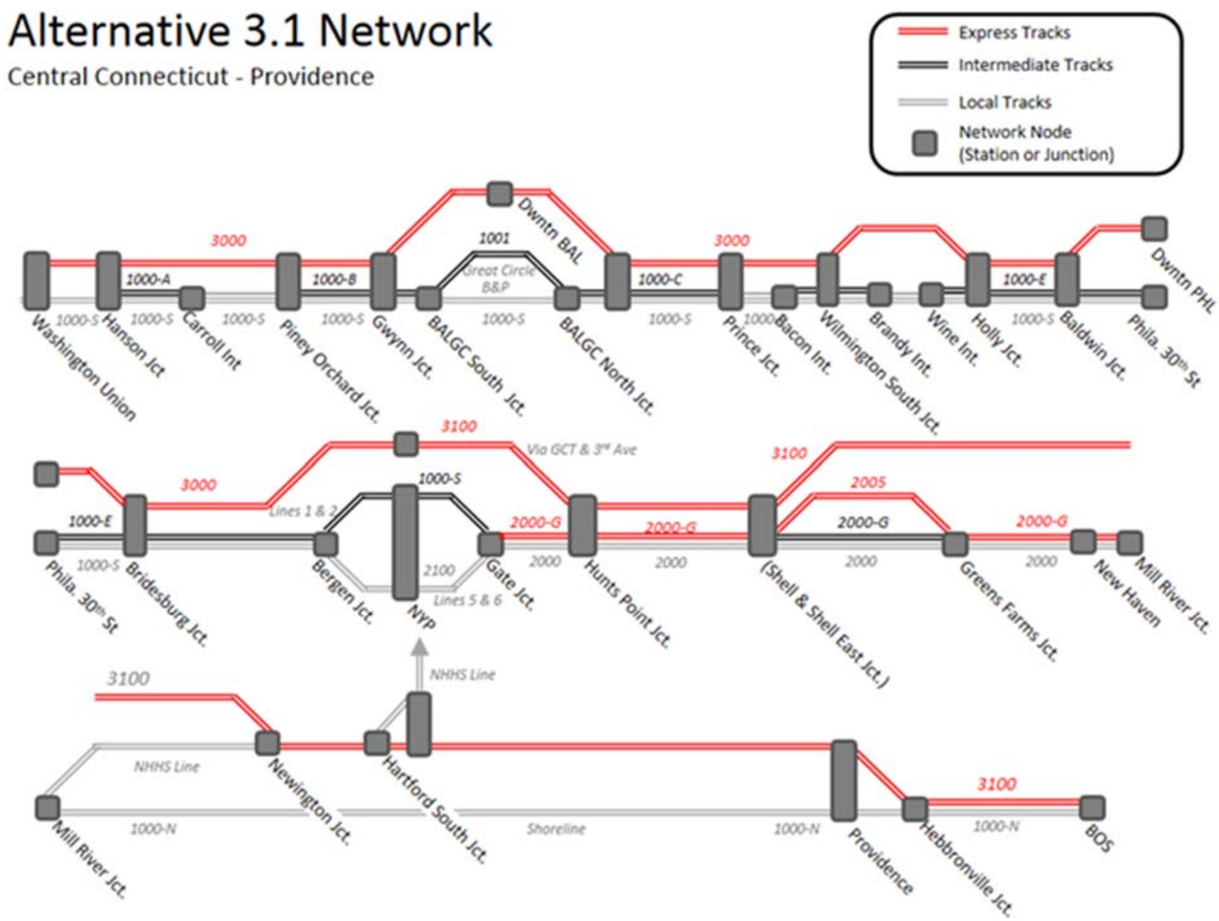
Figure 27: Representative Route Schematic – Alternative 3, All Route Options (Washington-to-New York)



Source: NEC FUTURE team, 2015

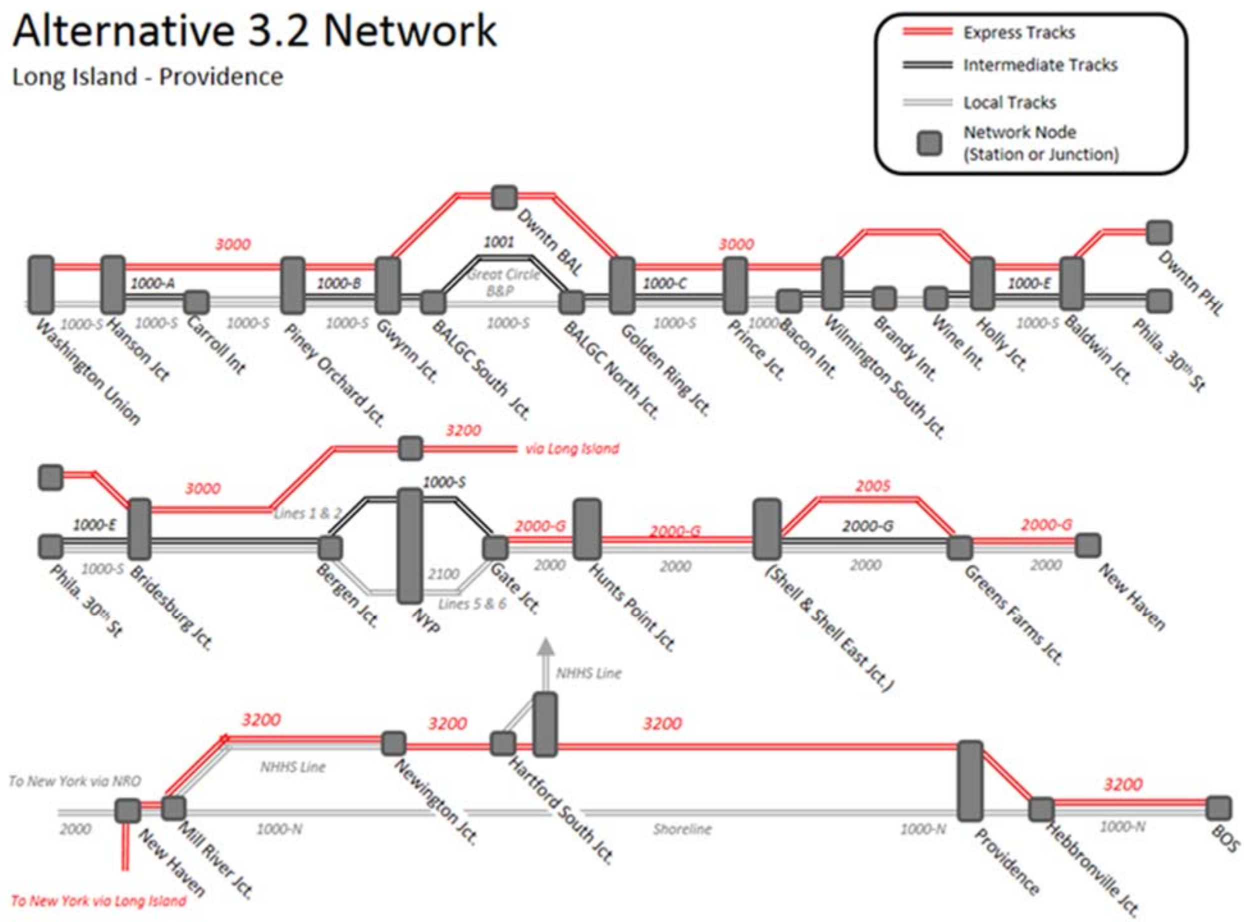
Figure 28 through Figure 31 depict the four north end routing variations for the second spine between New York and Boston. Alternative 3.1 provides the new high-speed route via Central Connecticut and Providence (New York-Danbury-Hartford-Providence-Boston). In Alternative 3.2, the north end route for the second spine goes via Long Island and Providence (New York-Long Island-New Haven-Hartford-Providence-Boston). Alternatives 3.3 and 3.4 include the routes via Worcester instead of Providence.

Figure 28: Representative Route Schematic – Alternative 3, Variation 3.1 (Central Connecticut-Providence Route)



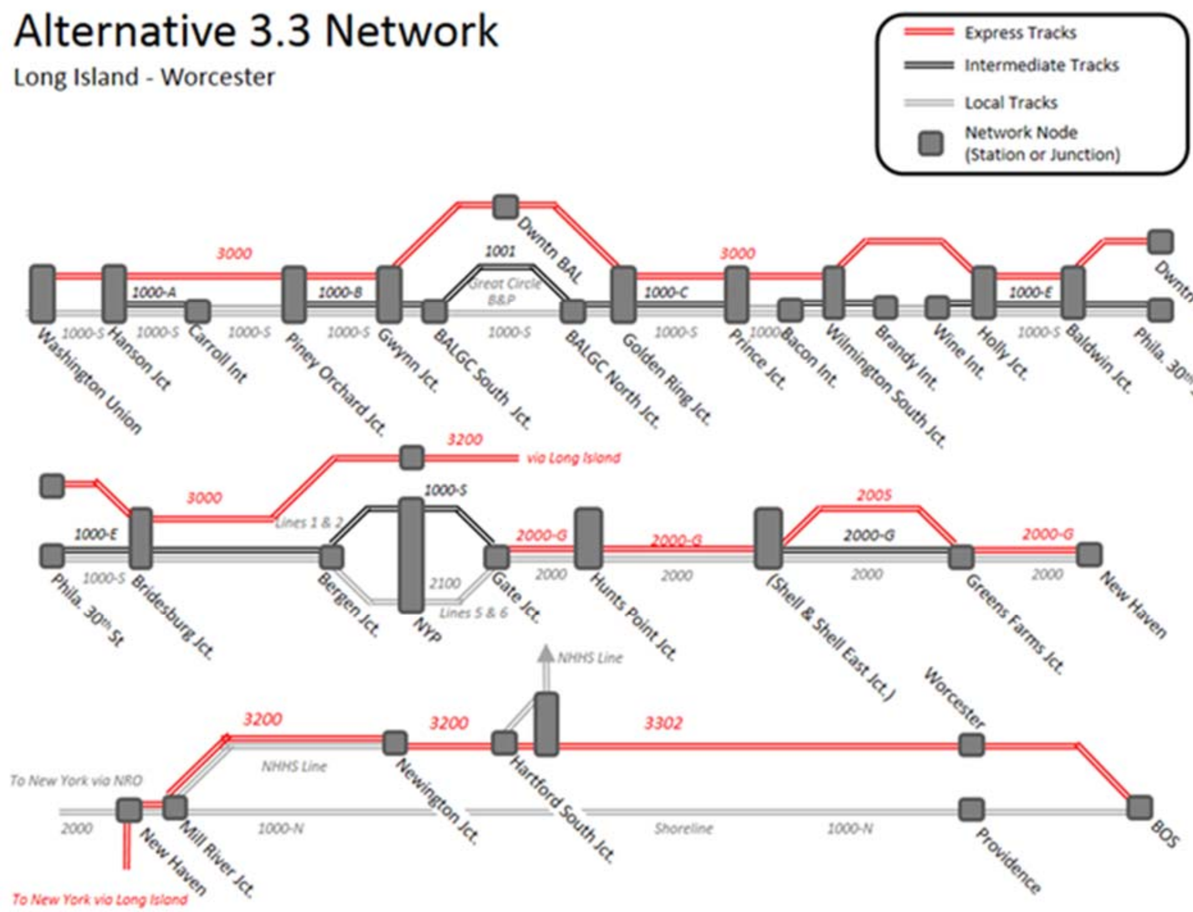
Source: NEC FUTURE team, 2015

Figure 29: Representative Route Schematic – Alternative 3, Variation 3.2 (Long Island-New Haven-Hartford-Providence Route)



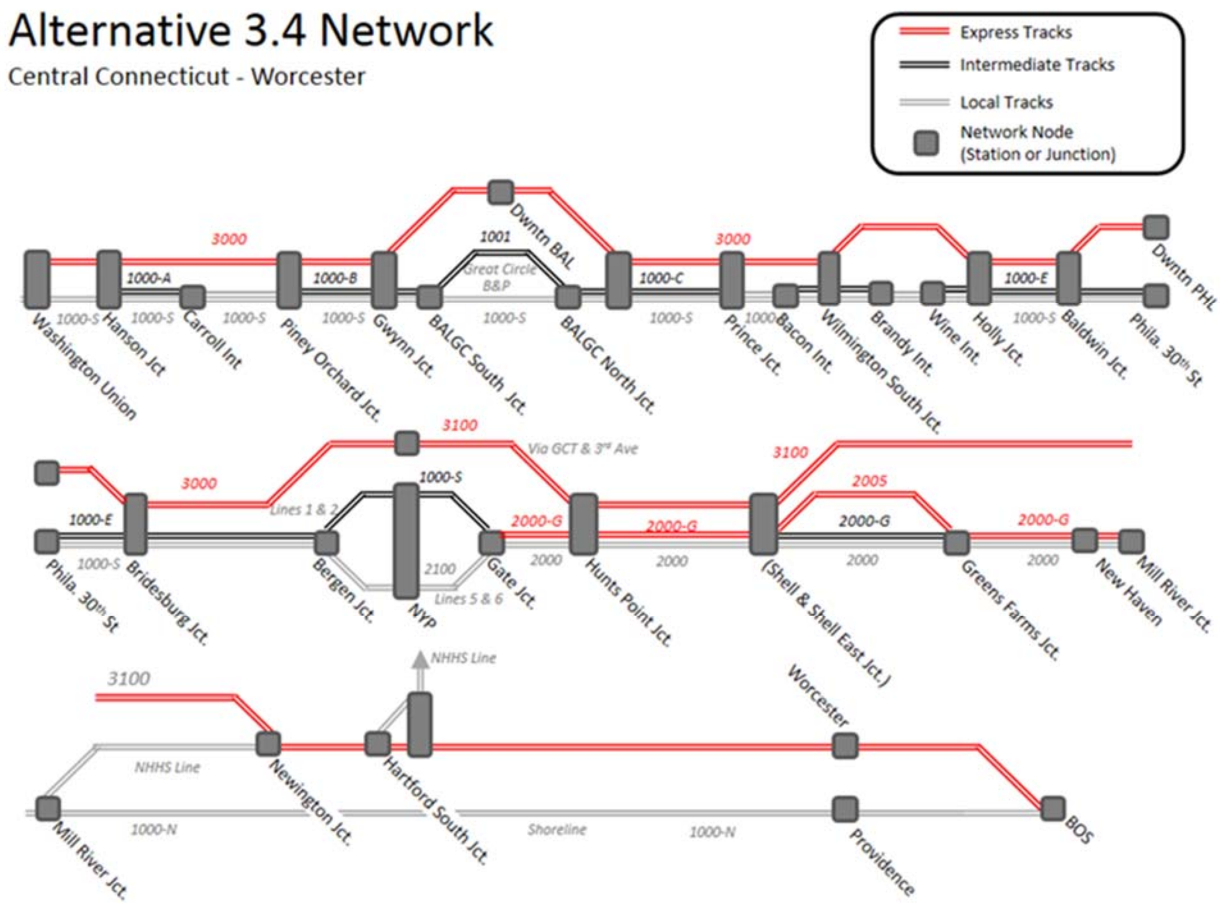
Source: NEC FUTURE team, 2015

Figure 30: Representative Route Schematic – Alternative 3, Variation 3.3 (Long Island-New Haven-Hartford-Worcester Route)



Source: NEC FUTURE team, 2015

Figure 31: Representative Route Schematic – Alternative 3, Variation 3.4 (Central Connecticut-Worcester Route)



Source: NEC FUTURE team, 2015

8 Appendix

8.1 TECHNICAL ASSUMPTIONS

This appendix summarizes assumptions for the analysis of the Tier 1 EIS Alternatives (Action Alternatives) with respect to selected operational and physical characteristics of the railroad, particularly segments of new track envisioned in the alternatives. The draft assumptions listed in this memorandum are for planning purposes only and are subject to change. Use of these assumptions for NEC FUTURE does not imply or indicate their future approval or adoption as standards by the FRA or any of the operating railroads.

This memorandum is intended to supplement rather than replace the methodology technical memoranda covering operations analysis and engineering. A separate memorandum, included in the Tier 1 Draft Environmental Impact Statement, describes the construction types and typical right-of-way cross-sections that define the representative routes for each of the Action Alternatives. The full range of relevant technical issues is addressed in these other documents.

8.1.1 Operating Environment and Equipment Tiers

The Northeast Corridor (NEC) is a complex operating environment, in which many different kinds of passenger and freight trains operate. It is unique in the U.S. in its functioning simultaneously as a high-speed rail line, a conventional-speed main line for regular intercity and commuter passenger trains, and in various locations as a line serving both through and local freight trains.

The FRA's passenger equipment safety standards currently govern the crashworthiness standards and emergency egress/rescue access systems of Tier I and Tier II passenger equipment (not to be confused with the National Environmental Policy Act (NEPA) Tier 1 and Tier 2 environmental review processes). Tier I equipment operates at speeds not exceeding 125 mph, Tier II equipment operates at speeds between 125 mph and 150 mph, and the standards require regulatory approval for the operation of Tier II passenger equipment that has not been previously used in revenue service in the U.S. The FRA track regulations also set the maximum allowable speed for different classes of track, and regulatory approval is required for equipment operating at speeds above 125 mph

Because the FRA has authorized the operation of Amtrak's Acela Express at speeds up to 150 mph, the existing NEC has trains operating in both a Tier I and Tier II environment. Because of this unique mix of services on the NEC, waivers to the FRA regulations in certain cases are granted by the FRA to permit operating characteristics that fall outside of the limits prescribed in the regulations. NEC Tier I operations are constrained by the maximum operational speed for passenger trains of 125 mph, but there are currently no Tier 1 restrictions regarding shared use or right-of-way with freight operations. The connecting corridors (e.g., New Haven-Hartford-Springfield) off of the NEC also operate in the Tier I environment.

Tier II standards govern operations along the portions of the NEC where maximum authorized speeds for passenger trains range between 125 mph and 150 mph Amtrak Acela Express trains are the only Tier II train equipment permitted to operate at these speeds. With a waiver, the Acela equipment can operate intermixed with other Tier I passenger and freight operations and operate above 125 mph, so long as there is temporal separation with any freight operations. Intermixed operations currently include Amtrak Intercity Corridor and Long Distance trains. Amtrak has petitioned the FRA for increasing the top speed of its Tier II operations to 160 mph in certain locations, which would require modification to its current waiver.

The FRA is currently developing Tier III passenger equipment safety standards. The Tier III standards would represent a relatively new national standard for high-speed rail operations and equipment, which will apply to the California high-speed system, and are assumed for future NEC operations in all of the Action Alternatives being considered for NEC FUTURE. In conjunction with the FRA track standards and other regulations, the Tier III standards will establish the crashworthiness standards for equipment that can operate on shared tracks or on separate tracks within a shared right-of-way and the infrastructure and systems required for safe operations.

It is assumed that Tier III passenger equipment safety standards (along with the FRA's track safety standards), would permit higher-performance high-speed rail operations, with maximum authorized speeds above 125 mph, up to 220 mph. The Tier III environment would require exclusive right-of-way for high-speed trains operating above 125 mph and prohibit other equipment types from sharing the exclusive high-speed tracks. There would be no intermixing of high-speed operations with freight or non-Tier III passenger operations (Tier I or Tier II) at speeds above 125 mph. Tier III equipment could operate, however, in a Tier I shared use environment on tracks used by conventional passenger and freight equipment, at speeds at or below 125 mph.

It is assumed that the FRA could waive Tier III standards to permit Tier III operations at speeds up to 160 mph in a shared use environment, allowing these trains to match the performance of the Tier II Acela Express when operating on the existing NEC. Otherwise, the FRA regulations would restrict the Tier III equipment operating in a shared use environment to a top speed of 125 mph, which would result in much slower average speeds and longer trip times than existing Acela equipment when operating on the existing corridor – which would tend to offset the benefits of high-speed operations in alternatives (or interim phases of implementation) that use both new high-speed lines and portions of the existing NEC.

Table 1 summarizes the above key elements of the current Tier I and Tier II operating environments on the existing NEC and the associated characteristics of the types of equipment operating on the corridor. Table 2 summarizes the same key elements for the Tier I and Tier III operating environments that are assumed to be in place on the NEC in the future, once Amtrak completes its planned replacement of the Acela Express fleet with new Tier III equipment.

The FRA's track safety standards also govern other factors, such as grade crossings. No grade crossings are permitted when operating speeds exceed 125 mph (Class 8 and Class 9 track). This is generally not an issue on the NEC, where there are no grade crossings except on portions of the Shore Line in southeastern Connecticut and Rhode Island where track curvature limits speeds to below 125 mph. Any new rail right-of-way included in the Action Alternatives will be completely grade-separated.

As noted previously, Tier III passenger equipment is assumed to be able to operate with a waiver above 125 mph, up to 160 mph (Class 8 track), on tracks that are also used by freight trains, as long as the freight trains operate with temporal separation (i.e., the operation of freight trains is strictly limited to times of day during which passenger service with Tier III equipment is not operating).

The requirement for exclusive use, along with track maintainability issues, will preclude operation of freight trains on Class 9 track with speeds up to 220 mph. The Action Alternatives will seek to provide for freight operations on separate conventional (non-high-speed) tracks. Where operation of freight trains on high-speed or express tracks (at Class 8 or below) is unavoidable and can be accommodated, either for normal or contingency operations, restrictions may be placed on the type, weight or maximum speed of freight trains operating on the high-speed tracks, with possible requirements for signaling, dragging equipment, overheated bearing and high impact wheel detectors in place at entry points to such tracks. Additional study is required to determine the most appropriate rail freight requirements and solutions for each Action Alternative.

The requirements for and costs of additional infrastructure to provide for safe operations in a mixed traffic environment remain to be determined. The FRA will make reasonable assumptions about infrastructure requirements and costs based on the latest information available for NEC FUTURE.

Intercity Long-Distance trains, and Intercity Corridor trains that operate for a portion of their route off-corridor on tracks owned by freight railroads, are assumed to operate with performance characteristics on the NEC that are similar to or better than existing Tier I Northeast Regional trains (i.e., 125 mph maximum speed, similar or better braking and acceleration rates).

Table 1. Operating Environments and Equipment Classification – Existing

Operating Environment	Characteristic	Rolling Stock			
		Tier III	Tier II	Tier I	Freight
Tier I	Max. Authorized Speed	Not Allowed	125 mph	125 mph	--
	Shared Track Use		Allowed	Allowed	Allowed
	Shared Right-of-Way		Allowed	Allowed	Allowed
Tier I and II with waiver	Max. Authorized Speed	Not Allowed	160 mph**	125 mph	--
	Shared Track Use		Allowed	Allowed	Not Allowed*
	Shared Right-of-Way		Allowed	Allowed	Allowed, with appropriate physical separation

*Except with temporal separation
**Speeds of 160 mph would only be permitted with modification of existing waiver permitting Amtrak's Acela Express to operate at speeds up to 150 mph.

Table 2. Operating Environments and Equipment Classification – Future Assumption

Operating Environment	Characteristic	Rolling Stock		
		Tier III	Tier I	Freight
Tier I	Max. Authorized Speed	125 mph	125 mph	--
	Shared Track Use	Allowed	Allowed	Allowed
	Shared Right-of-Way	Allowed	Allowed	Allowed
Tier III	Max. Authorized Speed	220 mph	n.a.	
	Track Use and Right-of-Way	Exclusive Use Only	Not Allowed	
Tier III with waiver	Max. Authorized Speed	220 mph	Separate tracks within right-of-way, in Tier 1 operating environment	
	Track Use	Exclusive Use Only		
	Right-of-Way	Shared right-of-way allowed with appropriate offset distance, barrier separation and intrusion detection and protection; requires waiver		
Tier I and III with waiver	Max. Authorized Speed	160 mph	125 mph	--
	Shared Track Use	Allowed	Allowed	Not Allowed*
	Shared Right-of-Way	Allowed	Allowed	Allowed, with appropriate physical separation

* Except with temporal separation

8.1.2 Maximum Authorized Speed on New High-Speed Lines

Assumptions regarding the maximum authorized speed (MAS) for trains operating on new tracks on the NEC or new connecting routes are presented in Table 3. Existing Tier II (Acela Express) rolling stock is assumed to be retired prior to the 2040 year of analysis. The replacement fleet is assumed to be composed of Tier III equipment.

Table 3. Assumed Maximum Operating Speeds on New Tracks

Case	Track Class	Equipment mix	Maximum Authorized Speed (MAS)		
			Tier III	Tier I	Freight
1	9	Tier III passenger equipment only	220 mph	n.a.	n.a.
2	8	Tier III and Tier I passenger equipment in mixed traffic operations; freight operating with temporal separation	160 mph*	125 mph	50 mph**
3	7	Tier III and Tier I passenger equipment and freight trains in mixed traffic operations	125 mph	125 mph	50 mph**

*Waiver required for operation of Tier III trainsets above 125 mph in shared use environment.
**Maximum values – Subject to further restrictions on speed or limitations on freight access imposed by signal system design, weight limitations, access windows, track maintenance requirements and other factors.

The maximum allowable speed will be reduced in locations with more restrictive civil speed limits, which may occur on account of track curvature, tunnels, adjacent tracks, stations, reduced clearances or other right-of-way conditions. Top speeds for passenger trains on off-corridor routes may be further limited by class of track, availability of cab signals or requirements of the host railroad (e.g., Class 6—110 mph; Class 5—90 mph; Class 4—80 mph).

As part of NEC FUTURE, the FRA is examining alternatives that have a maximum authorized speed for high-speed intercity trains of 220 mph, as well as alternatives that cap the maximum speed at 160 mph. The performance, cost and capacity tradeoffs of these two alternative configurations will be evaluated as Action Alternatives are developed and analyzed. In its assessment of procurement options for NEC high-speed equipment, Amtrak sought information on the performance and cost characteristics of potential trainsets with the capability of operating up to a continuous operating speed of 186 mph or 220 mph. Based on the results of the initial comparison of 220 mph and 160 mph top speeds, FRA may choose to examine in a later phase of analysis of NEC FUTURE a potential high-speed equipment type with an intermediate top speed (e.g., 186 mph).

8.1.3 Right-of-Way Infrastructure

NEC FUTURE will assume that intrusion detection and protection is required for new track on new right-of-way or new track parallel to existing rail lines with operating speeds greater than 125 mph – but is not required when speeds are at or below 125 mph. Currently, Class 8 and Class 9 track owners are required to submit a "right-of-way" barrier plan for the FRA approval that contains provisions designed to prevent vandalism, launching of objects from overhead bridges or structures into the path of trains, and intrusion of vehicles from adjacent rights of way. Train operations on existing NEC tracks with maximum authorized speeds greater than 125 mph are assumed to be able to continue, accommodating the equipment planned for the Action Alternatives, with the infrastructure and systems currently in place or planned for these portions of the NEC. Requirements for additional investment to provide for intrusion detection and protection will be determined on a location-specific basis. Full fencing of the right-of-way perimeter is assumed for all ROW with speeds above 125 mph. Underpasses or bridges for wildlife are assumed to be provided where necessary.

Inter-track barriers (crash walls) will be assumed where new Class 8 or 9 high-speed tracks are constructed parallel to the existing NEC or other existing rail lines, and where the track center spacing between adjacent existing and new tracks is less than 100 feet. Where high-speed tracks are provided in the center of the existing NEC and where the top speed for passenger trains is 160 mph or less, inter-track barriers will not be assumed. Design of inter-track barriers will be based on concepts developed for the California High Speed Train Project (CHSTP). The barrier system is assumed to provide breaks in the barrier wall at one-mile intervals to permit cross access for emergency and maintenance access.

8.1.4 Station Platform Geometry

Platform length assumptions for NEC FUTURE are shown in Table 4. These apply to new stations and to improvements to existing stations, based on the type of train services that will be using the stations. All station platforms on the NEC and new or upgraded connecting routes are assumed to have high-level platforms that facilitate efficient boarding for passengers and comply with the standards of the Americans with Disabilities Act (ADA).

New Intercity Express trains, other Intercity Corridor trains and Regional trains will be assumed to be interoperable at existing station platforms along the NEC. Even in alternatives that provide new dedicated high-speed rights-of-way, there may be locations where trains of various types will share tracks and station platforms, and interim phases of implementation will likely require shared operations over portions of the NEC. Therefore, new high-level platforms at both new and existing stations will be assumed to meet current NEC standards with a platform height 48 inches above the top of rail. New rolling stock operating on the NEC will be assumed to also meet ADA requirements, be compatible with the existing NEC standard for high-level station platforms, and be interoperable with other types of rolling stock at NEC station platforms.

Platforms will be located on tangent (i.e., straight) track wherever possible, to meet the ADA standard for a maximum 3-inch gap between train door sill and platform edge. Where curvature is unavoidable, platform tracks can have a horizontal curvature of no more than 1 degree, 40 minutes. Vertical curves are not allowed on station platform tracks. Platform tracks should be level wherever possible. Where platform tracks must be on a grade, they will be on a constant grade and should be as level as possible, with a maximum gradient of 0.5 percent. NEC FUTURE will assume that island platforms are at least 30 feet wide between platform edges. Side platforms should be 20 feet wide, and vertical circulation elements to and from side platforms should be located outboard of the passenger circulation and waiting zones on the platforms. At locations with physical constraints or low passenger volumes, narrower platforms can be considered, with minimum widths of 26 feet for island platforms and 15 feet for side platforms (with additional width required at points where vertical circulation is provided). Subsequent planning and design, at a Tier 2 level of project development, will confirm the most appropriate dimensions for station platforms.

The assumed station platform lengths shown in Table 4 are initial assumptions for purposes of developing and analyzing the Action Alternatives. Ideally, plans would protect the ability to utilize 400 meter long trainsets on the NEC, which is the current international standard. However, retrofitting existing NEC stations is a major challenge, especially since many existing station platforms are shorter, and their lengthening may be precluded or made very expensive by physical constraints. These planning standards are consistent with the plans for Washington Union Station developed in 2012 as part of the terminal master plan by Amtrak. These assumptions will be revisited as the project progresses and are subject to change based on ongoing NEC system planning that is occurring. Ultimate decisions about the scope of station improvements and new station construction will be made as part of Tier 2 projects that will follow the completion of the NEC FUTURE Tier 1 EIS.

Table 4. Station Platform Lengths

Train Service Type	Criteria	Minimum Platform Length
Express and Metropolitan Services	Planning standard, based on existing constrained platform length conditions at locations such as Boston, New York and Washington (equivalent in length to a 14-car conventional train)	1,200 ft.
	Planning goal, where space permits (accommodates two international-standard 200 meter trainsets coupled together)	1,350 ft.
Intercity Corridor and Long-Distance Services	Planning standard, based on 12 85-ft. coaches plus 2 locomotives	1,200 ft
Regional Rail Services	Planning standard for major stations, based on 12-car EMU trainsets, or 10 coaches plus 2 locomotives	1,050 ft.
	Local regional rail stations can be designed for shorter trains, based on passenger demand and train consists	As required

8.1.5 Rolling Stock

NEC FUTURE service plans for the Action Alternatives will be developed assuming combinations of the types and configurations of rolling stock shown in Table 5, for service on the NEC and in connecting corridors feeding the NEC. There is considerable potential variability in the characteristics of rolling stock that could serve the NEC, and more detailed planning subsequent to the NEC FUTURE process will inform the ultimate decisions about fleet standards and procurement. These planning assumptions will serve as initial guidance for system planning and sizing purposes, as the Action Alternatives are developed and analyzed.

These represent initial working assumptions, for purposes of alternatives development and analysis, which will be updated as the NEC FUTURE analysis progresses. The ultimate decisions about rolling stock procurement, including the configuration and maximum speed of high-speed trainsets, will be made subsequent to the completion of the NEC FUTURE process.

Table 5. Initial Menu of Rolling Stock Choices for Service Planning Purposes

Equipment Type	Tier	Length [1]	Locomotives	Loco Type / Traction Power Type	Train Length [2] (ft)	Seats/Car	Seats/Train	Operates Off-Corridor	Max. Speed on NEC (mph)	Boarding Platform Level	Remarks
Premium Express High-Speed Trainset	III	7-14	0	Concentrated or distributed power w/ Catenary	595-1190	50-60	350-840	No	220	High only	
Metropolitan or Intercity Corridor High-Speed Trainset	III	7-14	0	Concentrated or distributed power w/ Catenary	595-1190	60-70	420-980	No	220	High only	On NEC Spine and branches w/ catenary electrification
	III	12	0	Dual Power / Cat. + 3rd Rail	1020	60-70	720-840	Yes	160-220[5]	High only	NEC-Long Island run-through services
	III	12	0	High-Performance Dual Mode[3]	1020	60-70	720-840	Yes	160-220[6]	High or Hi-Lo	Other off-corridor extensions
	III	12	0	Dual Mode / 3rd Rail + Diesel	1020	60-70	720-840	Yes	160-220[6]	High or Hi-Lo	Long Island-Empire run-through services
Intercity Corridor Train	I	10	2	High-Performance Dual Mode[3]	1000	60-70	600-700	Yes	125	Hi-Lo	New loco type[3]
	I	12	2	Diesel loco	1170	60-70	720-840	Yes	(110)	Hi-Lo	Operates off-corridor only
	I	12	2	Electric loco / Catenary	1170	60-70	720-840	Yes	125	Hi-Lo	On NEC Spine w/ engine change
Regional Rail Electric Multiple-Unit (EMU) [4]	I	12	0	EMU / Catenary or 3rd Rail	1020	105	1260	Yes	100-125	High or Hi-Lo	Single level fleet, similar to M7, M8, Silverliner V
	I	12	0	EMU / Catenary or 3rd Rail	1020	135	1620	Yes	100-125	High or Hi-Lo	New fleet type – Bi-Level or Duplex EMU
Regional Rail Push-Pull, Single level or Bi-level[4]	I	10-12	2	Electric, Diesel or Dual-Mode loco	1000	135	1350-1620	Yes	125/100	High or Hi-Lo	Includes run-through services
	I	8	1	Electric, Diesel or Dual-Mode loco	755	135	1080	Yes	125/100	High or Hi-Lo	Includes run-through services
Intercity Long-Distance Train	I	10-12	2	Same locomotive options as Intercity Corridor trains	1170	n.a.	400	Yes	125	Hi-Lo	Operates on NEC Spine during off-peak hours only

[1] Measured in equivalent 85-foot car lengths. Also can be operated in smaller consists as warranted by demand. High-speed equipment assumed to comprise one or two intact trainset modules.
[2] Based on 85 ft. long passenger cars and 75 ft. long locomotives, or the equivalent length of intact trainset modules.
[3] Assumptions about future high performance dual mode locomotive or multiple-unit trainset (technology assumed to exist prior to 2040 horizon year): Catenary on NEC Spine; Diesel off-corridor; Top speed off-corridor: 110 mph; Braking rate: 1.6 mph/second; Acceleration: similar to AEM7 (placeholder with middle-of-the-road performance).
[4] Includes through-running services, assuming compatibility with traction power system (if any) on all lines served.
[5] There is currently no high speed trainset 220 mph-capable that has both overhead electrification and third rail equipment. Also of note, this trainset would need to be compatible with the three types of AC power present on the existing NEC.
[6] There is currently no trainset 220 mph-capable that is powered by overhead electrification and diesel.

8.1.6 Signaling and Train Control Systems

The future NEC is assumed to be equipped with a fixed block (cab, no wayside) signal system and an overlay Positive Train Control (PTC) system. PTC, based on the Amtrak Advanced Civil Speed Enforcement System (ACSES), provides four critical functions in addition to the cab signal-based Automatic Train Control functions:

- Permanent civil speed enforcement,
- Temporary civil speed enforcement,
- Positive stop enforcement,

- Roadway worker safety protection, including prevention of incursions into work zones and provision for enforced temporary speed restrictions while passing work zones on adjacent tracks.

The cab, no wayside system is assumed to be based on shorter block lengths where needed to provide for higher-density operation at shorter headways than the existing signal system. In these high-density locations, the signal system architecture assumes all passenger equipment is capable of braking speeds of 1.6 miles per hour per second (mphps) at the low end of the speed range and is assumed to support freight trains operating at reduced speed.[39]40 The Action Alternatives will be developed to *not preclude* reasonable future investment in signaling systems or other infrastructure along the existing NEC to enable freight trains to operate at higher speeds.

In the following locations, where overhead (i.e., through-running) freight trains operate on the NEC, the signal system is assumed to permit mixed traffic operation of freight and passenger trains and support operation of freight trains at normal operating speeds (up to 50 mph) on the non-high-speed tracks:

- Bayview (Baltimore), MD to Wilmington, DE
- New Haven, CT to Pawtucket, RI
- Other portions of the NEC where high-density signaling is not required for capacity purposes

For purposes of developing service plans prior to full network simulation analyses, given the signal system architecture described above, the assumed practical following headway for passenger trains is assumed to be:

- 220 mph top speed: 4 minutes
- 160 mph top speed: 3 minutes
- Slower-speed territory, including station approaches with merging and diverging movements: 2 minutes

These planning headways will be confirmed or modified as appropriate based on the results of the full network simulations.

Moving block technology is *not* assumed for the NEC or connecting corridors in the NEC FUTURE analysis. The European Train Control System Level 3 (ETCS-3) technology currently is under development and may be a potential option for the future of the NEC. This would provide continuous data transmission to and from the train, but train location and train integrity supervision would no longer need to rely on trackside equipment such as track circuits or axle counters.

[39] The maximum allowable speed of a freight train is assumed to be limited to the speed at which the engineer is able to control the movement of the train to permit stopping within half the range of vision, looking out for broken rail and misaligned track, and not exceeding the speed prescribed by Timetable Special Instructions and other directives, not exceeding 20 mph outside interlocking limits and 15 mph within interlocking limits.

However, since ETCS-3 is not yet fully implemented in Europe, and there are no high-speed rail systems currently in operation internationally that employ moving block technology, NEC FUTURE will make the conservative assumption (with respect to line capacity) that the NEC will continue to employ a fixed-block signaling system. The existing system will be assumed to be upgraded and reconfigured to provide the highest density of traffic that is practical given the projected future mix of traffic.

8.1.7 Other

8.1.7.1 Turnout Geometry and Interlockings

NEC FUTURE will assume the following geometry and maximum diverging speeds for turnouts on the existing NEC and new high-speed tracks:

- New very high-speed turnout: 160 mph*
- New high-speed turnout: 100 mph*
- #32.7 turnout: 80 mph
- #26.5 turnout: 60 mph
- #20 turnout (tangential): 45 mph

* These are placeholders for purposes of initial analysis and developing conceptual layouts and capital cost estimates. The performance and cost tradeoffs associated with potential higher-speed turnouts will be investigated. Assumptions regarding turnout dimensions and costs for high-speed turnouts will be derived based on experience with the California High-Speed Train Project and internationally, taking into account the characteristics of the NEC, including the available cab signal speeds.

Diverging speeds at interlockings will, to the greatest extent practicable, match the NEC cab signal speeds of 160 mph, 125 mph, 100 mph or 80 mph. The basis of these interlocking concepts will be planning and design concepts developed for the CHSTP and the Amtrak Next Generation plan for the NEC.

8.1.7.2 Grade Crossings

All new right-of-way will be free of grade crossings. Existing grade crossings will be eliminated where maximum authorized speeds are increased above 125 mph.

8.1.7.3 Maximum Speed on Tracks Adjacent to Station Platforms

In general, NEC FUTURE will plan for new stations and improvements to existing stations on the NEC that permit non-stopping express trains to pass through stations on tracks without platform edges. At locations without dedicated station bypass tracks, additional side tracks may be provided to accommodate station platforms. However, where space is constrained, or where the volume and speed of non-stopping trains does not warrant the construction of additional side platform tracks, non-stopping trains may need to operate on station tracks that have high-level platforms. In all cases where the speed of non-stopping trains will be greater than 160 mph, dedicated bypass tracks will be provided separately from the station platform tracks.

Passenger trains are assumed to be able to operate non-stop through stations on tracks with platforms at speeds up to 135 mph, provided that the station platforms are equipped with ADA-compliant signage and public address announcements to warn passengers of an approaching train. Passenger trains are assumed to be able to operate non-stop through stations on tracks with platforms at speeds up to 160 mph, provided that the station platforms are equipped with platform doors or screens that provide a physical barrier between the platform and the trackway.

8.1.7.4 Wide-Clearance Freight Traffic Routes

Equipment normally operating on the NEC will be assumed to comply with the Amtrak clearance diagram, designated as Drawing D-05-1355 Rev. E. However, there are occasions when trains with horizontal dimensions exceeding the normal standards operate on the NEC, and these operations need to be protected in the future NEC track configuration.

The Strategic Rail Corridor Network (STRACNET) consists of 38,800 miles of rail lines important to national defense and provides service to 193 defense installations whose mission requires rail service. The Railroads for National Defense Program (RND), in conjunction with the Federal Railroad Administration (FRA), established STRACNET to ensure that the minimum railroad access needs of the Department of Defense (DOD) are identified and coordinated with appropriate transportation authorities. STRACNET enables the deployment of heavy and tracked military vehicles via the railroad network among DOD installations and US seaports. A critical characteristic of STRACNET is the ability of these lines to accommodate oversize (high/wide) loads. Significant portions of the NEC are included in STRACNET. Provision for high and wide-load train movements along portions of the NEC designated as STRACNET routes will be preserved in all Action Alternatives.

On portions of the NEC where overhead (i.e., through-running) freight trains are operating, including the Bayview (Baltimore) to Wilmington and New Haven to Pawtucket segments, freight trains are assumed to operate on the local (non-high-speed) tracks, through stations that have high-level platforms. In these areas, freight bypass tracks are to be provided where space permits. Where space is constrained, gauntlet tracks are assumed to be provided in station areas on the local tracks with high-level platforms.

Local freight trains are assumed to be capable of operating on station tracks with high-level platforms without gauntlet tracks.

The above planning assumptions notwithstanding, Action Alternatives will be developed to not preclude reasonable future investment in infrastructure to enable freight trains to operate with greater clearances.

8.1.7.5 Topics for Further Research and Discussion

Recognizing the programmatic and conceptual nature of the infrastructure, equipment and service elements of the alternatives at this early stage of planning, all of the technical criteria and standards that would be necessary for the design and implementation of the rail system improvements are not available and are not required in order to initiate planning and develop the alternatives for environmental assessment purposes. Additional research and analysis will need to be undertaken to further define the requirements.

Topics and issues that may be appropriate for further research and discussion include, but are not necessarily limited to, the following:

1. Barrier design criteria; range of designs for various speeds and offset differences; specific assumptions related to the physical and operational characteristics of parallel freight trains
2. Functional criteria for intrusion detection and protection for adjacent transportation systems (passenger, freight, highway)
3. Tunnel cross-sections, associated with various design speeds (160 mph up to 220 mph)
4. High-speed turnout design criteria and length required for crossovers and turnouts
    a. Very high-speed turnout design criteria (e.g., between 160 and 220 mph) – investigate recent developments in Europe and Asia
    b. New turnout designs being developed by Amtrak (60 and 80 mph diverging moves in limited footprint)
5. Interlocking configurations, including at junctions and stations
6. Standard schematic plans and cross-sections for stations
7. Update rolling stock physical and operational characteristics
8. Freight train characteristics, including maximum speeds, horizontal and vertical clearances and maximum axle loads
9. Signal and train control system assumptions (e.g., build on existing nine-aspect cab signal system, increase the “super clear” speed to 160 mph, add one more aspect for 220 mph or 186 mph)
10. Electric traction power system assumptions (e.g., retention of existing three voltage/phase combinations plus 25 kV 60 Hz for anything of substantial length that is new, versus upgrading of existing system to 25 kV)
11. Criteria for maximum speed of non-stopping trains past station platforms, and separation of station platforms from high speed tracks (and associated side track geometry) with MAS greater than 135 mph
12. Confirm ADA and safety standards for stations, including assumptions concerning the speed of trains operating non-stop on tracks with station platforms
13. Confirm or define maximum speeds where grade crossings remain (Connecticut, Rhode Island)
14. Life safety criteria and requirements (e.g., NFPA 130 Fire Life Safety issues as they relate to train separation in tunnels, including criteria for 30 minute floor fire test and emergency evacuation of passengers and train crews)
15. Potential configuration and performance specifications of future dual-mode trainsets providing intercity service both on the NEC (with electric traction) and off-corridor (under diesel power), particularly with respect to the ability of the equipment to operate on the high-speed tracks on the NEC in mixed traffic with electric-only high-speed trainsets at acceptable levels of performance (i.e., top speed, acceleration and braking)
16. Passenger comfort standards (horizontal and vertical acceleration and jerk)
17. Traction power facility footprint size and interval frequency
18. Control of access/grade separations, possibly as it relates to speed
19. Maintenance access and access intervals
20. Open versus closed drainage systems

21. Integrated criteria for rolling stock performance and track design, with parameters including a range of maximum speeds, superelevation, unbalance, activation of tilt capability and track centerline spacing, for each rolling stock type and service territory on the NEC.

B.6. Capital Costs TM – Errata Sheet

	Incorrect Tier 1 Draft EIS Text/Table		Tier 1 Final EIS Text/Table (Volume 2) Page
	Page	Description	
1.		Final version replaces version included in Tier 1 Draft EIS	

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Capital Costs Technical Memorandum

October 5, 2015
Final Version

Submitted by:

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A JOINT VENTURE

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Tables

1. Methodology

The cost estimating methodology used for NEC FUTURE has evolved during the alternatives development process, from initial concept planning and service development through concept design for the Tier 1 Draft Environmental Impact Statement (Tier 1 Draft EIS) No Action and Action Alternatives. This section presents the process used to refine the methodology to develop capital costs.

1.1 INITIAL ALTERNATIVES COST METHODOLOGY

Capital costs were not a factor for the screening of the Initial List of Alternatives. This effort focused on whether each Initial Alternative meets the Purpose and Need, which did not include any direct consideration of potential capital costs as a differentiator. (See the *Preliminary Alternatives Report*, available on the NEC FUTURE website, for more information.)

1.2 PRELIMINARY ALTERNATIVES COST METHODOLOGY

The Preliminary Alternatives broadly defined information related to infrastructure investments, with minimal location-specific infrastructure design details. Driven by service planning and operational approaches, these alternatives had only general station, alignment, and related infrastructure requirements and service goals. An initial estimate of each Preliminary Alternative's approximate capital costs was sufficient for the screening step. (See the *Preliminary Alternatives Evaluation Report* for a detailed description of the Preliminary Alternatives and the screening process.[1])

The Federal Railroad Administration (FRA) included the following cost components in each estimate:

- **Repair, upgrade and/or expansion of existing alignments** – Typical elements ranged from comprehensive state-of-good-repair projects for major infrastructure components, to upgrades of signals, catenary, track beds, or other systems for the existing Northeast Corridor (NEC), to improvement projects involving additional tracks, curve modifications, and other elements that would substantially improve performance, raise speeds, and increase capacity. Major infrastructure projects include large discrete infrastructure elements such as tunnels, bridges, large elevated embankments, and interlockings.
- **Development of new alignments, stations and major infrastructure** – These elements included entirely new alignment options, designed for high-speed train operations, often with new or expanded station areas, along with other major infrastructure elements (e.g., yards).
- **Rolling Stock** – An estimated cost for rolling stock was added to each alternative by multiplying an estimated unit cost per trainset by the estimated trainset count required to operate the service assumptions associated with each Preliminary Alternative.

[1] *Preliminary Alternatives Report*. NEC FUTURE. April 2013. http://necfuture.com/pdfs/prelim_alts_report.pdf.

The primary sources of cost information came from domestic and international experiences in each of the cost areas, focusing on projects that were in advanced design/development levels or were already completed and in operation. The FRA based approximate comparative cost estimates for the Preliminary Alternatives on tunnel, at-grade, aerial, and major bridge sections.

1.3 NO ACTION AND ACTION ALTERNATIVES COST METHODOLOGY

For the Tier 1 Draft EIS, the FRA advanced the No Action Alternative and Action Alternatives for analysis. The No Action Alternative cost methodology estimate was calculated by summing the total cost of the No Action Alternative Project List, as described in section 3.2.1. For the Action Alternatives, the FRA completed more detailed cost analyses for typical right-of-way cross sections (typical cross sections), station layouts, trackwork configurations, rolling stock requirements, and maintenance and operations costs. Cost estimates address all key elements, such as station development, grade-crossing eliminations, vehicle and maintenance shop needs, supporting systems, right-of-way acquisition, and costs of linear or area-based infrastructure elements such as tunnel or aerial sections, or embankment or retained fill areas.

The FRA increased the number of typical cross sections to reflect the more detailed analysis of likely construction configurations along the Representative Route of the Action Alternatives. Cost estimates were developed for each of the typical cross sections. Cost estimates for linear elements are based on applying the appropriate typical cross sections by the estimated quantity (i.e., length) of that typical cross section along the Representative Route. Costs for the various elements are expressed as cost-per-unit length for infrastructure.

The FRA developed lump-sum cost estimates for discrete items such as stations, railroad junctions, shops, and rolling stock purchases. These costs are drawn from standard cost libraries and derived costs for recently completed similar projects.

This section identifies the key data that have been incorporated and the general underlying assumptions that have been made across all alternatives.

1.3.1 Data Collected

The FRA collected data that included information regarding existing and proposed stations, parking facilities, existing track configuration and previously planned and proposed track improvements such as interlockings, new structures, signal and catenary improvements, and other improvements that could increase the capacity of the existing NEC. Additional data collected includes design standards for Amtrak and other railroads that own or operate on the corridor or that may control track options currently used by Intercity trains as they pass along the corridor. These options refer to the use of some tracks currently not suitable for high-performance trainsets in areas owned and operated by freight or commuter rail. Upgrading these tracks gives the high-speed rail operator the “option” to route more trains through certain chokepoints on tracks currently not acceptable for high-speed service.

1.3.2 Capital Cost Benchmarking Data

The FRA collected data from other high-speed rail and passenger rail corridor investments as a means of benchmarking input into the capital cost model to estimate new high-speed rail infrastructure and to make improvements to the existing NEC. The FRA used the following U.S. examples: Amtrak NextGen HSR; California High-Speed Rail (CAHSR) Program; Chicago-St. Louis HSR Corridor Program (which is allowing for new 110 mph service); New Haven-Hartford-Springfield Rail Program; and the Amtrak Gateway Program. The FRA also included international HSR projects in England and Spain. In addition to the CAHSR cost data, which provided extensive design-level cost estimate inputs for common alternative elements, the FRA gathered costs from recently completed railroad projects to benchmark major infrastructure projects such as rehabilitation or construction of tunnels, significant bridges, and stations.

A key element of the benchmarking has been developing an understanding of the capital cost methodology and unit costs used for pricing the CAHSR Program, and aligning those estimates with the level of detail available for the Action Alternatives. The CAHSR Program has been particularly valuable because those estimates included extensive benchmarking to other domestic and international passenger rail projects, and recent contract awards have provided comparable construction costs that were then adjusted to reflect typical labor costs for infrastructure construction in the Northeastern United States.

The FRA benchmarked cost estimates of the No Action and Action Alternatives against cost estimates of the High Speed 2 (HS2) railway project in the United Kingdom. Where applicable, the FRA compared specific line-item costs from the HS2 cost estimate to the No Action and Action Alternatives' costs.

1.3.3 General Assumptions

As part of its capital cost estimating methodology, the FRA developed numerous general assumptions that were applied consistently across the analysis. Among the most critical to the analysis were the following:

- Application of approximate right-of-way widths for typical infrastructure and station configurations are consistent with Representative Routes and station areas. Right-of-way acquisition requirements were identified based upon the Representative Routes and station areas, but site-specific property acquisition needs were not identified. The FRA based right-of-way acquisition costs on an analysis of land cover information collected by the FRA.
- Major conflicts with existing infrastructure such as overpasses, buildings, highway interchanges, and local roadways are identified and categorized. At the earlier stages of alternatives development, allowances were included for resolution of typical conflict categories (e.g., conflicts with existing under- or overpasses, roadways, rail lines).
- Development of typical station types are based on the station typology (Major Hub, Hub, and Local), surface grade (elevated, at-grade, below grade) and size (number of tracks/platforms, multimodal connectivity)—all with a consistent platform length that was based on service and operational characteristics.

- Alignments are grade separated in areas where operating speeds in excess of 110 mph are planned to preclude conflicts with other modes of transportation. All track related to dedicated high-speed alignments are designed for a minimum operating speed of 160 mph and a maximum operating speed of 220 mph.
- All main line track are equipped with Positive Train Control (PTC) systems.
- Intercity and high-performance trainsets are powered by overhead catenary systems (OCS).
- The base year of the analysis is 2014. Where needed, source data costs were escalated to 2014 dollars for use in this analysis. Results are presented in base year 2014 dollars and are not escalated to the expected year of expenditure or the midpoint of construction. This is due to the uncertainty and variability of funding availability, which will inform the overall programmatic development time frame and the design and construction schedule.
- Costs for railroad force account[2] construction crews required to perform removal or cut-ins[3] of the existing railroad infrastructure were not included in the cost estimate.
- Cost estimates are consistent with the infrastructure required to meet the representative, non-prescriptive Service Plans[4] of each Action Alternative, as described in the *Service Plans and Train Equipment Options Technical Memorandum*, Appendix A of the *Tier 1 EIS Alternatives Report*.
- Estimated unallocated contingency costs were not included in the estimate. The FRA recognizes that all of the alternatives present unknown and indefinite cost risks of the types usually addressed by applying an unallocated contingency. However, a primary purpose of the Tier 1 Draft EIS capital cost estimate is to facilitate comparison between the No Action and Action Alternatives. The FRA believes that applying an unallocated contingency as a percentage of project costs would not provide useful insight into this comparative analysis, given the model and the level of analysis. Moreover, there is not a recognized industry-standard percentage that has reasonable precedence given the features of the NEC FUTURE capital cost model. Uncertainty about elements of project risks such as implementation timelines, project delivery methods, and funding sources also make it impractical to assign a discrete value to unallocated contingency at a corridor-wide level. Additional information about contingencies is provided in Section 2.10.
- Constructability access costs, which account for project costs for railroad flagging and protection, construction of laydown areas or track sidings in the work area, de-energizing of catenary adjacent to the work area, or other support costs that are exclusive of the cost

[2] Railroad force account typically describes work completed by the railroad's internal construction or maintenance employees within the railroad's right-of-way.
[3] Cut-ins refer to locations where existing track has been replaced with new track components such as rail and ties, or where the entire trackbed (including subballast and ballast) have been replaced in discrete lengths typically less than 5 miles in length.
[4] The FRA developed Service Plans for the No Action and Action Alternatives to describe the types and levels of passenger train service operating on the NEC in 2040. These Service Plans are representative and provide a technical basis that allows the FRA to estimate future ridership and capital investment needs and costs, as well as assess the environmental impacts associated with planned improvements. The Service Plans are not intended in any way to be prescriptive regarding how service should be operated in the future.

premium charged by railroad construction forces (see Section 2.4.4), do not include the following:

- Any penalties or fees associated with impacts to the operation of the host railroad that would result from the contractor's operations
- Railroad force account construction costs that exceed direct labor required for the work
- Costs for temporary access agreements with railroads

1.3.4 Derivation of Unit Costs for Typical Cross Sections

The FRA developed a cost-per-unit length for each typical cross section, which was derived from a buildup of assumed quantities and unit costs for standard items required to construct each of the typical cross sections. The FRA based the quantity and unit cost for each item on estimates of recent projects that were similar to each typical cross section configuration, and similar in complexity to the various elements included in NEC FUTURE. Those standard item costs that have a significant impact on total project capital cost, such as tunnel boring machine (TBM) costs, were evaluated in greater detail, with multiple options given the expected wide range in costs for different types of tunnels in different settings (e.g., a short rural tunnel to maintain grade through hilly terrain vs. a long urban area tunnel). The FRA normalized project costs from various sources to reflect the base year of the estimate and location of the project.

Where similar project references could not be identified, the FRA used a bottom-up estimate to develop the unit costs. This approach required analysis of production rates, labor and equipment rates, and material costs for each construction activity. The unit price analysis method was used to develop costs for complex construction elements including but not limited to viaducts, retained earth systems, tunneling and underground structures. This method allowed the FRA to develop unit prices based on current local construction and market conditions, such as changes that might affect productivity or the cost of labor or materials.

The FRA used the following sources to obtain basic cost data to develop any needed construction unit prices:

- Labor Rates – Federal Davis-Bacon Wage Determination
- Material Prices – material and supply prices for locally available material were obtained from local supplier quotes

2. Capital Cost Model

2.1 CONCEPTUAL LEVEL OF DETAIL

The NEC FUTURE capital cost model provides a conceptual cost estimate for each Action Alternative commensurate with the level of detail necessary to provide an accurate, documented, validated, and defensible cost comparison of the Action Alternatives. The conceptual level of detail was a function of deliberation, analysis, engineering assessment, and understanding of those components aggregated by the model. Actual costs could meaningfully differ after more refined engineering and design work is completed, selections of construction and staging methodologies are made, or price inflation/deflation occurs.

As described in Section 2.2, the level of detail and validity of the model was also a function of quality reviews at numerous development steps and of constructive critiques by both internal and external reviewers. These reviews reinforced the documentation process, the model's internal methodologies, and the inclusiveness of the model.

Even though the model reflects a conceptual level of detail, it is based on a validated methodology and documented references from actual construction projects. Construction specifications, construction plans, and detailed bid schedules were not available for the Action Alternatives; therefore, the FRA used and applied documented references from previously completed projects and construction programs to generate conceptual costs. Additionally, the FRA developed the cost estimates to generate conceptual costs for the end-to-end routes of the Action Alternatives from Washington, D.C., to Boston, MA. Therefore, the model is not intended to estimate the costs of specific smaller-scale projects separately (e.g., individual bridge replacements, tunnel construction projects, or station projects).

2.2 QUALITY CONTROL REVIEW PROCESS

Internal and external reviewers were instrumental in the review processes. The Capital Cost Estimating/Conceptual Engineering Technical Working Group (TWG) reviewed the methodology used for the cost estimate. In addition to representatives from the FRA, the TWG included representatives from railroad operators along the NEC, who are familiar with the planning and delivery of service changes and major infrastructure projects along the corridor. As such, the TWG members provided valuable feedback and insight into the development of the capital cost methodology. Workshops with the TWG included presentation and discussion of the following:

- Description of the Action Alternatives and the level of detail available
- Cost estimates developed, including all allowances
- Key risks considered in the analysis and how each was addressed in the cost estimate
- Relevant benchmarking data used and how it is relevant to the alternatives studied

In addition to the results of these workshops, the FRA incorporated discussion of the capital cost estimating methodology and benchmarking effort into the regularly planned TWG meetings for comment and input as work progressed.

In addition, the FRA conducted detailed quality assurance and quality control with CAHSR Program staff. The CAHSR reviews were conducted in late 2014. The FRA revised major unit costs as a result of the CAHSR reviews, which included aerial structure, station, and tunnel costs.

The FRA conducted detailed reviews of the functionality and cost components included in the model. The feedback resulted in improved unit price references and methodologies. Internal review processes considered all aspects of the capital cost estimate, and focused on reviewing sample cost estimates, unit cost sources, methodologies, and the organization and presentation of the cost estimates. As described in Section 2.12.2, the FRA completed map-based quality control reviews throughout late 2014 and early 2015.

2.3 UNIT COST LIBRARIES

2.3.1 Development

As described in Section 1.2, development of the unit cost libraries used in the model began with the preliminary cost model in 2013, which the FRA then reviewed and updated to 2014 dollars. Many unit prices were replaced with more accurate and validated unit prices where additional references and construction projects were identified.

Unit costs indexed in the model were named according to infrastructure construction line items (such as catenary, track, etc.). The development of these unit costs included both materials and all contractor labor leading up to and including final installation. The unit costs include an industry-standard assumption that approximately 50 percent of costs are attributed to material and approximately 50 percent are attributed to labor. Because labor costs can vary widely throughout the NEC, all unit prices were normalized to an average labor rate. Labor costs for the Philadelphia, PA, metropolitan area were determined to be a good average labor rate for the region. As such, notations in the unit cost library refer to an adjustment to Philadelphia labor rates. Where unit costs reference construction projects located outside the Study Area, the FRA adjusted the labor component of these costs consistent with the RS-Means 2013 edition to Philadelphia labor rates.

2.3.2 Standard Cost Categories

As capital costs were developed for the typical infrastructure configurations throughout the existing NEC, the FRA organized and reported capital cost estimates using the following Standard Cost Categories (SCC) as used throughout its passenger rail development programs:

- 10 Track Structures and Track
- 20 Stations, Terminals, Intermodal
- 30 Support Facilities: Yards, Shops, Administration Buildings
- 40 Site work, Right of Way, Land, Existing Improvements

- 50 Communications & Signaling
- 60 Electric Traction
- 70 Vehicles
- 80 Professional Services

2.4 LINEAR ELEMENT COSTS

Linear element costs represent those costs that are measured by linear attributes, such as route-feet or track-feet. The FRA calculated these costs by multiplying lengths by a unit cost per route-foot.

2.4.1 New Segments

New segments are sections of new track that may be constructed in new railroad right-of-way outside the existing NEC right-of-way. At the conceptual level, new segments are envisioned as being constructed according to one of the 46 typical cross sections.

Typical Cross Sections

The typical cross sections are a further refinement of the following six construction types identified in the Representative Route for the Action Alternatives: tunnel, trench, at-grade, embankment, aerial structure, and major bridge. The purpose of typical cross sections is to aid in the development and calculation of construction line-item quantities in the model. The typical cross sections define the requirements for major infrastructure components. Typical cross sections also provide for a quality control review of these quantities and a documentation source for how quantities were developed. The FRA developed quantities by calculating construction line items as they are depicted in the typical cross sections per route-foot. Each construction line item was assigned a unit cost, which was then multiplied by the quantity and summed to a total cost per route-foot for each typical cross section.

In a few cases, typical cross section costs were modified to reflect design parameters specific to an Action Alternative. As an example, Alternative 2 is designed for a top operating speed of 160 mph. Some typical cross sections used for Alternative 2 are also used by Alternative 3, where the top design speed is 220 mph. In these cases, specific section costs that apply only to ≥160 mph operation (e.g., additional safety requirements such as crash walls for adjacent tracks) were therefore not needed for Alternative 2, and were omitted from the typical cross section costs for that alternative.

Tunnel construction is represented by two typical cross sections: tunnel (applied to all tunnel lengths less than or equal to 10 miles) and long tunnel (applied to any tunnels greater than 10 miles in length). Given the conceptual nature of the capital cost model, tunneling costs for both tunnel and long tunnel typical cross sections use TBM unit costs. The FRA revised tunnel costs from the preliminary cost model to match the latest material provided by the CAHSR Program team in early 2015. Long-tunnel unit prices reflect unit prices extrapolated from Channel Tunnel (Chunnel/U.K.) prices inflated to 2014 dollars.

2.4.2 New Tracks

New tracks represent additional track or systems improvements along the existing NEC. These upgrades are defined as the addition of one or two tracks to the existing NEC by construction type (tunnel, trench, at-grade, embankment, aerial structure, and major bridge), or an upgrade to the catenary or signal systems. The FRA estimated the cost of these upgrades by calculating the unit price of construction line items, similar to those identified for new segments.

2.4.3 Curve Modifications

Curve modifications represent sections of existing track that would be modified to increase operating speeds. The overall intent is to increase speeds and reduce travel times. The FRA developed the costs of this construction by multiplying the appropriate typical cross section cost against the length of each curve modification. An additional track factor was multiplied against the length if the existing track configuration included more than two tracks.

2.4.4 Constructability Access

The cost methodology of the Preliminary Alternatives included complexity factors as a means of capturing construction access costs and costs associated with the complexities of constructing infrastructure in between or adjacent to existing and live operating railroad tracks. During this initial phase, these complexity factors were percentage increases applied to the quantity of the construction line items for each typical cross section. These factors reflected professional judgment and were appropriate for the high-level analysis done during the Preliminary Alternatives stage.

However, for the cost estimate for the Tier I EIS Alternatives, the FRA replaced the complexity factors with a methodology designed to assess specific representative costs for construction access and staging for activities within or adjacent to in-service tracks on the existing NEC. The FRA determined that additional costs were likely where construction would occur between or within 30 feet of existing operating railroad tracks. In these locations, this methodology assumes additional costs for railroad safety protection, access/egress to the construction site, and other items such as adding run-around tracks, or fitting staging and laydown areas into constrained site locations. The FRA did not assess these constructability access costs for typical cross sections where new tracks are more than 30 feet from existing tracks, or where tracks are constructed in a new right-of-way outside the existing NEC right-of-way.

Construction access costs mitigate the contractor’s impact to existing railroad operations. These costs do not represent penalties or fees associated with construction impacts to existing operations, railroad force account construction costs that exceed direct labor required for the work, or temporary construction access agreements with the operating railroads.

2.5 SUPPORTING INFRASTRUCTURE COSTS

Supporting infrastructure costs represent those costs that are not measured by route-foot or track-foot. Although there may be route-foot or track-foot elements included in the construction line items, the supporting infrastructure components of stations, junctions, and yards are identified at points along the Representative Route by stationing.

2.5.1 Stations

The FRA estimated station costs by calculating the cost of building a new station or upgrading an existing station. Elements included the surface grade of the station, the number of new, rebuilt or modified platforms, and other capacity or pedestrian circulation improvements.

For both new stations and upgraded existing stations, the FRA identified a station service type based on the types of rail service provided at the station now, and in the future. The station types are Major Hub, Hub, and Local. These three station types were refined into five sub-station types for cost estimation purposes as described below:

- **Gold** serves the largest markets in the Study Area and includes a full complement of passenger rail services.
- **Red** serves the major markets in the Study Area and includes regular Intercity-Express service.
- **Blue** serves the smaller intermediate Amtrak stations in the Study Area, as well as key Regional rail stations. Blue stations fill connectivity gaps in the existing passenger rail network. These stations include regular Intercity-Corridor trains and limited Intercity-Express service.
- **Green** serves the smaller intermediate Amtrak stations in the Study Area, as well as key Regional rail stations. Green stations include special trip generators and/or important intermodal connections. These stations include regular Intercity-Corridor trains and limited Intercity-Express service.
- **Purple** only offers Regional rail service in Regional rail service areas.

The five sub-station types above fit into the station types as follows: Gold and Red stations are Major Hubs, Blue and Green stations are Hubs, and Purple stations are Local. (See the *Station Identification and Location Analysis Technical Memorandum* for additional station details.)

The FRA also identified the surface grade: below grade, at-grade, or aerial. As such, the unit price library for stations includes 30 unique station descriptions: five station types at three surface grades, for both new and upgrade stations.

For each of the station descriptions, the unit price library included a construction cost based on actual construction costs of completed station projects, or bids for station construction. Where a completed project or bid reference could not be found, the cost of the station was calculated as a percentage increase or decrease of the cost of a referenced station. Of the 30 unique station descriptions, 23 references are provided, accounting for approximately 94 percent of all stations identified in the Action Alternatives. In all cases, the track and platform construction line items were excluded from the station description unit prices. Track costs of stations were included within the new segments, curve modifications, new tracks (Section 2.4) or junctions (Section 2.5.3).

For existing stations where an expansion was identified, the FRA calculated the cost of platforms by identifying the number of island or side platforms at the stations in each Action Alternative. For existing stations, the unit price of existing island and side platforms was subtracted from the cost estimate to represent the salvage value or reuse of existing platforms before including the unit price of island and side platforms in the Action Alternative. Therefore, the estimated cost for platforms at new stations is greater than the estimated cost at existing stations. For existing stations where an expansion was identified and the configuration of platforms in the Action Alternative would not change from the existing condition, the cost of a rebuilding or modifying a platform was added to the cost estimate. (See the *Stations Identification and Location Analysis Technical Memorandum* for stations in the Action Alternatives.)

2.5.2 Yards

Yard costs were estimated by calculating the unit price of construction line items at different types of yards and facilities. There are six different types of yards: Major Service and Inspection Facility, Service and Inspection Facility, Heavy Maintenance Facility, Maintenance-of-Way Facility, Storage Yard and Minor Service and Inspection Facility, and a Storage Yard. The FRA calculated the total cost of each yard type identified throughout the corridor. However, the cost estimates include yards and facilities used by Intercity operations and do not include yards and facilities used by Regional rail operators. The costs for these yards are non-site specific, and do not include acquisition costs for yard right-of-way. See the *Service Plans and Train Equipment Options Technical Memorandum* for additional information on the FRA's consideration of yards and facilities.

2.5.3 Junctions

Junction costs were estimated by calculating the unit price of construction line items, including different types of junctions, interchanges, or connections, referred to collectively as junctions. The FRA provided configurations for each of the 50 types of junctions. The FRA used these configurations to estimate the cost of each type identified throughout the corridor.

2.6 PROFESSIONAL SERVICES

Professional services represent programmatic (non-construction) costs of the project. For the Tier I EIS analysis, professional services costs used in the cost methodology of the Preliminary Alternatives were further refined and/or validated against additional sources. Financing for construction bonds (typically two percent of the direct costs) were not included in the cost model because programmatic funding sources and mechanisms for NEC FUTURE financing have not been identified, even at a conceptual level. Alternative means of financing could be pursued, which may negate the need to pay for construction bonds.

The professional service cost factors were applied to each alternative's total direct costs with allocated contingency included.

The professional service factors in the model are as follows:

- Service Development Plan/Service Environmental 0.00%[5]
- Preliminary Engineering/Project Environmental 2.00%
- Final Design 6.00%

[5] For the NEC, service development and environmental planning are being completed by the NEC FUTURE process.

- Project management for design and construction 3.00%
- Construction administration and management 4.00%
- Professional liability and other non-construction insurance 0.50%
- Legal, permits, and review fees by other agencies/cities, etc. 0.40%
- Survey, testing and investigation 0.20%
- Engineering inspection 0.20%
- Start-up 6.00% of SCC 50/60

2.7 ENVIRONMENTAL MITIGATION

Environmental mitigation costs include an allowance to account for the cost of environmental mitigation that relates to the following: hydrologic/water resources (which includes wetlands), hazardous waste and contaminated materials sites, cultural resources and historic properties, safety and security, noise and vibration, and air quality during construction.

The FRA subtracted tunnels from the construction line items for environmental mitigation since tunnels would have negligible environmental mitigation costs along and above their alignment with potential impacts only at their portal sites and only a few limited locations where ventilation structures would be needed at the surface.

Environmental mitigation was applied as 7.5 percent multiplied against the sum of an alternative's direct costs plus the allocated contingency. Environmental mitigation was grouped by construction line item and was assigned an FRA SCC of 40.

2.8 RIGHT-OF-WAY ACQUISITION COSTS

Land cover unit costs in a dollar-per-acre format were derived from prior technical studies of real estate requirements within the NEC, including Amtrak NextGen HSR, Technical Report (2011); Amtrak Vision for the NEC (2012 update); and data sets comprising CoStar, Property Shark, and Loopnet average sales transaction by land use category. These dollar-per-acre unit costs were multiplied by the number of acres within the Representative Route for each land cover type, as defined by the National Land Cover Database (NLCD).

Rural and natural undeveloped lands in the Northeast range from approximately $4,000 to $30,000 per acre. This high end cost of $30,000 per acre equates to approximately $0.69 per square foot, which was entered into the model for natural undeveloped land.

The FRA identified right-of-way acquisitions costs for those locations where the Representative Route does not represent the existing NEC right-of-way. Where the construction type is identified as tunnel or major bridge, right-of-way acquisition costs were reduced 95 percent to reflect 5 percent of the calculated value. In the case of tunnels, this reduction assumes that tunnels would be constructed 40 feet to 45 feet below surface grade, with right-of-way acquisition for intermittent ventilation shafts and other permanent surface features. In the case of major bridges, this reflects the right-of-way acquisition associated with air-rights.

Right-of-way acquisition costs for yards and stations were not included in the model since it is unknown which entity would pay for certain land assets. Furthermore, much of the potential right-of-way acquisition requirements for stations were already included within the Representative Route.

2.9 VEHICLES COSTS

Vehicles costs refer to the vehicles used on a railroad, also known as rolling stock. Rolling stock costs reflect the cost to acquire additional high-performance trainsets required to operate the representative Service Plans for each Action Alternative. The FRA specified (at a conceptual level) the rolling stock fleet size for each Action Alternative, including operational and spare equipment. These counts are based upon service planning data. The unit cost is $50 million per trainset, as per the Amtrak NextGen HSR Study.

2.10 CONTINGENCIES

Both allocated and unallocated contingencies are a means of addressing unknown project risks that can possibly increase the cost of a project.

2.10.1 Allocated

The FRA applied allocated contingency to each construction line item of the cost estimate in different percentages since each construction line item would face varying degrees of risk/unforeseen circumstances based upon its own nature. The cost model included both low and high allocated contingency percentages. The low percentages were based upon typical historical project values and were referenced from the Amtrak NextGen HSR Study. The high Allocated Contingency rates were 50 percent greater than the low allocated contingency rates to reflect unknown risk. The low and high allocated contingencies were the only difference between the low and high cost estimates.

2.10.2 Unallocated

Unallocated contingency identifies a reserve of project funds that are designated for use in the event the project encounters any of a wide range of unpredictable circumstances that impact project development and delivery. These potential project risks include, but are not limited to, unforeseen design or engineering impediments (e.g., geologic conditions, hidden or undocumented utilities or environmental resources), shifts in market or economic conditions (e.g., changes to construction material or labor costs or availability), changes in legal, political, or financial circumstances, unpredictable project delivery issues (e.g., construction site vandalism or obstruction, construction accidents, material defects, or construction errors), or external events outside the project’s control (e.g., severe weather or other natural disasters). Even though each item is unlikely on its own, any combination of these items could impact a project through schedule delays, damages, or other increases in cost.

Estimates of the appropriate unallocated contingency for project planning purposes usually rely on comparing the current project to previous successful projects of a similar scope and scale. The contingency value is usually applied as a single percentage value, multiplied as a factor against the overall project cost. Contingency values often are adjusted as project planning evolves from the earliest conceptual diagrams through to detailed construction-level engineering and budgeting documents.

The FRA recognizes that all of the Action Alternatives present unknown and indefinite cost risks of the types usually addressed by applying an unallocated contingency. However, for a number of reasons the FRA decided not to estimate unallocated contingency for the Tier 1 Draft EIS. First, a primary purpose of the Tier 1 Draft EIS capital cost estimate is to facilitate comparison between the No Action and Action Alternatives. The capital cost model was designed to serve this primary purpose through its focus on estimating the costs of specific infrastructure elements required for each of the alternatives. The FRA believes that at this corridor-wide, conceptual level of analysis, applying an unallocated contingency as a percentage of total costs would not provide value for this comparative analysis.

Furthermore, few comparable investment programs in scale and scope to the Action Alternatives exist to inform an empirical estimate of the appropriate level of contingency at this point of project development. Lastly, uncertainty about several elements that drive project risks, such as implementation timelines, project delivery methods, and funding sources, also make it impractical to assign a discrete value to unallocated contingency at a corridor-wide level. The FRA expects that many of these issues will be resolved as NEC FUTURE advances. Thus, applying unallocated contingency may be revisited in these later stages, as appropriate.

2.11 EXCLUSIONS

The level of analysis performed at this stage of NEC FUTURE does not allow for the development of some costs. These items currently excluded from the model include the following:

- State of good repair: The cost of the No Action Alternative Projects List includes those projects that are funded or included within approved funding plans, those projects that are funded or unfunded mandates, and those projects that are unfunded but necessary to keep the railroad running.
- Unallocated contingency (see Section 2.10.2).
- Finance charges (see Section 2.6).
- Property acquisition for yards and stations (see Section 2.8).
- Railroad force account construction costs (see Section 2.4.4).
- Penalties or fees associated with construction impacts to existing operations (see Section 2.4.4).
- Temporary construction access agreements with the operating railroads (see Section 2.4.4).

2.11.1 Levels of Uncertainty

The model currently accounts for some level of uncertainty through assumptions regarding various construction line items and components, including efficiencies of construction, types of contract execution, and the construction schedule. These uncertainties may have implications for the allocated contingency percentages and for the professional services should these uncertainties be better defined in the future. As a result, the FRA will continue to reevaluate the cost estimate in future iterations, which may reduce allocated contingencies or professional service percentages. These possible uncertainties may be associated with, but are not limited to the following:

- Efficiencies of construction or new methods of construction
- Railroad owners or operators
- Bonding requirements or ability to bond
- Contract execution types for construction or design (e.g., Design-Bid-Build versus Design-Build versus Design-Build-Operate-Maintain packaging)
- The construction schedule, or identification of a date of midpoint of construction for inflation
- How the various Action Alternatives may be split up into different projects based on size, limits, location and scope

2.12 ADDITIONAL QUALITY CONTROL REVIEW PROCEDURES

As described in Section 1.3.2 Capital Cost Benchmarking Data, the FRA completed numerous reviews to ensure quality control of the capital cost model.

2.12.1 Reviews with California HSR

The FRA completed numerous reviews with the CAHSR Program team. These reviews resulted in changes to aerial structure, station, and tunnel costs. In addition, the following revisions resulted from the quality control reviews with the CAHSR Program team and the FRA:

- Omission of sound walls since they were already included in environmental costs
- Revisions to unit costs to reflect the average labor rates of the Northeast
- Development of additional cost details for junction and yard costs developed from the bottom up including more detailed systems and high-speed turnout cost references
- Revisions to professional service percentages to be in line with Transit Cooperative Research Program (TCRP) documented percentages and percentages from the CAHSR Program
- Revisions to unit costs for earthwork, walkways, ductbanks, and landscaping to apply to validated real-world project examples
- Modification of how ventilation costs are applied to tunnels through a more detailed mechanism including unit prices for fan plants, tunnel vents and ventilation shafts
- Revision of the “Long Tunnel” threshold to be a minimum of 10 miles in length

- Revision of the "Tunnel" unit price to correspond to data provided by the CAHSR Program.

2.12.2 Quality Control Review of Input Data – GIS Graphical Display

Following receipt of input data, a graphical database of all inputs received was developed. The FRA reviewed this graphical input to confirm that the data in the capital cost model accurately reflected the definition of the Action Alternatives and the representative Service Plans developed for the Action Alternatives. This review was valuable in refining and validating capital cost estimates of the Action Alternatives, including refinements to stationing of new segments, new tracks NEC, and curve modifications.

2.12.3 Quality Control Review of Excel Functions

In addition to internal reviews and external reviews with the CAHSR Program team and TWG members, two professionals (not working directly on NEC FUTURE) reviewed the functionality of the capital cost model in Microsoft Excel. These professionals possessed a working knowledge of the functions within Microsoft Excel, and an understanding of the logic and intent of the model to calculate incremental costs of the components of the Action Alternatives. These reviews resulted in minor corrections and refinement of capital cost calculations that had a negligible effect on the total cost estimates.

2.13 RELATED PROJECTS

There are several ongoing rail projects located within the Study Area that are not included in the No Action Alternative Project List. These projects are included as Related Projects since they fall within one of the following three categories as described in the *No Action Alternative Report*:[6]

- Fully or partially funded projects located in a connecting corridor and not on the NEC
- Unfunded projects along the NEC with ongoing or completed National Environmental Policy Act/Preliminary Engineering (NEPA/PE)
- Fully or partially funded transit (e.g., NJ TRANSIT, MTA-Long Island Rail Road) or freight projects located off but connecting to the NEC

These Related Projects have independent utility, and many are currently undergoing their own separate NEPA processes, such as the Southeast High-Speed Rail Corridor – Washington, D.C., to Richmond, VA. Others are intended to address some of the NEC's most pressing reliability, safety and capacity needs, such as Boston South Station expansion, Portal Bridge replacement, and the Baltimore and Potomac (B&P) Tunnel replacement. The full-scale rehabilitation and/or replacement of bridges and tunnels identified as Major Backlog assets (e.g., New Haven Line Bridges and Hudson River Tunnels), are also included in this category of Related Projects since their construction is currently unfunded. See the *No Action Alternative Report* for a complete list of Related Projects included in the cost estimates for the Action Alternatives.

[6] *No Action Alternative Report*. NEC FUTURE. April 2015.
http://necfuture.com/pdfs/2015_04alternatives_report.pdf.

The following methodology was employed for inclusion of Related Projects:

- The cost model projected costs for Related Projects by utilizing unit costs multiplied by established lengths. In some instances (e.g., stations), point unit costs were employed to emulate the Related Project costs. These were high-level conceptual placeholders and the methodology employed to emulate Related Projects was consistent across all Action Alternatives.
- No gaps existed in the input data; each Related Project on the NEC mainline intended for inclusion was included in the input coding. This was confirmed during internal reviews (Section 2.12.2).
- At a later date, costs received by external sources will be checked against costs generated by the input coding.

3. Model Application and Cost Estimates

3.1 MODEL TESTING

The capital cost model was tested with inputs from a draft of Alternative 2.[7] The first comprehensive estimate was completed and presented internally in late 2014. The model was refined to address the comments and concerns raised in internal review, including revisions to several unit price references and calculations; both the allocated and unallocated contingencies; labor location adjustment factors; sound walls; professional services; tunnel costs; and the addition of constructability access. These refinements are reflected in the descriptions of the cost estimate in Section 2. The refined model was tested with inputs for another draft Alternative 2 and presented internally in early 2015. As shown in Table 1, the draft Alternative 2 cost estimate included both a high and low estimate by FRA SCC.

Table 1: DRAFT, Alternative 2 Cost Estimate (Used for Model Testing Only)

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$83,748	$87,651
20	Stations, Terminals, Intermodal	$5,182	$5,417
30	Support Facilities	$192	$204
40	Site work, Right-of-Way, Land, Existing Improvements	$24,027	$24,721
50	Communications & Signaling	$2,192	$2,291
60	Electric Traction	$2,897	$3,029
70	Vehicles	$6,600	$6,600
80	Professional Services	$29,086	$30,528
90	Unallocated Contingency	$0	$0
100	Finance Charges	$1,972	$2,070
	TOTAL	**$155,900**	**$162,600**
	Cost per Route Mile	$222	$231

Source: NEC FUTURE team, 2015

In addition to the project-wide benchmarking with HS2 (Section 1.3.2), and the model testing of draft Alternative 2, a small-scale validation of the cost model with the NJ High-Speed Rail Improvement Project, also known as "Raceway," was conducted. The trackwork, improvements, communications, and signaling, and electric traction associated with the narrative scope of the actual Raceway project, as described in the *No Action Alternative Report*, were modeled. This small-scale validation resulted in a low and high cost of $421 million and $442 million, respectively. The average of these two numbers is $432 million, which is within 5 percent of the $450 million budget for the Raceway project, which is currently under construction.

[7] This draft Alternative 2 is not the same as the Alternative 2 carried into the Tier 1 Draft EIS, which has a different operating plan and infrastructure requirement.

3.2 COST ESTIMATES FOR THE TIER 1 DRAFT EIS NO ACTION AND ACTION ALTERNATIVES

The FRA completed the cost estimates generated by the capital cost model for the No Action and Action Alternatives in early 2015 and are presented in Table 2 through Table 18.

3.2.1 No Action Alternative

The No Action Alternative cost estimate was calculated by summing the total cost of the No Action Alternative Project List.

Table 2: No Action Alternative Cost Estimate

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$0	$0
20	Stations, Terminals, Intermodal	$0	$0
30	Support Facilities	$0	$0
40	Site work, Right-of-Way, Land, Existing Improvements	$0	$0
50	Communications & Signaling	$0	$0
60	Electric Traction	$0	$0
70	Vehicles	$0	$0
80	Professional Services	$0	$0
NA	No Action Alternative Projects	$19,860	$19,860
	TOTAL	**$19,900**	**$19,900**

Source: NEC FUTURE team, 2015

3.2.2 Action Alternative Cost Estimates

The cost estimates for the Action Alternatives were calculated based on numerous inputs including new segment lengths, new track lengths, stations, yards and junctions, all of which were developed to accommodate the representative, non-prescriptive Service Plans for the Action Alternatives.

Table 3: Alternative 1 Cost Estimate

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$28,029	$29,381
20	Stations, Terminals, Intermodal	$5,900	$6,168
30	Support Facilities	$394	$419
40	Site work, Right-of-Way, Land, Existing Improvements	$7,408	$7,874
50	Communications & Signaling	$1,431	$1,496
60	Electric Traction	$1,772	$1,853
70	Vehicles	$2,550	$2,550
80	Professional Services	$6,774	$7,121
NA	No Action Alternative Projects	$9,330	$9,330
	TOTAL	**$63,600**	**$66,200**
	Cost per Route Mile of the Total	$112	$116
	Cost per Route Mile of the Linear Elements	$79	$83

Source: NEC FUTURE team, 2015
Note: Cost per route mile of the linear elements does not include stations, vehicles, yards & facilities, and the cost of the No Action Alternative Project List.

Table 4: Alternative 2 Cost Estimate

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$64,118	$67,142
20	Stations, Terminals, Intermodal	$8,156	$8,526
30	Support Facilities	$801	$853
40	Site work, Right-of-Way, Land, Existing Improvements	$24,128	$24,865
50	Communications & Signaling	$2,165	$2,263
60	Electric Traction	$2,982	$3,118
70	Vehicles	$5,450	$5,450
80	Professional Services	$13,789	$14,476
NA	No Action Alternative Projects	$9,330	$9,330
	TOTAL	**$131,000**	**$136,100**
	Cost per Route Mile of the Total	$186	$193
	Cost per Route Mile of the Linear Elements	$151	$158

Source: NEC FUTURE team, 2015
Note: Cost per route mile of the linear elements does not include stations, vehicles, yards & facilities, and the cost of the No Action Alternative Project List.

Table 5: Alternative 3.1 (via Central CT/Providence route option) Cost Estimate

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$162,322	$169,929
20	Stations, Terminals, Intermodal	$13,737	$14,361
30	Support Facilities	$1,743	$1,857
40	Site work, Right-of-Way, Land, Existing Improvements	$50,402	$51,832
50	Communications & Signaling	$2,957	$3,091
60	Electric Traction	$4,237	$4,429
70	Vehicles	$5,700	$5,700
80	Professional Services	$32,076	$33,667
NA	No Action Alternative Projects	$9,330	$9,330
	TOTAL	**$282,600**	**$294,200**
	Cost per Route Mile of the Total	$303	$316
	Cost per Route Mile of the Linear Elements	$269	$281

Source: NEC FUTURE team, 2015
Note: Cost per route mile of the linear elements does not include stations, vehicles, yards & facilities, and the cost of the No Action Alternative Project List.

Table 6: Alternative 3.2 (via Long Island/Providence route option) Cost Estimate

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$137,245	$143,744
20	Stations, Terminals, Intermodal	$14,677	$15,344
30	Support Facilities	$1,743	$1,857
40	Site work, Right-of-Way, Land, Existing Improvements	$62,423	$63,734
50	Communications & Signaling	$3,061	$3,200
60	Electric Traction	$4,494	$4,698
70	Vehicles	$5,700	$5,700
80	Professional Services	$28,040	$29,438
NA	No Action Alternative Projects	$9,330	$9,330
	TOTAL	**$266,800**	**$277,100**
	Cost per Route Mile of the Total	$279	$289
	Cost per Route Mile of the Linear Elements	$244	$254

Source: NEC FUTURE team, 2015
Note: Cost per route mile of the linear elements does not include stations, vehicles, yards & facilities, and the cost of the No Action Alternative Project List.

Table 7: Alternative 3.3 (via Long Island/Worcester route option) Cost Estimate

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$144,180	$151,018
20	Stations, Terminals, Intermodal	$14,019	$14,656
30	Support Facilities	$1,743	$1,857
40	Site work, Right-of-Way, Land, Existing Improvements	$68,255	$69,680
50	Communications & Signaling	$3,062	$3,201
60	Electric Traction	$4,493	$4,697
70	Vehicles	$5,700	$5,700
80	Professional Services	$29,187	$30,650
NA	No Action Alternative Projects	$9,330	$9,330
	TOTAL	**$280,000**	**$290,800**
	Cost per Route Mile of the Total	$291	$302
	Cost per Route Mile of the Linear Elements	$258	$268

Source: NEC FUTURE team, 2015
Note: Cost per route mile of the linear elements does not include stations, vehicles, yards & facilities, and the cost of the No Action Alternative Project List.

Table 8: Alternative 3.4 (via Central CT/Worcester route option) Cost Estimate

FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$169,256	$177,203
20	Stations, Terminals, Intermodal	$13,079	$13,673
30	Support Facilities	$1,743	$1,857
40	Site work, Right-of-Way, Land, Existing Improvements	$56,234	$57,778
50	Communications & Signaling	$2,957	$3,092
60	Electric Traction	$4,235	$4,428
70	Vehicles	$5,700	$5,700
80	Professional Services	$33,223	$34,878
NA	No Action Alternative Projects	$9,330	$9,330
	TOTAL	**$295,800**	**$308,000**
	Cost per Route Mile of the Total	$316	$329
	Cost per Route Mile of the Linear Elements	$283	$295

Source: NEC FUTURE team, 2015

Note: Cost per route mile of the linear elements does not include stations, vehicles, yards & facilities, and the cost of the No Action Alternative Project List.

Table 9: Cost of Alternative 3 Route Options – Stations and New Segments by FRA SCC

FRA SCC		New York City - Hartford				Hartford - Boston			
		New York City - Danbury - Hartford[5] (Alt. 3.1 & 3.4)		New York City - Long Island - Hartford[6] (Alt. 3.2 & 3.3)		Hartford - Worcester - Boston (Alt. 3.3 & 3.4)		Hartford - Providence - Boston (Alt. 3.1 & 3.2)	
FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)	LOW (millions)	HIGH (millions)	LOW (millions)	HIGH (millions)	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$71,427	$74,673	$44,203	$46,212	$34,683	$36,260	$31,369	$32,795
20	Stations, Terminals, Intermodal	$2,011	$2,103	$2,952	$3,086	$1,877	$1,963	$2,536	$2,651
40	Site work, Right-of-Way, Existing Imp.	$3,945	$4,424	$3,320	$3,665	$3,114	$3,447	$2,525	$2,797
50	Communications & Signaling	$459	$479	$538	$562	$405	$424	$453	$474
60	Electric Traction	$685	$717	$895	$936	$678	$709	$759	$794
80	Professional Services	$12,783	$18,248	$8,376	$11,905	$6,577	$9,359	$6,100	$8,659
	Subtotal	**$91,400**	**$100,700**	**$60,300**	**$66,400**	**$47,400**	**$52,200**	**$43,800**	**$48,200**

Source: NEC FUTURE team, 2015

Notes:

1. Includes the cost of new segments and stations with allocated contingency, environmental mitigation, professional services & finance charges.
2. Does not include curve modifications, new tracks, constructability access, junctions, yards & facilities, right-of-way acquisition, vehicles, and No Action Alternative projects.
3. Does not include railroad force account construction costs (adjacent to or in the center of existing tracks, or at railroad track cut-ins), temporary access agreements with railroads, or penalties/fees for maintenance of operations.
4. Does not include property acquisition costs for yards or stations.
5. New York City-Danbury-Hartford includes East River Tunnels 5&6.
6. New York City-Long Island-Hartford includes Ronkonkoma Station Local New Segment. East River Tunnels 5&6 are included in the New York City-Long Island-Hartford new segment.
7. Washington - New York City includes new segments and stations from Washington Union Station to Penn Station New York.
8. Columns may not add to the subtotal due to rounding.

Table 10: Cost of Alternative 3: New York City to Boston – Stations and New Segments by FRA SCC

FRA SCC		Alternative 3.1: New York City-Danbury-Hartford + Hartford-Providence-Boston		Alternative 3.2: New York City-Long Island-Hartford + Hartford-Providence-Boston		Alternative 3.3: New York City-Long Island-Hartford + Hartford-Worcester-Boston		Alternative 3.4: New York City-Danbury-Hartford + Hartford-Worcester-Boston	
FRA SCC	DESCRIPTION	LOW (millions)	HIGH (millions)	LOW (millions)	HIGH (millions)	LOW (millions)	HIGH (millions)	LOW (millions)	HIGH (millions)
10	Track Structures and Track	$102,796	$107,468	$75,572	$79,007	$78,886	$82,472	$106,110	$110,933
20	Stations, Terminals, Intermodal	$4,547	$4,754	$5,488	$5,737	$4,829	$5,049	$3,888	$4,066
40	Site work, Right-of-Way, Existing Imp.	$6,470	$7,221	$5,845	$6,462	$6,434	$7,112	$7,059	$7,871
50	Communications & Signaling	$912	$953	$991	$1,036	$943	$986	$864	$903
60	Electric Traction	$1,444	$1,511	$1,654	$1,730	$1,573	$1,645	$1,363	$1,426
80	Professional Services	$18,883	$26,907	$14,476	$20,564	$14,953	$21,264	$19,360	$27,607
	Subtotal	**$135,200**	**$148,900**	**$104,100**	**$114,600**	**$107,700**	**$118,600**	**$138,800**	**$152,900**

Source: NEC FUTURE team, 2015
Notes:
1. Includes the cost of new segments and stations with allocated contingency, environmental mitigation, professional services & finance charges.
2. Does not include curve modifications, new tracks, constructability access, junctions, yards & facilities, right-of-way acquisition, vehicles, and No Action Alternative projects.
3. Does not include railroad force account construction costs (adjacent to or in the center of existing tracks, or at railroad track cut-ins), temporary access agreements with railroads, or penalties/fees for maintenance of operations.
4. Does not include property acquisition costs for yards or stations.
5. New York City-Danbury-Hartford includes East River Tunnels 5&6.
6. New York City-Long Island-Hartford includes Ronkonkoma Station Local New Segment. East River Tunnels 5&6 are included in the New York City-Long Island-Hartford new segment.
7. Washington - New York City includes new segments and stations from Washington Union Station to Penn Station New York.
8. Columns may not add to the subtotal due to rounding.

Table 11: Cost of Alternative 3 Route Options – New Segments by Construction Type

CONSTRUCTION TYPE	New York City - Hartford				Hartford - Boston			
	New York City - Danbury - Hartford (Alt. 3.1 & 3.4)		New York City - Long Island - Hartford (Alt. 3.2 & 3.3)		Hartford - Worcester - Boston (Alt. 3.3 & 3.4)		Hartford - Providence - Boston (Alt. 3.1 & 3.2)	
DESCRIPTION	Cost (millions)	Construction Route Mileage	Cost (millions)	Construction Route Mileage	Cost (millions)	Construction Route Mileage	Cost (millions)	Construction Route Mileage
TUNNEL	$65,235	77	$34,258	51	$27,014	38	$26,069	41
TRENCH	$1,061	5	$5,648	30	$2,828	13	$2,150	10
AT-GRADE	$130	5	$626	19	$66	2	$800	23
EMBANKMENT	$577	16	$687	18	$879	22	$1,317	33
AERIAL	$1,458	11	$2,052	16	$3,529	27	$742	6
MAJOR BRIDGE	$173	1	$0	0	$0	0	$0	0
Subtotal	$68,634	**113**	**$43,271**	**132**	**$34,316**	**100**	**$31,077**	**111**
Cost per Construction Route Mileage	**$609**		**$328**		**$345**		**$279**	

Source: NEC FUTURE team, 2015
Note: Direct costs of new segments only. Does not include allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.

Table 12: Cost of Alternative 3: New York City to Boston – New Segments by Construction Type

CONSTRUCTION TYPE	Alternative 3.1: New York City-Danbury-Hartford + Hartford-Providence-Boston		Alternative 3.2: New York City-Long Island-Hartford + Hartford-Providence-Boston		Alternative 3.3: New York City-Long Island-Hartford + Hartford-Worcester-Boston		Alternative 3.4: New York City-Danbury-Hartford + Hartford-Worcester-Boston	
DESCRIPTION	Cost (millions)	Construction Route Mileage	Cost (millions)	Construction Route Mileage	Cost (millions)	Construction Route Mileage	Cost (millions)	Construction Route Mileage
TUNNEL	$91,304	118	$60,327	92	$61,272	89	$92,249	115
TRENCH	$3,211	14	$7,798	40	$8,475	43	$3,888	17
AT-GRADE	$930	28	$1,426	42	$692	21	$196	7
EMBANKMENT	$1,894	49	$2,003	51	$1,566	40	$1,457	38
AERIAL	$2,200	17	$2,794	22	$5,581	43	$4,987	38
MAJOR BRIDGE	$173	1	$0	0	$0	0	$173	1
Subtotal	**$99,711**	**224**	**$74,349**	**244**	**$77,587**	**232**	**$102,949**	**212**
Cost per Construction Route Mileage	**$445**		**$305**		**$335**		**$485**	

Source: NEC FUTURE team, 2015
Note: Direct costs of new segments only. Does not include allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.

Table 13: Cost of Alternative 3 Route Options – New Tracks

CONSTRUCTION TYPE	New York City - Hartford				Hartford - Boston			
	New York City - Danbury - Hartford (Alt. 3.1 & 3.4)		New York City - Long Island - Hartford[2] (Alt. 3.2 & 3.3)		Hartford - Worcester - Boston[3] (Alt. 3.3 & 3.4)		Hartford - Providence - Boston (Alt. 3.1 & 3.2)	
DESCRIPTION	Cost (millions)	Upgrade Route Mileage	Cost (millions)	Upgrade Route Mileage	Cost (millions)	Upgrade Route Mileage	Cost (millions)	Upgrade Route Mileage
ADDITIONAL TUNNEL TRACK	$0	0	$0	0	$1,972	5	$0	0
ADDITIONAL TRENCH TRACK	$0	0	$480	3	$371	2	$0	0
ADDITIONAL AT-GRADE TRACK	$0	0	$137	5	$294	15	$146	8
ADDITIONAL EMBANKMENT TRACK	$0	0	$0	0	$246	11	$196	9
ADDITIONAL AERIAL TRACK	$0	0	$0	0	$0	0	$0	0
ADDITIONAL MAJOR BRIDGE TRACK	$0	0	$0	0	$0	0	$0	0
FREIGHT TRACK UPGRADE	$0	0	$0	0	$0	0	$0	0
CATENARY SYSTEM UPGRADE	$47	15	$47	15	$0	0	$0	0
SIGNAL SYSTEM UPGRADE	$147	40	$147	40	$0	0	$0	0
Subtotal	**$194**		**$811**		**$2,883**		**$342**	

Source: NEC FUTURE team, 2015

Notes:

1. Direct costs of new tracks only. Does not include allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.
2. New York City-Long Island-Hartford includes same improvements as New York City-Danbury-Hartford, plus the Hell Gate Line 3rd and 4th Tracks (additional trench and at-grade tracks).
3. Hartford-Worcester-Boston includes the same improvements as Hartford-Providence-Boston, plus improvements along the existing NEC north of Providence: Malcom-Packard 3rd & 4th Track, Hebronville to Thatcher, and Canton Junction to Readville/Hyde Park.

Table 14: Cost of Alternative 3: New York City to Boston– New Tracks

CONSTRUCTION TYPE	Alternative 3.1: New York City-Danbury-Hartford + Hartford-Providence-Boston		Alternative 3.2: New York City-Long Island-Hartford + Hartford-Providence-Boston		Alternative 3.3: New York City-Long Island-Hartford + Hartford-Worcester-Boston		Alternative 3.4: New York City-Danbury-Hartford + Hartford-Worcester-Boston	
DESCRIPTION	**Cost (millions)**	**Upgrade Route Mileage**	**Cost (millions)**	**Upgrade Route Mileage**	**Cost (millions)**	**Upgrade Route Mileage**	**Cost (millions)**	**Upgrade Route Mileage**
ADDITIONAL TUNNEL TRACK	$0	0	$0	0	$1,972	5	$1,972	5
ADDITIONAL TRENCH TRACK	$0	0	$480	3	$851	4	$371	2
ADDITIONAL AT-GRADE TRACK	$146	8	$283	12	$431	19	$294	15
ADDITIONAL EMBANKMENT TRACK	$196	9	$196	9	$246	11	$246	11
ADDITIONAL AERIAL TRACK	$0	0	$0	0	$0	0	$0	0
ADDITIONAL MAJOR BRIDGE TRACK	$0	0	$0	0	$0	0	$0	0
FREIGHT TRACK UPGRADE	$0	0	$0	0	$0	0	$0	0
CATENARY SYSTEM UPGRADE	$47	15	$47	15	$47	15	$47	15
SIGNAL SYSTEM UPGRADE	$147	40	$147	40	$147	40	$147	40
Subtotal	**$536**		**$1,153**		**$3,695**		**$3,077**	

Source: NEC FUTURE team, 2015

Notes:

1. Direct costs of new tracks only. Does not include allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.
2. New York City-Long Island-Hartford includes same improvements as New York City-Danbury-Hartford, plus the Hell Gate Line 3rd and 4th Tracks (additional trench and at-grade tracks).
3. Hartford-Worcester-Boston includes the same improvements as Hartford-Providence-Boston, plus improvements along the existing NEC north of Providence: Malcom-Packard 3rd & 4th Track, Hebronville to Thatcher, and Canton Junction to Readville/Hyde Park.

Table 15: Cost of Alternatives 1, 2, and 3: Washington to New York City – New Segments by Construction Type

CONSTRUCTION TYPE	Alternative 1		Alternative 2		Alternative 3	
DESCRIPTION	**Cost (millions)**	**Construction Route Mileage**	**Cost (millions)**	**Construction Route Mileage**	**Cost (millions)**	**Construction Route Mileage**
TUNNEL	$2,566	6	$3,194	8	$29,178	50
TRENCH	$44	1	$405	2	$3,365	15
AT-GRADE	$88	4	$343	11	$2,470	69
EMBANKMENT	$196	6	$494	15	$2,450	67
AERIAL	$35	1	$211	2	$4,132	32
MAJOR BRIDGE	$3,061	6	$4,262	8	$3,193	6
Subtotal	**$5,990**	**20**	**$8,908**	**42**	**$45,156**	**235**
Cost per Construction Route Mileage	**$302**		**$210**		**$192**	

Source: NEC FUTURE team, 2015

Note: Direct costs of new segments only. Does not include allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.

Table 16: Cost of Alternative 1, 2, and 3: Washington to New York City – New Tracks by Construction Type

CONSTRUCTION TYPE	Alternative 1		Alternative 2		Alternative 3	
DESCRIPTION	**Cost (millions)**	**Upgrade Route Mileage**	**Cost (millions)**	**Upgrade Route Mileage**	**Cost (millions)**	**Route Mile**
ADDITIONAL TUNNEL TRACK	$743	2	$743	2	$743	2
ADDITIONAL TRENCH TRACK	$13	1	$13	1	$13	1
ADDITIONAL AT-GRADE TRACK	$964	49	$764	39	$649	33
ADDITIONAL EMBANKMENT TRACK	$513	18	$364	10	$287	9
ADDITIONAL AERIAL TRACK	$455	4	$78	1	$78	1
ADDITIONAL MAJOR BRIDGE TRACK	$0	0	$0	0	$0	0
FREIGHT TRACK UPGRADE	$504	31	$504	31	$504	31
CATENARY SYSTEM UPGRADE	$503	156	$430	134	$503	156
SIGNAL SYSTEM UPGRADE	$559	151	$517	140	$601	163
Subtotal	**$4,255**		**$3,414**		**$3,378**	

Source: NEC FUTURE team, 2015

Note: Direct costs of new segments only. Does not include allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.

Table 17: Cost of Alternative 1, 2, and 3: New York City to Boston – New Segments by Construction Type

CONSTRUCTION TYPE	Alternative 1		Alternative 2		Alternative 3	
DESCRIPTION	**Cost (millions)**	**Construction Route Mileage**	**Cost (millions)**	**Construction Route Mileage**	**Cost (millions)**	**Construction Route Mileage**
TUNNEL	$7,954	18	$25,443	39	$60,327 – $92,249	89 – 118
TRENCH	$1,471	7	$2,837	13	$3,211 – $8,475	14 – 43
AT-GRADE	$56	2	$1,323	45	$196 – $1,426	7 – 42
EMBANKMENT	$686	17	$2,077	53	$1,457 – $2,003	38 – 51
AERIAL	$821	7	$2,874	22	$2,200 – $5,581	17 – 43
MAJOR BRIDGE	$2,117	4	$1,093	2	$0 – $173	0 – 1
Subtotal	**$13,105**	**52**	**$35,648**	172	**$74,349 – $102,949**	**212 – 244**
Cost per Construction Route Mile	**$254**		**$207**		**$305 – $485**	

Source: NEC FUTURE team, 2015
Note: Direct costs only. Does not include allocated contingency, environmental Mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.

Table 18: Cost of Alternative 1, 2, and 3: New York City to Boston – New Tracks by Construction Type

CONSTRUCTION TYPE	Alternative 1		Alternative 2		Alternative 3	
DESCRIPTION	**Cost (millions)**	**Upgrade Route Mileage**	**Cost (millions)**	**Upgrade Route Mileage**	**Cost (millions)**	**Construction Route Mileage**
ADDITIONAL TUNNEL TRACK	$1,972	5	$0	0	$0 – $1,972	0 – 5
ADDITIONAL TRENCH TRACK	$851	4	$0	0	$0 – $851	0 – 4
ADDITIONAL AT-GRADE TRACK	$431	19	$177	7	$146 – $431	8 – 19
ADDITIONAL EMBANKMENT TRACK	$246	11	$83	3	$196 – $246	9 – 11
ADDITIONAL AERIAL TRACK	$0	0	$433	4	$0	0
ADDITIONAL MAJOR BRIDGE TRACK	$0	0	$0	0	$0	0
FREIGHT TRACK UPGRADE	$0	0	$0	0	$0	0
CATENARY SYSTEM UPGRADE	$47	15	$47	15	$47	15
SIGNAL SYSTEM UPGRADE	$147	40	$194	53	$147	40
Subtotal	**$3,695**		**$934**		**$536 – $3,695**	

Source: NEC FUTURE team, 2015
Note: Direct costs only. Does not include allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the subtotal due to rounding.

4. Conceptual Engineering Design Documentation

4.1 SOURCE DATA

The typical cross sections used for estimating purposes in this effort were developed using Amtrak Design standards and minimum clearance requirements for high-speed rail service. The typical cross sections used in the cost methodology of the Preliminary Alternatives were developed for the Amtrak NextGen HSR. With the addition of new details and the development of additional track configurations as part of NEC FUTURE, the FRA further refined and expanded these typical cross sections to accommodate multiple track configurations, and more-specific site conditions and construction methods.

Where specific information was not available, the FRA reached out to the CAHSR Program team for similar design parameters that could be used to generate sketches that could then be estimated and incorporated into the model.

The information available to assist in the cost estimating efforts described in this technical memorandum was limited to the following:

- Horizontal alignment and assumed vertical profile of the route centerline based upon existing aerial imagery
- Assumptions regarding special track work to be employed on the system (e.g., desired diverging move speeds on turnouts) and general interlocking layouts and locations
- Assumptions regarding general systems requirements for train control signal systems and communications
- Assumptions regarding traction power supply and catenary system requirements
- Assumed typical cross sections for the expected general infrastructure configurations
- Assumed typical layouts for stations
- General requirements for shops and yards based on the operating plan

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Stations Location and Access Analysis Technical Memorandum

October 1, 2015
Final Version

Submitted by:

PARSONS BRINCKERHOFF AECOM
A JOINT VENTURE

Table of Contents

Tables

1. Introduction

This technical memorandum describes the process for identifying stations served by the Action Alternatives. The station identification focuses on both existing stations and potential new stations where local and regional service gaps have been identified and improvements are recommended. For this process, the FRA defined general requirements for new and upgraded stations intended to serve as hubs, including the availability of multiple connecting modes of transportation, proximity to employment centers or significant activity centers, opportunities for station area development, availability of land for parking, and accessibility to regional highways.

The level of analysis for a Tier 1 Draft Environmental Impact Statement (Tier 1 Draft EIS) is intended to be conceptual and should be considered as representative of expected future conditions for planning purposes. While the stations identification is not intended to be used to select new station sites or to prescribe the extent of specific capital improvements at stations, assumptions about where train stations are located and how they are served are critical to the understanding of future travel behavior in the Study Area. These assumptions are also necessary to perform rail operations analysis, develop ridership projections and service plans, estimate capital costs, measure the benefits associated with improving rail service, and assess the environmental consequences of modified or expanded service and capital improvements.

This document also describes the station-related analyses performed by the FRA. Passenger rail stations represent the nexus between the rail network and passengers. As such, the quality of the rail passenger experience is determined based on travel metrics associated with existing and future rail stations and the trips between these stations. The evaluation of the Action Alternatives considers the impact on rail passengers, as the Action Alternatives represent new and improved mobility options compared to the No Action Alternative. Impacts are presented for 25 representative stations and 17 representative station-pairs to highlight the type and magnitude of benefits and effects on travel related to the No Action and Action Alternatives.

2. Methodology

To identify station upgrades and expansions, as well as new stations served by the Action Alternatives, the FRA first categorized existing stations using a typology, based on type of rail service and level of use. Through this effort, the FRA determined whether existing stations are adequately serving travel markets within the Study Area, and identified opportunities to better serve existing and future travel markets by either reconfiguring or expanding existing stations. In addition, locations for new stations were identified based on passenger demand and the needs of the rail network as well as local conditions, including population and employment levels, proximity to special activity centers, and access to highways or other modes of connecting transportation. To understand and describe the potential changes in service quality for passengers at stations, the FRA identified travel metrics associated with station-based and station-pair-based data.

2.1 STATION TYPOLOGY

For NEC FUTURE, the FRA developed a station typology, based on the size of the geographic market and type and quantity of rail service offered. (For a description of service types, refer to the *Service Plans and Train Equipment Options Technical Memorandum*.) This typology applies to existing stations and future stations included in each of the No Action and Action Alternatives. Stations are grouped based on similar characteristics into one of three categories:

- **Major Hub stations** serve the largest markets in the Study Area and have a full complement of rail services types, including Intercity-Express, Intercity-Corridor and Regional rail service. Major Hub stations serve the four primary markets: Washington, D.C., Philadelphia, New York, and Boston as well as other major markets within the Study Area, including but not limited to Baltimore, MD; Stamford, CT; and Providence, RI. Major Hub stations are located in the most populous and densely developed metropolitan areas along the NEC, serving Intercity and Regional rail travel to these major population and employment centers.
- **Hub stations** generally offer both Intercity and Regional rail service, although the Intercity service is limited to Intercity-Corridor service. The absence of regular Intercity-Express service is what distinguishes these stations from the Major Hub Stations. Hub stations include existing intermediate Amtrak stations like New Carrollton, MD; Trenton, NJ; Newark Airport, NJ; and New Rochelle, NY. This category also includes selected key Regional rail stations and new stations that have the potential to fill connectivity gaps in the existing intercity passenger rail network, serve significant employment and activity centers (including military installations and universities) and/or provide important inter-modal connections. Examples include Odenton, MD (adjacent to Fort Meade); Newark, DE (adjacent to the University of Delaware and a major redevelopment site); and T.F. Green Airport in Warwick, RI (major airport); and Willimantic/Storrs, CT (new station serving the University of Connecticut).
- **Local stations** only offer Regional rail service. Examples of Local stations include Halethorpe, MD; Claymont, DE; Torresdale, PA; Edison, NJ; Larchmont, NY; Westport, CT; Wickford Jct., RI; and Attleboro, MA. There are a limited number of locations on the NEC outside of Regional rail service areas where the existing Amtrak stations are best classified as Local stations (e.g., Mystic

and Westerly). Similarly, smaller stations on connecting corridors beyond the NEC are considered Local stations (e.g., Ashland, VA; Mt. Joy, PA; Rhinecliff, NY; Wallingford, CT).

2.2 STATION IDENTIFICATION

Station identification included identifying station upgrades and expansions, as well as new stations served by the Action Alternatives. To identify station upgrades and expansions, the FRA compiled information about existing NEC stations: location; physical configuration and characteristics (including extent to which stations meet ADA and applicable station standards); ownership; types and characteristics of train service; operational characteristics (including train schedules and track assignments); accessibility to other modes; and type and quantity of parking. In addition, information on planned capital improvements/service changes (including No Action Alternative projects) at existing stations was collected from multiple sources (commuter agencies, states, and Amtrak).

The FRA also used the Service Plans[1] identified for each Action Alternative to evaluate the adequacy of existing stations to meet market and service needs, and identify gaps or constraints along the NEC where existing stations will be unable to meet future needs or respond adequately to new service opportunities. Opportunities for new stations were investigated, both to fill gaps along the existing NEC and along the Representative Route[2] for each Action Alternative. This evaluation allowed the FRA to compile a list of candidate new stations, including multiple station locations when a clear solution was not apparent. Where multiple locations existed, the FRA selected one station as the basis for analysis. The FRA identified prototypical footprints for selected new stations and associated scopes for capital investment. Station locations were selected based on their likelihood to generate ridership and on their cost characteristics.

Using this information, the FRA evaluated each station and developed criteria for identifying stations that will need to be reclassified or upgraded to meet the service and infrastructure investments associated with each Action Alternative. Specifically, stations were categorized based on changes associated with:

- Reclassification, due to anticipated future change in the type or level of rail service
- Expansion to serve increased levels of ridership and/or better facilitate the movement of trains through the station

[1] Service Plans are a hypothetical train schedule for a typical future weekday and includes the train stops by station for both peak and non-peak periods. They provide a technical basis for the FRA to estimate future ridership, capital investment needs and costs, and assess the environmental impacts associated with planned construction and future operations.
[2] A Representative Route refers to a proposed route or potential alignment for an Action Alternative. The Representative Route includes horizontal and vertical dimensions, which are based on prototypical cross sections and define its footprint. Prototypical cross sections identify construction methods (tunnel, viaduct, bridge, fly-over, bypass, track type, etc.) and right-of-way requirements for tracks, structures, ancillary facilities, and stations associated with each Action Alternative. The Representative Route is the physical footprint used to asses potential effects of an Action Alternative within the Affected Environment. The Representative Route is used as a proxy for estimating the potential effects of a route whose location could shift during subsequent project-level reviews.

- Relocation to enable expansion, better serve travel markets and realize local development opportunities, or
- Partial reconstruction to enable expansion of railroad track capacity.

A common set of criteria was established to guide the identification of stations that warranted reclassification, expansion, relocation, and/or reconstruction, as well as new stations where none currently exist, based on the factors listed below. A station had to meet at least one criterion. However, many stations met multiple criteria.

- Ridership potential in either the interregional or regional travel markets. Virtually all stations proposed for inclusion to be upgraded have been identified based on their potential to serve new markets or better serve existing markets.
- Fills gap in Intercity or Regional rail service on a portion of the NEC or a new route that is not currently served by a station or where the distance between stations is greater than elsewhere on the corridor. This criterion is applied separately to the interregional and regional markets, since these markets are served by different sets of stations.
- Highway Access. The station can be conveniently accessed from interstate and/or major regional highways, particularly serving portions of the study area not well served by the existing NEC.
- Transit Access. The station provides existing or potential future transit connections.
- Airport Access. The station is located at or relatively close to an airport with air carrier service.
- Population/Employment Concentration. The station is located within an intermediate-sized city or at an existing, planned, or potential employment district.
- Activity Center. The station serves a significant local institution or potential generator of trips, including universities, hospitals, cultural centers, major recreation areas.
- Transit-Oriented Development (TOD) and Regeneration Potential. The station location generates significant development potential at or immediately adjacent to the station site, or where improved rail access potentially can contribute to the uplifting of existing communities and neighborhoods.
- New Intercity Route. The station is located along a new intercity route (NEC second spine or connecting corridor).
- Outside current Regional rail Service Area. The station expands the reach or coverage of the regional rail network.

The methodology employed to identify new stations was slightly different from that used to identify planned upgrades to existing stations. The FRA compiled information on planned new stations, from multiple sources including commuter agencies, states, and Amtrak and developed the following criteria to determine the need for new stations and identify appropriate station locations:

- Areas with significant and growing population and employment centers that are currently not served or underserved by rail.

- Fills gaps in Intercity or Regional rail service.
- Located in strategic locations with respect to the regional transportation network, such as near a major highway interchange, local or regional transit stop, or adjacent to an airport.
- Located near or adjacent to major activity center, such as university, military installation, medical facility, tourist attraction, or government center.
- Areas with significant Transit Oriented Development or economic regeneration potential.

2.3 STATION ANALYSIS

The FRA identified and evaluated a series of travel metrics associated with station-based and station-pair-based data to more succinctly describe the potential changes in service quality for users. These travel metrics are described below and categorized in Table 1, along with the unit of analysis and the measure used to analyze each metric.

- **Connectivity** measures the frequency and duration of passenger rail services. A higher frequency of service, or a shorter average headway, increases travel options. Similarly, a longer duration of service provides greater opportunity for travel
- **Accessibility** measures the type and number of connections available to passengers to arrive and depart from representative stations
- **Capacity** measures the ability of the station to provide the quantity of service predicted in the future alternatives by assessing whether the station will be new, expanded, or upgraded
- **Travel Time** is measured as the average scheduled time required to travel between representative station-pairs
- **Frequency** is measured as the number of trains per day providing service between representative station-pairs

Table 1: Travel Metrics

Unit of Analysis	Travel Metric	Measure
Representative station	Connectivity	■ Frequency of service measured in average headway ■ Daily hours of service
	Accessibility	■ Transit service ■ Private automobile access, roadway congestion, and parking ■ Independent (pedestrian and bicycle) and shared (taxis and carshare) access
	Capacity	■ Capital improvements
Representative station-pair	Travel Time	■ Average travel time
	Frequency	■ Number of trains per day

Source: NEC FUTURE team, 2015

Accessibility describes the travel modes available for passengers to arrive or depart from a passenger rail station. The FRA measured accessibility of representative stations in three major categories: transit, personal automobile, and independent and shared modes of transportation. The metrics for personal automobile and independent and shared modes of transportation are presented in Table 2.

Table 2: Accessibility Methodology

Accessibility Measure	Metric	High	Medium	Low	Poor	Data Source
Private automobile Accessible	Private automobile accessible yes or no	NA	NA	NA	NA	Google Earth Station Owner
Adjacent Roadway Congestion	High, Medium, Low, Poor	Uncongested	Occasional Peak Congestion	Regular Peak Congestion	Regular Peak and Off-Peak Congestion	Station Owner Station Master Plan
Parking Inventory	Number of parking spots available	NA	NA	NA	NA	Station Owner Station Master Plan
Station Environment	CBD, Urban, Suburban, Rural, Airport	NA	NA	NA	NA	Google Earth Station Owner
Pedestrian Network	High, Medium, Low, Poor	Sidewalk approaches from all directions (3 or more) AND sidewalk present on both sides of the street	Sidewalk approaches from 2 directions AND present on both sides of the street OR sidewalk approaches from more than 2 directions, but only present on one side of the street	Sidewalk approaches from one direction	No pedestrian pathway to station	Google Earth Station Owner
Bicycle Accessibility	High, Medium, Low, Poor	Dedicated, separated bike infrastructure to station	Dedicated but not separated	No bike infrastructure, but roadway can accommodate cyclists	Station inaccessible by bike	Google Earth Station Owner
Carshare and Rental Car Availability	High, Medium, Low, Poor	Carshare or rental car within station or in the immediate station vicinity	Carshare or rental car within half mile of the station	Carshare or rental car between a half mile and one mile from the station	Carshare and rental car unavailable within 1 mile of the station	Google Map Search Results, Zipcar.com, Enterprise.com, Avis.com, Hertz.com
Provision for Taxis	Presence of taxi queue yes or no	NA	NA	NA	NA	Station Owner Station Master Plan

The FRA based the existing conditions analysis on a review of 2012 printed timetables for Amtrak and the commuter railroads in the Study Area. For the No Action Alternative and the Action Alternatives, conceptual schedules were used to support the analysis of the travel metrics for 2040. Table 3 lists the data sources that were compiled and consulted by travel condition factor.

Table 3: Travel Metric Data Sources

Travel Metrics	Data Source / Existing Conditions	Data Source / 2040 Forecast
Connectivity	▪ Passenger Railroads (including Intercity and Commuter Railroads) ▪ NEC FUTURE No Action Alternative and capital plans/programs from State DOTs, transit agencies or public authorities, and rail station master plans	▪ NEC FUTURE Operations Model ▪ Passenger Railroads (including Intercity and Commuter Railroads) ▪ NEC FUTURE No Action Alternative and capital plans/programs from State DOTs, transit agencies or public authorities, and rail station master plans
Accessibility	▪ Passenger Railroads websites (including Intercity and Commuter Railroads) for parking and station access amenities ▪ NEC FUTURE No Action Alternative and capital plans/programs from State DOTs, transit agencies or public authorities, and rail station master plans ▪ Rail Station Master Plans ▪ Amtrak Master Plan, Amtrak High-Speed Rail Vision ▪ Public transportation provider websites ▪ Intercity bus carriers' websites ▪ Google Earth	▪ Passenger Railroads websites (including Intercity and Commuter Railroads) for parking and station access amenities ▪ NEC FUTURE No Action Alternative and capital plans/programs from State DOTs, transit agencies or public authorities, and rail station master plans ▪ Rail Station Master Plans ▪ Amtrak Master Plan, Amtrak High-Speed Rail Vision ▪ Public transportation provider websites ▪ Intercity bus carriers' websites ▪ Google Earth
Capacity	▪ NEC FUTURE No Action Alternative and capital plans/programs from State DOTs, transit agencies or public authorities, and rail station master plans	▪ NEC FUTURE No Action Alternative and capital plans/programs from State DOTs, transit agencies or public authorities, and rail station master plans
Frequency Travel Time	▪ Passenger Railroads (including Intercity and Commuter Railroads) Timetables	▪ NEC FUTURE Operations Model

Source: NEC FUTURE team, 2015

2.3.1 Representative Stations and Station-Pairs

To simplify and standardize the identification of changes in travel metrics, the FRA selected a series of "representative stations" and "representative station-pairs" as proxies for rail travel between stations within a metropolitan area. The final selection of the 25 representative stations was based on service type (Intercity and Regional rail), the volume of service (frequency), and location (representative of the entire NEC, connecting corridors, and Action Alternative route options). Table 4 presents these 25 representative stations, which consist of the four Major Hub stations (Washington Union Station, Philadelphia 30th Street Station, Penn Station New York, and Boston South Station) and a selection of 21 other stations, including some of the new stations proposed in Alternative 2 and Alternative 3. In addition, the FRA selected 17 station-pairs to highlight how the

No Action and Action Alternatives provide new Intercity travel linkages between markets or improve Intercity connections between existing markets. Table 5 presents the representative station-pairs.

Table 4: Representative Stations and Existing Station Type

Station	Existing Station Type	Station	Existing Station Type
Washington Union Station	Major Hub	Cross-Westchester	—
Odenton	Local	Nassau Hub	—
Baltimore Downtown	—	Ronkonkoma	Local
Newark, DE	Hub	Stamford	Major Hub
Wilmington	Major Hub	Danbury	—
Philadelphia 30th Street	Major Hub	New Haven	Major Hub
Philadelphia Market East	—	New London	Hub
Trenton	Hub	Hartford	Hub
Newark Liberty	Hub	Tolland/Storrs	—
Newark Penn Station	Major Hub	TF Green	Local
Secaucus	Local	Worcester	Local
Penn Station New York	Major Hub	Boston South Station	Major Hub
New Rochelle	Hub		

Source: NEC FUTURE team, 2015

Table 5: Representative Station-Pairs

Station 1	Station 2
Washington Union Station	Philadelphia
Washington Union Station	Penn Station New York
Washington Union Station	Boston South Station
Washington Union Station	Newark, DE
Philadelphia	Odenton
Penn Station New York	Baltimore (Penn Station and Downtown)
Penn Station New York	Wilmington
Ronkonkoma	Baltimore (Penn Station and Downtown)
Penn Station New York	Philadelphia
Boston Station	Philadelphia
Nassau Hub	Trenton
Danbury	Newark Penn Station
New Haven	Newark Penn Station
Stamford	Secaucus
Boston South Station	Penn Station New York
Hartford	Ronkonkoma
Boston South Station	Tolland / Storrs

Source: NEC FUTURE team, 2015
Philadelphia includes both Philadelphia 30th Street and Market East stations
Baltimore includes both Baltimore Penn and Downtown stations

3. Station Identification

3.1 EXISTING STATIONS

The FRA identified existing stations on the NEC that require station upgrades and expansion associated with implementation of the Action Alternatives. Future modifications fall into four main categories: reclassification, relocation, expansion, and partial reconstruction.

3.1.1 Reclassification

Station reclassification involves a change in the station type, reflecting a proposed or anticipated change in the mix of rail service available at the station. The most common reclassification represents an upgrade from a purely local station to a Hub station served by Metropolitan[3] trains. Odenton, MD is an example of this classification change.

Table 6 lists the existing stations that meet the criteria for an upgrade, along with the primary reasons why these stations were initially selected. The last two stations listed, Trenton, NJ and Hartford, CT, are reclassified as stations to receive Intercity-Express service. Hartford's reclassification reflects its location on the new segment in Alternative 2 and each of the Alternative 3 route options and the city's important role in the region, the concentration of population and employment that exists in that part of central Connecticut. Like Hartford, Trenton is a state capital and an important economic center; it is served by some Intercity-Express trains in Alternatives 2 and 3. As the level of Intercity-Express service increases to 4 trains per hour in the peak travel periods, the station is further reclassified as a Major Hub station.

Two existing stations with very limited Amtrak service today, Princeton Junction and New Brunswick NJ, are candidates for Metropolitan service. However, based on suburban population, concentrations of employment, and proximity to major research universities, there is very limited ability to expand the footprint of the existing stations to accommodate platforms on the express tracks or major increases in parking and access capacity. Therefore, the FRA has proposed a new station at North Brunswick, halfway between these two more constrained stations to more adequately serve as the Metropolitan station for this part of New Jersey. However, this station is intended to be representative, and any future decisions on a location for a new station will be part of a project level, Tier 2 environmental analysis.

[3] A new Intercity-Corridor rail service concept that upgrades the level of Intercity-Corridor rail service provided on the NEC which , offers frequent service (2–4 trains per hour) to large and mid-size markets and key transfer locations, and stops at more stations than current Intercity –Corridor service.

Table 6: Selection Criteria for Existing Stations Proposed for Metropolitan Service

Name	Volume of Commuter / Regional Ridership	Gap in Intercity or Regional Service	Highway Access	Transit Access	Airport Access	Population/Employment Concentration	Activity Center	TOD / Regeneration Potential	New Intercity Route	Outside Regional Rail Service Area
Odenton, MD	✓	✓	✓	✓			✓			
West Baltimore, MD				✓		✓		✓		
Aberdeen, MD							✓			
Newark, DE							✓	✓		
North Philadelphia, PA								✓		
Cornwells Heights, PA	✓	✓	✓			✓				
Princeton Junction, NJ	✓						✓			
New Brunswick, NJ							✓			
Secaucus, NJ										
New Rochelle, NY	✓					✓	✓			
Greens Farms, CT		✓	✓			✓			✓	
Mystic, CT										✓
Westerly, RI										✓
TF Green, RI		✓	✓		✓					
Ronkonkoma, NY	✓				✓				✓	
Trenton, NJ	✓	✓		✓		✓	✓	✓		
Hartford, CT						✓	✓	✓	✓	

Source: NEC FUTURE team, 2015

3.1.2 Expansion

Existing NEC stations were identified that are expected to require expansion to meet changing market demands and growing traffic levels. Station expansion, as defined for purposes of this document, includes a change in the configuration of tracks and platforms at the station, the introduction of new connecting modes of transportation such as rail or bus, or reconstruction or significant enlargement of the station facilities that handle passengers. Less intensive capital improvements such as the expansion of station parking, the extension of existing platforms or the conversion of platforms from low-level to high-level, is necessary at many stations along the NEC and by themselves are not considered expansion projects.

Table 7 presents the criteria used to identify the expansion associated with each station. The FRA performed this analysis using existing available information.

Table 8 summarizes the type of work expected at each of these stations associated with the Action Alternatives. No station expansions are required for the No Action Alternative. Examples of station expansion projects include construction of new platforms on either existing or new tracks, the conversion of stations with side platforms on the outer tracks to island platforms serving multiple tracks, or reconstruction of station concourses to improve passenger-handling capacity.

At many locations, these improvements reflect existing plans developed locally or at the regional or state level (e.g., Washington Union Station; Martin Airport, MD; and Newark, DE). At other locations, the FRA identified the need for future improvements based on projected future passenger demand, increases in the volume of train service, and proposed changes in train operating patterns and the types of train services offered at stations (e.g., stations requiring upgrades to support Metropolitan service, including new platforms on the express tracks or multiple station tracks and platforms).

Table 7: Selection Criteria for Identifying Existing Stations that Require Expansion

Station Name	Scope of Expansion				Criteria for Selection										
	Reclassified	Additional Platforms	Additional Tracks	Other Construction	Projected Regional Rail Ridership	Projected Intercity Ridership	Improved Highway Access	Improved Transit Connectivity/Access	Improved Airport Access	Improved Rail Passenger Transfers	Platforms on Express Tracks	Expanded Railroad Right-of-Way	Improved Train Operations	Activity Center	TOD / Redevelopment Potential
Washington Union, D.C.		✓	✓	✓	✓	✓		✓		✓			✓	✓	✓
New Carrollton, MD		✓	✓			✓		✓				✓	✓		✓
Odenton, MD	✓	✓	✓		✓	✓	✓	✓			✓		✓		
BWI Airport, MD		✓	✓		✓	✓			✓		✓	✓	✓		
Martin Airport, MD		✓		✓	✓			✓					✓		✓
West Baltimore, MD	✓	✓			✓			✓					✓		✓
Baltimore Penn Station, MD		✓	✓	✓						✓			✓	✓	✓
Aberdeen, MD	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Newark, DE	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓
Philadelphia 30th Street, PA				✓	✓	✓		✓	✓	✓			✓	✓	✓
North Philadelphia, PA	✓	✓		✓	✓			✓		✓			✓		✓
Cornwells Heights, PA	✓	✓			✓	✓				✓	✓	✓			
Trenton, NJ		✓	✓	✓	✓	✓				✓		✓	✓	✓	✓
Metropark, NJ		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓
Newark Airport, NJ		✓	✓	✓		✓	✓	✓	✓	✓		✓			
Newark Penn Station, NJ		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
Secaucus, NJ	✓	✓	✓	✓	✓	✓		✓		✓		✓			✓
Penn Station New York, NY		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
Jamaica, NY	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓		✓
New Rochelle, NY	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓		✓
Ronkonkoma, NY	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
Stamford, CT		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓
Green's Farms, CT	✓	✓	✓		✓	✓	✓			✓	✓	✓			
Bridgeport, CT		✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓
New Haven, CT		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓
Old Saybrook, CT		✓	✓			✓	✓			✓	✓	✓			
Mystic, CT	✓													✓	
Hartford, CT		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓		✓
Westerly, RI	✓													✓	
Kingston, RI		✓	✓		✓	✓				✓	✓		✓	✓	
TF Green Airport, RI	✓	✓	✓			✓	✓		✓	✓			✓	✓	

Station Name	Scope of Expansion				Criteria for Selection										
	Reclassified	Additional Platforms	Additional Tracks	Other Construction	Projected Regional Rail Ridership	Projected Intercity Ridership	Improved Highway Access	Improved Transit Connectivity/Access	Improved Airport Access	Improved Rail Passenger Transfers	Platforms on Express Tracks	Expanded Railroad Right-of-Way	Improved Train Operations	Activity Center	TOD / Redevelopment Potential
Providence, RI		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
Westwood/Rte 128, MA		✓	✓		✓					✓		✓	✓		✓
Readville, MA		✓						✓		✓		✓	✓		✓
Forest Hills, MA		✓						✓		✓		✓	✓		✓
Ruggles, MA		✓						✓		✓		✓	✓		✓
Boston Back Bay, MA		✓	✓	✓	✓	✓		✓		✓		✓	✓		
Boston South Station, MA		✓	✓	✓	✓	✓		✓		✓		✓	✓		

Source: NEC FUTURE team, 2015

Table 8: Station Expansion Associated with the Action Alternatives

Station	Expansion Scope	Action Alternatives
Washington Union, DC	Station and terminal expansion**	All
New Carrollton, MD	Additional track, 2 additional platforms	All
Odenton, MD	Additional track, track/platform reconfiguration	All
BWI Airport, MD	Additional track, 2 additional platforms New high-speed tracks and additional platforms*	All 3
Baltimore Penn Station, MD	Track and platform reconstruction, station expansion	All
Martin Airport, MD	Station relocation, track/platform reconfiguration	All
Aberdeen, MD	Station relocation, track/platform reconfiguration	All
Newark, DE	Station relocation, track/platform reconfiguration	All
Philadelphia 30th Street, PA	Station facilities, approach tracks	All
Trenton, NJ	New tracks and platforms on high-speed line*	3
Cornwells Heights, PA	Track and platform reconfiguration	All
Metropark, NJ	Track and platform reconfiguration New tracks and platforms on high-speed bypass*	1,2 3
Newark Airport, NJ	New tracks and platforms on high-speed bypass*	3
Newark Penn Station, NJ	Station capacity expansion New tracks and platforms on high-speed bypass*	All 3
Secaucus, NJ	Additional platforms and station tracks connected to new Hudson River tunnels	All
Penn Station New York, NY	Station and terminal expansion	All
Jamaica, NY	New upper level station on high-speed line*	3
New Rochelle, NY	Track platform and station reconfiguration, w/ potential upper level station on high-speed line*	All 3
Ronkonkoma, NY	Additional track and platform capacity	3
Stamford, CT	New tracks and platforms on high-speed bypass*	All
Green's Farms, CT	Additional track, track/platform reconfiguration	2
Bridgeport, CT	New lower level station on high-speed line*	3
New Haven Station, CT	Additional platform tracks on main level New lower level station on high-speed line*	All 3
Old Saybrook, CT	New tracks and platforms on high-speed bypass*	1,2
Hartford, CT	New lower level station and track relocation*	2, 3
Kingston, RI	Additional track and platform capacity	1,2
TF Green Airport, RI	Additional track and platform capacity	All
Providence, RI	New lower level station on high-speed line*	3
Westwood/Rte 128, MA	Additional track and platform capacity	All
Readville, MA	Additional platform	2
Forest Hills, MA	Additional platform	2
Ruggles, MA	Additional platform	2
Boston Back Bay, MA	New lower level station on high-speed line*	2,3
Boston South Station, MA	Station and terminal expansion	All

Source: NEC FUTURE team, 2015

* Improvements entail construction of new station facilities adjacent to and connected with existing station.

** Includes station facilities such as platforms, platform tracks, concourses and passenger-handling facilities, and other terminal facilities including rolling stock storage and maintenance facilities and the configuration of track connections to and from multiple branch lines.

3.1.3 Relocation

Stations were assumed to remain at existing locations, except in situations where:

- Station relocation is already planned by Amtrak or a commuter agency/operator
- Regulatory mandates (e.g., ADA, NFPA 130) require expansion at a different location (e.g., relocation of high-level station platforms off of curves)
- Sufficient space does not exist to expand tracks, platforms and/or parking to support future station demand and functional requirements
- Local environmental conditions indicate relocation is feasible and preferable to expansion at existing station site
- Station area development and TOD opportunities support and favor station relocation

Hartford Union Station in Hartford, CT, is the only major station relocation currently under consideration. The station is currently located under the Hartford Viaduct, a 100-year old structure that needs replacement. The station could be relocated as part of a parallel effort to rebuild I-84 through downtown Hartford. Minor relocations are already planned or envisioned at some stations, such as Martin Airport, MD and Newark, DE, in response to local transit-oriented development plans and to permit expansion of station infrastructure. No other stations are currently planned for relocation or explicitly require relocation as a result of the Action Alternatives. The need for station relocation due to the implementation of specific projects in an Action Alternative will be determined as part of a future Tier 2 environmental review process.

3.1.4 Partial Reconstruction

In the Action Alternatives, there are a number of existing stations that will need to be partially reconstructed to provide for additional main tracks within or adjacent to the existing right-of-way. These stations, typically served by Regional rail only, otherwise do not change their type or level of use. As a result, they are not included as a station upgrade or expansion.

Examples include Seabrook and Bowie State in Maryland, where the addition of a fourth main line track in all Action Alternatives requires one of the two existing station platforms to be reconstructed, with relatively minor modifications to pedestrian access and station parking. Similar situations would occur elsewhere, particularly in Alternative 2, which builds out a 4-track railroad along most of the NEC, impacting Regional rail stations at: Martin Airport, Edgewood and Perryville, MD; Churchman's Crossing, DE; North Philadelphia, PA; Jersey Avenue, NJ; and Hyde Park, MA. The FRA included capital costs associated with partial station reconstructions in capital cost estimates for each Action Alternative. Environmental impacts associated with reconstructing platforms and possibly relocating or expanding parking lots also were taken into account, based on analysis of the general station footprint requirement and the type of construction for the new main track(s), in the Tier 1 Draft EIS.

3.2 NEW STATIONS

In addition to existing stations, the FRA identified new stations. This section summarizes the assumptions regarding the identification of new stations on the NEC rail network, including those serving areas along the existing NEC that were previously unserved, high-speed express stations adjacent to existing stations, and those associated with new segments or new track. The analysis includes stations currently under planning by commuter rail operators or other entities, as well as stations identified to meet future market demand. New stations fall into one of the following categories.

- NEC stations planned by commuter rail operators, municipalities, or other transportation agencies
- NEC stations on the existing NEC
- Stations on potential new segments
- Stations serving new high-speed express tracks adjacent to existing stations

3.2.1 Planned Regional Rail Stations

Most new stations along the existing NEC are Regional rail stations under development or included in the long-range plans of the Regional rail operators and planning agencies. Table 9 lists these stations, along with the selection criteria used to identify these stations.

Table 9: Selection Criteria for Planned Regional Rail Stations

Name	Ridership Potential	Gap in Intercity or Regional Service	Highway Access	Transit Access	Airport Access	Population/ Employment Concentration	Activity Center	TOD / Regeneration Potential	New Intercity Route
Bayview, MD	✓		✓	✓		✓	✓	✓	
Elkton, MD	✓	✓							
Newport, DE	✓	✓				✓			
Edgemoor, DE	✓	✓				✓			
North Brunswick, NJ	✓	✓	✓					✓	
Hunts Point, NY	✓					✓			
Parkchester, NY	✓					✓			
Morris Park, NY	✓	✓		✓		✓	✓		
Co-op City, NY	✓					✓			
East Bridgeport, CT	✓					✓		✓	
North Haven, CT	✓	✓							✓
Newington, CT	✓	✓		✓					✓
West Hartford, CT	✓	✓		✓					✓

Source: NEC FUTURE team, 2015

The FRA included these new stations in the Action Alternatives generally as Regional rail (local) stations. Stations that are under construction, funded, or in the capital plans of local agencies or rail operators are included in the No Action Alternative. Some of these planned new Regional rail stations represent candidates for Metropolitan service. For example, Bayview, North Brunswick, and Morris Park, NY, fall into this category. These stations exhibit the following characteristics:

- Fills gap in existing Amtrak service
- Provides service to active or growing suburban area or outer portion of metro area
- Provides improved regional highway or transit access
- Coincides with major activity center, employment center or development zone

The other new Local stations are all anticipated to have ridership catchment areas that are more local in nature and best served by Regional rail.

3.2.2 New Stations on the Existing NEC

The FRA also selected stations on the existing NEC that serve a purpose consistent with the vision in one or more of the Action Alternatives. Table 10 identifies these new stations, and the criteria used to identify them.

Table 10: Selection Criteria for New Stations on the Existing NEC

Name	Ridership Potential	Gap in Intercity or Regional Service	Highway Access	Transit Access	Airport Access	Population/ Employment. Concentration	Activity Center	TOD / Regeneration Potential	New Intercity Route
Upton, MD	✓			✓		✓		✓	
Broadway, MD	✓			✓		✓		✓	
Baldwin, PA	✓	✓	✓					✓	
Cross-Westchester, NY	✓		✓						

Source: NEC FUTURE team, 2015

Baldwin, MD, and Cross-Westchester, NY, both provide highway access to the NEC and serve large suburban areas in the southwestern Philadelphia and northern New York suburbs, respectively. Baldwin is close to the interchange of I-95 with I-476 (the Blue Route), the western circumferential highway in the Philadelphia region. Cross-Westchester is at the eastern end of the Cross-Westchester Expressway (I-287), which provides access to all of Westchester County and the suburban counties lying west of the Hudson River across the Tappan Zee Bridge. A new station on the NEC is a logical terminus for future transit (e.g., bus rapid transit (BRT) or enhanced bus service) in the I-287 corridor that would link the NEC with White Plains, NY, and western portion of Westchester County, as well as Rockland and Orange Counties on the west side of a reconstructed Tappan Zee Bridge. These stations support visions of the NEC that either grow or transform the role of rail (i.e., Alternative 2 or 3).

Upton and Broadway, within Baltimore City, provide direct transfer connections from Regional rail and Metropolitan service operating on the NEC to the Baltimore Metro, providing connections to downtown Baltimore and the northern suburbs. These stations also offer potential development opportunities. These station concepts depend upon several external factors, including the outcome of engineering studies for the B&P and Union tunnels, and plans for the possible extension of the Baltimore Metro line. They provide transit system connectivity consistent with NEC FUTURE's service objectives for major urban areas.

The feasibility, practicality, and cost-effectiveness of these new stations should be assessed in future Tier 2 environmental analyses.

3.2.3 New Stations on New Segments

The FRA identified new stations along new segments (new right-of-way, parallel to the NEC, where the existing track is retained), as identified in Table 11. Select stations are also described in more detail below.

Table 11: Selection Criteria for New Stations on New Segments

Name	Action Alts.	Ridership Potential	Gap in Intercity or Regional Service	Highway Access	Transit Access	Airport Access	Population/ Employment Concentration	Activity Center	TOD / Regeneration Potential	New Intercity Route
Baltimore Downtown, MD	3	✓			✓		✓	✓	✓	✓
Rosedale, MD	3	✓					✓			✓
White Marsh, MD	3	✓		✓			✓			✓
Joppatowne, MD	3	✓					✓			✓
Philadelphia Market East, PA	3	✓			✓		✓	✓	✓	✓
Philadelphia Int'l. Airport, PA	2	✓				✓	✓	✓		✓
White Plains East, NY	3	✓		✓			✓	✓		✓
Nassau Hub, NY	3	✓			✓		✓	✓	✓	✓
Suffolk Hub - Rte 110, NY	3	✓					✓	✓	✓	✓
Nesconset Highway / Setauket / Stony Brook, NY	3	✓						✓		✓
Danbury, CT	3	✓					✓			✓
Waterbury South, CT	3	✓					✓			✓
New London/ Mystic, CT	1	✓								✓
Willimantic / Storrs, CT	3	✓	✓					✓		✓
Meriden, CT	2	✓	✓							✓
Worcester, MA	3	✓						✓		✓
Riverside/I-95, MA	3	✓		✓				✓		✓
Blue Star/I-495, MA	3	✓		✓				✓		✓

Source: NEC FUTURE team, 2015

Downtown Baltimore and Philadelphia stations, included in Alternative 3, provide two primary benefits: they are located on an Alternative 3 New Segment that significantly decrease trip times for New York-to-Washington, D.C. Intercity-Express service; and they are located in the central business districts of both cities (in contrast to the existing Amtrak stations, which are located on the periphery of those central business districts). In both cities, considerable development is already planned around the existing train stations, and Alternative 3 assumes that rail service to these stations also is increased significantly over existing levels.

The Philadelphia International Airport station provides access to this airport that is comparable to the service now provided to Newark Liberty International and BWI Thurgood Marshall Airports. The rail station could be located directly adjacent to the air terminal or accessible via a people-mover from the Chester Secondary/SEPTA Eastwick Station area. The station also has good highway access from I-95 and will serve the employment zone that surrounds the airport.

The New London/Mystic station is located on the Old Saybrook CT-Kenyon RI bypass in Alternative 1. Meriden/I-91 serves as a highway intercept point between New Haven and Hartford, CT in Alternative 2. These stations are in more suburban and rural areas, but provide good access to population in zones that are relatively far from other Intercity stations.

3.2.4 New Stations Adjacent to Existing Stations

The FRA also proposed new stations for development adjacent to existing stations, as part of expanded NEC capacity where a new segment is built parallel to the existing NEC (Alternatives 2 and 3). Rather than being wholly new and separate stations, these stations function as a single integrated facility in terms of access and parking – with multiple levels of tracks and platforms and convenient passenger connections between them. Examples of these types of stations are shown in Table 12, along with the criteria used to identify them.

Table 12: Selection Criteria for New Stations Adjacent to Existing Stations

Name	Ridership Potential	Gap in Intercity or Regional Service	Highway Access	Transit Access	Airport Access	Population/ Employment Concentration	Activity Center	TOD / Regeneration Potential	New Intercity Route
Trenton, NJ H.S.	✓			✓		✓	✓		
Metropark, NJ H.S.	✓		✓			✓	✓		
Newark Penn Station, NJ H.S.	✓			✓		✓	✓	✓	
Stamford, CT H.S.	✓					✓	✓		
Bridgeport, CT H.S.	✓					✓	✓	✓	
New Haven Station, CT H.S.	✓					✓	✓	✓	
Old Saybrook, CT H.S.	✓								✓
Providence Station, RI H.S.	✓					✓	✓		
Back Bay, MA H.S.	✓					✓	✓		
Hartford, CT H.S.*	✓					✓	✓	✓	✓
Jamaica, NY H.S.	✓			✓		✓	✓	✓	✓
Ronkonkoma, NY	✓				✓			✓	✓

Source: NEC FUTURE team, 2015

* The State of Connecticut is considering relocation of this station.

3.3 SUMMARY

Table 13 contains a complete list of the stations identified by the FRA, their location, type, and the Action Alternative(s) in which each station appears. The FRA assigned a station ID for use in the Tier 1 Draft EIS.

Table 13: NEC FUTURE Stations

Geography	County	Station ID	Station Name	Station Type	Alt 1	Alt 2	Alternative 3 Alt 3.1	Alt 3.2	Alt 3.3	Alt 3.4
D.C.		1	Washington Union	Existing	X	X	X	X	X	X
MD	Prince George's	2	New Carrolton	Existing	X	X	X	X	X	X
		3	Seabrook		X	X	X	X	X	X
		4	Bowie State		X	X	X	X	X	X
	Anne Arundel	5	Odenton	Existing	X	X	X	X	X	X
		6	BWI Airport		X	X	X	X	X	X
		6	BWI Airport H.S.	New			X	X	X	X
	Baltimore County	7	Halethorpe	Existing	X	X	X	X	X	X
		15	Martin Airport		X	X	X	X	X	X
	Baltimore City	8	West Baltimore	Existing	X	X	X	X	X	X
		9	Upton	New	X	X	X	X	X	X
		10	Baltimore Penn Station	Existing	X	X	X	X	X	X
		11	Baltimore Downtown	New			X	X	X	X
		12	Broadway		X	X	X	X	X	X
		13	Bayview		X	X	X	X	X	X
		14	Bayview H.S.				X	X	X	X
	Harford	16	Edgewood	Existing	X	X	X	X	X	X
		17	Aberdeen (NEC)		X	X	X	X	X	X
	Cecil	22	Perryville	Existing	X	X	X	X	X	X
		23	Elkton	New	X	X	X	X	X	X
DE	New Castle	24	Newark, DE	Existing	X	X	X	X	X	X
		25	Churchman's Crossing		X	X	X	X	X	X
		26	Newport	New	X	X	X	X	X	X
		27	Wilmington Station	Existing	X	X	X	X	X	X
		28	Edgemoor	New	X	X	X	X	X	X
		29	Claymont	Existing	X	X	X	X	X	X
PA	Delaware	30	Marcus Hook	Existing	X	X	X	X	X	X
		31	Highland Avenue		X	X	X	X	X	X
		32	Chester		X	X	X	X	X	X
		33	Eddystone		X	X	X	X	X	X
		34	Baldwin	New	X	X	X	X	X	X
		35	Crum Lynne	Existing	X	X	X	X	X	X
		36	Ridley Park		X	X	X	X	X	X
		37	Prospect Park		X	X	X	X	X	X
		38	Norwood		X	X	X	X	X	X
		39	Glenolden		X	X	X	X	X	X
		40	Folcroft		X	X	X	X	X	X
		41	Sharon Hill		X	X	X	X	X	X
		42	Curtis Park		X	X	X	X	X	X
		43	Darby		X	X	X	X	X	X

Table 13: NEC FUTURE Stations (continued)

Geography	County	Station ID	Station Name	Station Type	Alt 1	Alt 2	Alternative 3			
							Alt 3.1	Alt 3.2	Alt 3.3	Alt 3.4
		44	Philadelphia Airport*	New		X	X	X	X	X
		45	Philadelphia 30th St		X	X	X	X	X	X
		46	Philadelphia Market East				X	X	X	X
		47	North Philadelphia		X	X	X	X	X	X
	Philadelphia	48	Bridesburg		X	X	X	X	X	X
		49	Wissinoming		X	X	X	X	X	X
PA (cont'd)		50	Tacony		X	X	X	X	X	X
		51	Holmesburg Junction		X	X	X	X	X	X
		52	Torresdale	Existing	X	X	X	X	X	X
		53	Cornwells Heights		X	X	X	X	X	X
		54	Eddington		X	X	X	X	X	X
	Bucks	55	Croydon	Existing	X	X	X	X	X	X
		56	Bristol		X	X	X	X	X	X
		57	Levittown		X	X	X	X	X	X
		58	Trenton		X	X	X	X	X	X
	Mercer	60	Hamilton	Existing	X	X	X	X	X	X
		61	Princeton Junction		X	X	X	X	X	X
		62	North Brunswick	New	X	X	X	X	X	X
		63	Jersey Avenue		X	X	X	X	X	X
		64	New Brunswick		X	X	X	X	X	X
	Middlesex	65	Edison	Existing			X	X	X	X
		66	Metuchen		X	X	X	X	X	X
		67	Metropark		X	X	X	X	X	X
NJ		68	Metropark H.S.	New			X	X	X	X
		69	Rahway		X	X	X	X	X	X
	Union	70	Linden	Existing	X	X	X	X	X	X
		71	Elizabeth		X	X	X	X	X	X
		72	North Elizabeth		X	X	X	X	X	X
		73	Newark Airport	Existing	X		X	X	X	X
		74	Newark Penn Station		X	X	X	X	X	X
	Essex	75	Newark Penn Station H.S.	New			X	X	X	X
	Hudson	76	Secaucus	Existing	X	X	X	X	X	X
	New York	77	Penn Station New York	Existing	X	X	X	X	X	X
		9993	Grand Central Terminal				X			X
	Queens	144	Jamaica	Existing				X	X	
NY		145	Jamaica H.S.	New				X	X	
		78	Hunts Point		X	X	X	X	X	X
	Bronx	79	Parkchester	New	X	X	X	X	X	X
		80	Morris Park		X	X	X	X	X	X
		81	Co-op City		X	X	X	X	X	X

Table 13: NEC FUTURE Stations (continued)

Geography	County	Station ID	Station Name	Station Type	Alt 1	Alt 2	Alternative 3			
							Alt 3.1	Alt 3.2	Alt 3.3	Alt 3.4
NY (cont'd)	Westchester	82	New Rochelle	Existing	X	X	X	X	X	X
		83	Larchmont		X	X	X	X	X	X
		84	Mamaroneck		X	X	X	X	X	X
		85	Harrison		X	X	X	X	X	X
		86	Rye		X	X	X	X	X	X
		87	Cross-Westchester	New	X	X	X	X	X	X
		88	Port Chester	Existing	X	X	X	X	X	X
		151	White Plains East	New			X			X
	Putnam	153	Brewster - Katonah	New			X			X
	Nassau	146	Nassau Hub	New				X	X	
	Suffolk	148	Suffolk Hub	New				X	X	
		149	Ronkonkoma	Existing				X	X	
CT	Fairfield	89	Greenwich	Existing	X	X	X	X	X	X
		90	Cos Cob		X	X	X	X	X	X
		91	Riverside		X	X	X	X	X	X
		92	Old Greenwich		X	X	X	X	X	X
		93	Stamford		X	X	X	X	X	X
		94	Stamford H.S.	New	X					
		95	Noroton Heights	Existing	X	X	X	X	X	X
		96	Darien		X	X	X	X	X	X
		97	Rowayton		X	X	X	X	X	X
		98	South Norwalk		X	X	X	X	X	X
		99	East Norwalk		X	X	X	X	X	X
		100	Westport		X	X	X	X	X	X
		101	Greens Farms		X	X	X	X	X	X
		102	Southport		X	X	X	X	X	X
		103	Fairfield		X	X	X	X	X	X
		104	Fairfield Metro		X	X	X	X	X	X
		105	Bridgeport		X	X	X	X	X	X
		107	East Bridgeport	New	X	X	X	X	X	X
		108	Stratford	Existing	X	X	X	X	X	X
		154	Danbury	New			X			X
	New Haven	109	Milford	Existing	X	X	X	X	X	X
		110	West Haven		X	X	X	X	X	X
		111	New Haven Station		X	X	X	X	X	X
		112	New Haven Station H.S.	New		X		X	X	
		113	New Haven State Street	Existing	X	X	X	X	X	X
		156	Meriden High Speed	New		X		X	X	
		114	Branford	Existing	X	X	X	X	X	X
		115	Guilford		X	X	X	X	X	X
		116	Madison		X	X	X	X	X	X
		155	Waterbury South	New			X			X

Table 13: NEC FUTURE Stations (continued)

Geography	County	Station ID	Station Name	Station Type	Alt 1	Alt 2	Alternative 3 Alt 3.1	Alt 3.2	Alt 3.3	Alt 3.4
CT (cont'd)	Middlesex	117	Clinton	Existing	X	X	X	X	X	X
		118	Westbrook		X	X	X	X	X	X
		119	Old Saybrook		X	X	X	X	X	X
		120	Old Saybrook H.S.	New	X					
	New London	121	New London	Existing	X	X	X	X	X	X
		124	New London / Mystic H.S.	New	X					
		122	Mystic	Existing	X	X	X	X	X	X
	Hartford	160	West Hartford	New		X				
		160	Berlin	Existing		X				
		161	Newington	New		X				
		164	Hartford			X	X	X	X	X
	Tolland	165	Willimantic / Storrs	New		X	X	X		
		166	Tolland / Storrs						X	X
RI	Washington	123	Westerly	Existing	X	X	X	X	X	X
		125	Kingston		X	X	X	X	X	X
		126	Wickford Junction		X	X	X	X	X	X
	Kent	127	TF Green	Existing	X	X	X	X	X	X
	Providence	128	Providence Station	Existing	X	X	X	X	X	X
		129	Providence Station H.S.	New		X	X	X	X	X
		130	Pawtucket		X	X	X	X	X	X
MA	Bristol	131	South Attleboro	Existing	X	X	X	X	X	X
		132	Attleboro		X	X	X	X	X	X
		133	Mansfield		X	X	X	X	X	X
	Worcester	172	Worcester	Existing					X	X
		173	Grafton-Shrewsbury	New					X	X
		174	Westborough						X	X
		175	Blue Star Hwy (I-495)						X	X
	Middlesex	176	Southborough/Ashland	New					X	X
		178	Framingham						X	X
		181	Riverside (I-95)						X	X
	Suffolk	182	Beacon Park	New					X	X
	Norfolk	134	Sharon	Existing	X	X	X	X	X	X
		135	Canton Junction		X	X	X	X	X	X
		136	Rte 128		X	X	X	X	X	X
	Suffolk	137	Readville	Existing	X	X	X	X	X	X
		138	Hyde Park		X	X	X	X	X	X
		139	Forest Hills		X	X	X	X	X	X
		140	Ruggles Street		X	X	X	X	X	X
		141	Back Bay		X	X	X	X	X	X
		142	Back Bay H.S.	New			X	X	X	X
		143	Boston South Station	Existing	X	X	X	X	X	X

Source: NEC FUTURE team, 2015
* The airport is currently served by Regional rail service located off the existing NEC. The Philadelphia International Airport Station identified in the Action Alternatives would be built as part of the NEC FUTURE. The station area is co-located in Delaware County, PA.
H.S. = high speed

4. Station Analysis

This section describes the analysis of the travel metrics associated with station-based and station-pair-based data for representative stations and representative station-pairs. These metrics identify and quantify the potential changes in service quality for passengers.

4.1 CONNECTIVITY

Connectivity is a measure of the intensity and quality of transportation connections available to passengers at Regional rail stations. For NEC FUTURE, the FRA measured connectivity in two ways:

- Frequency: The availability of Intercity service at the station throughout the day is measured as average headway in minutes between train departures. Average headway, is an indication of how often a train is available, and how easy or convenient it is for passengers to make a trip or a connection via Intercity service.
- Hours of Service: The availability of Intercity service at the station throughout the day is measured by hours of service, which is a temporal measure of connectivity that indicates how long during the day the station serves as a useful connection point for Intercity service.

4.1.1 Frequency

Average headway is a measure of how frequently service is available at stations. The more frequently trains arrive; the more convenient it is for passengers to choose to travel via passenger rail. Shorter average headways for transportation services offer passengers more opportunities to travel, and less time spent at stations waiting to make connections to the Intercity network and last mile connections from a station to their final destination via rail. The greater the frequency of Intercity and Regional rail services at a station, the easier it is for travelers to make connections between these services at that station. Higher frequencies of service provide passengers with increased opportunities to choose a rail service that fits their needs.

The FRA calculated average headway by dividing the daily number of scheduled train departures at a station by the daily number of minutes that service is available at that station. Actual rail service at the station may be more or less frequent than the average, depending on the time of day. For example, during peak service, most Regional rail service runs more frequently, and during the late night and/or midday, service runs less frequently.

Table 14 presents the frequency of existing Intercity and Regional rail service, expressed as the average headway in minutes, for the representative stations. Shorter average headways indicate a greater frequency of service. In Table 14, Intercity includes Intercity-Express and Intercity-Corridor services on the NEC. For stations with more than one Regional rail line, the measure represents an average of each line’s average headway.

Table 14: Average Headway (Minutes) by Representative Station, 2012

Station	Intercity	Regional Rail
Washington Union Station	31	66
Odenton	No Service	40
Baltimore Downtown	New Station in Action Alternatives	
Newark, DE	60	84
Wilmington	31	57
Philadelphia 30th Street	25	45
Philadelphia Market East*	No Service	45
Trenton	41	31
Newark Liberty	101	20
Newark Penn Station	27	28
Secaucus	No Service	34
Penn Station New York	26	9
New Rochelle	151	25
Cross Westchester	New Station in Action Alternatives	
Nassau Hub	New Station in Action Alternatives	
Ronkonkoma*	No Service	45
Stamford	53	20
Danbury	No Service	92
New Haven	62	49
New London	102	153
Hartford	403	No Service
Tolland/Storrs	New Station in Action Alternatives	
TF Green	No Service	104
Worcester	No Service	69
Boston South Station	52	60

*Philadelphia Market East and Ronkonkoma stations are existing Regional rail stations on new Action Alternatives alignments. These stations have existing transportation infrastructure but they are not on the NEC.
Source: Published online schedules for Amtrak, WMATA, Maryland MTA, MARC, DART, SEPTA, NJ TRANSIT, LIRR, Metro-North, MTA NYCT, Shoreline East, MBTA, 2012

Table 15 identifies the average headways of Intercity service for the No Action and Action Alternatives. For Alternative 3, the average headway is presented as a range for representative stations not served by all of the Alternative 3 route options.

Table 15: Average Intercity Headway (Minutes) by Representative Station for Action Alternatives, 2040

	No Action	Alternative 1	Alternative 2	Alternative 3
Washington Union Station	31	17	11	8
Odenton	0	46	22	19
Baltimore Downtown	0	0	0	13
Newark, DE	60	46	22	19
Wilmington	31	17	11	12
Philadelphia 30th Street	25	17	11	25
Philadelphia Market East	0	0	0	9
Trenton H.S.	41	19	15	9
Newark Liberty	101	19	15	11
Newark Penn/Newark H.S.	27	14	10	7
Secaucus	0	0	19	12
Penn Station New York	26	14	10	7
New Rochelle	151	33	17	17
Cross-Westchester	0	33	16	21
Nassau Hub	0	0	0	0–14*
Ronkonkoma	0	0	0	0–14*
Stamford/Stamford H.S.	53	22	11	16
Danbury	0	0	0	0–22*
New Haven/New Haven H.S.	62	22	11	12
New London	102	175	58	43
Hartford/Hartford H.S.	403	67	10	8
Tolland/Storrs	0	0	0	0–21*
TF Green	0	39	41	43
Worcester	0	0	0	0–14*
Boston South Station	52	23	10	8

Source: NEC FUTURE team, 2015

* These stations have service in only two of the four Alternative 3 route options. Their average headways are represented as a range from zero (in the scenarios where there is no service) to an average of the headways for the two route options with service.

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4.1.2 Daily Hours of Service

Greater hours of service per day increase the availability of transportation services at that station for passengers. Stations that offer more hours of service for both Intercity and Regional rail modes increase the opportunities for connected transportation services between those modes.

Daily hours of service measures the number of hours in an average 24-hour weekday that passenger rail service is available. Longer service periods create opportunities for more convenient service. Stations with very limited hours of service require passengers to plan their travel within the limited service window. Passengers have more flexibility in deciding when to travel if service is available in the early morning, throughout the midday, in the evening, and late at night (an 18-hour service day or longer). Table 16 presents the existing hours of service for Intercity and Regional rail at the representative stations, and Table 17 demonstrates the daily hours of service for Intercity service at each of the Representative stations for the No Action Alternative and Action Alternatives.

Table 16: Daily Hours of Service by Representative Station, 2012

Station	Intercity	Regional Rail
Washington Union Station	18	12
Odenton	No Service	17
Baltimore Downtown	New Station in Action Alternatives	
Newark, DE	1	14
Wilmington	19	15
Philadelphia 30th Street	19	18
Philadelphia Market East*	No Service	18
Trenton	20	20
Newark Liberty	15	20
Newark Penn Station	20	20
Secaucus	No Service	19
Penn Station New York	20	24
New Rochelle	13	20
Cross-Westchester	New Station in Action Alternatives	
Nassau Hub	New Station in Action Alternatives	
Ronkonkoma*	No Service	22
Stamford	17	20
Danbury	No Service	17
New Haven	21	18
New London	17	15
Hartford	13	No Service
Tolland/Storrs	New Station in Action Alternatives	
TF Green	No Service	17
Worcester	No Service	19
Boston South Station	16	17

Source: Published online schedules for Amtrak, WMATA, Maryland MTA, MARC, DART, SEPTA, NJ Transit, LIRR, Metro-North, MTA NYCT, Shoreline East, MBTA, 2012

*Market East and Ronkonkoma stations are existing Regional rail stations on Action Alternatives new segments. These stations have existing transportation infrastructure but they are not on the NEC Spine.

Table 17: Daily Hours of Intercity Service by Representative Station for No Action and Action Alternatives, 2040

Station	No Action	Alternative 1	Alternative 2	Alternative 3
Washington Union Station	18	20	20	20
Odenton	—	17	17	18
Baltimore Downtown	—	—	—	18
Newark, DE	1	17	17	18
Wilmington	19	20	20	20
Philadelphia 30th Street	19	20	20	20
Philadelphia Market East*	—	—	—	18
Trenton	20	20	20	20
Newark Liberty	15	20	20	20
Newark Penn Station	20	20	20	20
Secaucus	—	—	17	18
Penn Station New York	20	20	20	21
New Rochelle	13	21	22	22
Cross-Westchester	—	21	18	18
Nassau Hub	—	—	—	0–19*
Ronkonkoma*	—	—	—	0–19*
Stamford	17	21	22	22
Danbury	—	—	—	0–17*
New Haven	21	21	22	22
New London	17	18	17	18
Hartford	13	15	18	18
Tolland/Storrs	—	—	—	0–17*
TF Green	—	18	17	18
Worcester	—	—	—	0–18*
Boston South Station	16	19	18	19

Source: NEC FUTURE team, 2015
*Average headway for the Alternative 3 route options for stations served by Intercity.
— = Not applicable within that alternative/route option.

4.2 ACCESSIBILITY

Accessibility describes the travel modes available for passengers to arrive or depart from a passenger rail station. For NEC FUTURE, the FRA measured accessibility of stations in three major categories:

- Via the multimodal transit network, including access to the station with Intercity, Regional rail, public transportation modes, and via intercity bus.
- Via private automobile, including a determination of the level of traffic congestion near the station, and the availability of station-related parking.
- Via independent and shared modes of transportation, including access to the station through pedestrian, cycling, carshare, car rental, and taxi. The assessment for independent modes also considered the station environment, (CBD, urban, suburban, or airport).

The FRA also considered that station accessibility is partially a function of the physical location of a station. For instance, an airport station is not expected to feature extensive pedestrian amenities. However, a station in a business district is evaluated for its accessibility to cyclists, transit users, pedestrians, and taxis.

4.2.1 Transit

The FRA examined the representative stations to determine the degree to which they are linked to the multi-modal transportation network. The greater the number of modes available at stations the greater the number of people who have access to the station and the greater the geographic reach of the station into the city and region.

The FRA assessed the multi-modal accessibility of existing stations by examining published rail and transit schedules. The presence of a multi-modal stop in the schedule at the station was assigned a “Yes” or “No.” The modes evaluated include:

- **Intercity rail**
- **Regional rail**
- **Public transit, excluding bus**
- **Public transit bus**
- **Intercity bus (private carriers)**

Table 18 outlines the availability Intercity-Express, Intercity-Corridor, Regional rail, public transit modes, and intercity bus service at each representative station. The “Public transit excl. Bus” category includes rail-based transit modes such as subway, trolley, and light rail. Table 18 also includes the availability of pedestrian, cyclist, or automobile network connections by representative station.

Some rail stations, such as Washington Union Station, Philadelphia 30th Street Station, Penn Station New York, and Boston South Station have a high degree of accessibility. Other stations have a more moderate degree of accessibility with one or both types of Intercity service, Regional rail service, but without some public transit modes or without intercity bus. For example, the New Rochelle Station today is served by Intercity-Corridor service, Regional rail, and public transit bus service, but is not accessible via Intercity-Express, rail-based public transit, or intercity bus.

Some stations have a more limited set of connections available because they lack Intercity service. For example, Danbury, a station included in two of the four Alternative 3 route options, is not currently served by Intercity trains. The station has Regional rail service and public transit bus service, but is not connected to a rail-based public transit network and is not served by intercity bus.

Table 18: Transit Service by Representative Station

Station	Intercity-Express	Intercity-Corridor	Regional Rail	Public Transit excl. Bus	Public Transit Bus	Intercity Bus
Washington Union Station	Yes	Yes	Yes	Yes	Yes	Yes
Odenton	No	No	Yes	No	Yes	No
Baltimore Downtown	New Station in Action Alternatives					
Newark, DE	No	Yes	Yes	No	Yes	No
Wilmington	Yes	Yes	Yes	No	Yes	Yes
Philadelphia 30th Street	Yes	Yes	Yes	Yes	Yes	Yes
Philadelphia Market East*	No	No	Yes	Yes	Yes	Yes
Trenton	Yes	Yes	Yes	Yes	Yes	No
Newark Liberty	No	Yes	Yes	No	No	No
Newark Penn Station	Yes	Yes	Yes	Yes	Yes	Yes
Secaucus	No	No	Yes	No	Yes	No
Penn Station New York	Yes	Yes	Yes	Yes	Yes	Yes
New Rochelle	No	Yes	Yes	No	Yes	No
Cross-Westchester	New Station in Action Alternatives					
Nassau Hub	New Station in Action Alternatives					
Ronkonkoma*	No	No	Yes	No	Yes	No
Stamford	Yes	Yes	Yes	No	Yes	Yes
Danbury	No	No	Yes	No	Yes	No
New Haven	Yes	Yes	Yes	No	Yes	Yes
New London	Yes	Yes	Yes	No	Yes	No
Hartford	No	Yes	No	No	Yes	No
Tolland/Storrs	New Station in Action Alternatives					
TF Green	No	No	Yes	No	Yes	No
Worcester	No	No	Yes	No	Yes	No
Boston South Station	Yes	Yes	Yes	Yes	Yes	Yes

Source: NEC FUTURE team, 2015

*Market East and Ronkonkoma stations are existing Regional rail stations on Action Alternatives routes. These stations have existing transportation infrastructure but they are not on the NEC Spine.

4.2.2 Private Automobiles

Vehicular accessibility is especially important for travelers whose origin or destination is far from the station, not accessible via the Regional rail or transit network, or who may be making a journey to the station from outside the metropolitan area. Travelers with luggage may also find accessing a station via personal vehicle is more convenient than other modes. As such, the FRA examined representative stations assess to identify if the station is accessible via private vehicle, the level of vehicular congestion, and the availability of parking.

The analysis measures the following:

- **Vehicle Accessible**: a determination of whether each station is accessible via personal vehicle with a Yes/No categorization.
- **Adjacent Roadway Congestion**: a determination of recurring roadway traffic congestion near the station and scored “High” (regular peak and off-peak congestion); “Medium” (Regular Peak Period Congestion); and “Low” (Occasional Peak Period Congestion or Uncongested).

- **Parking Inventory**: the number of parking spaces at or immediately adjacent to the station available. An inventory of parking spots provides insight on the degree to which stations are designed for access by users of the highway and roadway networks.

Table 19 presents the results of this examination.

Table 19: Private Automobile Access by Representative Station

Station	Automobile Accessible	Adjacent Roadway Congestion	Parking Inventory*
Washington Union Station	Yes	Medium	1,000
Odenton	Yes	Low	1,977
Baltimore Downtown	—	High	—
Newark, DE	Yes	Low	368
Wilmington	Yes	Medium	606
Philadelphia 30th Street	Yes	High	1,855
Philadelphia Market East	Yes	High	0
Trenton	Yes	Medium	2,300
Newark Liberty	No	Medium	—
Newark, NJ	Yes	High	400
Secaucus	Yes	High	1,094
New York Penn	Yes	High	0
New Rochelle	Yes	Medium	200
Cross-Westchester	—	—	—
Nassau Hub	—	Medium	—
Ronkonkoma	Yes	Medium	6,100
Stamford	Yes	Medium	600
Danbury	Yes	Low	147
New Haven	Yes	Medium	1,200
New London	Yes	Low	500
Hartford	Yes	Medium	161
Tolland/Storrs	—	Low	—
TF Green	Yes	Low	650
Boston South Station	Yes	High	446

Source: NEC FUTURE team, 2015
*This is a measure of the number of parking spaces associated with the station and does not include municipal, public, or available parking in the vicinity of the station.
— = Not applicable within that alternative/route option.

4.2.3 Independent and Shared Modes of Transportation

In addition to personal automobile accessibility, the FRA reviewed representative stations to evaluate the station environment and accessibility for pedestrians, cyclists, and users of carshare, rental cars, and taxis.

The type of station environment (CBD, urban, suburban, or airport) is a descriptive measure that assesses the context of the station's physical situation in terms of urban form, fabric, accessibility, and environment. The FRA assumed stations in a CBD or urban environment to have better non-personal-vehicle accessibility, closer access to more jobs, access to more commercial opportunities and businesses, and residential neighborhoods with more activities available around the immediate station area. Similarly, stations in a suburban environment were assumed to have a higher focus on automobile access compared to non-automobile access and fewer jobs and activities in the immediate station area. Stations in an airport environment were assumed not to be connected to any transportation networks other than walking or shuttle access directly into the airport.

Crosswalks and walking paths create a pedestrian network that accommodates station access for walkers. Stations with pedestrian amenities are accessible to travelers without the need for any other means of transportation. Similarly, a bicycle network makes cycling to a station a safer and more desirable option. Cycling allows travelers to access a station with a very low level of investment in a transportation mode. Available bicycle parking, in particular secure and weather protected parking, is another element that can make cycling easier and more attractive.

Carshare and rental car accessibility allows travelers to arrive at or depart from a station without the use of a personal automobile. Typically, a carshare service has a membership fee that ranges from $0 to about $250 a year, and members pay a fee for hourly or mileage based usage ranging from $0 to about $90 a day, depending on the membership type. Examples of carshare services include ZipCar and Enterprise CarShare.

Rental car users pay a fee based on hours and mileage ranging from about $70 to about $200+ per day, depending on the car and location. Examples of car rentals include Enterprise, Hertz, and Avis. The major carshare and rental car companies have a presence throughout the Study Area and a traveler from Boston is able to use their membership or rent a car just as easily in Boston as in Washington, D.C. Due to the state of technology, the ubiquitous nature of both carshare and rental car companies throughout the Study Area, and the changing nature of ownership in both modes (Enterprise now operates extensive carshare and rental car markets), the accessibility for carshare and rental cars are measured together.

Provisions for taxis means that a station is equipped for taxi service and that a traveler arriving at that station can reasonably expect that there will be a taxi queue with vehicles available. The availability of taxis is an important measure for passengers arriving at a station that need to make a connection to their final destination and travelers with tight schedules must be able to rely on getting into a taxi at the station in a timely manner.

The analysis measures the following:

- **Station Environment:** identifies the land use within which the station resides (CBD, Urban Suburban, Rural or Airport) based on station location.
- **Pedestrian Network:** measures the quality of the Pedestrian Network connection at stations to the adjacent pedestrian facilities. A “High” degree of pedestrian connectivity means that roadways with sidewalks are available from four directions and the sidewalk network around the station is complete; a “Medium” degree of pedestrian connectivity means that roadways with sidewalks are available from three directions and the sidewalk network around the station is incomplete; a “Low” degree of pedestrian connectivity means that roadways with sidewalks are available from one or two directions and the sidewalk network around the station is incomplete; a “Poor” degree of pedestrian connectivity means that the station is not accessible for pedestrians and this includes stations that are not connected to the roadway network (such as airport stations) or stations that are only accessible via the interstate or highway or stations with no sidewalks leading to the station.
- **Bicycle Accessibility:** A “High” degree of bicycle connectivity means that dedicated separated or protected cyclist infrastructure is available. A “Medium” degree of bicycle connectivity means that unprotected bicycle infrastructure (e.g., buffered lanes) is available. A “Low” degree of bicycle connectivity means that there are bicycle-accessible roadways but no bicycle-specific separate infrastructure (e.g., sharrows or no markings) is available. A “Poor” degree of bicycle infrastructure means that the station is not accessible via bicycle and this includes stations that are not connected to the road network (such as airport stations) or stations that are only accessible via the interstate or highway.
- **Carshare and Rental Car Availability:** identifies the degree of convenience and access for travelers needing short term access to a vehicle. A “High” degree of carshare and rental car accessibility means that a carshare or rental car available within the station or curbside adjacent to the station. A “Medium” degree of carshare or rental car accessibility means that a carshare or rental car is available within one-half mile of station. A “Low” degree of carshare or rental car accessibility means that a carshare or rental car available between one-half mile and one mile of station; and a “Poor” degree of carshare or rental car accessibility means that a carshare or rental car not available within one mile of station.
- **Provision for Taxis:** identifies the presence of a regular taxi queue at the station and scored as a Yes/No based on the presence of a regular queue of taxi service at station.

Table 20 presents the results of this examination.

Table 20: Independent and Shared Access by Representative Station

Station	Station Environment	Pedestrian Network	Bicycle Accessibility	Carshare and Rental Car Availability	Provision for Taxis
Washington Union Station	CBD	High	Low	High	Yes
Odenton	Suburb	Medium	Low	Poor	No
Baltimore Downtown	Urban	—	—	—	—
Newark, DE	Suburb	Medium	Low	Low	No
Wilmington	CBD	Medium	Medium	High	Yes
Philadelphia 30th Street	Urban	Med	Low	High	Yes
Philadelphia Market East	CBD	High	Low	High	TBD
Trenton	Urban	Medium	Low	Poor	No
Newark Liberty	Airport	Poor	Poor	High	No
Newark Penn Station	CBD	High	Low	Low	Yes
Secaucus	Suburb	Poor	Poor	Medium	Yes
Penn Station New York	CBD	High	High	High	Yes
New Rochelle	Suburb	Medium	Low	High	Yes
Cross-Westchester	Suburb	—	—	—	—
Nassau Hub	Suburb	—	—	—	—
Ronkonkoma	Suburb	Medium	Low	Poor	Yes
Stamford	Urban	Medium	Low	High	Yes
Danbury	Suburb	Medium	Low	Low	No
New Haven	Urban	High	Low	High	Yes
New London	Urban	High	Low	Poor	No
Hartford	CBD	High	Low	Low	Yes
Tolland/Storrs	Suburb	—	—	—	—
TF Green	Suburb	High	Low	High	No
Boston South Station	CBD	High	Medium	High	Yes

Source: NEC FUTURE Project team, 2015
— = Not applicable within that alternative/route option.

4.3 CAPACITY

Existing stations serving the Intercity and Regional rail services are considered to have generally adequate capacity in terms of platforms, concourse sizing, ticketing, and compatibility with equipment to serve the present-day level of service. However, many stations have some measure of capacity constraint, which could result in a degradation of station operations and functionality as the level of service at the station increases with the Action Alternatives.

In 2040, accessibility at the representative stations will depend on a number of factors, including the frequency of Intercity and Regional rail service, and changes to public transit and transportation networks. For example, cities that currently lack rail-based public transit may have built new systems by 2040. In response, the FRA has developed classifications for stations for the No Action Alternative and Action Alternatives based on a presumption of anticipated passenger volumes, estimated future metropolitan area populations, modeled Intercity service volumes, and modeled Regional rail operations to estimate what type of station classification best fits the service and passenger volumes expected. Changes in accessibility related to public transit, intercity bus, pedestrian networks, bicycle networks, and personal automobile use have not been estimated, but the changes in Intercity service and station classification can indicate whether existing levels of accessibility may be enough to meet future needs within the Action Alternatives.

Through the station identification process, the FRA qualitatively examined stations for the degree to which the service levels presumed as part of the No Action Alternative and Action Alternatives require station upgrades and station expansion. Table 21 identifies the type of capital improvement anticipated at the representative stations.

Definitions for the proposed station modifications used in Table 21 include the following:

- **New**: Construction of a new station
- **Expand**: Station will expand with additional tracks or platforms to accommodate additional trains or more frequent service.

Table 21: Potential Capital Improvements by Representative Station

Representative Station	Existing Station Type	Future Station Type	Station Modification Type
Washington Union Station	Major Hub	Major Hub	Expand
Odenton	Local	Hub	Expand
Baltimore Downtown	—	Major Hub	New
Newark, DE	Hub	Hub	Expand
Wilmington	Major Hub	Major Hub	Expand
Philadelphia 30th Street	Major Hub	Major Hub	Expand
Philadelphia Market East	—	Major Hub	New
Trenton	Hub	Hub	Expand
Newark Liberty	Hub	Hub	Expand
Newark Penn Station	Major Hub	Major Hub	Expand
Secaucus	Local	Hub	Expand
Penn Station New York	Major Hub	Major Hub	Expand
New Rochelle	Hub	Hub	Expand
Cross-Westchester	—	Hub	New
Nassau Hub	—	Hub	New
Ronkonkoma	Local	Hub	Expand
Stamford	Major Hub	Major Hub	Expand
Danbury	—	Hub	New
New Haven	Major Hub	Major Hub	Expand
New London	Hub	Hub	Expand
Hartford	Hub	Major Hub	Expand
Tolland/Storrs	—	Hub	New
TF Green	Local	Hub	Expand
Worcester	Local	Hub	Expand
Boston South Station	Major Hub	Major Hub	Expand

Source: NEC FUTURE team, 2015
— = Not applicable within that alternative/route option or not yet determined.

4.4 TRAVEL TIME

The Action Alternatives result in savings of travel time for users of both the Intercity and the Regional rail network. Table 22 shows the average travel time (hours:minutes) between representative station-pairs for the No Action and Action Alternatives. For Alternative 3, an average is provided of the four route options. Table 23 shows the average travel time between representative station pairs for each Alternative 3 route option.

Table 22: Average Travel Time (Hours:Minutes) by Representative Station-Pair for No Action and Action Alternatives, 2040

Average Station to Station Travel Time		No Action		Alt. 1		Alt. 2		Alt. 3*	
Station 1	Station 2	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor
Washington Union Station	Philadelphia	1:37	1:55	1:37	1:49	1:29	1:46	1:04	1:40
Washington Union Station	Penn Station New York	2:47	3:23	2:43	3:08	2:26	3:01	1:48	2:51
Washington Union Station	Boston South Station	6:33	8:02	5:45	6:57	5:07	6:22	3:57	5:47
Washington Union Station	Newark, DE		1:24		1:25		1:19		1:11
Philadelphia	Odenton				1:39		1:32		1:21
Penn Station New York	Baltimore	2:11	2:39	2:11	2:30	1:56	2:24	1:29	2:16
Penn Station New York	Wilmington	1:28	1:49	1:28	1:41	1:15	1:37	1:08	1:31
Ronkonkoma	Baltimore							1:58	2:56
Penn Station New York	Philadelphia	1:07	1:23	1:04	1:18	0:55	1:11	0:43	1:11
Boston South Station	Philadelphia	4:53	6:00	4:06	4:59	3:36	4:24	2:52	3:53
Nassau Hub	Trenton								1:11
Danbury	Newark Penn Station								1:01
New Haven Station	Newark Penn Station	1:59	2:16	1:36	1:43	1:24	1:34	1:14	1:31
Stamford	Secaucus						0:51		0:53
Boston South Station	Penn Station New York	3:31	4:13	2:54	3:34	2:33	3:15	2:01	2:45
Hartford	Ronkonkoma							0:39	0:42
Boston South Station	Tolland / Storrs								0:49

Source: NEC FUTURE team, 2015
* Average for Alternative 3 route options with service between station-pairs
Travel times for Philadelphia and Baltimore include an average of travel times for Philadelphia Market East and Philadelphia 30th Street and Baltimore Penn Station and Baltimore Downtown, respectively.
Blank cell = No service

Table 23: Average Travel Time (Hours:Minutes) by Representative Station-Pair for Alternative 3 Route Option, 2040

Average Station to Station Travel Time		Alternative 3.1		Alternative 3.2		Alternative 3.3		Alternative 3.4	
Station 1	Station 2	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor
Washington Union Station	Philadelphia	1:04	1:38	1:04	1:38	1:05	1:38	1:05	1:38
Washington Union Station	Penn Station New York	1:47	2:51	1:48	2:51	1:47	2:51	1:48	2:51
Washington Union Station	Boston South Station	3:52	5:44	3:54	5:53	4:03	5:48	4:01	5:44
Washington Union Station	Newark, DE		1:11		1:11		1:11		1:11
Philadelphia	Odenton		1:18		1:18		1:18		1:18
Penn Station New York	Baltimore	1:29	2:12	1:29	2:12	1:29	2:12	1:29	2:12
Penn Station New York	Wilmington	1:08	1:31	1:08	1:31	1:08	1:31	1:08	1:31
Ronkonkoma	Baltimore			1:58	2:58	1:58	2:54		
Penn Station New York	Philadelphia	0:43	1:08	0:43	1:07	0:42	1:08	0:43	1:07
Boston South Station	Philadelphia	2:47	3:23	2:49	3:39	2:58	3:30	2:56	3:22
Nassau Hub	Trenton				1:11		1:11		
Danbury	Newark Penn Station		1:01						1:01
New Haven Station	Newark Penn Station	1:22	1:35	1:07	1:27	1:07	1:26	1:21	1:35
Stamford	Secaucus		0:53		0:53		0:53		0:53
Boston South Station	Penn Station New York	1:57	2:43	1:57	2:49	2:07	2:47	2:03	2:42
Hartford	Ronkonkoma			0:41	0:43	0:37	0:41		
Boston South Station	Tolland / Storrs						0:50		0:49

Source: NEC FUTURE team, 2015
Note: Blank cell = No service
Alternative 3.1 = via Central CT/Providence route option; Alternative 3.2 = via Long Island/Providence route option; Alternative 3.3 = via Long Island/Worcester route option; Alternative 3.4 = via Central CT/Worcester route option
Travel times for Philadelphia and Baltimore include an average of travel times for Philadelphia Market East and Philadelphia 30th Street and Baltimore Penn Station and Baltimore Downtown, respectively.

In The No Action Alternative, a trip between Washington, D.C., and Boston takes 6:41 on an Intercity-Express train and 8:10 on an Intercity-Corridor train. In Alternative 1, those times are reduced to 5:45 and 6:55, a travel time savings of 14 percent on the Intercity-Express trip and 15 percent on the Intercity-Corridor trip. In Alternative 2 those times are reduced to 5:07 and 6:07, a travel time savings for 35 percent on the Intercity-Express trip and 25 percent on the Intercity-Corridor trip. In the Alternative 3 scenarios the Intercity-Express trip is reduced to 3:52 to 4:03, a travel time savings of 39 percent to 42 percent. In the Alternative 3 route options, the Intercity-Corridor trip is reduced to 5:31 to 5:42, a travel time savings of 30 percent to 32 percent.

4.5 FREQUENCY

The Action Alternatives also result in an increase in the number of Intercity trains per day. Table 24 shows the number of trains per day between representative station-pairs for the No Action and

Action Alternatives, and Table 25 shows the number of trains per day between the representative stations-pairs for the Alternative 3 route options. The FRA identified the number of trains per day between station pairs to represent the number of options that passenger rail travelers have to make these specific train pair journeys. The more trips that are offered during the day the more options a passenger has to make that journey and the more convenient the rail journey is. All of the Action Alternatives represent an increase in the number of trips per day offered between all of the representative station-pairs.

Between Boston and Washington, D.C., the No Action Alternative includes 9 Intercity-Express and 8 Intercity-Corridor trips while Alternative 1 includes 16 and 24, Alternative 2 includes 27 and 27, and Alternative 3 includes 59–62 and 42–43 trips. The Alternative 3 route options represent a nearly five-fold increase in service between Boston and Washington. This pattern is true for many of the representative station-pairs. This results in rail travel options that are more convenient for rail travelers and greatly increased rail connectivity between the representative station-pair markets.

The introduction of Metropolitan service as a subset of Intercity-Corridor expands connections between adjacent or proximate markets, resulting in added frequency and expanded travel choices. Examples of rail station pairs that experience significant changes in number of Intercity trains per day from the No Action Alternative to the Action Alternatives include:

- **Washington Union Station-Penn Station New York**: For the No Action Alternative, the number of trains per day southbound for combined Intercity services is 36 trains per day in the No Action Alternative; under Alternative 1, there are 70 trains per day; under Alternative 2, there are 96 trains per day; and under Alternative 3 (maximum), there are 152 trains per day. Alternative 3 results in an Intercity train from New York City to Washington, D.C., averaging a departure every 10 minutes.
- **Hartford-Stamford**: For the No Action Alternative, the number of trains per day southbound from Hartford to Stamford is 2; under Alternative 1, there are 9 southbound Intercity trains per day; under Alternative 2, there are 100 trains per day; and under the Alternative 3 (maximum), there are 60. Alternative 2 results in an Intercity train from Hartford to Stamford averaging a departure every 14 minutes.
- **Philadelphia 30th Street-BWI Airport:** For the No Action Alternative, the number of combined Intercity trains per day southbound from Philadelphia 30th Street to BWI Airport is 31; under Alternative 1 the number of Intercity trains per day southbound is 71; under Alternative 2 the number of Intercity trains per day is 111; and under Alternative 3 (maximum), the number of combined Intercity trains per day is 48, due to the introduction of trains to Philadelphia Market East. Alternative 2 results in an Intercity train from Philadelphia 30th Street to BWI Airport every 13 minutes.

Table 24: Number of Intercity Trains per Day by Representative Station-Pair by No Action and Action Alternatives, 2040

Station 1	Station 2	No Action		Alt. 1		Alt. 2		Alt. 3*	
		Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor	Intercity-Express	Intercity-Corridor
Washington Union Station	Philadelphia	16	22	24	46	41	69	74	80
Washington Union Station	Penn Station New York	16	22	24	45	41	54	74	76
Washington Union Station	Boston South Station	10	8	16	24	27	30	60	45
Washington Union Station	Newark, DE	—	1	—	22	—	46	—	57
Philadelphia	Odenton	—	—	—	22	—	46	—	57
Penn Station New York	Baltimore	16	22	24	45	41	54	53	76
Penn Station New York	Wilmington	16	22	24	45	41	54	21	76
Ronkonkoma	Baltimore	—	—	—	—	—	—	28	29
Penn Station New York	Philadelphia	16	32	24	62	41	77	74	110
Boston South Station	Philadelphia	10	8	16	26	27	45	60	50
Nassau Hub	Trenton	—	—	—	—	—	—	—	33
Danbury	Newark Penn Station	—	—	—	—	—	—	—	34
New Haven Station	Newark Penn Station	9	10	16	35	27	58	31	62
Stamford	Secaucus	—	—	—	—	—	47	—	35
Boston South Station	Penn Station New York	10	9	19	28	42	50	75	72
Hartford	Ronkonkoma	—	—	—	—	—	—	32	44
Boston South Station	Tolland / Storrs	—	—	—	—	—	—	—	46

Source: NEC Model, 2015

* Average for Alternative 3 route options with service between station pairs

— = Not applicable within that alternative/route option or not yet determined.

Frequencies for Philadelphia and Baltimore are included for both Philadelphia Market East and Philadelphia 30th Street and both Baltimore Penn Station and Baltimore Downtown, respectively.

Table 25: Number of Intercity Trains per Day by Representative Station-Pair for Alternative 3 Route Options, 2040

Station 1	Station 2	Alternative 3.1		Alternative 3.2		Alternative 3.3		Alternative 3.4	
		Intercity Express	Intercity Corridor	Intercity Express	Intercity Corridor	Intercity Express	Intercity Corridor	Intercity Express	Intercity Corridor
Washington Union Station	Philadelphia	73	79	73	80	73	79	75	80
Washington Union Station	Penn Station New York	73	75	73	76	73	75	75	76
Washington Union Station	Boston South Station	59	45	59	45	60	45	62	46
Washington Union Station	Newark, DE	—	56	—	57	—	56	—	57
Philadelphia	Odenton	—	56	—	57	—	56	—	57
Penn Station New York	Baltimore	52	75	52	76	52	75	54	76
Penn Station New York	Wilmington	20	75	20	76	20	75	22	76
Ronkonkoma	Baltimore	—	—	28	29	28	29	—	—
Penn Station New York	Philadelphia	73	108	73	112	73	108	75	110
Boston	Philadelphia	59	49	59	51	60	48	62	52
Nassau Hub	Trenton	—	—	—	33	—	33	—	—
Danbury	Newark Penn Station	—	34	—	—	—	—	—	34
New Haven Station	Newark Penn Station	16	44	44	78	44	78	19	46
Stamford	Secaucus	—	33	—	36	—	34	—	35
Boston South Station	Penn Station New York	75	72	75	70	75	72	76	72
Hartford	Ronkonkoma	—	—	32	43	32	44	—	—
Boston South Station	Tolland / Storrs	—	—	—	—	—	46	—	46

Source: NEC Model, 2015
— = Not applicable within that alternative/route option or not yet determined.
Note: Alternative 3.1 = via Central CT/Providence route option; Alternative 3.2 = via Long Island/Providence route option; Alternative 3.3 = via Long Island/Worcester route option; Alternative 3.4 = via Central CT/Worcester route option
Frequencies for Philadelphia and Baltimore are included for both Philadelphia Market East and Philadelphia 30th Street and both Baltimore Penn Station and Baltimore Downtown, respectively.

Ridership Analysis Technical Memorandum

October 5, 2015
Final Version

Submitted by:

PARSONS BRINCKERHOFF AECOM
A JOINT VENTURE

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1 Introduction

1.1 PURPOSE OF THIS DOCUMENT

This technical memorandum describes the ridership forecasting process the Federal Railroad Administration (FRA) used to evaluate potential rail service and investments in the Northeast Corridor (NEC) as part of the NEC FUTURE program. This technical memorandum provides a comprehensive summary of the FRA's ridership forecasting process, including: methodology development, collection of new survey data (with full geographic coverage of the NEC), examination of travel patterns in the corridor, development of new model tools to support the ridership forecasting, modification of existing regional forecasting tools to fit the forecasting framework, and integration of interregional and regional ridership forecasts. The FRA used ridership forecasts to develop and evaluate proposed rail service alternatives by producing: rail ridership estimates at various geographic levels, ticket (fare) revenue projections, rail passenger miles traveled, travel time and cost savings, as well as information related to the non-rail modes, such as vehicle-miles traveled and trips diverted to rail from other modes.

The FRA applied the information toward a further refinement of the alternatives and in the preparation of the Tier 1 Draft Environmental Impact Statement (EIS) and the Draft Service Development Plan (SDP). The ridership data prepared for the Tier I Draft EIS are representative. The ridership estimates are based on the Service Plans created for the No Action and Action Alternatives[1], assumed future fare policies, and regional and corridor-wide estimates of growth. The Service Plans and fare policy for each alternative were developed to represent the high level goals of each alternative but not strictly optimized to capture the maximum potential ridership for each station. Therefore, estimated ridership is representational and consistent with a Tier I Draft EIS level of detail.

1.2 ORGANIZATION OF DOCUMENT

This technical memorandum addresses multiple aspects of the NEC FUTURE ridership forecasting process, including the methodology and ridership forecasts used to develop, refine, and analyze the Tier 1 EIS Alternatives.

Section 2 describes the methodology developed in the initial stages of the forecasting process, for creating a cohesive forecast for regional and interregional travel, and any modifications in the actual application of the methodology. Both of these stages (initial methodology development and modifications undertaken during application) are part of the alternatives analysis, which results in

[1] The FRA developed Service Plans for the No Action and Action Alternatives to describe the types and levels of passenger train service that could operate on the NEC in 2040. These Service Plans depict a representative train operations pattern for a typical future weekday, and include the train stops by station for both peak and non-peak periods. The Service Plans are not prescriptive in terms of the way future operations would be conducted in 2040. The Service Plans provide a basis for estimating future ridership and capital investment needs and costs, as well as to assess the environmental impacts associated with planned construction and future operations.

the identification of alternatives for review in the Draft Tier 1 EIS. For additional information regarding the integration of the ridership forecasting process and development of alternatives, see the *Tier 1 EIS Alternatives Report*.

Section 3 describes the interregional forecasting process, including development of the baseline travel market, and the total demand and mode choice models, which comprise the two steps of the Interregional Model. This section also summarizes the process for applying the new Interregional Model to the Service Plans for the No Action Alternative and Action Alternatives. Model application is the technical term for running the model, and is distinct from the model estimation stage, which is the process of creating the model.

Section 4 discusses the regional modeling process and describes the adjustment and application of the metropolitan models in the NEC. The FRA produced regional forecasts for Washington D.C., Baltimore, Philadelphia, Northern and Central New Jersey, Long Island and Mid-Hudson, New York, Southwestern Connecticut, Rhode Island, and Boston.

Sections 5 and 5.3 define the No Action Alternative and Action Alternatives that underlie the interregional and regional forecasting. These sections also describe the anticipated demographic growth in the NEC, the incorporation of non-rail modes into the modeling process, and the development of rail Service Plans for the Action Alternatives.

The final section, Section 6, summarizes the results of the ridership forecasting process, combines the regional and interregional travel forecasts, and discusses implications of the No Action Alternative and Action Alternatives.

2 Methodology

This section outlines the methodology for the analysis of travel markets and the forecast of ridership and revenue associated with passenger rail transportation alternatives for NEC FUTURE. The FRA created a Ridership Technical Working Group (TWG) to provide guidance and review NEC FUTURE ridership efforts during the development of the new Interregional Model and adjustment and application of the existing regional models. The FRA's initial work involved early service planning and alternatives development and evaluation. During this initial stage, the FRA collected data, analyzed existing and future ridership forecasts, and performed forecasting to help identify and screen initial and preliminary alternatives. The FRA based the initial forecasting on existing available market data (such as Amtrak ridership data and existing regional model data), forecasts of ridership and revenue from prior studies (such as Amtrak NEC forecasts and existing regional model forecasts of regional rail ridership), and the use of existing ridership models. The FRA used the initial work to screen alternatives and to support the development of the framework for ridership forecasting using the updated models.

2.1 FORECASTING APPROACH

The initial NEC FUTURE ridership and revenue forecasting approach included three major components to address the full scope of travel markets relevant to the NEC. These include:

- A new Interregional Model, which addressed travel between major regions in the NEC, developed primarily from a new NEC household survey
- Existing regional models, which addressed travel within major regions in the NEC (e.g., Washington, Baltimore, Philadelphia, New York, Boston, etc.)
- The FRA's own CONNECT tool, which addressed travel between the NEC FUTURE market areas and external markets such as Buffalo, New York; Pittsburgh, Pennsylvania; and Raleigh, North Carolina

2.1.1 Integration of the Interregional and Regional Forecasts

Using separate forecasting models, the FRA forecasted interregional and regional ridership for the No Action Alternative and each of the Action Alternatives. The FRA combined these forecasts to form an overall ridership forecast for the No Action Alternative and for each of the Action Alternatives. Combining the forecasts involved the identification and application of the appropriate "model of record" for each NEC rail market. Table 1 summarizes the forecasting models used to evaluate the No Action and Action Alternatives for each region pair within the Study Area. Within each of the metropolitan regions (on the diagonal of the table), the associated regional model is used. The geographic coverage of each model is shown in Section 4. The majority of region pairs are analyzed using the new Interregional Model.

In certain instances estimates of commuter rail ridership were available not only from the regional models but also from the Interregional Model. These instances primarily reflect long distance commuting activity. In order to avoid double-counting, only the regional models were used to estimate commuter rail ridership.

Table 1: Models used to Evaluate NEC FUTURE Rail Markets

From/ To	Region	Boundaries	A	B	C	D	E	F	G – L
A	Washington Metro	Northern Virginia to Pautuxent River	R1	IR	IR	IR	IR	IR	IR
B	Baltimore Metro	Susquehanna River to Pautuxent River	IR	R2	IR	IR	IR	IR	IR
C	Wilmington/ Philadelphia Metro	Susquehanna River to Trenton	IR	IR	R3	IR	IR	IR	IR
D	NY Metro, West of Hudson	Trenton to New York City	IR	IR	IR	R4	IR	IR	IR
E	NY Metro, East of Hudson	New York City, Long Island & Coastal Connecticut	IR	IR	IR	IR	R5	IR	IR
F	Providence/Boston Metro	Rhode Island to SE New Hampshire	IR	IR	IR	IR	IR	R6	IR
G	Empire Corridor	New York City to Albany	IR	IR	IR	IR	IR	IR	IR
H	Inland Connecticut, Massachusetts	New Haven to Springfield	IR	IR	IR	IR	IR	IR	IR
I	Virginia	Richmond to Washington D.C.	IR	IR	IR	IR	IR	IR	IR
J	Keystone	Philadelphia to Harrisburg	IR	IR	IR	IR	IR	IR	IR
K	Vermont	Vermont to Springfield	IR	IR	IR	IR	IR	IR	IR
L	Maine	Maine-New Hampshire	IR	IR	IR	IR	IR	IR	IR
Tools:									
IR	NEC FUTURE Interregional Model								
R1	Enhanced WMATA Transit Post Processor of MWCOG Model								
R2	STOPS Application for Baltimore Metropolitan Area								
R3	DVRPC Regional Forecasting Model								
R4	NJ TRANSIT North Jersey Travel Demand Forecasting Model								
R5	MTA Regional Transit Forecasting Model								
R6	STOPS Application for Boston Metro/Rhode Island Area								

Source: NEC FUTURE, 2015

The FRA developed the initial interregional and regional ridership and revenue forecasting methodology in 2013, reviewed it several times with the NEC FUTURE Ridership TWG, and finalized the methodology in September 2014. Important contributions to the methodology during this time were made by staff from the Office of Management and Budget (OMB) and the FRA, using results of a pilot survey of NEC travelers to evaluate completion rates and survey duration (see Section 2.2.1). Subsequent modifications of the methodology are described in the component-relevant sections below.

2.2 INTERREGIONAL MARKETS

The travel demand modeling and forecasting approach for interregional travel consisted of the development and application of a two-stage model system. The first stage modeled total interregional travel volume by origin-destination (OD) pair. The second stage predicted the share of intercity passenger travelers expected to use each of the available intercity travel modes using a nested logit specification.

The two-stage model system was applied in reverse order (i.e., mode share before total travel demand) to allow mode share model results to be incorporated within the total demand model structure. This linkage provides the total travel model with sensitivity to changes in the level-of-service provided by all modes, allowing for the total number of trips to increase due to overall improvement in travel conditions.

2.2.1 Household Travel Survey

The development of a new comprehensive Interregional Model required new surveys of existing travel within the NEC. All of the existing available survey data was generally tied to specific existing models or forecasts focused exclusively on either intercity or certain regional sub-markets within the NEC. Although they collectively addressed all of the major NEC markets, these existing data sets and models did not provide a consistent integrated analysis and forecasting basis throughout the NEC.

To inform the Interregional Model, the FRA conducted a new extensive household survey, the NEC FUTURE Survey of Northeast Regional and Intercity Household Travel Attitudes and Behavior (Household Travel Survey). This new Household Travel Survey included a screener section to qualify and recruit respondents for the survey. Only interregional trips made between the respondent’s home and eligible out-of-state locations were considered as qualifying trips. Eligible areas excluded the respondent’s home state, nearby areas in adjoining states (typically less than 50 miles away from the home), and trips to locations outside of the NEC. This screening ensured that only trips meeting the definition of interregional were included in the data collection. If no qualifying trips were found, the respondent was asked questions to collect demographic information only and was not counted as a completed survey.

If a respondent took multiple qualifying trips, one was randomly selected to be the “reference trip” for the respondent. The actual mode chosen for the reference trip forms the basis for the revealed preference (RP) portion of the survey response. Respondents were then asked additional questions about this trip including:

- Type of train service used (if respondent’s “reference trip” was by train).
- Mode of access used (if respondent’s “reference trip” was anything other than “passenger car/truck/van”).
- Mode of egress used (if respondent’s “reference trip” was anything other than “passenger car/truck/van”).
- Fare paid (if respondent’s “reference trip” was anything other than “passenger car/truck/van”).
- Estimated one-way travel time and estimated cost for tolls, parking, and fuel (if respondent’s “reference trip” was anything other than “passenger car/truck/van”).
- Overall purpose of the respondent’s trip.

Six stated preference (SP) choice exercises represented the “core” of the survey and provided the primary basis for estimating the new mode choice model. These SP questions asked respondents to think about the context of their reference trip and then choose from among three modes of travel with characteristics specified by the survey. These characteristics varied across the questions, according to an experimental design that minimized correlations among variables.

The specific SP trade-off questions reflected an experimental design to address an appropriate cross-section of all the potential mode availability and service characteristic combinations. The detailed trip information obtained before the trade-off questions provided the context for the respondent’s travel choices and a basis for defining trip-relevant service characteristics in the trade-off questions. The responses to the survey questions provided the basis for estimating key sensitivities to changes in the service characteristics, by market segment, for the new model.

All qualifying respondents were asked demographic questions at the end of the survey.

The original design of the survey called for a two-phase approach. The recruit survey was conducted by telephone via computer-assisted telephone interviewing (CATI) using a dual frame sample with both landlines and cell phones. The follow-up survey was conducted via self-administration by respondents on the internet. Respondents without internet access were able to complete the follow-up survey by viewing a mailed packet of survey visuals and then providing answers to follow-up questions via a telephone interview. To test general operational and content issues with the survey, a pilot effort was conducted which obtained 307 completed surveys. While the pilot results showed that the survey was able to obtain the necessary information for modeling, the cumulative two-phase response rate of 4% (9% in recruitment and 49% in the follow-up) was lower than expected. As a consequence, the FRA reconsidered the data collection approach revised it as follows:

- Survey was changed from two-phases using telephone and internet or mail to one-phase conducted solely via telephone.
- Survey was shortened from an average length of 22 minutes in the pilot to an estimated 18 minutes. This required reducing the number of SP questions from 12 to 6.
- SP portion of the survey was simplified by dropping one service characteristic, reliability, because it was considered too complicated to effectively communicate to respondents via telephone.
- The amount of the incentive was increased from $5 to $10.
- The number of attempts per sampled household was increased from 5 to 10.

With these changes in place, the response rate increased to around 11%, which provided a sufficient number of completed surveys by key trip purpose and geography subsample.

To compensate for excluding reliability as a service characteristic in the mode-choice model, reliability was captured in schedule margin included in the Service Plans developed for each of the Action Alternatives.

The complete survey documentation can be found in Appendix A.

2.2.2 Total Travel Market Demand Model

In a two-stage travel demand modeling approach, total travel demand models (one for each trip purpose) are required in conjunction with the mode share models (also one for each trip purpose). Total travel demand forecasts define the total market size to which the mode shares are applied to produce ridership forecasts by mode. In general, two major factors influence total travel demand between any two geographic areas: growth in population and economic activity, and changes in the levels of service. Increases in population and economic activity contribute to organic growth, generating more travel. Improvements in levels of service generate additional trips through induced demand; more trips are taken by riders as travel between origins and destinations becomes more attractive due to better travel conditions (such as reduced travel time or cost). Measures used to represent the impacts of these changes include:

- Socio-economic data and forecasts used as the basis for estimates of organic growth:
  - population
  - employment
  - household income
- Composite modal level-of-service (LOS) was used as the basis for estimates of induced demand. The LOS is an output of the mode choice model and is the sums of the estimated utility of all modes for a particular zone pair, as shown in the following formula:

$$LOS_i = \sum_i \exp(U_i)$$

where:

LOS – Level of Service for a particular zone pair
i - mode
U_i - utility of mode i (see Section 2.2.3.1).

The total travel models have a multiplicative structure, with exponent coefficients on each of the independent variables. The models were estimated using a log-linear regression technique with total trips for each zone pair as the dependent variable. Separate models were estimated for each of the three trip purpose market segments reflected in the mode share models -- business, non-business, and commute. The models were estimated using base year data on travel by purpose between study zones (described in Section 3) using the following specification:

$$TRP(i,j) = Constant \times POP(i)^a \times POP(j)^b \times INC(i)^c \times EMP(j)^d \times LOS(i,j)^e$$

where:

TRP - trips
POP - population
EMP - employment
INC-– household income
LOS - level-of-service
B - base year

The total travel models are applied using a ratio formulation relying on data that relates total travel market growth to growth in the independent variables, computed as the ratio of the forecast year (2040) to the base year values. The application formula is as follows:

$$\frac{TRP_F(i,j)}{TRP_B(i,j)} = \left(\frac{POP_F(i)}{POP_B(i)}\right)^a x \left(\frac{POP_F(j)}{POP_B(j)}\right)^b x \left(\frac{INC_F(i)}{INC_B(i)}\right)^c x \left(\frac{INC_F(j)}{INC_B(j)}\right)^c x \left(\frac{EMP_F(i)}{EMP_B(i)}\right)^d x \left(\frac{EMP_F(j)}{EMP_B(j)}\right)^d x \left(\frac{LOS_F(i,j)}{LOS_B(i,j)}\right)^e$$

where:

TRP - trips	INC - household income
POP - population	LOS - level-of-service
EMP - employment	F - future year
	B - base year

That is, interzonal trips are projected to grow in proportion to population, adjusted for its estimated effect, *a;* in proportion to the employment changes in the attraction zone; adjusted for its estimated effect, *b*; in proportion to the income changes, adjusted for its estimated effect, *c*; and in proportion to changes in the overall level-of-service, adjusted for its estimated effect, *d*. These coefficients are interpreted as elasticities.

The results of the total travel market demand model estimation are found in Section 3.1.2.

2.2.3 Mode Choice Model

The mode share models estimate the share of total person travel by mode. The following travel modes were addressed:

- Auto (Passenger car/truck/van)
- Air
- Intercity Bus
- Train, addressing the following types of train service separately:
  - Intercity-Express (similar to Amtrak's Acela train service)
  - Intercity-Corridor (similar to Amtrak's Regional train service)
  - Regional rail (similar to the train service provided by MBTA, MNR, LIRR, NJ Transit, SEPTA, MARC, and VRE within specific regions)
  - Metropolitan rail, which would provide a new type of service to a mix of longer distance commuter and shorter distance intercity markets with amenities and pricing between existing regional commuter and Intercity-Corridor service; this service would be offered as a one-seat ride or with a required connection

The new model estimated mode share as a function of the following key independent service characteristics:

- Travel time
- Travel cost or fare, taking account of the cost implications of travel by group and individuals and also including parking charges
- Schedule of service provided by air, rail, and bus
- Alternative-specific constants reflecting the differences between modes not directly measured by other independent variables in the model (factors and traveler perceptions such as the comfort and convenience provided by each mode would be reflected here)

Three separate mode share estimates were undertaken with the following market segmentation by trip purpose:

- Business trips
- Non-business/non-work trips
- Commute (journey to work) trips

2.2.3.1 Nested Logit Model Structure

The mode choice model used a nested logit (NL) structure to reflect the differential substitution that exists between different modes of travel. The NL structure is preferable for mode choice modeling over multinomial logit (MNL) because of the Independence of Irrelevant Alternative (IIA) property inherent in the MNL model. The IIA property is problematic as any changes or additions to the alternatives results in a proportional change to the probabilities of all other alternatives. In other words, there is no differentiation among choices to account for similarities between modes and the potentially higher propensity for respondents to switch to a similar mode. The nested logit model, on the other hand, allows for grouping similar modes, so that they are more competitive within the nest versus other modes outside of the nest. The utility for each mode in the NL model can be described with this general formula:

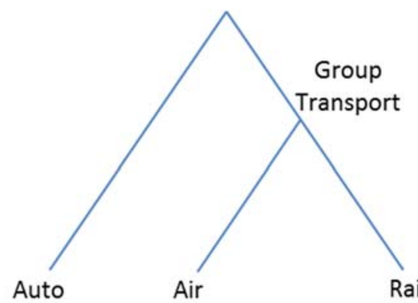
$$U_{Mode} = ASC_{Mode} + \beta_{TT} * Travel\ Time + \beta_{Cost} * Travel\ Cost + \cdots$$

where:

U_{Mode} - Utility of each mode
ASC_{Mode} - alternative-specific constant of each mode
$\beta_{TT/Cost}$ - estimated coefficient for each variable (travel time, travel cost, etc.)

The formulation of each mode's probability is dependent on its location in the nesting structure. An example nesting structure is shown in Figure 2. The mode share probabilities for auto and rail are shown below as examples of how the probabilities are calculated for an un-nested mode and for a nested mode.

Figure 1: Example Nesting Structure



$$PR_{Auto} = \frac{\exp(U_{Auto})}{\exp(U_{Auto}) + \exp\left(\mu_{Group\ Transport} * \Gamma_{Group\ Transport}\right)}$$

$$PR_{Rail} = PR_{Rail|Group\ Transport} * PR_{Group\ Transport}$$

$$PR_{Rail|Group\ Transport} = \frac{\exp\left(\frac{U_{Rail}}{\mu_{Group\ Transport}}\right)}{\exp\left(\frac{U_{Rail}}{\mu_{Group\ Transport}}\right) + \exp\left(\frac{U_{Air}}{\mu_{Group\ Transport}}\right)}$$

$$PR_{Group\ Transport} = \frac{\exp(\mu_{Group\ Transport} * \Gamma_{Group\ Transport})}{\exp(U_{Auto}) + \exp\left(\mu_{Group\ Transport} * \Gamma_{Group\ Transport}\right)}$$

$$\Gamma_{Group\ Transport} = \ln\left[\exp\left(\frac{U_{Rail}}{\mu_{Group\ Transport}}\right) + \exp\left(\frac{U_{Air}}{\mu_{Group\ Transport}}\right)\right]$$

$$\mu_{Nest} = Logsum\ parameter\ for\ nest\ (estimated)$$

The estimated Logsum parameter for the nest (or nesting coefficient) indicates the degree to which the nested modes are substitutable (or similar). The values of the nesting coefficient can be interpreted as follows:

- $\mu < 0$: Not theoretically consistent with NL model and nesting structure must be rejected.
- $0 \leq \mu < 1$: Implies non-zero correlation in the unobserved components (or error terms) of the nested modes and the closer μ is to zero, the more similar are the error terms of the modes with the nest.

- μ = 1: Implies zero correlation among the unobserved components (or error terms) nested modes, and mathematically collapses to a MNL model structure.
- μ > 1: Not theoretically consistent with NL model and nesting structure must be rejected.

2.2.3.2 Variable Specification and Data Segmentation

The FRA identified potential variable specifications and data segmentations as a first step of the mode choice model estimation process. Below are the descriptions of each of the options tested in the model estimation process. Not all options, however, were used in the final models.

Travel Time

Travel time is a key variable in mode choice decision-making, and was expressed in the model using two components: line-haul time and access/egress/connect time.[2] The FRA examined several different transformations of both time components, including:

- No transformation (where the travel time in minutes is used in the model directly)
- Scaled by highway distance (travel time / distance). Line-haul time and cost are often collinear which causes difficulty in RP model estimation because the model is unable to distinguish the mode choice impact for each variable independently. Scaling by distance helps to reduce this collinearity.
- Scaled by dampened highway distance (Adjusted Travel Time = Travel Time / (1.0 – k*distance). The parameter k is a specified parameter, not estimated, and is typically in the range of -0.01 to -0.1. This parameter was adjusted during model estimation to determine the value that created the best model fit. Similarly to scaling by straight distance, scaling by dampened distance reduces the collinearity between time and cost. Scaling by dampened highway distance also allows the model to exhibit lower sensitivity to time for longer trips. It is expected that a given increase in travel time, say, 15 minutes, would have a lower impact on longer trips because the 15 minutes would be smaller *percentage* of total trip time than for a shorter trip. Using the dampened distance has the additional advantage of allowing the model exhibit a differential impact for travel time changes depending on the relationship between travel time and distance. Consider two different trips that have the same travel time, but one covers a short distance and the other a longer distance. It is possible that the additional travel time would have a larger impact on a shorter distance trip, indicating that additional travel time is more onerous to the short-distance traveler.
- Log of travel time. Using the log of travel time is an additional method for handling collinearity. Similarly to dampened distance scaling, this method allowed for travelers to have a non-linear response to travel time.

Travel Cost

The FRA explored the following specifications of total travel cost in model estimation:

- No transformation. Where the travel cost in dollars is used in the model directly.

[2] Access/egress/connect time do not apply to the auto mode

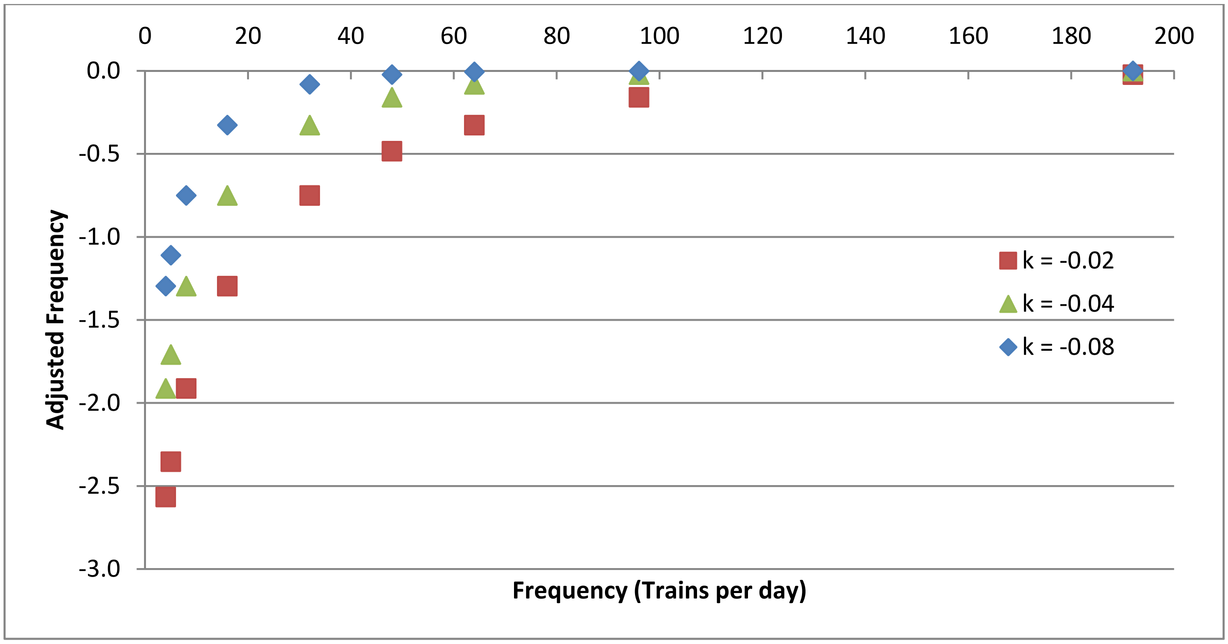
- Scaled by highway distance (travel cost / distance). Line-haul time and cost are often collinear which causes difficulty in RP model estimation because the model is unable to distinguish the mode choice impact for each variable independently. Scaling by distance helped to reduce this collinearity.
- Scaled by dampened highway distance (Adjusted Travel Cost = Travel Cost / (1.0 – k*distance, where k is a parameter). The advantages of scaling by dampened distance are explained above in the travel time discussion.
- Differentiate by mode (specify separate travel cost coefficients for each mode). Premium modes such as air and high-speed rail have very different pricing structures, and could attract customers who have a higher value of time and lower-cost sensitivity.
- Piece-wise linear. This transformation applies a different coefficient to segments of the total cost. For a potential specification of two cost segments, $1 to $99 and $100 or more, the first $99 of the total cost would have one coefficient, while the remainder of the total cost (total cost - $99) would have a second coefficient. This transformation allows for travelers to have different responses to incremental cost depending on total cost. For example, a $20 increase in fare could have a very large impact when the fare is originally $25 but only minor impact when the original fare is $300.
- Log of total cost. Similar of the other transformation, this transformation allowed differential responses to changes in cost depending on the level of the total cost.

Frequency of Service

Frequency of service affects all modes except for auto, and can play a large role in a traveler's decision-making process. The specifications tested are listed below.

- Total trains per day.
- Dampened trains per day (Adjusted Frequency = ln (1.0-exp(k*frequency))). This dampened specification accounts for the expectation that additional trains impact choice up until a certain saturation level, at which point travelers have enough options, and more trains will not increase the utility of the mode. The shape of this function can be adjusting using the k parameter, and some options for the level of k are shown in Figure 2.

Figure 2: Dampened Function of Frequency



Source: NEC FUTURE team, 2015

Record Weights

Combining the SP and RP datasets brings up the issue of what relative weigh to put on each source of data. Recall that each respondent provides information on one RP trip and six SP choice exercises. Judgmental approaches may use weights which can range from equal weight between each SP and RP record or equal weight between the set of SP records and each RP record. The six SP questions in the NEC Future survey were split into two groups: (1) three questions which hold values for mode 3 (out of three modes) constant, and (2) the other three questions which hold values for mode 2 (out of three modes) constant. Because the SP questions offer a more limited choice set than the RP, the SP question weights were set at 1/3 of the RP questions, as opposed to either end of the range (1 or 1/6).

The survey records are a sample of the population and may not have reflected actual traveler characteristics in the correct proportions due to sampling error or non-response issues. Incorporating record weights adjusts the sample to more accurately represent the total population. The FRA examined two different methods of weighting survey responses during the model estimation phase. The first method relied solely on the sample weights that were calculated to adjust survey records so that the demographics of the achieved sample match the general population.

The second method incorporated mode share weights. Mode share weights are used to adjust the survey records so that the mode shares by major market in the weighted sample match actual mode shares as represented in the base trip table (see Section 3.1.1.2). Using mode share weights potentially reduces the amount of validation needed after the estimation phase.

An example of the use of mode share weights is shown in Table 2 for New York to Washington. First, the number of survey records by mode for a particular market is computed. This is shown in the first row of the table, which has a total of 953 records. The next row shows the un-weighted mode share calculated directly from the survey records. In this example, there is a 54% auto mode share (510 auto records / 953 total records). The un-weighted mode share was then compared to the actual mode share from the base trip table. Because the actual mode share was calculated as 50% instead of 54% from the survey records, an additional factor was added to each auto record for that market pair that is equal to 0.94 (50% / 54%).

Table 2: Mode Share Weighting Example for New York – Washington Market

	Auto	Air	Intercity-Express Rail	Intercity-Corridor Rail	Regional Commuter Rail	Intercity Bus	Total
Number of Survey Records	510	66	55	80	0	242	953
Survey Mode Shares	54%	7%	6%	8%	0%	25%	100%
Base Trip Table Mode Shares	50%	16%	6%	12%	0%	15%	0.99
Mode Share Weight Factors = (Base Trip Table Mode Shares / Survey Mode Shares)	0.94	2.36	1.09	1.46	-	0.59	1.00

Source: NEC FUTURE team, 2015

Record Exclusion

A final method that was explored during estimation was to exclude records which were potentially erroneous or would not add value to the model estimation. The FRA tested three methods of exclusion:

- Mode exclusions. There were very few records either in the RP data or the SP data that were commuter trips taking the air mode. A possibility was to remove the air mode (and the associated records), from the commute model.
- Switching behavior restrictions. Large numbers of respondents who currently use auto did not switch to any other mode during the SP experiments, which indicated that they were auto-captive, and needed their personal vehicle either during or at either end of their trip. Because of this, they could potentially overwhelm the other responses, and cause issues in estimating the variable sensitivities. One option was to exclude these captive records from the estimation process.

Nesting Structures

Twelve nesting structures were identified for testing, which covered a large range of possibilities along the following dimensions:

- one- and two-level nest options,
- grouping the rail modes,
- grouping the premium and non-premium modes, and
- grouping common carrier modes.

These structures are shown in Figure 3. The variety of nesting structures allow for differing levels of similarity between modes, i.e., that they share certain unobservable characteristics. The impact of using nests is that it allows the model to exhibit the possibility that respondents are more likely to switch to other modes in the same nest as their chosen mode, and less likely to switch to modes in other nests. For instance, if respondents are more likely to switch to Intercity-Express from air since they are both premium modes (in price, amenities, and service characteristics) as opposed to from auto, then air and Intercity-Express should be nested together with auto in a separate nest. Some of the nesting structures contain two levels, indicating that modes share similarities in unobserved characteristics with the bottom level nest and additional (although lesser) similarities with modes in the upper level nest. Statistical tests performed on models using the same data but different nesting structures, as well as the estimated nesting coefficient values themselves informed which structure best fit the data.

Specific details on the variable specification and data segmentation testing for each model can be found in Section 3.3.1.

Figure 3: Potential Nesting Structures

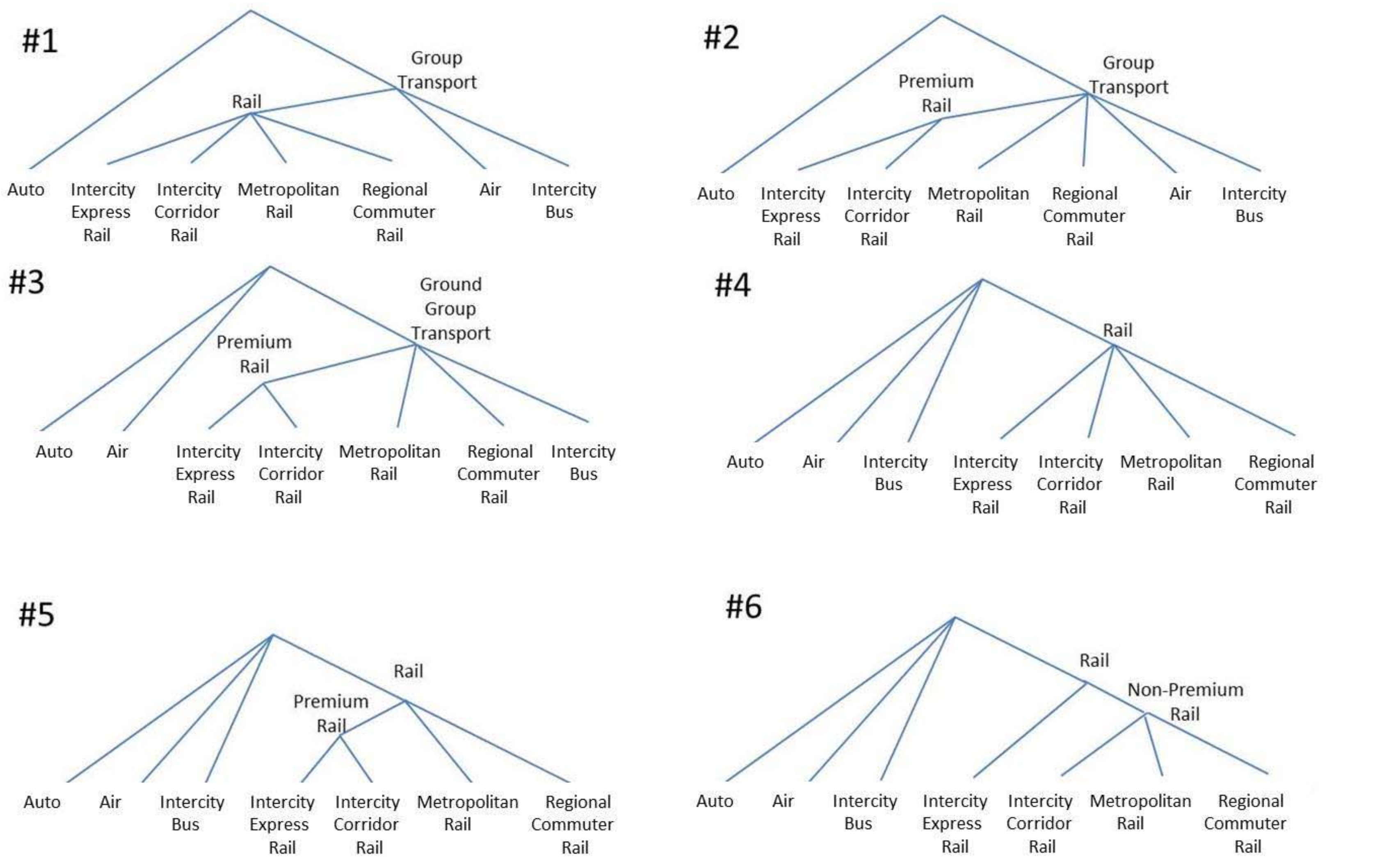
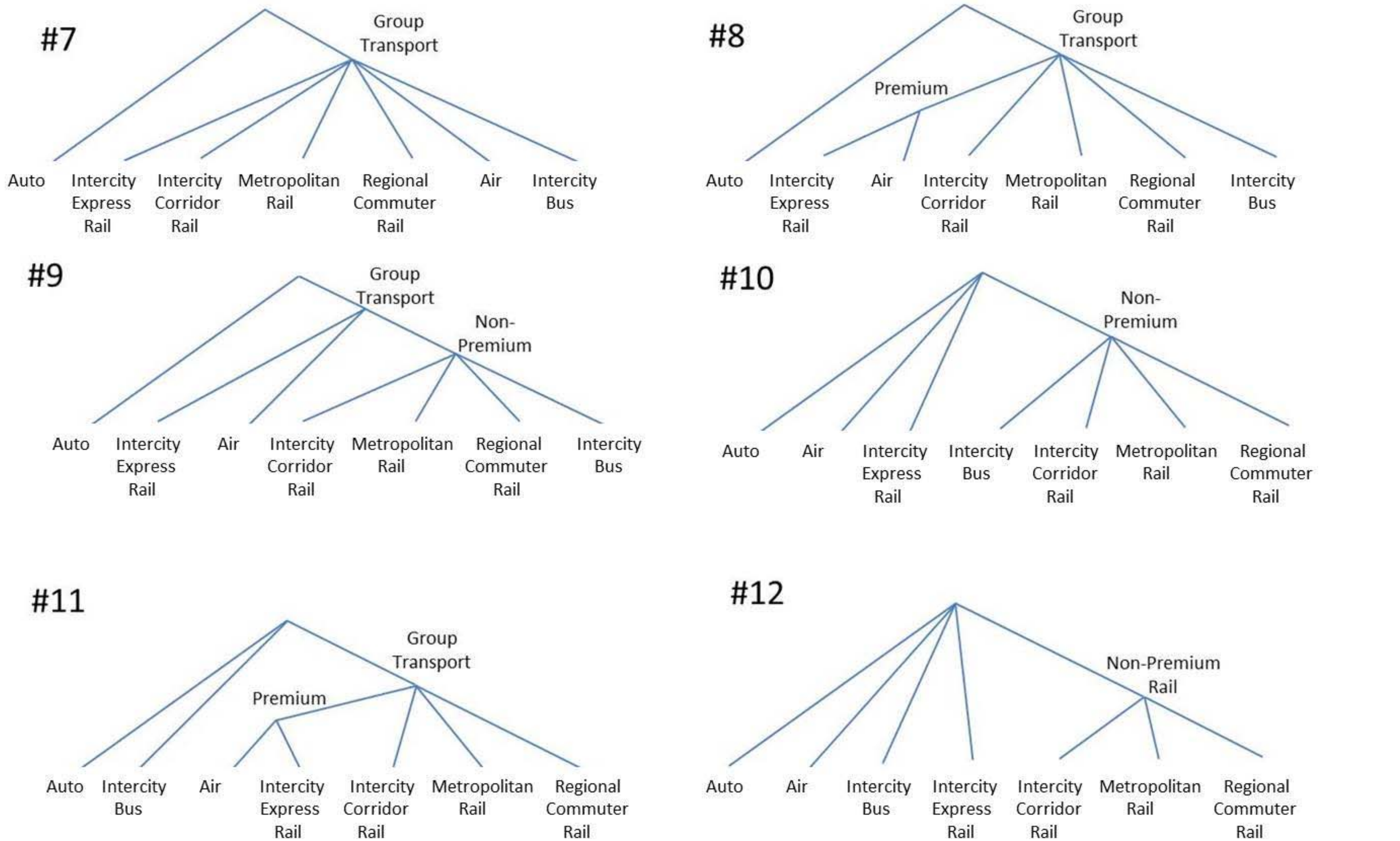


Figure 3: Potential Nesting Structures (continued)



Source: NEC FUTURE team, 2015

2.2.3.3 Survey Data Descriptive Analysis

The FRA exercised a second step in the mode choice estimation process and fully examined the completed survey responses to ensure that they would support the variable specifications and data segmentations identified in the first step of the model estimation process. Specific summaries examined in this step included:

- Number of records by trip purpose and geography to ensure that the survey responses had adequate geographic coverage for model estimation.
- Number of records by RP mode and geography to check for adequate mode coverage across different markets.
- Number of records by trip purpose and RP mode to ensure that the survey responses had adequate samples across modes.
- Number of records by SP mode to identify the number of responses who selected each mode in the SP questions, ensuring enough variation in the responses.
- Respondent switching behavior. One issue that can arise with SP surveys is not having enough variation within the service characteristics to encourage respondents to switch modes. This summary checked that there was enough switching behavior to estimate the key service variable sensitivities.

The results of the survey data descriptive analysis can be found in Section 3.2.2.

Model Estimation

Models of modal travel choice can be based on RP or SP data. Each type of data provides certain advantages over the other. RP data reflect actual behavior and take account of the real world conditions that respondents face. SP data takes account of a wider range of potential choices and attributes. The SP data reflect an experimental design that provides for explanatory variables that have a larger range of variability within and between alternatives and break the correlation between explanatory variables within each alternative. While models can be estimated with each type of data separately, the most robust models combine RP and SP data in order to take advantage of the unique characteristics of each type. Combining the two sets of data to estimate a single model can produce a model that retains the advantages of both RP and SP models and eliminate or dramatically reduce the disadvantages of each. The NEC FUTURE Household Travel Survey collected both types of data for use in studying travel patterns and travel behavior along the NEC.

The combined RP-SP model can be structured similarly to any NL model structure although because of the differences between the two types of data, the model structure must be slightly modified. The use of a scaling factor applied to the SP data allows for the combined estimation of the choice model, to account for a different error structure and possible biases of the SP data. This scaling factor is estimated by having a separate SP nest, as well as having an additional ASC for the SP modes. The other coefficient estimates can be constrained to be equal for both the RP and SP records.

2.2.3.4 Testing, Refinement, and Calibration

After model estimation, further testing, refinement, and calibration of the models was conducted. Model testing involved computing elasticities and conducting sensitivity analysis of key variables, such as time and cost, to ensure that the model behaves as expected and produces results that fall into reasonable ranges. Elasticity is defined as follows:

$$Elasticity\ = (\%\ Change\ in\ Probability)/(\%\ Change\ in\ Attribute)$$

For example, a sensitivity test was conducted whereby travel time by train was doubled, and the impact on both the train mode share as well as on the other mode shares was analyzed for reasonable results. Cost was also a key variable for sensitivity testing. In addition, the results of the mode estimation were explored at a market level and checked for reasonableness. Calibration factors in the form MSA-level alternative specific constants for each mode were added in order to better match observed the base year mode shares in each market.

An addition test of the estimated models was analysis of the Value of Time (VOT) implied by each model. VOT was calculated for each model by dividing the parameter on travel time by the parameter on cost. The estimated VOTs from each model were assessed for reasonableness as compared to VOT estimates from similar studies.

The SP questions in the Household Travel Survey presented four types of rail to respondents:

- High Speed Train
- Regional Train
- Commuter Train
- Metropolitan Train (a new service)

At the time the survey was developed, the FRA envisioned Metropolitan service as a rail mode that would be a service level above Regional rail services, but below Intercity-Corridor, in terms of service quality. Metropolitan would be moderately slower and cheaper than Intercity-Corridor, while not having reserved seats (so potentially some riders may need to stand), and no amenities such as restrooms or food service. When the Service Plans for the Action Alternatives became more fully developed, the Metropolitan trains ended up being very similar to the Intercity-Corridor trains in terms of frequency and stopping patterns than originally anticipated. In addition, they actually had faster travel times, due to the new equipment anticipated for use by the Metropolitan service.

To include a new mode in a logit model, the modeler must assert that the new mode is independent from the other modes included in the model so that it does violate the independence from irrelevant alternatives (IIA) property of the model. Using a nested logit lessens the stringency of the IIA requirement but does not eliminate it. Given that the more developed concept of Metropolitan service became very similar to the existing Intercity-Corridor service, the FRA decided to combine the Metropolitan mode with the Intercity-Corridor mode for ridership modeling purposes. The combined service retained the label “Intercity-Corridor.” The daily frequencies for Metropolitan and Intercity-Corridor were summed together and the travel times were averaged for each station pair to account for any differences in the service. The ASC estimated for Intercity-City rail mode was used to estimate mode share for the combined service.

As the naming convention of the rail modes differs across sections of the document, Table 3 provides a correspondence between the mode names.

Table 3: Intercity Rail Mode Naming Convention

Existing Name	Survey Name	Model Estimation Name	Application Name
Acela Rail	High Speed Train	Intercity-Express Rail	Intercity-Express Rail
Regional Rail	Regional Train	Intercity-Corridor Rail	Intercity-Corridor Rail
	Metropolitan Train	Metropolitan Rail	Intercity-Corridor Rail

Source: NEC FUTURE team, 2015

2.3 REGIONAL MARKETS

The FRA conducted the regional forecasting process with existing, off-the-shelf ridership tools to the maximum extent possible. Many of these tools have been used by Regional rail operators or other regional transit operators to plan Federal Transit Administration (FTA) New Starts investments and evaluate the implications of service and policy changes. By using the off-the-shelf tools the NEC FUTURE team maintained consistency with local existing and future planning efforts, and ridership and growth estimates.

Shorter distance, regional travel markets found within a specific major region will be addressed by the available regional models, which include:

- Washington: Metropolitan Washington Council of Governments (MWCOG)/Washington Metropolitan Area Transit Authority (WMATA) Forecasting Model
- Baltimore: Federal Transit Administration (FTA) Simplified Trips on Project Software (STOPS) implemented for the Baltimore metropolitan region.
- Philadelphia: Delaware Valley Regional Planning Commission (DVRPC) Model
- New Jersey: NJ TRANSIT North Jersey Travel Demand Forecasting Model
- New York – Metropolitan Transportation Authority (MTA)-Long Island Rail Road (LIRR)/MTA-Metro-North Railroad/Shore Line East: MTA Regional Transit Forecasting Model
- Boston: FTA STOPS implemented for Boston metropolitan region.

The FTA STOPS module was used to estimate ridership demand in locations without available local models. STOPS is the FTA’s new national forecasting model, which relies on a combination of national experience and local market-based information to estimate transit project ridership. STOPS is a series of programs designed to estimate transit project ridership using a streamlined set of procedures that bypass the time-consuming process of developing and applying a regional travel demand forecasting model. STOPS is similar in structure to regional models and includes many of the same computations of transit level-of-service and market share found in model sets maintained by Metropolitan Planning Organizations and transit agencies.

A more detailed discussion of the regional forecasting tools is included in Chapter 4 of the report.

2.4 EXTERNAL MARKETS

The ridership methodology includes external markets as a third market area, comprising existing and proposed corridor services to/from Buffalo, Pittsburgh, Lynchburg, and North Carolina; and existing long-distance overnight train services, including trains to/from Florida, New Orleans, Chicago, and Montreal. The proposed methodology for analyzing these external markets made use of the FRA's own CONNECT tool, a sketch-planning tool that produces ridership forecasts based on simplified frequency and travel time assumptions and MSA-level demographics. After examining the CONNECT tool and the various Service Plans for the external corridors, the FRA determined that CONNECT was not suitable to produce accurate forecasts in these markets, given the simplified nature of the tool and its distance limitations. The CONNECT tool was not utilized and explicit ridership forecasts for these long-distance external markets were not created. Instead the focus for the Connecting Corridors was to determine that there was sufficient peak and off-peak capacity to accommodate the planned numbers of trains coming onto the NEC from connecting corridors.

3 Interregional Model

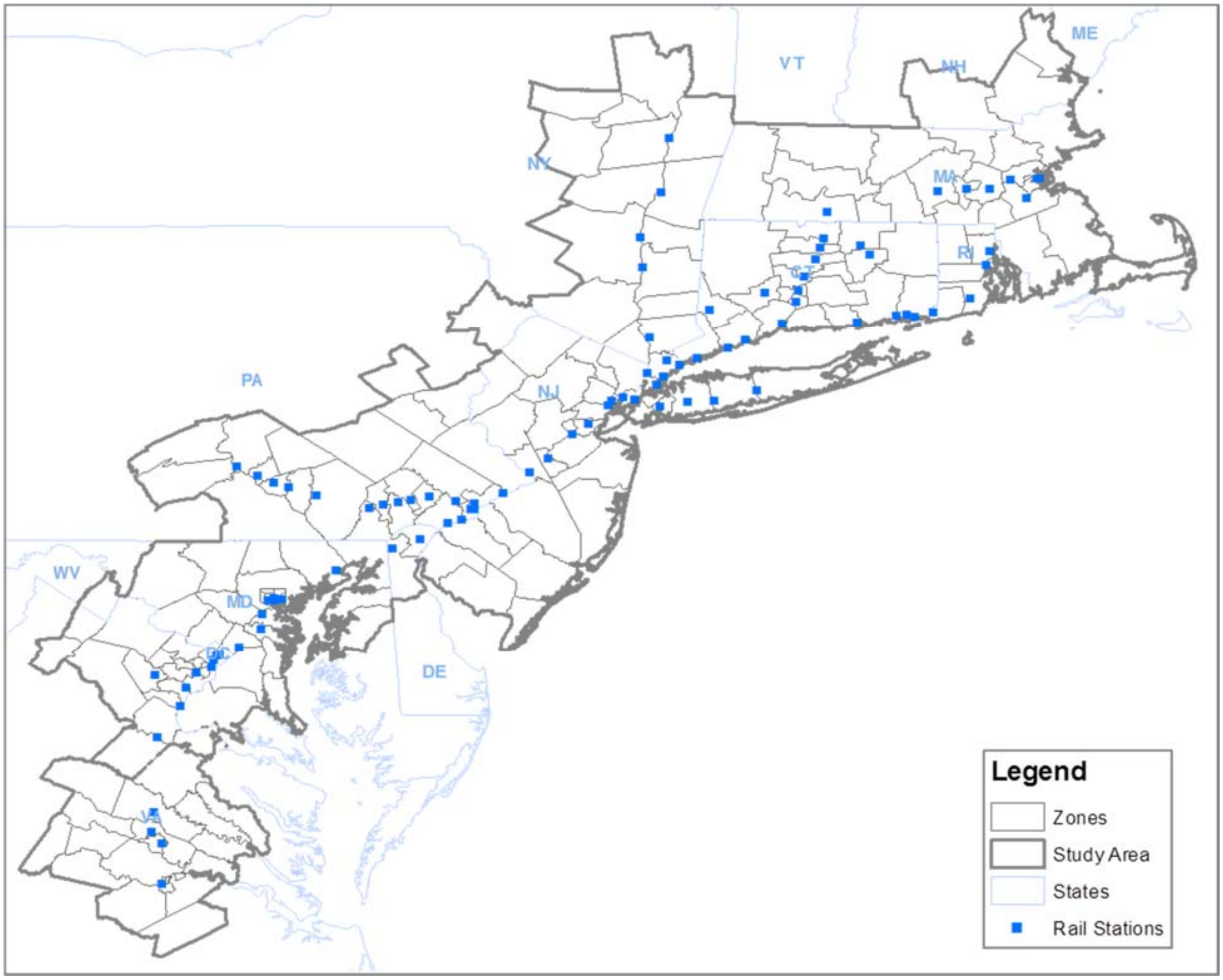
3.1 TOTAL TRAVEL MARKET DEMAND MODEL ESTIMATION

3.1.1 Baseline Travel Market Development

One of the key factors in travel demand forecasts is determining the total amount of travel occurring between origins and destinations. To forecast travel between origins and destinations it is important to develop the travel demand forecasting model at the appropriate level of analytical detail. To address this concern, the FRA developed a new zone system for the full range of alternatives. This new zone system expanded the existing interregional zone system used by Amtrak, based primarily on county boundaries. The Amtrak zone system encompasses 134 analysis zones defined to represent interregional travel in the NEC. In order to provide the geographic specificity required to represent the regional markets adequately, the FRA disaggregated the zone system to 200 zones, adding in finer zone definition in the urban areas by using Census Divisions as the basis for splitting the zones. The zone system for the model is shown in Figure 4. The zones were condensed into metropolitan areas for data summary purposes, and these areas are shown in Figure 5.

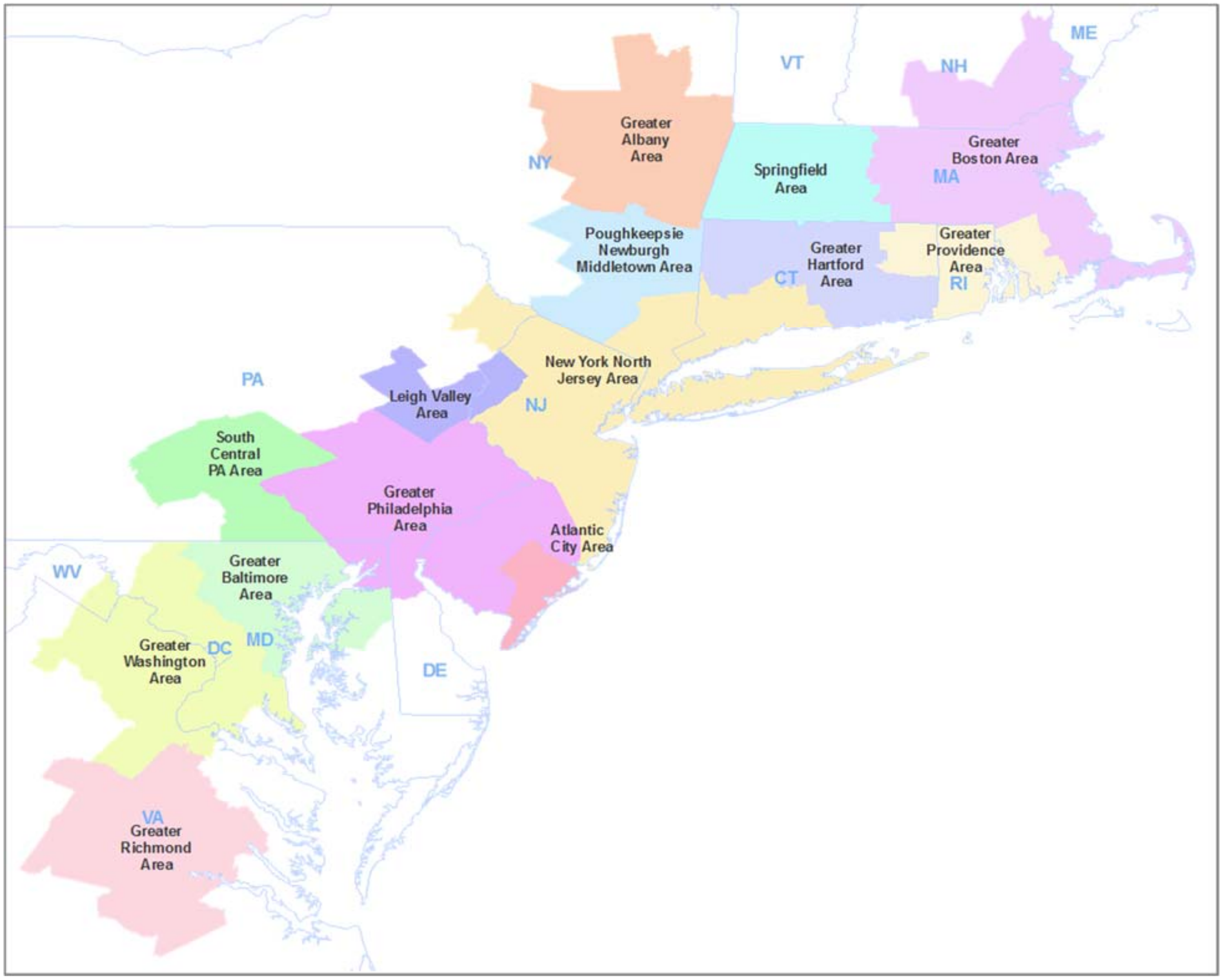
The interregional base travel market trip table consists of trips by origin and destination zone pair and intercity mode for the base modeling year of 2012. Multimodal interregional passenger market data for the Northeast were assembled from a number of different sources. This section highlights the key sources and methodology used to develop the base travel market data by intercity mode.

Figure 4: Study Area Zones



Source: NEC FUTURE team, 2015

Figure 5: Study Area Summary Metropolitan Areas



Source: NEC FUTURE team, 2015

3.1.1.1 Data Sources and Descriptions

The data sources for the base trip table vary by mode, including auto, air, rail, and bus. The sources are as follows:

- Auto market: NEC Automobile Origin-Destination (OD) Study (2014), prepared by RSG for the Northeast Corridor Commission
- Air market:
  - Air Carrier Statistics database (T-100 Domestic Market), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from http://www.transtats.bts.gov/Fields.asp?Table_ID=258
  - Airline Origin and Destination Survey (DB1B), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from http://www.transtats.bts.gov/Fields.asp?Table_ID=247
- Rail market: Amtrak Ridership and Ticket Revenue Data (FY 2013), provided by the Market Research and Analysis Department, Amtrak
- Bus market: Northeast Corridor Bus Schedule and Ridership Data (2014), prepared by RSG for the Northeast Corridor Commission
- Demographic Data: Demographic Growth Forecasts provided by Moody's Economy.com (annual for years 2010 through 2040)

The Northeast Corridor (NEC) Commission Auto Origin-Destination (OD) Study was developed using EZ-Pass data to identify travelers making longer distance auto trips in autumn 2013. Identified travelers were contacted to participate in a survey of travel patterns and trip characteristics throughout the entire NEC. The data took the form of individual survey records, geographically identified by origin and destination zip codes.

Air market data comes from two different datasets produced by the Bureau of Transportation Statistics (BTS). The first dataset is the Air Carrier Statistics database (T-100 Domestic Segment), which provides data on flight segments. This data also included the actual line-haul travel time (taken from the ramp-to-ramp time), which was averaged over all passengers for each airport pair, and the number of annual frequencies for each station pair. The Airline Origin and Destination (DB1B) dataset is a 10% sample of airline tickets which includes origin, destination, and other itinerary details, of which 12 months of data (2012 Q3-Q4 and 2013 Q1-Q2) was used to estimate the number of annual passengers between airports within the NEC. This data also included the actual fare paid by each passenger, which was averaged over all passengers for each airport pair.

Amtrak provided rail ridership data for FY 2013. This data included ridership and ticket revenue for station pairs within the NEC, split into Acela and regional trips (which correspond respectively to the Intercity-Express and Intercity-Corridor modes used in the model).

Similarly to the Auto OD Study, the Northeast Corridor Commission requested a study to quantify the bus travel market in the corridor, on which there was little data previously available. This study was completed in January 2014 and was conducted as an intercept study in addition to boarding and alighting counts in key cities. Using the count data, RSG estimated a bus trip table for the NEC.

This trip table contained the estimated number of annual trips between cities with intercity bus service.

Moody's Economy.com provided the demographic growth forecasts. These forecasts were developed from a national perspective that provides corridor-wide consistency with respect to key measures of growth, including population, income, and employment, based on detailed national and regional econometric modeling. This dataset is a custom forecast of demographic data obtained at the county level, and includes low, base, and high forecasts of total population, total non-farm employment, and total personal income. The demographic forecasts are discussed in more detail in Section 5.1.1.

The data for each mode from the sources above are either at the zip code level (auto trips) or station-to-station level. To distribute these trips to the zonal level, the trips were distributed similarly to the zonal populations. This is described in more detail in the trip table estimation process section below.

3.1.1.2 Baseline Trip Table Development Process

Using the data sources listed above, the FRA developed annual trip tables for each of the modes. The auto survey records from the OD study were not reliably distributed at the zonal level, so additional processing was required to finalize the auto trip table. The processing was completed by first assigning the auto OD survey records to the NEC FUTURE zones using zip codes. The zip code level data were then aggregated to the NEC FUTURE region-to-region level, to ensure the correct distribution of trips. The region-to-region level trips are then factored back down to the zonal level using the zonal population proportions within the regions, which was the 2012 population from Moody's Economy.com.

The other three modes (air, rail, and bus) were available at the station-to-station level, and were distributed to the zonal level in the same manner. The first step assigned the airports, rail stations, and bus boarding locations to the nearest NEC FUTURE zones. The station-to-station trips were then distributed to the zones using the same zonal population proportions as was done with the auto trips.

Table 4 summarizes the total estimated 2012 person trip volumes by mode along the corridor for travel between selected major markets, as well as for the total Study Area.

Total trips were segmented by purposes defined as follows:

- Business - includes all work related business trips
- Non-Business - includes, leisure/recreation, school, shopping, visit friends/relatives, personal business, and other trips
- Commuter - includes all commute to/from work trips

Table 4: Summary of Existing (2012) Annual Person Trips by Mode between Major Markets and Total Study Area

Origin Market	Destination Market	Auto	Air	Intercity-Express Rail	Intercity-Corridor Rail	Intercity Bus	Total
Boston	Hartford/ Springfield	3,546,047	—	—	4,522	228,832	3,779,471
Boston	New York	31,999,766	2,911,222	857,475	933,971	1,832,685	38,535,119
Boston	Philadelphia	2,990,145	1,347,578	38,670	113,532	74,393	4,564,317
Boston	Baltimore	1,019,913	1,395,068	7,114	18,588	41,772	2,482,456
Boston	Washington	813,116	2,717,932	19,155	63,864	37,234	3,651,300
Hartford/Springfield	New York	12,013,365	55,341	—	257,334	372,582	12,698,623
Hartford/Springfield	Philadelphia	1,355,415	148,549	—	17,931	6,117	1,528,012
Hartford/Springfield	Baltimore	188,360	171,871	—	4,409	3,851	368,491
Hartford/Springfield	Washington	331,218	342,613	—	14,227	5,985	694,043
Providence	New York	8,941,088	58,743	153,474	237,591	58,675	9,449,572
Providence	Philadelphia	1,167,253	136,902	10,284	28,540	5,901	1,348,879
Providence	Baltimore	1,836,285	163,063	2,135	6,754	2,345	2,010,582
Providence	Washington	135,242	326,763	4,530	17,367	3,663	487,566
New York	Philadelphia	39,149,532	828,899	522,157	1,962,317	1,698,209	44,161,114
New York	Baltimore	5,118,320	820,384	247,973	703,896	1,586,287	8,476,859
New York	Washington	8,575,252	1,996,075	1,063,569	1,794,617	1,673,015	15,102,526
Philadelphia	Baltimore	4,580,718	198,702	50,044	286,427	511,837	5,627,728
Philadelphia	Washington	4,017,246	464,782	235,193	706,775	296,762	5,720,758
Total Study Area		384,617,396	16,667,448	3,339,629	11,422,202	9,584,342	425,631,017

Source: NEC FUTURE team, 2015
Note: Trips represent total person trips in both directions

The segmentation was done using the trip purpose percentage share calculated from the NEC FUTURE Household Travel Survey, segmented by mode and trip length, for the entire Study Area. Trips by mode and purpose are shown in Table 5. The data in Table 5 shows that 70 percent of trips in the NEC market area are for non-business purpose.

Table 5: Summary of Existing (2012) Annual Person Trips by Mode and Purpose

Purpose	Auto	Air	Intercity-Express Rail	Intercity-Corridor Rail	Intercity Bus	Total
Business	63,195,087	8,716,858	1,724,564	2,698,277	1,030,920	77,365,706
Non-Business	274,271,937	7,950,590	1,423,448	7,126,202	6,990,935	297,763,112
Commute	47,150,373	0	191,617	1,597,723	1,562,491	50,502,204

Source: NEC FUTURE team, 2015

The final base trip table used in the Interregional Model was the total trips for each zone pair segmented by trip purpose.

3.1.2 Model Estimation Results

Total travel demand forecasts define the total market size to which the modal shares are applied to produce ridership forecasts by mode, as described in Section 2.2.3. This section describes the data used to estimate the new model, as well as the estimation results.

The FRA estimated the Interregional Model at the zonal level using the base year data (2013):

- Total trips by origin-destination pair from the baseline trip table
- Base year population from the Moody's demographic data
- Base year employment from the Moody's demographic data
- Base year Per Capita Income from the Moody's demographic

The FRA estimated three total demand models, one for each trip purpose, using SPSS and a linear regression form with the base year attributes. The model equation format for application is shown below, with zone I referring to the origin zone and zone j referring to the destination zone.

In the estimation process, it was necessary to constrain the relationship between population and employment because of high co-linearity. Given the size of the zones in the Interregional Model; both population and employment are correlated to the overall size of the community. A variety of ways to impose these constraints was tested in the estimation process, including the following:

- Constraining population and employment parameters to be equal,
- Using only population,
- Using only employment, and
- Changing the the dependent variable to be trips per person (effectively constraining the population parameter to be 1.0).

The FRA selected as the final model the version which provided reasonable results and good model fit statistics. The estimated coefficient values for each model are shown in Table 6, which can be interpreted as elasticities.

$$
\begin{aligned}
&Future\ Trips\ by\ Purpose \\
&\quad = Base\ Trips\ by\ Purpose\ \times \left(\frac{Future\ Population(i)}{Base\ Population(i)}\right)^{a} \\
&\quad \times \left(\frac{Future\ Population(j)}{Base\ Population(j)}\right)^{a} \times \left(\frac{Future\ Employment(i)}{Base\ Employment(i)}\right)^{b} \\
&\quad \times \left(\frac{Future\ Employment(j)}{Base\ Employment(j)}\right)^{b} \times \left(\frac{Future\ Per\ Capita\ Income(i)}{Base\ Per\ Capita\ Income(i)}\right)^{c} \\
&\quad \times \left(\frac{Future\ Per\ Capita\ Income(j)}{Base\ Per\ Capita\ Income(j)}\right)^{c} \times \left(\frac{Future\ LOS(i,j)}{Base\ LOS(i,j)}\right)^{d}
\end{aligned}
$$

Table 6: Total Demand Model Estimation Results

	Business Model		Non-Business Model		Commute Model	
Variable	Coeff.	**T-Stat**	**Coeff.**	**T-Stat**	**Coeff.**	**T-Stat**
Population (a)	0.7017	113.72	0.6027	117.04	0.6144	122.49
Employment (b)	0.7017	113.72	0.6027	117.04	0.6144	122.49
Per Capita Income (c)	n/a	n/a	0.3730	9.64	n/a	n/a
LOS (d)	0.1712	46.03	0.3289	85.22	0.3277	84.76
Model Characteristics						
Number of Records	19,900		19,900		19,900	
Rho-squared	0.4686		0.5795		0.5776	

Population and Employment coefficients were estimated together, so have the same value.
Source: NEC FUTURE team, 2015

3.2 MODE SHARE MODEL ESTIMATION

The FRA developed new model components using the new survey data, supplemented by network and service data as well as other relevant, available travel data. The detailed methodology used in this process is described in Section 2.3.3.

3.2.1 Data Sources

The estimation dataset comprises two types of data: mode choice data and modal service characteristics.

The NEC Household Travel Survey, described generally in Section 2.2.1 and in detail in Appendix A, is the source of information relating to respondents' mode choices. Each survey respondent provided up to seven estimation dataset records (one RP trip and six SP choice exercises). Each choice was accompanied by the trip's purpose and origin and destination zones.

For the RP records, the attributes for the respondents' chosen mode were provided by the respondents as part of the survey. The attributes of the non-chosen modes in the RP estimation dataset are based on current service characteristics. The current service characteristics also form the basis for the SP choice experiments. For each alternative mode, the experimental design combined time, cost, and frequency attributes at either the base value, +/- 15%, or +/- 30%.

The data sources and calculation processes for the modal service characteristics are provided below.

3.2.1.1 Auto Service Characteristics

The auto service characteristics include travel time, travel distance, and cost. In addition to auto line-haul service characteristics, these sources/methods apply to access/egress travel times and costs for all the other modes. Key sources include:

- Travel distance and time: Oak Ridge National Highway Network (2008), Center for Transportation Analysis, Oak Ridge National Laboratory. Retrieved from http://cta.ornl.gov/transnet/Highways.html.

- Travel cost: Standard Mileage Rates for estimating automobile operating cost (2012), Retrieved from http://www.irs.gov/Tax-Professionals/Standard-Mileage-Rates and published toll values. The mileage rate of $0.55/mile was used for the Business trip purpose and the incremental rate of $0.15/mile was used for Commute and Non-Business trips.

Auto travel time and distances were developed from an intercity highway network representing interstate, principal arterial, and other highway facilities connecting all study area zones and intercity passenger terminals. The highway network was derived from Oak Ridge National Laboratory's existing highway network database. Travel times were calculated for each link based on facility type, distance, and state speed limits.

To create zone-to-zone characteristics for auto, the FRA produced a set of network skims using an ArcGIS based application called Network Analyst. Network Analyst calculated the minimum path, based on minimizing travel time to/from each of the zones in the study area. Each minimum path calculation developed the time, distance, and toll costs associated with the trip. This process produced zone-to-zone distance and time matrices based on the minimum travel time route between each study area zone pair.

The access times and costs for all non-auto modes included the time and cost traveling from the origin zone to the bus boarding area/rail station/airport; the time and cost associated with the station, including waiting/boarding times; and the time/cost traveling from the destination bus alighting area/rail station/airport to the final destination zone. Access times and costs for travel between zones and stations/airports were developed using the same network procedure and cost per mile rates described above and used for the auto zone-to-zone travel characteristics.

3.2.1.2 Air Service Characteristics

The air service characteristics include travel time, travel cost, and frequency. These are developed using the following BTS datasets:

- Frequency and travel time: Air Carrier Statistics database (T-100 Domestic Market), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from http://www.transtats.bts.gov/Fields.asp?Table_ID=258.
- Fares: Airline Origin and Destination Survey (DB1B), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from http://www.transtats.bts.gov/Fields.asp?Table_ID=247.
- Access/egress time and cost: same sources as for auto travel time and cost for the segment of the trip which is from the origin zone to the origin airport and from the destination airport to the destination zone.

Line-haul travel time is calculated as the average ramp-to-ramp travel time from the T-100 Domestic Segment Database over one year of data. The access/egress travel time is calculated using the auto skimming process.

The calculated fare is the average fare for all passengers over a one-year time period between each pair of airports from the DB1B database. This fare is added to the mileage-based cost calculated from the auto skimming process for the access/egress portion of the trip to get the total cost for the air mode.

The frequencies were also taken from the DB1B database, which calculated the average number of daily frequencies between airports over a one year time period.

The appropriate airports were assigned to each zone based on which airport was the minimum highway distance from the centroid of the zone.

3.2.1.3 Bus Service Characteristics

The bus service characteristics include travel time, travel cost, and frequency.

- Travel Time: The intercity bus travel times were calculated using the auto travel times, multiplied by a 1.2 factor to account for slower bus speeds and intermediate stops. This factor was based on professional judgement.
- Travel Cost: Travel-time based formula based on existing fares, taken from publicly published fare data by operator.
- Access/egress time and cost: same sources as for auto travel time and cost for the segment of the trip which is from the origin zone to the boarding location and from the alighting location to the destination zone.

The intercity bus travel times were calculated using the auto travel times, multiplied by a factor of 1.2 to account for slower bus speeds and intermediate stops. This method was used to provide consistency across the modes. The use of auto travel time represents an average travel time, compared to often optimistic schedule times from the bus time tables (which do not vary by time of day). The access/egress travel time is calculated using the auto skimming process without an additional bus factor. Average daily bus frequencies were calculated from published time tables.

The intercity bus fares were taken from published fares by operator, with one or two weeks advance purchase, to represent an average fare paid. The access/egress cost calculated using the distance-based cost from the auto skimming process was added to the fare.

The appropriate bus stations were assigned to each zone based on which bus station was the minimum highway distance from the centroid of the zone.

3.2.1.4 Rail Service Characteristics

Similar to the other modes, the service characteristics for rail include travel time, cost, and frequency.

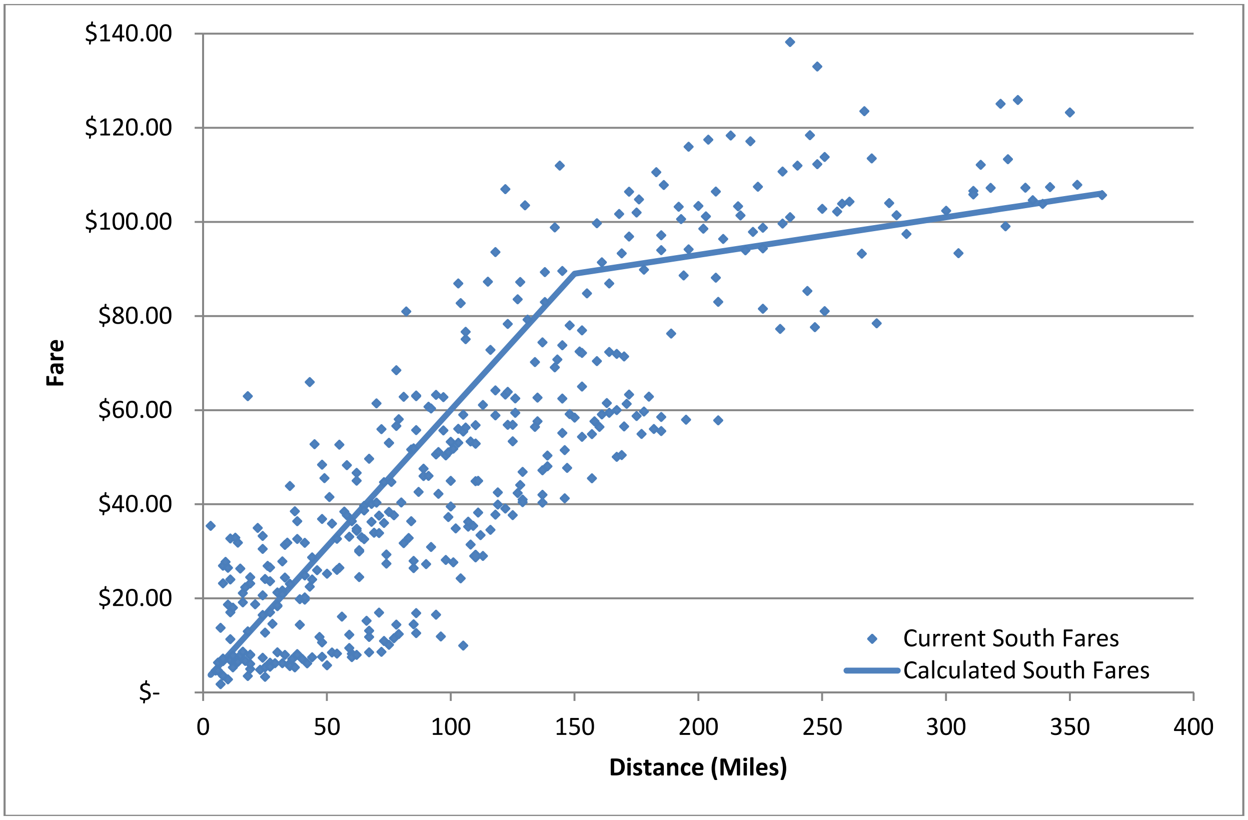
- Travel Time and Frequency:
  - For markets which currently have rail service (i.e. Acela between New York and Washington), travel time and frequency were taken from existing operator-published time tables for 2013.
  - For the new Metropolitan rail mode and markets which currently do not have rail service, travel time and frequency were based on Service Plans developed in the alternatives development process.

- Fares:
  - For markets which currently have rail service (i.e. Acela between New York and Washington), fares were the calculated average actual fares by station pair and service (from the Amtrak Ridership and Ticket Revenue data and published fares for Commuter rail).
  - For the new Metropolitan rail mode and markets which currently do not have rail service, distance-based fare formulas were calculated using existing fares.
- Access/egress time and cost: same sources as for auto travel time and cost for the segment of the trip which is from the origin zone to the boarding station and from the alighting station to the destination zone.

For the Interregional Model, the FRA assumed that rail fares would maintain the current fare structure. Distance-based fare equations were calculated based on current fares for three types of rail trips: trips entirely south of New York, trips north of New York, and trips through New York, as the current pricing structures were different in these different markets. Fares were calculated by trip geography to normalize fares for new travel markets while applying a consistent fare structure for the No Action Alternative and Action Alternatives. Figure 6 through Figure 9 show the current fares, as well as the calculated fares for each market.

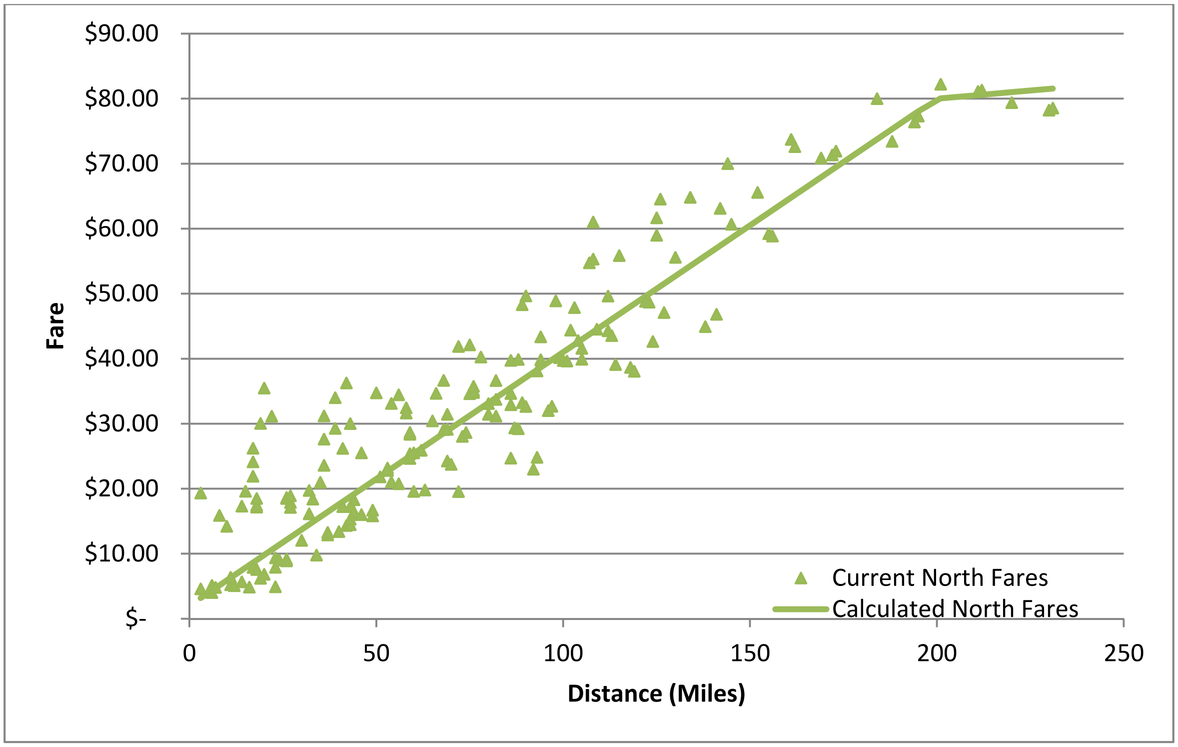
The fare equations were calculated by fitting a line to the current fare relationships and then calibrating to closely match the large key markets. The geographic equations are similar for express and non-express rail. Markets entirely south of New York show the highest rail fares, markets entirely north of New York have the lowest fares, and the through New York fares fall in the middle. This fare pricing reflects current congestion on the south end of the corridor, and is a fare policy that could potentially be adjusted in the future.

Figure 6: Non-Express Rail Distance-Based Fares for Trips South of New York



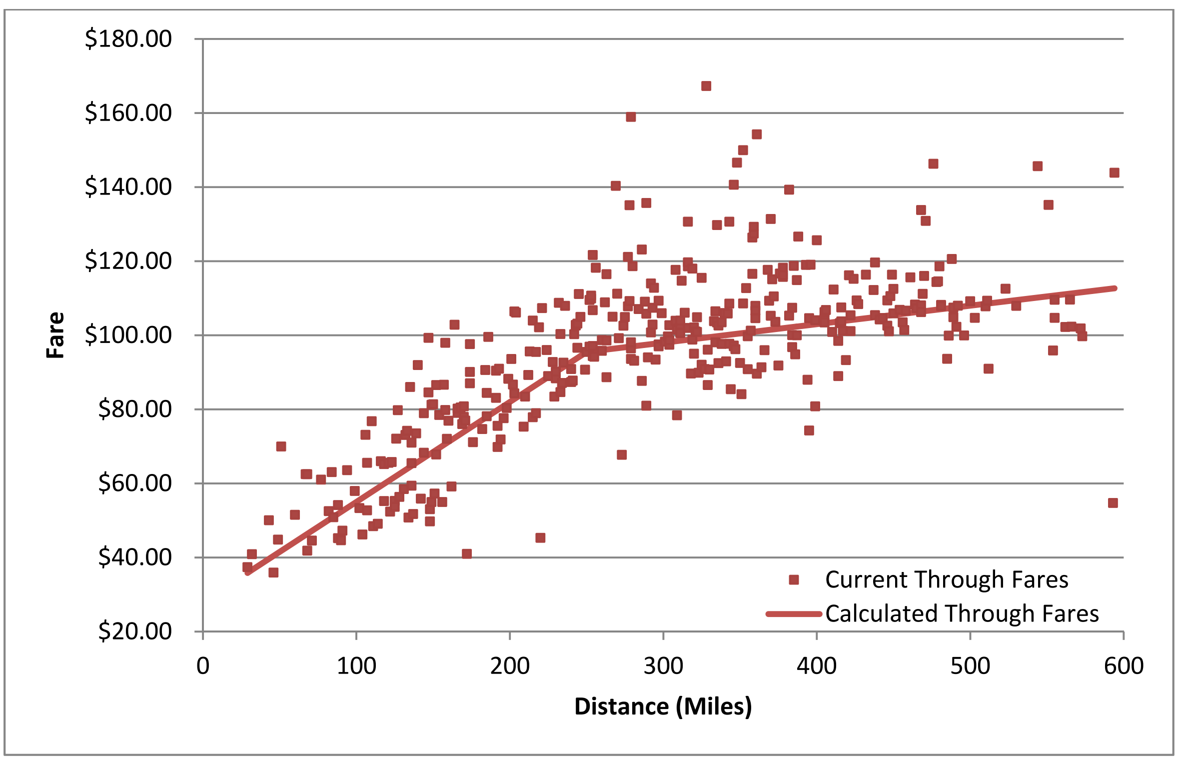
Source: NEC FUTURE team, 2015

Figure 7: Non-Express Rail Distance-Based Fares for Trips North of New York



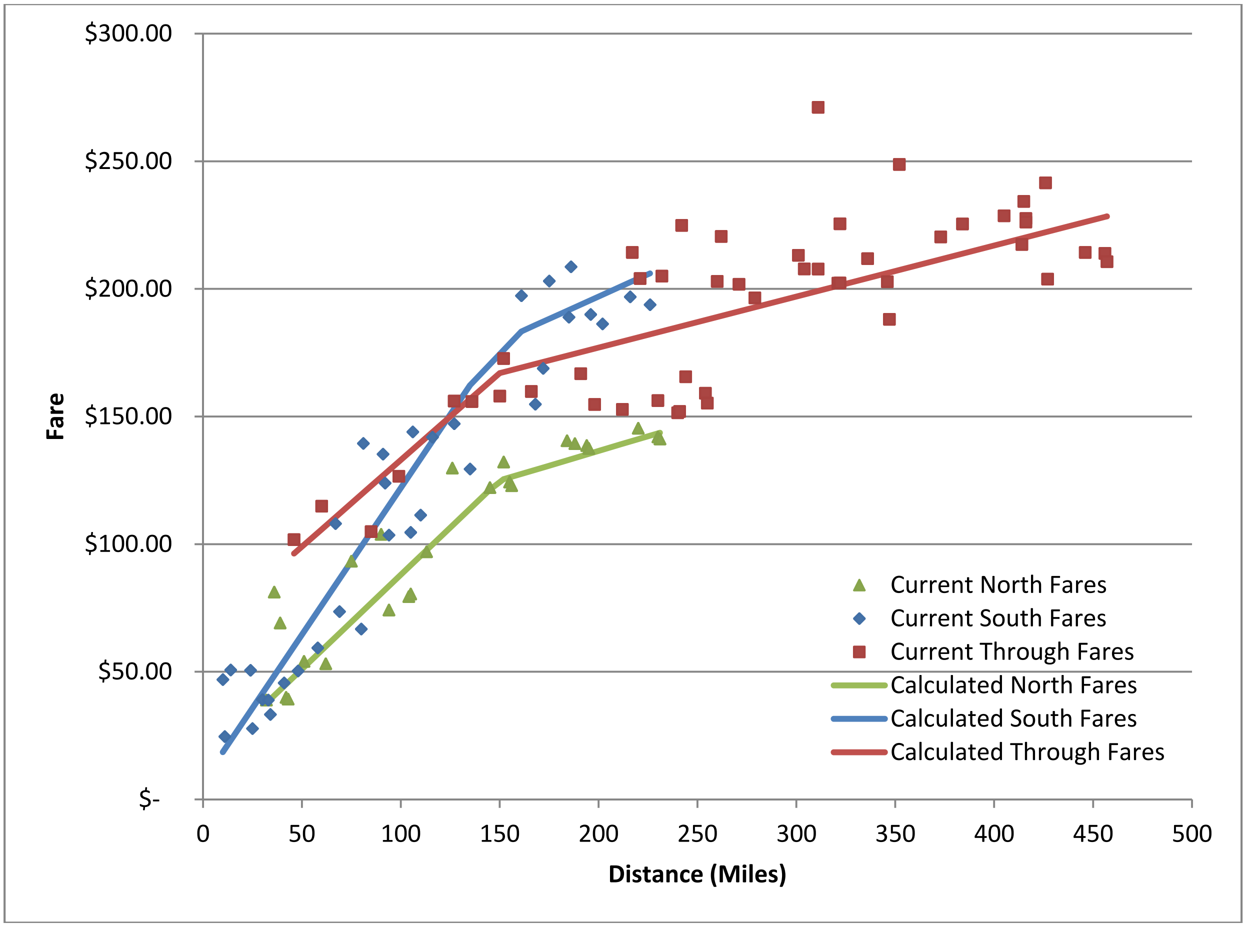
Source: NEC FUTURE team, 2015

Figure 8: Non-Express Distance-Based Fares for Trips through New York



Source: NEC FUTURE team, 2015

Figure 9: Express Distance-Based Fares



Daily train frequencies and average travel times were obtained from the Service Plans for each alternative, as described in detail in the *Service Plans and Train Equipment Options Technical Memorandum*. The FRA processed the Service Plans for input into the Interregional Model to assign an average travel time and daily frequencies for the Intercity-Express and Intercity-Corridor trains (including both Metropolitan trains and Intercity-Corridor-Other trains)[3] for each station pair. The service characteristics used for each zone pair included the service provided not only by corridor trains but also off-corridor services such as Keystone and Virginia services.

Access/egress travel time and cost were calculated for the portion of the trip from the origin zone to the boarding station and the alighting station to the destination zone in a similar manner to the other modes using the auto skimming process.

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[3] For detailed definitions on service types, see the *Tier 1 EIS Alternatives Report*. Metropolitan service provides the primary Intercity rail service on the NEC. Intercity-Corridor-Other service provides connectivity and direct one-seat service between non-electrified connecting corridors and the large and mid-size markets on the NEC.

3.2.2 Survey Data Descriptive Analysis

As described in the methodology discussion, once the potential variable specifications and data segmentations were identified, the survey data was summarized and reviewed to ensure that it could support of the desired specifications. Key aspects of the survey data which support the variable specifications and data segmentations are presented in the tables below.

Table 7 details the records available for estimating each of the models by trip purpose. The survey targets were developed using the three geographies to ensure adequate coverage (North of NY, South of NY, and Through NY). Commute trips through New York did not meet the minimum number of 300 respondents required for all the other cells. However, the number of all commute trips taken as a whole exceeds the study plan minimum of 300.

Table 7: Survey Records by Trip Purpose

	Business	Non-Business	Commute	Total
North of NY	553	2,630	418	**3,601**
South of NY	987	4,437	624	**6,048**
Through NY	420	1,664	125	**2,209**
TOTAL	**1,960**	**8,731**	**1,167**	**11,858**

Source: NEC FUTURE team, 2015

Table 8 presents a summary of the actual mode taken by the respondent in the reference trip by trip purpose. The table shows that enough records were found in each of these segments to support model estimation.

Table 8: Revealed Preference (RP) Mode and Trip Purpose

Mode	Non-Business	Business	Commute	Total
Car/Truck/Van	7,036	1,189	878	9,103
Plane	232	243	17	492
Train	726	396	144	1,266
Bus	737	131	128	996
TOTAL	**8,731**	**1,959**	**1,167**	**11,857**

Source: NEC FUTURE team, 2015

Table 9 summarizes the modes that respondents selected, both in their actual reference trip (Revealed Preference Mode) and in the choice experiments presented to them (Stated Preference Modes). Because each respondent was exposed to three modes in the SP questions, the total sums to 300%.

Table 9: Revealed and Stated Preference Modes

	Revealed Preference (RP) Mode		Stated Preference (SP) Modes	
	Count	Percentage	Count	Percentage
Intercity-Express Rail	297	3%	3,247	27%
Intercity Regional Train	744	6%	10,772	91%
Regional Commuter Train	225	2%	1,133	10%
Metropolitan Train	0	0%	2,269	19%
Car/Truck/Van	9,103	77%	10,244	86%
Plane	492	4%	2,613	22%
Intercity Bus	996	8%	5,296	45%
TOTAL	**11,857**	**100%**	**35,574**	**300%**

Source: NEC FUTURE team, 2015

Stated preference surveys may not present a large enough range of service characteristics to induce respondents to switch their mode preference. The model estimation process can be problematic if the respondents are not revealing the value they place on various characteristics of travel (such as time and cost), because they do not experience through the survey the point at which their preferences could switch to another mode. This condition reduces the number of viable records for estimation. Table 10 details the number of respondents who selected the same mode for all of the stated preference questions, whether with their current revealed preference mode, or an alternate mode. Approximately 60% of respondents did not switch modes, which indicates a potential issue. To investigate the issue, Table 11 provides information related to respondents who did not switch, comparing their current RP mode versus the mode they selected in the SP questions. Of these respondents, 69% were current auto users who only selected auto. This indicates that the non-switching behavior is due likely to a large portion of the market being “auto-captive” rather than to the design of SP choice exercises.

Table 12 and Table 13 further summarize the trip records by geographic segmentation.

Table 10: Respondent Switching Behavior across Stated Preference (SP) Questions

	Count	Percent
Didn't Switch – Stayed with Current Mode	5,454	46.0%
Didn't Switch – Stayed with an Alternate Mode	1,671	14.1%
Switched Among Different Modes	4,733	39.9%
TOTAL	**11,858**	**100.0%**

Source: NEC FUTURE team, 2015

Table 11: Respondents who didn't Switch Modes – Current Mode vs. Selected Mode

		Selected Mode								Total
		Intercity-Express Train	Intercity-Corridor Train	Regional Commuter Train	Metro-politan Train	Auto	Plane	Intercity Bus	Didn't Travel	
Current Mode	Intercity-Express Train	1%	1%	0%	0%	0%	0%	0%	0%	2%
	Intercity-Corridor Train	0%	3%	0%	0%	1%	0%	0%	0%	4%
	Regional Commuter Train	0%	0%	1%	0%	0%	0%	0%	0%	2%
	Metropolitan Train	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Auto	2%	9%	1%	1%	69%	1%	0%	0%	83%
	Plane	0%	1%	0%	0%	0%	2%	0%	0%	3%
	Intercity Bus	0%	2%	0%	0%	1%	0%	2%	0%	6%
	TOTAL	**4%**	**16%**	**2%**	**2%**	**72%**	**3%**	**2%**	**0%**	**100%**

Source: NEC FUTURE team, 2015

Table 12: Records by Major Market and Trip Purpose

Market		Business	Non-Business	Commute	Total
Boston	Hartford	36	112	27	175
	New York	224	882	91	1,197
	Philadelphia	33	115	9	157
	Baltimore	16	34	1	51
	Washington	61	171	6	238
Hartford	New York	72	280	42	394
	Philadelphia	12	42	1	55
	Baltimore	1	10	-	11
	Washington	7	26	-	33
Providence	New York	36	218	18	272
	Philadelphia	6	23	1	30
	Baltimore	3	7	-	10
	Washington	9	27	1	37
New York	Philadelphia	293	1,285	209	1,787
	Baltimore	64	284	42	390
	Washington	285	880	52	1,217
Philadelphia	Baltimore	33	213	29	275
	Washington	106	582	34	722
	Total Study Area	**8,731**	**1,959**	**1,167**	**11,857**

The individual market pair records do not sum to the total study area, due to exclusion of minor markets.
Source: NEC FUTURE team, 2015

Table 13: Records by Major Market and RP Mode

Market		Auto	Plane	Train	Bus	Total
Boston	Hartford	164	2	2	7	175
	New York	846	59	166	126	1,197
	Philadelphia	107	29	14	7	157
	Baltimore	21	26	2	2	51
	Washington	100	121	12	5	238
Hartford	New York	313	—	52	28	393
	Philadelphia	46	—	3	6	55
	Baltimore	8	2	—	1	11
	Washington	17	12	2	2	33
Providence	New York	230	2	26	14	272
	Philadelphia	26	2	1	1	30
	Baltimore	4	3	3	—	10
	Washington	18	17	2	—	37
New York	Philadelphia	1,307	20	220	240	1,787
	Baltimore	270	12	53	55	390
	Washington	715	81	229	192	1,217
Philadelphia	Baltimore	240	1	10	24	275
	Washington	582	11	76	53	722
	Total Study Area	**9,103**	**492**	**1,266**	**996**	**11,857**

The individual market pair records do not sum to the total study area, due to exclusion of minor markets.
Source: NEC FUTURE team, 2015

3.2.3 General Interregional Model Estimation Process

The FRA began the model estimation process by using only the RP data to determine model segmentations and the preliminary specification of variables and nesting structures. Once it was verified that there were no unusual results from the RP only models, SP only models were estimated, and the variable sensitivities produced by the SP models were compared to the initial RP only models to ensure the SP data was functioning correctly. Many of the variable specifications and nesting structures determined in the first step of the model estimation process were tested using both sets of data (RP data only and SP data only).

After the FRA determined that RP only and SP only model estimations both produced reasonable results for multiple specifications, combined RP/SP models were estimated. The estimation process was iterative, first selecting a nested choice structure to refine the variable specifications, and then testing the alternative nesting structures from Figure 2 (to test for differential substitutability among sets of modes). The nesting coefficient values helped determine the best nesting structure, as coefficients closer to zero indicated a better fit for nesting the specified modes together. The criteria for selecting the preferred models also included looking at the fit statistics (log-likelihood and rho-squared), as well as the statistical significance of the variable coefficients.

After the new inputs and data were assembled and loaded into the model, the FRA subjected the model to extensive testing and review to confirm adequately consideration of all key market segments and that sensitivities to changes in key inputs were reasonable and within the range of expectations set by existing models and forecasts. The model estimation process for each model, including adjustments made to the variable specifications and re-estimation work is described below.

3.2.4 Business Purpose Model

3.2.4.1 Process Description

The model estimation process for the Business model followed the general procedures outlined in Section 3.2.3. Specific observations about the estimation process are:

- The RP only model had difficulty converging due to low number of records. None of the nesting structures were statistically significant, in that the nesting coefficients were outside the theoretically acceptable range of 0 to 1. Therefore the only model estimated was an un-nested multinomial logit (MNL) model.
- The SP only model produced multiple models which converged with statistically significant variables using different variable specifications and nesting structures. This provided a good basis for comparison for the variable specifications of the combined RP/SP models.
- Removing mode share weights (using sample weights only) produced more reasonable Alternative-Specific Constants (ASCs). Using the mode share weights, which were applied at the MSA-to-MSA level, the differences between the ASCs were larger than typically accepted, and were accounting for most of the mode choice utility.
- All twelve nesting structures were tested for the combined RP/SP models, and the best-performing structure was two levels, with non-premium rail modes (Intercity-Corridor, Intercity Commuter, and Metropolitan) nested under a rail nest (structure #6 in Figure 2).
- Dampened frequency performed better than trains per day, and -0.08 was the preferred parameter (values were tested between -0.1 and -0.03), as it had the best statistical fit. The value of -0.08 is a typical value used in other intercity rail models, which means that train frequency is saturated at around 50 trains per day, or that additional trains over 50 per day do not impact the mode choice decision.
- Straight time and cost produced sensitivities that were too great at the higher end of time and cost values. As discussed in the methodology section, time and cost do not necessarily have a linear relationship, as an additional 10 minutes of travel time would typically impact a 20 minute base trip time more negatively than it would for a 120 minute trip time.
- Since the straight time and cost were producing unreasonable results, the dampened versions using highway distance were tested. Dampened time and cost caused issues with nesting structures and convergence, despite trying multiple adjustment parameters, and were not possible specifications.
- The next test was done only for cost, and involved splitting cost into two variables, one applied to premium modes (Air/Intercity-Express Rail), and one for non-premium modes, to allow the VOT to vary. This was done on the basis that premium modes have a very different cost structure than the non-premium modes, and an increase in cost for those modes would have less of an impact on the respondents' choice than a similar increase in cost on the non-premium modes. Business travelers are also less likely to personally pay for travel, and are therefore less

sensitive to the price differential between the premium and non-premium modes. This produced reasonable results.

- The ASCs for the four rail modes were similar, so they were tested by holding them equal. This change increased the importance of frequency, which is a key differentiator between Intercity Commuter/Metropolitan rail and Intercity-Corridor/Intercity-Express rail. By holding the ASCs constant for all four rail modes, the frequency variable picked up more explanatory power, and it is desirable to have more of the mode choice decision based on the variables as opposed to the unseen differences picked up by the ASCs.
- The intercity bus mode is attractive, based on the ASC, primarily due to un-modeled attributes such as flexibility and ease of access.

3.2.4.2 Estimation Results

Table 14 presents the results of the model estimation, with specific descriptions of the resulting parameter estimates for each variable below:

- The ASCs represent the unobserved attributes of each mode, and indicate the order and magnitude of mode preference given all other attributes held constant. Auto is the base mode, and all other ASCs are negative, indicating Auto is the preferred mode, with Bus being highly competitive and Air being the third preference. All the Rail mode ASCs are constrained to be equal to each other and shown to be least preferred. Constraining the rail mode ASCs to be equal allows more of the mode choice decision to be based on the differences in observed attributes, such as time, cost, and frequency.
- The access/egress portion of travel time is accounted for by adding up the Total Travel time and Access/Egress/Connect Travel Time coefficients, and is therefore almost twice as onerous to the business traveler versus the line haul time, indicating a preference for ease of access. Access/egress time is determined by station location. Travelers are more likely to choose the mode with the station (rail station, airport, or bus station) closest to their trip origin, particularly for shorter trips where the access/egress time are a larger portion of the total travel time.
- Cost was split into two variables, applicable to either premium modes (Air/Intercity-Express Rail) or Non-Premium modes (Auto, Intercity Bus, Intercity-Corridor, and Commuter rail). The cost coefficient for the premium modes is approximately half of that for the non-premium modes. This segmentation was done on the basis that premium modes have a very different cost structure than the non-premium modes, and an increase in cost for those modes would have less of an impact on the respondents' choice than a similar increase in cost on the non-premium modes. Business travelers are also less likely to personally pay for travel, and are therefore less sensitive to the price differential between the premium and non-premium modes.
- The business value of time varied by mode because the cost variable is split into two variables based on mode. The VOT for the premium modes was around $92/hour and for the non-premium modes it was around $41/hour. These are typical values for business travelers, and show that they are willing to pay higher prices to save time.

- The adjusted frequency variable uses the dampened frequency formulation, which essentially allows frequency to impact mode choice up to approximately 50 trains per day, at which point the impact tapers off. The strong negative value indicates that low values of frequency have a large negative impact on business travelers taking that mode, which is intuitive because business travelers usually have tighter constraints on their travel timing, and low frequencies would require them to potentially build in extra time for their entire trip. As they have high values of time, they are more willing to shift to a mode (even if it is more expensive) if it allows them to more tightly control the timing of their trip.
- The nesting coefficients indicate a moderate substitutability among the rail modes, and a less strong substitutability among the non-premium rail modes.

Table 14: Business Model Specification

Variable	Coeff.	T-Stat
Rail ASC	-1.18	-9.9
Auto ASC	0.00	n/a
Air ASC	-0.78	-3.8
Intercity Bus ASC	-0.22	-1.4
Total Travel Time	-0.011	-10.1
Access/Egress/Connect Travel Time	-0.0087	-5.5
Total Cost - Premium Modes (Air/Intercity-Express Rail)	-0.0073	-7.2
Total Cost - Non-Premium Modes	-0.016	-8.3
Adjusted Frequency	1.45	6.8
Rail Nest	0.65	13.7
Non-Premium Rail Nest	0.97	9.2

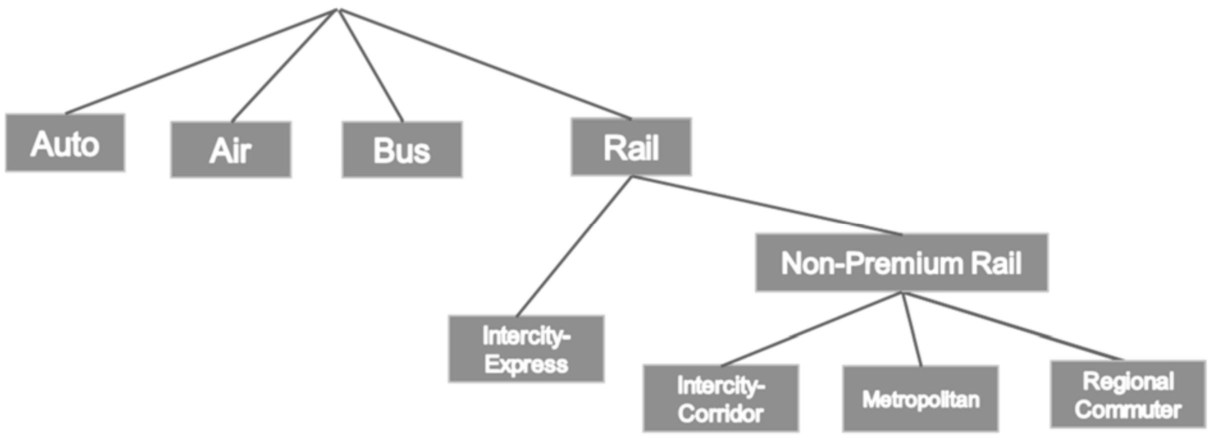
Log Likelihood		Rho-squared	
Constants Only	Final	w.r.t Zero	w.r.t. Constants
-9450.26	-8636.67	0.2016	0.0861

Estimation Records	
RP Records	1,487
SP Records	11,907
Total Records	13,394

Source: NEC FUTURE team, 2015

Figure 10 shows the final nesting structure used for the business mode choice model, selected due to best-fitting nesting coefficients and the intuitive explanation for mode of travel selection by business travelers. This nesting structure illustrates that business travelers view the premium rail service as distinct from the other rail services. Therefore the model indicates that the non-premium rail modes should be nested together.

Figure 10: Business Model Nesting Structure



Source: NEC FUTURE team, 2015

To test the reasonableness of the model results, the FRA calculated rail travel time and cost elasticities, and reviewed the results to make sure they fell in acceptable ranges. Previous experience suggests that the time and cost elasticities for intercity rail are typically within a range of -0.3 to -2. That range of -0.3 to -2 for elasticities indicates that 20% increases and decreases in the values of the service characteristics of a mode would shift that mode's share by 6% to 40%. A 40% mode share shift would indicate a large impact, and is only anticipated on the longer distance travel markets. For example, if rail currently has a 12% mode share and the calculated elasticity is -2 based on a 20% decrease in travel time, the mode share would be shifted by 40%, or would have a new mode share of 16.8%.

Table 15 shows the estimated elasticities for a 20% increase and a 20% decrease in selected rail service characteristics for key markets. Due to the structure of the logit model, the estimated elasticity depends on both the model coefficients and the relative values of modal attributes (for all modes) which vary by market.

Table 15: Business Model Service Variable Elasticities

Variable/Market	Elasticities		% Change in Mode Share	
	+20%	-20%	+20%	-20%
Intercity-Express Train Time (+20% / -20%)				
Boston - New York	-0.99	-0.79	-20%	16%
Boston – Washington	-1.81	-0.90	-36%	18%
New York – Philadelphia	-0.58	-0.57	-12%	11%
New York – Washington	-0.98	-0.80	-20%	16%
Philadelphia – Washington	-0.69	-0.66	-14%	13%
Intercity-Corridor Train Time (+20% / -20%)				
Boston - New York	-1.45	-0.92	-29%	18%
Boston – Washington	-2.41	-1.15	-48%	23%
New York – Philadelphia	-0.62	-0.67	-12%	13%
New York – Washington	-1.20	-0.83	-24%	17%
Philadelphia – Washington	-0.73	-0.66	-15%	13%
Intercity-Express Train Cost (+20% / -20%)				
Boston - New York	-1.06	-0.84	-21%	17%
Boston – Washington	-1.97	-0.94	-39%	19%
New York – Philadelphia	-0.63	-0.62	-13%	12%
New York – Washington	-1.04	-0.84	-21%	17%
Philadelphia – Washington	-0.75	-0.72	-15%	14%
Intercity-Corridor Train Cost (+20% / -20%)				
Boston - New York	-1.76	-1.04	-35%	21%
Boston – Washington	-3.41	-1.33	-68%	27%
New York – Philadelphia	-0.67	-0.74	-13%	15%
New York – Washington	-1.50	-0.90	-30%	18%
Philadelphia – Washington	-0.80	-0.71	-16%	14%

Source: NEC FUTURE team, 2015

3.2.5 Non-Business Purpose Model

3.2.5.1 Process Description

The model estimation process for the Non-Business model followed the general procedures outlined in Section 3.2.3. Specific observations about the estimation process were:

- The combined RP/SP model had time and cost parameter estimates that yielded unreasonable sensitivity estimates and the ASCs were much larger than the ASCs in the RP only and SP only models, which means a large amount of the explanatory power was shifted from the service variables to the ASCs. The RP only model and SP only model had similar parameter estimates for time and cost which appeared reasonable; however, the rank order of the ASCs differed between the RP only and SP only model. For instance, the bus mode was highly ranked in the RP model but low ranked in the SP model. One interpretation of that finding is that people say in a telephone survey that they aren't interested in taking the bus, but in actuality they do take the bus more often than one would expect given its cost and travel time. In the model that combined RP and SP data, that tension between the RP and SP data regarding the ASCs may have been the cause of difficulties in estimating appropriate parameters for the other service characteristics. Since the combined RP/SP data did not yield reasonable results and expert consensus is that RP data is preferred to SP, the RP only model was chosen as the final model. However it is important to reiterate that the elasticities from the RP only model were very similar to those from the SP only model. Because non-business was the most common trip purpose in the survey data (73.6%) there were sufficient number of records (8,731) to estimate a robust model. The number of records available for the other purposes was not sufficient to estimate an RP only model.

- Similarly to the Business model, removing mode share weights (using sample weights only) produced more reasonable ASCs. Using the mode share weights, which were applied at the MSA-to-MSA level, the differences between the ASCs were larger than typically accepted, and were accounting for most of the mode choice utility.
- After testing 12 nesting structures for the RP only model, the best-fitting structure was the rail nest (structure #4), combining all rail modes. This was determined by using the statistical fit measures of the nesting structures, as well as the statistical significance of the variables.
- Dampened frequency performed better than trains per day, and -0.08 was the preferred parameter (values were tested between -0.1 and -0.03), as it had the best statistical fit. The value of -0.08 is a typical value used in other intercity rail models, which means that train frequency is saturated at around 50 trains per day, or that additional trains over 50 per day do not impact the mode choice decision.
- Un-adjusted travel time and cost produced too-high sensitivities at the upper end of the time and cost values. As discussed in the methodology section, time and cost do not necessarily have a linear relationship, as an additional 10 minutes of travel time would typically impact a 20 minute base trip time more negatively than it would for a 120 minute trip time.
- Since the straight time and cost were producing unreasonable results, the dampened versions using highway distance were tested. The models using dampened travel time and cost did not converge.
- Using straight travel time combined with log of cost as well as a piecewise linear transformation of cost using four segments both produced reasonable sensitivities. The four segment cost variable was chosen for the final specification which allows the model the account for the finding that higher cost trips tend to be less sensitive to additional cost than less expensive trips.
- The ASCs for the four rail modes were tested by constraining some or all of them to be equal to each other. Constraining the ASCs reduced the impact of the frequency variable, which was not desirable because frequency is an important defining characteristic of the commuter rail option. Therefore the ASCs were left unconstrained.
- As mentioned above, the estimated ASC for bus shows that its un-modeled attributes (attributes other than time, cost, and frequency) make it a relatively attractive mode. These un-modeled attributes may include its usually flexible fares policies which allow a rider to choose an earlier or later departure if space is available or buying tickets last minute without paying large fare premiums.

- The Metropolitan train ASC is asserted to be the same as the Regional Commuter train based on the SP only model results (as there is no Metropolitan train mode in the RP only data).

3.2.5.2 Estimation Results

Table 16 presents the results of the model estimation, with specific descriptions of each variable below:

- The ASCs represent the unobserved attributes of each mode, and indicate the order and magnitude of mode preference given all other attributes held constant. The non-business model shares the same ASC ordering as the business model, with Auto as the base mode and all other ASCs having negative coefficients, indicating that Auto is the preferred mode, with Bus being highly competitive, Air being the third preferred, and the rail modes being the least preferred. The rail modes all have similar ASCs, but more preference is given to the faster services (like Intercity-Express).
- The access/egress portion of travel time is accounted for by adding up the Total Travel Time and Access/Egress/Connect Travel Time coefficients, and is therefore twice as onerous to the non-business traveler versus the line haul time, indicating a preference for ease of access. The relationship between the two types of time is similar to that seen in the business model, but the magnitude of the coefficients in the non-business model are approximately half of those in the business model, indicating time is less of a factor in the mode choice decision for non-business travelers as opposed to business travelers.
- Cost was included in the model as a piecewise linear transformation of cost using four segments. This specification allows the model the account for the finding that higher cost trips tend to be less sensitive to additional cost than less expensive trips.
- The non-business value of time varied by the total cost of the trip. The VOT for a trip costing less than $50 was around $6/hour, while a trip which cost $100 had a VOT of $9/hour, and a trip costing $200 had a VOT of $18/hour. These are lower values than have been seen in the corridor in the past, and indicate that price is becoming a particularly important piece of the mode choice decision, especially given that approximately 70% of travel in the study area is currently non-business. One reason for this shift in cost sensitivity could be the increased prevalence of low-cost Intercity Bus service that has occurred over the past several years, making travelers more aware of cheaper options in the interregional market.
- The adjusted frequency variable uses the dampened frequency formulation, which essentially allows frequency to impact mode choice up to approximately 50 trains per day, at which point the impact tapers off. The frequency coefficient has a much lower impact in the non-business model as opposed to the business model, as typically non-business travel is for leisure, recreation, or other purposes which have much less tight time constraints, and are more amenable to fewer options for departure time (and therefore fewer trains per day).
- The nesting coefficients indicate a moderate substitutability among the rail modes.

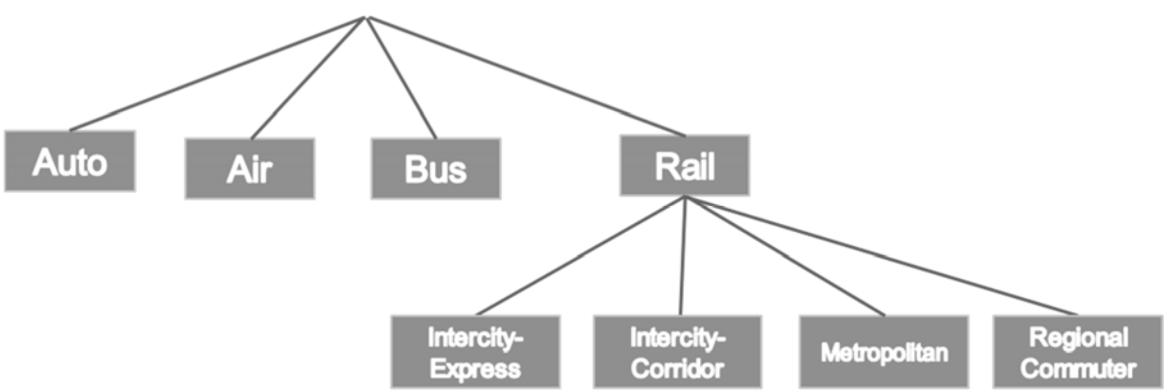
TABLE 16: NON-BUSINESS MODEL SPECIFICATION

Variable		Coeff.	T-Stat
Intercity-Express Rail ASC		-1.54	-5.7
Intercity-Corridor Rail ASC		-1.84	-7.7
Regional Commuter Rail ASC		-2.09	-9.2
Metropolitan Rail ASC		n/a	n/a
Auto ASC		0.0	n/a
Air ASC		-1.22	-4.3
Intercity Bus ASC		-1.11	-5.6
Total Travel Time		-0.0055	-8
Access/Egress/Connect Travel Time		-0.0056	-3.8
Total Cost <$50		-0.059	-9.1
Total Cost $50-$99		-0.029	-6.8
Total Cost $100-$149		-0.014	-3.3
Total Cost > $150		-0.010	-5.1
Adjusted Frequency		0.46	1.9
Rail Nest		0.7417	10.5
Log Likelihood		**Rho-squared**	
Constants Only	Final	w.r.t Zero	w.r.t. Constants
-5170.41	-4776.59	0.5698	0.0762
Estimation Records			
RP Records	8,657		
SP Records	-		
Total Records	8,657		

Source: NEC FUTURE team, 2015

Figure 11 illustrates the final nesting structure used in the non-business mode choice model, selected due to the best-fitting nesting coefficient. Non-business travelers are much more diverse, and do not exhibit strong travel patterns as a group like the other two purposes, so their nesting structure is simpler.

Figure 11: Non-Business Model Nesting Structure



Source: NEC FUTURE team, 2015

To test the reasonableness of the model results, travel time and cost elasticities, the FRA calculated and reviewed results to make sure they are in acceptable ranges, typically within a range of -0.3 to -

2. This range is discussed in more detail in Section 3.2.4. Table 17 shows the elasticities for 20% increases and decreases in the variables for key markets.

TABLE 17: SERVICE VARIABLE ELASTICITIES

Variable/Market	Elasticities		% Change in Mode Share	
	+20%	-20%	+20%	-20%
Intercity-Express Train Time (+20% / -20%)				
Boston - New York	-0.71	-1.44	-14%	29%
Boston – Washington	-1.24	-1.59	-25%	32%
New York – Philadelphia	-0.36	-1.30	-7%	26%
New York – Washington	-0.68	-1.42	-14%	28%
Philadelphia – Washington	-0.45	-1.23	-9%	25%
Intercity-Corridor Train Time (+20% / -20%)				
Boston - New York	-0.72	-1.20	-14%	24%
Boston - Washington	-1.04	-0.79	-21%	16%
New York - Philadelphia	-0.32	-1.19	-6%	24%
New York - Washington	-0.58	-1.17	-12%	23%
Philadelphia - Washington	-0.38	-1.16	-8%	23%
Intercity-Express Train Cost (+20% / -20%)				
Boston - New York	-0.80	-1.91	-16%	38%
Boston - Washington	-1.52	-2.06	-30%	41%
New York - Philadelphia	-0.39	-2.33	-8%	47%
New York - Washington	-0.77	-1.86	-15%	37%
Philadelphia - Washington	-0.49	-2.16	-10%	43%
Intercity-Corridor Train Cost (+20% / -20%)				
Boston - New York	-0.79	-1.85	-16%	37%
Boston - Washington	-1.07	-1.16	-21%	23%
New York – Philadelphia	-0.34	-1.65	-7%	33%
New York – Washington	-0.62	-1.58	-12%	32%
Philadelphia – Washington	-0.40	-1.40	-8%	28%

Source: NEC FUTURE team, 2015

3.2.6 Commute Purpose Model

3.2.6.1 Process Description

The model estimation process for the Commute model followed the general procedures outline in Section 3.2.3. Specific observations about the estimation process were:

- The RP only model had difficulty converging during initial testing. Non-switching auto records were removed to achieve convergence. These records are respondents whose RP mode was auto and they selected auto for all SP experiments, as explained in Section 3.2.2. The removed records accounted for about half of the commute records. These commuters are most likely auto-dependent and would never switch to a group transport mode.
- Unlike the other two models, the mode share weights were required to obtain convergence.
- Removing air from the choice set improved ASCs and time/cost coefficients. Since only 1.4% of respondents chose air as either their current mode or in the SP questions, air is not a logical

choice for commuting, and therefore the model was struggling to compensate for having it as a choice.

- The group transport nest structure (structure #7) produced the best model fit statistics. Most of the other nesting structures would not converge or did not have nesting coefficients which fell in the theoretically acceptable range of 0-1.
- Dampened frequency performed better than trains per day, and -0.08 was the preferred parameter (values were tested between -0.1 and -0.03), as it had the best statistical fit. The value of -0.08 is a typical value used in other intercity rail models, which means that train frequency is saturated at around 50 trains per day, or that additional trains over 50 per day do not impact the mode choice decision.
- Travel time and cost have a smaller range of values in the commute model versus the other models, and therefore an un-transformed variable for each produced reasonable time and cost sensitivities.
- One expects that the impact of an additional minute of access/egress/connect time to be higher than an additional minute of line-haul time, but ratio of the estimated parameters was much higher than could be reasonably expected. To correct for this issue, a range of constraints on the ratio of the parameters was explored: 1.0, 1.5, and 2.0 of line-haul time. Constraining the ratio to be 1.5 was determined to be the best choice for the final model.
- Multiple formulations were tested of constraining the rail ASCs to be equal, and it was determined they were best left unconstrained in the combined RP/SP model.
- Regional Commuter rail is the highly dominant mode in the commuter market as shown by the high value estimated for its ASC. The attractiveness of commuter rail in the long distance commuter market is primarily due to its high frequency, flexibility of tickets, and comfort relative to the auto mode.

3.2.6.2 Estimation Results

Table 18 presents the results of the model estimation, including specific descriptions of each variable below:

- The ASCs for the commute model exhibit a different pattern than those shown in the business and non-business models. The order of mode preference correlates strongly to the cost of the modes, with Commuter and Metropolitan rail being the most preferred, next Auto, then Intercity Bus, Intercity-Corridor, and finally Intercity-Express.
- The ratio of access/egress travel time to line haul time was constrained in the commute model, unlike the other two models. The ratio that was determined to have the best fit was approximately 2.5, making access/egress time more onerous in the commute model than in the other two models. Commute trips are typically shorter than the other interregional trips, and percentage of the total trip which is the access/egress portion is greater, making it a more important piece of the overall trip. The magnitude of the total travel coefficient is similar to that used in the non-business model.

- Cost was included as a linear variable in the commute model, which is a reasonable assumption given that the interregional commute trip is generally shorter than the other purposes, and therefore doesn't have as much variation in cost, and does not need to be scaled.
- The commute value of time is constant for all commute trips, and is approximately $28/hour. This is a slightly higher value than anticipated for the commute trip, but the ASCs account for a large portion of the utility equations, and show a strong preference toward the cheaper modes.
- Similar to the other two models, the frequency variable uses the dampened frequency formulation, and is an important piece of the commute mode choice. Similarly to business travel, commuters typically have tight time constraints, and more frequent trains allow them to manage their time effectively.
- The nesting coefficients indicate a moderate substitutability among the group transport modes, which is intuitive, as the major trade-off for commuters is driving alone or taking some form of transit.

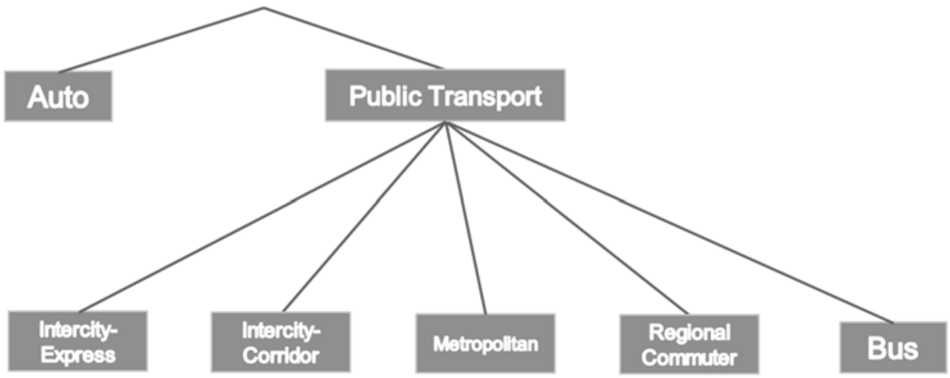
TABLE 18: COMMUTE MODEL SPECIFICATION

Variable		Coeff.	T-Stat
Intercity-Express Rail ASC		-2.20	-4
Intercity-Corridor ASC		-1.24	-6.3
Regional Commuter Rail ASC		1.59	8.5
Metropolitan Rail ASC		0.17	n/a
Auto ASC		0.00	n/a
Intercity Bus ASC		-0.19	-0.8
Total Travel Time		-0.0057	-8.8
Access/Egress/Connect Travel Time		-0.0085	n/a
Total Cost		-0.012	-6.9
Adjusted Frequency		1.22	4.3
Group Transport Nest		0.80	11.4
Log Likelihood		**Rho-squared**	
Constants Only	Final	w.r.t Zero	w.r.t. Constants
-3495.35	-3196.12	0.2096	0.0856
Estimation Records			
RP Records		642	
SP Records		3,619	
Excluded Air Records		129	
Excluded Auto Non-Switcher Records		3,626	
Total Records		4,261	

Source: NEC FUTURE team, 2015

Figure 12 shows the final nesting structure for the Commute model, selected due to the best-fitting nesting coefficient. The primary decision for a commuter falls between auto and some form of public transport, as shown by the nesting structure.

Figure 12: Commute Model Nesting Structure



Source: NEC FUTURE team, 2015

To test the reasonableness of the model results, travel time and cost elasticities were calculated and reviewed to make sure they are in acceptable ranges, typically within a range of -0.3 to -2, as described in detail in Section 3.2.4.2. Table 19 shows the elasticities for 20% increases and decreases in the variables for key markets.

TABLE 19: SERVICE VARIABLE SENSITIVITIES

Variable/Market	Commute		% Change in Mode Share	
	+20%	-20%	+20%	-20%
Intercity-Express Train Time (+20% / -20%)				
Boston - New York	-0.82	-1.92	-16%	38%
Boston – Washington	-1.51	-2.21	-30%	44%
New York – Philadelphia	-0.40	-1.21	-8%	24%
New York – Washington	-0.79	-1.89	-16%	38%
Philadelphia – Washington	-0.50	-1.45	-10%	29%
Intercity-Corridor Train Time (+20% / -20%)				
Boston - New York	-0.93	-0.86	-19%	17%
Boston - Washington	-1.37	-0.90	-27%	18%
New York - Philadelphia	-0.39	-0.63	-8%	13%
New York - Washington	-0.80	-0.82	-16%	16%
Philadelphia - Washington	-0.49	-0.65	-10%	13%
Intercity-Express Train Cost (+20% / -20%)				
Boston - New York	-0.97	-3.07	-19%	61%
Boston - Washington	-2.13	-3.84	-43%	77%
New York - Philadelphia	-0.43	-1.59	-9%	32%
New York - Washington	-0.94	-3.00	-19%	60%
Philadelphia - Washington	-0.56	-2.03	-11%	41%
Intercity-Corridor Train Cost (+20% / -20%)				
Boston - New York	-1.10	-1.01	-22%	20%
Boston - Washington	-1.64	-1.01	-33%	20%
New York – Philadelphia	-0.42	-0.71	-8%	14%
New York – Washington	-0.92	-0.94	-18%	19%
Philadelphia – Washington	-0.54	-0.73	-11%	15%

Source: NEC FUTURE team, 2015

3.3 INTERREGIONAL MODEL APPLICATION PROCESS

The Interregional Model application process involved multiple steps: processing the model inputs by mode; incorporating rail service schedules representing each alternative; assigning rail station pairs to each zone pair; and calculating the results of both pieces of the Interregional Model (total demand and mode choice).

The FRA used spreadsheet-based applications of both the total demand and mode choice models, and automatically computed the trips by mode once the inputs were formatted and inserted in the spreadsheet model.

3.3.1 Model Inputs by Mode

The primary inputs for the mode choice models were the service characteristics of the available modes: time (access/egress and line haul), cost, and frequency of service. For the non-rail modes (auto, air and intercity bus), the service characteristics were held constant across all alternatives and were based on existing service. The Service Plans vary by alternative and are described in detail in Section 5.3.

3.3.1.1 Auto

The FRA determined auto mode service characteristics for the base year using the process described in Section 3.2.1.1. For future year alternatives, the FRA applied additional congestion factors to the individual metropolitan areas based on information analyzed as part of the regional modeling effort. These factors ranged from 1% to 15%, with an average trip being 7-8% longer than the base year.

The regional forecasting models used forecasts of region-specific increases in automobile travel times to account for the effects of additional regional highway system congestion. Those same regional forecasts of highway travel times were used as the basis for forecasts of highway travel times for the Interregional Model. The FRA recognizes that interregional highway travelers experience urban congestion only during some portions of their journey, and that the urban congestion they experience will depend on what time of day (peak or off peak) they travel through each urban area. The approach for combining the regional forecasts for inclusion in the Interregional Model involved the following steps:

- Identified the 2040 forecasted local MPO-based estimates of travel time growth from the regional models for zonal pairs contained in the key corridors (notably I-95 and I-84). The resulting peak-period travel time changes between base year and forecast year are summarized in the first column of Table 20.
- Identified the number of people experiencing peak-period congestion. This was done by looking at New York Metropolitan Transportation Council (NYMTC) Hub-Bound estimates of Amtrak entries and exits into Manhattan over the course of an average weekday. With approximately three quarters of existing Amtrak customers beginning or ending their trip in New York City, the New York hourly counts provide a basis to identify what percentage rail riders would experience congestion on a typical weekday in each metropolitan region today. By knowing when

passengers typically arrive and depart NYC, it is possible to trace back the time of day that they hit other urban areas on their route.

- Established the average weekday peak highway travel time degradation by metropolitan area. This was done by multiplying the peak-period congestion change by the number of existing rail riders who experience congested conditions. This in effect averages the locally forecasted effects of additional highway system congestion over the course of an entire day.

TABLE 20: CURRENT YEAR TO 2040 MPO ESTIMATES OF HIGHWAY DEGRADATION APPLIED TO THE INTERCITY FORECASTING MODEL

Metropolitan Area	Time Degradation MPO	Pct of Day Congested	Peak Degradation
Washington	55%	28%	15.5%
Baltimore	8%	31%	2.3%
Philadelphia	5%	47%	2.1%
New York	20%	52%	10.4%
Rhode Island	4%	31%	1.2%
Boston	36%	29%	10.3%

Source: NEC FUTURE team, 2015

3.3.1.2 Air

Air characteristics for all alternatives (Existing Year, No Action, and all Action Alternatives) were held constant and were calculated using the procedures described in Section 3.2.1.2.

3.3.1.3 Bus

The bus service characteristics differed slightly from those used in model estimation, due to the availability of a new dataset, the Northeast Corridor Bus Schedule and Ridership Data. This dataset included frequencies and costs for most station pairs in the NEC, which were filled in as needed with frequencies from published time tables and costs calculated from a travel-time based formula estimated from the existing fares in the dataset.

The bus travel times used were still based on the auto travel times, for consistency, but future alternatives (No Action and Action) included the congestion factors described in Section 3.3.1.1, as well as an additional factor of 1.1 to account for the slower speeds of the buses, based on professional judgement and the bus travel times in the NEC bus dataset.

3.3.1.4 Rail

All of the service attributes described by mode above were static across the alternatives, and there were two processes which were alternative-specific, including processing the Service Plans and associated rail station assignment. These are described below.

Rail Station Assignment

The FRA's next step was to run the rail station assignment procedure, which ensures the best rail path is chosen for each zone pair. The Interregional Model assigns a single station pair to each zone pair to develop the appropriate rail service characteristics for each zonal pair. The FRA developed a simple utility model which examines the access/egress travel times, total travel times, daily frequencies, whether or not an integrated transit service is available, and transit factor terms (see the equations below). Two Transit Factor terms representing the two levels of transit systems present in the corridor were applied, one for the New York City zones (NYC Transit Factor) and one for the Boston, Washington, and Philadelphia zones (BosWasPhl Transit Factor). The assignment process selected the station pair with the maximum utility for each zone pair. The utility equations were calibrated iteratively until the catchment areas generally matched actual ridership patterns around major stations. The utility equations are based on the mode choice utilities estimated for the Interregional Model and are as follows:

$$\begin{aligned} Express\ Utility &= -0.00546 \times Line\ Haul\ Travel\ Time + (-0.011 * 1.5) \\ &\times (Access\ Travel\ Time + Egress\ Travel\ Time) + 0.2 \\ &\times \ln\left(1 - e^{-0.08 \times Daily\ Frequency}\right) + 2.25 \times (NYC\ Transit\ Factor_O \\ &+ NYC\ Transit\ Factor_D) + 2 \times (BosWasPhl\ Transit\ Factor_O \\ &+ BosWasPhl\ Transit\ Factor_D) \end{aligned}$$

$$\begin{aligned} Non-Express\ Utility &= -0.00546 \times Line\ Haul\ Travel\ Time + (-0.011 * 2) \\ &\times (Access\ Travel\ Time + Egress\ Travel\ Time) + 0.2 \\ &\times \ln\left(1 - e^{-0.08 \times Daily\ Frequency}\right) + 2.25 \times (NYC\ Transit\ Factor_O \\ &+ NYC\ Transit\ Factor_D) + 1 \times (BosWasPhl\ Transit\ Factor_O \\ &+ BosWasPhl\ Transit\ Factor_D) \end{aligned}$$

3.3.2 Base Year Service Characteristics by Mode

Base year service characteristics for all modes for select city pairs are shown in Table 21 through Table 23. These tables illustrate the trade-offs in service characteristics among modes. For the Tier I EIS Alternatives, the FRA held the air service characteristics constant at their current levels, while auto and bus experience travel time congestion (longer travel times). The rail service characteristics vary by alternative based on the Service Plans. The future year service characteristics are described in more detail in Section 5.

The auto travel costs in Table 22 are shown for full cost (used in the Business model) and for incremental cost (used in the Non-Business and Commute models). All other modes use a single cost for all models.

TABLE 21: LINE-HAUL TRAVEL TIME FOR SELECT CITY PAIRS (FOR CURRENT SERVICE)

Origin Market	Dest. Market	Distance (miles)	Auto	Air	Bus	Intercity-Express	Intercity-Corridor
Boston	Hartford	111	1:55	0:58	1:55	NA	5:01
Boston	New York	229	5:29	2:37	5:50	3:31	4:13
Boston	Philadelphia	322	7:01	2:10	7:31	4:53	6:00
Boston	Baltimore	416	8:53	2:11	9:42	5:57	7:16
Boston	Washington	456	9:50	2:26	10:33	6:33	8:02
Hartford	New York	120	3:50	2:31	4:13	NA	2:43
Hartford	Philadelphia	214	5:22	2:03	5:54	NA	4:24
Hartford	Baltimore	307	7:14	1:56	8:05	NA	5:37
Hartford	Washington	348	8:11	2:36	8:56	NA	6:20
Providence	New York	184	5:40	2:12	6:14	2:55	3:30
Providence	Philadelphia	278	7:13	2:35	7:56	4:17	5:17
Providence	Baltimore	372	9:05	1:40	10:07	5:21	6:33
Providence	Washington	412	10:02	2:20	10:58	5:57	7:19
New York	Philadelphia	95	2:14	1:24	2:28	1:07	1:23
New York	Baltimore	189	4:06	2:07	4:38	2:11	2:39
New York	Washington	229	5:04	3:18	5:30	2:47	3:23
Philadelphia	Baltimore	101	2:13	2:13	2:34	1:01	1:11
Philadelphia	Washington	141	3:11	2:38	3:26	1:37	1:55

Source: NEC FUTURE team, 2015

TABLE 22: TRAVEL LINE-HAUL COST FOR SELECT CITY PAIRS (FOR CURRENT SERVICE)

Origin Market	Dest. Market	Auto		Air	Bus	Intercity-Express	Intercity-Corridor
		Full ($0.55/mi)	Incremental ($0.15/mi)				
Boston	Hartford	$61	$17	$270	$29	NA	NA
Boston	New York	$126	$34	$170	$29	$141	$79
Boston	Philadelphia	$177	$48	$228	$52	$202	$101
Boston	Baltimore	$229	$62	$109	$46	$228	$108
Boston	Washington	$251	$68	$144	$43	$211	$101
Hartford	New York	$66	$18	$326	$30	NA	$44
Hartford	Philadelphia	$117	$32	$198	$30	NA	$84
Hartford	Baltimore	$169	$46	$130	$39	NA	$98
Hartford	Washington	$191	$52	$227	$43	NA	$98
Providence	New York	$101	$28	$390	$29	$139	$73
Providence	Philadelphia	$153	$42	$241	$39	$197	$98
Providence	Baltimore	$204	$56	$220	$48	$220	$104
Providence	Washington	$227	$62	$160	$51	$218	$99
New York	Philadelphia	$52	$14	$54	$31	$135	$61
New York	Baltimore	$104	$28	$133	$24	$189	$94
New York	Washington	$126	$34	$272	$25	$194	$94
Philadelphia	Baltimore	$55	$15	$122	$17	$104	$51
Philadelphia	Washington	$78	$21	$219	$14	$129	$63

Source: NEC FUTURE team, 2015

TABLE 23: DAILY FREQUENCIES FOR SELECT CITY PAIRS (FOR CURRENT SERVICE)

Origin Market	Dest. Market	Air	Bus	Intercity-Express	Intercity-Corridor
Boston	Hartford	4	11	NA	NA
Boston	New York	16	69	10	9
Boston	Philadelphia	20	3	10	8
Boston	Baltimore	15	2	10	8
Boston	Washington	22	2	10	8
Hartford	New York	4	26	NA	6
Hartford	Philadelphia	8	2	NA	5
Hartford	Baltimore	7	1	NA	5
Hartford	Washington	5	2	NA	5
Providence	New York	4	14	10	9
Providence	Philadelphia	7	2	10	8
Providence	Baltimore	16	1	10	8
Providence	Washington	16	1	10	8
New York	Philadelphia	7	83	16	32
New York	Baltimore	6	69	16	22
New York	Washington	7	93	16	22
Philadelphia	Baltimore	8	17	16	22
Philadelphia	Washington	9	17	16	22

Source: NEC FUTURE team, 2015

3.3.3 Model Calibration

As mentioned in Section 2.2.3.4, MSA-level calibration factors were required to match the base year mode shares at more detailed geographic level. To match current mode shares, the mode choice model was calibrated both at the MSA level and for select stations, by adding calibration factors to the ASCs for each zone pair. The MSA-level factors ranged from -14.58 to 10.00 with an average value of -1.33, and were applied to trips that had either end in the particular MSA.

The station-level calibration was done to account for the integrated transit systems that are present in Boston, New York City, Philadelphia, and Washington. This additional factor was only applied to station and zone combinations that are within the transit system areas. These station-level factors ranged from -4.00 to 3.80 with an average factor of 0.51, and worked to shift rail trips within the MSA to the more urban zones from a more uniform distribution across the entire MSA (negative factors were applied to suburban stations and positive factors were applied to urban stations). Because the local transit systems (and other access/egress modes) were not modeled explicitly in the mode choice models, this factor helped shift the modeled rail travel towards zones that were more transit accessible.

The final calibrated ASCs for each MSA pair were calculated using the following formula:

Calibrated ASC_{ij} = Estimated ASC + MSA_i factor + MSA_j factor + $Station_i$ factor + $Station_j$ factor

In general, in the MSA pairs which did not include the station-level calibration, the calibrated ASCs contributed to approximately half of the total utility of each mode. Thus unspecified factors such as individual perceptions of the mode, schedule preferences, auto ownership, and regional factors account for approximately half of the mode choice. Given the geographic extent of the Study Area, large differences in the performance of modes are anticipated across different regions, and the ASCs are used to adjust the mode preference accordingly.

3.3.4 Summarize Model Outputs

The primary output of the model was trips by mode for each zonal pair, which can be described in various ways to support alternatives evaluation. The FRA chose to use the following model outputs for NEC Future.

- Annual trips by mode for two levels of geographic aggregation:
  - MSA areas (collectively do not cover entire Study Area)
  - Greater metropolitan area (collectively covers the entire Study Area), which are shown in Figure 5.
- Annual rail passenger miles
- Annual and average weekday passengers at two levels:
  - Station boardings
  - Station-to-station ridership

4 Regional Models

The FRA applied six separate regional forecasting models during the evaluation of the NEC FUTURE alternatives. From these the key alternative attributes that will drive the magnitude of the forecasting results are:

- Rail travel time
- Access travel time
- Egress travel times
- Number of transfers required to make the trip
- Rail service frequency
- Attributes of competing modes including automobile and other transit modes (depending on the region - subway, bus, ferry and light rail transit [LRT])
- Total costs of travel (fares, park-and-ride costs and connecting transit service costs, if required)

While leveraging existing, off-the-shelf tools to the maximum extent possible, the FRA performed additional model development where targeted model improvements were required to prepare high-quality Regional rail forecasts. A discussion of each of the tools employed and their application is provided below by metropolitan region.

4.1 WASHINGTON, D.C., – WMATA TRANSIT POST-PROCESSOR OF THE MWCOG REGIONAL FORECASTING MODEL

The WMATA transit post-processor of the MWCOG regional forecasting model was used as the basis for the NEC FUTURE Regional rail forecasting in the Washington, D.C., metropolitan area. The model includes a complete representation of:

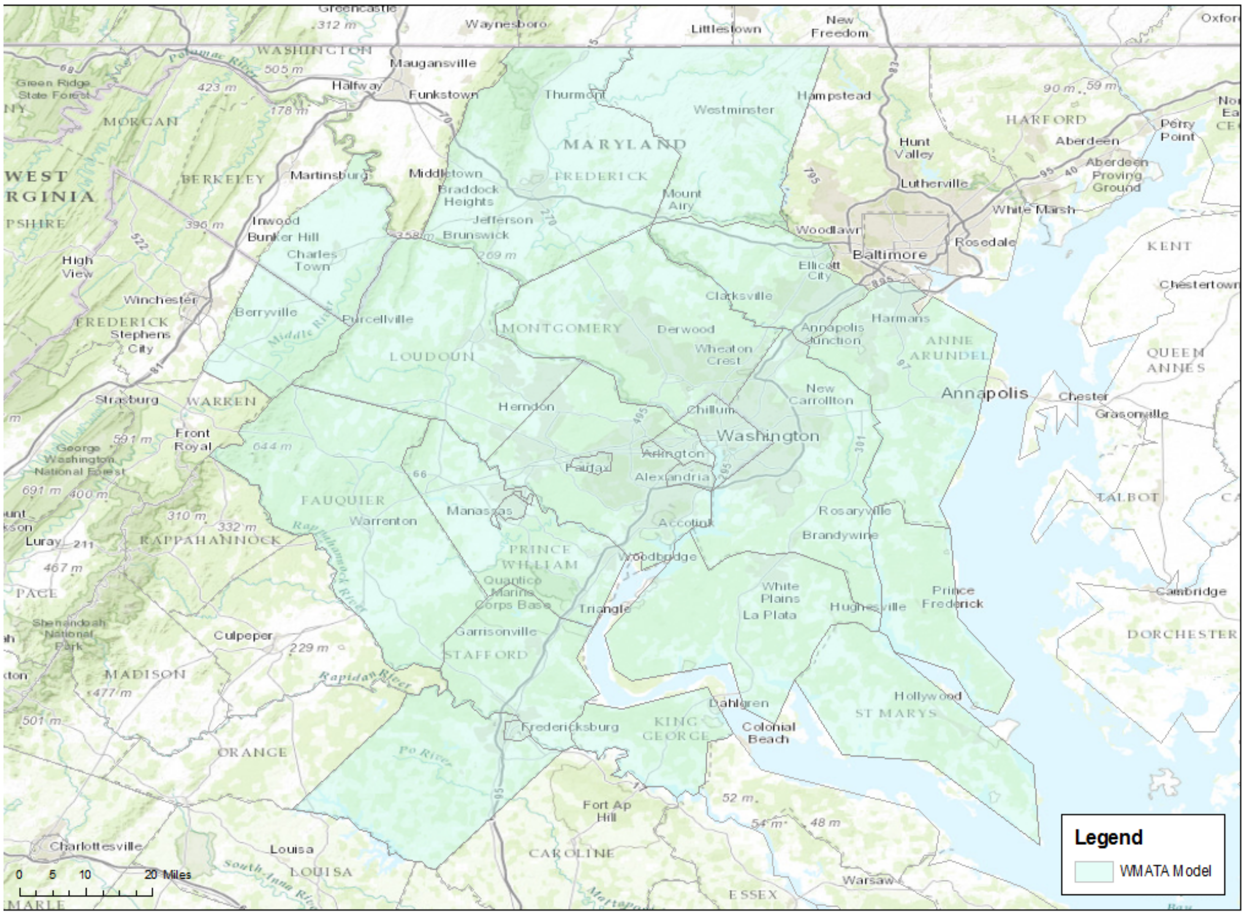
- Virginia Railway Express (VRE) service
- Maryland Area Regional Commuter (MARC) Brunswick service
- MARC Penn Line (Baltimore-Washington International [BWI] Airport to Union Station)
- MARC Camden Line (Dorsey to Union Station)
- WMATA Metrorail
- All regional bus service (WMATA Metrobus, DASH, ART, Ride On, Fairfax Connector, PRTC, TheBus and MTA Commuter Bus)

The counties included in the WMATA/MWCOG forecasting model include:

- **Maryland:**
  - Carroll County
  - Howard County
  - Anne Arundel County
  - Calvert County
  - St. Mary's County
  - Charles County
  - Prince Georges County
  - Montgomery County
  - Frederick County
- **District of Columbia**
- **Virginia:**
  - Arlington County
  - City of Alexandria
  - Fairfax County, including cities of Fairfax, Falls Church, Vienna
  - Prince William County, including City of Manassas and Manassas Park
  - Loudon County
  - Stafford County
  - Fauquier County
  - Spotsylvania County
  - Clarke County
- **West Virginia**
  - Jefferson County

Figure 13 provides a map of the WMATA/MWCOG modeling region.

Figure 13: WMATA/MWCOG Modeling Region



Source: NEC FUTURE team, 2015

The WMATA transit post-processor adds several improvements to enhance forecasting capabilities for transit. These improvements include:

- More detailed representation of Metrorail Stations and their access options. Inclusion of a "pedestrian environment variable", which uses census blocks per square mile as a measure of walk-ability within the metropolitan Washington, D.C. area. This measure was successful in explaining why some geographic areas have high transit market shares and other areas have lower transit market shares.
- Substitution of a mode choice model in place of geographically based, transit sub-mode specific constants. This approach more closely follows FTA New Starts guidance on ridership forecasting.
- Enhanced calibration and validation of the WMATA's Metrorail system.

The FRA determined during the model review process that further enhancements to the MWCOG/WMATA model were needed to support the NEC FUTURE alternatives evaluation. The section below discusses the necessary modifications.

4.1.1 Washington, D.C., Regional Rail Survey Data

The 2012 VRE and 2011 MARC on-board surveys facilitated the best available understanding of current commuter rail ridership patterns. These survey-based ridership patterns were used to calibrate and validate the NEC FUTURE regional models in Washington, D.C.

The model development approach, consistent with FTA best practices, started with the construction of a trip table for both the MARC and VRE customers based on survey data. The first step in the model calibration and validation process involved iteratively assigning this survey-based trip table to the regional model transit networks. The observed trip table was fed to the model for the purpose of determining if the networks, path-building, and assignment routines could replicate the surveyed travel patterns. These tests revealed that several model enhancements were required.

4.1.2 Washington, D.C., Regional Rail Network Improvements

Inspection of the WMATA networks indicated that the representation of key commuter rail stations and terminals required refinement to accurately represent the customer experience in access/egress and transfers at major urban stations. The existing model used generic two-minute access/entry and transfer times for all commuter rail stations. While those generic times are generally good enough for suburban stations, they understate the impedance associated with using the urban core stations, where the connections are more complicated, involve several complex transfers, and often include changes in elevations and grade (elevated to surface or elevated to underground). Most importantly, the models did not represent the difference in accessibility at Union Station between MARC (upstairs, often using high-level platforms) and VRE (downstairs with low-level platforms). The revised model provides an update to the egress and transfer times at the following stations:

- Union Station (VRE) – 6 min to Metro, 6 min to street
- Union Station (MARC) – 3 min to Metro, 3 min to street
- L'Enfant Plaza - – 4 min to Metro, 3 min to street
- Crystal City – 5 min to Metro, 5 min to street
- Alexandria – 6 min to Metro, 4 min to street

4.1.3 Washington, D.C., Regional Rail Path-Builder Refinements

The early survey assignments revealed that a large number of commuter rail trips were not assigned to the commuter rail networks from areas near the Metrorail system. That is, the model outputs for commuter rail could not replicate observed ridership on commuter rail. To better calibrate the model to match observed results, the following changes were made:

- Changed the weight on waiting time for commuter rail from 2.5 to 0.5.
- Adjusted the drive access weights upward from 1.5 to 2.5
- Implemented a 20% discount for commuter rail in-vehicle travel time.

- Reworked the path-building parameter that represents service frequency or "combined headways" for commuter rail.

The first adjustment was required because the commuter rail path-building procedures that identify the minimum path between all origins and destinations in the region used a very high weight for waiting time for commuter rail—2.5 times in-vehicle travel time (IVTT). In the Washington, D.C. area, Metrorail offers significantly more frequency than either MARC or VRE. While that waiting time relationship is likely accurate for higher frequency Metrorail and Metrobus service, it was set too high for the relatively infrequent commuter rail services offered currently. Customers who use commuter rail use the schedules and time tables to determine what time they need to arrive at the station so the heavy weight on waiting time for commuter rail needed to be adjusted downward.

The second adjustment was required because the original model output showed too many trips on the MARC Penn Line and too few trips on the MARC Camden Line. In addition to the high weight on waiting time (discussed above), the model had a relatively low weight on automobile access time 1.5 times IVTT. This combination of the high waiting time weight and the low drive-access weights meant the path-builder and the assignment routine routed more customers to Penn Line services and kept customers away from the Camden Line.

The 20% discount for commuter rail travel time is consistent with other models on the NEC (MTA and NJ TRANSIT) and provides additional favoring for the commuter rail to account for the fact that customers get a high-quality service, with guaranteed seats as compared to other regional transit modes.

The final adjustment involved tuning how the path-builder combines local and express train service for the purpose of calculating the waiting time (a surrogate for service frequency). The original model was set such that there was no tolerance for non-optimal trains, meaning only the fastest (express) trains were considered to be part of the minimum path and ignored the local trains from the selection of best path. The parameter was reset so that the path-builder would evaluate the composite travel time of waiting time and in-vehicle travel time. Doing so shifted the criteria, the path-builder uses so it would now accept a local train if the improved waiting time exceeded the extra travel time associated with choosing the local train. This adjustment significantly improved the station-level assignments by ensuring that local and express service were both evaluated by the path-builder.

With these adjustments, observed travel patterns were replicated for both MARC and VRE customers with the networks.

4.1.4 Washington, D.C., Regional Rail Mode Choice Calibration

Following the tuning of the transit path-building and assignment routines, the 2012 VRE and 2011 MARC on-board surveys were used to establish trip targets by trip purpose and geography, for the purpose of mode choice calibration. Several iterations were performed where: 1) the mode choice model was calibrated, 2) the resulting commuter rail trips were assigned to the refined networks and 3) the resulting output was reviewed and compared to observed ridership counts. The early attempts at mode choice calibration showed that while the overall total number of Regional rail trips was accurate the assignment of trips to individual stations was significantly different from the survey data.

The FRA compared the WMATA home-based-work trip table to the 2006-2010 American Community Survey (ACS) journey-to-work data. From this analysis, significant differences were found between the WMATA model (derived from the MWCOG gravity model) versus ACS data. Gravity models, often applied in urban forecasting models, frequently perform poorly for trip distribution. This is typically due to the fact that gravity models generally use only transportation performance as the basis for aligning where people live and work. In the real world, the drivers of residential choice include other factors such as housing stock, price of housing, and quality of schools.

To correct this issue, the home-based work trip table was rebuilt using an iterative proportional fitting (IPF or matrix balancing technique) such that:

- The total number of home-to-work flows originating and terminating in each Traffic Analysis Zone (TAZ) matches the MWCOG trip tables.
- The flow trips between TAZs matches the patterns observed in the Home-to-Work flows from the ACS.

The advantage of this approach was that it maintained consistency with the local regional trip making at the TAZ level and was consistent with local estimates of population and employment from trip generation, which is a significant portion of the model while replacing the weakest part of the forecasting process (trip distribution) with actual data. This change supplied the refined NEC FUTURE model with a total home-to-work person trip table that was more representative of measured behavior.

With the refinement to the total person trip table, the performance of the refined model greatly improved. However one imbalance remained that needed to be addressed. While the resulting forecasts showed the correct total number of commuter rail trips, the split between MARC and VRE was incorrect:

- MARC had 10% too few trips; while
- VRE had 10% too many trips

When attempting to identify the cause of the imbalance, it was found that the WMATA & MWCOG Models used values of time that are far in excess of typical urban forecasting models. Typically an urban model uses a value of time of between \$5/hour to \$18/hour (most are in the \$8-\$12/hour range). The WMATA and MWCOG mode choice models use values of times between \$31 and \$40/hour. These higher values of time mean that models are less sensitive to fares. The MWCOG model documentation cites the high percentage of federal workers in Washington who receive transit subsides as the rationale for the high values of time. A value of time of \$35 per hour (the average value used in the WMATA model) suggests that people are willing to pay \$2 in order to save 3.5 minutes of travel time. In contrast a value of time of \$10 per hour (a typical value from other urban models) suggests that people are willing to pay $2 only if they save 12 minutes of travel time.

The pricing structure of MARC and VRE are very different. Table 24 shows that in general, VRE is approximately $2 more expensive per trip than MARC, for travel of similar distances.

TABLE 24: COMPARISON OF MARC AND VRE PRICING STRUCTURES

VRE	Monthly	Per Trip	Distance (mi)	Cost Per Mile
Fredericksburg	$305.90	$7.65	55	$0.14
Leland Road	$287.40	$7.19	51	$0.14
Brooke	$287.40	$7.19	46	$0.16
Quantico	$250.80	$6.27	35	$0.18
Rippon	$232.40	$5.81	28	$0.21
Woodbridge	$232.40	$5.81	24	$0.24
Lorton	$214.10	$5.35	19	$0.28
Franconia-Springfield	$195.70	$4.89	14	$0.35
Alexandria	$177.30	$4.43	9	$0.49
Crystal City	$177.30	$4.43	5	$0.89
L'Enfant	$158.80	$3.97	2	$1.99

MARC	Monthly	Per Trip	Distance (mi)	Cost Per Mile
Perryville	$275.00	$6.88	75	$0.09
Aberdeen	$250.00	$6.25	69	$0.09
Edgewood	$225.00	$5.63	59	$0.10
Martin State Airport	$200.00	$5.00	50	$0.10
Baltimore Penn	$175.00	$4.38	38	$0.12
West Baltimore	$175.00	$4.38	35	$0.13
Halethorpe	$150.00	$3.75	31	$0.12
BWI Airport	$150.00	$3.75	28	$0.13
Odenton	$125.00	$3.13	21	$0.15
Bowie State	$125.00	$3.13	15	$0.21
Seabrook	$100.00	$2.50	10	$0.25
New Carrollton	$100.00	$2.50	8	$0.31

Source: NEC FUTURE team, 2015

A travel time penalty, or "shadow price" of 8.5 minutes of equivalent in-vehicle travel time was applied to VRE services to represent the application of a more typical urban model value of time. This adjustment immediately addressed the imbalance of commuter rail trips between MARC and VRE. Rather than adjusting the model value of time, which would require complete and wholesale recalibration of the model, these shadow prices were used in model calibration and application. This finding has been provided to both VRE and MWCOG to assist in their future model development efforts.

4.1.5 Washington, D.C., Regional Rail Model Validation

With the adjustments to Washington, D.C., Regional rail model discussed above, the refined forecasting model reproduced existing conditions. Key validation measures are:

- For MARC:
  - Total daily MARC boardings are replicated within 3%.
  - Total daily MARC boardings at Union Station (terminal) are replicated within 5%.
  - Total daily MARC Penn Line boardings (NEC) are replicated within 4%.
  - Total daily MARC Camden Line boardings are replicated within 2%.
- For VRE:
  - Total daily VRE boardings are replicated within 3%.
  - Total daily VRE boardings at Urban Core Stations (Alexandria, Crystal City, L'Enfant and Union Station) are replicated within 9%l
  - Total daily VRE Fredericksburg Line boardings (NEC) are replicated within 10%l
  - Total daily VRE Manassas Line boardings are replicated within 5%l

The detailed station validation is shown at the Station Level in Appendix C for MARC and VRE.

4.2 BALTIMORE MARYLAND REGIONAL RAIL MARKET, FTA SIMPLIFIED TRIPS ON PROJECT SYSTEM

The Baltimore regional market is unique among other major regions analyzed in the NEC FUTURE forecasting process. The MARC OD survey reveals that the bulk of rail trips produced and attracted from the Baltimore region represent travel between the Baltimore and Washington regions. Since the bulk of travel is interregional travel it can be analyzed using the interregional forecasting process.

However, for the small portion of Regional rail activity that exists, a regional forecasting tool is required. Baltimore Metropolitan Council (BMC) maintains a regional forecasting model; however, it does not have the capabilities required for use in the NEC FUTURE context. Specifically, it contains only a partial representation of Washington, D.C., market, contains only a limited representation of Virginia areas, and it has a coarse representation of intra-Baltimore Regional rail trips.

Therefore, an FTA Simplified Trips on Project System (STOPS) based application was developed for the Baltimore regional market. FTA STOPS module is the FTA's new national forecasting model, which relies on a combination of national experience and local market-based information to estimate transit project ridership. STOPS is a series of programs designed to estimate transit project ridership using a streamlined set of procedures that bypass the process of developing and applying a regional travel demand forecasting model. STOPS is quite similar in structure to regional models and includes many of the same computations of transit level-of-service and market share found in model sets maintained by Metropolitan Planning Organizations and transit agencies.

The STOPS application includes all relevant transit services to commuter rail in the Baltimore area including:

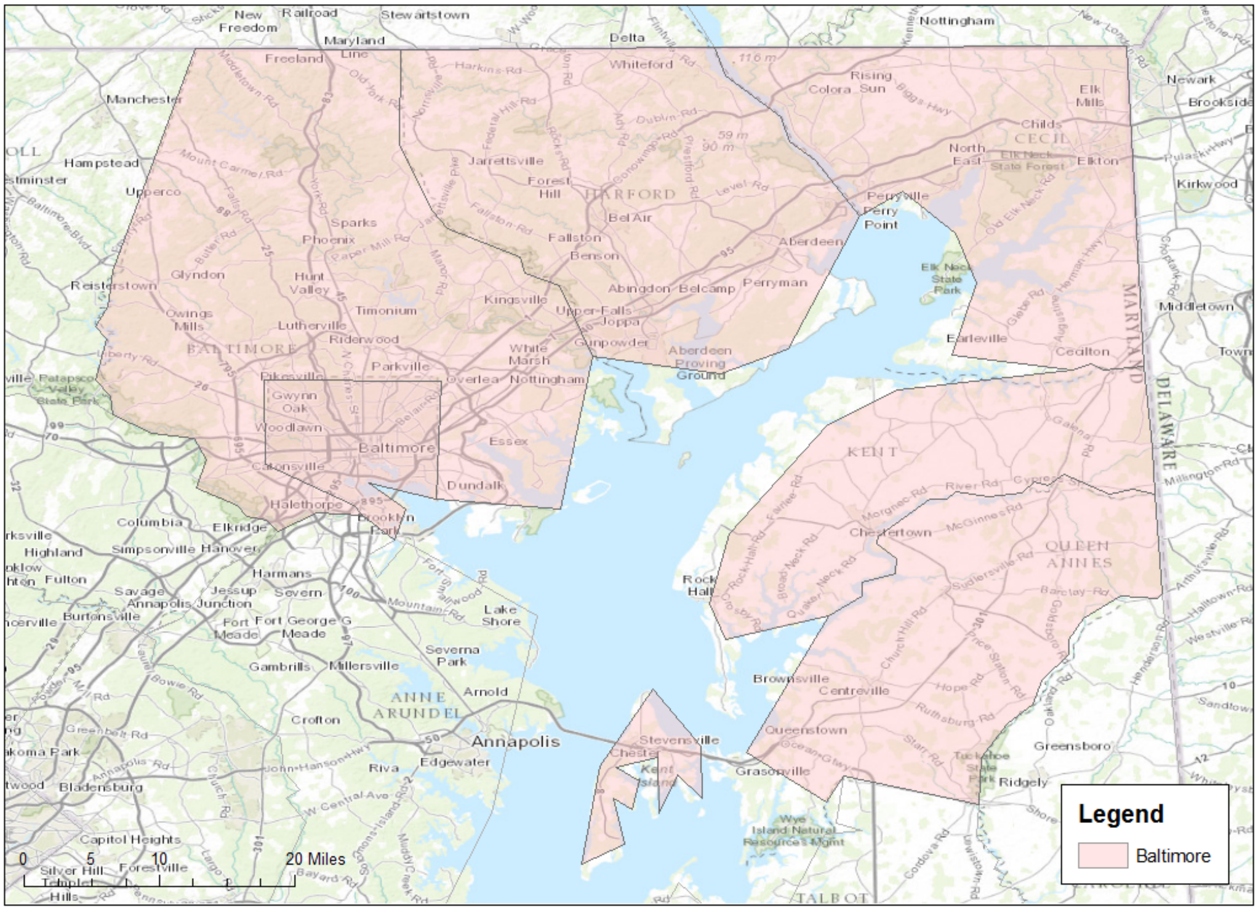
- MARC (BWI Airport to Perryville)
- Baltimore Light Rail
- Baltimore Subway
- MTA Buses

The Baltimore area STOPS model representation includes the following counties:

- Cecil County, Maryland
- Harford County, Maryland
- Baltimore County, Maryland
- Baltimore City, Maryland
- Kent County, Maryland
- Queen Anne's County, Maryland

A map of the Baltimore metropolitan area is included in Figure 14.

Figure 14: Baltimore STOPS Application Area



Source: NEC FUTURE team, 2015

4.2.1 Baltimore STOPS-based Data Assembly

The data assembled to implement a STOPS-based forecast for the Baltimore regional travel markets include:

- U.S. Census Bureau Transportation Planning Package (CTPP) of home-to-work flows in the BMC model region.
- MARC General Transit Feed Specification Data (GTFS) to represent commuter rail service within Baltimore.
- Maryland MTA General Transit Feed Specification Data to represent regional transit services in the Baltimore metropolitan region.
- MARC rail ridership data. Identification of MARC trips that occur wholly within the Baltimore metropolitan area shows that out of 30,000 MARC average weekday linked trips per day, only 700 trips (2 percent) are wholly within the Baltimore area.
- Station boarding counts for the intra-Baltimore region. The 2012 MARC OD survey was used to identify the number of Regional rail trips occurring within the Baltimore market.

- Table of BMC automobile travel times for current conditions and 2040.

4.2.2 Baltimore STOPS Calibration

The Baltimore STOPS application reproduced existing conditions to a high degree of fidelity. Key validation measures are:

- Total daily MARC Baltimore market boardings are perfectly replicated.
- Total daily MARC Baltimore boardings at Penn Station are replicated within 4 trips.
- Total daily MARC Penn Line boardings (NEC) are perfectly replicated.

The detailed station validation is shown at the Station Level in Appendix D for Baltimore market MARC trips.

4.3 PHILADELPHIA REGIONAL RAIL MARKET, DELAWARE VALLEY REGIONAL PLANNING COMMISSION MODEL

In Philadelphia, FRA used the current version of the Delaware Valley Regional Planning Commission (DVRPC) Forecasting Model. This model is the regional metropolitan planning organization (MPO) forecasting model, which covers the entire Philadelphia region and represents all regional transit services including:

- SEPTA Regional Rail
- NJ TRANSIT Atlantic City Line
- SEPTA Subway
- DRPA PATCO
- Regional bus routes (SEPTA, NJ TRANSIT, others)

The geographic area for the DVRPC model encompasses the entire metropolitan area and includes the following counties:

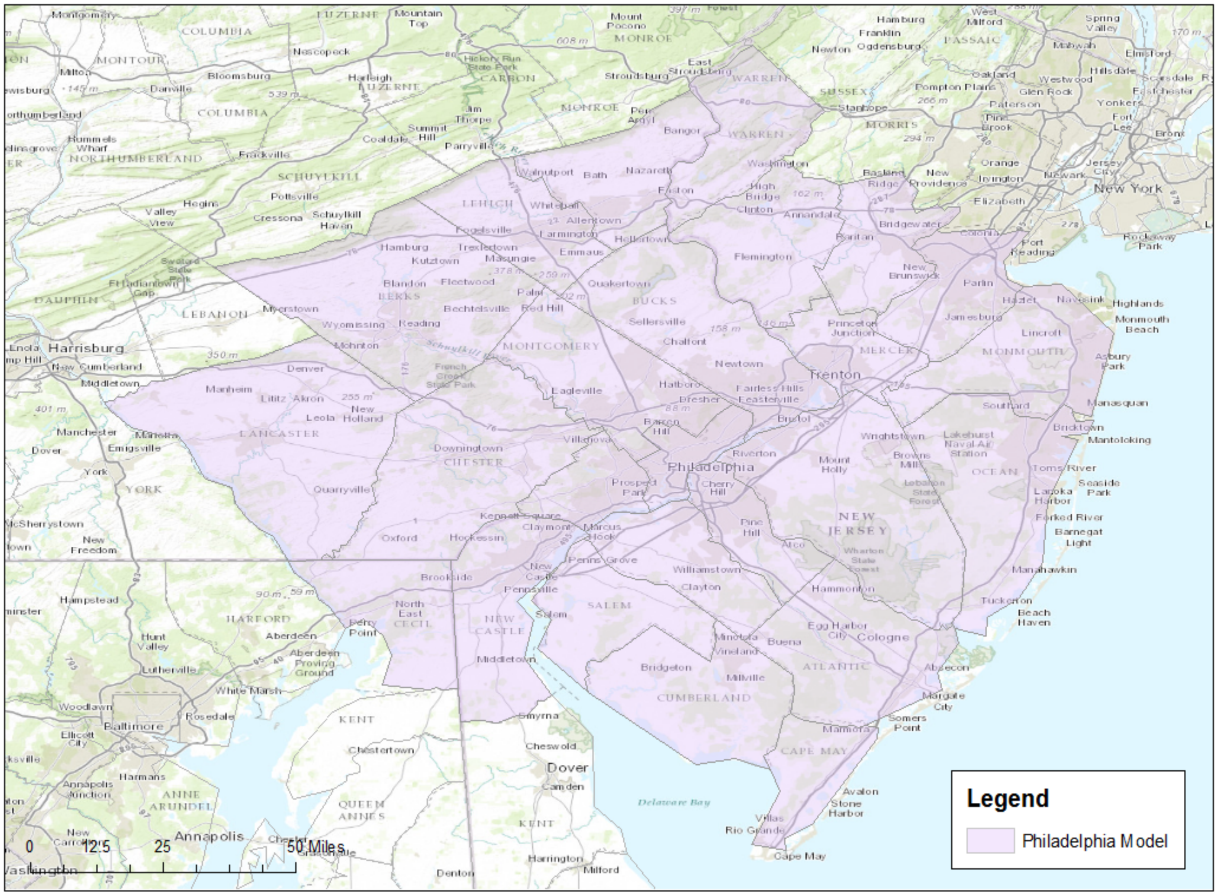
- **Maryland:**
  - Cecil County
- **Delaware:**
  - New Castle County
- **Pennsylvania:**
  - Chester County
  - Delaware County
  - Lancaster County

- Berks County
- Lehigh County
- Northampton County
- Montgomery County
- Bucks County
- Philadelphia

- **New Jersey:**
  - Salem County
  - Cumberland County
  - Cape May County
  - Atlantic County
  - Gloucester County
  - Camden County
  - Burlington County
  - Mercer County
  - Warren County
  - Hunterdon County
  - Somerset County
  - Middlesex County
  - Monmouth County
  - Ocean County
  - Atlantic County

A map of the DVRPC forecasting area is included in Figure 15.

Figure 15: DVRPC Modeling Area



Source: NEC FUTURE team, 2015

The DVRPC forecasting model was calibrated to represent base year 2012 conditions and was validated to commuter rail ridership using DVRPC's 2011 comprehensive regional transit survey. The summary of the DVRPC regional validation is provided in Appendix E.

For the purpose of the NEC FUTURE, DVRPC staff utilized its model to produce ridership forecasts for each alternative. The results from the DVRPC model were used to evaluate NEC FUTURE alternatives service between Newark, Delaware and Trenton, New Jersey.

4.4 NORTHERN AND CENTRAL NEW JERSEY REGIONAL RAIL MARKET, NJ TRANSIT NORTH JERSEY TRAVEL DEMAND FORECASTING MODEL

In northern New Jersey, the current version of NJ TRANSIT's North Jersey Travel Demand Forecasting Model (NJTDFM) was used for ridership forecasting. This model is NJ TRANSIT's regional forecasting model which simulates all transit travel in Central and Northern New Jersey. The NJTDFM forecasting model was calibrated to represent base year 2010 conditions and was validated to commuter rail ridership using NJ TRANSIT's Year 2005 comprehensive rail surveys.

The NJTDFM includes a representation of all Northern New Jersey based transit services including:

- NJ TRANSIT commuter rail system, except the Atlantic City Rail Line
- NJ TRANSIT Light Rail Services, including Hudson-Bergen LRT, River Line LRT and Newark LRT
- Port Authority of New York and New Jersey Port Authority Trans-Hudson (PATH) service.
- Regional bus services (NJ TRANSIT and private operators)
- Trans-Hudson Express Bus Lane (XBL) and supporting infrastructure that provides bus priority treatments into the Port Authority Bus Terminal during the AM peak period
- Regional Ferry services offered crossing the Hudson River and from Monmouth County
- Ferry buses that provide service between ferry terminals and locations within Manhattan
- NYC Subway System for distribution of Trans-Hudson transit customers to their ultimate destination
- SEPTA's Northeast Corridor Line between Cornwall Heights and Trenton
- Metro-North Port Jervis and Pascack Valley Lines from Orange and Rockland Counties
- PANYNJ AirTrain connection to the Northeast Corridor at Newark Liberty International Airport (EWR)
- Metro-North Hudson Line service from Beacon and Tarrytown, to capture Orange and Rockland County customers who cross the Hudson River to access Hudson Line service

The geographic area for the NJTDFM model encompasses all of Northern New Jersey and surrounding area and included New York City:

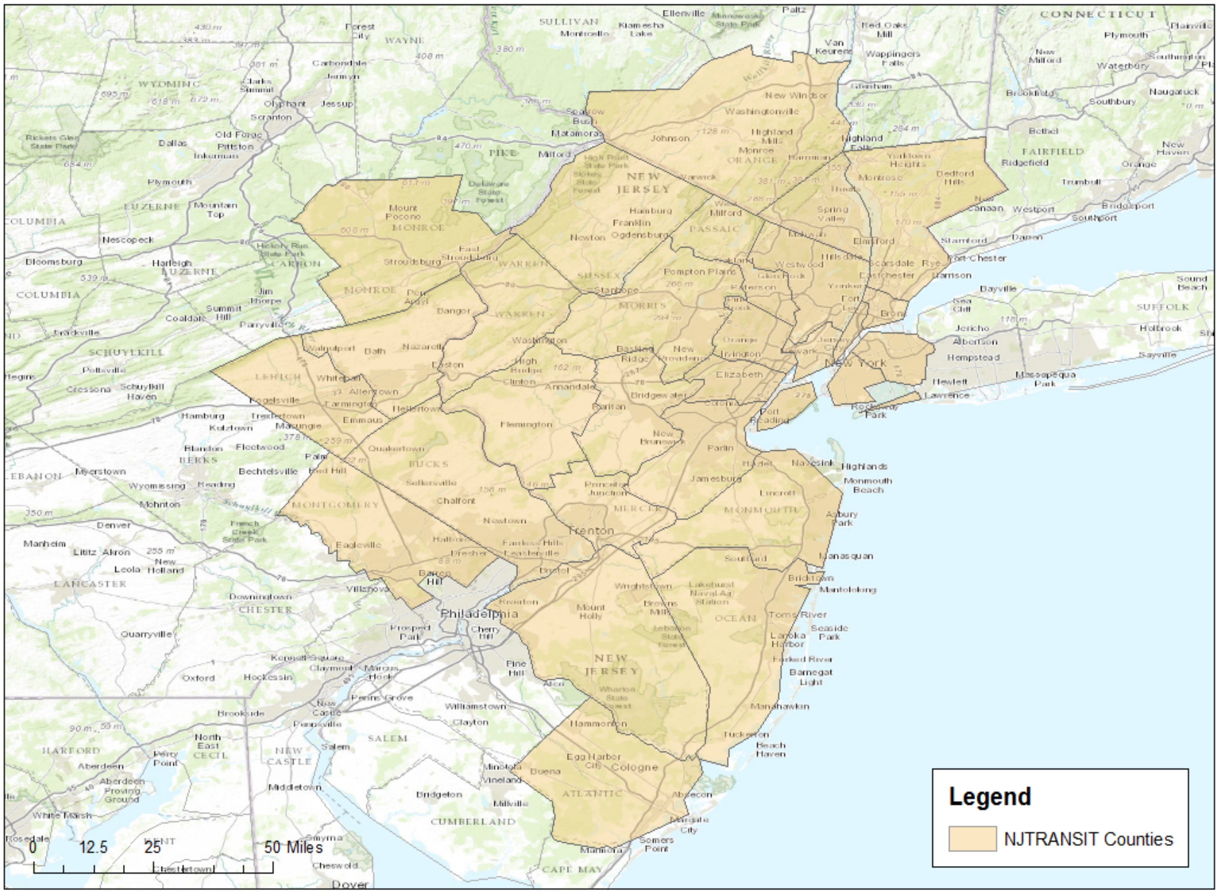
- **Pennsylvania:**
  - Lehigh County
  - Northampton County
  - Montgomery County
  - Monroe County
  - Bucks County
- **New Jersey:**
  - Atlantic County
  - Burlington County
  - Mercer County
  - Warren County
  - Hunterdon County
  - Somerset County

- Middlesex County
- Monmouth County
- Ocean County
- Essex County
- Bergen County
- Morris County
- Sussex County
- Passaic County
- Union County
- Hudson County

- **New York:**
  - Orange County
  - Rockland County
  - New York County
  - Queens County
  - Bronx County
  - Richmond County
  - Kings County
  - Westchester County

A map of the NJTDFM forecasting area is included in Figure 16.

Figure 16: NJTDFM Modeling Area



Source: NEC FUTURE team, 2015

One of the most important elements about the NJTDFM is its Trans-Hudson capacity analysis post-processing tool used to justify the Access the Region's Core (ARC) project. The ARC project was justified in large part as a mechanism to relieve current and forecasted Trans-Hudson capacity limitations. A procedure was developed and accepted by FTA in the evaluation of the ARC project where:

- Unconstrained NJTDFM assignments are compared to the available capacity by mode to cross the Hudson River.
- Time penalties are iteratively applied to constrain the total transit demand across the Hudson River to available capacity.
- The final results balance the assigned volumes with the available capacity.

For the purpose of the NEC FUTURE, NJTDFM forecasts were used to identify the impacts associated with the No Action and Action alternatives. The results from the NJTDFM model were used to evaluate market response to service offerings from points north of Trenton, New Jersey and New York City.

The NJTDFM was also used to forecast West of Hudson market impacts from Metro-North territory (Orange and Rockland Counties). Orange and Rockland Counties, New York are included in the NJTDFM and the MTA's Regional Transit Forecasting Model (RTFM). Because these rail markets overlap, these markets were simulated using the NJTDFM and removed these markets from the MTA RTFM to avoid double-counting. This was done because the bulk of these trips enter Manhattan with all of the other Trans-Hudson services.

The NJTDFM is validated to a high degree of fidelity. Key validation measures are:

- Total daily NJ TRANSIT boardings are replicated within 1%.
- Total daily NJ TRANSIT boardings at Penn Station (terminal) are replicated within 1%.
- All NJ TRANSIT lines are replicated within 10%.
- Total daily NJ TRANSIT boardings on the NEC and New Jersey Coast Line are replicated within 7%.

The detailed station validation is shown at the station level in Appendix F for NJ TRANSIT and Metro-North's Pascack Valley and Port Jervis Lines.

4.5 LONG ISLAND, MID-HUDSON AND SOUTHWESTERN CONNECTICUT REGIONAL RAIL MARKET, MTA REGIONAL TRANSIT FORECASTING MODEL

For the East-of-Hudson portion of the New York City Regional rail market, the NEC FUTURE forecasting process used the MTA RTFM. The MTA's model simulates all transit travel within New York City, Long Island, Mid-Hudson (Westchester, Putnam and Dutchess Counties) and coastal Connecticut. The RTFM forecasting model was calibrated to represent base year 2010 conditions and was validated to commuter rail ridership using Long Island Rail Road 2006 origin-destination survey and Metro-North's Year 2007 origin-destination survey. The RTFM includes a representation of all regional commuter rail operators including:

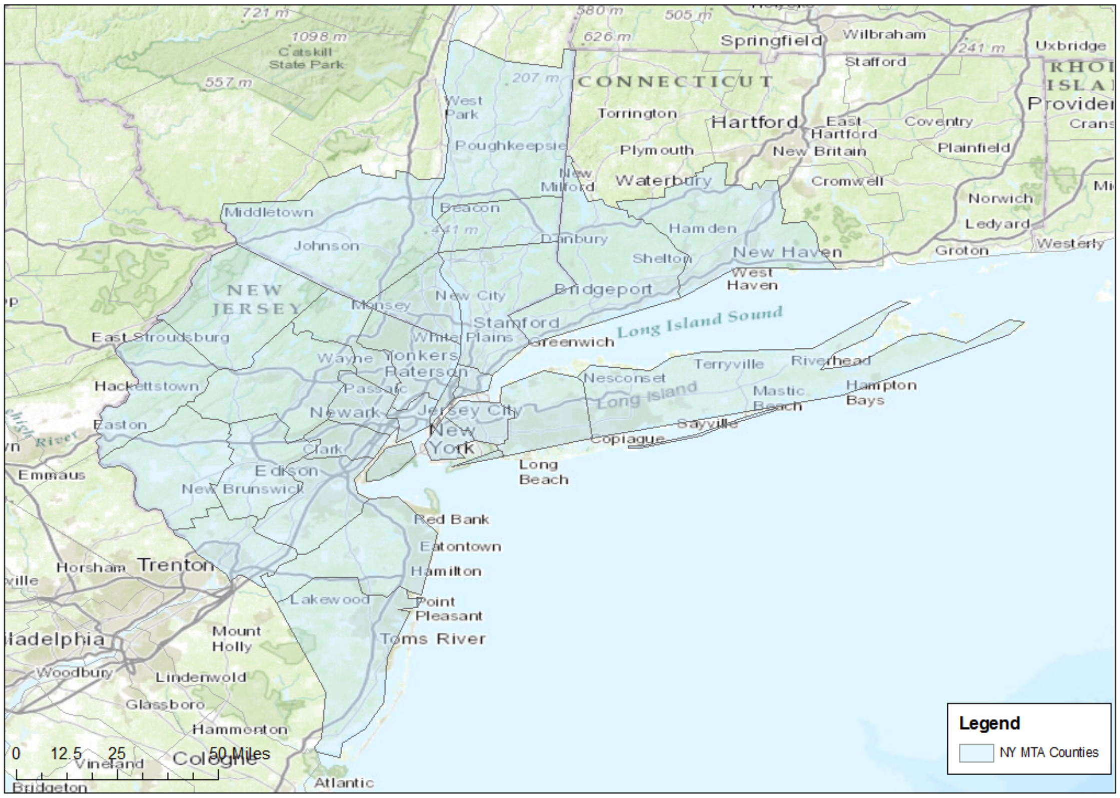
- MTA-Long Island Railroad
- MTA-Metro-North Railroad
- Shore Line East (New Haven State Street to Stamford)
- NJ TRANSIT commuter rail
- New York City Transit (NYCT) Subway
- PANYNJ AirTrain Connections to Newark Liberty International Airport (EWR) and John F. Kennedy International Airport (JFK)
- PANYNJ PATH
- Regional ferry service
- Regional bus services (NYCT, MTA bus, NICE, BeeLine, Suffolk Transit, CT Transit, etc.)

The geographic area for the RTFM model encompasses all of New York Metropolitan area including**:**

- **New Jersey**
  - Mercer County
  - Warren County
  - Hunterdon County
  - Somerset County
  - Middlesex County
  - Monmouth County
  - Ocean County
  - Essex County
  - Bergen County
  - Morris County
  - Sussex County
  - Passaic County
  - Union County
  - Hudson County
- **New York**
  - Orange County (trips taken out, to avoid double-counting with NJTDFM)
  - Rockland County (trips taken out, to avoid double-counting with NJTDFM)
  - New York County
  - Queens County
  - Bronx County
  - Richmond County
  - Kings County
  - Westchester County
  - Putnam County
  - Dutchess County
- **Connecticut:**
  - Fairfield County
  - New Haven County
  - Litchfield County

A map of the RTFM forecasting area is included in Figure 17.

Figure 17: RTFM Modeling Area



Source: NEC FUTURE team, 2015

The current version of the RTFM that was employed for NEC FUTURE was used to develop the Metro-North Penn Station Access Environmental Assessment forecasts in 2013. The calibration of this version of the model included an effort to accurately represent growth in non-traditional, emerging markets. Two markets of considerable emphasis include reverse-peak commutation from Manhattan to Bronx and the significant growth (two-ways) in Metro-North utilization to Connecticut activity centers, especially Stamford.

The RTFM is validated to a high degree of fidelity. Key validation measures are:

- Total AM peak-period LIRR and MNR boardings are replicated within 2%.
- Total AM peak-period LIRR terminal arrivals at Penn Station are replicated within 2%.
- Total AM peak-period MNR terminal arrivals at Penn Station are replicated within 1%.
- Total AM peak-period boardings by LIRR and MNR lines are replicated within 10%, with most achieving a 5% difference.

The detailed station validation is shown at the station level in Appendix G for LIRR and Metro-North East of Hudson Lines.

4.6 RHODE ISLAND/BOSTON REGIONAL RAIL MARKET, FTA SIMPLIFIED TRIPS ON PROJECT SYSTEM

The original forecasting approach for Rhode Island and Boston metropolitan market was to request that the Central Transportation Planning Staff (CTPS) of the Boston MPO to run demand forecasts for the Boston area (similar to the approach employed for the Philadelphia market). Unfortunately, CTPS reported that they could not meet the NEC FUTURE schedule. In response, an FTA STOPS-based forecasting methodology was developed for the Boston metropolitan region.

4.6.1 Boston Area STOPS-based Data Assembly

The data required to implement a STOPS-based forecast were assembled for the Boston regional travel markets. Because Massachusetts Bay Transportation Authority (MBTA) service extends into Rhode Island, the Boston STOPS application was developed to include all of Rhode Island and Eastern Massachusetts. The services embedded into the Boston STOPS application include:

- MBTA commuter rail service
- MBTA subway service
- Regional bus service
- MBTA Ferry Service

The geographic area for the Boston STOPS application encompasses all of New York Metropolitan area including**:**

- **Rhode Island**
  - Providence
  - Bristol
  - Kent
  - Washington
  - Newport
- **Massachusetts:**
  - Essex
  - Middlesex
  - Norfolk
  - Suffolk
  - Bristol
  - Plymouth
  - Worcester

A map of the Boston STOPS forecasting area is included in Figure 18.

Figure 18: Boston STOPS Modeling Area

Source: NEC FUTURE team, 2015

Below describes the data that was assembled for the STOPS application:

- U.S. Census Transportation Planning Package (CTPP) of home-to-work flows for Rhode Island and Massachusetts.
- MBTA General Transit Feed Specification Data (GTFS) to represent all MBTA commuter rail services operating in Rhode Island, Eastern Massachusetts and Southeast New Hampshire.
- GTFS data to represent regional transit services in the Boston metropolitan region.
- Regional Rail count data by station that was obtained from CTPS. The count data by station were fed into the STOPS process to facilitate the auto-calibration routines.
- MBTA subway station-level count data. This count data by station were fed into the STOPS model to facilitate the automatic calibration for STOPS to mimic overall subway activity.
- Total MBTA region-wide unlinked trips from the National Transit Database. This parameter is used by STOPS to calibrate itself to the total number of regional unlinked trips.
- Current and 2040 estimates of highway travel times from Rhode Island Department of Transportation (RIDOT) obtained from the Rhode Island Statewide model.

- Current and 2040 estimates of highway travel time within the Boston metropolitan region from CTPS.

Because the Boston area STOPS methodology overlaps two adjoining areas (CTPS and Rhode Island), a data assembly step was performed to successfully combine both modeling areas for STOPS. This activity involved:

- Developing a combined RIDOT statewide model and CTPS TAZ system. The approach started by used the CTPS model definitions and then added Rhode Island DOT TAZs to complete the region.
- Combining the two regional model's highway travel times (CTPS and RIDOT) into one set of comprehensive automobile travel times for current conditions and 2040 conditions.

4.6.2 Boston STOPS Application Adjustments to 2040 Highway Travel Times

The final application of the STOPS model deviated in one respect from the FTA's documentation. The deviation was required to generate coherent Year 2040 No Action Alternative STOPS-based forecasts in the Boston metropolitan area. The issue involved the magnitude of the growth in the underlying highway travel times supplied by RIDOT and CTPS.

This deviation was required because the initial applications of STOPS revealed a much larger change in MBTA rail ridership between NEC FUTURE's base year calibration and 2040, as compared to the underlying demographic growth. The results of the STOPS Forecast of MBTA commuter rail unlinked trips, using the FTA methodology, implied that MBTA commuter rail trips would double by 2040 in the No Action Alternative. As a basis of comparison, the Boston central business district (CBD) employment growth is projected to grow by only 15%.

The more than doubling of the Boston commuter rail trips was deemed unrealistic. Further investigation showed that highway travel time degradation was the driver of the high level of commuter rail ridership growth in 2040.

For most of the zones to the Boston CBD, the CTPS and RIDOT supplied highway travel times degrade by 30-50% in 2040. In Boston, where there are sprawling commute patterns for MBTA commuter rail service, this generally translates to an increase in total highway travel time on the order of 10-35 minutes between base and 2040.

This finding was reported to FTA, which revealed a previously undocumented element of STOPS. STOPS weights automobile travel time in excess of 45 minutes as two times the weight of automobile travel time under 45 minutes. This weighting effectively doubles the effect of the highway degradation for long automobile trips. This feature is included in an effort to calibrate STOPs to reflection national New Starts project experience.

To address the issue of unrealistically high commuter rail forecasts the STOPS process was adjusted to remove the weighting of highway travel times in excess of 45 minutes and also to place an upper limit on the forecasted degradation of highway travel times to just 20 percent. FTA concurred with the approach used to establish the 2040 No Action Alternative forecasts and the plausibility of the forecast.

4.6.3 Boston STOPS Calibration

The Boston STOPS-based regional forecasting process reproduced existing conditions very well with:

- Total daily MBTA boardings replicated within 5%.
- Total daily MBTA boardings at North Station and South Station replicated within 3%.
- Total daily MBTA boardings by line replicated within 10%.

The detailed station validation is shown at the station level in Appendix H for MBTA services.

5 Alternatives Description

5.1 YEAR 2040 CONTEXT

For analysis purposes, all alternatives tested used a forecast year of 2040. Travel demand forecasts are driven by demographics and service levels. This section describes the background data used across the 2040 No Action and Action Alternatives, which lead to the forecasts described Section 6.

5.1.1 Year 2040 Demographic Forecasts

The fundamental driver of growth in total trip making in the NEC FUTURE Study Area comes from forecasted growth in population, employment, and income. Forecasts used as the basis for growth were extracted from Moody's Analytics June 2013 "base" demographic forecasts. These forecasts were obtained on a county-level basis for the NEC FUTURE Study Area. The detailed county-level demographic forecasts are summarized in Appendix B.

Table 25 and Table 26 present the population and employment projections, and percentage change for the major NEC metropolitan areas as contained in Moody's Analytics June 2013 forecasts. Three forecasts were supplied by Moody's. They include "low", "base" and "high" conditions. All of the forecasted results use the "base" (or most likely) condition. Table 25 shows that population in the major metropolitan markets is projected to grow between 6.2% (Hartford) to 29% (Washington D.C.). The low-high bounds are also fairly tightly bound to the "base" condition, generally plus or minus 5% points of the base forecast.

While the "base" forecasts shows employment growing slightly faster than population, the low-high bounds are much wider for employment than population. This is an important element of the demographic forecasts, as Moody's forecast suggests larger uncertainty associated with future NEC employment. Their "low" scenario includes a contraction of the overall job market (as compared to today), while their "high" scenario includes a full boom in economic activity with large scale growth in employment. This suggests that one of the significant risks to the forecasts is the strength of the regional employment market, as Moody's has placed a wide band on these forecasts.

TABLE 25: NEC POPULATION FORECASTS

Market	Population				Percentage Change vs 2013		
	2013	2040 (Low)	2040 (Base)	2040 (High)	2040 (Low)	2040 (Base)	2040 (High)
Boston	6,450,199	6,601,973	6,887,907	7,187,507	2.5%	6.8%	11.3%
Hartford/Springfield	1,793,652	1,876,120	1,905,128	1,934,799	4.7%	6.2%	7.8%
Providence	970,100	981,930	1,036,320	1,093,830	1.4%	6.8%	12.5%
New York	22,210,216	23,276,389	24,306,295	25,392,888	5.0%	9.4%	14.2%
Philadelphia	6,600,373	6,874,020	7,108,418	7,352,289	4.3%	7.7%	11.3%
Baltimore	2,773,720	3,000,040	3,144,720	3,298,650	8.3%	13.4%	18.7%
Washington	5,930,470	7,126,550	7,654,620	8,237,550	20.5%	29.1%	38.6%

Source: NEC FUTURE team, 2015

TABLE 26: NEC EMPLOYMENT FORECASTS

Market	Employment				Percentage Change vs 2013		
	2013	2040 (Low)	2040 (Base)	2040 (High)	2040 (Low)	2040 (Base)	2040 (High)
Washington	3,104,290	2,780,660	3,857,570	4,800,890	(2.8%)	24.3%	61.8%
Baltimore	1,363,290	1,279,250	1,678,610	2,022,560	1.7%	23.1%	55.4%
Philadelphia	3,007,064	2,680,470	3,575,796	4,322,700	(4.0%)	18.9%	49.8%
New York	10,076,605	8,809,933	11,826,539	14,660,218	(6.0%)	17.4%	51.2%
Providence	426,410	351,670	475,500	559,910	(9.6%)	11.5%	39.3%
Hartford/Springfield	872,692	729,401	963,242	1,145,307	(9.7%)	10.4%	37.4%
Boston	3,275,290	2,755,633	3,736,399	4,599,365	(8.5%)	14.1%	47.6%

Source: NEC FUTURE team, 2015

While the Moody's Analytics demographic forecasts serve as the overall county-level control totals for growth, the forecasting process required demographic data at the sub-county level, for both the Regional Models and the Interregional Model.

5.1.1.1 Regional Demographic Data Process

For the purpose of developing the sub-county level demographic process for the regional models, a methodology was employed where:

- Local MPO adopted forecasts of population, households and employment were used as the starting point
- County-level adjustment factors were derived to scale the MPO total population, households and employment to the Moody's control totals.

This approach used a process where the growth on the NEC came from one consistent NEC wide source (Moody's) and used the local MPO forecasts as the basis for where growth occurs at the sub-county level. This means that localized development and redevelopment initiatives are reflected in the NEC FUTURE forecasts.

5.1.1.2 Interregional Demographic Data Process

The Interregional Model process required that the demographic data be at the zonal level, which was smaller or larger than the county-level, depending on the particular zone. This process was completed by first splitting the county-level forecasts to the Census Division level, which is a much smaller geographic area. The population and income were split using the ratios of population at the Census Division versus the county from 2010 Census data, and employment was split using the ratios of employment from 2010 Census Data. Once the demographic forecasts were split, they were summed to equal the zonal level demographics.

5.1.2 Service Level Forecasts - Non-Rail Modes

For all 2040 alternatives (No Action and Action Alternatives), the non-rail modes were held constant across alternatives in terms of frequency, travel time, and cost for both the Regional and Interregional Model. The future year service characteristics for the non-rail modes in the

Interregional Model are discussed in Section 3.3.1. The future year service characteristics for the non-rail modes in the Regional models are unchanged from the source models.

5.2 NO ACTION ALTERNATIVE DESCRIPTION

The No Action Alternative represents the Year 2040 condition where an NEC FUTURE alternative is not implemented and serves as the basis of comparison to evaluate impacts of the Action Alternatives. This section discusses the elements used to establish the Year 2040 NEC FUTURE No Action Alternative forecasts.

5.2.1 Year 2040 No Action Alternative Railroad Service Plan

For both Interregional Model and regional models, the basis for the 2040 No Action Alternative Service Plan are today's level-of-service. The infrastructure improvements included in the No Action Alternative are described in the *No Action Alternative Report*. No Action Alternative infrastructure improvements include those projects that are funded or in approved funding plans, represent safety or other mandates, or are necessary to keep the railroad operating. With one exception (described below), the No Action Alternative represents no significant change in capacity or service from today.

The only service change that is included between today's service and the 2040 No Action Alternative is the completion of the LIRR East Side Access (ESA) project. The analysis assumes implementation of the LIRR ESA Operating Plan version 3.0 for the LIRR East Side Access. Otherwise, the No Action Alternative Service Plan for all other rail operators, including VRE, MARC, SEPTA, NJ TRANSIT, Metro-North, Shore Line East and MBTA are identical to today's service. Intercity service does not change from existing conditions to the No Action Alternative. A more thorough discussion concerning the contents of the No Action Alternative is described in the *Service Plans and Train Equipment Train Options Technical Memorandum* and the *No Action Alternative Report*.

5.2.2 Rail Pricing

For the No Action Alternative, Regional rail pricing was held constant through the analysis in real dollars, meaning Regional rail fares are assumed to grow with inflation.

For the Interregional Model, the rail fares were assumed to maintain the current fare structure for the No Action Alternative, as described in Section 3.2.1.4.

5.3 ACTION ALTERNATIVES DESCRIPTION

This section documents the Action Alternatives (focusing on the Service Plans) that were evaluated with the NEC FUTURE forecasting process.

5.3.1 Action Alternative Service Plans

- **Alternative 1 maintains the role of rail** as it is today, keeping pace with the level of rail service required to support proportional growth in population and employment, building off Service Plans developed by the NEC service operators to meet the projected organic increase in travel demand. To keep pace, Alternative 1 would include new rail services and investment to expand capacity, add tracks, and relieve key chokepoints, particularly through northern New Jersey, New York, and Connecticut.

- **Alternative 2 grows the role of rail**, expanding rail service at a faster pace than the proportional growth in regional population and employment. South of New Haven, CT, service and infrastructure improvements would be focused generally within or adjacent to the existing NEC; however, north of New Haven, a new supplemental route would be added between New Haven, Hartford, and Providence to increase resiliency, serve new markets, and address capacity constraints. The existing NEC generally would expand to four tracks, with six tracks through portions of New Jersey and southwestern Connecticut. Alternative 2 would include new direct service to Philadelphia International Airport, and some Regional rail run-through service in New York City and Washington, D.C., to increase terminal throughput.
- **Alternative 3 transforms the role of rail**, positioning rail as a dominant mode for interregional and regional travelers and commuters. Service and infrastructure improvements would include upgrades on the NEC and the addition of a two-track second spine that would operate adjacent to the NEC south of New York and expand to new markets north of New York. This new spine would support high-performance rail services between major markets and would provide additional capacity for Intercity and Regional rail services on both the existing NEC and new spine. Alternative 3 would support a wide variety of new Intercity and Regional rail services, tailored to the needs of specific markets, including non-stop express trains, high-speed zone-express trains serving the long-distance commute market, and new service to markets off the existing NEC.

  Alternative 3 also includes four sub-options with different high-speed route options on the North End. These new route options are:
- Alternative 3.1 - New York to Boston via Central Connecticut and Providence
- Alternative 3.2 - New York to Boston via Long Island and Providence
- Alternative 3.3 - New York to Boston via Long Island and Worchester
- Alternative 3.4- New York to Boston via Central Connecticut and Worchester

The Intercity peak-hour Service Plan summary is shown in Table 27. The service approximately doubles in Alternative 1 compared to the No Action Alternative, quadruples versus the No Action Alternative in Alternative 2, and has more than four times the service versus the No Action in select locations (primarily north of New York) in Alternative 3, as described in the Alternative summaries above. The reasons for this are discussed in the *Service Plans and Train Equipment Options Technical Memorandum*. A summary of travel times and daily service frequencies for the major city pairs are provided in Table 28 and Table 29. The Regional rail Service Plans are summarized in Table 30.

TABLE 27: INTERCITY SERVICE IN STANDARD PEAK HOUR

	Existing	No-Action	Alt 1	Alt 2	Alt 3
South End					
Intercity Express	1	1	2	4	6
Intercity Corridor					
Washington-Philadelphia	1	1	2	2	2
Philadelphia-New York	2	2	2	2	2
Metropolitan					
Washington-Philadelphia	0	0	2	4	4
Philadelphia-New York	0	0	3	4	8
North End					
Intercity Express	<1	<1	2	4	6
Intercity Corridor					
New York-New Haven	<1	<1	2	2	2
New York-Boston	<1	<1	1	0	0
New York-Springfield	0	0	1	2	2
Metropolitan					
New York-New Haven	0	0	2	4	4
New York-Boston (OSB-KEN Bypass)	0	0	2	0	0
New York-Boston	0	0	0	0	0
New York-Springfield	0	0	0	1	2
New Route	0	0	0	4	4
Connecting Corridors					
Virginia	<1	<1	2	2	4
Empire	1	1	2	2	2
Keystone	1	1	1	2	2
Springfield	<1	<1	1	2	2
Knowledge Corridor	1 tpd	1 tpd	<1	1	1
Inland Route	0	0	<1	1	1
Other	0	0	0	0	2

Intercity-Corridor includes the new Metropolitan service as well as the base Intercity-Corridor service.
Source: NEC FUTURE team, 2015

TABLE 28: SELECTED STATION PAIRS INTERCITY SERVICE PLAN SUMMARY – NO ACTION, ALTERNATIVE 1 AND ALTERNATIVE 2

Intercity-Express	Existing/No Action		Alternative 1		Alternative 2	
Trip Pair	**FREQ**	**TT**	**FREQ**	**TT**	**FREQ**	**TT**
Boston-New York	10	212	19	174	42	153
Boston-Philadelphia	10	293	16	246	27	216
Boston-Washington	10	394	16	345	27	307
New York – Philadelphia	16	68	24	64	41	55
New York – Washington	16	167	24	163	41	146
Philadelphia – Washington	16	97	24	97	41	89
Intercity-Corridor	**Existing/No Action**		**Alternative 1**		**Alternative 2**	
Trip Pair	**FREQ**	**TT**	**FREQ**	**TT**	**FREQ**	**TT**
Boston-New York	9	253	28	215	50	219
Boston-Philadelphia*	8	361	26	302	45	301
Boston-Washington	8	482	24	417	30	423
New York - Philadelphia*	32	84	62	79	77	72
New York – Washington	22	204	45	188	54	181
Philadelphia* - Washington	22	116	46	110	69	128

Source: NEC FUTURE team, 2015
Note: Intercity-Corridor Travel Time Weighted Averages (based on Travel Times to Market East and 30th Street Station)

TABLE 29: SELECTED STATION PAIRS INTERCITY SERVICE PLAN SUMMARY – ALTERNATIVE 3 OPTIONS

Intercity-Express	Alternative 3.1		Alternative 3.2		Alternative 3.3		Alternative 3.4	
Trip Pair	**FREQ**	**TT**	**FREQ**	**TT**	**FREQ**	**TT**	**FREQ**	**TT**
Boston-New York	75	117	75	118	75	128	76	124
Boston-Philadelphia	59	168	59	169	60	178	62	176
Boston-Washington	59	233	59	234	60	243	62	242
New York – Philadelphia	73	43	73	43	73	43	75	44
New York – Washington	73	108	73	108	73	108	75	108
Philadelphia – Washington	73	65	73	65	73	65	75	65
Intercity-Corridor	**Alternative 3.1**		**Alternative 3.2**		**Alternative 3.3**		**Alternative 3.4**	
Trip Pair	**FREQ**	**TT**	**FREQ**	**TT**	**FREQ**	**TT**	**FREQ**	**TT**
Boston-New York	72	180	70	187	72	184	72	179
Boston-Philadelphia*	49	266	51	285	48	272	52	264
Boston-Washington	45	371	45	380	45	375	46	371
New York - Philadelphia*	108	71	113	71	108	71	110	71
New York – Washington	75	172	77	172	75	172	76	172
Philadelphia* - Washington	79	118	81	118	79	118	80	118

Source: NEC FUTURE team, 2015
Note: Intercity-Corridor Travel Time Weighted Averages (based on Travel Times to Market East and 30th Street Station)

TABLE 30: AVERAGE WEEKDAY REGIONAL RAIL SERVICE PLAN SUMMARY (TRAINS/HOUR)

	Existing/No-Action				Alt 1				Alt 2				Alt 3			
	PK	SHD	REV	OPK	PK	SHD	REV	OPK	PK	SHD	REV	OPK	PK	SHD	REV	OPK
Washington Region																
MD Regional Rail	3	2.5	1.5	1.3	6	5	3	2	10	6	5	3	12	8	6	3
VA Regional Rail	5.5	1	0.2	0.1	6	4	2	0.4	8	6	4	4	8	6	4	4
Philadelphia Region																
North Side Regional Rail	7	4	4	2.3	8	5	5	3	12	6	5	4	12	7	6	4
South Side Regional Rail	5	4	3.5	3	6	6	6	3	14	10	12	7	20	14	16	11
New York Region																
NJ-NEC/NJCL Trans-Hudson	15	8	7	3	20	10	7	3	22	14	10	4	24	14	10	4
NJ-Other Regional Rail	6	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0
NJ-Inner Branch	0	0	0	0	10	8	6	6	20	14	10	8	30	24	20	12
CT-Nhaven Line (PS&GCT)	22	16	12	3	26	20	16	8	32	19	15	6	36	19	15	6
Boston Region																
NEC Regional Rail	9	4	4	2.6	12	10	10	4	14	10	10	5	20	14	12	9
Other Regional Rail	3	2	1	0.5	4	3	1	1	4	3	1	1	8	4	2	2

PK - Peak Period, Peak Direction
SHD -Shoulder of Peaks
REV - Reverse Peak
OPK- Off-Peak

Source: NEC FUTURE team, 2015

Table 30 above shows the levels of service progressing across each of the Action Alternatives in the regional models. In all of the regional rail markets, the Action Alternatives offer increased service and capacity throughout the day, which utilize the available capacity and responds to the overarching vision for each alternative. Also included in the Action Alternatives for the regional rail markets is the new Metropolitan service. The approach taken was to represent the portions of Metropolitan trains operating within each region. These trains were simulated as additional service frequencies opportunities for travel within regions. Fares for Metropolitan were assumed to be consistent with commuter rail fares for travel within regions. Alternative 1 essentially has approximately 1.5 times greater service over the No Action Alternative, Alternative 2 about doubles service over the No Action Alternative, and Alternative 3 has approximately 2.5 times the service over the No Action Alternative.

5.3.2 Rail Pricing

For the Action Alternatives, Regional rail pricing was held constant through the analysis in real dollars, meaning Regional rail fares are assumed to grow with inflation.

For the interregional alternatives, changes in Action Alternative pricing were considered for the following reasons:

- Strong customer demand coupled with the inability to add service during peak hours has allowed Amtrak to significantly raise fares on the NEC during the past decade.

- These capacity constraints coupled with higher demand on the South End has led to significantly higher pricing on a per mile basis on the South End as compared the North End.
- The NEC FUTURE household survey revealed NEC travelers who are non-business generally have very low values of time. This means these customers are generally more sensitive to fare than they are to travel time. Because the NEC FUTURE program is attempting to identify the rail capacity necessary to serve existing and growing markets along and off the NEC, understanding the impact of pricing in essential to identifying potential infrastructure needs.

While the analysis started with the assumption that current Amtrak pricing structures would be in place, the impact of lower fares on resulting rail demand was evaluated. The purpose of these tests was to establish the model's sensitivity to pricing and understand the impacts associated with lowering fares on the Intercity-Corridor service. It was found that operating and maintenance costs associated with Action Alternatives were lower than the associated passenger fare revenues, so there appears to be flexibility to discount fares and the system would still be able to cover operating expenses.

Multiple fare discounts were tested for the non-express service and a 30 percent discount off of current fares on non-express services was identified as fare policy that would attract additional riders while at the same time still covering operating expenses. This fare policy was used to establish the Action Alternative forecasts. This fare policy was not intended as a fare-maximizing or ridership-maximizing analysis.

6 Ridership Forecasts and Findings

This section describes the ridership forecasts for the No Action and Action Alternatives resulting from the methodology described above. The ridership forecasts provide the basis for estimating the magnitude and incidence of benefits to users of rail services associated with the alternatives. The ridership forecasts are also the basis for estimating ancillary benefits to other travelers indirectly impacted by rail service changes in the corridor. The benefit measures associated with the alternatives largely stem from predicted changes in travel behavior in response to new services and reduced and/or more reliable travel times provided by the alternatives for certain markets.

This section discusses the key alternative evaluation measures associated with:

- Annual total rail linked (trips from ultimate origin to ultimate destination, ignoring transfers) trips
- Impacts to rail passenger miles
- Impacts to non-rail linked trips
- Impacts to automobile vehicle-miles of travel
- Peak-hour forecasted impacts at key screenline locations with an analysis of forecasted demand versus seat supply

It is important to note that the year 2040 ridership forecasts presented below were constrained to the available seated capacity for each alternative when forecasted demand exceeded available seats. Instead of simply removing rail trips in excess of available capacity, the process used in this analysis involved iteratively running the forecasting model (for both Interregional Model and regional models) to identify the appropriate shadow prices or “time penalties” required to divert trips from rail to other non-rail modes. In essence, this approach applies additional travel time to divert trips from rail to other non-rail modes and to balance forecasted rail demand to seated capacity. This approach identifies the modes that would be used in the event of a capacity constrained rail system, which is important for estimating other evaluation measures such as auto vehicle miles traveled. However, this analysis did not apply capacity constraints to other modes. Capacity constraints for rail were most evident in the No Action Alternative, where the most significant constraint was identified at the Hudson River screenline, where all three types of rail service – Intercity-Express, Intercity-Corridor and Regional rail, were shown to have peak ridership demand significantly above available seating capacity in the average weekday peak hour. Capacity constraints were applied to the following services, by alternative:

- **No Action Alternative:** Intercity-Express, Intercity-Corridor and New Jersey Regional rail crossing the Trans-Hudson screenline
- **Alternative 1:** NJ Regional rail crossing the Trans-Hudson screenline

Alternatives 2 and 3 did not require adjustments for capacity constraints.

As a result of applying the capacity constraints to the Hudson River screenline, Alternative 1 was shown to operate with ridership at levels very close to the seating capacity provided on Regional rail trains during peak hours. Alternative 2 also operates at ridership levels close to seating capacity but no adjustments for capacity constraints are required. By contrast, Alternative 3 provided significant residual capacity, available to accommodate future growth in ridership beyond what was estimated in the regional models for 2040.

The Service Plans developed for the alternatives were intended to be demonstrative of possible future service and were not optimized for ridership or revenue potential. In addition, the mix of service (Intercity-Express versus Intercity-Corridor) was not held constant across alternatives, which impacts the share of riders choosing each rail mode.

The remainder of this section provides discussion and findings related to the ridership forecasts for each alternative. Region-to-region summaries of ridership trip tables by mode are provided in Appendix I (Intercity rail) and Appendix J (Regional rail) of this report.

6.1 IMPACTS TO RAIL LINKED TRIPS

The number of rail-linked trips that each alternative attracts is an indicator of the value of proposed NEC FUTURE improvements. Linked trips by mode represent the region-wide total travel from each origin to each destination traveling by rail. The linked trip tables are a direct output from the both the Interregional Model and regional models. Each linked trip is counted once, no matter how many transfers are made or how many rail vehicles are boarded. Accordingly, this measure is directly related to the total travel occurring by rail and provides a basis for comparing alternatives that force many transfers to alternatives that force few transfers.

Table 31 provides the forecasted annual estimate of rail linked trips. Table 32 summarizes the annual rail linked trips by mode for the Alternative 3 route options. The key findings shown in Table 31 include:

- The vast majority of existing and forecasted rail linked trips are on regional rail services.
- Appendix J shows that approximately 75% of the forecasted Regional rail trips are concentrated in the Northern New Jersey, New York and Southwestern Connecticut (the New York City metropolitan area).
- While making up a relatively small share of the total rail travel, Intercity rail service linked trips are forecasted to grow more rapidly than the Regional rail linked trips.
- Appendix I shows that for Intercity rail travel more than 80% of linked trips have at least one trip end in Northern New Jersey, New York and Southwestern Connecticut (the New York City area).

The growth in the No Action Alternative ridership compared to existing ridership (shown in Table 31) reflects organic growth due to demographic changes in the Study Area. However, recall that the ridership estimates for the No Action Alternative had to be reduced to meet capacity constraints (for both Intercity and Regional rail). Based on regional estimates, growth of Regional rail exceeds growth of Intercity rail in terms of absolute number of trips, due to the overall size of the regional market. Intercity-Express ridership grows at a much higher rate than the Intercity-Corridor because Intercity-Corridor existing demand is already close to capacity in contrast to Intercity-Express, which has more available seats. Since the No Action Alternative essentially maintains the service currently offered, the amount of organic growth from the No Action Alternative compared to existing ridership demonstrates the need to facilitate future rail ridership, which will be at a significantly higher level in 2040 than is currently observed.

TABLE 31: ANNUAL INTERREGIONAL AND REGIONAL LINKED RAIL TRIPS (IN 1,000S OF ONE-WAY TRIPS)

Passenger Rail Trips	Existing	2040 No Action	2040 Alternative 1	2040 Alternative 2	2040 Alternative 3 (average)
Intercity-Express	3,300	5,700	5,100	6,500	7,600
Intercity-Corridor	11,400	13,600	28,600	30,600	31,400
Subtotal Interregional	14,700	19,300	33,600	37,100	39,000
Subtotal Regional	324,500	419,800	474,500	495,400	545,500
Total Rail Trips	339,200	439,100	508,100	532,400	579,900
Regional as a percentage of total trips	95.7%	95.6%	93.4%	93.1%	94.1%

Source: NEC FUTURE team, 2015

TABLE 32: YEAR 2040 ALTERNATIVE 3 ROUTE OPTIONS, INTERREGIONAL AND REGIONAL RAIL TRIPS (IN 1,000S OF ONE-WAY TRIPS)

Alternative 3 Route Options	Central Connecticut/ Providence (3.1)	Long Island/ Providence (3.2)	Long Island/ Worcester(3.3)	Central Connecticut/ Worcester (3.4)
Intercity-Express	7,900	7,800	7,600	7,100
Intercity-Corridor	31,000	30,900	32,200	31,500
Subtotal-Interregional	38,900	38,700	39,800	38,600
Subtotal Regional	545,500	545,500	545,500	545,500
Total Rail Trips	**584,500**	**584,200**	**585,300**	**584,100**

Source: NEC FUTURE team, 2015

Intercity-Express trips decrease in Alternative 1 compared to the No Action Alternative. This occurs for multiple reasons. First, the analysis includes a 30 percent discount in fares for Intercity-Corridor service over the fares in the No Action Alternative because the new equipment envisioned for the Action Alternatives has lower operating costs than the current equipment (see *Operations and Maintenance Costs Technical Memorandum* for more details on operating costs). In addition, Intercity-Corridor service (which includes Metropolitan service) provides improved speeds, which are more comparable to the Intercity-Express service in the No Action Alternative. As a result, Intercity-Corridor service (including Metropolitan service) attracts some riders that would have chosen Intercity-Express service in the No Action Alternative, as it has significant cost savings for a similar travel time. Finally, Intercity-Corridor service has a much larger increase in service compared to the Intercity-Express service, as seen in Table 28. Increases in ridership are also the result of the changes in service associated with the Action Alternatives. These Service Plans are not prescriptive, and do not necessarily reflect the operating plans of any of the NEC operators.

The Intercity-Corridor ridership approximately doubles compared to the No Action Alternative, while the Intercity-Express ridership decreases by approximately 11%. Overall, interregional ridership grows by 75%, and the Regional rail ridership grows by 13% over the No Action Alternative.

The Alternative 2 forecast shows growth relative to the No Action Alternative in both Intercity-Express and Intercity-Corridor ridership, with 14% and 125% increases, respectively. These increases in ridership are the result of service changes associated with the Action Alternatives. These Service Plans are not prescriptive, and do not necessarily reflect the operating plans of any of the NEC operators. The higher growth in the Intercity-Corridor ridership is primarily due to the proposed reduced fare structure and suggested improvements in service (for both frequency and travel time) for the Intercity-Corridor service. As described in the mode choice model description sections (Sections 3.2.4, 3.2.5, and 3.2.6), the dampened function of frequency used in the Interregional Model mean the impact of frequency flattens out at approximately 50 trains per day, and further increases in frequency have minimal to no impact. As shown in Table 28, for most key markets in Alternative 2 in the Intercity-Corridor service reaches the 50 trains per day level and there are approximately 40 trains per day in most of the Intercity-Express markets. This means that frequency is approaching optimal levels of frequency based on the model sensitivities in Alternative 2. Travel times in Alternative 2 are also greatly improved over the No Action Alternative, with the Intercity-Corridor travel times approaching the same travel times as Intercity-Express. This means that travelers, approximately 70% of whom are non-business travelers who are primarily sensitive to cost as opposed to time (as described in Section 3.2.5.2), are able to travel with express-like speeds at the reduced fare of the Intercity-Corridor service. The Regional rail ridership has a more modest increase over the No Action Alternative, with an 18% increase.

The Alternative 3 variations, on average, have an increase of 33% in Intercity-Express forecasted ridership and 131% increase in Intercity-Corridor forecasted ridership over the No Action Alternative. Ridership increases are the result of Service Plans developed by the FRA, which do not necessarily reflect operating plans from any of the operating railroads within the corridor The addition of the second spine on the north end contributes (along with the addition of new markets and increased speeds) to the forecasted increase in Intercity-Express ridership. The frequencies of both types of Intercity services for all key markets are at or well above the 50 trains per day level (see Table 29), at which point additional trains do not attract new riders according the Interregional Model specifications. The major benefit of the Alternative 3 options over the No Action Alternative is highly increased speeds, but the Interregional Model for non-business travelers (the largest traveler segment) shows that non-business travelers are much more sensitive to cost than travel time. As a result, there is not as significant of an impact to total ridership for Alternative 3 as some may have expected. The Intercity-Express mode exhibits the biggest travel time improvement, and the fare structure remains the same as in the No Action Alternative while the Intercity-Corridor mode has a 30% decrease in fare over the No Action Alternative's fare. Business travelers are the most likely to take Intercity-Express rail, due to their higher values of time described in Section 3.2.4.2; although, they comprise only 18% of all travelers. The low prevalence of riders willing to pay for increased travel times contributes to the difficulty in gaining large increases in the Intercity-Express ridership. The Regional rail ridership has an increase of 30% in overall ridership, due to the large increases in frequency over the No Action Alternative, which include relief from all the capacity constraints that are present in the No Action Alternative.

The Alternative 3 variations resulted in similar forecasted ridership totals, with the small differences in forecasted intercity ridership due to the different markets served. One of the findings from examining the differences between the Alternative 3 variations was that, in the No Action Alternative, there were riders traveling long distances from these “new” markets to take a train on the NEC. By adding in Alternative 3 stations in these new areas, it increased the accessibility and reduced the travel time, but in some cases the total cost increased, as riders were spending a larger portion of their trip on the train, which has a higher per mile cost as opposed to driving to access a train station further away. The high cost sensitivity in the non-business model combined with the higher cost of longer rail vs. access trips also contributed to the smaller than expected ridership in the transformative Alternative 3 variations. The major impact of adding in new stations is that existing riders shifted to stations that are closer to their origin and/or destination resulting in short access/egress trips.

In addition to absolute trip numbers, the distribution of trip-making patterns also plays a key role in the assessment of the alternatives. As mentioned above, both the regional and interregional trips are heavily focused on the New York metropolitan region. To further examine the geography of the trips, Table 33 looks at the break-down of the total interregional trips by three segments:

- Trips from a major metropolitan region (Boston, New York, Philadelphia, or Washington, D.C., as shown in Figure 5 and in Appendix I) to another major metropolitan region,
- Trips from a major metropolitan region to a non-major region (all other regions in the study area, and
- Trips from one non-major region to another non-major region.

One of the goals of introducing the new Metropolitan service (included in the Intercity-Corridor service for modeling purposes) was to provide access to formerly unserved or under-served markets, typically the non-major markets. While rail services in these non-major markets double their mode shares in Alternatives 2 and 3 relative to the No Action Alternative, ridership in these markets are still a very small amount of trips relative to ridership for markets with at least one end or both ends in one of the four major metropolitan areas in the corridor.

For Alternative 1 compared to the No Action Alternative, the impact of the new Metropolitan markets can start to be seen in the mode share for the major to/from non-major region market, in which the Intercity-Corridor mode share more than doubles from 3.1% to 7.4%. For all of the market segments, the mode share increases for Alternative 1 over the No Action Alternative are seen in the Intercity-Corridor ridership, instead of the Intercity-Express ridership due to the introduction of the reduced fares for that service. The Intercity-Express mode shares remain relatively constant. The majority of rail trips are in the major to major region segment, but the highest increases in mode share are seen in the major to non-major region segment. This is primarily due to high rail mode share saturation in the existing major to major segment, whereas the major to non-major region market has additional opportunities for growth and more room for improvement in the services offered.

Alternative 2 compared to the No Action Alternative also sees large increases in the Intercity-Corridor mode share focused on the major to non-major region segment due to the increased service, new markets served and fare structure.

Alternative 3 compared to the No Action Alternative exhibits similar patterns to the other Alternatives, with slightly higher increases in mode share. The Intercity-Express mode share increases by 50% over the No Action Alternative for trips in the major to major region segment, as these are heavily business travelers benefiting from the time savings and high frequencies offered in Alternative 3.

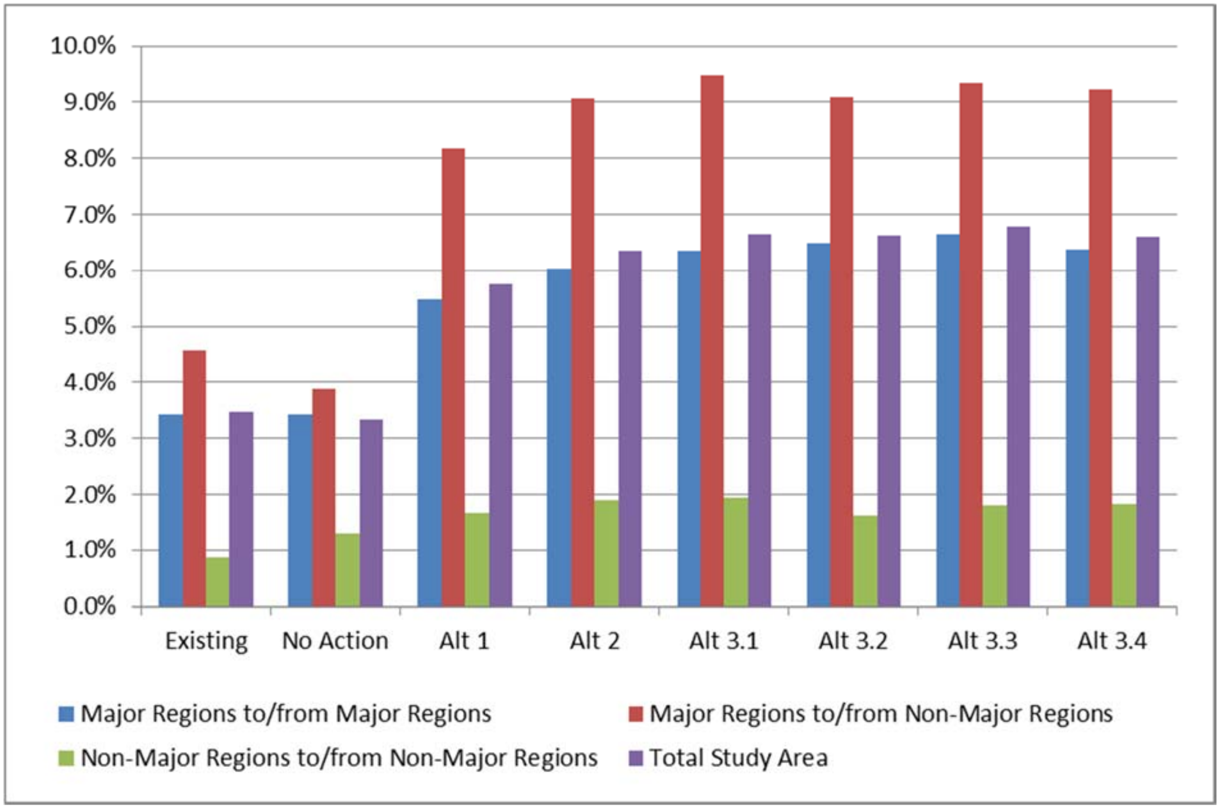
TABLE 33: INTERREGIONAL TRIPS (IN 1,000S OF ONE-WAY TRIPS) AND MODE SHARE BY GEOGRAPHIC SEGMENT

		Intercity Express Trips	Intercity-Corridor Trips	Total Intercity Rail Trips	Total Interregional Trips	Intercity Express Mode Share	Intercity-Corridor Mode Share	Intercity Rail Mode Share
Existing 2013	Major – Major	2,600	6,600	9,200	268,300	1.0%	2.4%	3.4%
	Major – Non-Major	700	4,500	5,200	113,500	0.6%	4.0%	4.6%
	Non-Major – Non-Major	20	350	370	43,200	0.0%	0.8%	0.9%
	Total Study Area	3,300	11,400	14,700	425,000	0.8%	2.7%	3.5%
No Action	Major – Major	4,600	8,000	12,600	368,100	1.2%	2.2%	3.4%
	Major – Non-Major	1,100	4,800	6,000	153,900	0.7%	3.1%	3.9%
	Non-Major – Non-Major	40	710	750	57,500	0.1%	1.2%	1.3%
	Total Study Area	5,700	13,600	19,300	579,500	1.0%	2.3%	3.3%
Alt 1	Major – Major	3,900	16,500	20,400	370,800	1.0%	4.4%	5.5%
	Major – Non-Major	1,100	11,100	12,200	149,500	0.8%	7.4%	8.2%
	Non-Major – Non-Major	-	1,000	1,100	63,800	0.1%	1.6%	1.7%
	Total Study Area	5,100	28,600	33,600	584,100	0.9%	4.9%	5.8%
Alt 2	Major – Major	4,800	17,600	22,400	371,500	1.3%	4.7%	6.0%
	Major – Non-Major	1,600	11,900	13,500	148,600	1.1%	8.0%	9.1%
	Non-Major – Non-Major	100	1,200	1,200	65,000	0.1%	1.8%	1.9%
	Total Study Area	6,500	30,600	37,100	585,200	1.1%	5.2%	6.3%
Average Alt 3	Major – Major	5,800	18,300	24,100	372,100	1.6%	4.9%	6.5%
	Major – Non-Major	1,700	12,100	13,800	148,400	1.1%	8.2%	9.3%
	Non-Major – Non-Major	100	1,100	1,200	65,300	0.2%	1.7%	1.8%
	Total Study Area	7,600	31,500	39,100	585,800	1.3%	5.4%	6.7%

Figure 19 takes a closer look at the changes in Intercity rail mode shares across the alternatives. Due to the capacity constraints, the No Action Alternative reduces the mode share in all geographic segments except for the non-major regions to non-major regions segment.

In all alternatives, the largest increases in mode share are in the major regions to/from non-major regions segment. The non-major to/from non-major region segment has the most modest increases in mode share and also has the smallest number of trips.

Figure 19: Intercity Rail Mode Share (Intercity-Express + Intercity-Corridor)



6.2 IMPACTS TO RAIL PASSENGER MILES

Total passenger miles are calculated as a function of the total rail passengers for each station pair multiplied by the rail distance between the station pairs and then summed by service type. Generally, rail passenger miles will exhibit the same patterns as seen for passenger trips. While the trips using intercity rail services make up a small percentage of total trips, they are typically much longer than trips made on regional services, so they account for much larger percentage of total passenger miles.

As shown in Table 34, Intercity-Express passenger miles decrease in Alternative 1 compared to the No Action Alternative, which is a similar to the result for passenger trips which was discussed in Section 6.1. The intercity passenger miles share increases from 22% in the No Action Alternative to 31% in Alternative 1, accounting for almost one-third of all passenger miles in the study area. In contrast, the Intercity passenger trips share increases from 4% to 7% in Alternative 1. Alternative 1 has a quarter more total passenger rail miles compared to the No Action Alternative.

Alternatives 2 and 3 have a similar split for Intercity passenger miles versus regional passenger miles, with 32% and 31% of total passenger rail miles being Intercity rail. Alternative 2 has approximately one-third more passenger rail miles compared to the No Action Alternative, and

Alternative 3 on average has approximately 1.5 times the passenger rail miles compared to the No Action Alternative.

TABLE 34: TOTAL ANNUAL INTERCITY AND REGIONAL RAIL PASSENGER MILES (IN 1,000S)

Service Type	No Action	Alternative 1	Alternative 2	Alternative 3 (average)
Intercity-Express	1,076,300	944,400	1,211,000	1,459,900
Intercity-Corridor	2,026,700	4,665,800	5,021,400	5,105,600
Regional	11,264,356	12,547,148	13,455,849	14,713,860
Total Passenger Miles	14,367,356	18,157,348	19,688,249	21,279,360
Regional as a percentage of total passenger miles	78.4%	69.1%	68.3%	69.1%
Percent increase compared to No Action		26%	37%	48%

Source: NEC FUTURE team, 2015

The Alternative 3 routing options between New York and Boston result in growth in passenger miles as shown in Table 35. Similar to the passenger rail trips, there are only small differences between the routing options, with the Long Island/Worcester option having the greatest number of passenger rail miles.

TABLE 35: ALTERNATIVE 3 ROUTE OPTIONS – TOTAL ANNUAL INTERCITY PASSENGER MILES (IN 1,000S)

Service Type	Central CT/ Providence (3.1)	Long Island/ Providence (3.2)	Long Island/ Worcester (3.3)	Central CT/ Worcester (3.4)
Intercity-Express	1,536,900	1,511,800	1,433,200	1,357,700
Intercity-Corridor	5,121,600	4,857,100	5,255,000	5,188,700
Total Passenger Miles	6,658,500	6,368,900	6,688,200	6,546,400

Source: NEC FUTURE team, 2015

6.3 IMPACTS TO NON-RAIL LINKED TRIPS AND AUTOMOBILE VEHICLE-MILES OF TRAVEL

Using the No Action Alternative as a baseline, additional impacts of each of the Action Alternatives can be measured by trips diverted from other modes.

Table 36 summarizes the total forecasted Intercity rail trips and those diverted from auto, air, or intercity bus (as compared to the No Action Alternative). Intercity rail trips also include those trips diverted from other rail services (for example, from Intercity-Express to Intercity-Corridor). Compared to the No Action Alternative, 36 percent of the total Intercity rail trips estimated for Alternative 1 are diverted from other modes; of those diversions, the majority of diversions are auto diversions. Alternatives 2 and 3 divert 44 percent and 46 percent of the total Intercity rail trips respectively. Table 37 presents the trips diverted from other modes for the Alternative 3 route options, each of which have similar diversions.

Another source of new rail ridership was induced demand, or new trips due to improving the overall transportation system. These trips are generated in the Total Travel Market Demand Model, and generated an additional 0.7% (for Alt 1) to 1.1% (for Alt 3.3) total trips over the No Action Alternative.

TABLE 36: TOTAL INTERCITY ANNUAL PASSENGER RAIL TRIPS DIVERTED FROM OTHER MODES AS OPPOSED TO THE NO ACTION ALTERNATIVE (1,000S OF TRIPS)

Mode	Alternative 1	Alternative 2	Alternative 3 (average)
Auto Diversions	9,500	12,700	13,800
Air Diversions	1,300	1,800	2,200
Intercity Bus Diversions	1,400	1,700	1,900
Induced Rail Trips	200	400	400
Total Rail Trips	33,600	37,100	39,000
% Trips Diverted from Other Modes	36%	44%	46%

Source: NEC FUTURE team, 2015

TABLE 37: ALTERNATIVE 3 OPTIONS - TOTAL INTERCITY ANNUAL PASSENGER RAIL TRIPS DIVERTED FROM OTHER MODES AS OPPOSED TO THE NO ACTION ALTERNATIVE (1,000S OF TRIPS)

Mode	Central Connecticut/ Providence (3.1)	Long Island/ Providence (3.2)	Long Island/ Worcester (3.3)	Central Connecticut/ Worcester (3.4)
Auto Diversions	13,700	14,200	13,500	13,600
Air Diversions	2,200	2,300	2,200	2,200
Intercity Bus Diversions	1,900	2,000	1,900	1,900
Induced Rail Trips	400	400	400	400
Total Rail Trips	39,000	39,800	38,600	38,700
% Trips Diverted to Rail	46%	47%	46%	46%

Source: NEC FUTURE team, 2015

Table 38 below presents the Regional rail annual passenger trips diverted from other modes. Each of the regional forecasting tools applied follows FTA's New Starts requirements for a fixed total person trip table for 2040. Because the fixed trip table is not allowed to increase, unlike the forecasts from the Interregional Model, there are no "induced" trips. The percentage of Total Rail Trips Diverted from Other Modes is calculated by dividing the Total Diverted Rail Trips from the Action Alternative by the Total Rail Trips of the No Action Alternative (420,000).

TABLE 38: TOTAL ESTIMATED REGIONAL ANNUAL RAIL TRIPS DIVERTED FROM OTHER MODES AS OPPOSED TO THE NO ACTION ALTERNATIVE (1,000S OF TRIPS)

Mode	Alternative 1	Alternative 2	Alternative 3
Auto Diversions	36,200	42,100	73,700
Other Transit Diversions (bus, subway, LRT)	18,500	33,500	47,400
Total Diverted Rail Trips	54,700	75,600	121,100
Total Rail Trips	474,500	495,400	545,500
% of Total Rail Trips Diverted from Other Modes	13%	18%	29%

Source: NEC FUTURE team, 2015

The effectiveness of the Action Alternatives in diverting trips from auto is also reflected in the annual reduction in automobile mode vehicle-miles traveled (VMT) versus the No Action Alternative, as shown in Table 39. This is a benefit to all travelers, as it helps reduce congestion on the highway network. Increases in both Intercity and Regional rail ridership result in reduced VMT; the largest reductions are achieved in Alternative 3. Table 40 provides details for each of the Alternative 3 route options. In this metric, VMT reduced due to trips diverted to Intercity rail are approximately double that of the VMT reduction associated with Regional rail for Alternatives 1 and 2, and approximately 1.5 times that of Regional rail in Alternative 3.

TABLE 39: ANNUAL REDUCTION IN AUTOMOBILE VEHICLE-MILES TRAVELED COMPARED TO NO ACTION ALTERNATIVE (IN 1,000S OF MILES)

Market/Service Type	Alternative 1	Alternative 2	Alternative 3 (average)
Intercity Rail Market Automobile VMT Reduction	(1,280.7)	(1,733.2)	**(1,890.6)**
Regional Rail Market Automobile VMT Reduction	(684.0)	(850.1)	(1,223.5)
Total VMT Reduction	**(1,964.6)**	**(2,583.3)**	**(3,114.2)**

Source: NEC FUTURE team, 2015

TABLE 40: ANNUAL REDUCTION IN AUTOMOBILE VEHICLE-MILES TRAVELED COMPARED TO NO ACTION ALTERNATIVE – ALTERNATIVE 3 ROUTE OPTIONS (IN 1,000S OF MILES)

Market/Service Type	Central Connecticut/ Providence (3.1)	Long Island/ Providence (3.2)	Long Island/ Worcester (3.3)	Central Connecticut/ Worcester (3.4)
Intercity Rail VMT Reduction	(1,913.1)	(1,805.7)	(1,977.0)	(1,866.7)
Regional Rail VMT Reduction	(1,223.5)	(1,223.5)	(1,223.5)	(1,223.5)
Total VMT Reduction	**(3,136.6)**	**(3,029.2)**	**(3,200.5)**	**(3,090.2)**

Source: NEC FUTURE Travel Demand Model outputs, April 2015

6.4 PEAK-HOUR, PEAK-DIRECTION IMPACTS AT KEY SCREENLINES

For each of the Action Alternatives, FRA compared available railroad capacity and the extent to which that capacity was utilized at key screenlines during the average weekday peak hour in 2040. A significant shortcoming of the No Action Alternative is the existence of capacity constraints, such that the system cannot serve the amount of passengers who want to travel by rail, pushing them onto other modes (primarily auto). The four key screenline locations that were analyzed include:

- North of Washington Union Station
- Hudson River, between New Jersey and Manhattan
- East River, between Manhattan and Queens
- South of Boston South Station

Table 41 summarizes the 2040 forecasted peak-hour capacity constrained ridership volumes and available seat capacity at key locations for peak-hour trains for each alternative (including both Intercity and Regional ridership), as well the unserved ridership, the number of riders which are turned away (estimated as the difference between the constrained and unconstrained demand). The location with the largest number of riders who are not accommodated due to the fact that demand exceeds capacity for the No-Action Alternative is the Hudson River screenline, with approximately 6,600 unserved riders per hour. The small amount forecasted unserved demand at the Washington, D.C., East River, and Boston screenlines is a result of the Intercity service being over-subscribed in the No Action Alternative.

Alternative 1 remains capacity constrained at the Hudson River screenline, although the amount of unserved ridership is reduced. While there are only modest capacity constraints in the No Action Alternative for the other screenlines, the capacity increases that result from Alternative 1 attract a significant amount of new riders. Chapter 9 of the Tier 1 Draft EIS contains additional information on the capacity of Alternative 1.

Alternatives 2 and 3 address the capacity constraints that are present in the No Action Alternative, and meet all the forecasted demand. Chapter 9 of the Tier 1 Draft EIS contains additional information on the capacity of Alternatives 2 and 3.

TABLE 41: WEEKDAY AM PEAK-HOUR, PEAK-DIRECTION VOLUME/CAPACITY AT KEY LOCATIONS

Screenline	No Action Alternative	Alternative 1	Alternative 2	Alternative 3 (average)	Alternative 3 (range)
Washington, D.C., (north of Union Station)					
Total Practical Capacity (Slots/Hour)	12	16	20	32	32
Total Trains per Hour	6	12	20	24	24
Total-Practical Seats per hour (Intercity and Regional rail)	6,400	11,750	17,435	20,927	20,927
Total Constrained Ridership (passengers per hour)	5,809	9,615	11,173	12,403	12,328-12,514
Volume/Capacity Ratio	0.91	0.82	0.64	0.59	0.59-0.60
Total Ridership Unserved (passengers turned away per hour)	44	0	0	0	0
Hudson River					
Total Practical Capacity (Slots/Hour)	24	44	52	76	76
Total Trains per Hour	24	37	52	70	70
Total-Practical Seats per hour (Intercity and Regional rail)	28,850	44,835	63,035	78,905	78,905
Total Constrained Ridership (passengers per hour)	30,374	44,993	61,280	71,111	71,029-71,257
Volume/Capacity Ratio	1.05	1.00	0.97	0.90	0.90
Total Ridership Unserved (passengers turned away per hour)	6,601	2,889	0	0	0

East River					
Total Practical Capacity (Slots/Hour)	40	48	70	74	74
Total Trains per Hour	38	48	60	73	72-74
Total-Practical Seats per hour (Intercity and Regional rail)	38,260	45,352	56,338	68,261	67,277-69,244
Total Constrained Ridership (passengers per hour)	32,795	42,450	49,289	52,430	52,239-52,630
Volume/Capacity Ratio	0.86	0.94	0.87	0.77	0.76-0.78
Total Ridership Unserved (passengers turned away per hour)	340	0	0	0	0
Boston South					
Total Practical Capacity (Slots/Hour)	24	24	24	32	24-40
Total Trains per Hour	11	17	22	28	24-32
Total-Practical Seats per hour (Intercity and Regional rail)	10,000	16,128	20,870	23,420	20,260-26,580
Total Constrained Ridership (passengers per hour)	9,562	13,528	14,682	18,480	18,213-18,731
Volume/Capacity Ratio	0.96	0.84	0.70	0.79	0.70-0.90
Total Ridership Unserved (passengers turned away per hour)	75	0	0	0	0

Source: NEC FUTURE team, 2015

Note: Ridership Values are both Intercity and Regional rail services, in the standard peak hour, year 2040.

6.5 KEY FINDINGS

The FRA selected a number of key results and findings from the ridership forecasting process and has summarized them below.

6.5.1 Trip Characteristics of Rail and Total Travel Markets

The FRA has identified two general findings describing the behavior of travelers in the NEC:

- In the No Action Alternative and Action Alternatives the majority of passenger rail ridership, as well as overall travel in the corridor, is focused on the New York metropolitan area. Approximately 75% of Regional rail ridership trips and 80% of Intercity rail ridership trips have at least one trip end in the New York metropolitan area.
- The majority of total travel (by all modes) in the interregional markets is for non-business purposes, making up approximately 70% of interregional travel. The rest of the total interregional market is made up of 18% business travel and 12% commuter travel

6.5.2 Market Responses to Action Alternatives

The FRA has identified two general findings regarding the market response to the service improvements in the Action Alternatives.

- Rail trips in the Study Area are predominantly Regional rail trips, which comprise 96% of all trips in the No Action Alternative, 96% in Alternative 1, 93% in Alternative 2 and 94% in Alternative 3. Alternative 1 demonstrated an overall increase in total rail trips over the No Action Alternative of 16%. Alternative 2 demonstrated a 21% increase, and Alternative 3 a 32% increase over the No Action Alternative.
- The mode split between Intercity and Regional rail shifts more in favor of Intercity if measured with passenger miles instead of trips because Intercity rail trips are typically much longer than Regional rail trips. In Alternative 1, Intercity passenger miles comprise 31% of the total miles as compared to 22% in the No Action Alternative. Alternatives 2 and 3 have a similar split, with 32% and 31% of total passenger rail miles being Intercity rail. The overall increase in passenger miles over the No Action Alternative was 26% for Alternative 1, 37% for Alternative 2, and 48% for Alternative 3. In all of the Action Alternatives, the number of passenger miles grew at a greater rate than the number of overall trips, indicating that the distances that travelers are covering by rail are longer overall than in the No Action Alternative.

6.5.3 Service Variable Sensitivities

The FRA has identified five major findings associated with ridership demand sensitivity to service characteristics relating to mode choice selection. The need to determine the amount and type of service that would accommodate future corridor demand drove the interactive process of developing Service Plans for each alternative. This process utilized feedback from the travel demand analysis and engineering and capital costing analyses. The Interregional Model development process provided insights into the potential responses of current residents of the study area toward the three different levels of rail service. The representative Service Plans the FRA developed for each of the alternatives allow for anticipated future growth and provide a basis for the FRA to assess the environmental impacts of the alternatives at a programmatic level. The critical service variables in the mode choice model include travel time, travel cost, and frequency of service.

The five key findings related to ridership demand sensitivity to service characteristics in the NEC are:

- Travel time and travel cost typically have an inverse relationship, and can be used to calculate the Value of Time (VOT), or the amount respondents are willing to pay to save additional travel time. The new business and commuter Interregional Models had VOTs that were similar to others seen in the corridor or for similar prior models. However, the non-business model demonstrated much lower values of time, ranging from around $6 to around $20 (allowed to vary by total cost of the trip). These are lower values than represented in the corridor in the past, and indicate that price is becoming a particularly important piece of the mode choice decision, especially given that approximately 70% of interregional travel in the study area is currently non-business. One indication of this shift in cost sensitivity may be the increased prevalence of low-cost Intercity Bus service that has occurred over the past several years, making travelers more aware of cheaper options in the interregional market. The market for Intercity Express rail service continues to appeal to business travelers who place a higher value on time and are willing to pay for the service/time savings; but this is only 18% of total travelers.

- In all three mode choice models of the Interregional Model (business, non-business, and commute), the FRA utilized a dampened function of frequency. This specification accounts for the expectation that additional departure options impact choice up until a certain saturation level, at which point travelers have enough options, and more frequency will not increase the utility of the mode. This saturation point in the models is around 50 trains per day, which indicates that once the trains are less than 30 minutes apart, the importance of frequency drops off. Alternative 1 comes close to hitting this saturation point with respect to service frequency, with both Intercity- Express and Intercity-Corridor service operated at 30 minute intervals. The frequency dampening factor becomes apparent in Alternatives 2 and 3, which provide Intercity-Express and Intercity-Corridor/Metropolitan train service at time intervals of 15 minutes or less. Despite this increase in frequency, there is a lower incremental increase in ridership demand. This is particularly clear with Alternative 3, which despite addition of a second spine, generates only 1.9 million additional Intercity rail trips.
- Investment in major improvements in Intercity rail service – travel time reductions, frequency increases, and price reductions – will impact rail mode share, but may not significantly change the rail volumes for travel between metro areas that have only a small overall demand (e.g., Danbury-Springfield). Thus, increases in rail volume are most dependent on share changes for travel between the large markets in the area (such as New York, Boston, Philadelphia, and Washington), but these already have a large rail share. Where rail is the dominant mode of travel (Philadelphia-New York, and to a slightly lesser extent Washington-New York), capturing additional rail share by further improving rail service is relatively difficult. In markets where there are multiple competing modes (such as New York-Boston), significant improvements in rail service tend to result in a higher modal shift in favor of rail.
- There is corresponding growth in Regional rail trips across each of the alternatives. Regional rail trips are forecast to increase by 13% for Alternative 1, 18% for Alternative 2, and 30% for Alternative 3 compared to the No Action Alternative. The conditions that influence Regional rail ridership demand –the opportunities for growth that are provided by the Action Alternatives, and the levels of growth – vary region-by-region; however, in all cases the models forecast a strong response of Regional rail ridership. In Alternative 1, ridership grows at a rate commensurate with the anticipated growth in population and employment, which was the expected result.
- The FRA has identified that the most significant finding to emerge from the analysis with respect to Regional rail ridership is the potential to grow Regional rail travel beyond keeping pace with demographic growth. This would be achieved by investing in rail system capacity and operating additional Regional rail service. The Regional rail ridership growth rates estimated for Alternatives 2 and 3 (18% and 30% respectively) demonstrate the potential for increasing rail's share of regional travel markets, and thereby growing the role of rail in regional travel.

7 Risk and Forecast Uncertainty

The FRA recognizes that the travel forecasts supporting planning investments must be able to address the uncertainty about a range of future assumptions that serve as inputs to the travel models. The behavioral responses of travelers to changes or new features in the transportation system must also be considered. The forecasting process should disclose the risk and uncertainty associated with any long term planning effort, including potential outcomes associated with any of the Tier I Draft EIS Alternatives. Many sources of uncertainty about inputs to the forecasting methods can be addressed through sensitivity testing or other methods; however even the use of these methods will not eliminate all elements of risk and uncertainty. Also, increases in ridership are the result of the NEC FUTURE Service Plans, which are not prescriptive and do not necessarily reflect the future operating plans of any of the railroads within the corridor.

7.1 DATA INPUTS

The first type of uncertainty surrounding the travel forecasts are related to data inputs. These sources of uncertainty include:

- Demographics
  - Population, employment, income levels
  - Location/magnitude of changes in demographics
- Rail Project Implementation
  - Physical scope: service extensions, station locations, inter-modal connections, and access
  - Service plan: travel times, fares, other
- Transportation System: Levels of service and costs
  - Highway: congestion, parking prices, gasoline prices
  - Other transit: background transit service levels and fares
  - Other intercity modes – air and bus
  - Investments in connecting corridors that could result in increased demand on the study area corridor

A primary driver of the total travel forecasts are the demographic forecasts. This analysis has relied on the “base” forecast to represent a moderate and reasonable picture of what is expected to happen in terms of population, employment and income in the future. However, there is uncertainty in the “base” forecast. The actual demographics in 2040 may vary in both size and distribution. For example, differences between various sources and locations of growth in employment and population may occur in the New York City metropolitan area, greatly impact travel patterns in the largest trip generator in the corridor. The demographic forecasts do not incorporate effects on future spatial development patterns or economic activity that might result from major improvements in the quantity, quality and extent of the rail transportation network, such as might occur in the Action Alternatives.

The second category of the data inputs that can provide uncertainty are the rail services being modeled. The FRA examined a large Study Area currently served by multiple rail operators. Thus, the actual implementation of the Service Plans modeled may differ from the planned implementation, and specific details which were assumed or simplified for analysis (such as station location and access characteristics) could impact the forecasted rail ridership.

Another key component of risk is the condition of the transportation system in the Study Area overall, and the levels of service and costs associated with the non-rail modes. In the modeled alternatives, the FRA made assumptions about the capacity and attractiveness of the non-rail modes, variations of which could impact mode choice in the study area significantly. In general, the non-rail modes were held constant to current service levels, with the exception that a level of future congestion was added to highway travel time (impacting access/egress time, auto travel time, and bus travel time). There is uncertainty in how these non-rail modes will respond in the future, to both changes in the rail mode (more competitive service) and other factors, such as fuel price changes or changes in trip-making. With overall growth in study area population and employment for the period through 2040, the travel demand models generally show an increase in travel by other modes as well as rail, in all of the Action Alternatives. To the extent that other modes may be constrained in their physical or operational capacity to accommodate growth, FRA had no basis within the scope of NEC FUTURE to estimate the magnitude of such constraints, and the non-rail modes therefore were not capacity constrained in the Interregional Model and regional models.

7.2 MODEL

There are inherent uncertainties surrounding the model itself, which include:

- Coefficient estimates
- Survey results
  - Stated preference questions are based on theoretical experiments, not actual experience
  - Based on current attitudes, and do not account for unseen attributes changing, such as overall mode preferences or other attributes such as multi-modal stations allowing ease for transfer, future growth around stations, future rates of car ownership, etc.

Each coefficient estimate specified in Section 3.2 has a standard error associated with it (which can be calculated using the t-stat shown in the model estimation results tables) which implies a range around the estimate. While the model produces a point estimate for the forecast, there is an error bar associated with each variable coefficient around that estimate and as a result the model forecasts also have probabilistic ranges associated with them.

In addition to the coefficients, there is uncertainty produced by the survey results used to estimate the model, in multiple dimensions. The first dimension is that the decisions made by the respondent in the stated choice questions which make up the basis for the mode choice model are made with all available information in front of them, and are assumed to make a rational decision for the mode which creates the most utility for the respondent. This may not be the actual decision the respondent would make if faced with this decision in their daily life, and may be biased by their current perception of each mode. For example, intercity bus was seen as less desirable in the SP experiments, but was actually a preferred mode using the RP data only.

The second dimension of uncertainty related to the survey results are the limitation of basing the model on current attitudes. This can limit the ability of the model to forecast results in areas where modes may change dramatically, such as in Alternative 3, where the service is in intended to be transformative – with trains running at headways more typical of transit services than intercity railroads, the convenience of not having to rely on a timetable or advance reservations for basic intercity travel, the ability to make intercity rail trips to other places within the NEC in timeframes previously only possible for trips within a region, the increase in the geographic reach of the NEC rail network, the ability to get to rail stations in a greater variety of ways, and a dramatic improvement in the overall convenience of traveling by rail. Respondents base their answers on their current perception of how travel operates, but a more reliable service could potentially shift the general attitude towards rail over time. In the mode choice model, this is represented by the alternative specific constant (which captures all unseen attributes), but it does not vary across alternatives. Another example of how the current attitudes may be limiting the model is in how the rail system is connected to the overall transportation network. One of the ideas behind transforming the transportation network would be increased connectivity, including such things as multi-modal stations, rental car facilities, and other ways that would allow travelers to more easily use the rail system. Respondents currently familiar with more limited options at rail stations today might not fully realize the advantages of this connectivity and allow it to influence their response.

Appendix A – Household Travel Survey Technical Memorandum

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Household Travel Survey Technical Memorandum

March 15, 2015
Final Version

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1. Overview

1.1 STUDY OBJECTIVES

The Survey of Northeast Regional and Intercity Household Travel Attitudes and Behavior (NEC Survey) was commissioned by the Federal Railroad Administration (FRA) to collect information on intercity and regional travel behavior and preferences of Northeast residents, and inform the modeling efforts as part of the NEC FUTURE Program.

The goal of the NEC survey is to help the NEC FUTURE program in preparing a Passenger Rail Corridor Investment Plan (PRCIP) for the Northeast region. The PRCIP, when completed, will improve the capacity and reliability of passenger rail travel in the Northeast.

The results of the survey will be used to develop a new model for forecasting future travel behavior in response to future services provided by different modes of travel in the Northeast. The primary use of the model will be to analyze the ridership impacts of alternative rail investment plans for the Northeast Corridor (NEC) as part of the aforementioned PRCIP for the Northeast region. In addition, the new NEC model and the data underlying the model will be available to the FRA for use in future projects involving the NEC.

The information collected included frequency of trips, origin and destination, modes of travel, trip purpose, party size, trip costs, and other trip characteristics. The survey also obtained stated travel preferences under alternative choice scenarios that included different and new travel modes, travel times, costs, schedules, and other service characteristics.[1]

1.2 RESPONDENT UNIVERSE

The respondent universe consisted of all persons aged 18 to 74 residing in households with a working telephone located within the Northeast Corridor of the United States[2]. The surveys were conducted among those who spoke English[3].

1.3 STUDY AREA

The study area spans the Northeast Corridor, including counties within the following States: Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, and Washington DC/District of Columbia. For purposes of defining and analyzing transportation alternatives for NEC FUTURE, the Study Area encompasses

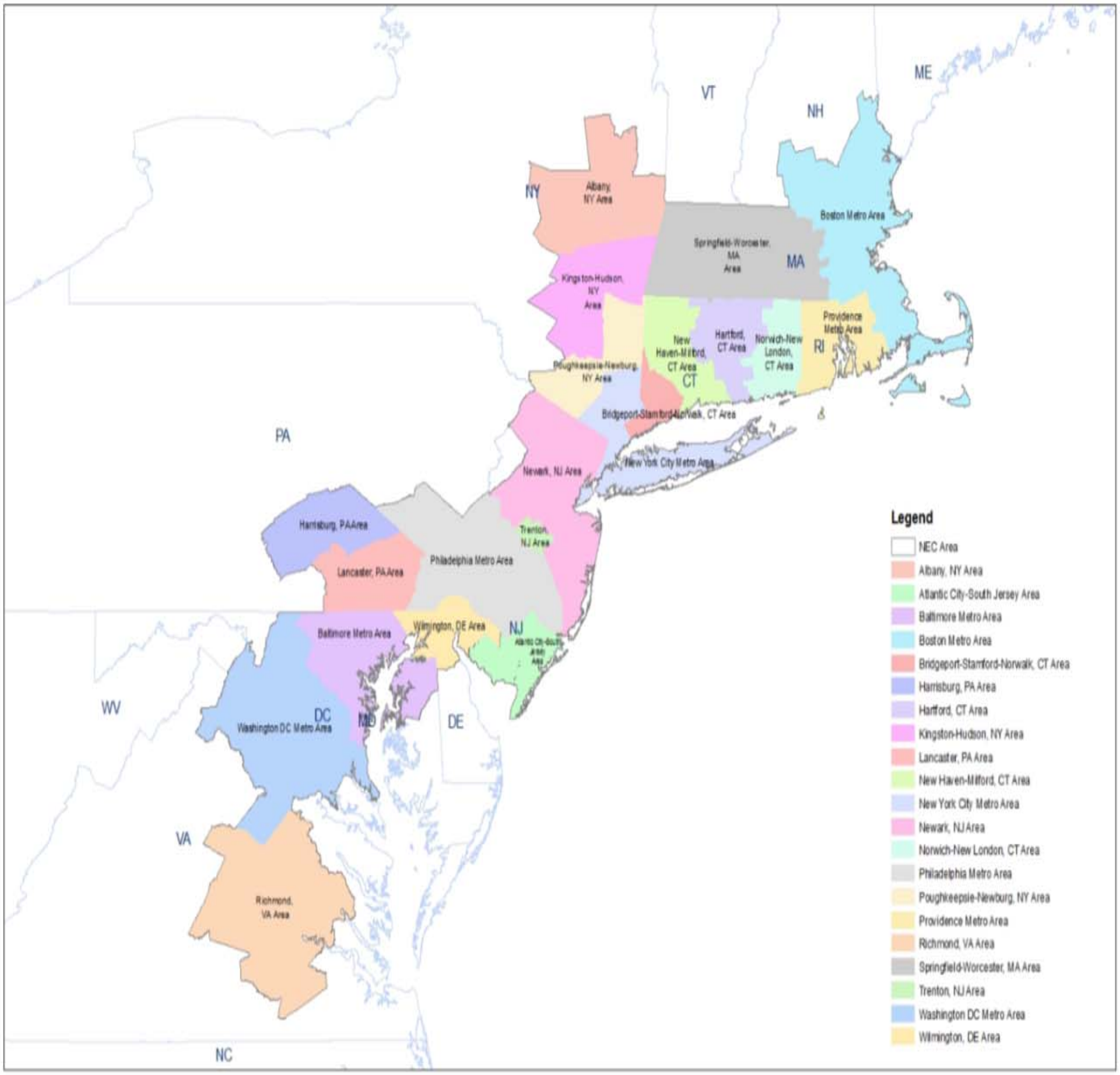
[1] OMB Control Number for the Survey is 2130-0600.

[2] Using a telephone household sample does not cause coverage bias as telephone service for many household is intermittent and thus will include households that were recently part of the non-telephone population.

[3] Limiting to English speaking respondents has minimal impact, based on the prevalence of the use of English in the United States and especially among target respondents, who are long distance travelers.

the region served by the NEC, plus those areas that can be reached directly by train or via a transfer to connecting rail corridors from the NEC. It is defined graphically in Figure 1.

Figure 1: Northeast Corridor Geography



2. Sampling and Survey Design

2.1 DUAL FRAME SAMPLING

The NEC Survey sample design employed a partially overlapping dual frame design containing probability samples drawn from independent sampling frames for landline phones and for cell phones.

2.1.1 Random Digit Dialing (RDD) of Landline and Cell Samples

List-assisted landline RDD sampling provides only a small coverage error for landline telephone households within landline banks, yet the restriction of the sampling frame to only landline banks would have introduced a much more serious coverage error. The increasing percentage of households that have abandoned their landline telephones for cell phones has significantly eroded the population coverage provided by landline-based surveys. The key group that is missing from landline RDD samples is the cell phone-only group. There is also potential bias in landline samples from under-coverage of young people who tend to rely on their cell phones more than their landline phones. Therefore, the cell phone sample for this survey was designed to be composed of both cell phone-only and cell phone users with a landline in their household.

Due to the higher cost of cell phone interviews compared to landline interviews, dual frame surveys are not usually designed with proportional allocation of sample between the landline and cell phone strata. The most recent data published from the National Health Interview Survey[4] shows 27.1% of adults residing in cell phone-only households in the Northeast region of the United States during the first half of 2013.

The sample allocation consisted of a two-stratum design (landline and cell phone) with 22% of the total sample being obtained from the cell phone frame.

2.1.2 Generation of Landline Sample

The landline sample was drawn from telephone banks randomly selected from an enumeration of the Working Residential Hundred Blocks within the active telephone exchanges. The Working Hundreds Blocks are defined as each block of 100 potential telephone numbers within an exchange that includes one or more residential listings (i.e., this will be a list-assisted sample). A two-digit number was then randomly generated for each selected Working Residential Hundred Block to complete the phone number to be called. By randomly generating these numbers, a process known as random digit dialing (RDD), every number in the sampling frame of Hundreds Blocks had an equal probability of selection regardless of whether it is listed or unlisted. The RDD sample of telephone numbers was dialed to determine which are currently working residential household telephone numbers. The systematic dialing of those numbers to obtain a residential contact was done to yield a probability sample of landline telephone numbers.

[4] Blumberg, Stephen J. and Julian V. Luke. Wireless Substitution: Early Release of Estimates From the National Health Interview Survey, January-June 2013. U.S. Department Of Health And Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. Released 12/2013.

2.1.3 Generation of Cell Sample

The cell phone sample was randomly selected from 1,000 banks used exclusively for cell phones, using RDD. Stratification by area code was not performed since area code is not a great predictor of geography for cell phone sample. Procedures for sample selection were similar to those used in selecting the landline sample, except that the cell sample was not list-assisted. In addition, the cell phone was treated as a single user device. Therefore the cell phone sample did not require the same recruit procedures used within the landline sample to select a single participant from multiple eligible household members.

2.2 SURVEY SAMPLE CHARACTERISTICS

2.2.1 Survey Sample Requirements

The key dimension driving survey sample size requirements is trip purpose. Prior survey research and model estimation analysis, including most other intercity and regional surveys/models nationwide, have consistently shown trip purpose to be a significant determinant of travel behavior with respect to key sensitivities to service characteristics. For example, travelers on business trips typically show a higher value of time than travelers on non-business trips. For the purposes of this NEC research, trips were divided into the following three strata:

- Commute Trips, including only the daily commute to or from the usual place of work
- Business Trips, which include all non-commute trips associated with a business purpose such as company meetings, sales trips, etc.
- Non-Business Trips, which includes all other non-commute and non-business trips

Another important dimension is geography. The survey sample needed to address a cross-section of trips in different markets representative of the NEC. In the NEC FUTURE study, initial analysis of available market data and conceptual future rail alternatives has identified and confirmed the importance of the following key geographic stratification of the NEC:

- Travel North of New York
- Travel South of New York
- Travel through the New York Area (between points north of and south of New York)

The above stratification is particularly important with respect to business and non-business intercity trips, where there are important differences in the characteristics and availability of different modes of travel. The specific type of longer commute trip between regions addressed within the new NEC model is in itself a unique market. However, it is a much smaller market that does not lend itself to similar geographic stratification.

The new NEC model will be stratified into business, non-business and commute trips. Therefore, it is important to ensure the overall survey sample provides sufficient numbers of completed surveys within each of these segments. It is a given that larger samples will provide more precision, but there is a diminishing return on this relationship and requirements must be properly balanced with the need to efficiently and effectively use available resources.

2.2.2 Survey Sample Development

As with any sampling plan, there is always some uncertainty as to whether the data will actually reflect the universe of travelers until the survey itself is completed. However, existing data sets were used to derive NEC sample expectations. In the survey sample development stage, two key sources were examined to assess the expected distribution of the NEC sample: (1) the 2006 Amtrak NEC Traveler Surveys, which used a similar survey approach, and (2) the 2006 to 2008 3-year ACS CTPP Journey to Work (JTW) flow data, which provided a basis for estimating the incidence of longer commuter trips between NEC regions. Table 1 below provides the estimated size of the key trip purpose and geography subsamples for a total target sample of 12,500 completed surveys.

Table 1: Target Survey Sample by Trip Purpose and Geography

	Business	Non-Business	Commute	Total
North of NY	517	2,462	*	
South of NY	1,242	5,816	*	
Through NY	371	1,367	*	
Total	**2,130**	**9,645**	**725**	**12,500**

** Stratification of commuter travel by these markets was not examined independently.*

2.2.3 Obtained Survey Sample

In total, 11,858 completed surveys were obtained. Table 2 provides the breakdown by trip purpose and geography. Taking into account weighting, the margin of error at 95% confidence level for an estimated population percentage of 50% based on the total sample size is plus or minus 1.4 percentage points.

Table 2: Obtained Survey Sample by Trip Purpose and Geography

	Business	Non-Business	Commute	Total
North of NY	553	2,630	418*	
South of NY	987	4,437	624*	
Through NY	420	1,664	125*	
Total	**1,960**	**8,731**	**1,167**	**11,858**

* *Stratification of commuter travel by these markets was not examined independently.*

2.3 SURVEY CONTENT AND STRUCTURE

The information collected in the survey included frequency of trips, origin and destination, modes of travel (and class of service if applicable), trip purpose, party size, trip costs, and other trip characteristics. The NEC Survey was also designed to elicit travel preferences under alternative choice scenarios that included different and new modes, costs, schedules and other service characteristics. The background variables and stated preference module are described below.

2.3.1 Travel and Background Data Collected

The NEC Survey included questions about current longer distance trips and Stated Preference (SP) questions about alternative choices in response to different mode availability and modal service characteristics. For the purposes of this survey longer distance trips are defined as those made from the home area to other eligible areas. Eligible areas excluded the respondent's home State, nearby areas in adjoining States (typically less than 50 miles away from the home), and areas where the trip would have been entirely outside of the NEC. The survey collections information related to longer distance trips that were taken by the respondent during the 12 months prior to the interview date. The long distance trips tend to be less frequent and are likely more memorable. In order to minimize respondent burden, the survey collected information on a single qualifying origin and destination

The travel and background variables collected included:

- Trip data
  - Origin & destination
  - Frequency of trips in the last 12 months for that origin & destination
  - Purpose of each trip: Commute, Business, Non-business
  - Travel modes for a randomly selected trip purpose
  - Fare, duration, trip party, and information on access & egress for the most recent trip for the randomly selected travel mode for the randomly selected trip purpose (the reference trip)
- Demographic data
  - Age, gender, household size, vehicles owned, education, employment, income, race and Hispanic/Latino ethnicity, landline/cell phone ownership

2.3.2 Stated Preference Module

Six SP trade-off questions relating to the reference trip were presented to the respondent. The specific SP trade-off questions reflected an experimental design that addressed a cross section of all of the potential mode availability and service characteristic combinations so that each respondent was not asked to address too complex a choice task or was unnecessarily burdened by a longer interview. Specifically, each respondent was presented with choice questions addressing three of the following seven modes of travel within the NEC:

- High Speed Train
- Regional Train
- Commuter Train

- Metropolitan Train (a new service type)
- Passenger Car/Truck/Van
- Plane
- Bus

For a specific respondent, the selected modes used in the stated preference questions included the respondent's first choice mode, (i.e., the mode they actually used for the reference trip) and two randomly selected modes. Thus, each respondent will be asked to choose from among three modes of travel. The number of respondents that was exposed to each of the NEC modes is as follows:

- High Speed Train: 3,247 respondents
- Regional Train: 10,772 respondents
- Commuter Train: 1,133 respondents
- Metropolitan Train: 2,269 respondents
- Passenger Car/Truck/Van: 10,244 respondents
- Plane: 2,613 respondents
- Bus: 5,296 respondents

Note that the above total to 35,574, or three times the obtained sample size, because each respondent was exposed to three modes.

The detailed trip information obtained before the stated preference trade-off questions provided the context for the respondent's travel choices and a basis for defining trip-relevant service characteristics in the trade-off questions. The stated preference questions varied the values of a randomly selected subset of service characteristics for each mode using an experimental design that minimized the correlation among independent variables. Respondents were randomly assigned to one of three subgroups that saw changes in these variables[5]:

- Group 1: travel time and cost (schedule fixed)
- Group 2: travel time and schedule (cost fixed)
- Group 3: cost and schedule (travel time fixed)

This survey design limited the number of changing variables that any one respondent needed to react to and thus made the task more manageable. Respondents were presented with a total of six SP questions that addressed three choices of mode of travel with varying characteristics within one of the three pairs of variables listed above.

Base values of all variables were pre-determined for each mode for each possible origin and destination in the market area. This was done for each mode using the following sources:

[5] An earlier version of the survey also explored reliability as a service characteristic, but as a result of changes stemming from the results of the pilot study (see Section 2.4), it was not possible to retain reliability as a service characteristic of the modes in the final study.

- High Speed Train: Based on current Amtrak Acela average travel times and fares
- Regional Train: Based on current Amtrak Regional average travel times and fares
- Commuter Train: Based on current commuter rail average travel times and fares from different commuter rail operators including MBTA, MNR, NJT, LIRR, SEPTA, MARC and VRE.
- Metropolitan Train: Based on current commuter rail travel times and Amtrak Regional average travel times and fares. The process involved averaging the two sources to create values that were in-between Regional and commuter services, to reflect the proposed service.
- Passenger Car/Truck/Van: Based on highway travel time skims using the NHPN road network and mileage based costs
- Plane: Based on FAA BTS air data average travel times and fares.
- Bus: Based on current bus average travel times and fares from published schedule for all bus service operators
- Access/Egress for all modes (except auto): Based on highway travel time skims using the NHPN road network

The service characteristics for all the modes for a particular respondent were determined by the origin and destination of the respondent's reference trip. In addition, the respondent's self-reported fare information for the mode the respondent actually took is used for that mode in the SP questions. If the respondent did not remember the fare paid, the base values for that mode and origin and destination were used.

In the pilot survey phase, most self-reported rail, air and bus fares by respondents were reasonable when compared to published fares. The project team developed transportation network models of all modes which produced the relevant base values for travel times and costs, which also scale with trip length and geography. To allow the SP questions to explore a wide variety for potential service offerings across all modes, high and low values for the service characteristics were computed as follows:

- Total Travel Time High: randomize among +15%, +30% over base values
- Total Travel Time Low: randomize among -15%, -30% under base values
- Total Cost High: randomize among +15%, +30% over base values
- Total Cost Low: randomize among -15%, -30% under base values
- Schedule High: randomize among next two higher amounts over base (e.g., "Every Two Hours", "Every Three Hours")
- Schedule Low: randomize among next three lower amounts under base (e.g., "Every 30 minutes", "Every 20 minutes", "Every 15 minutes")

The responses to the SP survey questions will be used to provide the basis for estimating key sensitivities to changes in the service characteristics in the new model. Considerable care has been taken in the design of the NEC FUTURE survey to avoid presenting or showing any bias for/against any specific mode to respondents. First and foremost, the survey is household-based and mode neutral in recruiting respondents and identifying specific trips they have taken. Key elements of this effort included:

- Identification of the survey as USDOT-sponsored, not FRA, when speaking with respondents
- Randomized order of presenting candidate markets to select a specific market where the respondent made a trip
- Random selection of specific mode and trip purpose taken in this market
- Use of this randomly selected mode as one of the available modes shown in the stated preference questions
- Randomly selecting from remaining available modes to complete the list of modes shown to each respondent in the stated preference questions
- Randomizing the order that these modes were shown to respondents
- Using similar language throughout the survey where mode-specific information was presented to respondents

2.4 PILOT STUDY

Prior to moving forward with the full scale study, a pilot study was conducted to consider the effectiveness of the stated preference exercises, test the strength of the model, and assess response rates.

2.4.1 Scope and Timeline

The pilot consisted of 626 recruits, which resulted in 307 follow-up completes. The fielding period encompassed August 28, 2013 through November 4, 2013.

The pilot was a two-phase process: the recruitment survey and the follow-up survey. The recruitment survey was conducted by telephone. Recruitment respondents who qualified (being an adult and having taken a qualifying longer distance trip in the Northeast) and agreed to the second part of the study were offered two options for completing the follow-up survey.

Those with Internet access were sent a unique link via email to their individualized Internet follow-up survey. Those without Internet access were first mailed a packet of customized stated preference choice exercises. They were then able to view the travel scenarios when they were called for the phone version of the follow-up survey. For respondents without internet access, the recruitment survey also collected the necessary information from the respondent to develop SP choice questons that were customized to the particulars of the respondent's reference trip.

The two phase format was first chosen so that respondents could be exposed to the SP choice questions using a visual format (either through the internet or printed materials). The visual representation was considered essential due to the complex nature of the SP choice questions which for the pilot study had four service characteristics that could vary with among three modes, and 12 SP questions for each respondent.

2.4.2 Results

- The geographic distribution of the survey population reflected the relative population of the areas within the Northeast Corridor, with the areas near the largest cities being the most commonly reported home areas.
- The majority of respondents' trips were for leisure or non-business purposes (79.2%) with business (15.6%) and commuting (5.2%) distant second and third reasons for travel.
- The majority chose internet (86.3%) as their follow-up mode.
- The recruitment response rate was 9%[6] which is calculated as the number of complete interviews divided by the number of complete interviews plus the number of non-interviews (e.g.,screened/refusals/breakoffs) plus an estimate of the number of cases of unknown eligibility (e.g., no answer/busy/answering machine/un-screened refusals/callbacks) that are likely to be actually eligible. The factor for estimating the rate of eligibility among the unknown eligibility cases is determined as: (screened contacts and complete interviews minus screen-outs) divided by (screened contacts and complete interviews). Un-useable numbers are excluded from the calculation altogether.
  - Achieving a robust response rate was challenging because to be considered a "complete" response a respondent had to have traveled to a qualifying area and agree to participate in the follow-up survey. This represented a double hurdle for meeting the recruitment completion criteria.
  - Roughly one-quarter (22%) of respondents we spoke with screened out because they had not traveled to a qualifying area.
  - Of those who took a qualifying trip and met the other qualifying criteria of being an adult and living in the study area about half agreed to participate in the follow-up survey.
- The follow-up response rate was 49% overall (50% for Internet follow-up and 41% for mail/phone follow-up). This rate was calculated as the percentage of respondents who completed the follow-up survey divided by those who both qualified for the survey and agreed to the follow-up in the recruitment phase.
- The cumulative response rate across both parts of the pilot survey (recruitment and follow-up) was 4%.
- A preliminary look at non-response bias (which compared key demographic measures to the distribution in the general population) showed some differences—particularly, the follow-up survey respondents skewed higher in terms of household income and age and were less likely to be Hispanic compared to the general population in the study areas. However, the demographics of the general population in the Northeast Corridor is likely different from

[6] 12% calculated from landline sample. Cell sample recruit response rate was 4%.

long distance travelers in this region, who may indeed have higher incomes, and generally be older and less Hispanic than non long distance travelers.

- The average recruitment survey length was 7 minutes. The follow-up survey ran 15 minutes for the phone portion of the mail/phone version and 18 minutes for the Internet version.
- Pilot survey responses were preliminarily tested for general operational and content issues with the survey as well as respondent fatigue in the stated preference questions. One issue with stated preference questions is respondent fatigue, whereby increasing the number of experiments, alternatives and attributes can result in survey drop-offs. The questionnaire was designed to include 12 experiments with 3 alternatives, each with 2 attributes that vary and 2 that are fixed.
  - One approach that was used to assess fatigue in the pilot phase was to count the number of experiments declined (no response provided). Very few respondents declined to answer any of the SP questions.
  - Additionally, an analysis of the time spent answering each SP question was conducted, and it did not indicate that respondents were getting tired and taking longer to answer the latter questions in the series. On average, respondents took the longest to understand and answer the first question in the series.
- Variation in mode switching behavior was also analyzed to ensure the level of the variation in the stated preference variables was adequate for model estimation. Each respondent was assigned three modes for the series (their existing mode of travel, their second choice mode, and a randomly assigned mode that is available for their origin-destination pair). 48% of respondents did not switch modes at all, indicating that the variation may not be great enough between the variables. Of the non-switching mode respondents, 78% used Auto, which tends to be the hardest mode to switch to a shared ride mode. This did not indicate a problem with the questionnaire design but rather that the non-auto modes were not competitive enough to attract travelers to make the switch.
- Additionally, the mode switching behavior was analyzed for illogical responses (switching modes to a less desirable circumstance) and most appeared to be making logical switches.
- Test models were run in order to estimate whether key variables such as time and cost were providing meaningful coefficients. Simple multinomial logit (MNL) mode choice models were tested for all of the respondents and for business and non-business trip purposes, and in all cases the coefficients behaved as expected.
- The pilot results indicated Passenger car/truck/van as the primary chosen mode, reflecting the results of similar studies in the northeast.

2.4.3 Recommendations to the Main Study

The following recommendations were implemented based on the pilot study results:

- The SP variable values were adjusted to increase the relative attractiveness of non-auto modes, by reducing rail travel times and increasing auto travel times that were presented to respondents using Auto. Since the pilot results showed that many Auto respondents continued to choose auto across all SP questions, making the non-auto modes more attractive should create more variable responses.

- To improve response rates:
- The survey design was simplified from a two-phase methodology to a one-phase CATI telephone survey. As a result of this change, the SP questions could no longer be presented visually. In an effort to simplify the SP questions for ease of understanding when asked verbally via the telephone interview, the reliability was dropped from the service characteristics used to describe the alternative modes. In addition, the schedule of the alternative modes was changed from being a deviation (in minutes) from the respondent's preferred arrival or departure time, to being described as the number of minutes between departures.
- The total survey length was shortened from the pilot (7 minutes for the recruit and 15-18 minutes for the follow-up) to 18 minutes for the revised one-phase survey.
- The incentive was increased from $5 to $10.
- The maximum number of attempts per phone number dialed was increased from 5 to 10.

3. Field Implementation

3.1 ONE-PHASE CATI SURVEY

The original design of data collection efforts called for a two-phase survey approach. The recruit survey would be conducted by telephone via computer-assisted telephone interviewing (CATI) using a dual frame sample with both landlines and cell phones. The follow-up survey was to be conducted mostly via self-administration by respondents on the Internet. Respondents without Internet access would complete the follow-up survey by viewing a mailed packet of survey visuals and then providing answers to follow-up questions via a telephone interview.

Based on the findings from the pilot study, including a relatively low overall response rate across both phases, the original proposed data collection approach was reconsidered and revised. A one-phase dual frame CATI methodology was used for the main study. This methodology provided adequate sample population coverage and response rates at a reasonable schedule and cost.

3.1.1 Scope, Timeline and Survey Length

The NEC FUTURE survey was administered via CATI to a randomly selected sample of 11,858 respondents age 18 to 74 years old residing in the Northeast Corridor who have made longer distance trips in the Northeast Corridor within the past 12 months. 9,216 interviews were conducted with the landline sample, and 2,642 interviews conducted with the cell phone sample. The survey was fielded from April 23, 2014 through July 31, 2014. The average survey length was 16 minutes.

3.1.2 Recruitment and Eligibility

In the survey’s introduction, respondents were informed that participation is voluntary, and their answers will be kept private and will be used only for statistical purposes. Name and address was collected for the purpose of mailing incentive checks. Name and address, along with phone number were removed from the final data file.

Questionnaire Outline

An outline of the questionnaire screener is as follows:

- Safety (Cell phone sample only). Respondents were first asked if they were in a safe place to talk (e.g., not driving).
- Household Members (Landline sample only). To identify a random member of the household to participate in the survey, respondent was asked to provide number of people in household.
- Age. Respondents were asked to confirm age as one aspect of eligibility.
- Home location (Cell phone sample only). Those in the cell phone sample were asked to confirm their home location (this is already known for land lines).

- Regular/Daily Commute Trips. The respondent was asked if his/her regular commute trip is to an eligible out-of-state location and, if so, how many times in a typical week they make the trip, by mode. Eligible areas excluded the respondent's home State, nearby areas in adjoining States (typically less than 50 miles away from the home), and areas where the trip would have been entirely outside of the NEC.
- Other Qualifying Non-Commute Trips. If no qualifying commute trip was given based on responses to the preceding section on commute trips, the respondent was then asked about non-commute trips to out-of-state locations. This line of questioning included those pertaining to frequency in the past 12 months, mode and trip purpose. Eligible areas excluded the respondent's home State, nearby areas in adjoining States (typically less than 50 miles away from the home), and areas where the trip would have been entirely outside of the NEC.
- Selection of Reference Trip. The screener concluded with the random selection of a specific mode and trip purpose from those identified above. For reference trip assignment purposes, the respondent was also asked whether a round trip was taken.
- Demographics. If no qualifying trip was found in either the Commute or Non-Commute series of questions, the survey skipped to collect demographic information. In these cases, the interview was not counted as a completed survey. Demographic data collected included: age, gender, household size, vehicles owned, education, employment status, income, race and Hispanic/Latino ethnicity, and landline/cell phone ownership.

Upon completing the questionnaire screener, eligible participants were then taken through the main questionnaire. An outline of the main questionnaire is as follows:

- Reference Trip Details. In the first series of questions in the main questionnaire, the respondent was asked specifics about the reference trip assigned upon completion of the screener. As applicable for the reference trip, these questions included the specific type of rail service used, access and egress mode of travel, fare for common carrier modes, cost for auto mode, station/terminal waiting time, party size, trip purpose, specific origin and destination airport/station, and whether a connection was involved and the duration of reference trip. Trip data obtained in this section provided revealed preferences for the respondent's travel choices and may have helped to form the basis for defining trip-relevant service characteristics in subsequent trade-off questions (e.g., self-reported fare for train trips was generally used as the base fare in the stated preference module7).
- Main Mode Choice Trade-Off Questions. The trade-off questions included choice exercises that provided information used for estimating the new mode choice model. Specifically, six trade-off questions relating to the reference trip and three trip characteristics (i.e., travel cost, travel time and schedule) were presented to the respondent. The specific trade-off questions reflected an experimental design that addressed a cross section of all of the potential mode availability and the three trip characteristic combinations.

[7] Respondents who did not remember their fare, or gave unreasonable estimates, were provided default value in the trade-offs section based on published fares for travel between their place of origin and destination.

- To lessen respondent burden, each individual respondent was presented with three mode scenarios: Mode A representing the actual mode the respondent used for the reference trip and two randomly selected alternatives (Mode B and Mode C). Mode alternatives were described by the (one-way) total travel time, total cost, and schedule.
- The first choice exercise asked respondents to choose a mode based on the "base" characteristics of the three alternative modes. The next five choice exercises modified the characteristics of the available alternatives using percent changes over or under the base values.
- For an individual respondent, only two of the three characteristics changed from the base trip values. One group of respondents (Version 1) saw travel cost and travel time vary, but schedule remained the same. In Version 2, travel time varied but travel time and schedule did not vary. Other respondents were shown scenarios in which schedule was varied but travel cost and travel time were fixed (Version 3).
- Additionally, subversions of the survey varied the order of characteristics presented. For example, Version 1a listed time first followed by cost while Version 1b listed cost first, then time.

- Demographics. Respondents completing the entire survey, as well as those ineligible for the main survey based on their non-qualifying trip behavior, were asked to answer a set of demographic questions prior to ending the interview. These questions included age, gender, household size, vehicles owned, education, employment status, income, race and Hispanic/Latino ethnicity, and landline/cell phone ownership.

3.1.3 Incentive Structure

Respondents received a $10 check for their participation in the survey. The $10 check was mentioned during the introduction and awarded after the respondent completed the survey. The $10 served as a token of appreciation for the respondents' effort and was used to help maximize response rate.

The pilot phase study offered a $5 incentive for a two-phase survey effort. Given that the survey was reduced in total length to 18 minutes or shorter and revised to a one-phase design, the $10 amount was deemed a sufficient incentive to encourage participation.

3.2 CONTACT STRATEGY

Interviewing was conducted according to a schedule designed to facilitate successful contact with sampled households and complete interviews with the designated respondent within those households. Initial telephone contact was attempted during the hours of the day and days of the week that have the greatest probability of respondent contact based on the call history of previous surveys conducted at Abt SRBI. Based on these contact goals, interviewing was conducted generally between 5:30 p.m. and 9:30 p.m. on weekdays; between 9:00 a.m. and 9:30 p.m. on Saturdays; and between 12:00 noon and 9:30 p.m. on Sundays. The NEC FUTURE survey also included some limited weekday daytime calling within its calling algorithm.

The NEC FUTURE survey employed a 10 call strategy for landline and cell phone numbers where up to 10 call attempts were made to unanswered numbers before the number was classified as a permanent no answer. This change from the pilot protocol of 5 call attempts was enacted to help improve the survey response rate. Callbacks to unanswered numbers were made on different days over a number of weeks according to a standard callback strategy. If contact was made but the interview could not be conducted at that time, the interviewer rescheduled the interview at a time convenient to the respondent.

3.2.1 Initiating Contact

When a household was reached in the landline sample in the screener, the interviewer first screened for age eligibility. If only one household member was age eligible, then the interviewer will seek to interview that individual. If there was more than one eligible household member, then the interviewer randomly selected one respondent from among them using the last birthday method. That person was targeted for interview. Appointments were set up with respondents if it was inconvenient for them to be interviewed at the time of contact. If the randomly selected respondent was not available at the time of contact, then the interviewer obtained a good time to call back to reach that person.

For cell phone sample records, the interviewer immediately asked questions to determine whether the person on the phone was in a situation that could pose a safety risk to that individual (e.g., driving at the time of the call). If the contacted individual was found to be in a situation that could pose a risk, the interviewer terminated the call and scheduled a call back. If it was safe for the contacted individual to proceed with the call, then the interviewer proceeded with the screening questions. The interviewer first screened for age eligibility. If the cell phone user was eligible to participate, then the interviewer proceeded with the interview. If it was an inconvenient time for the respondent, then the interviewer scheduled an appointment for a better interview time.

When contact was made with an answering machine or voice mail, a message was left according to a set protocol. For landline numbers, a message was left on the 3rd attempt. The message explained that the household had been selected as part of a national USDOT study, asked that they call our toll-free number to schedule an interview, and included reference to the FRA web site which included information about the survey so that prospective respondents could verify the survey’s legitimacy.

3.2.2 Refusal Tracking

Higher response rates can be achieved through procedures built on careful documentation of refusal cases. The Project Director reviewed the information about refusals and terminations on the CATI system on an ongoing basis to identify any problems with the contact script, questionnaire or interviewing procedures that might have contributed to non-participation. In addition to relying on the CATI data records, the Project Director also consulted with the interviewing Shift Supervisor, who monitored the interviewing and debriefed the interviewers.

3.2.3 FRA Website

FRA placed on its web site information that prospective respondents were able to access to verify the survey's legitimacy. The interviewers provided concerned respondents with the web address to FRA's home page. There was a link on the home page that directed respondents to information on the source of the survey and why participation is important. A toll-free number to reach Abt SRBI, the survey contractor, was also provided for scheduling of interviews.

3.3 INTERVIEWER PROTOCOLS

3.3.1 Training

Abt SRBI phone interviewers received training for both the pilot and the main study. During training, interviewers were given general background information on the purpose of the research and provided an overview of the study and data collection. Included in the training was a thorough review of the questionnaire. In general, training objectives included:

- Briefing on study purpose
- Familiarization of questionnaire in the CATI structure
- Imparting an understanding of each question and valid response options
- Testing of various paths through mock interviews
- Rehearsing of interview procedures
- Distribution of study related materials and resources

3.3.2 Monitoring

Each interviewer was monitored throughout the course of the project. The monitor evaluated the interviewer on his or her performance and discussed any problems that an interviewer was having with the shift supervisor. Before the end of the interview shift, the monitor and/or shift supervisor discussed the evaluation with the interviewer. If the interviewer was not able to meet study standards, he or she was removed from the project.

All interviewers on the project underwent two types of monitoring, in-script entry visual review and audio monitoring. For in-script entry visual review, the study monitor sat at a computer allowing access to view what interviewers are recording real-time. Also, the audio from the interview was monitored. The audio-monitoring allowed the supervisor to determine the quality of the interviewer's performance in terms of:

- Initial contact and recruitment procedures;
- Reading the questions, fully and completely, as written;
- Reading response categories, fully and completely, (or not reading them) according to study specifications;
- Whether or not ambiguous or confused responses are clarified;

- How well questions from the respondent are handled without alienating the respondent;
- Avoiding bias by either comments or vocal inflection;
- Ability to persuade wavering, disinterested or hostile respondents to continue the interview; and,
- General professional conduct throughout the interview.
- The combined real-time visual and audio monitoring allowed monitoring of interviewer accuracy for code punches and verbatim responses.

3.4 RESPONSE RATES

3.4.1 Definition

The NEC FUTURE survey response rate was calculated as the number of complete interviews divided by the number of complete interviews plus the number of non-interviews (e.g.,screened/refusals/breakoffs) plus an estimate of the number of cases of unknown eligibility (e.g., no answer/busy/answering machine/un-screened refusals/callbacks) that are likely to be actually eligible.

The factor for estimating the rate of eligibility among the unknown eligibility cases is determined as: (screened contacts and complete interviews minus screen-outs) divided by (screened contacts and complete interviews). Un-useable numbers are excluded from the calculation altogether.

3.4.2 Summary

The NEC FUTURE survey response rate was a cumulative 11% across both landline and cell phone samples. It was 12% for the landline sample and 7% for the cell phone sample. The response rate calculation summaries (for landline+cell, landline only and cell only) are shown in Table 3, Table 4, and Table 5.

Table 3: Survey Response Rate (Landline + Cell)

		Original Count	Estimated Qualified Household*	Estimated Response Eligible^
T1	**TOTAL**	**761,150**		
A	**NON-Usable Numbers**	**449,394**		
A1	NIS/DIS/Change#/Intercepts	379,667		
A2	Non-residential #	35,958		
A3	Computer/Fax tone	22,992		
A4	Line problem	10,777		
T2	**Total Usable Numbers**	**311,756**		
B	**UNKNOWN ELIGIBLE HOUSEHOLD*^**	**157,147**	**64,365**	**31,850**
B1	Probable unassigned number	46,306		
B2	No answer/Busy	30,399		
B3	Answering machine	80,442		
C	**NOT ELIGIBLE RESPONDENT^**	**7,321**	**7,321**	**3,623**
C1	Language barrier	3,716		
C2	Health/Deaf	2,910		
C3	Respondent away for duration	695		
D	**UNKNOWN ELIGIBLE RESPONDENT^**	**113,057**		**55,944**
D1	Callback	76,581		
D2	Spanish Callback not screened	0		
D3	Refusals not screened	36,476		
E	**CONTACTS SCREENED**	**22,004**		
E1	Qualified callback	2,910		2,910
E2	Refusals – Qualified	1,988		1,988
E3	Terminates	0		0
E4	Screen-outs	17,106		
F	**COMPLETE**	**11,858**		**11,858**
A'	**ESTIMATED ELIGIBLE HH RATE =T2/T1**	**40.96%**		
B'	**ELIGIBLE RESPONSE RATE = E+F-E4/(E+F)**	**49.48%**		
C'	**SUM RESPONSE ELIGIBLE COUNT**			**108,173**
D'	**RESPONSE RATE = F/C'**	**10.96%**		

*Estimated Qualified HH=Original Count * A'
^Response Eligible = Qualified Household Count * B'

Table 4: Survey Response Rate (Landline Only)

		Original Count	Estimated Qualified Household*	Estimated Response Eligible^
T1	**TOTAL**	**661,384**		
A	**NON-Usable Numbers**	**434,288**		
A1	NIS/DIS/Change#/Intercepts	368,810		
A2	Non-residential #	32,860		
A3	Computer/Fax tone	22,867		
A4	Line problem	9,751		
T2	**Total Usable Numbers**	**227,096**		
B	**UNKNOWN ELIGIBLE HOUSEHOLD*^**	**117,366**	**40,299**	**20,491**
B1	Probable unassigned number	46,262		
B2	No answer/Busy	25,683		
B3	Answering machine	45,421		
C	**NOT ELIGIBLE RESPONDENT^**	**5,039**	**5,039**	**2,562**
C1	Language barrier	2,037		
C2	Health/Deaf	2,561		
C3	Respondent away for duration	441		
D	**UNKNOWN ELIGIBLE RESPONDENT^**	**78,640**		**39,986**
D1	Callback	50,400		
D2	Spanish Callback not screened	0		
D3	Refusals not screened	28,240		
E	**CONTACTS SCREENED**	**16,481**		
E1	Qualified callback	2,320		2,320
E2	Refusals – Qualified	1,530		1,530
E3	Terminates	0		0
E4	Screen-outs	12,631		
F	**COMPLETE**	**9,216**		**9,216**
A'	**ESTIMATED ELIGIBLE HH RATE =T2/T1**	**34.34%**		
B'	**ELIGIBLE RESPONSE RATE = E+F-E4/(E+F)**	**50.85%**		
C'	**SUM RESPONSE ELIGIBLE COUNT**			**76,105**
D'	**RESPONSE RATE = F/C'**	**12.11%**		

*Estimated Qualified HH=Original Count * A'

^Response Eligible = Qualified Household Count * B'

Table 5: Survey Response Rate (Cell Only)

		Original Count	Estimated Qualified Household*	Estimated Response Eligible^
T1	**TOTAL**	**99,766**		
A	**NON-Usable Numbers**	**15,106**		
A1	NIS/DIS/Change#/Intercepts	10,857		
A2	Non-residential #	3,098		
A3	Computer/Fax tone	125		
A4	Line problem	1,026		
T2	**Total Usable Numbers**	**84,660**		
B	**UNKNOWN ELIGIBLE HOUSEHOLD*^**	**39,781**	**33,758**	**15,256**
B1	Probable unassigned number	44		
B2	No answer/Busy	4,716		
B3	Answering machine	35,021		
C	**NOT ELIGIBLE RESPONDENT^**	**2,282**	**2,282**	**1,031**
C1	Language barrier	1,679		
C2	Health/Deaf	349		
C3	Respondent away for duration	254		
D	**UNKNOWN ELIGIBLE RESPONDENT^**	**34,417**		**15,554**
D1	Callback	26,181		
D2	Spanish Callback not screened	0		
D3	Refusals not screened	8,236		
E	**CONTACTS SCREENED**	**5,523**		
E1	Qualified callback	590		590
E2	Refusals – Qualified	458		458
E3	Terminates	0		0
E4	Screen-outs	4,475		
F	**COMPLETE**	**2,642**		**2,642**
A'	**ESTIMATED ELIGIBLE HH RATE =T2/T1**	**84.86%**		
B'	**ELIGIBLE RESPONSE RATE = E+F-E4/(E+F)**	**45.19%**		
C'	**SUM RESPONSE ELIGIBLE COUNT**			**35,531**
D'	**RESPONSE RATE = F/C'**	**7.44%**		

*Estimated Qualified HH=Original Count * A'
^Response Eligible = Qualified Household Count * B'

4. Quality Assurance and Quality Control

4.1 CHECKS FOR CONSISTENCY AND COMPLETENESS

Abt SRBI implemented a comprehensive quality assurance and quality control system to ensure the delivery of a clean database with a maximum degree of consistency, completeness and accuracy. The process began with the software Abt SRBI uses for telephone surveys. Abt SRBI's CATI system is able to program loops, rotations, randomization and extremely complex skip patterns. The system includes automatic range checks for data entry. It can be programmed to conduct complicated calculations. Abt SRBI's CATI system can also carry forward earlier responses, which can be integrated into later questions. All these functions ensured the quality of the data collected and were customized to the unique study specifications of the NEC FUTURE survey.

In addition to programming capabilities within the Abt SRBI CATI system, ad-hoc manual inspections of collected data were conducted as further checks. This primarily included doing common sense checks on the frequencies of questions, and examining the distribution of key survey variables (e.g., chosen mode, trip purpose, etc.).

4.1.1 CATI Software

The data were collected electronically through the use of CATI. The CATI system allows a computer to perform a number of functions prone to error when done manually by interviewers, including:

- Providing correct question sequence;
- Automatically executing skip patterns based on prior answers to questions (which decreases overall interview time and consequently the burden on respondents);
- Recalling answers to prior questions and displaying the information in the text of later questions;
- Providing random rotation of specified questions or response categories (to avoid bias);
- Ensuring that questions cannot be skipped; and
- Rejecting invalid responses or data entries (e.g., out of range).

The CATI system lists questions and corresponding response categories automatically on the screen, eliminating the need for interviewers to track skip patterns and flip pages. This ability within CATI to customize and check responses "in-the-moment" makes the survey methodology more efficient to administer and helps to achieve high-quality data with a lower respondent burden due to this efficiency. Moreover, the data entered by interviewers get directly stored in SRBI servers.

CATI systems typically include safeguards to reduce interviewer error in direct key entry of survey responses. CATI also allows the computer to perform a number of critical assurance routines that are monitored by survey supervisors, including tracking average interview length, refusal rate, and termination rate by interviewer; and performing consistency checks for inappropriate combination of answers.

4.1.2 Survey Tool Program Testing

The project team tested the CATI program thoroughly in test mode – running the interviewing program through multiple loops. The analytical staff tested all possible response categories for each question and numerous origin/destination & travel mode combinations in order to identify embedded logic errors, as well as obvious skip problems. Several analysts tested the program simultaneously to identify problems quickly, and to double check the comprehensiveness of the testing protocols.

After initial testing and corrections, the questionnaire program was also run through our autopilot program. This program tests the interview program by initiating the CATI interview and then by generating a dummy database of random responses as the questions appear. This database permitted us to track the response pattern compared to the hard copy questionnaire in order to further identify skip or other programming errors.

5. Weighting the Data

5.1 LANDLINE SAMPLE BASE WEIGHTS

For producing population-based estimates and for all statistical analyses, each respondent was assigned a sampling weight. To properly compute the weights for survey respondents (n=11,858), information required for weighting was also collected from adults who reported living inside the study area but were screened out because their travel patterns made them ineligible for the survey (n=13,094). Base weights and post-stratification weights were computed for both respondents and screen-outs as outlined in the steps below. The final weight variable, labeled WEIGHT, contains valid weight values for respondents only. The final weight assigned to each respondent consists of a base sampling weight and a post-stratification adjustment of this weight.

For the landline sample, the base weights were computed in two stages. The first stage base weight is calculated as the inverse of the probability of selecting the respondent. Since households are selected through the selection of landlines, the probability of selecting the household is the same as the probability of selecting the telephone number of the household. Specifically, the weight is the ratio of (1) the number of telephone numbers in the 1+ working banks (groups of 100 consecutive numbers that contain at least one directory-listed residential number) and (2) the number of telephone numbers drawn from those banks and actually released for data collection. The probability of selecting each landline telephone number is computed separately for each study area county, resulting in 140 sampling strata. The probability of selecting telephone numbers in the landline sample is computed as

$$\frac{N_h}{n_h}$$

where N_h is the count of landline numbers in each sampling stratum *h*, and n_h is the count of landline numbers from each sampling stratum *h* in the released sample replicates.

The second stage base weights adjust for the fact that only one adult in the household was selected to complete the interview. When landline numbers were dialed, interviewers asked to speak with "the member of this household age 18 or older who has had the most recent birthday." The probability that that individual was selected among all of the eligible (ages 18+) household members is the reciprocal of the number of adults in the household. We denote the number of adults, *A*, in household *i* as A_i. For cases from the landline sample, the sampling weight for within-household selection is simply A_i.

The final base weights for the landline sample are the product of the first stage and the second stage base weights described above.

5.2 CELL SAMPLE BASE WEIGHTS

There is only one stage of base weighting for cases selected from the cell sample. This base weight accounts for the probability of selecting the cell phone number from the cell sample in each study area county. The probability of selecting telephone numbers in the cell phone sample is computed as

$$\frac{N_h}{n_h}$$

where N_h is the count of cell phone numbers in each sampling stratum h, and n_h is the count of cell phone numbers from each sampling stratum h in the released sample replicates.

5.3 COMBINED SAMPLE BASE WEIGHTS

The final base weights for the landline and cell sample were then integrated into a combined sample base weight using composite estimation (Hartley 1962). The combined sample base weights adjust for the overlap between the landline RDD frame and the cellular RDD frame. Respondents who reported living in households with both a landline telephone and a cell phone were integrated into the sample using a compositing factor set to equal to 0.5. Cell phone only and landline-only respondents received a compositing factor set equal to 1.

5.4 POST-STRATIFICATION ADJUSTMENT OF COMBINED SAMPLE BASE WEIGHTS

The post-stratification adjustment of the final combined base weights was done through a process known as raking. Raking is a post-stratification procedure that can be used when post-strata are formed using more than one variable but only the marginal population totals are known. The raking procedure adjusts the combined sample base weights such that the sum of the weights agrees with population totals by age, gender, race/ethnicity etc. Prior to raking the weights, missing values in the survey variables used for weighting were imputed using the modal response in the survey data. These imputed values were used only for the purposes of weighting and were not included in the final survey dataset. Raking is used to reduce biases from non-response and non-coverage in sample surveys. The raking procedure aligned survey respondents and screen-outs to known population benchmarks[8] for the study's geographic area on the following dimensions:

- Age By Gender
- Education Level By Gender
- Race/Ethnicity
- State of Residence
- Household Telephone Service By State (cell phone only, landline only, or dual service)

All of the population benchmarks (control totals), with the exception of telephone service, were obtained from the 2012 American Community Survey 5 year Estimates, filtered on adults aged 18 and older living in households in the 140 counties in the study area. The telephone service population estimates were constructed from the model-based estimates released by the National

[8] The raking procedure did not include income because the non-response rate for income questions are generally high (18% for this study) and there are also general concerns that respondents often don't accurately report their income category. For these reasons, income was not used a population benchmark dimension.

Center for Health Statistics for the year 2012[9]. These state-level estimates were then re-based on adults, ages 18 and older, living in households with a telephone, and updated to reflect national increases in the cell phone only population since 2012.

The final weight variable, labeled WEIGHT, contains valid weight values for only respondents who completed the entire survey (n=11,858). A summary of the weights is shown in Table 6.

Table 6: Summary of Weights

Weight Variable	Number of cases (n)	Minimum weight	Maximum weight	Standard Deviation	Design effect	Effective n
WEIGHT	11,858	0.035	12.106	1.090	2.44	4,869

5.5 DESIGN EFFECT AND VARIANCE ESTIMATION

Weighting and survey design features that depart from simple random sampling tend to result in an increase in the variance of survey estimates. This increase, known as the design effect or deff, should be incorporated into the margin of error, standard errors, and tests of statistical significance. The design effect is the ratio of the variance derived from a survey sample design to the variance that would be obtained from a simple random sample, assuming the same sample size. We estimate the design effect based on the study sample weights as the ratio of the average of the squared weights to the average of the weights. The formula for that estimation is:

$$\frac{n\sum_i w_i^2}{(\sum_i w_i)^2} = 1 + cv^2(w_i)$$

where *n* equals the sample size. Weighting has a statistical impact on the resulting sample size in that the weighted sample, in effect, is reduced. In statistical tests where weighted data are used, those tests need to use what is called the effective sample size for variance calculations[10]. The effective sample size (or effective base) is calculated as *n* divided by the design effect. Thus, the sample size of 11,858 has a statistical effective sample size of 4,869 (i.e., 11,858/2.44). The use of these weights in statistical analyses ensures that the demographic characteristics of survey respondents closely approximate the demographic characteristics of the population in the study area. As such, they produce estimates that are generalizable to the study population.

[9] Blumberg SJ, Ganesh N, Luke JV, Gonzales G. Wireless substitution: State-level estimates from the National Health Interview Survey, 2012. National health statistics reports; no 70. Hyattsville, MD: National Center for Health Statistics. 2013.

[10] For generalized and approximate values of the standard error (se) for a given proportion (p) that incorporate the Deff, the following formula can be used:

$$\mathrm{se}(p) = z[\mathrm{Deff}(\mathrm{pq/n})]^{1/2}$$

where z = the normalized confidence level (e.g., for 2-tailed 95% confidence, z. 975 = 1.96), p is your study proportion of interest, q = (1 - p), and n is the sample size. However, variance calculations that take into account complex sample designs may also be used with available statistical packages such as SAS, SPSS or STATA.

Appendix A: NEC Questionnaire

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Survey of Northeast Regional and Intercity Household Travel Attitudes and Behavior

Screener

INTRO. Hello. My name is _____________ from Abt SRBI, calling on behalf of the U.S. Department of Transportation. We are conducting an important survey that will help plan transportation in your area. This survey is completely voluntary and any answers you give are kept strictly private to the extent permitted by law. This survey should take approximately 18 minutes of your time. We will send you a $10 incentive as a token of appreciation for your participation after the completion of the survey.
[IF REQUESTED BY RESPONDENT, Privacy Statement and Paperwork Reduction Act Burden Statement:
Privacy Statement:

Your name may be requested for interview scheduling or mailing your token of appreciation. When analysis of the questionnaire is completed, all name and address files will be destroyed. Thus permanent data will be anonymous. The U.S. Department of Transportation privacy information can be found at http://www.dot.gov/privacy]

Paperwork Reduction Act Burden Statement
The US Department of Transportation, Federal Railroad Administration is conducting this survey to collect data on travel patterns along the Northeast Corridor. This information will be used to estimate a forecasting model of travel mode choice in the Northeast Corridor. The information obtained will be used to provide guidance to future service planning. 49 USC 103 (j)(5) (6) authorizes collection of this information. A federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB Control Number. The OMB Control Number for this information collection is 2130-0600. Public reporting for this collection of information is estimated to be approximately 18 minutes per response. All responses to this collection of information are voluntary. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Information Collection Clearance Officer, Federal Railroad Administration, 1200 New Jersey Avenue, SE, Washington, D.C. 20590.

ASK C1 IF CELL SAMPLE, THEN SKIP TO S1b. IF LANDLINE, SKIP TO S1.

C1 Are you currently driving, or someplace else where it is NOT safe to talk?

1 Yes/Call Me Later	**Ask for Name and Schedule Callback**
2 No	**Skip to S.1b & ask for age 18+ verification**
3 Refused	**Thank and Terminate**

S1 So that we interview a random cross-section of the population, may I please ask how many persons 18 or older live in your household?

(1-10, 10 = "10 or more)
98 No one in household 18-74 **Thank and Terminate**
99 Refused **Thank and Terminate**

ASK S1A IF S1>1. OTHERWISE, SKIP TO S1B.

S1A May I please speak to the member of this household age 18 or older who has had the most recent birthday?

1 Speaking with respondent	**Skip to S1C**
2 Respondent comes to phone	**Skip to S1B**
3 Not Available	**Ask for Name and Schedule Callback**
6 Refused	**Thank and Terminate**

Speaking With Respondent:

S1B Hello. My name is _____________ from Abt SRBI, calling on behalf of the U.S. Department of Transportation. We are conducting an important survey that will help plan transportation in your area. This survey is completely voluntary and any answers you give are kept strictly private to the extent permitted by law. This survey should take approximately 18 minutes of your time. We will send you $10 as a thank-you for your participation after the completion of the survey. [If coming from C.1 or if S1=1, skip to here and ask:] Are you 18 years of age or older?
[IF REQUESTED BY RESPONDENT, Privacy Statement and Paperwork Reduction Act Burden Statement], provide info from first page:

1 Yes	**Continue**
2 No	**Thank and Terminate**
3 Refused	**Thank and Terminate**

ASK S1C FOR ALL SAMPLE (LANDLINE OR CELL).

S1C First, I'd like to confirm your home state. Do you live in **(Read name of state from sample.)**?

1 Yes	**Skip to Instructions before S1E**
2 No	**Continue to S1D**
3 Refused	**Go to End Interview Routine**

S1D Then what state do you live in?

PROGRAMMER: DO NOT INCLUDE STATE ASKED IN S1C IN ANSWER LIST

1. Connecticut
2. Delaware
3. Maryland
4. Massachusetts
5. New Hampshire
6. New Jersey
7. New York
8. Pennsylvania
9. Rhode island
10. Virginia
11. Washington DC/District of Columbia
12. All other States, specify -> **Go to End Interview Routine**

99. Refused -> **Go to End Interview Routine**

IF S1C OR S1D = 11 (WASHINGTON, DC), SKIP S1E AND GO DIRECTLY TO S2A.

S1E. And what city or town in (State from S1C/S1D) do you live in?

PROGRAMMER: SHOW LIST OF CITIES IN (STATE FROM S1C/S1D). PROVIDE "CITY/TOWN NOT FOUND" AND "DON'T KNOW/REFUSED" AS RESPONSES FOR EACH STATE LIST.

Interviewer: Confirm spelling of city with respondent. As you type, a list of cities matching what you typed so far will be presented. The list will become more focused and fewer cities will be presented as you type in more letters of the city. Choose appropriate response.

PROGRAMMER: CONSULT LIST OF QUALIFYING CITIES FOR EACH STATE. IF CITY MENTIONED IS A QUALIFYING CITY, CONTINUE WITH S2A. OTHERWISE GO TO END INTERVIEW ROUTINE.
SET *[HOME CITY]* = (Home City from S1E/Washington, DC from S1C/S1D)

The following questions ask whether the respondent's usual commute to work trip qualifies as an interregional trip and would therefore be relevant for our model. If the respondent has an interregional commute, that commute trip will be the reference trip for the SP choice exercises. We will collect data on commuter trips by all modes to this location and then randomly select a mode to use as the reference trip.

S2A. Now I'd like you to think about trips for the purpose of daily commuting. Did you commute in the **past 12 months** to a state outside of (Home State from S1C/S1D)?

1 Yes	**Continue**
2 No	**Skip to S3A**
3 Don't know/Refused	**Skip to S3A**

S2B To which state did you commute to in the **past 12 months**? (Do Not Read List)
PROGRAMMER: DO NOT INCLUDE RESPONDENT'S HOME STATE FROM S1C/S1D

1. Connecticut
2. Delaware
3. Maryland
4. Massachusetts
5. New Hampshire
6. New Jersey
7. New York
8. Pennsylvania
9. Rhode island
10. Virginia
11. Washington DC/District of Columbia
12. All other state mentions, specify -> **Go to S3A**

99. Refused -> **Go to S3A**

IF S2B = 11 (WASHINGTON, DC), SKIP S2C AND GO DIRECTLY TO S2D.

S2C. What city or town did you commute to in (State from S2B)?

PROGRAMMER: SHOW LIST OF CITIES IN (STATE FROM S2B). PROVIDE "CITY/TOWN NOT FOUND" AND "DON'T KNOW/REFUSED" AS RESPONSES FOR EACH STATE LIST.

Interviewer: Confirm spelling of city with respondent. As you type, a list of cities matching what you typed so far will be presented. The list will become more focused and fewer cities will be presented as you type in more letters of the city. Choose appropriate response.

PROGRAMMER: CONSULT LIST OF QUALIFYING CITIES FOR EACH STATE, AND CHECK THAT ORIGIN AND DESTINATION CITY PAIR MEETS LONG DISTANCE TRAVEL CRITERIA. IF CITY MENTIONED MEETS BOTH QUALIFICATIONS, CONTINUE WITH S2D. OTHERWISE SKIP TO S3A.
SET *[Commute City]* = (Commute City from S2C/Washington, DC from S2B)

S2D. How many days in a typical week did you commute to (Commute City from S2C/Washington, DC from S2B)? (1-7, 8=Don't Know, 9=Refused)

PROGRAMMER: IF RESPONDENT HAS INDICATED AT LEAST ONE COMMUTE TRIP TO AREA IN S2D (1-7), ASK S2E. OTHERWISE, SKIP TO S3A.

S2E. Of the (Number from S2D) times in a typical week you commuted, how many times did you travel by (**ROTATE AND READ MODES**)? (0-7; 9=DK/Ref) **(RECONCILE RESPONSES TO NUMBER FROM S.2D)**

S2E # By Mode of Transportation			
1. Passenger Car/Truck/Van	2. Plane	3. Train	4. Bus

PROGRAMMER: IF RESPONDENT ANSWERED S2E, SKIP ALL QUESTIONS IN S3 SERIES AND GO TO INSTRUCTIONS AFTER S3F.

The following questions will determine if the respondent took any qualifying interregional non-commute trip. The list of states comprising the region of interest for this study will be randomized so as to not bias the respondent into thinking about the most recent trip or the most frequently visited place. The first such trip that is identified will be used as the location of the reference trip. We will collect data on trips by all modes and purposes to this location and then randomly select a mode-purpose combination to use as the reference trip. In addition to providing this basis of the reference trip, the data on number of traips by mode and purpose will also provide information on overall shares by mode and purpose within markets, supplementing other available aggregate data.

S3A1. Now I'm going to ask you about trips which you may have taken in the **past 12 months** to states beyond the state you live in for **any reason other than daily commuting**. This may include business trips or leisure which include vacation trips, or family occasions or other non-business reasons. Have you taken any business or leisure trips in the past 12 months?

1. Yes **CONTINUE**
2. No **SKIP TO TEXT BEFORE D-1**

S3A2. I'm going to read a list of states. As I read each one, please tell me if you have taken **any <u>non</u>-commute** trips from your home to that state in the **past 12 months**.

Have you traveled to (State) in the past 12 months for reasons other than daily commuting? Have you traveled to (Next state)?

PROGRAMMER: RANDOMIZE ORDER OF STATES PRESENTED. DO NOT INCLUDE RESPONDENT'S HOME STATE FROM S1C/S1D.

IF "NO" OR "DK/REF" TO ANY STATE, KEEP ASKING THE NEXT RANDOMIZED STATE. IF NO OTHER STATES LEFT TO ASK ABOUT, SKIP TO TEXT BEFORE D-1.

IF "YES" TO A STATE IN S3A, ASK S3B FOR THAT STATE. HOWEVER, IF S3A = 11 (WASHINGTON, DC), NO NEED TO ASK S3B. JUST CHECK THAT ORIGIN AND DESTINATION CITY PAIR MEETS LONG DISTANCE TRAVEL CRITERIA. IF YES, SKIP TO INSTRUCTIONS BEFORE S3D. IF NO, ASK THE NEXT RANDOMIZED STATE IN LIST. IF NO OTHER STATES LEFT TO ASK ABOUT, SKIP TO TEXT BEFORE D-1.

	S3A		
	1. Yes	2. No	DO NOT READ 9. Don't know/ Refused
1. Connecticut			
2. Delaware			
3. Maryland			
4. Massachusetts			
5. New Hampshire			
6. New Jersey			
7. New York State			
8. Pennsylvania			
9. Rhode Island			
10. Virginia			
11. Washington DC			

S3B. What city or town did you travel to in (State from S3A)?
Interviewer: if more than one city/town, say: Please tell me the city or town for which you made the most trips to in the past 12 months.

PROGRAMMER: SHOW LIST OF CITIES IN (STATE FROM S3A). PROVIDE "CITY/TOWN NOT FOUND" AND "DON'T KNOW/REFUSED" AS RESPONSES FOR EACH STATE LIST.

Interviewer: Confirm spelling of city with respondent. As you type, a list of cities matching what you typed so far will be presented. The list will become more focused and fewer cities will be presented as you type in more letters of the city. Choose appropriate response.

PROGRAMMER: CONSULT LIST OF QUALIFYING CITIES FOR EACH STATE, AND CHECK THAT ORIGIN AND DESTINATION CITY PAIR MEETS LONG DISTANCE

TRAVEL CRITERIA. IF CITY MENTIONED MEETS BOTH QUALIFICATIONS, SKIP TO INSTRUCTIONS BEFORE S3D.
IF CITY DOES NOT MEET BOTH QUALIFICATIONS, ASK:

S3C1. Have you been to any other cities or towns in (State from S3A just asked) in the past 12 months, for reasons other than daily commuting? Please think of any cities or towns in (State from S3A just asked) that are at least 25 miles away from the one you just told me about.

1	Yes	**CONTINUE WITH S3C2.**
2	No, none, at least 25 miles away	**RETURN TO S3A AND ASK ABOUT NEXT RANDOMIZED STATE IN LIST. IF NO OTHER STATES LEFT TO ASK ABOUT, SKIP TO TEXT BEFORE D-1.**
3	Don’t know/Refused	**RETURN TO S3A AND ASK ABOUT NEXT RANDOMIZED STATE IN LIST. IF NO OTHER STATES LEFT TO ASK ABOUT, SKIP TO TEXT BEFORE D-1.**

S3C2. What other city or town did you travel to in (State from S3A just asked)?
PROGRAMMER: SHOW LIST OF CITIES IN (STATE FROM S3A). PROVIDE “CITY/TOWN NOT FOUND” AND “DON’T KNOW/REFUSED” AS RESPONSES FOR EACH STATE LIST.

Interviewer: Confirm spelling of city with respondent. As you type, a list of cities matching what you typed so far will be presented. The list will become more focused and fewer cities will be presented as you type in more letters of the city. Choose appropriate response.

PROGRAMMER: CONSULT LIST OF QUALIFYING CITIES FOR EACH STATE, AND CHECK THAT ORIGIN AND DESTINATION CITY PAIR MEETS LONG DISTANCE TRAVEL CRITERIA.
IF CITY MENTIONED MEETS BOTH QUALIFICATIONS, CONTINUE TO S3D. IF CITY DOES NOT MEET BOTH QUALIFICATIONS, THEN ASK ABOUT NEXT RANDOMIZED STATE IN LIST. IF NO OTHER STATES LEFT TO ASK ABOUT, SKIP TO TEXT BEFORE D-1.

SET *[NON-COMMUTE CITY]* = (Non-Commute City from S3B/S3C2/Washington, DC from S3A)

S3D. How many trips did you make from your home to (***[Non-Commute City]*** in the past 12 months? (**IF NECESSARY**: Your best estimate is fine.) (1-999; 998=998 or more; 999=DK/Ref) **IF DK/REF, SKIP TO TEXT BEFORE D-1.**

S3E. Of these ***([Total Trips] from S3D)*** trips, how many were for (**ROTATE BUSINESS, AND LEISURE or NON-BUSINESS**): <Business>│<Leisure or Non-Business>)?

(RECONCILE RESPONSES TO TOTAL TRIPS FROM S3D) (**IF NECESSARY**: Your best estimate is fine.) (0-999; 998=998 or more; 999=DK/Ref) **(MUST HAVE AT LEAST ONE RESPONSE IN S3E SERIES THAT IS 1-998 TRIPS)**

S3F. Now, I'd like to get more information on the modes of travel you used between ***[Home City]*** and ***[Non-Commute City]***. For the (**ROTATE AND READ TOTALS FROM S3E IF 1-998**) trips you made for (**ROTATE AND READ IN PURPOSE:** <Business>│<Leisure or Non-Business>), how many were by (**ROTATE AND READ MODES**)? If you used different modes for the departing and return trips, please count them as half trips. (**IF NECESSARY**: Your best estimate is fine.)
Please remember that I'm focusing on trips between ***[Home City]*** and ***[Non-Commute City]***), excluding daily commuting (**REPEAT FOR EACH MODE**) (**REPEAT ENTIRE PROCESS FOR EACH PURPOSE ≥1 IN S3E; IF S3E=0/DK/ REF, THEN SKIP THAT PURPOSE**) (0-999; 998=998 or more; 999=DK/Ref) **(RECONCILE RESPONSES TO TOTAL FOR EACH PURPOSE) (MUST HAVE AT LEAST ONE RESPONSE OF 1-998 TRIPS IN S3F SERIES FOR EACH PURPOSE ASKED)**

	S3E	S3F # By Mode of Transportation			
	TOTAL	1. Passenger Car/Truck/Van	2. Plane	3. Train	4. Bus
A. Business					
B. Leisure or Non-Business					

PROGRAMMER:
SET [TRIP CITY] = [COMMUTE CITY]/[NON-COMMUTE CITY] (NOTE THAT BASED ON QUESTIONNAIRE, THERE CAN ONLY BE ONE OF EITHER COMMUTE CITY OR NON-COMMUTE CITY BUT NOT BOTH]

SELECT A MODE AND TRIP PURPOSE COMBINATION.
IF S2E=1-7 FOR ANY OF THE 4 MODES (GAVE AT LEAST ONE COMMUTING MODE), SET *[Actual Mode]* = MODE IN S2E WITH HIGHEST NUMBER OF TIMES COMMUTED AND SET *[Trip Purpose]* = COMMUTING.
OTHERWISE, RANDOMLY SELECT A MODE AND TRIP PURPOSE COMBINATION WHERE TRIPS≥1 (1-998 TRIPS) IN S3E & S3F. SET *[Actual Mode]* = RANDOMLY SELECTED MODE AND *[Trip Purpose]* =RANDOMLY SELECTED TRIP PURPOSE.
AVOID PLANE IF *[AirAvailable]* = 0, OR BUS IF *[BusAvailable]* = 0 UNLESS THESE ARE THE ONLY AVAILABLE MODES BASED ON RESEPONDENT'S ANSWERS. SEE

REFERENCE EXCEL FILE. [IF NECESSARY, WE MAY ALSO NEED TO OVER-SAMPLE CERTAIN COMBINATIONS.]

S4. Now I'd like you to think about your most recent ***[Actual Mode]*** trip from ***[Home City]*** to ***[Trip City]*** for ***[Trip Purpose]***. Did you immediately return home after visiting ***[Trip City]***, or did you travel to another city after visiting ***[Trip City]***?

1 Immediately returned home (Round trip) **Continue**
2 Traveled to a third city (One-way trip) **Continue**
9 No such trip/Don't know/Refused **Skip to Text before D-1**

SET RANDOMLY:
IF S4=1 (Round Trip):
[Origin City] = [Home City]
AND *[Destination City] = [Trip City]*
OR
[Origin City] = [Trip City]
AND
[Destination City] =[Home City]

IF S4=2 (One-way Trip):
[Origin City] = [Home City]
AND *[Destination City] = [Trip City]*

Set [Origin Zone] (used for lookup table for Q14A and tradeoff questions) to be based on [Origin City]
&
Set [Destination Zone] (used for lookup table for Q14A and tradeoff questions) to be based on [Destination City]

If S3F2 Plane Total Trips >0 or S2e2=1-7 set ***[AirAvailable]***=1)
If S3F4 Bus Total Trips >0 or S2e4=1-7 set ***[BusAvailable]***=1)

MAIN QUESTIONNAIRE

The following questions ask specifics about the reference trip, including specific type of rail service if rail was the actual mode taken, access and egress mode of travel, fare for common carrier modes, cost for auto mode, station/terminal waiting time, party size, trip purpose, specific origin and destination airport/station, whether a connection was involved and length of trip. The questions cycle through each potential mode that the respondent may have used, but each respondent is asked questions about only one mode,the actual mode the used for the reference trip.

Specific One-Way Trip & Mode

Now, please think about your most recent **one-way** ***[Actual Mode]*** trip from ***[Origin City]*** to ***[Destination City]*** for ***[Trip Purpose]***.

Programmer: Insert the following text if the *[Destination City]* selected is *[Home City]:* Please note that we are now asking about the return trip from ***[Origin City]*** to ***[Destination City]***

Ask Q1 only if ***[Actual Mode]*** = "Train" AND (***[AcelaAvailable]***=1 OR ***[CRAvailable]***=1)
If ***[Actual Mode]*** = "Train" AND (***[AcelaAvailable]***=0 AND ***[CRAvailable]***=0), set Q1=2 and skip to instructions after Q1
(See reference Excel file; note that regular "non-Acela" Amtrak service is available in all markets to be surveyed)

1. What was the primary type of train service you used to travel between ***[Origin City]*** and ***[Destination City]***? (Read List)
(If necessary: read appropriate text descriptions of available train services) (See reference Excel file for *[Amtrak Train Name]*)

   1 An Amtrak Acela train (list only if ***[AcelaAvailable]***=1)
   2 An Amtrak ***[AmtrakTrainName]*** train (not Acela)
   3 A ***[CROperator]*** train (list only if ***[CRAvailable]***=1)

   Do Not Read

   8 Don't Know
   9 Refused

THERE ARE NO Q2-Q3

Skip to instructions before Q9A if ***[Actual Mode]*** = "Passenger Car/Truck/Van"

Ask Q4A, Q5A & Q6A if ***[Actual Mode]***="Train" (Then skip to instructions before Q9A)

4A. At which station did you board the train (replace "train" with Q1 answer, if available) on your one-way trip from ***[Origin City]*** to ***[Destination City]***? (Read List of Stations for ***[Origin City]*** if necessary) **(See reference Excel file) (999=DK) (Provide an Other Specify option in case respondent gives response not in reference file)** (Accept Only ONE Answer and set ***[Origin Station]***) (If DK, set ***[Origin Station]*** as "your origin station")

5A. Which ONE of the following best describes the MAIN form of transportation you used to get to ***[Origin Station]*** to board the train? Did you get to the train by … (Read List)? (Accept Only ONE Answer)

(Do Not Rotate)
2 Local Bus
3 Commuter rail
4 Subway
5 Private car - parked at station
6 Private car - dropped off at station
7 Taxi
8 Rental car
9 Walk
10 Or some other way (Specify:)____________
Do Not Read
99 Don't know/Not sure

6A. Approximately how much time did you spend at the station from the time you arrived at ***[Origin Station]*** to the time your train departed (Read List If Necessary)?

1 10 minutes or less
2 11-20 minutes
3 21-30 minutes
4 31-40 minutes
5 41-50 minutes
6 51-60 minutes (0:51-1:00)
7 61-75 minutes (1:01-1:15)
8 76-90 minutes (1:16-1:30)
9 91-105 minutes (1:31-1:45)
10 106-120 minutes (1:46-2:00)
11 over 2 hours
Do Not Read
99 Don't know/Not sure

Ask Q4B, Q5B & Q6B if ***[Actual Mode]***=”Plane” (Then skip to skip to instructions before Q9A)

4B. At which airport did you board the plane on your one-way trip from ***[Origin City]*** to ***[Destination City]***? (Read List of Airports for ***[Origin City]*** if necessary) **(999=DK) (Provide an Other Specify option in case respondent gives response not in reference file) (See reference Excel file)** (Accept Only ONE Answer and set ***[Origin Airport]***) (If DK, set ***[Origin Airport]*** as “your origin airport”)

5B. Which ONE of the following best describes the MAIN form of transportation you used to get to ***[Origin Airport]*** to board the plane? Did you get to the airport by … (Read List)? (Accept Only ONE Answer)

(Do Not Rotate)
1 Amtrak train (only display for ***[Origin Airport]***=”Newark” OR “BWI”)
2 Local Bus
3 Commuter rail
4 Subway
5 Private car - parked at airport
6 Private car - dropped off at airport
7 Taxi
8 Rental car
9 Walk
10 Or some other way (Specify:)____________
Do Not Read
99 Don’t know/Not sure

6B. Approximately how much time did you spend at the airport from the time you arrived at ***[Origin Airport]*** to the time your plane departed (Read List If Necessary)? NOTE: This includes the time it took to pass through security.

1 10 minutes or less
2 11-20 minutes
3 21-30 minutes
4 31-40 minutes
5 41-50 minutes
6 51-60 minutes (0:51-1:00)
7 61-75 minutes (1:01-1:15)
8 76-90 minutes (1:16-1:30)
9 91-105 minutes (1:31-1:45)
10 106-120 minutes (1:46-2:00)
11 over 2 hours
Do Not Read
99 Don’t know/Not sure

Ask Q5C if ***[Actual Mode]***=”Bus”

5C. Which ONE of the following best describes the MAIN form of transportation you used to get to the bus terminal or stop serving ***[Origin City]*** to board the bus on your one-way trip from ***[Origin City]*** to ***[Destination City]***? Did you get to the terminal or stop by … (Read List)? (Accept Only ONE Answer)

(Do Not Rotate)
2 Local Bus
3 Commuter rail
4 Subway
5 Private car - parked at terminal/stop
6 Private car - dropped off at terminal/stop
7 Taxi
8 Rental car
9 Walk
10 Or some other way (Specify:)____________
Do Not Read
99 Don’t know/Not sure

THERE ARE NO Q7-Q8

Ask Q9A, Q10A, Q11A, Q12A, Q13A if ***[Actual Mode]***="Train" (Then skip to instructions before Q15)

9A. At which station did you get off the train (replace "train" with Q1 answer, if available) on your one-way trip from ***[Origin City]*** to ***[Destination City]***? (Read List of Stations for ***[Destination City]*** if necessary) **(See reference Excel file) (999=DK)** (**Provide an Other Specify option in case respondent gives response not in reference file)** (Accept Only ONE Answer and set ***[Destination Station]***) (If DK, set ***[Destination Station]*** as "your destination station")

10A. Which ONE of the following best describes the MAIN form of transportation you used to get from ***[Destination Station]*** to your final destination in ***[Destination City]***? Was it … (Read List)? (Accept Only ONE Answer)

(Do Not Rotate)
2 Local Bus
3 Commuter rail
4 Subway
5 Private car - parked at station
6 Private car - picked up at station
7 Taxi
8 Rental car
9 Walk
10 Or some other way (Specify:)____________
Do Not Read
99 Don't know/Not sure

11A. Did your one-way trip from ***[Origin Station]*** to ***[Destination Station]*** require that you connect from one train to another train at another station to complete the trip? (Do Not Read List)

1 Yes
2 No
99 Don't know/Not sure

12A. What total fare did you pay for your trip by train from ([**Q4A answer**] *in text*) to ([**Q9A answer**] *in text*)? If you traveled with other people, please just provide the amount for your individual fare.

$__ __ __ __ (0 – 999; 998="$998 or more;" 999=DK)
Total Fare

Ask Q13A if Q12A = 1-998

13A. Was the $**(Amount in Q12A)** a one-way or round trip fare?

1 One-way fare
2 Round trip fare
Do Not Read
3 Don't know/Not sure

Do the following if Q13A is asked. If Q13A=2, Set ***[Rail Fare]*** = Q12A / 2; otherwise if Q13A=1 or 3 set ***[Rail Fare]*** = Q12A

Ask Q9B, Q10B, Q11B, Q12B, Q13B if ***[Actual Mode]***="Plane" (Then skip to instructions before Q15)

9B. At which airport did you get off the plane on your one-way trip from ***[Origin City]*** to ***[Destination City]***? (Read List of Airports for ***[Destination City]*** if necessary) **(See reference Excel file) (999=DK) (Provide an Other Specify option in case respondent gives response not in reference file)** (Accept Only ONE Answer and set ***[Destination Airport]***) (If DK, set ***[Destination Airport]*** as "your destination airport")

10B. Which ONE of the following best describes the MAIN form of transportation you used to get from ***[Destination Airport]*** to your final destination in ***[Destination City]***? Was it … (Read List)? (Accept Only ONE Answer)

(Do Not Rotate)
1 Amtrak train (only display for ***[Destination Airport]***="Newark" OR "BWI")
2 Bus
3 Commuter rail
4 Subway
5 Private car - parked at airport
6 Private car – picked up at airport
7 Taxi
8 Rental car
9 Walk
10 Or some other way (Specify:)____________
Do Not Read
99 Don't know/Not sure

11B. Did your one-way trip from ***[Origin Airport]*** to ***[Destination Airport]*** require that you connect from one plane to another plane at another airport to complete the trip? (Do Not Read List)

1 Yes
2 No
3 Don't know/Not sure

12B. What total fare did you pay for your trip by plane from ([**Q4B answer**] *in text*) to ([**Q9B answer**] *in text*)? If you traveled with other people, please just provide the amount for your individual fare.

$__ __ __ __ (0 – 999; 998="$998 or more;" 999=DK)
Total Fare

Ask Q13B if Q12B = 1-998
13B. Was the $**(Amount in Q12B)** a one-way or round trip fare?

1 One-way fare
2 Round trip fare
Do Not Read
3 Don't know/Not sure

Do the following if Q13B is asked. If Q13B=2, Set ***[Air Fare]*** = Q12B / 2; otherwise if Q13B=1 or 3 set ***[Air Fare]*** = Q12B

Ask Q10C, Q11C, Q12C if ***[Actual Mode]***=”Bus” (Then Skip to instructions before Q15)

10C. Which ONE of the following best describes the MAIN form of transportation you used after you got off the bus to get from the bus terminal or stop to your final destination in ***[Destination City]***? Was it … (Read List)? (Accept Only ONE Answer)

(Do Not Rotate)
2 Local Bus
3 Commuter rail
4 Subway
5 Private car - parked at terminal/stop
6 Private car - picked up at terminal/stop
7 Taxi
8 Rental car
9 Walk
10 Or some other way (Specify:)____________
Do Not Read
99 Don’t know/Not sure

11C. Did your one-way trip from ***[Origin City]*** to ***[Destination City]*** require that you transfer from one bus to another bus in route to complete the trip? (Do Not Read List)

1 Yes
2 No
3 Don’t know/Not sure

12C. What one-wayfare did you pay for your trip by bus from ***[Origin City]*** to ***[Destination City]***? If you traveled with other people, please just provide the amount for your individual fare.

$__ __ __ __ (0 – 999; 998=”$998 or more;” 999=DK)
Total Fare

If Q12C = 1-998, set ***[Bus Fare]*** = Q12C

Ask Q14A, Q14B, Q14C & Q14D if ***[Actual Mode]*** = "Passenger Car/Truck/Van"

Lookup default auto times [Auto_Travel_Time_1], [Auto_Travel_Time_2], [Auto_Travel_Time_3] based on [Origin Zone] and [Destination Zone] in reference Excel file. [Origin Zone] and [Destination Zone] will be based on [Origin City] and [Destination City] respectively.

14A. What do you estimate was your <u>one-way</u> travel time by passenger car/truck/van from ***[Origin City]*** to ***[Destination City]***? Was it closest to **(Read List. Accept Only One Answer)?**

Rotate
1 ***[Auto_Travel_Time_1]***
2 ***[Auto_Travel_Time_2]***
3 ***[Auto_Travel_Time_3]***
Do Not Read
4 Don't know/Not sure

If **[Q14A]**=1 set ***[Auto_Travel_Time]*** = ***[Auto_Travel_Time_1]***
If **[Q14A]**=2 or 4 set ***[Auto_Travel_Time]*** = ***[Auto_Travel_Time_2]***
If **[Q14A]**=3 set ***[Auto_Travel_Time]*** = ***[Auto_Travel_Time_3]***

14B. What do you estimate was the cost of your <u>one-way</u> trip by passenger car/truck/van from ***[Origin City]*** to ***[Destination City]*** …?

For Tolls $__ __ __ (000 – 997; 998="$998 or more;" 999=DK)
Tolls

14C. For Parking $__ __ __ (000 – 997; 998="$998 or more;" 999=DK)
Parking

14D. For Fuel $__ __ __ (001 – 997; 998="$998 or more;" 999=DK)
Fuel

If none of Q14B, Q14C or Q14D = 999, set ***[Car Fare]*** = Q14B+Q14C+Q14D

Ask All.

15. Which ONE of the following best describes the main purpose of your ***[Actual Mode]*** trip from ***[Origin City]*** to ***[Destination City]***? Was it …? **(Read List. Accept Only One Answer.)**

1 Daily commute to or from work
2 Business travel
3 Travel to or from school
4 Visit family or friends
5 Vacation where you're away for about a week or more
6 Leisure/recreation such as dining, sporting events, theater or long weekend getaways
7 Personal or family business such as a wedding, funeral or medical trip
8 Shopping
9 Other (Specify)_______
Do Not Read
99 Don't know/Not sure

16. Did you travel alone or in a group on this ***[Actual Mode]*** trip? "Group" means two or more people who planned to travel together on the same trip.

1 Alone	Skip to instructions before Q24A
2 In a group	Ask Q17
Do Not Read	
3 Don't know/Not sure	Skip to instructions before Q24A

17. Which ONE of the following best describes the other people in your group? **(Read List. Accept Only One Answer) Interviewer:** If respondent's travel group included family along with friends/business associates, please select "Family"

1 Family
2 Friends
3 Business associates
Do Not Show
4 Don't know/Not sure

18. Including yourself, how many adults 18 or older were in the group?

adults: __ __ [1-20; 20 = "20 or more"; 99=DK]

19. And, how many were children… **(Read List)**?

Under 6 years of age: __ __ [0-20; 20 = “20 or more”; 99=DK]
6-12 years: __ __ [0-20; 20 = “20 or more”; 99=DK]
13-17 years: __ __ [0-20; 20 = “20 or more”; 99=DK]

THERE ARE NO Q20-Q23

Ask Q24A if S4 = 1 (Round Trip) and ***[Trip Purpose]*** = business or leisure or non-business. Otherwise, skip to Main Mode Choice Trade-Offs Section.
24A. About how many nights were you away from home on your round trip?

__ [0-7; 8 = ”8 or more;” 9=DK]
Nights

If Q24A = 0, ask Q24B. Otherwise skip to Main Mode Choice Trade-Offs Section

24B. Approximately how many hours did you spend at **[Trip City]**, excluding travel time?

__ [0-24; 99=DK]
Number of Hours

Main Mode Choice Trade-Off Questions

In the following section, respondents are asked 6 Stated Preference choice exercises that relate to one way reference trip for that respondent. The actual mode the respondent used for the reference trip is always ModeA. Two other modes are randomly selected by the program to be available as alternatives.

The alternatives are described by the (one-way) total travel time, total cost, and schedule. Total travel time is the sum of access time, station waiting time, line haul time, transfer time (if relevant) and egress time.

Total cost is the sum of the (one-way) access costs, fare, and egress costs. For the passenger Car/Truck/Van option, cost is the sum of gas costs, tolls, and parking fees.

Schedule is described as departures every “X minutes” or “X hours.” Schedule is not described for the passenger Car/Truck/Van option.

Estimates of the current average values for these descriptors for each mode and origin zone/destination pair are derived from transportation network models of all the modes. These values, called “base” values are contained in a lookup database that is referenced by the CATI program.

If the respondent provided values of fares are within a reasonable range of the values found in the lookup database, the program will adapt the base values to include the respondent provided information. In addition, the program will use the actual reported cost and travel time from respondents who used auto, regardless of database estimate.

The first choice exercise asks respondents to choose a mode based on the “base” characteristics of the three alternative modes. The next five choice exercises modify the characteristics of the available alternatives using percent changes over or under the base values.

For an individual respondent, only two of the three characteristics will change from the base values. One group of respondents (those receiving version 1) will see travel cost and travel time vary, but schedule will remain unchanged from the base values. Version 2 will vary travel time and schedule and keep travel cost fixed. Version 3 will vary schedule and travel cost and keep travel time fixed.

There are also subversions of the survey whereby the order of the two characteristics is reversed. For instance, version 1a lists time first followed by cost while version 1b lists cost first followed by time.

Available modes include:

- ***"High Speed Train" (Where Database file is Not #N/A)***
- ***"Regional Train"***
- ***"Commuter Train" (Where Database file is Not #N/A)***
- ***"Metropolitan Train" (Where Database file is Not #N/A, randomized with or without a transfer)***
- ***"Passenger Car/Truck/Van"***
- ***"Plane" (Where Database file is Not #N/A) (Note: Same as if [Air_Available]=1)***
- ***"Bus" (Where Database file is Not #N/A) (Note: Same as if [Bus_Available]=1)***

Select three modes for trade-off questions as follows:

If [Actual Mode] = "Passenger Car/Truck/Van" OR "Plane" OR "Bus", Set [MODEA] = [Actual Mode]
If [Q1] = 1, [MODEA] = "High Speed Train"
If [Q1] = 2, 8 OR 9, [MODEA] = "Regional Train"
If [Q1] = 3, [MODEA] = "Commuter Train"

Set [MODEB] = RANDOMIZE AMONG AVAILABLE MODES ≠ [MODEA]
Set [MODEC] = RANDOMIZE AMONG AVAILABLE MODES ≠ [MODEA] ≠ [MODEB]

If in setting [MODEA], [MODEB] or [MODEC], the particular mode selected is not available because Database file values for that mode are #N/A, then please select from remaining modes that are still available (not #N/A in Database file and not already selected as [MODEA], [MODEB] or [MODEC]).

For MODEB and MODEC selection, prioritize to select "Regional Train," "Metropolitan Train," or both if not already selected as MODE and Database file values for the mode(s) are not #N/A.

Set base values for characteristics of each of the three modes. Variables to be assigned include: [TimeA], [CostA], and [SchedA] associated with [MODEA]; [TimeB], [CostB], and [SchedB] associated with [MODEB]; and [TimeC], [CostC], and [SchedC] associated with [MODEC]. These values will be set based on [Origin Zone] and [Destination Zone] from lookup database. Use modifications where respondent-provided data is available and reasonable. These characteristics include:

- ***High Speed Train***
  - ***Total Time***
  - ***Total Cost***
  - ***Schedule***
- ***Regional Train***
  - ***Total Time***
  - ***Total Cost***
  - ***Schedule***
- ***Commuter Train***
  - ***Total Time***
  - ***Total Cost***
  - ***Schedule***
- ***Metropolitan Train***
  - ***Total Time***
  - ***Total Cost***
  - ***Schedule***
- ***Plane***
  - ***Total Time***
  - ***Total Cost***
  - ***Schedule***
- ***Bus***
  - ***Total Time***
  - ***Total Cost***
  - ***Schedule***
- ***Car***
  - ***Total Time***
  - ***Total Cost***

Where actual mode is rail/air/bus, use respondent-provided fares if within a reasonable range of database values. For chosen car mode, use respondent-provided total cost when provided; otherwise use database values.

For Example (repeat formula for all non Auto modes)
If [MODEA] = "High Speed Train," check if respondent provided [Rail Fare] is within acceptable database value range (Within 'Acela Lo' and 'Acela Hi') for rail fare based on [Origin Zone] to [Destination Zone]. If it is, [Fare Diff] = [Rail Fare] – [Acela Fare] from Benchmark reference file, then apply that difference (as an addition if positive; as a subtraction if negative) to [Total Cost] for High Speed Train in database ([Total Cost] = [Total Cost] + [Fare Diff]); otherwise use database value for that zone pair.

If [MODEA] (essentially [Actual Mode])="Passenger Car/Truck/Van," [Total Cost] = [Car Fare] if available (that is, none in Q14B-D=999); otherwise use SP database value for that zone pair.

Also if [MODEA]="Passenger Car/Truck/Van," use [Auto_Travel_Time] set from Q14A for Total Travel Time.

Randomly assign respondent to one of three sub-groups which will see variations in 2 trip characteristics (Note: these will be [Var1] and [Var2], [Var3] and [Var4], [Var5] and [Var6] referenced in the appropriate grid):
(1) travel time and travel cost (use Version 1 questions)
(2) travel time and schedule (use Version 2 questions)
(3) travel cost and schedule (use Version 3 questions)

Schedule will take one of the following values for each mode:

- ***"Every 5 minutes"***
- ***"Every 10 minutes"***
- ***"Every 15 minutes"***
- ***"Every 20 minutes"***
- ***"Every 30 minutes"***
- ***"Every Hour"***
- ***"Every Two Hours"***
- ***"Every Three Hours"***
- ***"Every Four Hours"***

Use base values for other variables that will not change across trade-off questions. Set high and low values for variables that change as follows:

- ***TimeHi: randomize among +15%, +30% over base values***
- ***TimeLo: randomize among -15%, -30% under base values***
- ***CostHi: randomize among +15%, +30% over base values***
- ***CostLo: randomize among -15%, -30% under base values***
- ***SchedHi = randomize among next two higher values (e.g., if Schedule = "Every Hour" then randomize among "Every Two Hours", Every Three Hours")***
- ***SchedLo = randomize among next three lower values (e.g., if Schedule = "Every Hour" then randomize among "Every 30 minutes", "Every 20 minutes", "Every 15 minutes")***

Instructions to respondent:

In the next series of questions, I ask you to make a choice about which travel mode you would prefer for that trip from ***[Origin City]*** to ***[Destination City]*** that you just told me about. For these next questions, I would like you to consider a choice between

- ***[MODEA];***
- ***[MODEB]; and***
- ***[MODEC]***.

Provide description of MODEA, MODEB and MODEC if they are rail.
If MODEA, MODEB or MODEC = "Commuter Train":
Read description of commuter rail: The commuter train is similar to the existing services provided by ***[CROperator]*** (name of commuter rail operator in respondent's home area). It provides passengers with shared bench seating – not individual seats. Seating is not guaranteed so some passengers might have to stand during the busiest times. Service is provided by a single train, so no transfer is required.

If MODEA, MODEB and MODEC = "High Speed Train":
Read description of High Speed Train: The high-speed train is very similar to Amtrak's Acela service. It provides passengers with individual seats, as opposed to the shared bench seating on commuter trains. Seating is guaranteed so passengers do not have to stand even during the busiest times. Service is provided by a single train, so no transfer is required.

If MODEA, MODEB and MODEC = "Regional Train":
Read description of Regional Train: The regional train is similar to Amtrak's Regional, Empire, and Keystone service. It provides passengers with individual seats, as opposed to the shared bench seating on commuter trains. Seating is guaranteed so passengers do not have to stand even during the busiest times. Service is provided by a single train, so no transfer is required.

If MODEA, MODEB and MODEC = "Metropolitan Train":
Read description of Metropolitan Train: The metropolitan train is a proposed new service. It provides passengers with individual seats, as opposed to the shared bench seating on commuter trains. However, like commuter trains, seating is not guaranteed so some passengers might have to stand during the busiest times. (***RANDOMIZE***: "This service will be provided by a single train, so no transfer is required.", "This service will be provided by two trains, requiring a transfer, but schedules are coordinated to minimize transfer time and riders purchase just one ticket.").

Note that, if the trip is made by train, plane or bus, the total travel time information I describe includes all time including getting to and from the airport or station and time waiting at the airport or station. The total cost includes the fare as well as the cost of getting to and from the airport or station.

The SP questions rely on an experimental design that provides for variations in five (5) different variables across three (3) modes. Although the experimental design could have also accommodated a sixth variable, we believe this would make the task too difficult for respondents. Furthermore, the sixth variable is not required when one of the modes is car and one of the variables is schedule, which is not relevant for car. A full orthogonal design generates eight (8) total combinations in the five (5) variables at two levels each, from which six are randomly selected to use in the six SP questions for a given respondent. The tables shown below reflect this same experimental design, with differences between them only reflecting the specific variables that are being used.

Note that the variable levels used for the first mode, which is the current mode used by the respondent, reflect base and high (worse) values and the variable levels used for the other two modes reflect base and low (better) values. This has been done to present alternative choices that are more attractive than the current mode, since little is learned about preferences by presenting non-chosen modes that get even worse.

Version 1 (vary travel time and travel cost and keep schedule fixed)
Please assume that the schedules for ***[MODEA]***, ***[MODEB]***, and ***[MODEC]*** are always the same in every case, with …

- ***[MODEA]*** providing service departing ***[SchedA]***;
- ***[MODEB]*** providing service departing ***[SchedB]***; and
- ***[MODEC]*** providing service departing ***[SchedC]***

(where [MODEA], [MODEB], or [MODEC] =”Passenger Car/Truck/Van”, schedule variable does not exist so skip over appropriate MODE and Sched text)

Randomize among Versions 1a and 1b (time-cost or cost-time order)
Version 1a (Q25A-Q30A)

25A. First, please consider the situation where the ***[MODEA]*** **Total Travel Time** is ***[TimeA]*** and one-way **Total Cost** is ***[CostA]***; the ***[MODEB]*** **Total Travel Time** is ***[TimeB]*** and one-way **Total Cost** is ***[CostB]***; and the ***[MODEC]*** **Total Travel Time** is ***[TimeC]*** and one-way **Total Cost** is ***[CostC]***. Under these conditions, and assuming these were the only choices available, what would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you …

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read
8 Don’t know/Not sure

For Q26A-Q27A, randomly select 2 rows of values from A1, A2, and A3 in table
For Q28A-Q30A, randomly select 3 rows of values from B1, B2, B3, and B4 in table

26A-30A. Next, please consider the situation where the ***[MODEA]*** **Total Travel Time** is ***[var1]*** and one-way **Total Cost** is ***[var2]***; the ***[MODEB]*** **Total Travel Time** is ***[var3]*** and one-way **Total Cost** is ***[var4]***; and the ***[MODEC]*** **Total Travel Time** is ***[var5]*** and one-way **Total Cost** is ***[var6]***. What would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you…

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read

8 Don't know/Not sure

	MODEA		MODEB		MODEC	
	Travel Time [var1]	Total Cost [var2]	Travel Time [var3]	Total Cost [var4]	Travel Time [var5]	Total Cost [var6]
Q25A	[TimeA]	[CostA]	[TimeB]	[CostB]	[TimeC]	[CostC]
A1	[TimeHiA]	[CostHiA]	[TimeLoB]	[CostB]	[TimeC]	[CostC]
A2	[TimeA]	[CostHiA]	[TimeLoB]	[CostLoB]	[TimeC]	[CostC]
A3	[TimeHiA]	[CostA]	[TimeB]	[CostLoB]	[TimeC]	[CostC]
B1	[TimeA]	[CostHiA]	[TimeB]	[CostLoB]	[TimeLoC]	[CostC]
B2	[TimeHiA]	[CostA]	[TimeLoB]	[CostLoB]	[TimeLoC]	[CostC]
B3	[TimeA]	[CostA]	[TimeLoB]	[CostB]	[TimeLoC]	[CostC]
B4	[TimeHiA]	[CostHiA]	[TimeB]	[CostB]	[TimeLoC]	[CostC]

Version 1b (Q25B-Q30B)

25B. First, please consider the situation where the ***[MODEA]*** one-way **Total Cost** is ***[CostA]*** and **Total Travel Time** is ***[TimeA]***; the ***[MODEB]*** one-way **Total Cost** is ***[CostB]*** and **Total Travel Time** is ***[TimeB]***; and the ***[MODEC]*** one-way **Total Cost** is ***[CostC]*** and **Total Travel Time** is ***[TimeC]***. Under these conditions, and assuming these were the only choices available, what would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you…

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read

8 Don't know/Not sure

For Q26B-Q27B, randomly select 2 rows of values from A1, A2, and A3 in table
For Q28B-Q30B, randomly select 3 rows of values from B1, B2, B3, and B4 in table

26B-30B. Next, please consider the where the ***[MODEA]*** one-way **Total Cost** is ***[var1]*** and **Total Travel Time** is ***[var2]***; the ***[MODEB]*** one-way **Total Cost** is ***[var3]*** and **Total Travel Time** is ***[var4]***; and the ***[MODEC]*** one-way **Total Cost** is ***[var5]*** and **Total Travel Time** is ***[var6]***. What would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you…

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read

8 Don't know/Not sure

This table matches the prior table, only the order of the columns (cost and time) have been switched)

	MODEA		MODEB		MODEC	
	Total Cost [var1]	Travel Time [var2]	Total Cost [var3]	Travel Time [var4]	Total Cost [var5]	Travel Time [var6]
Q25B	[CostA]	[TimeA]	[CostB]	[TimeB]	[CostC]	[TimeC]
A1	[CostHiA]	[TimeHiA]	[CostLoB]	[TimeB]	[CostC]	[TimeC]
A2	[CostA]	[TimeHiA]	[CostLoB]	[TimeLoB]	[CostC]	[TimeC]
A3	[CostHiA]	[TimeA]	[CostB]	[TimeLoB]	[CostC]	[TimeC]
B1	[CostA]	[TimeHiA]	[CostB]	[TimeLoB]	[CostLoC]	[TimeC]
B2	[CostHiA]	[TimeA]	[CostLoB]	[TimeLoB]	[CostLoC]	[TimeC]
B3	[CostA]	[TimeA]	[CostLoB]	[TimeB]	[CostLoC]	[TimeC]
B4	[CostHiA]	[TimeHiA]	[CostB]	[TimeB]	[CostLoC]	[TimeC]

Version 2 (vary travel time and schedule and keep travel cost fixed)

Please assume that the one-way total costs for ***[MODEA]***, ***[MODEB]***, and ***[MODEC]*** are always the same in every case, with …

- ***[MODEA]*** one-way **Total Cost** at ***[CostA]***;
- ***[MODEB]*** one-way **Total Cost** at ***[CostB]***; and
- ***[MODEC]*** one-way **Total Cost** at ***[CostC]***

Version 2 (Q25C-Q30C)

(where [MODEA], [MODEB], or [MODEC] =”Passenger Car/Truck/Van”, schedule variable does not exist so skip over appropriate MODE and Sched text in questions)

25C. First, please consider the situation where the ***[MODEA]*** **Total Travel Time** is ***[TimeA]*** providing service departing ***[SchedA]***; the ***[MODEB]*** **Total Travel Time** is ***[TimeB]*** providing service departing ***[SchedB]***; and the ***[MODEC]*** **Total Travel Time** is ***[TimeC]*** providing service departing ***[SchedC]***. Under these conditions, and assuming these were the only choices available, what would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you…

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read

8 Don’t know/Not sure

Since schedule is not relevant for the car mode, there are 3 different designs depending on which mode is car.

For Q26C-Q27C, randomly select 2 rows of values from A1, A2, and A3 in table
For Q28C-Q30C, randomly select 3 rows of values from B1, B2, B3, and B4 in table
Use appropriate table depending upon which mode is ”Passenger Car/Truck/Van”

26C-30C. Next, please consider the situation where the ***[MODEA]*** **Total Travel Time** is ***[var1]*** providing service departing ***[var2]***; the ***[MODEB]*** **Total Travel Time** is ***[var3]*** providing service departing ***[var4]***; and the ***[MODEC]*** **Total Travel Time** is ***[var5]*** providing service departing ***[var6]***. What would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you…

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read

8 Don’t know/Not sure

	MODEA (Car)		MODEB (not Car)		MODEC (not Car)	
	Travel Time [var1]	N/A	Travel Time [var3]	Schedule [var4]	Travel Time [var5]	Schedule [var6]
Q25C	[TimeA]		[TimeB]	[SchedB]	[TimeC]	[SchedC]
A1	[TimeHiA]		[TimeLoB]	[SchedHiB]	[TimeC]	[SchedC]
A2	[TimeA]		[TimeLoB]	[SchedHiB]	[TimeC]	[SchedLoC]
A3	[TimeHiA]		[TimeB]	[SchedB]	[TimeC]	[SchedLoC]
B1	[TimeA]		[TimeB]	[SchedHiB]	[TimeLoC]	[SchedLoC]
B2	[TimeHiA]		[TimeLoB]	[SchedB]	[TimeLoC]	[SchedLoC]
B3	[TimeA]		[TimeLoB]	[SchedB]	[TimeLoC]	[SchedC]
B4	[TimeHiA]		[TimeB]	[SchedHiB]	[TimeLoC]	[SchedC]

	MODEA (not Car)		MODEB (Car)		MODEC (not Car)	
	Travel Time [var1]	Schedule [var2]	Travel Time [var3]	N/A	Travel Time [var5]	Schedule [var6]
Q25C	[TimeA]	[SchedA]	[TimeB]		[TimeC]	[SchedC]
A1	[TimeHiA]	[SchedHiA]	[TimeLoB]		[TimeC]	[SchedC]
A2	[TimeA]	[SchedHiA]	[TimeLoB]		[TimeC]	[SchedLoC]
A3	[TimeHiA]	[SchedA]	[TimeB]		[TimeC]	[SchedLoC]
B1	[TimeA]	[SchedHiA]	[TimeB]		[TimeLoC]	[SchedLoC]
B2	[TimeHiA]	[SchedA]	[TimeLoB]		[TimeLoC]	[SchedLoC]
B3	[TimeA]	[SchedA]	[TimeLoB]		[TimeLoC]	[SchedC]
B4	[TimeHiA]	[SchedHiA]	[TimeB]		[TimeLoC]	[SchedC]

	MODEA (not Car)		MODEB (not Car)		MODEC (Can be Car)	
	Travel Time [var1]	Schedule [var2]	Travel Time [var3]	Schedule [var4]	Travel Time [var5]	N/A(car) or Schedule [var6]
Q25C	[TimeA]	[SchedA]	[TimeB]	[SchedB]	[TimeC]	[SchedC]
A1	[TimeHiA]	[SchedHiA]	[TimeLoB]	[SchedB]	[TimeC]	[SchedC]
A2	[TimeA]	[SchedHiA]	[TimeLoB]	[SchedLoB]	[TimeC]	[SchedC]
A3	[TimeHiA]	[SchedA]	[TimeB]	[SchedLoB]	[TimeC]	[SchedC]
B1	[TimeA]	[SchedHiA]	[TimeB]	[SchedLoB]	[TimeLoC]	[SchedC]
B2	[TimeHiA]	[SchedA]	[TimeLoB]	[SchedLoB]	[TimeLoC]	[SchedC]
B3	[TimeA]	[SchedA]	[TimeLoB]	[SchedB]	[TimeLoC]	[SchedC]
B4	[TimeHiA]	[SchedHiA]	[TimeB]	[SchedB]	[TimeLoC]	[SchedC]

Version 3 (vary travel cost and schedule and keep travel time fixed)

Please assume that the total travel time for ***[MODEA]***, ***[MODEB]***, and ***[MODEC]*** are always the same in every case, with …

- ***[MODEA]*** **Total Travel Time** at ***[TimeA]***;
- ***[MODEB]*** **Total Travel Time** at ***[TimeB]***; and
- ***[MODEC]*** **Total Travel Time** at ***[TimeC]***

Version 3 (Q25D-Q30D)

(where [MODEA], [MODEB], or [MODEC] =”Passenger Car/Truck/Van”, schedule variable does not exist so skip over appropriate MODE and Sched text in questions)

25D. First, please consider the situation where the ***[MODEA]*** one-way **Total Cost** is ***[CostA]*** providing service departing ***[SchedA]***; the ***[MODEB]*** one-way **Total Cost** is ***[CostB]*** providing service departing ***[SchedB]***; and the ***[MODEC]*** one-way **Total Cost** is ***[CostC]*** providing service departing ***[SchedC]***. Under these conditions, and assuming these were the only choices available, what would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you…

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read

8 Don’t know/Not sure

For Q26D-Q27D, randomly select 2 rows of values from A1, A2, and A3 in table
For Q28D-Q30D, randomly select 3 rows of values from B1, B2, B3, and B4 in table
Use appropriate table depending upon which mode is ”Passenger Car/Truck/Van”

26D-30D. Next, please consider the situation where the ***[MODEA]*** one-way **Total Cost** is ***[var1]*** providing service departing ***[var2]***; the ***[MODEB]*** one-way **Total Cost** is ***[var3]*** providing service departing ***[var4]***; and the ***[MODEC]*** one-way **Total Cost** is ***[var5]*** providing service departing ***[var6]***. What would you choose for your trip from ***[Origin_City]*** to ***[Destination_City]***? Would you…

1 Travel by ***[MODEA]***;
2 Travel by ***[MODEB]***;
3 Travel by ***[MODEC]***;
4 Not make the trip at all

Do Not Read

8 Don’t know/Not sure

	MODEA (Car)		MODEB (not Car)		MODEC (not Car)	
	Total Cost [var1]	N/A	Total Cost [var3]	Schedule [var4]	Total Cost [var5]	Schedule [var6]
Q25D	[CostA]		[CostB]	[SchedB]	[CostC]	[SchedC]
A1	[CostHiA]		[CostLoB]	[SchedHiB]	[CostC]	[SchedC]
A2	[CostA]		[CostLoB]	[SchedHiB]	[CostC]	[SchedLoC]
A3	[CostHiA]		[CostB]	[SchedB]	[CostC]	[SchedLoC]
B1	[CostA]		[CostB]	[SchedHiB]	[CostLoC]	[SchedLoC]
B2	[CostHiA]		[CostLoB]	[SchedB]	[CostLoC]	[SchedLoC]
B3	[CostA]		[CostLoB]	[SchedB]	[CostLoC]	[SchedC]
B4	[CostHiA]		[CostB]	[SchedHiB]	[CostLoC]	[SchedC]

	MODEA (not Car)		MODEB (Car)		MODEC (not Car)	
	Total Cost [var1]	Schedule [var2]	Total Cost [var3]	N/A	Total Cost [var5]	Schedule [var6]
Q25D	[CostA]	[SchedA]	[CostB]		[CostC]	[SchedC]
A1	[CostHiA]	[SchedHiA]	[CostLoB]		[CostC]	[SchedC]
A2	[CostA]	[SchedHiA]	[CostLoB]		[CostC]	[SchedLoC]
A3	[CostHiA]	[SchedA]	[CostB]		[CostC]	[SchedLoC]
B1	[CostA]	[SchedHiA]	[CostB]		[CostLoC]	[SchedLoC]
B2	[CostHiA]	[SchedA]	[CostLoB]		[CostLoC]	[SchedLoC]
B3	[CostA]	[SchedA]	[CostLoB]		[CostLoC]	[SchedC]
B4	[CostHiA]	[SchedHiA]	[CostB]		[CostLoC]	[SchedC]

	MODEA (not Car)		MODEB (not Car)		MODEC (can be Car)	
	Total Cost [var1]	Schedule [var2]	Total Cost [var3]	Schedule [var4]	Total Cost [var5]	N/A(car) or Schedule [var6]
Q25D	[CostA]	[SchedA]	[CostB]	[SchedB]	[CostC]	[SchedC]
A1	[CostHiA]	[SchedHiA]	[CostLoB]	[SchedB]	[CostC]	[SchedC]
A2	[CostA]	[SchedHiA]	[CostLoB]	[SchedLoB]	[CostC]	[SchedC]
A3	[CostHiA]	[SchedA]	[CostB]	[SchedLoB]	[CostC]	[SchedC]
B1	[CostA]	[SchedHiA]	[CostB]	[SchedLoB]	[CostLoC]	[SchedC]
B2	[CostHiA]	[SchedA]	[CostLoB]	[SchedLoB]	[CostLoC]	[SchedC]
B3	[CostA]	[SchedA]	[CostLoB]	[SchedB]	[CostLoC]	[SchedC]
B4	[CostHiA]	[SchedHiA]	[CostB]	[SchedB]	[CostLoC]	[SchedC]

Demographics

Ask All
The last few questions are for classification purposes only.

D-1. Into which of the following categories does your age fall? (Read List)
1 18-24
2 25-34
3 35-44
4 45-54
5 55-64
6 65 or older
Do Not Read
8 Don't know/Not sure

D-2. Record Gender:

1 Male
2 Female

D-3. How many people, including yourself, live in your household?

__ __ __ __ __ (1-10; 10=="10 or more;" 99=DK)

D-4. How many motor vehicles are owned, leased, or available for regular use by the people who currently live in your household?

__ __ __ __ __ (0-10; 10=="10 or more;" 99=DK)

D-5. What is your 5-digit home zip code? (DK=99999)

__ __ __ __ __

D-6. What is the last grade of school you completed?
1 Grade school or less
2 Some high school
3 High school graduate
4 Technical/training beyond high school
5 Some college
6 College graduate
7 Graduate school
Do Not Read
8 Don't know/Not sure

D-7. What is your current employment status?
1 Employed full-time
2 Employed part-time
3 A student
4 Retired
5 A homemaker, or
6 Not employed
7 Other (Specify)____
Do Not Read
8 Don’t know/Not sure

D-8. What is the total annual income of your household, before taxes?
1 Less than $25,000
2 $25,000 - $49,999
3 $50,000 - $74,999
4 $75,000 - $99,999
5 $100,000 - $149,999
6 $150,000 - $199,999
7 $200,000 - $249,999
8 $250,000 or over
Do Not Read
9 Don’t know/Not sure

D-9. Are you Hispanic or Latino? (Do Not Read List)
1 Yes
2 No
3 Don’t know/Not sure

D-10. What is your race? Please select one or more. Would you say...? **(Note:** Select all that apply**)** (Read List)
1 White
2 Black or African American
3 Asian
4 Native Hawaiian or Other Pacific Islander, or
5 American Indian or Alaska native
Do Not Read
8 Don’t know/Not sure

ASK D11 FOR LANDLINE SAMPLE
D-11. Now thinking about your telephone use, do you have a working cell phone? [INTERVIEWER: THIS INCLUDES SHARED CELL PHONES.] (Do Not Read List)
1 Yes
2 No
3 Don’t know/Not sure

ASK D12 FOR CELL SAMPLE

D-12. Now thinking about your telephone use, in addition to the cell phone, do you also have a regular phone that you use to make and receive calls where you currently live? [IF NEEDED: A regular telephone is sometimes called a landline or phone that is wired to a jack in the wall.] (Do Not Read List)

1 Yes
2 No
3 Don't know/Not sure

END INTERVIEW ROUTINE

Thank you! Let me take down your name and mailing address to make sure we send the ten dollar "thank-you" check to the right address. Again, all information you give are kept strictly private.

May I please have your **(Record):**

Name:
Street Address:
City:
State:
Zip code:

Interviewer Note: Confirm spelling of name and mailing information with respondent.

[Interviewer Note: (If Needed): The U.S. Department of Transportation privacy information can be found at http://www.dot.gov/privacy]

PROGRAMMER: PROVIDE OPTION FOR RESPONDENT TO DECLINE INCENTIVE IF WANTED

Thank you very much for your time!

Appendix B: Report on Survey Non-Response

New York, NY
Silver Spring, MD
Cambridge, MA
Chicago, IL
Durham, NC
Fort Meyers, FL
Hadley, MA
Huntington, WV
Scottsdale, AZ
West Long Branch, NJ

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Survey of Northeast Regional and Intercity Household Travel Attitudes and Behavior (NEC FUTURE Study)

Report on Survey Non-Response

November 12, 2014

Prepared for
Federal Railroad Administration

Submitted by
PB-AECOM a Joint Venture

Prepared by
Abt SRBI Inc.

Table of Contents

1. Introduction

Non-response, the failure to obtain survey measures on all sampled individuals, can undermine the rationale for inference in probability-based samples. There are two main potential consequences from non-response: (1) non-response bias and (2) underestimation of the standard errors. While a low response rate doesn't necessarily imply non-response bias, a low response rate becomes an issue when non-respondents differ significantly from respondents demographically or on a characteristic related to the variables the study aims to measure. A non-response bias analysis provides insight into the degree to which non-response introduces bias or affects the estimation of standard errors.

The NEC FUTURE Study is a stated-preference study designed to specifically support the development of a new travel demand forecasting model for the NEC. The target population consisted of residents of the Northeast Corridor who travelled to an area outside of their immediate vicinity. For purposes of making a non-response adjustment during the weighting of the data, non-eligible respondents (i.e., those who did not travel to a qualifying area in the past 12 months) were still asked basic demographic questions. The study was conducted by telephone from April 2014 through July 2014. The sample weights include a non-response adjustment based solely on the comparison to population estimates of the northeast residents. However, the non-response bias analysis for the NEC FUTURE study consisted of three parts:

1. **ACS Comparison.** The demographic composition of the respondents was compared to the general adult population residing in the Northeast Corridor based on 2012 American Community Survey (ACS) 5-year estimate data. The NEC FUTURE respondents used in this comparison (n=24,952) contained all qualifying completes and non-qualifying screen outs who did not qualify but provided their demographic info.
2. **Auxiliary Data Comparison.** Additional sample data associated with each telephone number was purchased from the sampling vendor, SSI. This data is known as auxiliary data and contains information gathered through credit bureau reports associated with specific phone number and the geographic location of the household. For example, the auxiliary data contains information on the percentage of various racial groups in the vicinity of the household, household income, and whether the household is in an urban, suburban or rural area. The qualifying completed cases were compared to non-qualifying screen outs using this data, as well as to non-respondents.
3. **Non-Response Follow-up Study.** A non-response follow-up (NRFU) survey was conducted among 590 households who had a final disposition of soft refusal or non contact when the main field collection ended. The NRFU was conducted approximately 2 months after data collection was completed. NRFU respondents completed a brief (7 minutes) survey that collected screener and demographic data. The NEC FUTURE Survey respondents (including both qualifying and non-qualifying) were compared to the NRFU respondents on key demographic and behavioral variables.

2. Comparison to American Community Survey (ACS) Data

NEC FUTURE respondents were compared on key demographic measures to the general population residing within the Northeast Corridor (based on 2012 ACS 5-year estimate data).

The NEC respondent sample was drawn from all persons aged 18 to 74 residing in English speaking households with a working telephone located within the Northeast Corridor. In order to qualify for the main study, respondents needed to have taken a long distance interstate trip between two qualifying regions within the past 12 months. The interstate trip could have either been for leisure, business or commuting.

The n=24,952 NEC FUTURE respondents which were compared to population demographics from the 2012 ACS (5-year estimate) include both completes who qualified for the study and screen outs who did not qualify but provided their demographic info. Because the demographics of long distance travelers between specific areas within the Northeast Corridor may differ from the general Northeast Corridor population, both qualifying and non-qualifying respondents were included in the NEC respondent base to ensure its comparability to the general population.

The analysis examined age, gender, race/ethnicity, income, education, household size, employment status, and geographic distribution within the Northeast Corridor.

Survey weights were computed to align survey respondents (qualified completes and non-qualifying screen outs) to ACS benchmarks. The alignment process, called “raking,” was applied to a subset of the demographic dimensions collected in the survey: age, gender, education level, race/ethnicity, state of residence and telephone service. Other demographic information was not used in the raking; including more dimensions would likely increase the variance of the weights and reduce precision. See Section 5.0: “Weighting the Data” in the main technical memorandum for detailed description of the weighting procedure.

(Note on reporting: Throughout the report, percentages have been rounded to the nearest whole number. Occasionally this will cause the sum of percentages to equal slightly more or less than 100. Don’t know/Refused answers were not shown in the tables.)

Table 2.1: Demographic Comparison to ACS (Age, Gender)

		ACS Benchmark (n=40,248,754)	Respondents (Qualified and Not Qualified) (n=24,952)	Diff vs. Population
AGE	18-24	13%	6%	-7%
	25-34	17%	9%	-8%
	35-44	18%	13%	-5%
	45-54	20%	20%	0%
	55-64	15%	22%	7%
	65+	17%	30%	13%
GENDER				
	Male	48%	41%	-7%
	Female	52%	59%	7%

The study population was older than the general population by a significant margin. Seniors were almost twice as likely to be found in the study sample compared to their proportion in the population. As result, younger respondents, especially those 18-34, were underrepresented in the sample. Gender was also skewed with females being overrepresented in the sample by 7 points.

Table 2.2: Demographic Comparison to ACS (Race and Ethnicity)

		ACS Benchmark (n=40,248,754)	Respondents (Qualified and Not Qualified) (n=24,952)	Diff vs. Population
RACE/ETHNICITY	White Non-Hispanic	63%	69%	6%
	Black/African American Non-Hispanic	15%	18%	3%
	Hispanic	13%	8%	-5%
	Multi-race/other race Non-Hispanic[1]	9%	5%	-4%

Only half of Hispanics were represented in the sample. There were also smaller differences for other race/ethnicity categories when compared to ACS general population information.

[1] The difference in the other race/multi-race category may be attributed to the fact that the NEC survey did not include an “other race” option, while the ACS does. 8% of respondents did not answer the race questions; some of them could have potentially selected the other race category if it were an option.

Table 2.3: Demographic Comparison to ACS (Income and Household Size)

		ACS Benchmark (n=19,371,076)[2]	Respondents (Qualified and Not Qualified) (n=24,952)	Diff vs. Population
HOUSEHOLD INCOME	<$25k	19%	19%	0%
	$25-49.9k	19%	21%	2%
	$50-74.9k	17%	17%	0%
	$75-99.9k	13%	14%	1%
	$100-149.9k	16%	14%	-2%
	$150-199.9k	8%	7%	-1%
	$200-249.9k	4%	3%	-1%
	$250k or over	5%	5%	0%
HOUSEEHOLD SIZE	1 person	28%	24%	-5%
	2 people	31%	33%	2%
	3 people	16%	16%	0%
	4 people	14%	15%	1%
	5 people	6%	7%	1%
	6+ people	4%	5%	2%

In regards to income, the study sample matched the general population quite well. Likewise, there was very little difference with regards to household size, although single person households were slightly underrepresented.

Table 2.4: Demographic Comparison to ACS (Education, Employment)

		ACS Benchmark (n=40,248,754)	Respondents (Qualified and Not Qualified) (n=24,952)	Diff vs. Population
EDUCATION	Less than High School	13%	6%	-7%
	High School Graduate	27%	25%	-2%
	Some College	26%	20%	-6%
	College Graduate	20%	29%	9%
	Graduate School	14%	21%	7%
EMPLOYMENT STATUS				
	Employed	63%	54%	-9%
	Unemployed	6%	8%	2%
	Not in Labor Force	32%	38%	6%

Those with at least a college degree were much more likely to be in the study when compared to the population (50% vs 34%). In terms of employment status, those who are not in the labor force were overrepresented in the sample as one would typically expect with a telephone survey.

[2] Based on ACS households.

Table 2.5: Geographic Comparison to ACS

		ACS Benchmark (n=40,248,754)	Respondents (Qualified and Not Qualified) (n=24,952)	Diff vs. Population
STATE DISTRIBUTION	Connecticut	7%	7%	0%
	Delaware	1%	1%	0%
	Maryland	10%	10%	0%
	Massachusetts	13%	13%	0%
	New Hampshire	2%	1%	-1%
	New Jersey	17%	16%	-1%
	New York	28%	26%	-1%
	Pennsylvania	13%	14%	1%
	Rhode Island	2%	2%	0%
	Virginia	7%	8%	0%
	Washington DC	1%	2%	1%

The geographic distribution of the study sample within the Northeast Corridor reflected the Northeast Corridor population distribution across the inclusive states.

3. Auxiliary Sample Data Comparison

Auxiliary data refers to additional data which can be appended to sample purchased from Survey Sampling Inc (SSI). Most of this data comes from credit bureaus via various applications the household has completed and is associated with their phone number. While the auxiliary data are only available for some households, a comparison of respondents to non-respondents is still a worthwhile exercise because if strong systematic bias is present in the sample it will likely be obvious when such a comparison is made. The auxiliary data represent the most recent information on demographic characteristics including household income, race of those living in the respondent's neighborhood, and type of area the household is located in. The quality of this information varies since most of this is gathered though credit bureaus and applications for services. The younger and more mobile/itinerant populations are not as likely to be represented in the auxiliary data. Neither are minorities or lower income individuals. This data does, however, give us a more robust analysis of who completed and who did not at the case level, rather than at the aggregate level.

In total, just under twelve thousand (n=11,858) individuals qualified and completed the NEC survey. As shown in Table 3.1, around nine thousand (n=9,216) of these qualifying respondents were derived from the landline sample with the remaining 2,642 completes coming from cell sample. See Section 3.0: "Field Implementation" in the main technical memorandum for a summary of survey results.

Table 3.1: Respondent Status by Sample Type

	Non-Qualifying Respondents (n=13,094)	Qualifying Respondents (n=11,858)	Total (n=24,952)
Sample Type			
Landline	**10,188**	**9,216**	**19,404**
Cell phone	2,906	2,642	5,548

Non-qualifying respondents included participants deemed ineligible due to reporting of no travel to a qualifying area, no commute/business/leisure trips taken, and other criteria assessed during the screening interview. For the purposes of this analysis, only landline qualifying respondents (n=9,216) and landline non-qualifying respondents (n=10,188) were compared.

In total, 850,000 landline phone numbers were loaded and available as sample for dialing on the NEC survey. The non-respondent landline sample that did not include qualifying and non-qualifying respondents encompassed 209,769 phone numbers. The majority of landline numbers loaded into the Sample Management System was bad numbers (e.g., business phones, disconnected, etc.) and was excluded from the analysis.

Note: The base sizes shown in Tables 3.2 through 3.5 are slightly less than the base sizes shown in Table 3.1 due to exclusion of cases without auxiliary data available.

Respondents to the NEC survey were largely classified as suburban (Table 3.2). Qualifying respondents were slightly more likely to be classified as suburban (73.2%) than non-qualifying respondents (67%) and non-respondents (69%).

Table 3.2: Geographic Classification by Respondent Type

	Qualifying Respondents (n=9,208)	Non-Qualifying Respondents (n=10,178)	Non-Respondents (n=209,769)
Geographic Classification			
Urban	25.3%	31.9%	29.8%
Suburban	73.2%	67.0%	69.0%
Rural	1.5%	1.1%	1.2%

Data are unweighted.
Based to landline sample.

The geographic distribution by state of qualifying respondents was roughly the same as non-respondents. The distributions were also generally similar between qualifying and non-qualifying respondents, with exception of Connecticut and New York: a slightly larger group of non-qualifying respondents to the NEC survey were from New York in comparison to qualifying respondents. In Connecticut, the opposite was true: a greater proportion of qualifying respondents resided in Connecticut in comparison to non-qualifying respondents (Table 3.3).

Table 3.3: Geographic Distribution (State) by Respondent Type

	Qualifying Respondents (n=9,208)	Non-Qualifying Respondents (n=10,178)	Non-Respondents (n=209,769)
Geographic Distribution			
Connecticut	8.9%	5.4%	6.5%
Delaware	1.3%	1.2%	1.0%
Maryland	10.7%	9.1%	9.0%
Massachusetts	12.3%	12.7%	13.0%
New Hampshire	1.4%	1.6%	1.7%
New Jersey	16.8%	16.3%	18.5%
New York	23.3%	29.0%	28.1%
Pennsylvania	13.2%	13.9%	12.2%
Rhode Island	2.7%	2.2%	1.8%
Virginia	7.8%	7.1%	6.9%
Washington DC	1.7%	1.5%	1.2%

Data are unweighted.
Based to landline sample.

Auxiliary income data suggested non-qualifying respondents had a substantially lower average household income in comparison to their qualifying respondent counterparts (Table 3.4). A difference of 33% separated the median incomes of qualifying respondents and non-qualifying respondents ($95,523 vs. $68,000, respectively). Non-respondents had both a mean and median income which was closer to qualifying respondents than non-qualifying respondents.

Table 3.4: Annual Household Income by Respondent Type

	Qualifying Respondents (n=9,208)	Non-Qualifying Respondents (n=10,178)	Non-Respondents (n=209,769)
Household Income			
Mean	$114,613	$80,709	$98,224
Median	$95,523	$68,000	$85,122
Data are unweighted. Based to land line sample.			

According to auxiliary data obtained regarding the overall racial composition of participant neighborhoods, qualifying respondents were more likely to reside in predominately white areas than non-qualifying respondents (Table 3.5). Non-respondents fell between qualifying and non-qualifying respondents in terms of the percentage residing in predominantly white areas.

Table 3.5: Neighborhood Racial Distribution (Average Percent) by Respondent Type

	Qualifying Respondents (n=9,208)		Non-Qualifying Respondents (n=10,178)		Non-Respondents (n=209,769)	
Racial Distribution of Neighborhood						
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**
White	77.2%	86.0%	70.5%	81.0%	74.1%	83.0%
Black/African-American	12.8%	4.0%	18.1%	6.0%	14.0%	5.0%
Hispanic	7.7%	4.0%	10.4%	5.0%	9.9%	5.0%
Asian, Native Hawaiian or Other Pacific Islander	5.2%	3.0%	4.8%	3.0%	5.8%	3.0%
American Indian or Alaska Native	0.1%	0.0%	0.2%	0.0%	0.2%	0.0%
Data are unweighted. Based to records containing race data. Based to landline sample.						

4. Non-Response Follow-up Study Results

The purpose of the Non-Response Follow-Up Study (NRFU) is to ascertain travel behavior and demographic characteristics of those who did not respond to the original survey and to contrast the characteristics of this population to those that did participate. For the purposes of this analysis, NRFU respondents were compared to respondents to the main survey (including completes and screen-outs). If main survey respondents and NRFU respondents are substantively different, survey estimates are biased.

The NRFU survey instrument consisted of screening, travel and demographic questions from the main study questionnaire, and used a methodology similar to that employed for the original survey. The NRFU survey was conducted from September 25, 2014 to September 28, 2014, approximately 2 months after the main data collection closed at the end of July, 2014. The NRFU was conducted via telephone with randomly selected respondents that had previously not participated in the main survey. Overall 590 interviews were completed.

Sample for the NRFU was drawn from the remaining sample from the main survey. Records with a final disposition of soft refusal or non-contact were eligible to be included in the NRFU. However, due to the large amount of calling that was done for the main survey, not all cases with these dispositions were included in the NRFU sample.

The NRFU questionnaire contained questions that covered general screening and demographics. Additionally, NRFU respondents were asked if they remembered receiving a call regarding the initial Department of Transportation information request, and, if so, why they had refused to participate. The average interview length for the NRFU was 7 minutes. Respondents who completed the NRFU survey received a $25 check incentive for completing the survey. Respondents were informed of the incentive during the introduction to the survey.

The results of the NRFU and main survey were compared to evaluate the differences between NRFU respondents and main survey respondents (main survey completes and screen-outs). This analysis examined age, gender, race/ethnicity, income, education, employment status, and geographic distribution. Data are unweighted, and 'Don't know/Refused answers are not shown in the table.

Table 4.1: Comparison of NEC FUTURE Study Respondents with Non-Respondents by Age and Gender

	Respondents (NRFU) (n=590)	**Respondents (Main Survey) (n=24,592)**	**Difference NRFU vs. Main Survey (% point)**
Age			
18-24	5%	6%	-1%
25-34	6%	9%	-3%
35-44	13%	13%	0%
45-54	22%	20%	2%
55-64	21%	22%	-1%
65+	33%	30%	3%
Gender			
Male	40%	41%	-1%
Female	60%	59%	1%

Table 4.1 compared main survey respondents and NRFU respondents by age and gender. Comparisons between the main survey respondents and NRFU respondents were very similar in terms of age and gender. The NRFU respondents tended to be slightly older than the main survey respondents with 76% of the respondents being 45 or older. This was slightly higher than the 72% of respondents 45 or older in the main survey.

Table 4.2: NRFU Comparison (Race and Ethnicity)

	Respondents (NRFU) (n=590)	Respondents (Main Survey) (n=24,592)	Difference NRFU vs. Main Survey (% point)
Race			
White	72%	75%	-3%
Black/African American	21%	20%	1%
Asian	5%	4%	1%
Native Hawaiian or Other Pacific Islander	<1%	1%	-<1%
American Indian or Alaska Native	2%	1%	1%
Hispanic Ethnicity			
Yes	6%	7%	-1%
No	91%	93%	-2%

The race profile of main survey respondents and NRFU respondents as shown in Table 4.2 was fairly similar in all race categories except for white. The percentage of white respondents in the NRFU sample is 3 percentage points lower than the main survey. Both the main survey and the NRFU reached a similar proportion of Hispanic respondents.

Table 4.3: NRFU Comparison (Household Income and Education)

	Respondents (NRFU) (n=590)	Respondents (Main Survey) (n=24,592)	Difference NRFU vs. Main Survey (% point)
Household Income			
Less than $25,000	19%	19%	0%
$25,000 - $49,999	22%	21%	1%
$50,000 - $74,999	18%	17%	1%
$75,000 - $99,999	13%	14%	-1%
$100,000 - $149,999	15%	14%	1%
$150,000 - $199,999	6%	7%	-1%
$200,000 - $249,999	2%	3%	-1%
$250,000 or over	5%	5%	0%
Education			
Grade school or less	1%	1%	0%
Some high school	6%	4%	2%
High school graduate	25%	25%	0%
Technical/ training beyond high school	2%	3%	-1%
Some college	17%	17%	0%
College graduate	29%	28%	1%
Graduate School	20%	20%	0%

Table 4.3 shows the distributions for income and education in each sample. Income and education were both comparable in the NRFU and main survey.

Table 4.4: NRFU Comparison (Employment Status)

	Respondents (NRFU) (n=590)	Respondents (Main Survey) (n=24,592)	Difference NRFU vs. Main Survey (% point)
Employment Status			
Employed-full time	43%	42%	1%
Employed part time	8%	10%	-2%
Student	2%	3%	-1%
Retired	33%	29%	4%
Homemaker	4%	4%	0%
Not employed	6%	7%	-1%
Other	4%	4%	0%

The employment status of respondents (Table 4.4) who participated in the NRFU was similar to the profile of those who responded to the main survey. A somewhat higher percentage of NRFU respondents reported that they were retired.

Table 4.5: NRFU Comparison Geographic Distribution

	Respondents (NRFU) (n=590)	Respondents (Main Survey) (n=24,592)	Difference NRFU vs. Main Survey (% point)
Geographic Distribution			
Connecticut	6%	7%	-1%
Delaware	2%	1%	1%
Maryland	11%	10%	1%
Massachusetts	14%	13%	1%
New Hampshire	2%	1%	1%
New Jersey	12%	16%	-4%
New York	28%	26%	2%
Pennsylvania	13%	14%	-1%
Rhode Island	2%	2%	0%
Virginia	9%	8%	1%
Washington DC	1%	2%	-1%

The state of residence of main survey respondents and NRFU respondents was fairly similar, with only New Jersey being slightly higher for main survey respondents.

Finally, only 12% of NRFU respondents recalled receiving a call regarding this Department of Transportation information request previously. Among the few (12%) who remembered the survey request, the vast majority (63%) cited being too busy as the reason for non-response. No other reason given totaled more than 6% of those who recalled the initial survey request.

5. Conclusion

Overall, the results of the non-response bias analysis were encouraging. Both the auxiliary data and the NRFU results showed very little differences between respondents (total qualifying and non-qualifying) and non-respondents. However, both auxiliary data comparisons and NRFU studies are limited in what they can tell us about the representativeness of the sample. The auxiliary data, while an excellent source of additional data on a case by case basis, has large holes in the dataset which cannot be assumed to be random. That is, a certain segment of the population is more likely to have information about their income, racial composition and age of household members due to credit applications they have completed or subscriptions they have purchased. The bias contained in the auxiliary data cannot be measured on a case by case basis with much certainty so we are forced to view the results with this caveat in mind.

The NRFU study presents another issue, in that we are completing an abbreviated survey with folks who did not originally respond (although most NRFU respondents do not recall the original request for an interview). However, these NRFU respondents are not necessarily a good representation of all non-respondents from the main survey. Most likely the NRFU respondents represent those who are more likely to respond to surveys but did not have a chance or the time to do so during the main study. As a result, most of the comparisons between respondents (total qualifying and non-qualifying) and NRFU respondents do not show much of a difference. Both the auxiliary data and the NRFU study should be viewed as high level tests of non-response bias. If either one of these showed significant differences, then this would be a red flag and would likely indicate that non-ignorable non-response bias is present in the study. However, if the comparisons do not show much of a difference it is important that one does not draw the conclusion that there is no non-response bias associated with the study.

The demographic comparison to ACS data, the final component of the non-response bias analysis, is the gold standard in terms of identifying issues with non-response. Although the analysis is conducted at the aggregate level, the ACS represents the best estimate of who lives in the Northeast Corridor. When conducting the comparison, we found a few variables which were biased enough to be of concern, namely, age, gender, Hispanic ethnicity, and education. These four variables were different enough from the population characteristics and the non-response adjustment which was made during the weighting process took this into account. So, although we found non-ignorable non-response when comparing demographic characteristics from the study respondents to the general population, we were able to mitigate the bias through a weighting process that adjusted the demographics from the study sample to match the population.

Appendix B – Moody's Demographic Forecasts of Population and Employment

	Base Population			Base Employment		
	2012	2040	% Growth	2012	2040	% Growth
NEW HAMPSHIRE						
Hillsborough County	403,240	424,710	5%	199,390	223,140	12%
Rockingham County	298,530	342,300	15%	144,330	181,090	25%
Strafford County	124,440	148,990	20%	47,720	62,480	31%
Subtotal	**826,210**	**916,000**	**11%**	**391,440**	**466,710**	**19%**
MASSACHUSETTS						
Barnstable County	215,760	239,870	11%	93,600	105,270	12%
Berkshire County	130,080	128,630	-1%	63,180	65,950	4%
Bristol County	552,010	636,570	15%	217,120	266,060	23%
Dukes County	17,120	22,190	30%	11,030	18,520	68%
Essex County	757,220	795,390	5%	312,620	360,140	15%
Franklin County	71,510	71,740	0%	26,740	27,980	5%
Hampden County	466,200	492,780	6%	202,960	223,770	10%
Hampshire County	160,000	177,190	11%	61,980	71,600	16%
Middlesex County	1,541,010	1,621,720	5%	849,730	984,460	16%
Nantucket County	10,360	12,790	23%	8,120	13,000	60%
Norfolk County	683,230	699,870	2%	329,920	360,280	9%
Plymouth County	500,230	480,360	-4%	177,800	181,990	2%
Suffolk County	747,330	868,480	16%	615,460	762,510	24%
Worcester County	807,500	864,160	7%	325,930	349,880	7%
Subtotal	**6,659,560**	**7,111,740**	**7%**	**3,296,190**	**3,791,410**	**15%**
RHODE ISLAND						
Bristol County	49,110	51,470	5%	14,260	15,660	10%
Kent County	164,730	171,130	4%	76,080	82,790	9%
Newport County	82,070	85,080	4%	40,380	43,860	9%
Providence County	628,750	681,830	8%	282,560	320,930	14%
Washington County	125,950	131,890	5%	51,180	56,120	10%
Subtotal	**1,050,610**	**1,121,400**	**7%**	**464,460**	**519,360**	**12%**
NEW YORK						
Bronx County	1,412,300	1,546,200	9%	249,740	313,910	26%
Dutchess County	297,310	314,260	6%	115,250	124,610	8%
Kings County	2,572,620	2,929,300	14%	540,030	705,960	31%
Nassau County	1,349,900	1,441,720	7%	623,410	734,360	18%
New York County	1,622,080	1,693,690	4%	2,472,840	2,964,140	20%
Orange County	374,910	418,510	12%	136,510	155,920	14%
Putnam County	99,550	91,030	-9%	25,990	27,260	5%
Queens County	2,277,530	2,508,940	10%	533,260	674,370	26%
Richmond County	471,130	476,810	1%	96,360	111,860	16%
Rockland County	318,650	366,450	15%	122,210	161,310	32%
Suffolk County	1,499,210	1,573,540	5%	645,430	747,040	16%
Westchester County	963,150	1,011,060	5%	431,840	520,330	20%
Subtotal	**13,258,340**	**14,371,510**	**8%**	**5,992,870**	**7,241,070**	**21%**

Source: NEC FUTURE team, 2015

	Base Population			Base Employment		
	2012	2040	% Growth	2012	2040	% Growth
CONNECTICUT						
Fairfield County	935,040	1,003,210	7%	421,190	478,010	13%
Hartford County	897,290	960,590	7%	512,840	572,760	12%
Litchfield County	187,460	192,660	3%	62,110	51,610	-17%
Middlesex County	165,400	172,050	4%	67,430	73,140	8%
New Haven County	863,230	916,260	6%	365,880	398,240	9%
New London County	274,320	290,400	6%	131,630	150,050	14%
Tolland County	151,410	156,800	4%	41,990	45,350	8%
Windham County	117,680	132,860	13%	39,440	36,010	-9%
Subtotal	**3,591,830**	**3,824,830**	**6%**	**1,642,510**	**1,805,170**	**10%**
NEW JERSEY						
Atlantic County	275,730	305,480	11%	135,300	156,660	16%
Bergen County	920,650	972,940	6%	456,200	500,900	10%
Burlington County	451,730	513,150	14%	202,180	241,480	19%
Camden County	513,840	558,480	9%	203,400	232,450	14%
Cape May County	96,340	102,100	6%	40,540	45,440	12%
Cumberland County	158,110	185,180	17%	56,850	65,010	14%
Essex County	788,000	836,320	6%	358,370	408,960	14%
Gloucester County	290,260	355,200	22%	102,090	131,330	29%
Hudson County	654,440	775,470	18%	248,810	306,260	23%
Hunterdon County	126,960	121,750	-4%	49,280	50,810	3%
Mercer County	368,870	420,200	14%	245,110	289,000	18%
Middlesex County	825,670	1,062,850	29%	409,390	525,910	28%
Monmouth County	629,800	685,840	9%	259,800	282,290	9%
Morris County	498,780	562,140	13%	287,700	348,620	21%
Ocean County	581,970	714,570	23%	158,580	194,290	23%
Passaic County	503,260	499,500	-1%	181,350	187,000	3%
Salem County	65,710	68,590	4%	22,930	24,840	8%
Somerset County	328,670	416,900	27%	182,790	231,440	27%
Sussex County	147,240	137,060	-7%	38,360	38,380	0%
Union County	545,320	647,930	19%	234,480	299,590	28%
Warren County	107,470	103,630	-4%	37,300	40,050	7%
Subtotal	**878,820**	**10,045,280**	**13%**	**3,910,810**	**4,600,710**	**18%**
DELAWARE						
New Castle County	547,200	670,490	23%	282,520	369,050	31%
Subtotal	**547,200**	**670,490**	**23%**	**282,520**	**369,050**	**31%**
WEST VIRGINIA						
Jefferson County	54,700	66,880	22%	16,270	19,630	21%
Subtotal	**54,700**	**66,880**	**22%**	**16,270**	**19,630**	**21%**
WASHINGTON, DC						
District of Columbia (DC)	636,710	806,400	27%	732,990	851,370	16%
Subtotal	**636,710**	**806,400**	**27%**	**732,990**	**851,370**	**16%**

Source: NEC FUTURE team, 2015

	Base Population			Base Employment		
	2012	2040	% Growth	2012	2040	% Growth
PENNSYLVANIA						
Bucks County	627,100	597,200	-5%	262,800	287,700	9%
Carbon County	65,020	71,590	10%	17,790	22,680	27%
Chester County	507,940	568,710	12%	251,880	324,200	29%
Delaware County	561,430	538,690	-4%	218,870	241,530	10%
Lehigh County	355,930	448,370	26%	186,080	271,520	46%
Montgomery County	809,500	843,890	4%	489,510	586,730	20%
Northampton County	299,640	346,190	16%	106,070	142,000	34%
Philadelphia County	1,549,930	1,655,370	7%	670,410	823,260	23%
Pike County	56,880	60,090	6%	10,670	12,590	18%
Subtotal	**4,833,370**	**5,130,100**	**6%**	**2,214,080**	**2,712,210**	**22%**
MARYLAND						
Anne Arundel County	552,420	689,580	25%	251,670	348,270	38%
Baltimore City	621,580	608,340	-2%	355,860	386,160	9%
Baltimore County	819,030	916,360	12%	391,080	484,870	24%
Calvert County	89,780	93,130	4%	23,290	24,540	5%
Carroll County	167,270	164,340	-2%	59,130	64,410	9%
Cecil County	101,840	121,020	19%	29,940	39,390	32%
Charles County	151,130	180,360	19%	44,720	54,200	21%
Frederick County	240,390	282,210	17%	95,960	116,170	21%
Harford County	249,280	281,750	13%	90,880	113,920	25%
Howard County	301,240	424,970	41%	167,140	261,460	56%
Kent County	20,190	22,330	11%	6,950	10,470	51%
Montgomery County	1,008,740	1,255,200	24%	476,490	611,750	28%
Prince George's County	882,760	954,360	8%	329,340	361,680	10%
Queen Anne's County	48,730	59,380	22%	14,460	19,520	35%
Subtotal	**5,254,380**	**6,053,330**	**15%**	**2,336,910**	**2,896,810**	**24%**
VIRGINIA						
Alexandria City	147,090	210,480	43%	104,660	140,520	34%
Arlington County	222,670	345,140	55%	187,870	273,450	46%
Clarke County	14,350	15,120	5%	4,140	4,100	-1%
Fairfax County	1,160,410	1,499,760	29%	620,310	757,130	22%
Fauquier County	66,710	73,820	11%	22,710	23,610	4%
King George County	24,650	41,370	68%	11,590	28,280	144%
LoudounCounty	341,070	601,550	76%	155,690	257,930	66%
Prince Wiliam County	491,150	801,620	63%	125,430	192,310	53%
Spotsylvania	153,870	200,040	30%	61,190	74,680	22%
Stafford County	135,190	184,800	37%	41,250	52,990	28%
Warren County	38,210	42,380	11%	12,700	13,230	4%
Subtotal	**2,795,370**	**4,016,080**	**44%**	**1,347,540**	**1,818,230**	**35%**
TOTAL	**48,387,100**	**54,134,040**	**12%**	**22,628,590**	**27,091,730**	**20%**

Source: NEC FUTURE team, 2015

Appendix C – Detailed Validation for Washington, D.C. Regional Rail Services

Table C-1: Year 2012 Average Weekday MARC Passenger Boardings by Station (Counts vs. Modeled)

Line	Station	Year 2012 Counts Peak	Year 2012 Counts Off-Peak	Year 2012 Counts Total	Year 2012 Model Peak	Year 2012 Model Off-Peak	Year 2012 Model Total
Camden MARC	Dorsey	568	47	615	885	-	885
	Jessup	-	-	-	-	-	-
	Savage	413	35	448	515	-	515
	Laurel Park	7	-	7	-	-	-
	Laurel	551	43	594	468	19	486
	Muirkirk	312	23	335	214	7	221
	Greenbelt	64	3	67	77	14	91
	College Park	126	26	152	26	6	32
	Riverdale	29	3	32	62	18	80
	Subtotal	**2,070**	**180**	**2,250**	**2,244**	**64**	**2,308**
Penn MARC	New Carrollton	258	182	440	347	167	514
	Seabrook	257	21	278	124	144	268
	Bowie	452	99	551	470	253	723
	Odenton	1,771	236	2,007	1,625	231	1,856
	BWI	1,439	321	1,760	1,151	244	1,395
	Subtotal	**4,177**	**859**	**5,036**	**3,716**	**1,039**	**4,755**
Brunswick MARC	Brunswick	656	44	700	344	11	355
	Point of Rocks	465	40	505	335	5	339
	Dickerson	14	5	19	11	1	11
	Barnesville	69	5	74	3	1	4
	Boyds	14	2	16	2	-	2
	Germantown	728	39	767	631	-	631
	Metropolitan Grove	219	27	246	354	2	356
	Gaithersburg	438	35	473	255	5	260
	Washington Grove	27	8	35	63	3	66
	Shady Grove	-	-	-	-	-	-
	Rockville	538	39	577	492	3	495
	Garrett Park	25	7	32	23	4	27
	Kensington	225	14	239	520	3	523
	Silver Spring	723	21	744	627	11	637
	Duffields	164	6	170	42	-	42
	Harpers Ferry	74	3	77	302	-	302
	Frederick	142	-	142	-	-	-
	Monocacy/I-270	262	-	262	46	-	46
	Subtotal	**4,783**	**295**	**5,078**	**4,048**	**45**	**4,093**
MARC	Union Station	7,430	1,024	8,454	7,857	1,086	8,942
	Total MARC	**18,460**	**2,358**	**20,818**	**17,864**	**2,233**	**20,097**

Source: NEC FUTURE team, 2015

Table C-2: Year 2012 Average Weekday VRE Passenger Boardings by Station (Counts vs. Modeled)

		Year 2012 Counts			Year 2012 Model		
Line	Station	Peak	Off-Peak	Total	Peak	Off-Peak	Total
VRE	Union Station	1,941	-	1,941	2,712	27	2,738
	L'Enf ant	3,870	-	3,870	3,739	-	3,739
	Crystal City	2,052	-	2,052	2,068	2	2,070
	Alexandria	957	-	957	1,077	19	1,095
	Backlick Road	260	-	260	175	2	177
	Rolling Road	503	-	503	355	6	361
	Burke Centre	1,047	-	1,047	1,233	34	1,267
	Manassas Park	828	-	828	618	9	627
	Manassas	944	-	944	1,147	22	1,168
	Broad Run/Airport	1,141	-	1,141	1,400	20	1,419
	Franconia/Springfield	259	-	259	214	3	217
	Lorton	618	-	618	547	5	552
	Woodbridge	664	-	664	841	8	849
	Rippon	614	-	614	1,253	10	1,263
	Potomac Shores	-	-	-	-	-	-
	Quantico	518	-	518	43	2	45
	Brooke	552	-	552	441	-	441
	Leeland Road	884	-	884	222	1	223
	Fredericksburg	1,432	-	1,432	1,337	7	1,344
	Spotsylvania	-	-	-	-	-	-
	Sudley Manor	-	-	-	-	-	-
	Gainesville	-	-	-	-	-	-
	Haymarket	-	-	-	-	-	-
	Total VRE	**19,084**	**-**	**19,084**	**19,419**	**173**	**19,591**

Source: NEC FUTURE team, 2015

Appendix D – Detailed Validation for Baltimore Regional Rail Services

Table D-1: Year 2013 Average Weekday Baltimore Regional MARC Passenger Boardings by Station (Counts vs. Modeled)

Station Name	2013 Counts	2013 Model
Perryville	-	58
Aberdeen	61	82
Edgewood	57	58
Martin State Airport	38	52
Penn Station	256	252
West Baltimore	182	130
Halethorpe	130	93
Camden Yards	-	-
St. Denis	-	-
Total	**724**	**724**

Source: NEC FUTURE team, 2015

Appendix E – Detailed Validation for Philadelphia Regional Rail Services

Table E-1: Year 2010 Average Weekday SEPTA Regional Rail Passenger Boardings by Station (Counts vs. Modeled)

Line	DAILY COUNT	VISUM	Diff	%Diff
Trunk Lines	59,596	52,454	(7,142)	-12%
R1 - Airport	2,445	2,203	(242)	-10%
R2 - Wilmington	4,429	4,895	466	11%
R2 - Warminster	2,437	2,699	262	11%
R3 - Elwyn	4,997	5,779	782	16%
R3 - West Trenton	5,453	5,796	343	6%
R5 - Thorndale	12,209	14,125	1,916	16%
R5 - Doylestown	6,266	6,545	279	4%
R6 - Norristown	5,339	5,875	536	10%
R6 - Cynwyd	296	302	6	2%
R7 - Trenton	5,837	5,795	(42)	-1%
R7 - Chestnut Hill East	2,637	2,408	(229)	-9%
R8 - Fox Chase	2,269	2,183	(86)	-4%
R8 - Chestnut Hill West	2,767	2,306	(461)	-17%
TOTAL	**116,977**	**113,366**	**(3,611)**	**-3%**

Source: NEC FUTURE team, 2015

Table E-2: Year 2010 Average Weekday SEPTA Regional Rail Passenger Boardings by Station (Counts vs. Modeled)

Station	Counts AM	Counts MD	Counts PM	Counts NT	Counts Daily	Model AM	Model MD	Model PM	Model NT	Model Daily
Trunk Lines										
Glenside	686	115	96	177	1,074	1,065	243	277	103	1,688
Jenkintown	1,085	258	229	204	1,776	1,096	272	378	114	1,861
Elkins Park	427	61	33	44	565	645	122	69	28	862
Melrose Park	325	48	18	52	443	227	42	88	29	384
Fern Rock	290	102	167	199	758	332	182	391	105	1,010
Wayne Junction	271	121	85	151	628	376	164	284	108	932
North Philadelphia R8	2	1	6	2	11	44	51	98	12	205
North Philadelphia R7	48	22	40	28	138	96	73	166	29	364
North Broad	85	37	16	38	176	181	90	66	25	363
Temple	177	882	1,428	635	3,122	735	613	1,115	295	2,758
Market East	1,512	2,073	8,849	1,380	13,814	760	1,502	9,487	1,375	13,124
Suburban	1,351	2,384	17,856	2,938	24,529	833	1,721	16,066	2,120	20,741
30th Street	1,691	1,780	5,454	1,356	10,281	1,349	1,216	3,898	599	7,063
University City	60	329	1,689	203	2,281	162	134	628	176	1,099
Subtotal	**8,010**	**8,213**	**35,966**	**7,407**	**59,596**	**7,901**	**6,426**	**33,011**	**5,116**	**52,454**
R1 - Airport										
Easmrick	145	45	82	50	322	77	79	128	63	347
Terminal A	49	140	154	192	535	280	520	480	431	1,691
Terminal B	87	92	113	132	424	7	5	11	1	24
Terminal C & D	100	253	170	240	763	-	-	-	-	-
Terminal E & F	55	95	111	140	401	11	28	84	18	140
Subtotal	**436**	**625**	**630**	**754**	**2,445**	**376**	**631**	**683**	**513**	**2,203**
R2 - Wilmington										
Darby	63	12	13	5	93	105	18	29	17	169
Curtis Park	60	11	27	2	100	110	18	48	20	196
Sharon Hill	98	10	7	4	119	118	26	11	9	163
Folcroft	117	20	26	11	174	121	20	40	20	202
Glenolden	191	25	20	12	248	191	28	31	15	266
Norwood	149	29	12	5	195	142	19	12	8	181
Prospect Park	173	25	16	7	221	182	31	45	22	280
Ridley Park	192	34	19	3	248	151	28	56	22	256
Crum Lynne	70	6	11	5	92	47	12	22	8	89
Eddystone	35	3	13	7	58	50	17	58	8	132
Chester	128	53	92	29	302	127	40	195	44	407
Highland Avenue	50	9	14	10	83	51	15	51	13	131
Marcus Hook	383	32	40	11	466	284	64	89	21	458
Claymont	508	20	20	7	555	380	24	40	7	451
Wilmington	368	69	342	69	848	383	44	334	23	784
Churchmans Crossing	279	-	16	-	295	236	-	74	-	309
Newark. DE	308	-	21	3	332	205	-	218	-	423
Subtotal	**3,172**	**358**	**709**	**190**	**4,429**	**2,882**	**404**	**1,353**	**256**	**4,895**
R2 - Warminster										
Warminster	734	119	78	100	1,031	794	118	45	13	970
Hatboro	346	29	53	45	473	263	59	44	22	387
Willow Grove	340	43	54	54	491	477	73	126	38	713
Crestmcnt	47	5	6	12	70	60	15	23	12	110
Roslyn	178	15	19	25	237	99	20	35	13	166
Ardsley	106	14	5	10	135	269	35	27	20	351
Subtotal	**1,751**	**225**	**215**	**246**	**2,437**	**1,961**	**319**	**300**	**119**	**2,699**

Source: NEC FUTURE team, 2015

Station	Counts AM	Counts MD	Counts PM	Counts NT	Counts Daily	Model AM	Model MD	Model PM	Model NT	Model Daily
R3 - Elwyn										
Elwyn	406	30	48	20	504	457	95	2	1	554
Media	373	57	58	41	529	292	58	159	45	554
Moylan-Rose Valley	201	17	19	11	248	76	13	10	4	104
Wallingford	241	30	10	17	298	204	37	36	14	292
Swathmore	598	92	72	24	786	247	96	157	49	549
Morton-Rutledge	459	45	19	46	569	848	-	80	26	954
Secane	440	45	15	22	522	259	8	31	16	314
Primos	273	39	17	35	364	272	16	93	41	422
Clifton-Aldan	290	16	10	23	339	139	24	67	35	265
Gladstone	188	15	11	7	221	247	30	31	20	330
Landsdowne	323	50	16	22	411	414	71	86	32	603
Femwood-Yeadon	76	21	12	10	119	105	40	96	27	268
Angora	12	11	4	2	29	73	23	51	21	168
49th Street	30	9	8	11	58	100	42	208	53	403
Subtotal	**3,910**	**477**	**319**	**291**	**4,997**	**3,733**	**554**	**1,106**	**386**	**5,779**
R3 - West Trenton										
West Trenton. NJ	177	18	51	18	264	83	12	35	2	131
Yardley	288	41	33	43	405	402	30	22	8	462
Woodboume	388	38	42	46	514	548	43	59	13	663
Langhorne	485	65	44	82	676	825	111	65	18	1,019
Neshaminy Falls	208	32	7	27	274	39	7	19	6	71
Trevose	185	16	38	36	275	333	42	96	24	494
Somerton	678	32	35	122	867	628	78	145	31	882
Forest Hills	335	22	18	45	420	80	15	69	9	173
Philmont	518	56	28	51	653	549	93	51	11	704
Bethayres	528	32	24	52	636	283	45	72	12	413
Meadowbrook	86	17	7	20	130	275	35	19	8	337
Rydal	57	18	22	10	107	67	29	61	18	176
Nobel	145	24	41	22	232	143	31	76	20	270
Subtotal	**4,078**	**411**	**390**	**574**	**5,453**	**4,255**	**571**	**790**	**180**	**5,796**
R5 - Thorndale										
Overbrook	501	115	91	65	772	404	150	150	75	779
Merlon	197	30	14	12	253	98	25	30	12	185
Narberth	624	99	95	48	866	605	138	90	30	863
Wynnewood	488	62	65	62	677	136	26	26	12	200
Ardmore	517	126	106	92	841	702	165	179	53	1,099
Haverford	236	56	63	20	375	371	140	203	70	784
Bryn Mawr	416	128	218	69	831	248	155	273	69	745
Rosemont	241	41	59	19	360	232	69	71	23	394
Villanova	209	80	188	94	571	241	54	27	4	325
Radnor	246	44	173	24	487	96	34	21	1	152
St. Davids	175	33	39	11	258	154	96	167	34	451
Wayne	383	92	119	71	665	189	86	128	30	433
Strafford	542	71	109	41	763	669	167	121	39	996
Devon	399	32	55	20	506	288	57	39	9	394
Berwyn	170	27	50	14	261	400	112	145	38	695
Daylesford	149	20	21	16	206	225	51	61	20	357
Paoli	549	111	482	98	1,240	732	185	402	57	1,375
Malvern	406	41	56	34	537	313	197	254	69	833
Exton	516	21	36	13	586	1,118	217	41	5	1,382
Whitford	292	19	9	3	323	367	79	20	9	475
Downingtown	304	28	16	10	358	389	57	72	28	547
Thomdale	382	44	28	19	473	613	56	7	6	682
Subtotal	**7,942**	**1,320**	**2,092**	**855**	**12,209**	**8,590**	**2,317**	**2,524**	**694**	**14,125**

Source: NEC FUTURE team, 2015

Station	Counts AM	Counts MD	Counts PM	Counts NT	Counts Daily	Model AM	Model MD	Model PM	Model NT	Model Daily
R5 - Doylestown										
Doylestown	186	54	31	25	298	163	54	77	23	317
Del Val College	22	16	17	7	62	58	40	33	14	144
New Britain	25	14	5	10	54	19	8	10	7	44
Chalfont	67	7	14	17	105	111	23	8	6	148
Link Bek	15	2	24	6	47	31	14	20	6	70
Colmar	216	22	12	27	277	227	47	8	4	287
Fortuna	41	8	17	9	75	37	15	24	13	89
Lansdale	862	248	151	130	1,391	838	154	142	45	1,177
Pennbrook	244	69	78	23	414	148	51	57	13	267
Noah Wales	548	82	107	96	833	475	111	132	30	748
Gwynedd Valley	167	16	41	27	251	222	70	42	12	347
Penllyn	93	23	15	20	151	83	27	40	13	163
Ambler	633	120	102	90	945	562	135	147	37	881
Fort Washington	565	78	185	69	897	490	120	68	13	691
Oreland	168	25	40	24	257	334	71	53	19	477
North Hills	147	27	18	19	211	370	161	110	56	697
Subtotal	**3,999**	**811**	**857**	**599**	**6,266**	**4,164**	**1,100**	**969**	**312**	**6,545**
R6 - Norristown										
Elm Street	282	27	56	42	407	643	111	44	23	821
Main Street	126	33	21	47	227	126	21	29	17	192
Norristown T.C.	559	90	145	69	863	288	115	181	43	627
Conshohocken	382	29	183	65	659	339	98	301	75	813
Spring Mill	173	24	135	31	363	210	58	125	29	422
Miquon	251	12	123	45	431	539	104	25	4	671
Ivy Ridge	510	31	18	27	584	293	53	56	34	435
Manayunk	362	62	52	50	526	104	34	63	23	223
Wissahickon	417	44	28	25	514	127	70	354	97	649
East Falls	481	120	53	33	687	402	108	146	69	726
Allegheny	33	19	13	13	78	89	82	97	26	295
Subtotal	**3,576**	**491**	**825**	**447**	**5,339**	**3,159**	**856**	**1,421**	**438**	**5,875**
R6 - Cynwyd										
Wynnefield Avenue	87	1	2	-	90	83	3	9	-	75
Bala	66	3	9	-	78	19	3	47	-	69
Cynwyd	118	4	5	1	128	111	10	38	-	158
Subtotal	**271**	**8**	**16**	**1**	**296**	**193**	**16**	**92**	**-**	**302**
R7 - Trenton										
Bridesburg	51	33	34	36	154	76	59	106	19	260
Tacony	116	36	17	25	194	61	13	22	12	108
Holmesburg Jct.	417	83	39	74	613	115	28	78	35	255
Torresdale	776	72	41	107	996	692	100	147	52	991
Comwells Heights	1,125	88	46	67	1,326	1,086	164	27	8	1,285
Eddington	6	6	14	3	29	30	14	38	9	91
Croydon	204	33	36	38	311	343	42	34	21	440
Bristol	157	62	63	40	322	429	54	95	41	618
Levittown	374	49	43	60	526	589	65	62	12	728
Trenton	286	290	521	269	1,366	353	127	486	52	1,018
Subtotal	**3,512**	**752**	**854**	**719**	**5,837**	**3,774**	**666**	**1,095**	**260**	**5,795**

Source: NEC FUTURE team, 2015

Station	Counts AM	Counts MD	Counts PM	Counts NT	Counts Daily	Model AM	Model MD	Model PM	Model NT	Model Daily
R3 - Elwyn										
Chestnut Hill East	180	28	58	30	296	75	19	50	16	160
Gravers	121	11	11	4	147	77	26	32	18	153
Wyndmoor	575	67	40	44	728	365	81	98	56	600
Mount Airy	244	32	16	14	306	152	38	76	33	299
Sedgwick	220	31	12	15	278	136	21	33	23	213
Stenton	366	59	23	36	484	190	31	47	26	293
Washington Lane	143	29	18	16	204	109	11	31	20	170
Germantown	67	28	22	14	131	100	17	72	19	208
Wister	44	11	7	3	65	178	34	65	36	312
Subtotal	**1,960**	**296**	**205**	**176**	**2,637**	**1,381**	**277**	**503**	**247**	**2,408**
Fox Chase	1,036	98	65	61	1,260	572	104	34	14	724
Ryers	273	32	24	18	347	274	52	38	24	387
Cheltenham	232	29	4	19	284	235	41	46	30	352
Lawndale	166	34	15	15	230	222	34	41	25	322
Olney	112	14	10	12	148	255	52	59	32	398
Subtotal	**1,819**	**207**	**118**	**125**	**2,269**	**1,559**	**283**	**217**	**124**	**2,183**
R3 - Elwyn										
Queen Lane	318	54	97	13	482	296	72	77	46	492
Chelten Avenue	271	54	48	9	380	161	39	81	28	310
Tulpehocken	105	32	18	5	158	115	28	34	19	196
Upsal	283	56	33	16	388	95	20	27	20	162
Carpenter	272	44	31	8	355	266	66	52	31	415
Allen Lane	201	46	27	5	279	99	23	37	23	182
St. Martins	162	30	30	1	223	62	24	29	14	128
Highland	53	3	4	-	60	4	2	8	1	16
Chestnut Hill West	220	73	107	42	442	205	60	102	38	405
Subtotal	**1,885**	**392**	**391**	**99**	**2,767**	**1,304**	**334**	**448**	**220**	**2,306**
Total	**46,321**	**14,586**	**43,587**	**12,483**	**116,977**	**45,233**	**14,756**	**44,512**	**8,865**	**113,366**

Source: NEC FUTURE team, 2015

Appendix F – Detailed Validation for New Jersey Regional Rail Services

Table F-1: Year 2010 Average Weekday NJ TRANSIT Passenger Trips by Station (Counts vs. Modeled), Main, Bergen, Port Jervis Lines

	2010 Counts	2010 Model		
MAIN/BERGEN/PORT JERVIS	Total Daily	Productions	Attactions	Total
Portiere's	338	306	-	306
Otisville	123	48	-	48
Middletown	951	849	1	850
Campbell Hall	327	522	-	522
Salisbury Mills	997	620	-	620
Harriman	1,505	1,894	-	1,894
Tuxedo	339	353	-	353
Sloatsburg	143	1	-	1
Subtotal	**4,724**	**4,593**	**1**	**4,594**
Suffern	1,860	2,087	-	2,087
Mahwah	484	36	-	36
Route 17	1,510	1,715	13	1,728
Ramsey	1,404	818	117	935
Allendale	832	859	49	908
Waldwick	970	578	27	605
Ho-Ho- Kus	882	965	33	998
Ridgewood	2,800	2,242	197	2,439
Glen Rock (Main)	540	562	28	590
Glen Rock (Bergen)	1,374	1,030	17	1,047
Subtotal	**12,656**	**10,892**	**481**	**11,373**
Hawthorne	930	963	197	1,160
Paterson	1,282	1,027	286	1,313
Clifton	1,514	1,151	122	1,273
Passaic	1,130	881	94	975
Delawanna	1,146	909	164	1,073
Lyndhurst	1,494	1,157	60	1,217
Kingsland	834	985	89	1,074
Subtotal	**8,330**	**7,073**	**1,012**	**8,085**
Radbum	2,810	1,931	64	1,995
Broadway	542	843	118	961
Plauderville	726	382	69	451
Garfield	466	451	42	493
Wesmont	-	-	-	-
Rutherford	2,012	1,341	117	1,458
Subtotal	**6,556**	**4,948**	**410**	**5,358**
TOTAL	**32,266**	**27,506**	**1,904**	**29,410**

Source: NEC FUTURE team, 2015

Table F-2: Year 2010 Average Weekday NJ TRANSIT Passenger Trips by Station (Counts vs. Modeled), Pascack Valley Line

	2010 Counts	2010 Model		
PASCACK VALLEY LINE	**Total Daily**	**Productions**	**Attractions**	**Total**
Spring Valley	308	364	3	367
Nanuet	958	1,511	1	1,512
Pearl River	702	630	23	653
Montvale	348	578	4	582
Park Ridge	352	422	9	431
Woodcliff Lake	214	402	5	407
Hillsdale	704	500	8	508
Westwood	740	711	21	732
Emerson	424	473	6	479
Oradell	624	552	17	569
River Edge	968	666	41	707
Subtotal	**6,342**	**6,809**	**138**	**6,947**
N. Hackensack	882	534	23	557
Hackensack-Anderson St	628	386	97	483
Hackensack-Essex	578	646	165	811
Teterboro/VVilliams Ave	184	272	44	316
Wood-ridge	568	448	35	483
Subtotal	**2,840**	**2,286**	**364**	**2,650**
Sports Complex	-	-	-	-
TOTAL	**9,182**	**9,095**	**5,021**	**9,597**

Source: NEC FUTURE team, 2015

Table F-3: Year 2010 Average Weekday NJ TRANSIT Passenger Trips by Station (Counts vs. Modeled), Boonton Line

	2010 Counts	2010 Model		
BOONTON LINE	**Total Daily**	**Productions**	**Attractions**	**Total**
Hackettstown	308	341	16	357
Mount Olive	74	-	-	-
Netcong (Both Lines)	410	309	2	311
Lake Hopatcong (Both Lines)	238	267	-	267
Mount Arlington	248	8	13	21
Dover	2,872	2,638	74	2,712
Denville (Both Lines)	1,126	1,405	104	1,509
Subtotal	**5,276**	**4,968**	**209**	**5,177**
Mountain Lakes	78	122	47	169
Boonton	170	143	20	163
Towa co	238	134	-	134
Lincoln Park	280	231	17	248
Mountain View	412	257	83	340
Wayne Rt 23 Transit Ctr	180	87	4	91
Subtotal	**1,358**	**974**	**171**	**1,145**
Little Falls	382	454	66	520
Great Notch	48	-	-	-
Montclair St. University	1,066	441	17	458
Montclair Heights	650	741	7	748
Mountain Ave	242	594	19	613
Upper Monclair	1,018	398	-	398
Watchung Ave	1,418	1,263	18	1,281
Walnut St	1,852	1,464	9	1,473
Subtotal	**6,676**	**5,355**	**136**	**5,491**
Montclair-Bay St	1,964	1,517	56	1,573
Glen Ridge	2,008	1,859	3	1,862
Bloomfield	1,900	1,643	27	1,670
Watsessing Ave	384	767	8	775
Subtotal	**6,256**	**5,786**	**94**	**5,880**
TOTAL	**19,566**	**17,083**	**610**	**17,693**

Source: NEC FUTURE team, 2015

Table F-4: Year 2010 Average Weekday NJ TRANSIT Passenger Trips by Station (Counts vs. Modeled), Morris and Essex Lines

	2010 Counts	2010 Model		
MORRIS/ESSEX LINES	**Total Daily**	**Productions**	**Attractions**	**Total**
Mount Tabor	82	305	65	370
Morris Plains	1,360	2,021	145	2,166
Morristown	3,782	3,398	435	3,833
Convent Station	2,460	1,368	54	1,422
Madison	2,888	2,226	226	2,452
Chatham	3,000	2,754	136	2,890
Subtotal	**13,572**	**12,072**	**1,061**	**13,133**
Gladstone	346	470	5	475
Peapack	88	167	-	167
Far Hills	318	32	-	32
Bernardsville	374	510	2	512
Basking Ridge	206	401	104	505
Lyons	900	515	6	521
Millington	342	274	8	282
Stirling	174	339	-	339
Gilette	280	385	28	413
Berkeley Heights	996	549	107	656
Murray Hill	1,114	542	160	702
New Providence	1,070	837	190	1,027
Subtotal	**6,208**	**5,021**	**610**	**5,631**
Summit	7,122	6,266	584	6,850
Short Hills	2,856	1,749	295	2,044
Millburn	3,384	2,862	174	3,036
Maplewood	6,068	4,772	431	5,203
South Orange	7,212	5,583	567	6,150
Mountain Station	616	411	161	572
Highland Avenue	484	300	241	541
Orange	2,268	1,567	502	2,069
Brick Church	3,092	3,213	389	3,602
East Orange	606	159	36	195
Subtotal	**33,708**	**26,882**	**3,380**	**30,262**
NEWARK BROAD ST	**4,962**	**692**	**2,930**	**3,622**
TOTAL	**58,450**	**44,667**	**7,981**	**52,648**

Source: NEC FUTURE team, 2015

Table F-5: Year 2010 Average Weekday NJ TRANSIT Passenger Trips by Station (Counts vs. Modeled), Raritan Valley Line

	2010 Counts	2010 Model		
RARITAN VALLEY LINE	**Total Daily**	**Productions**	**Attractions**	**Total**
Bloomsbury	-	-	-	-
Hampton	-	-	-	-
High Bridge	152	611	1	612
Annandale	234	297	-	297
Lebanon	60	394	-	394
White House	242	282	7	289
North Branch	200	407	-	407
Raritan	1,344	1,264	54	1,318
Somerville	1,260	990	51	1,041
Bridgewater	688	1,303	37	1,340
Subtotal	**4,180**	**5,548**	**150**	**5,698**
Bound Brook	1,362	1,060	46	1,106
Dunellen	2,002	1,660	61	1,721
Plainfield	1,936	1,967	142	2,109
Netherwood	1,118	996	144	1,140
Fanwood	1,826	1,760	88	1,848
Westfield	4,572	3,848	112	3,960
Garwood	180	142	25	167
Cranford	2,350	2,049	106	2,155
Roselle Park	1,730	1,216	38	1,254
Union Township	2,392	929	129	1,058
Subtotal	**19,468**	**15,627**	**891**	**16,518**
West Trenton	-	-	-	-
1-95	-	-	-	-
Hopewell	-	-	-	-
Belle Mead	-	-	-	-
Hillsborough	-	-	-	-
Subtotal	**-**	**-**	**-**	**-**
TOTAL	**23,648**	**21,175**	**1,041**	**22,216**

Source: NEC FUTURE team, 2015

Table F-6: Year 2010 Average Weekday NJ TRANSIT Passenger Trips by Station (Counts vs. Modeled), Northeast Corridor/North Jersey Coast Lines

NORTHJERSEY COASTLINE/ NORTHEAST CORRIDOR	2010 Counts Total Daily	2010 Model Productions	Attractions	Total
Bay Head	462	108	2	110
Pt Pleasant Beach	634	688	20	708
Manasquan	436	581	11	592
Spring Lake	426	602	15	617
Belmar	618	333	17	350
Bradley Beach	546	691	37	728
Asbury Park	1,152	360	63	423
Allenhurst	326	229	8	237
Elberon	396	421	75	496
NJ CL Bay Head-Elberon	**4,996**	**4,013**	**248**	**4,261**
Long Branch	2,482	2,397	200	2,597
Little Silver	1,850	2,252	131	2,383
Red Bank	2,872	2,509	294	2,803
Middletown	3,614	4,051	123	4,174
Hazlet	1,972	3,404	8	3,412
Matawan	5,744	5,205	122	5,327
South Amboy	2,306	1,335	31	1,366
Perth Amboy	1,964	836	121	957
Woodbridge	3,546	2,071	245	2,316
Avenal	332	494	119	613
NJ CL Long Branch-Avenal	**26,682**	**24,554**	**1,394**	**25,948**
Subtotal - NJCL	**31,678**	**28,567**	**1,642**	**30,209**
Trenton	9,860	9,904	866	10,770
Hamiton	9,916	7,080	49	7,129
Princeton Junction	14,528	15,010	545	15,555
Jersey Ave	3,620	2,986	217	3,203
North Brunswick		-	-	-
New Brunswick	10,956	9,365	1,071	10,436
Edison	6,468	6,309	546	6,855
Metuchen	7,848	6,465	192	6,657
Metro park	15,012	12,375	717	13,092
NEC Trenton-Metropark	**78,208**	**69,494**	**4,203**	**73,697**
Rahway	6,428	4,978	709	5,687
Linden	4,262	2,669	529	3,198
Elizabeth	7,856	5,006	958	5,964
North Elizabeth	1,006	792	319	1,111
Newark International Airport	5,734	-	4,317	4,317
NEC Rahway-Newark Airport	**25,286**	**13,445**	**6,832**	**20,277**
Subtotal NEC	**103,494**	**82,939**	**11,035**	**93,974**
Total	**135,172**	**111,506**	**12,677**	**124,183**

Source: NEC FUTURE team, 2015

Table F-7: Year 2010 Average Weekday NJ TRANSIT Passenger Trips by Station (Counts vs. Modeled), Trans-Hudson and Urban Core Facilities

NJ URBAN CORE AND MANHATTAN FACILITIES	2010 Counts Total Daily	2010 Model Productions	Attractions	Total
Newark Penn Station (NJT)				
NEC/NJCL		28,251	28,844	57,095
Raritan Valley Line		140	20,281	20,421
Subtotal	**52,898**	**28,391**	**49,125**	**77,516**
Hoboken (NJT)				
NJCL		-	429	429
Main Line		197	5,040	5,237
Port Jervis/Bergen Line		64	14,679	14,743
Pascack Valley Line		28	6,054	6,082
Montclair-Boonton Line		-	3,503	3,503
Morristown Line		-	2,542	2,542
Gladstone Line		174	4,091	4,265
Subtotal	**32,116**	**463**	**36,338**	**36,801**
Existing NY Penn Station (NJT)	159,782	2,864	156,897	159,761
South Ferry Terminal		1,372	46,195	47,567
World Financial Center		128	5,966	6,094
Midtown Ferry Terminal		671	27,889	28,560
Lower Manhattan Ferry Terminal		16	7,651	7,667
Lincoln Tunnel				
PABT		6,449	159,996	166,445
Non- PABT		6,756	3,533	10,289
Subtotal	**175,000**	**13,205**	**163,529**	**176,734**
George Washington Bridge Bus Term	11,500	3,085	9,723	12,808
Holland Tunnel Buses	10,500	-	10,274	10,274
Total		**50,195**	**513,587**	**563,782**

Source: NEC FUTURE team, 2015

Note: NY Penn Station is highlighted for being the most significant terminal in Manhattan for NJTRANSIT.

Appendix G – Detailed Validation for New York Regional Rail Services

Table G-1: Year 2010 AM Peak-Period (6-10 AM) Boarding and Alighting Passengers by Metro-North Station (Counts vs. Modeled), Hudson Line

	2007 Metro-North OD Survey Counts by Station						2010 FRA NEC FUTURE Base Model					
	Inbound			Outbound			Inbound			Outbound		
	Ons	Offs	Total	Ons	Offs	Total	ONS	OFFS	TOTAL	ONS	OFFS	TOTAL
METRO NORTH HUDSON LINE												
Poughkeepsie	969	-	969	-	130	130	785	-	785	-	432	432
New Hamburg	840	-	840	-	8	8	736	47	783	67	47	114
Beacon	1,855	10	1,865	16	42	59	1,146	34	1,179	95	37	132
Cold Spring	347	-	347	-	26	26	396	1	397	3	1	4
Garrison	267	-	267	-	8	8	251	2	253	2	3	5
Peekskill	947	28	975	-	31	31	1,145	37	1,182	7	173	181
Cortiandt	763	12	775	-	7	7	197	25	222	11	27	39
Croton-Harmon	2,676	327	3,003	-	54	54	2,047	62	2,109	13	41	55
Ossining	958	15	973	-	52	52	1,240	23	1,262	20	112	132
Scarborough	725	4	729	2	4	6	661	14	675	8	25	32
Philipse Manor	270	-	270	3	-	3	195	5	201	1	16	17
Tarrytown	1,730	73	1,803	28	224	252	1,613	107	1,720	91	331	421
Irvington	635	14	649	-	111	111	500	18	518	9	49	59
Ardsley-on-Hudson	187	12	199	-	41	41	2	-	2	-	2	2
Dobbs Ferry	754	22	776	-	80	80	832	56	888	20	132	152
Hastings-on-Hudson	800	24	824	-	45	45	694	23	717	18	162	180
Greystone	355	12	367	-	22	22	956	17	973	39	152	191
Glenwood	235	-	235	11	13	24	343	5	348	3	6	9
Yonkers	650	108	758	75	71	146	837	123	960	146	330	476
Ludlow	164	16	180	-	-	-	920	36	955	40	43	83
RIerdale	591	15	606	-	7	7	823	122	945	134	23	157
Spuyten Duyvil	895	6	901	14	-	14	866	93	959	125	4	129
Marble Hill	155	235	390	183	-	183	-	240	240	255	2	257
University Hts.	61	30	91	89	-	89	11	64	75	37	1	37
Morris Hts.	-	22	22	57	-	57	82	208	289	98	-	98
Yankee Stadium	-	-	-	-	-	-	-	-	-	-	-	-
Total	**17,831**	**985**	**18,816**	**477**	**977**	**1,454**	**17,278**	**1,360**	**18,638**	**1,242**	**2,151**	**3,393**

Source: NEC FUTURE team, 2015

Table G-2: Year 2010 AM Peak-Period (6-10 AM) Boarding and Alighting Passengers by Metro-North Station (Counts vs. Modeled), Harlem Line

	2007 Metro-North OD Survey Counts by Station						2010 FRA NEC FUTURE Base Model					
	Inbound			Outbound			Inbound			Outbound		
	Ons	Offs	Total	Ons	Offs	Total	ONS	OFFS	TOTAL	ONS	OFFS	TOTAL
METRO NORTH HARLEM LINE												
Wassaic	65	-	65	-	13	13	71	-	71	-	1	1
Tenmile River	11	-	11	-	2	2	-	-	-	-	-	-
Dover Plains	80	-	80	-	4	4	46	-	46	-	-	-
Harlem Valley-	100	-	100	-	7	7	208	-	208	-	1	1
Pawling	198	-	198	-	-	-	-	-	-	-	-	-
Patterson	104	-	104	-	-	-	-	-	-	-	-	-
Southeast	966	34	1,000	-	11	11	564	35	599	1	47	48
Brewster	744	12	756	-	26	26	1,193	13	1,206	22	96	117
Croton Falls	451	-	451	-	48	48	431	3	434	3	3	6
Purdy's	404	-	404	-	6	6	300	1	301	1	3	5
Goldens Bridge	987	16	1,003	-	27	27	855	2	856	2	2	4
Katonah	723	-	723	-	72	72	779	1	780	1	2	3
Bedford Hills	421	34	455	9	106	115	704	3	707	2	14	15
Mount Kisco	723	110	833	-	156	156	1,306	46	1,352	6	75	81
Chappaqua	1,443	69	1,512	-	86	86	837	9	847	7	12	18
Pleasantville	611	13	624	-	72	72	617	37	654	16	103	119
Hawthorne	511	14	525	7	109	116	386	66	452	17	115	132
Valhalla	260	5	265	-	45	45	108	26	134	11	73	84
North White Plains	1,437	36	1,473	-	328	328	2,415	67	2,482	26	201	226
White Plains	3,608	425	4,033	208	2,530	2,737	2,585	420	3,005	48	2,462	2,510
East White Plains	-	-	-	-	-	-	-	-	-	-	-	-
Hartsdale	2,130	8	2,138	-	99	99	1,305	15	1,320	39	73	112
Scarsdale	2,915	30	2,945	20	231	251	3,848	41	3,889	83	184	266
Crestwood	1,372	70	1,442	17	38	55	1,232	8	1,240	11	147	158
Tuckahoe	928	12	940	48	26	74	1,611	39	1,650	92	188	280
Bronxville	1,984	29	2,013	57	125	182	1,817	67	1,884	108	247	354
Fleetwood	1,647	11	1,658	157	6	163	2,275	88	2,363	131	370	501
Mt. Vernon West	788	2	790	160	31	191	662	50	711	115	132	247
Wakefield	320	16	336	137	8	145	919	108	1,027	196	98	294
Woodlawn	720	33	753	215	28	243	322	180	502	403	17	419
Williams Bridge	114	51	165	251	11	262	183	132	315	357	7	364
Botanical Garden	146	201	347	41	47	88	170	153	323	158	5	163
Tremont	-	26	26	-	-	-	76	255	330	180	6	186
Melrose	-	25	25	10	-	10	50	362	412	237	3	240
Total	**26,914**	**1,282**	**28,196**	**1,337**	**4,298**	**5,635**	**27,872**	**2,226**	**30,099**	**2,271**	**4,687**	**6,958**

Source: NEC FUTURE team, 2015

Table G-3: Year 2010 AM Peak-Period (6-10 AM) Boarding and Alighting Passengers by Metro-North Station (Counts vs. Modeled), New Haven Line

	2007 Metro-North OD Survey Counts by Station						2010 FRA NEC FUTURE Base Model					
	Inbound			Outbound			Inbound			Outbound		
	Ons	Offs	Total	Ons	Offs	Total	ONS	OFFS	TOTAL	ONS	OFFS	TOTAL
METRO NORTH												
NEW HAVEN LINE												
Danbury	204	-	204	-	11	11	324	-	324	-	31	31
Bethel	253	-	253	-	-	-	92	22	114	4	6	9
Redding	55	-	55	-	-	-	-	-	-	-	-	-
Branchville	140	-	140	-	-	-	338	1	339	2	-	2
Cannondale	150	-	150	-	-	-	405	1	406	1	1	2
Wilton	168	4	172	-	-	-	124	6	130	1	3	4
Merrit-7	122	112	234	-	-	-	98	36	134	4	5	9
New Canaan	779	3	782	-	16	16	1,047	-	1,047	-	28	28
Talmadge Hill	324	-	324	-	-	-	133	6	139	1	14	14
Springdale	346	2	348	-	5	5	413	12	425	5	58	64
Glenbrook	243	-	243	-	-	-	296	20	316	10	92	102
NH State Street	6	-	6	-	154	154	127	-	127	-	214	214
New Haven	1,692	-	1,692	-	319	319	1,231	1	1,232	11	330	341
West Haven	-	-	-	-	-	-	-	-	-	-	-	-
Milford	1,239	19	1,258	17	96	113	1,066	88	1,154	81	176	256
Startford	1,128	29	1,157	15	18	33	921	174	1,095	116	162	277
East Bridgeport	-	-	-	-	-	-	-	-	-	-	-	-
Bridgeport	1,916	270	2,186	118	124	242	1,735	406	2,141	152	513	665
Fairfield Metro	-	-	-	-	-	-	-	-	-	-	-	-
Fairfield	2,152	107	2,259	61	189	250	2,266	90	2,356	31	106	137
Southport	242	8	250	4	10	14	254	36	289	16	28	43
Green's Farms	511	8	519	10	6	16	843	50	892	9	49	58
Westport	1,559	132	1,692	33	89	122	1,554	111	1,666	41	88	128
East Norwalk	460	73	533	22	24	47	275	112	387	32	171	203
South Norwalk	1,299	518	1,817	35	300	336	1,650	490	2,140	152	191	342
Rowayton	401	13	414	21	23	44	280	18	298	5	49	54
Darien	927	84	1,011	21	96	117	988	31	1,020	25	60	85
Noroton Heights	1,020	19	1,039	15	-	15	651	95	746	43	59	102
Stamford	3,468	2,604	6,072	273	1,595	1,869	4,170	2,263	6,433	375	1,915	2,290
Old Greenwich	609	43	652	-	56	56	539	68	606	34	79	113
Riverside	494	20	514	-	4	4	586	14	601	34	43	77
Cos Cob	578	24	602	-	24	24	703	24	727	24	58	82
Greenwich	1,458	622	2,081	82	834	916	1,697	613	2,310	80	888	968
Port Chester	1,261	68	1,329	88	309	397	1,333	58	1,391	113	522	634
Cross Westchester	-	-	-	-	-	-	-	-	-	-	-	-
Rye	1,303	59	1,362	22	346	368	1,347	93	1,440	81	235	316
Harrison	1,469	78	1,548	102	216	318	1,980	693	2,674	78	282	361
Mamaroneck	1,206	31	1,237	51	188	238	1,577	52	1,629	105	314	419
Larchmont	2,332	28	2,360	51	138	189	2,001	67	2,069	91	331	422
New Rochelle	2,192	116	2,308	268	412	680	1,941	170	2,111	242	705	947
Pelham	1,577	24	1,601	78	36	114	1,576	71	1,647	122	254	375
Mount Vernon East	923	122	1,045	505	109	614	1,047	60	1,107	175	182	357
Fordham (both lines)	174	751	925	1,927	88	2,014	75	695	769	2,600	66	2,666
Total	**36,385**	**5,992**	**42,377**	**3,818**	**5,836**	**9,654**	**37,684**	**6,747**	**44,431**	**4,893**	**8,307**	**13,200**

Source: NEC FUTURE team, 2015

Appendix H – Detailed Validation for Boston Regional Rail Services

Table H-1: Year 2012 Average Weekday MBTA Boarding Passengers by Station (Counts vs. Modeled), Rockport/Newburyport Lines

Branch/Station	2012 Counts	2012 Model
Rockport/Newburyport		
Rockport	174	178
Gloucester	354	97
West Gloucester	53	61
Manchester	203	73
Beverley Depot	124	3
Prides Crossing	13	23
Montserrat	216	49
Newburyport	538	444
Rowley	78	37
Ipswich	393	123
Hamilton/Wenham	248	128
North Beverley	223	283
Beverley Depot	1,432	1,687
Salem	2,104	2,291
Swampscott	719	856
Lynn	551	835
River Works Commrail	66	81
Chelsea	182	621
Subtotal	**7,671**	**7,870**

Source: NEC FUTURE team, 2015

Table H-2: Year 2012 Average Weekday MBTA Boarding Passengers by Station, Haverhill/Lowell Lines

Branch/Station	2012 Counts	2012 Model
Haverhill		
Haverhill	386	120
Bradford	209	455
Lawrence	562	833
Andover	369	571
Ballardvale	152	391
North Wilmington	69	132
Reading	813	235
Wakefield	496	401
Greenwood	128	90
Melrose Highlands	181	282
Melrose/Cedar Park	141	32
Wyoming Hill	66	185
Malden Center Commra	102	410
Subtotal	**3,674**	**4,137**
Lowell		
Lowell	1590	1341
North Billerica	792	1022
Wilmington	497	1134
Anderson/Woburn	895	1397
Mishawum	29	14
Winchester Center	474	434
Wedgemere	286	223
West Medford	559	757
Subtotal	**5,122**	**6,322**

Source: NEC FUTURE team, 2015

Table H-3: Year 2012 Average Weekday MBTA Boarding Passengers by Station (Counts vs. Modeled), Fitchburg/Worcester Lines

Branch/Station	2012 Counts	2012 Model
Fitchburg		
Fitchburg	287	158
North Leominster	213	326
Shirley	167	141
Ayer	284	188
Littleton/Route 495	214	256
South Acton	689	949
West Concord	346	9
Concord	390	264
Lincoln	185	169
Silver Hill	7	0
Hastings	27	56
Kendal Green	104	0
Brandeis/Roberts	459	292
Waltham	448	483
Waverley	101	211
Belmont	105	179
Porter Square Commra	1,616	1,491
Subtotal	**5,642**	**5,172**
Worcester		
Worcester	915	815
Grafton	364	498
Westborough	473	499
Southborough	423	121
Ashland	449	276
Framingham	950	2,023
West Natick	816	733
Natick	578	563
Wellesley Square	512	486
Wellesley Hills	250	389
Wellesley Farms	269	89
Riverside/I-95	0	0
Auburndale	183	115
West Newton	173	178
Newtonville	289	273
Yawkey	362	598
Subtotal	**7,006**	**7,656**

Source: NEC FUTURE team, 2015

Table H-4: Year 2012 Average Weekday MBTA Passenger Trips by Station (Counts vs. Modeled), Needham Heights, Franklin and Fairmont Lines

Branch/Station	2012 Counts	2012 Model
Needham Heights		
Needham Heights	254	279
Needham Center	181	13
Needham Junction	386	187
Hersey	515	311
West Roxbury	361	148
Highland	292	559
Bellevue	248	190
Roslindale Village	373	799
Forest Hills Commrail	97	119
Subtotal	**2,707**	**2,605**
Franklin		
Forge Park/Route 495	674	328
Franklin	526	809
Norfolk	619	520
Walpole	639	861
Plimptonville	9	12
Windsor Gardens	276	309
Norwood Central	940	802
Norwood Depot	311	214
Islington	107	246
Dedham Corporate	382	145
Endicott	252	361
Subtotal	**4,735**	**4,607**
Fairmount		
Readville	344	938
Fairmount	125	205
Morton Street	68	94
Talbot Ave Commrail	0	137
Four Corners/Geneva	0	176
Uphams Corner	52	60
Newmarket Commrail	0	26
Subtotal	**589**	**1,636**

Source: NEC FUTURE team, 2015

Table H-5: Year 2012 Average Weekday MBTA Boarding Trips by Station and Direction (Counts vs. Modeled), Providence, Middleborough/Lakeville and Kingston/Plymouth

Branch/Station	2012 Counts	2012 Model
Providence		
Westerly	0	0
Kingston Ri	0	0
Wickford Junction Co	159	183
TF Green Commrail	157	264
Providence	1,383	1,483
Providence Station H	0	0
Pawtucket	0	0
South Attleboro	923	1,249
Attleboro	1,394	1,094
Mansfield	1,823	2,088
Sharon	1,149	773
Stoughton	776	227
Canton Center	389	419
Canton Junction	1,137	2,614
Route 128	1,349	650
Subtotal	**10,639**	**11,044**
Middleborough/Lakeville		
Middleborough/Lakeville	616	323
Bridgewater	555	377
Campello	300	595
Brockton	318	767
Montello	330	507
Holbrook/Randolph	380	174
Subtotal	**2,499**	**2,743**
Kingston/Plymouth		
Kingston/Route 3	630	691
Plymouth	21	96
Halifax	293	412
Hanson	384	422
Whitman	417	374
Abington	579	530
South Wheymouth	421	887
Subtotal	**2,745**	**3,412**

Source: NEC FUTURE team, 2015

Table H-6: Year 2012 Average Weekday MBTA Passenger Boarding by Station and Direction (Counts vs. Modeled), Urban Core Facilities

Branch/Station	2012 Counts	2012 Model
Greenbush		
Greenbush Commrail	405	523
N Scituate Commrail	339	239
Cohasset Commrail	254	311
Nantasket Junction	168	196
West Hingham	215	160
East Weymouth	466	474
Weymouth Landing	326	281
Subtotal	**2,173**	**2,184**
Hyde Park, Ruggles, & Back Bay		
Hyde Park	575	1,701
Ruggles Commrail	1,690	939
Back Bay Commrail	7,995	7,387
Subtotal	**10,260**	**10,027**
Braintree, Quincy, & JFK		
Braintree Commrail	235	226
Quincy Center Commrail	217	206
JFK/UMASS Commrail	421	764
Subtotal	**873**	**1,196**
South Station		
South Station Commrail	21,772	21,811
North Station		
North Station Commrail	16,436	16,915

Source: NEC FUTURE team, 2015

Appendix I – MSA-to-MSA Level Interregional Trips by Mode for each Alternative

Table I-1: Trip Tables by Mode and MSA pair: Existing (2013)

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	181,683	1,220,032	274,954	331,129	30,063	770,297	235,446	22,545	33,451	85,832	41,191	14,375	55,127	3,182	3,299,306
Greater Washington Area	1,220,032	32,479,558	1,936,209	2,542,653	234,572	4,106,873	1,358,767	159,063	184,429	121,289	235,735	113,665	381,308	68,630	45,142,783
Greater Baltimore Area	274,954	1,936,209	11,823,819	2,296,706	181,262	2,458,625	598,813	96,256	142,810	229,972	156,208	1,086,280	368,085	31,220	21,681,219
Greater Philadelphia Area	331,129	2,542,653	2,296,706	3,415,507	532,594	18,459,926	1,946,907	140,800	195,843	130,946	759,731	866,188	1,491,606	221,382	33,331,919
Leigh Valley Area	30,063	234,572	181,262	532,594	97,729	5,136,317	239,961	23,211	50,421	20,823	151,118	194,690	472,793	51,220	7,416,774
New York - North Jersey Area	770,297	4,106,873	2,458,625	18,459,926	5,136,317	122,439,296	795,798	2,131,898	3,128,391	2,293,999	8,336,620	6,472,649	15,086,836	2,059,157	193,676,683
South Central PA Area	235,446	1,358,767	598,813	1,946,907	239,961	795,798	697,210	80,687	108,552	107,991	165,133	69,413	107,111	54,514	6,566,304
Atlantic City Area	22,545	159,063	96,256	140,800	23,211	2,131,898	80,687	55,051	39,245	40,474	130,361	21,941	30,926	28,890	3,001,348
Poughkeepsie-Newburgh-Middletown Area	33,451	184,429	142,810	195,843	50,421	3,128,391	108,552	39,245	211,943	264,377	289,097	178,860	534,281	156,361	5,518,061
Greater Albany Area	85,832	121,289	229,972	130,946	20,823	2,293,999	107,991	40,474	264,377	751,454	431,501	273,628	871,516	312,180	5,935,983
Greater Hartford Area	41,191	235,735	156,208	759,731	151,118	8,336,620	165,133	130,361	289,097	431,501	3,283,341	1,099,810	2,315,638	172,480	17,567,964
Greater Providence Area	14,375	113,665	1,086,280	866,188	194,690	6,472,649	69,413	21,941	178,860	273,628	1,099,810	2,114,476	411,346	42,297	12,959,620
Greater Boston Area	55,127	381,308	368,085	1,491,606	472,793	15,086,836	107,111	30,926	534,281	871,516	2,315,638	411,346	743,940	391,092	23,261,603
Springfield Area	3,182	68,630	31,220	221,382	51,220	2,059,157	54,514	28,890	156,361	312,180	172,480	42,297	391,092	2,099	3,594,704
Total Trips	3,299,306	45,142,783	21,681,219	33,331,919	7,416,774	193,676,683	6,566,304	3,001,348	5,518,061	5,935,983	17,567,964	12,959,620	23,261,603	3,594,704	382,954,271

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	22,830	13,006	103,752	344	96,657	342	-	2,131	3,993	2,030	1,716	75,883	20	322,704
Greater Washington Area	22,830	-	-	287,729	58,197	981,295	71,872	-	18,220	97,845	194,399	248,759	1,322,144	83,331	3,386,622
Greater Baltimore Area	13,006	-	-	88,273	2,799	385,930	4,408	-	10,339	114,319	104,409	238,500	545,114	35,454	1,542,551
Greater Philadelphia Area	103,752	287,729	88,273	-	3,187	431,241	132,729	-	2,600	39,373	126,014	105,485	647,521	-	1,967,904
Leigh Valley Area	344	58,197	2,799	3,187	1	9,792	199	-	4	20	115	351	19,887	22	94,918
New York - North Jersey Area	96,657	981,295	385,930	431,241	9,792	-	9,290	-	-	28,906	17,692	46,504	1,430,566	9,937	3,447,809
South Central PA Area	342	71,872	4,408	132,729	199	9,290	-	-	172	113	710	1,120	3,496	-	224,451
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	11,805	-	11,805
Poughkeepsie-Newburgh-Middletown Area	2,131	18,220	10,339	2,600	4	-	172	-	-	-	48	166	6,754	-	40,435
Greater Albany Area	3,993	97,845	114,319	39,373	20	28,906	113	-	-	-	105	479	7,519	-	292,672
Greater Hartford Area	2,030	194,399	104,409	126,014	115	17,692	710	-	48	105	-	-	342	-	445,864
Greater Providence Area	1,716	248,759	238,500	105,485	351	46,504	1,120	-	166	479	-	-	-	-	643,080
Greater Boston Area	75,883	1,322,144	545,114	647,521	19,887	1,430,566	3,496	11,805	6,754	7,519	342	-	-	-	4,071,032
Springfield Area	20	83,331	35,454	-	22	9,937	-	-	-	-	-	-	-	-	128,764
Total Trips	322,704	3,386,622	1,542,551	1,967,904	94,918	3,447,809	224,451	11,805	40,435	292,672	445,864	643,080	4,071,032	128,764	16,620,611

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	264	15,161	3,725	423	59,768	1,082	200	552	-	2,853	107	1,370	-	85,504
Greater Washington Area	264	282	74,362	44,972	4,178	695,755	10,893	1,940	5,157	-	3,126	1,474	1,132	-	843,535
Greater Baltimore Area	15,161	74,362	214	49,062	9,419	235,739	20,397	794	1,200	-	3,588	1,245	860	-	412,042
Greater Philadelphia Area	3,725	44,972	49,062	39,096	4,354	785,078	30,744	330	1,033	-	3,203	3,462	14,486	-	979,547
Leigh Valley Area	423	4,178	9,419	4,354	1,281	225,192	1,341	80	142	285	3,325	915	10,184	292	261,410
New York - North Jersey Area	59,768	695,755	235,739	785,078	225,192	1,657,307	38,143	36,741	26,005	181,690	386,372	158,355	879,577	71,232	5,436,952
South Central PA Area	1,082	10,893	20,397	30,744	1,341	38,143	-	901	408	-	-	-	-	-	103,909
Atlantic City Area	200	1,940	794	330	80	36,741	901	-	100	-	240	93	278	-	41,696
Poughkeepsie-Newburgh-Middletown Area	552	5,157	1,200	1,033	142	26,005	408	100	306	983	710	293	7,460	1,606	45,957
Greater Albany Area	-	-	-	-	285	181,690	-	-	983	-	-	-	25,357	15,371	223,686
Greater Hartford Area	2,853	3,126	3,588	3,203	3,325	386,372	-	240	710	-	-	-	130,255	44,219	577,890
Greater Providence Area	107	1,474	1,245	3,462	915	158,355	-	93	293	-	-	-	64,167	6,095	236,204
Greater Boston Area	1,370	1,132	860	14,486	10,184	879,577	-	278	7,460	25,357	130,255	64,167	74,519	24,779	1,234,422
Springfield Area	-	-	-	-	292	71,232	-	-	1,606	15,371	44,219	6,095	24,779	-	163,593
Total Trips	85,504	843,535	412,042	979,547	261,410	5,436,952	103,909	41,696	45,957	223,686	577,890	236,204	1,234,422	163,593	10,646,348

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	9,036	17,595	98,837	1,205	539,693	-	7,284	8,076	-	5,247	2,327	9,609	753	699,660
Greater Baltimore Area	-	17,595	2,130	22,243	195	121,011	-	920	1,667	-	1,763	1,527	3,742	163	172,955
Greater Philadelphia Area	-	98,837	22,243	6,654	445	227,885	-	499	628	-	4,474	4,078	17,187	1,082	384,012
Leigh Valley Area	-	1,205	195	445	-	296	-	35	0	-	60	262	3,312	17	5,826
New York - North Jersey Area	-	539,693	121,011	227,885	296	22,031	-	14,002	201	-	31,082	65,398	409,217	3,150	1,433,966
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	7,284	920	499	35	14,002	-	123	73	-	463	101	184	81	23,765
Poughkeepsie-Newburgh-Middletown Area	-	8,076	1,667	628	0	201	-	73	0	-	121	207	2,559	18	13,549
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	5,247	1,763	4,474	60	31,082	-	463	121	-	536	1,053	4,727	42	49,569
Greater Providence Area	-	2,327	1,527	4,078	262	65,398	-	101	207	-	1,053	687	7,858	39	83,537
Greater Boston Area	-	9,609	3,742	17,187	3,312	409,217	-	184	2,559	-	4,727	7,858	5,021	532	463,948
Springfield Area	-	753	163	1,082	17	3,150	-	81	18	-	42	39	532	1	5,877
Total Trips	-	699,660	172,955	384,012	5,826	1,433,966	-	23,765	13,549	-	49,569	83,537	463,948	5,877	3,336,664

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	995	39,829	3,831	15,217	2,392	106,982	5,715	458	3,249	12,833	5,395	1,616	7,778	282	206,571
Greater Washington Area	39,829	164,463	172,151	324,981	7,848	926,559	55,509	8,862	15,932	12,519	27,874	13,455	32,734	4,110	1,806,827
Greater Baltimore Area	3,831	172,151	10,025	106,378	3,040	302,709	10,362	1,179	4,667	9,385	11,054	6,085	6,547	1,259	648,672
Greater Philadelphia Area	15,217	324,981	106,378	428,040	9,097	873,146	170,162	2,414	3,363	6,730	32,408	23,055	53,757	9,693	2,058,441
Leigh Valley Area	2,392	7,848	3,040	9,097	65	61,551	6,078	34	44	104	1,744	2,241	9,881	310	104,430
New York - North Jersey Area	106,982	926,559	302,709	873,146	61,551	509,870	48,698	10,826	53,731	195,370	314,920	205,999	484,053	66,130	4,160,544
South Central PA Area	5,715	55,509	10,362	170,162	6,078	48,698	26,335	1,232	848	3,740	3,813	1,987	1,997	534	337,011
Atlantic City Area	458	8,862	1,179	2,414	34	10,826	1,232	167	81	475	744	173	301	129	27,076
Poughkeepsie-Newburgh-Middletown Area	3,249	15,932	4,667	3,363	44	53,731	848	81	937	4,502	973	556	2,325	686	91,894
Greater Albany Area	12,833	12,519	9,385	6,730	104	195,370	3,740	475	4,502	12,306	3,162	1,881	7,257	2,038	272,300
Greater Hartford Area	5,395	27,874	11,054	32,408	1,744	314,920	3,813	744	973	3,162	17,693	10,682	31,337	1,992	463,792
Greater Providence Area	1,616	13,455	6,085	23,055	2,241	205,999	1,987	173	556	1,881	10,682	15,921	78,805	392	362,848
Greater Boston Area	7,778	32,734	6,547	53,757	9,881	484,053	1,997	301	2,325	7,257	31,337	78,805	58,166	4,338	779,275
Springfield Area	282	4,110	1,259	9,693	310	66,130	534	129	686	2,038	1,992	392	4,338	6	91,900
Total Trips	206,571	1,806,827	648,672	2,058,441	104,430	4,160,544	337,011	27,076	91,894	272,300	463,792	362,848	779,275	91,900	11,411,581

Source: NEC FUTURE team, 2015

Table I-2: Trip Tables by Mode and MSA pair: No Action Alternative

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	243,600	1,756,617	336,754	450,659	37,674	867,514	325,620	26,996	32,748	61,191	49,961	19,245	68,977	4,394	4,281,951
Greater Washington Area	1,756,617	48,867,568	2,890,046	3,786,489	351,341	5,886,465	1,984,323	224,403	239,672	155,350	326,992	154,292	527,940	95,995	67,247,492
Greater Baltimore Area	336,754	2,890,046	15,987,960	3,219,835	246,380	3,406,623	849,320	130,279	190,198	311,657	208,813	1,503,185	506,238	42,362	29,829,650
Greater Philadelphia Area	450,659	3,786,489	3,219,835	5,033,982	707,218	24,644,822	2,784,699	192,119	262,842	169,766	1,021,709	1,164,014	2,039,123	296,061	45,773,338
Leigh Valley Area	37,674	351,341	246,380	707,218	126,956	6,480,643	346,418	28,735	64,798	27,079	198,838	263,300	625,929	68,198	9,573,509
New York - North Jersey Area	867,514	5,886,465	3,406,623	24,644,822	6,480,643	161,917,513	1,101,396	2,741,211	4,139,304	3,103,747	10,796,170	8,530,229	19,942,550	2,735,872	256,294,060
South Central PA Area	325,620	1,984,323	849,320	2,784,699	346,418	1,101,396	969,316	106,583	147,735	139,251	225,268	95,391	150,534	74,173	9,300,029
Atlantic City Area	26,996	224,403	130,279	192,119	28,735	2,741,211	106,583	71,331	52,113	55,079	172,039	28,834	40,621	38,585	3,908,927
Poughkeepsie-Newburgh-Middletown Area	32,748	239,672	190,198	262,842	64,798	4,139,304	147,735	52,113	277,660	357,599	372,137	234,775	704,216	202,940	7,278,738
Greater Albany Area	61,191	155,350	311,657	169,766	27,079	3,103,747	139,251	55,079	357,599	1,049,054	558,482	362,393	1,149,623	419,313	7,919,585
Greater Hartford Area	49,961	326,992	208,813	1,021,709	198,838	10,796,170	225,268	172,039	372,137	558,482	4,144,333	1,382,644	3,022,515	231,386	22,711,286
Greater Providence Area	19,245	154,292	1,503,185	1,164,014	263,300	8,530,229	95,391	28,834	234,775	362,393	1,382,644	2,700,332	533,431	54,562	17,026,628
Greater Boston Area	68,977	527,940	506,238	2,039,123	625,929	19,942,550	150,534	40,621	704,216	1,149,623	3,022,515	533,431	969,506	523,259	30,804,462
Springfield Area	4,394	95,995	42,362	296,061	68,198	2,735,872	74,173	38,585	202,940	419,313	231,386	54,562	523,259	2,689	4,789,789
Total Trips	4,281,951	67,247,492	29,829,650	45,773,338	9,573,509	256,294,060	9,300,029	3,908,927	7,278,738	7,919,585	22,711,286	17,026,628	30,804,462	4,789,789	516,739,442

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	33,918	10,822	138,819	281	80,908	502	-	1,582	1,892	2,875	2,908	104,188	31	378,727
Greater Washington Area	33,918	-	-	428,877	84,684	1,345,211	105,709	-	18,988	133,511	272,593	359,250	1,915,227	115,049	4,813,018
Greater Baltimore Area	10,822	-	-	119,400	3,143	520,230	5,537	-	11,717	151,746	138,186	364,934	750,999	46,214	2,122,928
Greater Philadelphia Area	138,819	428,877	119,400	-	3,448	551,305	185,276	-	3,090	51,091	168,260	150,914	883,018	-	2,683,499
Leigh Valley Area	281	84,684	3,143	3,448	2	10,882	293	-	5	22	171	538	23,682	26	127,179
New York - North Jersey Area	80,908	1,345,211	520,230	551,305	10,882	-	13,303	-	-	42,390	26,084	72,422	1,969,995	15,017	4,647,747
South Central PA Area	502	105,709	5,537	185,276	293	13,303	-	-	205	136	1,094	1,784	5,414	-	319,253
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	15,890	-	15,890
Poughkeepsie-Newburgh-Middletown Area	1,582	18,988	11,717	3,090	5	-	205	-	-	-	57	204	8,315	-	44,165
Greater Albany Area	1,892	133,511	151,746	51,091	22	42,390	136	-	-	-	138	681	9,942	-	391,550
Greater Hartford Area	2,875	272,593	138,186	168,260	171	26,084	1,094	-	57	138	-	-	448	-	609,906
Greater Providence Area	2,908	359,250	364,934	150,914	538	72,422	1,784	-	204	681	-	-	-	-	953,636
Greater Boston Area	104,188	1,915,227	750,999	883,018	23,682	1,969,995	5,414	15,890	8,315	9,942	448	-	-	-	5,687,118
Springfield Area	31	115,049	46,214	-	26	15,017	-	-	-	-	-	-	-	-	176,338
Total Trips	378,727	4,813,018	2,122,928	2,683,499	127,179	4,647,747	319,253	15,890	44,165	391,550	609,906	953,636	5,687,118	176,338	22,970,953

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	3,746	79,568	21,316	7,531	357,263	7,477	3,816	3,855	-	9,684	455	6,778	-	501,489
Greater Washington Area	3,746	599	100,336	68,628	13,399	1,342,505	14,485	9,126	6,732	-	3,887	2,048	2,321	-	1,567,812
Greater Baltimore Area	79,568	100,336	256	59,064	29,198	365,565	23,755	2,821	1,546	-	3,649	1,458	1,570	-	668,786
Greater Philadelphia Area	21,316	68,628	59,064	67,196	9,973	1,268,354	38,107	1,630	1,429	-	3,455	3,957	20,560	-	1,563,672
Leigh Valley Area	7,531	13,399	29,198	9,973	5,872	791,569	4,299	567	420	630	7,908	2,182	28,236	448	902,231
New York - North Jersey Area	357,263	1,342,505	365,565	1,268,354	791,569	3,809,442	62,375	170,694	49,646	323,240	542,894	246,189	1,660,882	86,054	11,076,670
South Central PA Area	7,477	14,485	23,755	38,107	4,299	62,375	-	3,346	554	-	-	-	-	-	154,397
Atlantic City Area	3,816	9,126	2,821	1,630	567	170,694	3,346	-	445	-	681	269	766	-	194,162
Poughkeepsie-Newburgh-Middletown Area	3,855	6,732	1,546	1,429	420	49,646	554	445	468	1,465	837	378	10,860	1,636	80,272
Greater Albany Area	-	-	-	-	630	323,240	-	-	1,465	-	-	-	33,328	15,468	374,131
Greater Hartford Area	9,684	3,887	3,649	3,455	7,908	542,894	-	681	837	-	-	-	152,367	41,406	766,767
Greater Providence Area	455	2,048	1,458	3,957	2,182	246,189	-	269	378	-	-	-	83,515	5,769	346,219
Greater Boston Area	6,778	2,321	1,570	20,560	28,236	1,660,882	-	766	10,860	33,328	152,367	83,515	105,162	23,933	2,130,277
Springfield Area	-	-	-	-	448	86,054	-	-	1,636	15,468	41,406	5,769	23,933	-	174,714
Total Trips	501,489	1,567,812	668,786	1,563,672	902,231	11,076,670	154,397	194,162	80,272	374,131	766,767	346,219	2,130,277	174,714	20,501,601

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	11,200	26,177	130,630	4,705	933,654	-	8,995	17,367	-	5,752	2,383	8,205	787	1,149,857
Greater Baltimore Area	-	26,177	3,287	25,593	868	191,792	-	956	3,656	-	1,840	1,649	3,582	170	259,567
Greater Philadelphia Area	-	130,630	25,593	7,870	1,500	360,017	-	510	1,187	-	3,917	3,977	16,262	927	552,391
Leigh Valley Area	-	4,705	868	1,500	-	1,218	-	89	1	-	936	2,468	21,768	117	33,671
New York - North Jersey Area	-	933,654	191,792	360,017	1,218	96,374	-	19,033	758	-	75,921	120,384	771,960	6,752	2,577,863
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	8,995	956	510	89	19,033	-	126	142	-	382	86	139	66	30,522
Poughkeepsie-Newburgh-Middletown Area	-	17,367	3,656	1,187	1	758	-	142	1	-	211	232	2,800	31	26,386
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	5,752	1,840	3,917	936	75,921	-	382	211	-	648	1,157	6,649	49	97,462
Greater Providence Area	-	2,383	1,649	3,977	2,468	120,384	-	86	232	-	1,157	743	9,084	42	142,204
Greater Boston Area	-	8,205	3,582	16,262	21,768	771,960	-	139	2,800	-	6,649	9,084	7,287	909	848,646
Springfield Area	-	787	170	927	117	6,752	-	66	31	-	49	42	909	1	9,851
Total Trips	-	1,149,857	259,567	552,391	33,671	2,577,863	-	30,522	26,386	-	97,462	142,204	848,646	9,851	5,728,421

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	955	29,741	2,454	14,147	1,385	98,113	5,482	355	16,264	85,075	5,670	1,670	7,497	401	269,210
Greater Washington Area	29,741	368,273	219,960	369,431	6,266	1,055,525	64,788	9,158	45,314	40,257	28,633	12,016	33,914	6,608	2,289,886
Greater Baltimore Area	2,454	219,960	16,318	132,262	3,056	381,762	13,916	1,359	15,776	43,024	11,151	6,289	7,623	2,111	857,064
Greater Philadelphia Area	14,147	369,431	132,262	386,475	9,058	1,281,581	121,127	2,889	8,158	24,631	33,298	22,619	65,194	12,101	2,482,970
Leigh Valley Area	1,385	6,266	3,056	9,058	50	79,130	3,815	29	63	200	1,476	1,820	9,864	273	116,484
New York - North Jersey Area	98,113	1,055,525	381,762	1,281,581	79,130	666,264	41,141	15,640	36,520	158,067	314,928	180,508	455,066	47,478	4,811,724
South Central PA Area	5,482	64,788	13,916	121,127	3,815	41,141	26,416	867	2,678	19,306	3,622	1,926	2,542	1,840	309,467
Atlantic City Area	355	9,158	1,359	2,889	29	15,640	867	215	186	1,450	673	141	225	175	33,362
Poughkeepsie-Newburgh-Middletown Area	16,264	45,314	15,776	8,158	63	36,520	2,678	186	455	2,132	2,545	2,003	12,249	605	144,948
Greater Albany Area	85,075	40,257	43,024	24,631	200	158,067	19,306	1,450	2,132	6,770	13,163	11,202	52,898	3,610	461,787
Greater Hartford Area	5,670	28,633	11,151	33,298	1,476	314,928	3,622	673	2,545	13,163	21,839	13,423	35,822	2,248	488,492
Greater Providence Area	1,670	12,016	6,289	22,619	1,820	180,508	1,926	141	2,003	11,202	13,423	22,862	92,455	458	369,392
Greater Boston Area	7,497	33,914	7,623	65,194	9,864	455,066	2,542	225	12,249	52,898	35,822	92,455	77,188	4,275	856,812
Springfield Area	401	6,608	2,111	12,101	273	47,478	1,840	175	605	3,610	2,248	458	4,275	7	82,190
Total Trips	269,210	2,289,886	857,064	2,482,970	116,484	4,811,724	309,467	33,362	144,948	461,787	488,492	369,392	856,812	82,190	13,573,789

Source: NEC FUTURE team, 2015

Table I-3: Trip Tables by Mode and MSA pair: Alternative 1

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	242,819	1,739,238	334,791	439,652	36,679	795,669	318,140	26,702	39,811	102,663	41,509	16,748	63,535	3,841	4,201,798
Greater Washington Area	1,739,238	48,772,092	2,817,292	3,686,720	349,408	5,547,694	1,966,551	220,332	247,834	164,368	297,651	144,352	513,120	93,749	66,560,400
Greater Baltimore Area	334,791	2,817,292	15,980,818	3,172,912	245,187	3,218,634	847,941	129,597	192,477	319,864	190,473	1,488,507	495,100	41,380	29,474,974
Greater Philadelphia Area	439,652	3,686,720	3,172,912	4,934,947	703,362	24,264,065	2,763,718	191,332	262,722	175,027	969,337	1,118,943	1,954,861	284,706	44,922,302
Leigh Valley Area	36,679	349,408	245,187	703,362	126,917	6,463,764	345,679	28,729	64,776	27,036	195,543	259,008	617,809	67,761	9,531,658
New York - North Jersey Area	795,669	5,547,694	3,218,634	24,264,065	6,463,764	161,224,276	1,078,771	2,733,292	4,097,316	2,964,026	10,273,515	8,199,851	19,417,084	2,667,307	252,945,264
South Central PA Area	318,140	1,966,551	847,941	2,763,718	345,679	1,078,771	965,835	106,366	148,676	147,583	214,737	90,446	143,000	74,216	9,211,658
Atlantic City Area	26,702	220,332	129,597	191,332	28,729	2,733,292	106,366	71,287	52,092	54,873	169,583	28,346	40,288	38,308	3,891,128
Poughkeepsie-Newburgh-Middletown Area	39,811	247,834	192,477	262,722	64,776	4,097,316	148,676	52,092	276,446	352,247	371,455	234,301	704,541	202,204	7,246,898
Greater Albany Area	102,663	164,368	319,864	175,027	27,036	2,964,026	147,583	54,873	352,247	1,033,472	561,606	366,390	1,172,726	418,653	7,860,533
Greater Hartford Area	41,509	297,651	190,473	969,337	195,543	10,273,515	214,737	169,583	371,455	561,606	4,139,512	1,372,949	2,995,923	230,621	22,024,415
Greater Providence Area	16,748	144,352	1,488,507	1,118,943	259,008	8,199,851	90,446	28,346	234,301	366,390	1,372,949	2,689,598	505,933	54,372	16,569,742
Greater Boston Area	63,535	513,120	495,100	1,954,861	617,809	19,417,084	143,000	40,288	704,541	1,172,726	2,995,923	505,933	955,129	519,823	30,098,871
Springfield Area	3,841	93,749	41,380	284,706	67,761	2,667,307	74,216	38,308	202,204	418,653	230,621	54,372	519,823	2,686	4,699,627
Total Trips	4,201,798	66,560,400	29,474,974	44,922,302	9,531,658	252,945,264	9,211,658	3,891,128	7,246,898	7,860,533	22,024,415	16,569,742	30,098,871	4,699,627	509,239,269

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	33,415	10,778	135,417	268	69,108	479	-	1,678	3,733	1,995	2,338	93,467	23	352,700
Greater Washington Area	33,415	-	-	406,088	83,769	1,258,585	104,585	-	20,050	134,847	258,008	342,461	1,862,520	111,156	4,615,485
Greater Baltimore Area	10,778	-	-	114,034	3,146	480,860	5,536	-	11,915	153,406	134,194	360,951	741,645	45,297	2,061,761
Greater Philadelphia Area	135,417	406,088	114,034	-	3,410	531,887	183,103	-	3,057	51,055	162,453	142,132	855,298	-	2,587,935
Leigh Valley Area	268	83,769	3,146	3,410	2	10,765	292	-	5	22	167	500	23,941	26	126,314
New York - North Jersey Area	69,108	1,258,585	480,860	531,887	10,765	-	12,448	-	-	37,133	24,131	61,230	1,794,888	13,481	4,294,516
South Central PA Area	479	104,585	5,536	183,103	292	12,448	-	-	208	146	1,041	1,486	4,383	-	313,709
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	15,871	-	15,871
Poughkeepsie-Newburgh-Middletown Area	1,678	20,050	11,915	3,057	5	-	208	-	-	-	57	203	8,135	-	45,308
Greater Albany Area	3,733	134,847	153,406	51,055	22	37,133	146	-	-	-	138	690	10,493	-	391,665
Greater Hartford Area	1,995	258,008	134,194	162,453	167	24,131	1,041	-	57	138	-	-	439	-	582,623
Greater Providence Area	2,338	342,461	360,951	142,132	500	61,230	1,486	-	203	690	-	-	-	-	911,992
Greater Boston Area	93,467	1,862,520	741,645	855,298	23,941	1,794,888	4,383	15,871	8,135	10,493	439	-	-	-	5,411,081
Springfield Area	23	111,156	45,297	-	26	13,481	-	-	-	-	-	-	-	-	169,983
Total Trips	352,700	4,615,485	2,061,761	2,587,935	126,314	4,294,516	313,709	15,871	45,308	391,665	582,623	911,992	5,411,081	169,983	21,880,943

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	3,733	78,838	20,200	7,101	325,292	7,139	3,758	3,492	-	8,928	363	6,190	-	465,034
Greater Washington Area	3,733	589	94,005	63,240	13,039	1,228,828	14,157	8,826	6,823	-	3,178	1,550	1,430	-	1,439,397
Greater Baltimore Area	78,838	94,005	252	57,118	28,921	339,548	23,688	2,786	1,548	-	3,127	1,188	1,132	-	632,151
Greater Philadelphia Area	20,200	63,240	57,118	64,128	9,838	1,223,429	37,248	1,624	1,411	-	2,882	3,318	18,369	-	1,502,805
Leigh Valley Area	7,101	13,039	28,921	9,838	5,866	785,206	4,271	566	418	622	7,837	2,106	27,721	444	893,956
New York - North Jersey Area	325,292	1,228,828	339,548	1,223,429	785,206	3,757,106	60,737	169,626	45,193	287,486	461,891	216,249	1,536,573	80,250	10,517,411
South Central PA Area	7,139	14,157	23,688	37,248	4,271	60,737	-	3,329	547	-	-	-	-	-	151,117
Atlantic City Area	3,758	8,826	2,786	1,624	566	169,626	3,329	-	445	-	640	227	610	-	192,435
Poughkeepsie-Newburgh-Middletown Area	3,492	6,823	1,548	1,411	418	45,193	547	445	448	1,390	799	364	10,782	1,620	75,280
Greater Albany Area	-	-	-	-	622	287,486	-	-	1,390	-	-	-	34,692	15,513	339,703
Greater Hartford Area	8,928	3,178	3,127	2,882	7,837	461,891	-	640	799	-	-	-	148,869	41,355	679,505
Greater Providence Area	363	1,550	1,188	3,318	2,106	216,249	-	227	364	-	-	-	76,067	5,758	307,189
Greater Boston Area	6,190	1,430	1,132	18,369	27,721	1,536,573	-	610	10,782	34,692	148,869	76,067	102,662	23,518	1,988,615
Springfield Area	-	-	-	-	444	80,250	-	-	1,620	15,513	41,355	5,758	23,518	-	168,458
Total Trips	465,034	1,439,397	632,151	1,502,805	893,956	10,517,411	151,117	192,435	75,280	339,703	679,505	307,189	1,988,615	168,458	19,353,055

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	14,374	26,779	113,003	1,236	700,495	-	8,556	10,109	-	11,483	4,915	15,938	1,174	908,062
Greater Baltimore Area	-	26,779	4,328	27,475	259	170,059	-	1,179	2,586	-	3,896	3,280	6,576	294	246,711
Greater Philadelphia Area	-	113,003	27,475	7,012	796	356,714	-	511	951	-	8,348	8,113	30,940	1,808	555,669
Leigh Valley Area	-	1,236	259	796	-	844	-	45	0	-	124	419	4,349	20	8,093
New York - North Jersey Area	-	700,495	170,059	356,714	844	67,219	-	20,933	606	-	100,927	126,000	674,150	6,464	2,224,412
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	8,556	1,179	511	45	20,933	-	138	113	-	1,003	193	282	150	33,103
Poughkeepsie-Newburgh-Middletown Area	-	10,109	2,586	951	0	606	-	113	0	-	339	305	3,736	32	18,779
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	11,483	3,896	8,348	124	100,927	-	1,003	339	-	766	1,626	7,758	67	136,337
Greater Providence Area	-	4,915	3,280	8,113	419	126,000	-	193	305	-	1,626	1,721	8,990	47	155,609
Greater Boston Area	-	15,938	6,576	30,940	4,349	674,150	-	282	3,736	-	7,758	8,990	8,512	947	762,178
Springfield Area	-	1,174	294	1,808	20	6,464	-	150	32	-	67	47	947	1	11,005
Total Trips	-	908,062	246,711	555,669	8,093	2,224,412	-	33,103	18,779	-	136,337	155,609	762,178	11,005	5,059,957

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	2,055	55,375	6,306	35,652	3,389	273,586	16,129	828	12,490	56,263	21,059	6,220	30,345	1,305	521,001
Greater Washington Area	55,375	493,591	337,423	595,283	14,595	2,183,496	92,495	16,133	48,351	35,360	84,730	45,943	117,687	15,528	4,135,991
Greater Baltimore Area	6,306	337,423	25,464	211,909	5,816	788,958	16,065	2,137	16,522	41,078	40,114	29,639	32,337	4,868	1,558,634
Greater Philadelphia Area	35,652	595,283	211,909	552,345	17,275	2,047,371	156,917	4,120	9,748	22,967	110,750	91,099	206,154	27,307	4,088,897
Leigh Valley Area	3,389	14,595	5,816	17,275	132	117,447	4,913	86	100	296	6,669	9,470	39,094	951	220,233
New York - North Jersey Area	273,586	2,183,496	788,958	2,047,371	117,447	1,688,224	77,637	30,228	92,761	388,695	1,128,372	668,114	1,667,589	144,023	11,296,500
South Central PA Area	16,129	92,495	16,065	156,917	4,913	77,637	31,557	1,192	2,060	13,056	18,138	8,926	14,670	2,184	455,939
Atlantic City Area	828	16,133	2,137	4,120	86	30,228	1,192	263	262	1,953	3,152	704	780	445	62,284
Poughkeepsie-Newburgh-Middletown Area	12,490	48,351	16,522	9,748	100	92,761	2,060	262	1,790	8,180	3,892	3,055	14,449	1,531	215,190
Greater Albany Area	56,263	35,360	41,078	22,967	296	388,695	13,056	1,953	8,180	23,845	12,433	9,022	36,195	4,753	654,095
Greater Hartford Area	21,059	84,730	40,114	110,750	6,669	1,128,372	18,138	3,152	3,892	12,433	28,616	26,935	77,972	3,377	1,566,206
Greater Providence Area	6,220	45,943	29,639	91,099	9,470	668,114	8,926	704	3,055	9,022	26,935	48,443	147,475	736	1,095,780
Greater Boston Area	30,345	117,687	32,337	206,154	39,094	1,667,589	14,670	780	14,449	36,195	77,972	147,475	101,493	9,784	2,496,024
Springfield Area	1,305	15,528	4,868	27,307	951	144,023	2,184	445	1,531	4,753	3,377	736	9,784	12	216,801
Total Trips	521,001	4,135,991	1,558,634	4,088,897	220,233	11,296,500	455,939	62,284	215,190	654,095	1,566,206	1,095,780	2,496,024	216,801	28,583,575

Source: NEC FUTURE team, 2015

Table I-4: Trip Tables by Mode and MSA pair: Alternative 2

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	242,800	1,739,201	334,777	443,265	37,235	794,073	319,447	26,694	39,384	100,775	41,247	17,217	64,133	3,776	4,204,025
Greater Washington Area	1,739,201	48,718,937	2,808,385	3,675,716	349,148	5,488,161	1,957,986	219,538	246,067	163,569	294,557	141,456	507,798	92,789	66,403,308
Greater Baltimore Area	334,777	2,808,385	15,978,968	3,167,000	244,925	3,185,582	843,774	129,426	191,809	319,043	188,937	1,484,595	491,293	40,637	29,409,151
Greater Philadelphia Area	443,265	3,675,716	3,167,000	4,896,535	701,957	24,154,359	2,749,504	191,003	262,022	171,818	959,126	1,104,810	1,926,058	278,989	44,682,163
Leigh Valley Area	37,235	349,148	244,925	701,957	126,909	6,459,447	345,104	28,712	64,774	27,028	195,085	257,767	611,792	67,560	9,517,445
New York - North Jersey Area	794,073	5,488,161	3,185,582	24,154,359	6,459,447	161,097,895	1,061,385	2,730,076	4,096,792	2,961,990	10,231,378	8,119,960	19,248,036	2,631,878	252,261,011
South Central PA Area	319,447	1,957,986	843,774	2,749,504	345,104	1,061,385	962,583	106,280	148,265	144,338	209,500	88,524	138,349	73,124	9,148,163
Atlantic City Area	26,694	219,538	129,426	191,003	28,712	2,730,076	106,280	71,266	52,070	54,836	168,747	28,095	40,120	38,022	3,884,885
Poughkeepsie-Newburgh-Middletown Area	39,384	246,067	191,809	262,022	64,774	4,096,792	148,265	52,070	276,446	352,247	371,138	234,011	702,204	202,010	7,239,240
Greater Albany Area	100,775	163,569	319,043	171,818	27,028	2,961,990	144,338	54,836	352,247	1,033,472	560,888	365,783	1,172,017	417,887	7,845,691
Greater Hartford Area	41,247	294,557	188,937	959,126	195,085	10,231,378	209,500	168,747	371,138	560,888	4,130,626	1,356,447	2,957,371	230,448	21,895,493
Greater Providence Area	17,217	141,456	1,484,595	1,104,810	257,767	8,119,960	88,524	28,095	234,011	365,783	1,356,447	2,689,012	506,945	54,205	16,448,827
Greater Boston Area	64,133	507,798	491,293	1,926,058	611,792	19,248,036	138,349	40,120	702,204	1,172,017	2,957,371	506,945	937,873	518,900	29,822,887
Springfield Area	3,776	92,789	40,637	278,989	67,560	2,631,878	73,124	38,022	202,010	417,887	230,448	54,205	518,900	2,685	4,652,909
Total Trips	4,204,025	66,403,308	29,409,151	44,682,163	9,517,445	252,261,011	9,148,163	3,884,885	7,239,240	7,845,691	21,895,493	16,448,827	29,822,887	4,652,909	507,415,197

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	33,415	10,778	137,362	271	68,548	485	-	1,646	3,600	1,913	2,420	94,874	22	355,334
Greater Washington Area	33,415	-	-	405,293	83,837	1,224,448	103,994	-	19,377	134,738	248,738	338,063	1,842,883	108,824	4,543,608
Greater Baltimore Area	10,778	-	-	113,826	3,137	470,075	5,524	-	11,727	153,231	131,586	359,892	737,939	44,782	2,042,497
Greater Philadelphia Area	137,362	405,293	113,826	-	3,403	525,965	181,673	-	3,042	51,020	159,243	140,101	848,803	-	2,569,730
Leigh Valley Area	271	83,837	3,137	3,403	2	10,717	292	-	5	22	165	491	23,227	26	125,595
New York - North Jersey Area	68,548	1,224,448	470,075	525,965	10,717	-	11,782	-	-	37,125	22,879	59,625	1,744,129	12,563	4,187,856
South Central PA Area	485	103,994	5,524	181,673	292	11,782	-	-	207	142	1,003	1,392	3,897	-	310,390
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	15,864	-	15,864
Poughkeepsie-Newburgh-Middletown Area	1,646	19,377	11,727	3,042	5	-	207	-	-	-	57	203	8,039	-	44,302
Greater Albany Area	3,600	134,738	153,231	51,020	22	37,125	142	-	-	-	138	690	10,499	-	391,205
Greater Hartford Area	1,913	248,738	131,586	159,243	165	22,879	1,003	-	57	138	-	-	431	-	566,152
Greater Providence Area	2,420	338,063	359,892	140,101	491	59,625	1,392	-	203	690	-	-	-	-	902,876
Greater Boston Area	94,874	1,842,883	737,939	848,803	23,227	1,744,129	3,897	15,864	8,039	10,499	431	-	-	-	5,330,585
Springfield Area	22	108,824	44,782	-	26	12,563	-	-	-	-	-	-	-	-	166,217
Total Trips	355,334	4,543,608	2,042,497	2,569,730	125,595	4,187,856	310,390	15,864	44,302	391,205	566,152	902,876	5,330,585	166,217	21,552,211

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	3,732	78,826	20,811	7,377	323,524	7,222	3,755	3,476	-	8,855	373	6,255	-	464,205
Greater Washington Area	3,732	587	93,320	63,213	12,959	1,208,313	13,938	8,746	6,733	-	3,015	1,435	1,096	-	1,417,089
Greater Baltimore Area	78,826	93,320	250	56,924	28,878	334,521	23,382	2,774	1,540	-	3,061	1,134	1,054	-	625,664
Greater Philadelphia Area	20,811	63,213	56,924	63,037	9,792	1,212,534	36,572	1,612	1,407	-	2,793	3,214	17,932	-	1,489,839
Leigh Valley Area	7,377	12,959	28,878	9,792	5,865	783,272	4,233	565	417	622	7,818	2,075	27,223	442	891,538
New York - North Jersey Area	323,524	1,208,313	334,521	1,212,534	783,272	3,745,178	59,595	169,168	45,184	287,451	459,085	204,048	1,502,823	77,696	10,412,391
South Central PA Area	7,222	13,938	23,382	36,572	4,233	59,595	-	3,320	544	-	-	-	-	-	148,806
Atlantic City Area	3,755	8,746	2,774	1,612	565	169,168	3,320	-	445	-	615	215	563	-	191,779
Poughkeepsie-Newburgh-Middletown Area	3,476	6,733	1,540	1,407	417	45,184	544	445	448	1,390	792	359	10,664	1,614	75,013
Greater Albany Area	-	-	-	-	622	287,451	-	-	1,390	-	-	-	34,659	15,462	339,585
Greater Hartford Area	8,855	3,015	3,061	2,793	7,818	459,085	-	615	792	-	-	-	144,915	41,341	672,290
Greater Providence Area	373	1,435	1,134	3,214	2,075	204,048	-	215	359	-	-	-	76,360	5,749	294,961
Greater Boston Area	6,255	1,096	1,054	17,932	27,223	1,502,823	-	563	10,664	34,659	144,915	76,360	100,920	23,415	1,947,878
Springfield Area	-	-	-	-	442	77,696	-	-	1,614	15,462	41,341	5,749	23,415	-	165,718
Total Trips	464,205	1,417,089	625,664	1,489,839	891,538	10,412,391	148,806	191,779	75,013	339,585	672,290	294,961	1,947,878	165,718	19,136,756

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	15,410	29,170	132,308	1,551	845,795	-	9,558	13,242	-	25,031	7,147	22,397	4,617	1,106,227
Greater Baltimore Area	-	29,170	4,737	31,584	339	204,469	-	1,333	3,474	-	9,086	4,830	9,108	1,264	299,395
Greater Philadelphia Area	-	132,308	31,584	7,242	1,393	418,600	-	569	1,198	-	18,076	11,417	41,070	6,624	670,082
Leigh Valley Area	-	1,551	339	1,393	-	980	-	68	1	-	250	597	5,829	67	11,074
New York - North Jersey Area	-	845,795	204,469	418,600	980	68,241	-	25,500	735	-	155,148	175,892	892,659	18,930	2,806,947
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	9,558	1,333	569	68	25,500	-	157	139	-	2,314	300	425	460	40,823
Poughkeepsie-Newburgh-Middletown Area	-	13,242	3,474	1,198	1	735	-	139	0	-	463	439	4,998	75	24,764
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	25,031	9,086	18,076	250	155,148	-	2,314	463	-	9,912	5,206	11,702	219	237,407
Greater Providence Area	-	7,147	4,830	11,417	597	175,892	-	300	439	-	5,206	2,250	11,933	84	220,096
Greater Boston Area	-	22,397	9,108	41,070	5,829	892,659	-	425	4,998	-	11,702	11,933	8,178	633	1,008,933
Springfield Area	-	4,617	1,264	6,624	67	18,930	-	460	75	-	219	84	633	1	32,975
Total Trips	-	1,106,227	299,395	670,082	11,074	2,806,947	-	40,823	24,764	-	237,407	220,096	1,008,933	32,975	6,458,723

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	2,081	55,427	6,340	26,752	2,207	279,698	14,214	843	13,293	59,938	21,764	5,375	27,322	1,427	516,681
Greater Washington Area	55,427	568,935	349,216	589,479	14,680	2,220,282	106,611	16,331	48,721	36,663	87,486	54,921	147,233	16,663	4,312,648
Greater Baltimore Area	6,340	349,216	27,606	216,671	6,175	830,522	22,673	2,224	16,788	42,540	40,440	35,442	40,367	5,630	1,642,635
Greater Philadelphia Area	26,752	589,479	216,671	613,125	19,014	2,177,751	180,400	4,566	10,454	27,692	119,431	112,169	248,544	30,636	4,376,684
Leigh Valley Area	2,207	14,680	6,175	19,014	146	126,215	5,752	87	104	306	7,141	11,031	47,839	1,172	241,868
New York - North Jersey Area	279,698	2,220,282	830,522	2,177,751	126,215	1,887,218	105,063	31,900	93,385	391,641	1,129,831	757,384	1,813,688	187,518	12,032,097
South Central PA Area	14,214	106,611	22,673	180,400	5,752	105,063	36,225	1,319	2,616	17,613	26,057	11,947	22,480	3,717	556,687
Atlantic City Area	843	16,331	2,224	4,566	87	31,900	1,319	272	265	2,001	2,941	950	971	505	65,174
Poughkeepsie-Newburgh-Middletown Area	13,293	48,721	16,788	10,454	104	93,385	2,616	265	1,790	8,180	4,202	3,318	16,664	1,764	221,545
Greater Albany Area	59,938	36,663	42,540	27,692	306	391,641	17,613	2,001	8,180	23,845	13,511	9,909	37,225	5,931	676,993
Greater Hartford Area	21,764	87,486	40,440	119,431	7,141	1,129,831	26,057	2,941	4,202	13,511	31,241	46,386	132,043	3,470	1,665,944
Greater Providence Area	5,375	54,921	35,442	112,169	11,031	757,384	11,947	950	3,318	9,909	46,386	48,363	141,836	939	1,239,969
Greater Boston Area	27,322	147,233	40,367	248,544	47,839	1,813,688	22,480	971	16,664	37,225	132,043	141,836	129,924	11,384	2,817,519
Springfield Area	1,427	16,663	5,630	30,636	1,172	187,518	3,717	505	1,764	5,931	3,470	939	11,384	14	270,770
Total Trips	516,681	4,312,648	1,642,635	4,376,684	241,868	12,032,097	556,687	65,174	221,545	676,993	1,665,944	1,239,969	2,817,519	270,770	30,637,213

Source: NEC FUTURE team, 2015

Table I-5: Trip Tables by Mode and MSA pair: Alternative 3.1

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	242,819	1,740,041	335,773	444,604	37,493	803,523	321,813	26,870	39,960	102,202	41,760	17,665	64,805	3,834	4,223,161
Greater Washington Area	1,740,041	48,716,793	2,812,356	3,671,314	349,025	5,438,556	1,968,703	220,502	231,083	163,067	287,594	138,299	502,940	92,436	66,332,710
Greater Baltimore Area	335,773	2,812,356	15,980,314	3,171,742	245,080	3,169,689	848,252	129,609	186,118	318,114	185,158	1,479,711	487,926	40,434	29,390,276
Greater Philadelphia Area	444,604	3,671,314	3,171,742	4,901,946	702,289	24,146,987	2,751,230	191,234	260,825	172,143	958,353	1,105,805	1,919,293	276,722	44,674,488
Leigh Valley Area	37,493	349,025	245,080	702,289	126,912	6,461,628	345,204	28,723	64,761	27,031	194,691	256,421	608,145	67,386	9,514,790
New York - North Jersey Area	803,523	5,438,556	3,169,689	24,146,987	6,461,628	161,046,351	1,067,908	2,731,030	4,093,527	2,959,586	10,174,398	8,063,485	19,117,650	2,625,607	251,899,925
South Central PA Area	321,813	1,968,703	848,252	2,751,230	345,204	1,067,908	963,101	106,370	148,170	145,072	210,519	88,828	141,731	72,051	9,178,953
Atlantic City Area	26,870	220,502	129,609	191,234	28,723	2,731,030	106,370	71,282	51,950	54,887	168,421	27,926	40,024	37,968	3,886,796
Poughkeepsie-Newburgh-Middletown Area	39,960	231,083	186,118	260,825	64,761	4,093,527	148,170	51,950	276,446	352,247	369,443	232,006	689,314	201,676	7,197,526
Greater Albany Area	102,202	163,067	318,114	172,143	27,031	2,959,586	145,072	54,887	352,247	1,033,472	558,770	364,636	1,168,024	417,905	7,837,155
Greater Hartford Area	41,760	287,594	185,158	958,353	194,691	10,174,398	210,519	168,421	369,443	558,770	4,126,306	1,358,134	2,958,600	229,911	21,822,058
Greater Providence Area	17,665	138,299	1,479,711	1,105,805	256,421	8,063,485	88,828	27,926	232,006	364,636	1,358,134	2,688,774	505,496	54,198	16,381,385
Greater Boston Area	64,805	502,940	487,926	1,919,293	608,145	19,117,650	141,731	40,024	689,314	1,168,024	2,958,600	505,496	937,287	519,606	29,660,841
Springfield Area	3,834	92,436	40,434	276,722	67,386	2,625,607	72,051	37,968	201,676	417,905	229,911	54,198	519,606	2,686	4,642,419
Total Trips	4,223,161	66,332,710	29,390,276	44,674,488	9,514,790	251,899,925	9,178,953	3,886,796	7,197,526	7,837,155	21,822,058	16,381,385	29,660,841	4,642,419	506,642,483

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	33,434	10,805	137,892	276	69,973	491	-	1,739	3,702	1,984	2,620	97,326	22	360,265
Greater Washington Area	33,434	-	-	403,514	83,880	1,175,914	105,027	-	12,726	134,614	239,648	330,640	1,815,079	107,721	4,442,197
Greater Baltimore Area	10,805	-	-	114,270	3,131	463,567	5,526	-	9,728	153,019	129,250	358,029	732,475	44,484	2,024,284
Greater Philadelphia Area	137,892	403,514	114,270	-	3,406	524,378	181,861	-	2,943	51,026	158,874	141,426	850,043	-	2,569,632
Leigh Valley Area	276	83,880	3,131	3,406	2	10,735	292	-	5	22	163	480	22,518	26	124,937
New York - North Jersey Area	69,973	1,175,914	463,567	524,378	10,735	-	11,978	-	-	37,126	22,467	57,677	1,683,720	12,460	4,069,994
South Central PA Area	491	105,027	5,526	181,861	292	11,978	-	-	205	143	978	1,450	4,190	-	312,141
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	15,856	-	15,856
Poughkeepsie-Newburgh-Middletown Area	1,739	12,726	9,728	2,943	5	-	205	-	-	-	57	198	7,487	-	35,088
Greater Albany Area	3,702	134,614	153,019	51,026	22	37,126	143	-	-	-	138	687	10,414	-	390,891
Greater Hartford Area	1,984	239,648	129,250	158,874	163	22,467	978	-	57	138	-	-	431	-	553,990
Greater Providence Area	2,620	330,640	358,029	141,426	480	57,677	1,450	-	198	687	-	-	-	-	893,207
Greater Boston Area	97,326	1,815,079	732,475	850,043	22,518	1,683,720	4,190	15,856	7,487	10,414	431	-	-	-	5,239,537
Springfield Area	22	107,721	44,484	-	26	12,460	-	-	-	-	-	-	-	-	164,712
Total Trips	360,265	4,442,197	2,024,284	2,569,632	124,937	4,069,994	312,141	15,856	35,088	390,891	553,990	893,207	5,239,537	164,712	21,196,732

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	3,745	79,235	20,862	7,467	327,838	7,284	3,793	3,626	-	8,926	390	6,331	-	469,497
Greater Washington Area	3,745	587	93,689	63,119	12,883	1,187,920	14,253	8,820	5,898	-	2,889	1,364	970	-	1,396,137
Greater Baltimore Area	79,235	93,689	251	57,115	28,913	332,064	23,595	2,782	1,474	-	2,977	1,087	993	-	624,175
Greater Philadelphia Area	20,862	63,119	57,115	63,217	9,806	1,212,195	36,684	1,614	1,404	-	2,781	3,248	18,059	-	1,490,105
Leigh Valley Area	7,467	12,883	28,913	9,806	5,866	784,140	4,239	565	418	622	7,796	2,046	26,760	440	891,962
New York - North Jersey Area	327,838	1,187,920	332,064	1,212,195	784,140	3,744,735	59,989	169,150	45,137	287,453	452,518	197,717	1,478,984	77,377	10,357,217
South Central PA Area	7,284	14,253	23,595	36,684	4,239	59,989	-	3,322	545	-	-	-	-	-	149,912
Atlantic City Area	3,793	8,820	2,782	1,614	565	169,150	3,322	-	444	-	610	207	533	-	191,839
Poughkeepsie-Newburgh-Middletown Area	3,626	5,898	1,474	1,404	418	45,137	545	444	448	1,390	776	349	10,278	1,609	73,794
Greater Albany Area	-	-	-	-	622	287,453	-	-	1,390	-	-	-	34,348	15,464	339,277
Greater Hartford Area	8,926	2,889	2,977	2,781	7,796	452,518	-	610	776	-	-	-	144,996	41,309	665,579
Greater Providence Area	390	1,364	1,087	3,248	2,046	197,717	-	207	349	-	-	-	76,023	5,747	288,177
Greater Boston Area	6,331	970	993	18,059	26,760	1,478,984	-	533	10,278	34,348	144,996	76,023	100,813	23,480	1,922,569
Springfield Area	-	-	-	-	440	77,377	-	-	1,609	15,464	41,309	5,747	23,480	-	165,425
Total Trips	469,497	1,396,137	624,175	1,490,105	891,962	10,357,217	149,912	191,839	73,794	339,277	665,579	288,177	1,922,569	165,425	19,025,664

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	16,438	31,136	152,241	1,771	1,121,093	-	9,528	43,262	-	35,210	10,118	36,290	6,901	1,463,988
Greater Baltimore Area	-	31,136	4,731	30,312	341	242,677	-	1,196	11,170	-	11,785	6,453	11,781	1,725	353,307
Greater Philadelphia Area	-	152,241	30,312	6,560	1,013	495,550	-	508	3,014	-	21,427	14,915	50,793	7,073	783,408
Leigh Valley Area	-	1,771	341	1,013	-	1,032	-	57	2	-	321	759	7,374	83	12,752
New York - North Jersey Area	-	1,121,093	242,677	495,550	1,032	85,917	-	27,979	1,992	-	166,820	190,785	1,069,635	21,532	3,425,012
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	9,528	1,196	508	57	27,979	-	139	285	-	2,619	325	482	533	43,651
Poughkeepsie-Newburgh-Middletown Area	-	43,262	11,170	3,014	2	1,992	-	285	1	-	579	788	11,497	89	72,681
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	35,210	11,785	21,427	321	166,820	-	2,619	579	-	7,960	5,765	12,764	188	265,437
Greater Providence Area	-	10,118	6,453	14,915	759	190,785	-	325	788	-	5,765	2,275	12,314	91	244,589
Greater Boston Area	-	36,290	11,781	50,793	7,374	1,069,635	-	482	11,497	-	12,764	12,314	8,327	678	1,221,936
Springfield Area	-	6,901	1,725	7,073	83	21,532	-	533	89	-	188	91	678	1	38,894
Total Trips	-	1,463,988	353,307	783,408	12,752	3,425,012	-	43,651	72,681	-	265,437	244,589	1,221,936	38,894	7,925,656

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	2,055	54,172	4,305	24,032	1,706	256,874	10,822	550	12,052	57,155	20,636	4,350	22,898	1,323	472,929
Greater Washington Area	54,172	570,761	340,750	576,613	14,694	2,133,494	88,078	14,749	52,903	37,686	101,587	68,025	179,489	16,356	4,249,357
Greater Baltimore Area	4,305	340,750	25,659	209,703	5,897	832,461	15,628	2,094	19,884	44,228	47,042	43,692	50,151	5,864	1,647,358
Greater Philadelphia Area	24,032	576,613	209,703	603,675	18,752	2,114,605	177,398	4,255	10,313	27,166	117,273	104,595	245,835	33,733	4,267,950
Leigh Valley Area	1,706	14,694	5,897	18,752	141	121,805	5,607	83	119	302	7,616	12,792	53,501	1,388	244,402
New York - North Jersey Area	256,874	2,133,494	832,461	2,114,605	121,805	1,941,903	94,848	27,570	96,779	395,192	1,217,409	842,329	1,956,339	194,186	12,225,794
South Central PA Area	10,822	88,078	15,628	177,398	5,607	94,848	35,481	1,188	2,741	16,568	23,973	11,614	16,936	5,164	506,045
Atlantic City Area	550	14,749	2,094	4,255	83	27,570	1,188	269	272	1,933	3,067	1,173	1,128	500	58,831
Poughkeepsie-Newburgh-Middletown Area	12,052	52,903	19,884	10,313	119	96,779	2,741	272	1,790	8,180	6,451	5,724	29,128	2,212	248,548
Greater Albany Area	57,155	37,686	44,228	27,166	302	395,192	16,568	1,933	8,180	23,845	16,581	11,567	43,607	5,905	689,914
Greater Hartford Area	20,636	101,587	47,042	117,273	7,616	1,217,409	23,973	3,067	6,451	16,581	39,555	43,359	129,394	4,284	1,778,226
Greater Providence Area	4,350	68,025	43,692	104,595	12,792	842,329	11,614	1,173	5,724	11,567	43,359	48,840	144,269	940	1,343,271
Greater Boston Area	22,898	179,489	50,151	245,835	53,501	1,956,339	16,936	1,128	29,128	43,607	129,394	144,269	130,837	10,180	3,013,691
Springfield Area	1,323	16,356	5,864	33,733	1,388	194,186	5,164	500	2,212	5,905	4,284	940	10,180	12	282,046
Total Trips	472,929	4,249,357	1,647,358	4,267,950	244,402	12,225,794	506,045	58,831	248,548	689,914	1,778,226	1,343,271	3,013,691	282,046	31,028,362

Source: NEC FUTURE team, 2015

Table I-6: Trip Tables by Mode and MSA pair: Alternative 3.2

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	244,229	1,768,156	337,437	454,489	38,196	889,965	327,408	27,153	46,054	128,425	50,500	19,356	69,177	4,551	4,405,097
Greater Washington Area	1,768,156	48,717,004	2,810,666	3,668,343	348,990	5,413,667	1,968,402	220,515	244,848	163,254	287,532	138,917	504,284	92,605	66,347,183
Greater Baltimore Area	337,437	2,810,666	15,980,253	3,171,211	245,074	3,158,165	848,099	129,609	191,263	318,116	184,985	1,480,959	488,861	40,541	29,385,239
Greater Philadelphia Area	454,489	3,668,343	3,171,211	4,894,607	702,044	24,051,198	2,748,113	191,202	262,046	171,777	958,566	1,109,598	1,926,544	275,747	44,585,485
Leigh Valley Area	38,196	348,990	245,074	702,044	126,911	6,456,870	345,070	28,723	64,774	27,030	194,644	256,879	609,576	67,359	9,512,140
New York - North Jersey Area	889,965	5,413,667	3,158,165	24,051,198	6,456,870	161,033,301	1,064,512	2,729,360	4,096,721	2,959,734	10,153,933	8,066,608	19,116,884	2,617,755	251,808,672
South Central PA Area	327,408	1,968,402	848,099	2,748,113	345,070	1,064,512	962,356	106,347	148,297	144,539	211,248	89,077	142,283	71,513	9,177,264
Atlantic City Area	27,153	220,515	129,609	191,202	28,723	2,729,360	106,347	71,282	52,080	54,886	168,303	27,972	40,045	37,924	3,885,401
Poughkeepsie-Newburgh-Middletown Area	46,054	244,848	191,263	262,046	64,774	4,096,721	148,297	52,080	276,446	352,247	370,883	234,170	703,624	201,904	7,245,357
Greater Albany Area	128,425	163,254	318,116	171,777	27,030	2,959,734	144,539	54,886	352,247	1,033,472	558,727	364,866	1,168,890	417,813	7,863,779
Greater Hartford Area	50,500	287,532	184,985	958,566	194,644	10,153,933	211,248	168,303	370,883	558,727	4,124,834	1,357,220	2,956,329	230,021	21,807,724
Greater Providence Area	19,356	138,917	1,480,959	1,109,598	256,879	8,066,608	89,077	27,972	234,170	364,866	1,357,220	2,689,095	505,860	54,195	16,394,774
Greater Boston Area	69,177	504,284	488,861	1,926,544	609,576	19,116,884	142,283	40,045	703,624	1,168,890	2,956,329	505,860	942,781	519,178	29,694,316
Springfield Area	4,551	92,605	40,541	275,747	67,359	2,617,755	71,513	37,924	201,904	417,813	230,021	54,195	519,178	2,686	4,633,793
Total Trips	4,405,097	66,347,183	29,385,239	44,585,485	9,512,140	251,808,672	9,177,264	3,885,401	7,245,357	7,863,779	21,807,724	16,394,774	29,694,316	4,633,793	506,746,223

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	34,310	10,839	140,577	284	84,505	507	-	2,052	7,071	2,912	2,927	102,889	31	388,903
Greater Washington Area	34,310	-	-	402,758	83,876	1,156,124	105,017	-	19,129	134,618	240,011	332,102	1,819,940	107,887	4,435,773
Greater Baltimore Area	10,839	-	-	114,176	3,131	455,930	5,525	-	11,652	153,016	129,450	358,532	733,767	44,573	2,020,592
Greater Philadelphia Area	140,577	402,758	114,176	-	3,406	521,293	181,537	-	3,046	51,024	158,571	141,635	851,043	-	2,569,066
Leigh Valley Area	284	83,876	3,131	3,406	2	10,705	292	-	5	22	163	484	22,727	26	125,123
New York - North Jersey Area	84,505	1,156,124	455,930	521,293	10,705	-	11,799	-	-	37,075	22,412	58,069	1,685,659	12,304	4,055,876
South Central PA Area	507	105,017	5,525	181,537	292	11,799	-	-	207	142	976	1,480	4,563	-	312,045
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	15,858	-	15,858
Poughkeepsie-Newburgh-Middletown Area	2,052	19,129	11,652	3,046	5	-	207	-	-	-	57	204	8,104	-	44,456
Greater Albany Area	7,071	134,618	153,016	51,024	22	37,075	142	-	-	-	138	688	10,430	-	394,223
Greater Hartford Area	2,912	240,011	129,450	158,571	163	22,412	976	-	57	138	-	-	431	-	555,121
Greater Providence Area	2,927	332,102	358,532	141,635	484	58,069	1,480	-	204	688	-	-	-	-	896,122
Greater Boston Area	102,889	1,819,940	733,767	851,043	22,727	1,685,659	4,563	15,858	8,104	10,430	431	-	-	-	5,255,411
Springfield Area	31	107,887	44,573	-	26	12,304	-	-	-	-	-	-	-	-	164,821
Total Trips	388,903	4,435,773	2,020,592	2,569,066	125,123	4,055,876	312,045	15,858	44,456	394,223	555,121	896,122	5,255,411	164,821	21,233,389

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	3,757	79,776	21,790	7,673	374,420	7,538	3,839	3,835	-	9,738	476	6,810	-	519,651
Greater Washington Area	3,757	587	93,601	62,932	12,870	1,173,378	14,245	8,818	6,536	-	2,894	1,376	998	-	1,381,993
Greater Baltimore Area	79,776	93,601	251	57,089	28,911	329,306	23,582	2,782	1,525	-	2,975	1,098	1,011	-	621,908
Greater Philadelphia Area	21,790	62,932	57,089	62,979	9,799	1,199,923	36,535	1,611	1,407	-	2,771	3,257	18,153	-	1,478,246
Leigh Valley Area	7,673	12,870	28,911	9,799	5,866	782,509	4,231	565	417	622	7,796	2,056	26,902	441	890,657
New York - North Jersey Area	374,420	1,173,378	329,306	1,199,923	782,509	3,735,555	59,717	168,965	45,155	287,136	449,334	198,404	1,474,847	76,820	10,355,470
South Central PA Area	7,538	14,245	23,582	36,535	4,231	59,717	-	3,318	544	-	-	-	-	-	149,711
Atlantic City Area	3,839	8,818	2,782	1,611	565	168,965	3,318	-	445	-	610	210	542	-	191,705
Poughkeepsie-Newburgh-Middletown Area	3,835	6,536	1,525	1,407	417	45,155	544	445	448	1,390	789	361	10,733	1,611	75,196
Greater Albany Area	-	-	-	-	622	287,136	-	-	1,390	-	-	-	34,409	15,458	339,015
Greater Hartford Area	9,738	2,894	2,975	2,771	7,796	449,334	-	610	789	-	-	-	144,701	41,313	662,921
Greater Providence Area	476	1,376	1,098	3,257	2,056	198,404	-	210	361	-	-	-	76,063	5,747	289,045
Greater Boston Area	6,810	998	1,011	18,153	26,902	1,474,847	-	542	10,733	34,409	144,701	76,063	101,295	23,455	1,919,918
Springfield Area	-	-	-	-	441	76,820	-	-	1,611	15,458	41,313	5,747	23,455	-	164,844
Total Trips	519,651	1,381,993	621,908	1,478,246	890,657	10,355,470	149,711	191,705	75,196	339,015	662,921	289,045	1,919,918	164,844	19,040,280

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	16,509	30,774	150,427	1,747	1,106,614	-	9,505	14,313	-	34,813	10,238	36,818	6,872	1,418,630
Greater Baltimore Area	-	30,774	4,725	30,149	340	235,521	-	1,194	3,405	-	11,738	6,603	12,266	1,743	338,459
Greater Philadelphia Area	-	150,427	30,149	6,450	1,012	530,789	-	506	1,151	-	22,340	15,206	55,577	7,212	820,819
Leigh Valley Area	-	1,747	340	1,012	-	1,036	-	57	1	-	310	766	7,470	83	12,822
New York - North Jersey Area	-	1,106,614	235,521	530,789	1,036	66,101	-	28,835	704	-	166,666	195,694	1,057,717	20,698	3,410,375
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	9,505	1,194	506	57	28,835	-	139	140	-	2,719	353	512	547	44,506
Poughkeepsie-Newburgh-Middletown Area	-	14,313	3,405	1,151	1	704	-	140	0	-	409	439	5,291	63	25,916
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	34,813	11,738	22,340	310	166,666	-	2,719	409	-	10,481	5,601	12,517	219	267,814
Greater Providence Area	-	10,238	6,603	15,206	766	195,694	-	353	439	-	5,601	2,282	12,366	90	249,637
Greater Boston Area	-	36,818	12,266	55,577	7,470	1,057,717	-	512	5,291	-	12,517	12,366	9,037	683	1,210,254
Springfield Area	-	6,872	1,743	7,212	83	20,698	-	547	63	-	219	90	683	1	38,210
Total Trips	-	1,418,630	338,459	820,819	12,822	3,410,375	-	44,506	25,916	-	267,814	249,637	1,210,254	38,210	7,837,442

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	24	11,882	1,089	5,141	390	35,829	2,794	94	1,782	9,535	3,592	1,106	7,704	149	81,111
Greater Washington Area	11,882	570,370	343,594	584,527	14,791	2,240,240	88,539	14,750	50,237	37,402	101,719	64,678	169,898	15,877	4,308,505
Greater Baltimore Area	1,089	343,594	25,751	210,857	5,908	872,205	15,871	2,096	17,755	44,230	47,147	40,951	46,483	5,554	1,679,491
Greater Philadelphia Area	5,141	584,527	210,857	615,442	19,122	2,243,958	182,581	4,305	10,464	27,718	116,514	98,980	228,463	35,125	4,383,195
Leigh Valley Area	390	14,791	5,908	19,122	143	130,884	5,802	82	103	303	7,716	12,127	50,772	1,424	249,565
New York - North Jersey Area	35,829	2,240,240	872,205	2,243,958	130,884	1,997,063	100,393	30,269	93,528	395,253	1,252,918	829,029	1,970,186	207,479	12,399,234
South Central PA Area	2,794	88,539	15,871	182,581	5,802	100,393	36,551	1,224	2,573	17,326	22,810	11,248	15,483	5,918	509,113
Atlantic City Area	94	14,750	2,096	4,305	82	30,269	1,224	269	252	1,933	3,122	1,076	1,045	544	61,062
Poughkeepsie-Newburgh-Middletown Area	1,782	50,237	17,755	10,464	103	93,528	2,573	252	1,790	8,180	4,619	3,119	14,246	1,926	210,574
Greater Albany Area	9,535	37,402	44,230	27,718	303	395,253	17,326	1,933	8,180	23,845	16,639	11,243	42,243	6,044	641,894
Greater Hartford Area	3,592	101,719	47,147	116,514	7,716	1,252,918	22,810	3,122	4,619	16,639	38,828	44,805	133,040	4,085	1,797,553
Greater Providence Area	1,106	64,678	40,951	98,980	12,127	829,029	11,248	1,076	3,119	11,243	44,805	48,356	143,629	945	1,311,292
Greater Boston Area	7,704	169,898	46,483	228,463	50,772	1,970,186	15,483	1,045	14,246	42,243	133,040	143,629	121,374	10,778	2,955,343
Springfield Area	149	15,877	5,554	35,125	1,424	207,479	5,918	544	1,926	6,044	4,085	945	10,778	12	295,861
Total Trips	81,111	4,308,505	1,679,491	4,383,195	249,565	12,399,234	509,113	61,062	210,574	641,894	1,797,553	1,311,292	2,955,343	295,861	30,883,792

Source: NEC FUTURE team, 2015

Table I-7: Trip Tables by Mode and MSA pair: Alternative 3.3

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	242,776	1,739,131	335,638	443,835	37,444	800,641	321,359	26,851	39,622	100,775	41,692	17,737	64,718	3,829	4,216,048
Greater Washington Area	1,739,131	48,716,878	2,812,543	3,671,250	349,027	5,400,201	1,968,660	220,518	244,534	162,938	287,225	140,187	496,887	92,378	66,302,356
Greater Baltimore Area	335,638	2,812,543	15,980,313	3,171,802	245,080	3,156,817	848,252	129,612	191,259	318,114	184,855	1,486,714	486,997	40,523	29,388,519
Greater Philadelphia Area	443,835	3,671,250	3,171,802	4,901,946	702,281	24,047,267	2,751,233	191,233	262,062	172,143	956,454	1,114,789	1,914,706	275,873	44,576,872
Leigh Valley Area	37,444	349,027	245,080	702,281	126,912	6,457,146	345,204	28,723	64,774	27,031	194,582	259,491	607,503	67,350	9,512,549
New York - North Jersey Area	800,641	5,400,201	3,156,817	24,047,267	6,457,146	161,031,674	1,066,566	2,729,275	4,096,707	2,959,628	10,145,132	8,155,755	19,011,199	2,616,542	251,674,550
South Central PA Area	321,359	1,968,660	848,252	2,751,233	345,204	1,066,566	963,101	106,370	148,310	145,072	209,765	90,000	141,411	71,688	9,176,991
Atlantic City Area	26,851	220,518	129,612	191,233	28,723	2,729,275	106,370	71,282	52,080	54,887	168,509	28,123	39,820	37,979	3,885,261
Poughkeepsie-Newburgh-Middletown Area	39,622	244,534	191,259	262,062	64,774	4,096,707	148,310	52,080	276,446	352,247	370,953	234,268	703,696	201,920	7,238,878
Greater Albany Area	100,775	162,938	318,114	172,143	27,031	2,959,628	145,072	54,887	352,247	1,033,472	558,643	365,221	1,165,821	417,818	7,833,810
Greater Hartford Area	41,692	287,225	184,855	956,454	194,582	10,145,132	209,765	168,509	370,953	558,643	4,127,482	1,368,931	2,952,467	229,979	21,796,670
Greater Providence Area	17,737	140,187	1,486,714	1,114,789	259,491	8,155,755	90,000	28,123	234,268	365,221	1,368,931	2,690,182	507,050	54,245	16,512,693
Greater Boston Area	64,718	496,887	486,997	1,914,706	607,503	19,011,199	141,411	39,820	703,696	1,165,821	2,952,467	507,050	907,821	515,181	29,515,276
Springfield Area	3,829	92,378	40,523	275,873	67,350	2,616,542	71,688	37,979	201,920	417,818	229,979	54,245	515,181	2,685	4,627,990
Total Trips	4,216,048	66,302,356	29,388,519	44,576,872	9,512,549	251,674,550	9,176,991	3,885,261	7,238,878	7,833,810	21,796,670	16,512,693	29,515,276	4,627,990	506,258,461

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	33,406	10,802	137,667	275	69,466	490	-	1,710	3,600	1,976	2,660	97,090	22	359,165
Greater Washington Area	33,406	-	-	403,517	83,881	1,153,180	105,026	-	19,117	134,605	239,201	341,131	1,812,794	107,610	4,433,467
Greater Baltimore Area	10,802	-	-	114,283	3,131	455,589	5,526	-	11,652	153,019	129,160	361,135	733,803	44,530	2,022,631
Greater Philadelphia Area	137,667	403,517	114,283	-	3,406	521,216	181,861	-	3,047	51,026	158,497	143,186	851,187	-	2,568,894
Leigh Valley Area	275	83,881	3,131	3,406	2	10,708	292	-	5	22	163	509	22,564	26	124,984
New York - North Jersey Area	69,466	1,153,180	455,589	521,216	10,708	-	11,873	-	-	37,074	22,283	61,956	1,676,524	12,275	4,032,145
South Central PA Area	490	105,026	5,526	181,861	292	11,873	-	-	207	143	973	1,564	4,187	-	312,143
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	15,856	-	15,856
Poughkeepsie-Newburgh-Middletown Area	1,710	19,117	11,652	3,047	5	-	207	-	-	-	57	203	8,139	-	44,137
Greater Albany Area	3,600	134,605	153,019	51,026	22	37,074	143	-	-	-	138	691	10,416	-	390,733
Greater Hartford Area	1,976	239,201	129,160	158,497	163	22,283	973	-	57	138	-	-	431	-	552,879
Greater Providence Area	2,660	341,131	361,135	143,186	509	61,956	1,564	-	203	691	-	-	-	-	913,036
Greater Boston Area	97,090	1,812,794	733,803	851,187	22,564	1,676,524	4,187	15,856	8,139	10,416	431	-	-	-	5,232,992
Springfield Area	22	107,610	44,530	-	26	12,275	-	-	-	-	-	-	-	-	164,463
Total Trips	359,165	4,433,467	2,022,631	2,568,894	124,984	4,032,145	312,143	15,856	44,137	390,733	552,879	913,036	5,232,992	164,463	21,167,523

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	3,743	79,177	20,775	7,443	325,969	7,260	3,788	3,607	-	8,919	392	6,323	-	467,396
Greater Washington Area	3,743	587	93,694	63,117	12,883	1,169,605	14,251	8,821	6,575	-	2,890	1,454	875	-	1,378,496
Greater Baltimore Area	79,177	93,694	251	57,117	28,913	329,237	23,595	2,782	1,525	-	2,970	1,124	979	-	621,364
Greater Philadelphia Area	20,775	63,117	57,117	63,217	9,806	1,199,092	36,684	1,614	1,407	-	2,773	3,305	18,041	-	1,476,948
Leigh Valley Area	7,443	12,883	28,913	9,806	5,866	782,663	4,239	565	417	622	7,794	2,102	26,813	441	890,567
New York - North Jersey Area	325,969	1,169,605	329,237	1,199,092	782,663	3,735,562	59,903	168,957	45,154	287,128	448,450	202,537	1,459,643	76,779	10,290,677
South Central PA Area	7,260	14,251	23,595	36,684	4,239	59,903	-	3,322	545	-	-	-	-	-	149,801
Atlantic City Area	3,788	8,821	2,782	1,614	565	168,957	3,322	-	445	-	610	232	523	-	191,660
Poughkeepsie-Newburgh-Middletown Area	3,607	6,575	1,525	1,407	417	45,154	545	445	448	1,390	791	362	10,689	1,611	74,965
Greater Albany Area	-	-	-	-	622	287,128	-	-	1,390	-	-	-	34,222	15,458	338,821
Greater Hartford Area	8,919	2,890	2,970	2,773	7,794	448,450	-	610	791	-	-	-	144,305	41,307	660,807
Greater Providence Area	392	1,454	1,124	3,305	2,102	202,537	-	232	362	-	-	-	76,553	5,747	293,806
Greater Boston Area	6,323	875	979	18,041	26,813	1,459,643	-	523	10,689	34,222	144,305	76,553	98,782	22,973	1,900,719
Springfield Area	-	-	-	-	441	76,779	-	-	1,611	15,458	41,307	5,747	22,973	-	164,315
Total Trips	467,396	1,378,496	621,364	1,476,948	890,567	10,290,677	149,801	191,660	74,965	338,821	660,807	293,806	1,900,719	164,315	18,900,342

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	16,572	31,291	151,697	1,770	1,103,809	-	9,495	14,358	-	36,732	6,059	33,961	7,047	1,412,791
Greater Baltimore Area	-	31,291	4,732	30,164	341	235,542	-	1,191	3,405	-	12,281	3,901	11,266	1,736	335,848
Greater Philadelphia Area	-	151,697	30,164	6,560	1,017	531,000	-	508	1,154	-	22,023	8,988	48,165	7,059	808,336
Leigh Valley Area	-	1,770	341	1,017	-	1,037	-	57	1	-	322	442	7,023	80	12,088
New York - North Jersey Area	-	1,103,809	235,542	531,000	1,037	66,050	-	28,936	699	-	180,476	131,486	1,002,275	19,653	3,300,962
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	9,495	1,191	508	57	28,936	-	139	140	-	2,421	239	513	458	44,098
Poughkeepsie-Newburgh-Middletown Area	-	14,358	3,405	1,154	1	699	-	140	0	-	252	273	3,526	26	23,833
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	36,732	12,281	22,023	322	180,476	-	2,421	252	-	9,842	2,290	11,393	271	278,303
Greater Providence Area	-	6,059	3,901	8,988	442	131,486	-	239	273	-	2,290	1,150	10,436	83	165,347
Greater Boston Area	-	33,961	11,266	48,165	7,023	1,002,275	-	513	3,526	-	11,393	10,436	5,759	530	1,134,846
Springfield Area	-	7,047	1,736	7,059	80	19,653	-	458	26	-	271	83	530	3	36,945
Total Trips	-	1,412,791	335,848	808,336	12,088	3,300,962	-	44,098	23,833	-	278,303	165,347	1,134,846	36,945	7,553,395

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	2,115	55,541	4,583	25,525	1,809	264,826	11,464	583	12,694	59,938	20,777	4,163	23,353	1,333	488,705
Greater Washington Area	55,541	570,493	340,319	577,273	14,693	2,277,282	88,143	14,757	50,613	37,875	101,274	54,183	195,760	16,454	4,394,660
Greater Baltimore Area	4,583	340,319	25,659	209,753	5,897	875,261	15,628	2,095	17,761	44,228	47,199	32,134	50,239	5,652	1,676,409
Greater Philadelphia Area	25,525	577,273	209,753	603,693	18,765	2,252,494	177,394	4,256	10,439	27,166	119,958	95,750	252,738	35,110	4,410,314
Leigh Valley Area	1,809	14,693	5,897	18,765	140	130,275	5,607	82	103	302	7,776	8,843	54,373	1,437	250,103
New York - North Jersey Area	264,826	2,277,282	875,261	2,252,494	130,275	1,999,426	97,108	30,333	93,553	395,414	1,254,502	750,847	2,214,295	210,219	12,845,835
South Central PA Area	11,464	88,143	15,628	177,394	5,607	97,108	35,481	1,188	2,556	16,568	25,104	9,699	17,335	5,672	508,946
Atlantic City Area	583	14,757	2,095	4,256	82	30,333	1,188	269	251	1,933	3,157	950	1,384	564	61,802
Poughkeepsie-Newburgh-Middletown Area	12,694	50,613	17,761	10,439	103	93,553	2,556	251	1,790	8,180	4,680	3,143	15,945	1,941	223,649
Greater Albany Area	59,938	37,875	44,228	27,166	302	395,414	16,568	1,933	8,180	23,845	16,761	10,752	46,976	6,036	695,972
Greater Hartford Area	20,777	101,274	47,199	119,958	7,776	1,254,502	25,104	3,157	4,680	16,761	35,676	31,652	140,120	4,091	1,812,726
Greater Providence Area	4,163	54,183	32,134	95,750	8,843	750,847	9,699	950	3,143	10,752	31,652	47,734	142,794	885	1,193,528
Greater Boston Area	23,353	195,760	50,239	252,738	54,373	2,214,295	17,335	1,384	15,945	46,976	140,120	142,794	180,758	17,575	3,353,642
Springfield Area	1,333	16,454	5,652	35,110	1,437	210,219	5,672	564	1,941	6,036	4,091	885	17,575	12	306,982
Total Trips	488,705	4,394,660	1,676,409	4,410,314	250,103	12,845,835	508,946	61,802	223,649	695,972	1,812,726	1,193,528	3,353,642	306,982	32,223,274

Source: NEC FUTURE team, 2015

Table I-8: Trip Tables by Mode and MSA pair: Alternative 3.4

Annual Auto Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	242,776	1,739,131	335,638	443,835	37,444	800,557	321,359	26,851	39,622	100,775	41,692	17,734	64,701	3,829	4,215,944
Greater Washington Area	1,739,131	48,716,817	2,812,399	3,670,295	349,031	5,485,099	1,968,591	220,456	244,074	162,946	286,576	139,905	495,966	92,294	66,383,580
Greater Baltimore Area	335,638	2,812,399	15,980,251	3,171,174	245,078	3,181,174	848,225	129,599	189,795	318,120	184,722	1,486,276	486,310	40,411	29,409,174
Greater Philadelphia Area	443,835	3,670,295	3,171,174	4,901,755	702,259	24,158,193	2,751,224	191,218	262,257	172,146	956,089	1,113,863	1,909,210	276,227	44,679,745
Leigh Valley Area	37,444	349,031	245,078	702,259	126,912	6,461,619	345,204	28,723	64,762	27,031	194,566	259,338	606,317	67,359	9,515,642
New York - North Jersey Area	800,557	5,485,099	3,181,174	24,158,193	6,461,619	161,064,778	1,067,908	2,731,292	4,094,586	2,959,630	10,158,800	8,157,600	19,061,824	2,623,026	252,006,086
South Central PA Area	321,359	1,968,591	848,225	2,751,224	345,204	1,067,908	963,101	106,370	148,172	145,072	210,559	90,055	141,060	72,064	9,178,964
Atlantic City Area	26,851	220,456	129,599	191,218	28,723	2,731,292	106,370	71,279	52,108	54,886	168,391	28,091	39,778	37,981	3,887,022
Poughkeepsie-Newburgh-Middletown Area	39,622	244,074	189,795	262,257	64,762	4,094,586	148,172	52,108	276,446	352,247	369,706	233,912	693,462	201,716	7,222,867
Greater Albany Area	100,775	162,946	318,120	172,146	27,031	2,959,630	145,072	54,886	352,247	1,033,472	558,668	365,153	1,165,094	417,907	7,833,148
Greater Hartford Area	41,692	286,576	184,722	956,089	194,566	10,158,800	210,559	168,391	369,706	558,668	4,129,418	1,368,615	2,954,604	229,838	21,812,245
Greater Providence Area	17,734	139,905	1,486,276	1,113,863	259,338	8,157,600	90,055	28,091	233,912	365,153	1,368,615	2,690,160	506,960	54,247	16,511,911
Greater Boston Area	64,701	495,966	486,310	1,909,210	606,317	19,061,824	141,060	39,778	693,462	1,165,094	2,954,604	506,960	907,678	515,294	29,548,256
Springfield Area	3,829	92,294	40,411	276,227	67,359	2,623,026	72,064	37,981	201,716	417,907	229,838	54,247	515,294	2,685	4,634,876
Total Trips	4,215,944	66,383,580	29,409,174	44,679,745	9,515,642	252,006,086	9,178,964	3,887,022	7,222,867	7,833,148	21,812,245	16,511,911	29,548,256	4,634,876	506,839,459

Annual Air Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	33,406	10,802	137,667	275	69,483	490	-	1,710	3,600	1,976	2,660	97,046	22	359,138
Greater Washington Area	33,406	-	-	403,274	83,881	1,197,498	105,023	-	18,348	134,606	238,402	340,567	1,808,459	107,350	4,470,815
Greater Baltimore Area	10,802	-	-	114,199	3,131	467,297	5,526	-	11,236	153,017	128,919	361,006	732,893	44,390	2,032,415
Greater Philadelphia Area	137,667	403,274	114,199	-	3,406	524,855	181,861	-	3,073	51,026	158,306	142,917	849,662	-	2,570,244
Leigh Valley Area	275	83,881	3,131	3,406	2	10,735	292	-	5	22	163	508	22,414	26	124,859
New York - North Jersey Area	69,483	1,197,498	467,297	524,855	10,735	-	11,978	-	-	37,126	22,267	61,912	1,678,822	12,383	4,094,354
South Central PA Area	490	105,023	5,526	181,861	292	11,978	-	-	205	143	980	1,560	4,164	-	312,220
Atlantic City Area	-	-	-	-	-	-	-	-	-	-	-	-	15,855	-	15,855
Poughkeepsie-Newburgh-Middletown Area	1,710	18,348	11,236	3,073	5	-	205	-	-	-	57	203	7,755	-	42,593
Greater Albany Area	3,600	134,606	153,017	51,026	22	37,126	143	-	-	-	138	691	10,404	-	390,773
Greater Hartford Area	1,976	238,402	128,919	158,306	163	22,267	980	-	57	138	-	-	431	-	551,638
Greater Providence Area	2,660	340,567	361,006	142,917	508	61,912	1,560	-	203	691	-	-	-	-	912,022
Greater Boston Area	97,046	1,808,459	732,893	849,662	22,414	1,678,822	4,164	15,855	7,755	10,404	431	-	-	-	5,227,904
Springfield Area	22	107,350	44,390	-	26	12,383	-	-	-	-	-	-	-	-	164,171
Total Trips	359,138	4,470,815	2,032,415	2,570,244	124,859	4,094,354	312,220	15,855	42,593	390,773	551,638	912,022	5,227,904	164,171	21,269,000

Annual Bus Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	3,743	79,177	20,775	7,443	326,039	7,260	3,788	3,607	-	8,919	392	6,321	-	467,465
Greater Washington Area	3,743	587	93,681	63,072	12,884	1,199,347	14,250	8,821	6,824	-	2,878	1,445	864	-	1,408,395
Greater Baltimore Area	79,177	93,681	251	57,093	28,912	332,980	23,593	2,781	1,545	-	2,971	1,117	971	-	625,072
Greater Philadelphia Area	20,775	63,072	57,093	63,217	9,805	1,212,653	36,684	1,614	1,416	-	2,767	3,300	17,965	-	1,490,362
Leigh Valley Area	7,443	12,884	28,912	9,805	5,866	784,128	4,239	565	418	622	7,791	2,098	26,702	440	891,914
New York - North Jersey Area	326,039	1,199,347	332,980	1,212,653	784,128	3,746,375	59,989	169,187	45,151	287,453	450,817	202,458	1,469,871	77,279	10,363,725
South Central PA Area	7,260	14,250	23,593	36,684	4,239	59,989	-	3,322	545	-	-	-	-	-	149,883
Atlantic City Area	3,788	8,821	2,781	1,614	565	169,187	3,322	-	447	-	608	230	516	-	191,879
Poughkeepsie-Newburgh-Middletown Area	3,607	6,824	1,545	1,416	418	45,151	545	447	448	1,390	780	356	10,314	1,609	74,848
Greater Albany Area	-	-	-	-	622	287,453	-	-	1,390	-	-	-	34,175	15,463	339,104
Greater Hartford Area	8,919	2,878	2,971	2,767	7,791	450,817	-	608	780	-	-	-	144,580	41,299	663,410
Greater Providence Area	392	1,445	1,117	3,300	2,098	202,458	-	230	356	-	-	-	76,538	5,747	293,680
Greater Boston Area	6,321	864	971	17,965	26,702	1,469,871	-	516	10,314	34,175	144,580	76,538	98,770	22,987	1,910,573
Springfield Area	-	-	-	-	440	77,279	-	-	1,609	15,463	41,299	5,747	22,987	-	164,823
Total Trips	467,465	1,408,395	625,072	1,490,362	891,914	10,363,725	149,883	191,879	74,848	339,104	663,410	293,680	1,910,573	164,823	19,035,133

Annual Intercity-Express Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Washington Area	-	16,527	31,225	152,762	1,762	996,668	-	9,606	-	-	39,567	6,465	36,329	7,579	1,298,492
Greater Baltimore Area	-	31,225	4,737	30,567	341	216,821	-	1,210	55	-	13,356	4,199	12,099	1,869	316,480
Greater Philadelphia Area	-	152,762	30,567	6,789	1,016	464,664	-	526	245	-	23,956	9,692	50,423	7,835	748,475
Leigh Valley Area	-	1,762	341	1,016	-	1,010	-	57	-	-	361	474	7,434	88	12,542
New York - North Jersey Area	-	996,668	216,821	464,664	1,010	51,498	-	27,563	17	-	188,396	133,489	975,559	21,797	3,077,483
South Central PA Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic City Area	-	9,606	1,210	526	57	27,563	-	144	41	-	2,613	255	541	497	43,053
Poughkeepsie-Newburgh-Middletown Area	-	-	55	245	-	17	-	41	-	-	-	137	-	-	496
Greater Albany Area	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Hartford Area	-	39,567	13,356	23,956	361	188,396	-	2,613	-	-	6,336	2,317	11,571	270	288,743
Greater Providence Area	-	6,465	4,199	9,692	474	133,489	-	255	137	-	2,317	1,186	10,702	84	169,001
Greater Boston Area	-	36,329	12,099	50,423	7,434	975,559	-	541	-	-	11,571	10,702	5,765	533	1,110,957
Springfield Area	-	7,579	1,869	7,835	88	21,797	-	497	-	-	270	84	533	3	40,555
Total Trips	-	1,298,492	316,480	748,475	12,542	3,077,483	-	43,053	496	-	288,743	169,001	1,110,957	40,555	7,106,276

Annual Intercity-Corridor Rail Trips	Greater Richmond Area	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	Leigh Valley Area	New York - North Jersey Area	South Central PA Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Richmond Area	2,115	55,541	4,583	25,525	1,809	264,869	11,464	583	12,694	59,938	20,778	4,168	23,450	1,333	488,851
Greater Washington Area	55,541	570,626	340,628	578,111	14,695	2,146,533	88,253	14,730	67,973	37,858	100,617	55,098	200,831	16,392	4,287,887
Greater Baltimore Area	4,583	340,628	25,741	210,405	5,902	836,347	15,671	2,092	23,814	44,223	46,632	32,685	51,641	5,879	1,646,242
Greater Philadelphia Area	25,525	578,111	210,405	603,778	18,801	2,129,548	177,407	4,259	11,034	27,163	118,862	96,605	260,994	33,641	4,296,133
Leigh Valley Area	1,809	14,695	5,902	18,801	141	121,856	5,607	83	120	302	7,755	9,027	56,084	1,417	243,599
New York - North Jersey Area	264,869	2,146,533	836,347	2,129,548	121,856	1,947,681	94,844	27,577	97,272	395,128	1,223,118	747,632	2,160,718	197,712	12,390,835
South Central PA Area	11,464	88,253	15,671	177,407	5,607	94,844	35,481	1,188	2,738	16,568	23,950	9,614	17,945	5,145	505,875
Atlantic City Area	583	14,730	2,092	4,259	83	27,577	1,188	268	311	1,933	3,118	980	1,436	522	59,082
Poughkeepsie-Newburgh-Middletown Area	12,694	67,973	23,814	11,034	120	97,272	2,738	311	1,790	8,180	6,682	3,772	34,853	2,249	273,481
Greater Albany Area	59,938	37,858	44,223	27,163	302	395,128	16,568	1,933	8,180	23,845	16,732	10,851	48,111	5,901	696,733
Greater Hartford Area	20,778	100,617	46,632	118,862	7,755	1,223,118	23,950	3,118	6,682	16,732	36,721	32,084	136,700	4,306	1,778,056
Greater Providence Area	4,168	55,098	32,685	96,605	9,027	747,632	9,614	980	3,772	10,851	32,084	47,729	142,681	881	1,193,805
Greater Boston Area	23,450	200,831	51,641	260,994	56,084	2,160,718	17,945	1,436	34,853	48,111	136,700	142,681	181,000	17,397	3,333,840
Springfield Area	1,333	16,392	5,879	33,641	1,417	197,712	5,145	522	2,249	5,901	4,306	881	17,397	12	292,787
Total Trips	488,851	4,287,887	1,646,242	4,296,133	243,599	12,390,835	505,875	59,082	273,481	696,733	1,778,056	1,193,805	3,333,840	292,787	31,487,206

Source: NEC FUTURE team, 2015

Appendix J – MSA-to-MSA Level Regional Rail Trips for each Alternative

Table J-1: Regional Rail Linked Trips by MSA pair: Year 2040 No Action Alternative, Origin-Destination Format

Annual Intercity-Corridor Rail Trips	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	South Central PA Area	Leigh Valley Area	New York - North Jersey Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Washington Area	13,649,394	4,309,919	39,312	0	0	0	0	0	0	0	0	0		17,998,625
Greater Baltimore Area	4,309,919	263,633	0	0	0	0	0	0	0	0	0	0	0	4,573,553
Greater Philadelphia Area	39,312	0	31,963,840	0	0	786,472	4,144	0	0	0	0	0	0	32,793,768
South Central PA Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leigh Valley Area	0	0	0	0	0	181,892	0	0	0	0	0	0	0	181,892
New York - North Jersey Area	0	0	786,472	0	181,892	314,804,584	0	3,103,116	0	0	0	0	0	318,876,064
Atlantic City Area	0	0	4,144	0	0	0	0	0	0	0	0	0	0	4,144
Poughkeepsie-Newburgh-Middletown Area	0	0	0	0	0	3,103,116	0	177,896	0	0	0	0	0	3,281,012
Greater Albany Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Hartford Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Providence Area	0	0	0	0	0	0	0	0	0	0	706,230	2,384,633	0	3,090,863
Greater Boston Area	0	0	0	0	0	0	0	0	0	0	2,384,633	36,637,525	0	39,022,158
Springfield Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	17,998,625	4,573,553	32,793,768	0	181,892	318,876,064	4,144	3,281,012	0	0	3,090,863	39,022,158	0	419,822,078

Source: NEC FUTURE team, 2015

Table J-2: Regional Rail Linked Trips by MSA pair: Year 2040 Alternative 1, Origin-Destination Format

Annual Intercity-Corridor Rail Trips	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	South Central PA Area	Leigh Valley Area	New York - North Jersey Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Washington Area	23,377,514	5,886,307	62,517	0	0	0	0	0	0	0	0	0		29,326,338
Greater Baltimore Area	5,886,307	426,647	0	0	0	0	0	0	0	0	0	0	0	6,312,954
Greater Philadelphia Area	62,517	0	35,215,712	0	0	1,027,120	12,580	0	0	0	0	0	0	36,317,929
South Central PA Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leigh Valley Area	0	0	0	0	0	206,016	0	0	0	0	0	0	0	206,016
New York - North Jersey Area	0	0	1,027,120	0	206,016	339,779,880	0	3,251,856	0	0	0	0	0	344,264,872
Atlantic City Area	0	0	12,580	0	0	0	0	0	0	0	0	0	0	12,580
Poughkeepsie-Newburgh-Middletown Area	0	0	0	0	0	3,251,856	0	172,272	0	0	0	0	0	3,424,128
Greater Albany Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Hartford Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Providence Area	0	0	0	0	0	0	0	0	0	0	3,976,895	4,066,870	0	8,043,765
Greater Boston Area	0	0	0	0	0	0	0	0	0	0	4,066,870	42,492,685	0	46,559,555
Springfield Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	29,326,338	6,312,954	36,317,929	0	206,016	344,264,872	12,580	3,424,128	0	0	8,043,765	46,559,555	0	474,468,138

Source: NEC FUTURE team, 2015

Table J-3: Regional Rail Linked Trips by MSA pair: Year 2040 Alternative 2, Origin-Destination Format

Annual Intercity-Corridor Rail Trips	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	South Central PA Area	Leigh Valley Area	New York - North Jersey Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Washington Area	29,992,651	6,716,964	62,927	0	0	0	0	0	0	0	0	0		36,772,542
Greater Baltimore Area	6,716,964	454,706	0	0	0	0	0	0	0	0	0	0	0	7,171,670
Greater Philadelphia Area	62,927	0	36,386,392	0	0	1,264,216	12,580	0	0	0	0	0	0	37,726,115
South Central PA Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leigh Valley Area	0	0	0	0	0	208,088	0	0	0	0	0	0	0	208,088
New York - North Jersey Area	0	0	1,264,216	0	208,088	349,257,504	0	3,152,696	0	0	0	0	0	353,882,504
Atlantic City Area	0	0	12,580	0	0	0	0	0	0	0	0	0	0	12,580
Poughkeepsie-Newburgh-Middletown Area	0	0	0	0	0	3,152,696	0	171,976	0	0	0	0	0	3,324,672
Greater Albany Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Hartford Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Providence Area	0	0	0	0	0	0	0	0	0	0	3,624,370	4,141,210	0	7,765,580
Greater Boston Area	0	0	0	0	0	0	0	0	0	0	4,141,210	44,346,465	0	48,487,675
Springfield Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	36,772,542	7,171,670	37,726,115	0	208,088	353,882,504	12,580	3,324,672	0	0	7,765,580	48,487,675	0	495,351,426

Source: NEC FUTURE team, 2015

Table J-4: Regional Rail Linked Trips by MSA pair: Year 2040 Alternative 3, Origin-Destination Format

Annual Intercity-Corridor Rail Trips	Greater Washington Area	Greater Baltimore Area	Greater Philadelphia Area	South Central PA Area	Leigh Valley Area	New York - North Jersey Area	Atlantic City Area	Poughkeepsie-Newburgh-Middletown Area	Greater Albany Area	Greater Hartford Area	Greater Providence Area	Greater Boston Area	Springfield Area	Total Trips
Greater Washington Area	37,063,509	7,482,062	99,645	0	0	0	0	0	0	0	0	0		44,645,216
Greater Baltimore Area	7,482,062	481,676	0	0	0	0	0	0	0	0	0	0	0	7,963,738
Greater Philadelphia Area	99,645	0	37,925,888	0	0	1,490,804	12,580	0	0	0	0	0	0	39,528,917
South Central PA Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leigh Valley Area	0	0	0	0	0	249,972	0	0	0	0	0	0	0	249,972
New York - North Jersey Area	0	0	1,490,804	0	249,972	374,433,488	0	3,449,436	0	0	0	0	0	379,623,700
Atlantic City Area	0	0	12,580	0	0	0	0	0	0	0	0	0	0	12,580
Poughkeepsie-Newburgh-Middletown Area	0	0	0	0	0	3,449,436	0	172,272	0	0	0	0	0	3,621,708
Greater Albany Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Hartford Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Providence Area	0	0	0	0	0	0	0	0	0	0	4,218,795	4,665,130	0	8,883,925
Greater Boston Area	0	0	0	0	0	0	0	0	0	0	4,665,130	56,309,010	0	60,974,140
Springfield Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	44,645,216	7,963,738	39,528,917	0	249,972	379,623,700	12,580	3,621,708	0	0	8,883,925	60,974,140	0	545,503,896

Source: NEC FUTURE team, 2015

B.9. Operations and Maintenances Costs TM – Errata Sheet

	Incorrect Tier 1 Draft EIS Text/Table		Tier 1 Final EIS Text/Table (Volume 2) Page
	Page	Description	
1.		Final version replaces version included in Tier 1 Draft EIS	

NEC FUTURE
A Rail Investment Plan for the Northeast Corridor

Operations and Maintenance (O&M) Costs Technical Memorandum

October 5, 2015
Final Version

Submitted by:

PARSONS BRINCKERHOFF AECOM
A JOINT VENTURE

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1. Introduction

1.1 PURPOSE OF ANALYSIS

The Federal Railroad Administration (FRA) prepared the operations and maintenance (O&M) cost estimates to provide representative estimates of the costs to operate and maintain the proposed Service Plans[1] for the Tier 1 Draft Environmental Impact Statement (Tier 1 Draft EIS) No Action and Action Alternatives. This technical memorandum documents the data sources, key assumptions, and approach used to estimate these O&M cost projections for the NEC FUTURE program (NEC FUTURE). The methodology produced high-level, order-of-magnitude estimates for O&M costs appropriate for a Tier 1 Draft EIS level of review. In conjunction with the capital cost estimates, these O&M estimates facilitate comparative cost analysis between the No Action and each Action Alternative, and, for Intercity services, assess whether the proposed Service Plans are likely to generate an operating surplus where revenues exceed costs.

Where available, the FRA used data on recent actual Amtrak and commuter-rail O&M costs as a starting point for the analysis. The availability of this information varied across the type of rail service and cost category, and was supplemented by additional cost estimates where needed to provide a more comprehensive data set. To facilitate consistent application of cost estimates across all proposed NEC FUTURE Service Plans, the FRA combined these data, generalized them across the corridor, and applied them based on key assumptions about the operational characteristics of the NEC FUTURE service types (e.g., Intercity-Express, Intercity-Corridor, Metropolitan, and Regional rail, as further defined in the *Service Plans and Train Equipment Options Technical Memorandum*).

The estimation of O&M costs for the NEC FUTURE alternatives considered the following assumptions and data availability constraints:

- **Amtrak O&M cost data is proprietary**: Amtrak actual costs by cost center and the resulting unit costs are important baseline inputs to the O&M cost estimates. However, these data are proprietary business information that is strictly governed by a non-disclosure agreement signed by the participants of this analysis. To respect this proprietary information, the FRA has reported the methodology of how these data were used, and presented summary-level results only. For this analysis, existing Amtrak services (i.e., Acela Express and Northeast Regional) are referenced solely in the context of applying currently available data. The source for this data does not presume the potential operator of NEC FUTURE proposed service.
- **Peer agency cost data is incomplete and unreliable**: Outside of the Northeast Corridor (NEC), there are no other passenger rail operations in the United States that share substantially similar operating characteristics to those proposed in the NEC FUTURE alternatives. Comparable international passenger rail data—in terms of unit O&M costs—are either governed by

[1] The Service Plans developed for the No Action and Action Alternatives are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assessment of the environmental impacts associated with planned improvements. The Service Plans are not intended to be prescriptive regarding how service should be operated in the future. In addition, the Service Plans are not intended to predict future operating patterns of the NEC operators.

confidentiality considerations similar to Amtrak or are poor analogues to apply because of different specifications (e.g., vehicle weights, vehicle buff strengths), different operating speeds and frequencies, and lack of documentation.

- **California High-Speed Rail Authority (CHSRA) O&M costing methodology is confidential and applicable only on new alignments**: Only the most highly aggregate unit costs (e.g., total maintenance-of-way cost per train mile) are available from the CHSRA O&M cost methodology. The FRA used the unit costs derived from the CHSRA data to estimate costs for new segments and do not represent typical costs for the exiting NEC.
- **Unit O&M costs for NEC FUTURE Regional services are not available from the commuter railroads**: The commuter railroads do not have O&M cost models. The only available source of cost and operational data for these services are the National Transit Database (NTD) reports that are submitted by those agencies to the Federal Transit Administration. The NTD data provide limited ability to develop useful unit costs, particularly for maintenance-of-way, because all non-vehicle maintenance functions (e.g., track, structure, power, signal, and communications) are combined, even though the underlying cost drivers for these individual functions are different.

1.2 STRUCTURE OF TECHNICAL MEMORANDUM

The FRA structured this technical memorandum to present the step-by-step process used to develop the O&M costs. Section 2 discusses the approach taken to develop the O&M cost estimates and how the approach incorporates best practices in estimating high-speed rail O&M costs. Section 3 provides an overview of the model structure. Section 4 discusses the various data inputs and sources of information. Section 5 presents a discussion on the unit cost calculation and application. Section 6 presents the summary-level analytical results for the No Action and Action Alternatives as well as a high-level contribution analysis comparing all alternatives.

2. Methodology

The FRA used the Office of Inspector General's (OIG) June 2011 report entitled *HSIPR Best Practices: Operating Costs Estimation* (OIG Report) as a key reference document in developing the O&M cost model.[2] In particular, the FRA used Section 4, "Best practice: preliminary stage proposals," to structure the O&M cost estimates for NEC FUTURE. That section identified the following seven key cost areas that provide clear groupings under which O&M costs can be categorized:

- Train crews: drivers, conductors, onboard services (OBS)
- Energy: diesel fuel or electricity costs associated with train propulsion power
- Stations: ticket sales, customer information and train dispatching services; station building utility and maintenance costs
- Rolling stock: lease payments on rolling stock are considered an operating cost
- Train maintenance: routine planned maintenance of the rolling stock fleet; maintenance resulting from vandalism and accidents; includes all costs associated with train cleaning
- Railroad: costs to operate and maintain the railroad (infrastructure) for a specified train ervice plan
- General and Administrative (G&A): management, marketing, sales and reservations, all general office expenses

For the proposed NEC FUTURE service types, all but the rolling stock cost area are anticipated O&M cost areas. The FRA included rolling stock procurement costs in the capital cost estimates.

The OIG Report also identified key elements of the representative Service Plans that contribute to estimating of O&M costs, including:

- Route operated
- Key stations served
- Train frequency
  - End-to-end (network) travel time and distance
  - Assumed/required turnaround times
  - Daily number of seats provided
  - Days of operation
  - Start and end time of service day

In addition to providing information on train frequency, these representative Service Plans provided the basis for calculating train hours and train miles—a critical input for estimating operating costs,

[2] Office of the Inspector General (OIG), 2011. *HSIPR Best Practices: Operating Costs Estimation*. U.S. Department of Transportation, Washington, D.C., https://www.oig.dot.gov/foia-electronic-reading-room.

since numerous resource needs (e.g., number of trains, propulsion energy, and staffing requirements) tend to vary directly with changes in train hours or in train miles. The Service Plans are intended to be representational only, required for analysis of capacity, performance, and costs, as well as assessments of environmental impacts associated with planned improvements. The Service Plans are not intended in any way to be prescriptive regarding how service should be operated in the future. Additionally, the physical characteristics, such as the route operated and stations served, provide the basis for determining route and track distances (e.g., route and track miles) as well as ridership. Changes in physical characteristics directly affect the level of resources required to maintain the railroad right-of-way as well as physical plant operations and cleaning.

General best practices in O&M cost modeling for transportation planning recommend leveraging the most recent, stable cost experience regarding current service operations and characteristics of technologies similar to that being proposed, as well as applying the operating plan at a level of detail that is consistent with the plan detail applied in the travel demand modeling. To comply with this recommendation, as well as the guidance from the OIG Report, the O&M cost model used recent (i.e., FY 2013) actual Amtrak cost experience to project O&M costs for Intercity service for the No Action and Action Alternatives Service Plans. The FRA used Amtrak cost data as a baseline for projecting costs for existing portions of the NEC. This assumption recognizes that the underlying NEC O&M costs are a function of the corridor's extensive existing operations, unique infrastructure and equipment maintenance needs, and detailed labor agreements. It also recognizes the availability of relevant and reasonably high-quality source data about the NEC cost experience. As such, the FRA did not use projected costs for other proposed intercity high-speed rail services (e.g., California high-speed rail, international high-speed rail) for the existing NEC territory.

To align the level of effort in developing the O&M costs to the conceptual level of detail in the No Action and Action Alternatives, the O&M cost modeling approach leveraged existing Amtrak financial data reports. One such report was the Amtrak Performance Tracking (APT) system report.

Since the NEC FUTURE Service Plans include corridor-wide Intercity and Regional rail service, the analysis needed to consider infrastructure-related costs (e.g., maintenance–of-way, train dispatching, propulsion, and physical plant maintenance) incurred on the territory that the Service Plans operate on, regardless of service or operator. These costs are representative of the Service Plans and associated infrastructure improvements, and were developed for planning purposes only. Assembling this data from existing Amtrak reports is difficult since O&M-related costs are allocated by Amtrak's current business lines and services. Thus, the O&M cost model leveraged an analytical tool—the cost aggregation database, which was developed for the Northeast Corridor Infrastructure and Advisory Commission (NEC Commission)—that captures the full O&M cost for infrastructure-related O&M activities on the existing NEC from Washington, D.C., to Boston. The cost aggregation database addresses the energy (e.g., propulsion power and maintenance), stations, and railroad cost areas mentioned in the OIG Report. Section 4.1.1 further describes the cost aggregation database.

The O&M cost model utilized the APT reports as source material for non-infrastructure-related Intercity costs, such as train crews, train maintenance, transportation operations, and G&A. These cost areas are service dependent (e.g., different crew or equipment requirements by service). Since these costs are exclusively Intercity transportation- and equipment-related costs, the APT reports were the appropriate data source. Specifically, the APT report is utilized to address the energy (e.g., diesel train fuel), train crews (which includes train operations), train maintenance, and G&A (which includes sales and marketing and corporate operation costs) cost areas mentioned in the OIG Report. Section 4.1.2 provides further information on the APT report.

While O&M costs for segments of the existing NEC are based upon current Intercity costs in the corridor, some of the NEC FUTURE alternatives propose significant new, off-corridor rights-of-way as well as different equipment types that incur a different O&M cost profile. Thus, relevant unit costs for new high-speed rail operations for the proposed California High-Speed Rail project are included for new equipment (e.g., electric multiple-unit trainsets) and new off-corridor rights-of-way. These unit costs are utilized because of the following:

- Dedicated high-speed segments on new rights-of-way are designed to current international standards such as those proposed for the California system. It is unlikely that this new track hosts the same mix of varied and complex infrastructure and operations of the current or upgraded NEC.
- New multiple-unit high-performance equipment will have a different maintenance cost experience than the current equipment in use on the NEC today.

The unit costs for new high-speed operations address the train maintenance and railroad cost areas mentioned in the OIG Report. Section 4.4 provides further information on the unit costs applied.

To address non-infrastructure-related costs for the commuter-rail operators, the FRA used transportation-related commuter-rail costs to present a complete assessment of O&M costs for the projected Regional rail service. The FRA also used cost data from the NTD reports because the commuter railroads did not have their own O&M cost models for use in this analysis. While NTD reports recognized limitations (particularly in not separating different non-vehicle maintenance functions), they were the only sources of O&M costs and level-of-service data available for all NEC commuter operations. The FRA used right-of-way maintenance unit costs only for MTA-Metro-North Railroad because it owns the NEC right-of-way between New Rochelle, NY, and New Haven, CT. These costs address all the cost areas mentioned in the OIG Report. Section 4.1.3 provides further information on the commuter-rail costs.

Table 1 shows how each type of O&M cost discussed above and identified for use in the O&M cost model addresses the cost areas mentioned in the OIG Report.

Once the FRA assembled appropriate cost information, cost drivers were assigned to each cost group. The existing unit cost was calculated by dividing existing cost by the existing cost-driver value. The unit cost was then applied to the projected cost-driver value to obtain the forecast O&M cost.

Table 1: O&M Cost Areas Addressed by Various Cost Data Types Used in the O&M Cost Model

Type of Cost for Use in O&M Cost Model	Office of Inspector General Best Practice Cost Area Addressed					
	Train Crews	Energy	Stations	Train Maintenance	Railroad	G&A (incl. sales & marketing, corp. mgmt.)
Intercity infrastructure-related		✓ *(electric propulsion)*	✓		✓	
Intercity train-based, transportation service and national operations	✓	✓ *(diesel fuel)*		✓		✓
High-speed operation on new right-of-way and for new equipment				✓	✓	
Transportation-related commuter-rail costs for operators along the NEC	✓	✓	✓	✓	✓ *(where applicable)*	✓

Source: NEC FUTURE team, 2015

The NEC FUTURE Service Plans are different from the existing service, and the operating and physical characteristics associated with the proposed Service Plans are likely to alter O&M cost experiences. Thus, the FRA used these representative Service Plans to evaluate certain impacts to unit costs resulting from efficiencies in technology or inefficiencies in capacity. These impacts were implemented as adjustment factors and multiplied to the existing unit costs to obtain the projected unit costs. Section 5.3.2 presents further discussion on these factors.

To achieve the objective of determining whether the proposed Intercity service results in an operating surplus, the FRA subtracted forecasted O&M cost from the forecasted revenue, which yielded the net contribution amount. A positive net contribution indicates that the Intercity revenues exceed the O&M cost of the representative Service Plan.

3. Model Structure

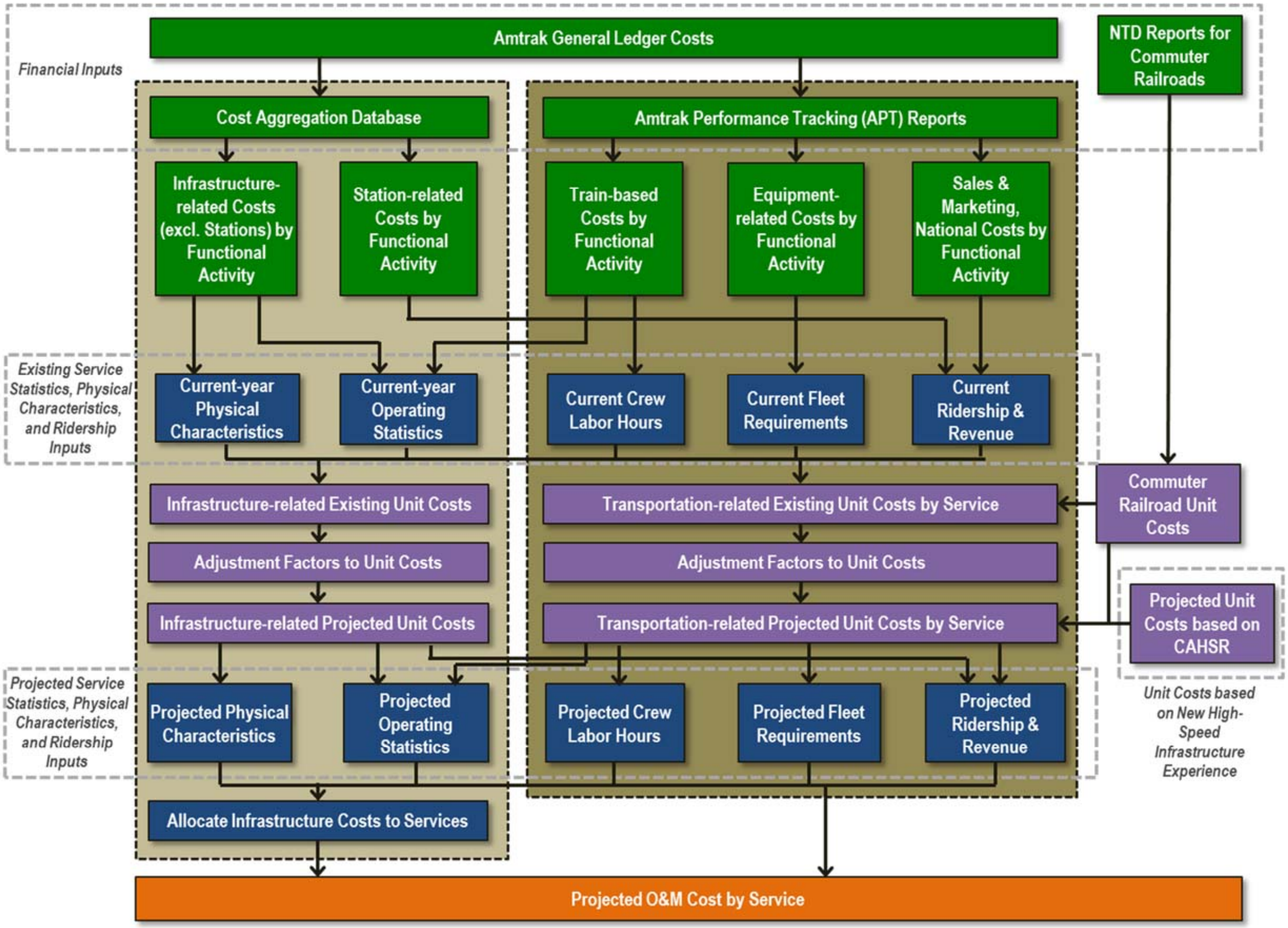
The O&M cost model is a Microsoft Excel-based spreadsheet model that compiles various data inputs from a number of sources, which derive unit O&M costs through a transformation of the cost data and level-of-service information. Unit costs are generally derived function-by-function as cost divided by either quantity of service or physical characteristics. The FRA then applied these unit O&M costs to projected level-of-service and physical characteristics information to produce O&M cost forecasts for the No Action and Action Alternatives for each of the proposed NEC FUTURE service types.

Figure 1 describes the model structure applied in the O&M cost model, which consists of the following five major elements:

- Data input elements are surrounded by a **light gray** rectangle with dashed lines.
- Cost/financial data elements are shaded in **green.**
- Cost-driver variables elements are shaded in **blue.**
- Unit cost elements are in various shades of **purple.**
- The application element is shaded in **orange.**

Solid arrows indicate the direction of data flow and that the element is directly used in a calculation. The elements surrounded by a **light-tan**-shaded rectangle represent the process to derive infrastructure-related unit costs and O&M cost projections. Elements surrounded by the **dark-tan**-shaded rectangle represent the process to derive transportation-, equipment-, and G&A-related unit costs and O&M cost projections.

Figure 1: O&M Cost Model Structure



Source: NEC FUTURE team, 2015

The O&M cost model is structured in a series of sheets within a single file that addresses the following sequential phases:

- **Cost identification and aggregation**. The O&M cost model first identified the O&M costs from each cost/financial data input (e.g., the cost aggregation database, the APT reports, or the NTD reports) that represent the O&M costs associated with the representative Service Plans for the No Action and Action Alternatives and are the types of costs identified in the OIG Report. The FRA then aggregated these costs to a corridor-wide level by type of cost (e.g., by cost area) and by functional activity. Transportation- and equipment-related costs (e.g., costs from the APT reports) were also aggregated by existing service type (e.g., Acela Express, Northeast Regional). This level of aggregation is acceptable for a Tier 1 Draft EIS review since it captures high-level costs related to major O&M activities that are driven by a different cost driver.
- **Cost-driver variables.** The O&M cost model then incorporated from the various cost-driver inputs the existing physical characteristics (e.g., the number of track miles), operating statistics (e.g., the number of train miles, train frequency), crew labor hours, fleet requirements, and ridership and revenue data. The FRA assigned costs associated with each functional activity a cost driver based on industry knowledge and experience. For infrastructure-related cost areas and functional activities, the FRA selected an allocation driver to allocate those costs to the various users of the infrastructure based on industry knowledge and experience.
- **Unit cost.** To calculate the existing unit costs, the O&M cost model divided the existing costs aggregated by cost area, functional activity, and by service (e.g., for train crews and operations, train maintenance, and G&A cost areas) by the appropriate existing cost-driver variable. Recognizing that there may be some efficiency gained from new technologies, or some inefficiency resulting from increased corridor traffic/density, the O&M cost model multiplied the existing unit costs for certain functional activities by adjustment factors to calculate projected NEC FUTURE unit costs.
- **Application.** To determine the O&M cost forecast for the No Action and Action Alternatives, the O&M cost model multiplied the unit costs by cost area, functional activity, and by service (where applicable) with the projected cost-driver values. The projected unit costs were applied to the increment of cost-driver value above the current conditions; the existing unit costs were applied to existing amount of the cost-driver value.

Section 4 describes the data input in detail, while Section 5 describes each of the four phases mentioned above in detail.

4. Data Inputs

This section describes the four categories of data sources utilized in the O&M cost model. Section 4.1 describes financial inputs. Section 4.2 describes existing physical characteristics, services statistics, and ridership. Section 4.3 describes projected physical characteristics, service statistics, and ridership. Section 4.4 describes the unit costs based on new high-speed rail infrastructure.

4.1 FINANCIAL INPUTS

The financial inputs to the O&M cost model include Amtrak's general ledger (for the cost aggregation database and the APT reports) and the NTD (for the commuter railroads). The FRA derived unit costs using Amtrak FY 2013 data in 2013 dollars.[3] Application of the unit costs, discussed in Section 5, included a conversion to 2014 dollars using appropriate Association of American Railroads inflation indices.

4.1.1 Cost Aggregation Database

The NEC Commission maintains the cost aggregation database, which is a Microsoft Access-based database that contains all actual costs reported in Amtrak's general ledger for fiscal year 2013. The database identifies shared infrastructure-related operating costs for six major cost areas and 19 functional activities. Costs are associated with geographic segments. Costs are aggregated by cost center, by internal order, and by cost element. The internal order information generally denotes the functional activity, while the cost element information differentiates salary, wages, materials, and other cost categories. Costs are classified as either a direct cost, which are traceable to a specific physical asset or service provided to customers (e.g., maintenance-of-way or maintenance of equipment), or indirect costs, which are shared across multiple routes or services (e.g., supervision, support, and administrative functions).

Actual Amtrak cost experience was the source of the projection of costs for shared infrastructure (electric propulsion, maintenance-of-way, police (road, yard, and station), power directors, train dispatching, and station maintenance) for the No Action and Action Alternatives within the existing NEC right-of-way. The FRA aggregated this confidential information from the Amtrak general ledger for development of shared infrastructure unit costs.

4.1.2 Amtrak Performance Tracking (APT) Report

The APT system allocates and reports Amtrak financial and performance data by service and by Amtrak business line. The system considers all costs from Amtrak's general ledger and aggregates costs into major activities called cost families that align with the cost areas mentioned in the OIG Report. The APT system allocates costs to the services based on cost directly incurred by those services (e.g., trainmen and enginemen working a particular train on a route) or by an allocation rule (e.g., allocating shared costs by a performance measure such as ridership). To be consistent

[3] The FRA used FY 2013 costs in the O&M cost model since they were the most recent complete set of financial data available for the analysis. Amtrak was still in the process of reconciling final costs for FY 2014 during the model development.

with the cost aggregation database, FY 2013 APT data were used in the O&M cost model. The FRA did not use non-infrastructure-related (e.g., train crews and operations, train maintenance, and G&A) financial and performance data for the Acela Express and the Northeast Regional services in the analysis.

4.1.3 National Transit Database (NTD) Reports

The FRA obtained the NTD reports for the 2012 reporting period[4] for the following agencies for commuter-rail mode only:

- Massachusetts Bay Transportation Authority (MBTA)
- Connecticut Department of Transportation (ConnDOT)
- MTA-Metro-North Railroad (MNR)
- MTA-Long Island Rail Road (LIRR)
- New Jersey Transit Corporation (NJ TRANSIT)
- Southeastern Pennsylvania Transportation Authority (SEPTA)
- Maryland Transit Administration (MARC)

The NTD reports summarize costs for the following functions: vehicle operations, vehicle maintenance, non-vehicle maintenance, and G&A categories. The reports also convey the number of track miles, annual total vehicle revenue hours, and annual total vehicle revenue miles. The FRA inflated costs to FY 2013 dollars for use in the O&M cost model. Unit costs were developed by the following:

- Dividing vehicle operations costs by total vehicle revenue hours
- Dividing vehicle maintenance costs by total vehicle revenue miles
- Dividing non-vehicle maintenance costs by the number of track miles

4.2 EXISTING PHYSICAL CHARACTERISTICS, SERVICE STATISTICS, AND RIDERSHIP

The FRA assigned five major cost-driver types to costs to derive unit costs: physical characteristics (e.g., track miles, route miles), operating statistics (e.g., revenue hours, revenue miles, and frequency), crew labor hours, fleet requirements, and ridership and ticket revenue. This section details the sources for the existing cost-driver variables. To be consistent with the cost inputs, all cost-driver values reflect physical and service characteristics of the NEC in 2013.

- Amtrak's Engineering department provided the following existing physical characteristics:
  - Number of track miles
  - Number of route miles

[4] At the time of this analysis, NTD reports from 2012 were the most recent year available.

- The APT report for Acela Express and Northeast Regional services and the Amtrak timetable provided the following existing operating statistics:
  - Annual train revenue miles, by service
  - Annual train frequency, by service
  - Annual train revenue hours, by service
- The APT report for Acela Express and Northeast Regional services provided the existing crew labor hours and included information on the following:
  - Trainmen crews
  - Enginemen crews
  - Onboard service crews
- Amtrak's Engineering department provided existing fleet requirements and included the number of trainsets by service.
- The APT report for Acela Express and Northeast Regional services provided existing ridership and ticket revenue.

4.3 PROJECTED PHYSICAL CHARACTERISTICS, SERVICE STATISTICS, AND RIDERSHIP

The FRA used engineering, service planning, and ridership data sources from the NEC FUTURE models for the projected values of the five major categories of cost-driver variables for the No Action and Action Alternatives.

- Projected physical characteristics were developed from engineering data:
  - Number of track miles for both the existing NEC right-of-way and new rights-of-way
  - Number of route miles for both the existing NEC right-of-way and new rights-of-way
- Projected operating statistics were developed from the representative Service Plans:
  - Annual train revenue miles, by service
  - Annual train frequency, by service
  - Annual train revenue hours, by service
- Projected crew labor hours were derived by multiplying the projected train revenue hours and the ratio between existing crew labor hours to existing revenue hours by service.
- Projected fleet requirements were developed from representative Service Plans.
- Projected ridership and ticket revenue were developed from ridership data.

4.4 UNIT COSTS BASED ON NEW HIGH-SPEED INFRASTRUCTURE

Unit costs for maintenance of new high-speed right-of-way and new high-speed multiple-unit equipment were provided by the NEC FUTURE team's experience in developing O&M costs for the CHSRA. High and low estimates are provided for maintenance of infrastructure per track mile and maintenance of equipment per train mile. The O&M cost model utilized the high estimates. The unit costs were derived by the CHSRA in 2014 dollars and were initially converted to 2013 dollars to be consistent with the unit costs derived from Amtrak data. The combined unit costs (both Amtrak- and CHSRA-derived) were subsequently converted to 2014 dollars in the application of the unit costs as described in Section 5.

5. Unit Cost Calculation and Application

This section describes the calculation of O&M unit costs and their application to projected levels of services for the No Action and Action Alternatives. Section 5.1 describes the different types of costs and the process to identify and aggregate them into the appropriate level of detail for a Tier 1 analysis. Section 5.2 reviews the assignment of cost-driver variables to each cost area and functional activity. Section 5.3 discusses the derivation of unit costs. Section 5.4 discusses the application of the unit costs to the projected cost-driver variable values to obtain the projected O&M costs.

While this section describes the calculation of O&M unit costs by dividing costs by cost driver, no actual costs or resulting unit costs are shown because of the proprietary nature of the information. The numeric values are available and were reviewed by parties who signed a non-disclosure agreement.

5.1 COST IDENTIFICATION AND AGGREGATION

This section describes the process of identifying and aggregating O&M costs from the cost aggregation database and the APT reports for the Acela Express and Northeast Regional services.

5.1.1 Infrastructure-related Costs from the Cost Aggregation Database

Table 2 lists the six major cost areas and 23 functional activities that are infrastructure-related costs identified through the cost aggregation database; the table maps each cost area to the cost areas identified in the OIG Report. For this analysis, the FRA included four additional station-related functional activities (i.e., costs associated with baggage & express, first-class lounge, porters, and ticketing functions) as infrastructure-related costs. Costs were aggregated at this level of detail to be consistent with the work done for the NEC Commission in determining groups of costs that could be affected by different cost drivers.

Functional activities associated with electric propulsion, maintenance-of-way, and power directors cost areas generally reflect the cost for maintenance activity on a particular asset class. The exception is electric traction power, which is the actual cost to provide electric propulsion to trains on the NEC.

For the train dispatching cost area, the FRA differentiated costs for blocks and tower operations at major terminals from costs for centralized control and dispatching along the entire NEC. The police cost area has separate functional activities for road costs (e.g., detectives who patrol the right-of-way), yard costs (e.g., patrols at the yard), and station costs (e.g., police located at stations).

Functional activities associated with stations represent the major types of amenities found at Intercity stations as well as station facility maintenance and station cleaning operations. Industry knowledge and experience suggest that for long-range alternatives analysis, ridership is an appropriate cost driver for these functional activities. However, there is no station-by-station ridership information for the Regional rail services in the No Action and Action Alternatives. Thus, the station costs applied in the O&M cost model are only the Intercity (e.g., modeled on existing Amtrak) portion of the total station O&M cost. These costs were estimated by applying a ratio of Amtrak's existing train stops and existing passenger on-offs to all NEC operators' existing train stops and existing passenger on-offs at Amtrak stations.

Table 2 also differentiates between existing infrastructure and new infrastructure for maintenance-of-way. The FRA categorized the new infrastructure maintenance-of-way by costs associated with additional track along the existing NEC mainline, and by cost associated with new alignment track.

Table 2: Cost Areas and Functional Activities Included from the Cost Aggregation Database

Cost Area	OIG Report Cost Area	Functional Activity
EXISTING INFRASTRUCTURE		
Electric Propulsion	Energy	Electric Traction Power
		Frequency Converter Maintenance
Maintenance-of-Way	Railroad	Bridges
		Communication Systems
		Electric Traction
		Equipment
		Facilities
		Signal & Interlocking
		Track
Police – Road, Yard, & Station	Railroad	Road
		Yard
Power Directors	Railroad	Power Directors & Load Dispatchers
Train Dispatching	Railroad	Blocks & Towers
		Control & Dispatch
Police – Road, Yard, & Station	Railroad	Station Police
Station Maintenance & Services	Stations	Baggage & Express
		First Class Lounge
		Porters
		Station Maintenance
		Station Operations
		Stationmasters & Ushers
		Ticketing
		Utilities
NEW INFRASTRUCTURE		
Maintenance-of-Way	Railroad	Existing Alignment – New Track
Maintenance-of-Way – New		New Alignment – Track

Source: NEC FUTURE team, 2015

For this analysis, the infrastructure-elated costs were aggregated at the level of detail suggested in Table 2 (i.e., corridor-wide by cost area and by functional activity). The geographic or location-based information from the cost aggregation database was only utilized to determine the NEC territory for which representative Service Plans for the No Action and Action Alternatives applied. The analysis excluded infrastructure-related costs for the existing New Haven to Springfield branch line as well as the Harrisburg line west of Philadelphia. These costs were developed for planning purposes only, based on the representative Service Plans.

5.1.2 Transportation, Equipment, and G&A Costs from the APT Report

In addition to infrastructure-related costs, train crews and operations, train maintenance, and G&A costs needed to be 1) identified and 2) mutually exclusive to the costs included from the cost aggregation database. Table 3 lists nine additional cost areas and 30 functional activities from the APT report that are transportation, equipment, sales and marketing, and national operations costs. The table also maps the APT report cost areas to the cost areas mentioned in the OIG Report. The FRA aggregated these costs by cost area, functional activity, and by existing service (e.g., Acela Express and Northeast Regional).

Table 3: Cost Areas and Functional Activities Included from the APT Report

Cost Area	OIG Report Cost Area	Functional Activity
Maintenance of Equipment (MoE)	Train Maintenance	Turnaround
		Locomotive Maintenance
		Car Maintenance
		MoE Support
		MoE Multiple Functions
		High-speed Rail Maintenance
		Backshop
Onboard Services (OBS)	Train Crews	Crew
		Supplies – Food & Beverage (F&B)
		Commissary/ Management - F&B
		Support
Trainmen & Enginemen (T&E)	Train Crews	Trainmen Crew
		Enginemen Crew
		Other T&E Activity
		T&E Support
Yard	Train Crews	Train & Equipment
		Equipment Moves
	Railroad	Yard Direct
		Terminal Rent/ Yard Services
Fuel	Energy	Train Fuel (Diesel)
Other Transportation Ops	Railroad	Transportation – Multiple Functions
		Transportation Support
Sales & Marketing	G&A	Sales
		Information & Reservations
		Marketing
Police, Security, Environmental	G&A	National Police – Special Ops.
		Emergency Mgmt. & Corp. Security
		Environmental & Safety
G&A	G&A	G&A Fixed
		G&A Variable

Source: NEC FUTURE team, 2015

Functional activities associated with the maintenance of equipment (MoE) cost area reflect the cost associated with turnaround servicing (e.g., train cleaning) as well as costs associated with asset-specific maintenance activities (e.g., locomotive and car maintenance). The APT report also distinguishes between MoE support costs (e.g., material handling and fleet engineering) and MoE multiple function costs that support more than one MoE maintenance activity. The FRA included costs associated with maintaining current Acela Express equipment in the high-speed rail maintenance functional activity. Current Acela MoE costs were applied to calibrate the O&M cost model based on Amtrak experience and to project the O&M cost for the No Action Alternative (since no new fleet is assumed in that alternative). Finally, the FRA captured costs associated with major overhauls and repairs in the backshop functional activity.

Functional activities for the trainmen and enginemen (T&E), onboard service (OBS), and yard cost areas generally reflect crew requirements and the support to provide crew assignments and dispatch crews. Also included in the OBS cost area were costs for food and beverage supplies as well as costs for commissary operation and management.

The fuel cost area was included in the O&M cost model since this is the cost for diesel train fuel. Functional activities for the other transportation operations cost area represent costs for transportation-related administrative functions (e.g., T&E, OBS, and passenger services) and costs for multiple transportation-related activity supervision and support.

The G&A costs as defined by the OIG Report include corporate-level and sales and marketing activities. Amtrak further categorizes these G&A costs into the sales and marketing cost area, police, security, and environment cost area, and a G&A cost area.

The sales and marketing cost-area functional activities distinguish between costs associated with sales, information and reservations, and marketing activities. The police, security, and environmental cost-area functional activities distinguish between costs for special operations police (who are not detectives or station and yard patrolmen), corporate security, and corporate environmental and safety initiative implementation.

The G&A cost area includes corporate administration, general centralized services (e.g., human resources, labor relations), and financial centralized services (e.g., payables, receivables, and payroll) costs. The majority of G&A costs are considered fixed costs (i.e., the costs will not vary with a change in service). The variable G&A cost are costs associated with the treasury mandatory function. This function includes various finance department costs, the largest of which are associated with passenger credit card transactions and insurance premiums.

5.2 SELECTION OF COST DRIVERS

This section introduces the cost drivers used to derive unit costs. These cost drivers—assembled from the various inputs described in Section 4.2—were transformed to meet the requirements of this analysis, and were assigned to costs at the functional activity level. In addition to deriving unit costs, the FRA used these cost drivers to allocate infrastructure-related costs to the various Intercity and Regional/Commuter services. In several instances, the cost driver used to derive the unit cost was different from the cost driver (i.e., allocation driver) that was used to allocate infrastructure-related costs across the NEC FUTURE service types. Cost-driver and allocation-driver assignments were based on industry knowledge and experience with changes in O&M costs as a result of changes in cost-driver values.

5.2.1 Cost Drivers and Allocation Drivers for Infrastructure-Related Costs

Since infrastructure-related O&M costs were aggregated by territory regardless of the service operated, those costs required an assignment of a cost driver as well as an allocation driver. The unit cost resulting from the cost-driver element represents the change in O&M cost per change in service. The allocation driver was selected as a method to distribute the costs on a consistent basis across all alternatives to the different NEC FUTURE service types.

Functional activities associated with electric propulsion and power directors were assigned electrified train miles for both the cost driver and the allocation driver. Electrified train miles were derived from existing train miles based on the existing electrified service across the NEC. This cost driver was derived to better associate electric propulsion costs to actual consumption by service (e.g., currently the MBTA does not run electrified service on the NEC).

Maintenance-of-way costs are driven by inspection and testing activities on the different infrastructure asset classes. Much of this activity is done on a calendar basis rather than based on the activity level along the corridor. As such, the number of track miles was assigned as the cost driver for all maintenance-of-way functional activities. Existing track miles pertain to existing maintenance-of-way costs. Any additional track miles along the NEC or new track miles off-corridor were assigned those respective track mile values. The allocation driver was different for all functional activities since it needed to be a service-related statistic to be able to allocate costs to each of the services. Costs associated with maintaining bridges, equipment, facilities, and track assets were allocated on the basis of train miles to reflect the share of usage of the infrastructure corridor-wide. Communication systems and signal and interlocking costs were allocated on the basis of train frequency to reflect the share of occupancy on the network. Electric traction maintenance costs were allocated on the basis of electrified train miles to reflect the electric propulsion consumption by user.

Road and yard police functional activity costs are driven by patrols that do not vary with increases in service but do vary with increases in territory (in distance covered, not the number of tracks). Thus, police road and yard costs are driven by total route miles. These costs were assigned train miles as the allocation driver to reflect the share of usage of the infrastructure corridor-wide.

Train dispatching costs are driven by the amount of territory managed (not necessarily on the level of activity on the NEC). Thus, track miles are assigned as the cost driver for dispatching costs. These costs were allocated to the services on the basis of frequency to reflect the share of occupancy on the network.

Stations costs, including station police costs, are driven by passenger activity level at the station. Thus, ridership was assigned as the cost driver. As mentioned in Section 5.1.1, since only the Intercity portion of station costs was included, Intercity ridership was used as the allocation driver.

Table 4 summarizes the assignment of cost driver and allocation driver to each infrastructure-related functional activity.

Table 4: Infrastructure-related Functional Activity Cost Drivers and Allocation Drivers

Cost Area	Functional Activity	Cost Driver	Allocation Driver
EXISTING INFRASTRUCTURE			
Electric Propulsion	Electric Traction Power	Electrified Train Miles	Electrified Train Miles
	Freq. Converter Maintenance	Electrified Train Miles	Electrified Train Miles
Maintenance-of-Way	Bridges	Existing Track Miles	Train Miles
	Comm. Systems	Existing Track Miles	Frequency
	Electric Traction	Existing Track Miles	Electrified Train Miles
	Equipment	Existing Track Miles	Train Miles
	Facilities	Existing Track Miles	Train Miles
	Signal & Interlocking	Existing Track Miles	Frequency
	Track	Existing Track Miles	Train Miles
Police – Road, Yard, & Station	Road	Total Route Miles	Train Miles
	Yard	Total Route Miles	Train Miles
Power Directors	Power Directors & Load Dispatchers	Electrified Train Miles	Electrified Train Miles
Train Dispatching	Blocks & Towers	Track Miles	Frequency
	Control & Dispatch	Track Miles	Frequency
Police – Road, Yard, & Station	Station Police	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	Baggage & Express	NEC Intercity Ridership	NEC Intercity Ridership
	First Class Lounge	NEC Intercity Ridership	NEC Intercity Ridership
	Porters	NEC Intercity Ridership	NEC Intercity Ridership
	Station Maintenance	NEC Intercity Ridership	NEC Intercity Ridership
	Station Operations	NEC Intercity Ridership	NEC Intercity Ridership
	Stationmasters & Ushers	NEC Intercity Ridership	NEC Intercity Ridership
	Ticketing	NEC Intercity Ridership	NEC Intercity Ridership
	Utilities	NEC Intercity Ridership	NEC Intercity Ridership
NEW INFRASTRUCTURE			
Maintenance-of-Way	Existing Alignment – New Track	New Track Miles	Train Miles
Maintenance-of-Way – New	New Alignment – Track	New Track Miles	Train Miles

Source: NEC FUTURE team, 2015

5.2.2 Cost Drivers for Intercity Transportation, Equipment, and G&A Costs

For costs from the APT report, the FRA assigned a cost driver to each functional activity and each existing service (i.e., Acela Express and Northeast Regional).

Both MoE and yard functional activity costs are largely driven by the equipment requirements to provide the level-of-service specified in the representative Service Plans. For MoE, many maintenance activities are calendar based and costs depend on the number of trainsets needing periodic maintenance. The exception is turnaround servicing cost, which does vary with the frequency of service. Costs associated with yard activity are driven by the number trainsets needing assembly and movement to and from the yard at the beginning and end of the day.

Crew-based costs for onboard services and T&E are driven by the labor hours worked, which is a function of the number of train revenue hours. Projected labor hours for each crew position were derived from the ratio of existing labor hours by position to train revenue hours by service. Food and beverage and commissary costs are driven as a percentage of the food and beverage revenue.

Fuel and other transportation operations costs are driven by train miles to reflect the general share of usage of the corridor.

Sales and marketing, police, security, and environmental, and G&A variable costs are driven either by Intercity ridership or by ticket revenue. Generally, costs associated with passenger interaction (e.g., information and reservations, national police, emergency management and corporate security, and environmental and safety costs) are driven by Intercity ridership. Costs associated with activities related to financial performance (e.g., sales, marketing, and G&A variable costs) are driven by ticket revenue.

Table 5 summarizes the assignment of cost drivers by service for each functional activity for transportation, equipment, and G&A costs. The cost drivers by functional activity are the same for the existing NEC Intercity services. This is true when deriving existing unit costs only. Section 5.3.3 and Section 5.3.4 discuss the differences in projected unit costs by service.

Table 5: Transportation, Equipment, and National Functional Activity Cost Drivers by Service

Cost Area	Functional Activity	Existing NEC Intercity Service Cost Driver
Maintenance of Equipment (MoE)	Turnaround	Frequency
	Locomotive Maintenance	Train Sets
	Car Maintenance	Train Sets
	MoE Support	Train Sets
	MoE Multiple Functions	Train Sets
	HSR Maintenance	Train Sets
	Backshop	Train Sets
Onboard Services	Crew	OBS Labor Hours
	Supplies - F&B	% of F&B Revenue
	Commissary/Management - F&B	% of F&B Revenue
	Support	OBS Labor Hours
Trainmen & Enginemen (T&E)	Trainmen Crew	Trainmen Labor Hours
	Enginemen Crew	Enginemen Labor Hours
	Other T&E Activity	T&E Labor Hours
	Support	T&E Labor Hours
Yard	Train & Equipment	Train Sets
	Equipment Moves	Train Sets
	Yard Direct	Train Sets
	Terminal Rent/Yard Services	Train Sets
Fuel	Train Fuel (Diesel)	Train Miles
Other Transportation Ops	Transportation – Multiple Functions	Train Miles
	Transportation Support	Train Miles

Table 5: Transportation, Equipment, and National Functional Activity Cost Drivers by Service (continued)

Cost Area	Functional Activity	Existing NEC Intercity Service Cost Driver
Sales & Marketing	Sales	Ticket Revenue
	Information & Reservations	NEC Intercity Ridership
	Marketing	Ticket Revenue
Police, Security, Environmental	National Police - Special Ops	NEC Intercity Ridership
	Emergency Mgmt & Corp Security	NEC Intercity Ridership
	Environmental & Safety	NEC Intercity Ridership
G&A	G&A Fixed	Fixed
	G&A Variable	Ticket Revenue

Source: NEC FUTURE team, 2015

Cost drivers for transportation-related costs associated with the NEC FUTURE Regional service are governed by the NTD reports for each of the existing commuter-rail operators on the NEC (see Section 4.1.3 for derivation).

5.2.3 Existing Cost-Driver Values

Table 6 lists the various cost drivers utilized for this analysis and shows the existing (2013) cost-driver values for existing Intercity services (e.g., Acela Express and Northeast Regional) and for all Regional/ Commuter services.

Table 6: Existing Cost-Driver Values

Statistic	INTERCITY			REGIONAL	NEC Total
	Acela Express	Northeast Regional	Intercity Total	All Services	
Annual Train Revenue Hours	50,839	101,637	152,476	314,276	466,752
Total Train Trips	9,515	16,429	25,944	204,345	230,289
Train Sets	20	25	45	—	45
Trainmen labor hours	164,621	594,121	758,742	—	758,742
Enginemen labor hours	84,853	217,197	302,050	—	302,050
Trainmen and Enginemen labor hours	249,475	850,925	1,100,400	—	1,100,400
OBS labor hours	234,068	174,423	408,491	—	408,491
Annual Train Revenue Miles	3,313,867	5,656,296	8,970,163	10,114,260	19,084,423
Electrified Train Miles	3,313,867	5,656,296	8,970,163	5,699,152	14,669,314
Ticket Revenue	$530,820,821	$568,744,563	$1,099,565,384	—	$1,099,565,384
Passenger Ridership	3,343,143	8,044,216	11,387,359	—	11,387,359

Source: NEC FUTURE team, 2015

5.3 DERIVATION OF UNIT COSTS

This section discusses the process used to derive the unit cost by functional activity, and examines how the unit costs were adjusted due to changes in operations, changes in amenities, or changes in cost indices.

5.3.1 Unit Cost Calculation

Unit costs are calculated by dividing the O&M cost associated with a cost area and functional activity by the cost driver value, as shown in the sample equation below:

Track Maintenance Costs ÷ Number of Track Miles = Unit Cost per Track Mile

$50,000,000 ÷ 1,000 track miles = $50,000 per track mile

The FRA derived the unit costs for the following cost types:

- **Operations on shared infrastructure**: general railroad infrastructure costs on infrastructure segments hosting both Intercity and Regional rail services.
- **Operations on new high-speed segments**: costs that result from maintenance of new segments hosting high-speed operations (affecting some of proposed services for some of the alternatives.)
- **Transportation operations costs**: train and engine crew costs for activities unique to each operator and each service.
- **Regional rail specific transportation operations costs**: costs associated with Regional rail operations for vehicle operations, vehicle maintenance, non-vehicle maintenance, and G&A costs.

5.3.2 Unit Cost Expansion/ Reduction Factors

For projected future services, the FRA applied unit cost expansion/reduction factors to address anticipated changes resulting from more-frequent service or from the implementation of next generation technologies. Table 7 lists the expansion/ reduction factors and the corresponding cost area and functional activity that they apply to. The expansion factors for maintenance-of-way were based on insights from Amtrak Engineering staff based on experience in the implementation of Amtrak's capital program and operational experience from track possessions. More-frequent service will mean fewer and shorter available maintenance windows between trains. The reduction factor for Station Maintenance and Services were based on the expectation that passenger handling costs associated with the NEC FUTURE alternatives decrease with the implementation of automated passenger gates (similar to technology being installed at airports) and more vertical circulation facilities (e.g., elevators and escalators).

Table 7: Unit Cost Expansion/ Reduction Factor

Cost Area	Functional Activity	Cost Expansion/ Reduction Factor	Rationale
Maintenance-of-Way	Communications Systems	1.25	More-frequent service; fewer and shorter available maintenance windows
	Signal & Interlocking	1.25	
	Track	1.25	
Station Maintenance and Services	First Class Lounge	0.7	More extensive use of self-service ticketing and passenger access
	Stationmasters and Ushers	0.7	

Source: NEC FUTURE team, 2015

The expansion/ reduction factor was multiplied with the associated unit cost to produce the adjusted projected unit cost, as shown in the sample equation below:

Unit Cost per Track Mile × Expansion Factor = Projected Unit Cost per Track Mile

$50,000 per track mile × 1.25 = $62,500 per track mile

5.3.3 Projected Maintenance of Equipment Unit Costs by Service

For projections of MoE costs, the analysis used the unit costs for new high-performance equipment estimated for the CHSRA. Unlike the unit cost derived from existing costs, the FRA projected the new high-performance equipment unit cost based on train miles instead of the number of trainsets. Additionally, the electric multiple unit trainsets for NEC FUTURE are projected to be used for Intercity-Express and Metropolitan services only. The Intercity-Corridor equipment will resemble existing Northeast Regional equipment. This is consistent with the *Service Plans and Train Equipment Options Technical Memorandum*.

Table 8 shows how the cost drivers are associated with the new Intercity services and indicate which unit cost will be applied to project equipment-related O&M costs. The Intercity-Express and Metropolitan service applied the CHSRA MoE unit costs, which were applied per train mile. For Intercity-Corridor service, units are based on existing Northeast Regional service, which are applied per trainset.

Table 8: Application of Maintenance of Equipment Projected Unit Costs by Service

Functional Activity	Application to NEC FUTURE Services		
	Intercity-Express	Metropolitan	Intercity-Corridor
Turnaround	Frequency	Frequency	Frequency
Locomotive Maintenance	Train Miles	Train Miles	Train Sets
Car Maintenance	Train Miles	Train Miles	Train Sets
MoE Support	Train Miles	Train Miles	Train Sets
MoE Multiple	Train Miles	Train Miles	Train Sets
HSR Maintenance	Train Miles	Train Miles	Train Sets
Backshop	Train Miles	Train Miles	Train Sets

Source: NEC FUTURE team, 2015

5.3.4 Projected Onboard Services Unit Costs by Service

The FRA assumes that the new Intercity-Express service includes onboard services characteristics that are similar to the existing Acela Express service. These services comprise food and beverage, commissary, and onboard service crew costs. Therefore, the FRA applied Acela Express onboard services unit costs for the onboard services functional activities for the new Intercity-Express service.

For the Intercity-Corridor and Metropolitan service types, the FRA assumed food and beverage amenities such as vending machines or a third-party/contracted operation. For this analysis, the FRA assumed that revenues roughly equal (or perhaps exceed) costs; thus, these costs would not have a material impact on the overall O&M costs of these service types. Estimates of these costs were therefore excluded from this analysis.

5.3.5 Calculation of Unit Costs for New High-Speed Infrastructure and Equipment

The FRA first de-inflated the unit costs for new high-speed infrastructure to 2013 dollars using the Association of American Railroads index to be consistent with other data sources used in the analysis. The unit costs were also converted from California labor rates to Philadelphia MSA labor rates (which represent a median wage rate for the Northeast Region) using the Bureau of Labor Statistics transportation wage index.

5.4 APPLICATION OF UNIT COSTS TO PROJECTED COST DRIVER VALUES

Once all infrastructure-related and transportation- and equipment-related unit costs were calculated and adjusted to a projected unit cost, these unit costs were applied to the projected cost-driver values for the No Action and Action Alternatives to obtain the projected O&M costs for each alternative.[5] A sample calculation is shown in the equation below:

Projected Unit Cost per Track Mile × Projected Num. of Track Miles = Projected Track Maint. Costs

$62,500 per track mile × 2,000 track miles = $125,000,000

For shared infrastructure costs, the unit cost is accompanied by an allocation driver. The projected cost that resulted from applying the unit cost to the projected cost driver value was allocated to the Intercity services and Regional/Commuter operators using the designated allocation driver. The cost driver and allocation driver were the same for certain functional activities.

The FRA then inflated projected O&M costs to 2014 dollars using the Association of American Railroads index to ensure consistent reporting of cost data across the NEC FUTURE analysis.

5.4.1 Fare Strategy

The ridership model run for 2013 base trips was performed using the current (i.e., today's) fares, to accurately match existing ridership. Initial model runs were consistent with current fares, but because the future alternatives include new markets, the FRA calculated distance-based fare equations based on current fares for three types of rail trips—including trips entirely south of New York, trips north of New York, and trips through New York—since there are market-based differences in the pricing structures for these trips today.

The O&M costs associated with these existing fare scenarios were substantially lower than the associated revenues. Therefore, multiple fare discounts were tested for the Intercity-Corridor service. Keeping the Intercity-Express fares at the existing level while reducing the Intercity-Corridor fares by 30 percent was the second set of scenarios examined to create a range of ridership numbers for each Action Alternative. This set of fare policies is not intended as a fare-maximizing or

[5] For a complete description of the alternatives, see the NEC FUTURE Service Planning Technical Memorandum

ridership-maximizing analysis, but is intended to demonstrate that Intercity service operates profitably over multiple fare structures and to provide a range of ridership results.

Table 9 shows the projected cost-driver values for Intercity services as well as for all Regional/ Commuter services for the No Action and Action Alternatives.

Table 9: Projected Cost-Driver Values

Alternative	Statistic	INTERCITY				REGIONAL	NEC Total
		Intercity-Express	Intercity-Corridor	Metropolitan	Intercity Total	All Commuters	
No Action	Annual Train Revenue Hours	50,839	101,637		152,476	314,276	466,752
	Total Train Trips	9,515	16,429		25,944	204,345	230,289
	Train Sets	20	25		45	—	45
	Trainmen labor hours	164,621	594,121		758,742	—	758,742
	Enginemen labor hours	84,853	217,197		302,050	—	302,050
	Trainmen and Enginemen labor hours	249,475	850,925		1,100,400	—	1,100,400
	OBS labor hours	234,068	174,423		408,491	—	408,491
	Annual Train Revenue Miles	3,313,867	5,656,296		8,970,163	10,114,260	19,084,423
	Electrified Train Miles	3,313,867	5,656,296		8,970,163	5,699,152	14,669,314
	Ticket Revenue	$944,340,615	$876,071,140		$1,820,411,754	—	$1,820,411,754
	Ridership	5,740,060	13,268,306		19,008,365	—	19,008,365
1	Annual Train Revenue Hours	73,460	107,411	119,813	300,684	310,256	610,939
	Total Train Trips	16,200	22,010	30,530	68,740	384,180	452,920
	Train Sets	23	15	28	66	—	66
	Trainmen labor hours	237,870	627,874	700,366	1,566,111	—	1,566,111
	Enginemen labor hours	122,609	229,536	256,037	608,182	—	608,182
	Trainmen and Enginemen labor hours	360,479	857,410	956,404	2,174,293	—	2,174,293
	OBS labor hours	338,217	184,332	205,614	728,164	—	728,164
	Annual Train Revenue Miles	4,014,000	4,664,700	5,694,200	14,372,900	16,476,705	30,849,605
	Electrified Train Miles	4,014,000	4,664,700	5,694,200	14,372,900	15,863,473	30,236,373
	Ticket Revenue	$651,796,698	$580,660,645	$805,432,508	$2,037,889,852	$—	$2,037,889,852
	Ridership	4,285,763	11,878,772	16,477,006	32,641,541	—	32,641,541

Table 9: Projected Cost-Driver Values (continued)

Alternative	Statistic	INTERCITY				REGIONAL	NEC Total
		Intercity-Express	Intercity-Corridor	Metropolitan	Intercity Total	All Commuters	
2	Annual Train Revenue Hours	126,630	81,484	256,050	464,164	282,540	746,704
	Total Train Trips	35,400	22,010	71,000	128,410	447,735	576,145
	Train Sets	44	19	65	128	—	128
	Trainmen labor hours	410,039	476,318	1,496,744	2,383,101	—	2,383,101
	Enginemen labor hours	211,353	174,131	547,174	932,658	—	932,658
	Trainmen and Enginemen labor hours	621,392	650,449	2,043,917	3,315,759	—	3,315,759
	OBS labor hours	583,018	139,838	439,416	1,162,271	—	1,162,271
	Annual Train Revenue Miles	11,274,000	4,541,160	18,320,130	34,135,290	15,459,255	49,594,545
	Electrified Train Miles	11,274,000	4,541,160	18,320,130	34,135,290	14,846,023	48,981,313
	Ticket Revenue	$1,000,331,339	$351,731,264	$1,134,616,979	$2,486,679,582	$—	$2,486,679,582
	Ridership	6,459,220	7,244,599	23,369,675	37,073,494	—	37,073,494
3.1	Annual Train Revenue Hours	169,310	81,484	316,388	567,182	317,110	884,292
	Total Train Trips	53,400	22,010	87,330	162,740	493,620	656,360
	Train Sets	35	19	79	133	—	133
	Trainmen labor hours	548,241	476,318	1,849,452	2,874,011	—	2,874,011
	Enginemen labor hours	282,589	174,131	676,116	1,132,835	—	1,132,835
	Trainmen and Enginemen labor hours	830,830	650,449	2,525,567	4,006,846	—	4,006,846
	OBS labor hours	779,521	139,838	542,964	1,462,323	—	1,462,323
	Annual Train Revenue Miles	19,582,800	4,195,390	25,641,295	49,419,485	21,500,970	70,920,455
	Electrified Train Miles	19,582,800	4,195,390	25,641,295	49,419,485	20,887,738	70,307,223
	Ticket Revenue	$1,127,142,811	$304,727,513	$1,209,080,131	$2,640,950,455	$—	$2,640,950,455
	Ridership	7,126,986	6,273,105	24,890,062	38,290,152	—	38,290,152

Table 9: Projected Cost-Driver Values (continued)

Alternative	Statistic	INTERCITY				REGIONAL	NEC Total
		Intercity-Express	Intercity-Corridor	Metropolitan	Intercity Total	All Commuters	
3.2	Annual Train Revenue Hours	171,890	81,484	323,133	576,507	333,588	910,095
	Total Train Trips	53,400	22,010	87,330	162,740	493,620	656,360
	Train Sets	35	19	79	133	—	133
	Trainmen labor hours	556,595	476,318	1,888,880	2,921,793	—	2,921,793
	Enginemen labor hours	286,895	174,131	690,529	1,151,555	—	1,151,555
	Trainmen and Enginemen labor hours	843,490	650,449	2,579,409	4,073,348	—	4,073,348
	OBS labor hours	791,399	139,838	554,539	1,485,777	—	1,485,777
	Annual Train Revenue Miles	20,213,100	4,012,920	22,825,790	47,051,810	21,965,520	69,017,330
	Electrified Train Miles	20,213,100	4,012,920	22,825,790	47,051,810	21,352,288	68,404,098
	Ticket Revenue	$1,236,660,015	$297,539,753	$1,180,560,954	$2,714,760,721	$—	$2,714,760,721
	Ridership	7,837,418	6,216,863	24,666,908	38,721,189	—	38,721,189
3.3	Annual Train Revenue Hours	176,510	81,484	316,116	574,110	333,588	907,698
	Total Train Trips	52,800	22,010	75,000	149,810	493,620	643,430
	Train Sets	35	19	79	133	—	133
	Trainmen labor hours	571,555	476,318	1,847,861	2,895,734	—	2,895,734
	Enginemen labor hours	294,606	174,131	675,534	1,144,270	—	1,144,270
	Trainmen and Enginemen labor hours	866,161	650,449	2,523,395	4,040,005	—	4,040,005
	OBS labor hours	812,670	139,838	542,497	1,495,005	—	1,495,005
	Annual Train Revenue Miles	19,845,000	4,353,720	21,160,840	45,359,560	22,659,495	68,019,055
	Electrified Train Miles	19,845,000	4,353,720	21,160,840	45,359,560	22,046,263	67,405,823
	Ticket Revenue	$1,191,720,147	$355,609,145	$1,211,753,106	$2,759,082,397	$—	$2,759,082,397
	Ridership	7,553,380	7,310,935	24,912,319	39,776,634	—	39,776,634

Table 9: Projected Cost-Driver Values (continued)

Alternative	Statistic	INTERCITY				REGIONAL	NEC Total
		Intercity-Express	Intercity-Corridor	Metropolitan	Intercity Total	All Commuters	
3.4	Annual Train Revenue Hours	177,780	81,484	320,885	580,149	317,110	897,259
	Total Train Trips	53,400	22,010	86,620	162,030	493,620	655,650
	Train Sets	35	19	79	133	—	133
	Trainmen labor hours	575,668	476,318	1,875,737	2,927,723	—	2,927,723
	Enginemen labor hours	296,725	174,131	685,725	1,156,581	—	1,156,581
	Trainmen and Enginemen labor hours	872,393	650,449	2,561,462	4,084,304	—	4,084,304
	OBS labor hours	818,517	139,838	550,681	1,509,037	—	1,509,037
	Annual Train Revenue Miles	19,393,200	4,353,720	19,894,555	43,641,475	22,194,945	65,836,420
	Electrified Train Miles	19,393,200	4,353,720	19,894,555	43,641,475	21,581,713	65,223,188
	Ticket Revenue	$1,123,015,860	$309,477,714	$1,217,944,554	$2,650,438,128	—	$2,650,438,128
	Ridership	7,106,260	6,379,757	25,107,429	38,593,446	—	38,593,446

Source: NEC FUTURE team, 2015

6. Results

6.1 SUMMARY OF REVENUE, O&M COSTS, AND NET CONTRIBUTION

For the No Action and Action Alternatives, the results are shown in 2014 dollars for each service and are organized as follows:

- Revenues (includes ticket and food and beverage for appropriate services)
- O&M costs:
  - Shared infrastructure costs
  - Transportation operations costs
  - Sales & Marketing, National Operations costs
  - G&A costs
- Net Contribution (revenue minus O&M costs)

Recognizing an interest in determining if the Intercity services in the No Action and Action Alternatives covered the full cost of operations from passenger revenues, this analysis included all projected O&M costs to determine the net contribution. This allowed for an evaluation of the complete picture of revenues and costs, and the resulting net contributions by each alternative. The FRA already accounted for equipment cost recovery in the capital cost estimates. Table 10 through Table 16 present the summary results of revenue, O&M costs, and net contribution for the No Action and Action Alternatives.

6.2 CONTRIBUTION ANALYSIS ACROSS ALTERNATIVES

Table 17 compares the revenue, O&M cost, and net contribution by service type across the No Action and Action Alternatives. For all alternatives, total revenues exceed total costs for the proposed Intercity service types (e.g., Intercity-Express, Metropolitan, and Intercity-Corridor services).

Table 10: No Action Alternative O&M Cost Summary and Contribution Analysis

		INTERCITY SERVICES				REGIONAL SVCS	
Revenue		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Ticket Revenue		$927,000,000	—	$899,400,000	$1,826,400,000	—	$1,826,400,000
Food & Beverage Revenue		$37,100,000	—	$36,000,000	$73,100,000	—	$73,100,000
(Assumed 4% of ticket revenue)							
TOTALREVENUE		**$964,100,000**	**—**	**$935,400,000**	**$1,899,500,000**	**—**	**$1,899,500,000**
O&M Costs		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs							
*	Electric Propulsion	$18,300,000	—	$31,200,000	$49,500,000	$31,400,000	$80,900,000
	Maintenance-of-Way	$29,700,000	—	$50,700,000	$80,400,000	$107,800,000	$188,200,000
	Maintenance-of-Way - New	—	—	—	—	—	—
*	Police - Road, Yard, & Station	$5,400,000	—	$11,600,000	$17,000,000	$3,800,000	$20,800,000
	Power Directors	$1,500,000	—	$2,500,000	$4,000,000	$2,500,000	$6,500,000
*	Train Dispatching	$1,800,000	—	$3,000,000	$4,800,000	$25,700,000	$30,500,000
*	Station Maintenance & Services	$38,100,000	—	$90,400,000	$128,500,000	—	$128,500,000
Transportation Operations Costs							
*	Regional Transportation Ops	—	—	—	—	$494,100,000	$494,100,000
*	Maintenance of Equipment	$72,600,000	—	$101,200,000	$173,800,000	—	$173,800,000
*	Onboard Services	$32,000,000	—	$18,700,000	$50,700,000	—	$50,700,000
*	Trainmen & Enginemen	$18,600,000	—	$59,300,000	$77,900,000	—	$77,900,000
*	Yard	$6,600,000	—	$19,100,000	$25,700,000	—	$25,700,000
*	Fuel	$200,000	—	$1,800,000	$2,000,000	—	$2,000,000
*	Other Transportation Ops	$5,900,000	—	$13,700,000	$19,600,000	—	$19,600,000
Sales & Marketing, National Ops Costs							
*	Sales & Marketing	$58,600,000	—	$48,200,000	$106,800,000	—	$106,800,000
*	Police, Security, Environmental	$7,600,000	—	$10,000,000	$17,600,000	—	$17,600,000
G&A Costs							
*	G&A	$61,400,000	—	$86,900,000	$148,300,000	—	$148,300,000
TOTAL O&M COSTS		**$358,300,000**	**—**	**$548,300,000**	**$906,600,000**	**$665,300,000**	**$1,571,900,000**
** = Indicates above-the-rail (ATR) cost area*							
Net Contribution Cost Definition		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION		**$605,800,000**	**—**	**$387,100,000**	**$992,900,000**		

Source: NEC FUTURE team, 2015

Table 11: Alternative 1 O&M Cost Summary and Contribution Analysis

		INTERCITY SERVICES				REGIONAL SVCS	
Revenue		Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity	Commuter RRs	Total NEC
Ticket Revenue		$773,000,000	$795,700,000	$573,700,000	$2,142,400,000	—	$2,142,400,000
Food & Beverage Revenue		$30,900,000	—	—	$30,900,000	—	$30,900,000
(Assumed 4% of ticket revenue)							
TOTALREVENUE		**$803,900,000**	**$795,700,000**	**$573,700,000**	**$2,173,300,000**	—	**$2,173,300,000**
O&M Costs		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs							
*	Electric Propulsion	$31,400,000	$43,000,000	$34,600,000	$109,000,000	$46,200,000	$155,200,000
	Maintenance-of-Way	$38,200,000	$54,600,000	$43,200,000	$136,000,000	$115,900,000	$251,900,000
	Maintenance-of-Way - New	$4,300,000	$5,900,000	$4,700,000	$14,900,000	$6,800,000	$21,700,000
*	Police - Road, Yard, & Station	$5,200,000	$13,300,000	$9,800,000	$28,300,000	$3,100,000	$31,400,000
	Power Directors	$2,500,000	$3,400,000	$2,800,000	$8,700,000	$3,700,000	$12,400,000
*	Train Dispatching	$1,600,000	$3,100,000	$2,200,000	$6,900,000	$23,600,000	$30,500,000
*	Station Maintenance & Services	$33,700,000	$110,600,000	$79,700,000	$224,000,000	—	$224,000,000
Transportation Operations Costs							
*	Regional Transportation Ops	—	—	—	—	$552,000,000	$552,000,000
*	Maintenance of Equipment	$36,200,000	$50,200,000	$91,100,000	$177,500,000	—	$177,500,000
*	Onboard Services	$33,900,000	—	—	$33,900,000	—	$33,900,000
*	Trainmen & Enginemen	$26,900,000	$73,000,000	$65,400,000	$165,300,000	—	$165,300,000
*	Yard	$7,600,000	$9,200,000	$11,500,000	$28,300,000	—	$28,300,000
*	Fuel	$400,000	$600,000	$2,000,000	$3,000,000	—	$3,000,000
*	Other Transportation Ops	$10,100,000	$13,900,000	$15,200,000	$39,200,000	—	$39,200,000
Sales & Marketing, National Ops Costs							
*	Sales & Marketing	$49,500,000	$76,100,000	$35,100,000	$160,700,000	—	$160,700,000
*	Police, Security, Environmental	$6,700,000	$22,100,000	$8,800,000	$37,600,000	—	$37,600,000
G&A Costs							
*	G&A	$42,800,000	$59,700,000	$51,100,000	$153,600,000	—	$153,600,000
TOTAL O&M COSTS		**$331,000,000**	**$538,700,000**	**$457,200,000**	**$1,326,900,000**	**$751,300,000**	**$2,078,200,000**
** = Indicates above-the-rail (ATR) cost area*							
Net Contribution Cost Definition		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION		**$472,900,000**	**$257,000,000**	**$116,500,000**	**$846,400,000**		

Source: NEC FUTURE team, 2015

Table 12: Alternative 2 O&M Cost Summary and Contribution Analysis

		INTERCITY SERVICES				REGIONAL SVCS	
Revenue		Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity	Commuter RRs	Total NEC
Ticket Revenue		$984,300,000	$1,117,100,000	$346,300,000	$2,447,700,000	—	$2,447,700,000
Food & Beverage Revenue		$39,400,000	—	—	$39,400,000	—	$39,400,000
(Assumed 4% of ticket revenue)							
TOTALREVENUE		**$1,023,700,000**	**$1,117,100,000**	**$346,300,000**	**$2,487,100,000**	—	**$2,487,100,000**
O&M Costs		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs							
*	Electric Propulsion	$62,600,000	$100,000,000	$26,600,000	$189,200,000	$61,000,000	$250,200,000
	Maintenance-of-Way	$59,500,000	$98,000,000	$26,700,000	$184,200,000	$110,100,000	$294,300,000
	Maintenance-of-Way - New	$19,700,000	$31,400,000	$8,400,000	$59,500,000	$20,200,000	$79,700,000
*	Police - Road, Yard, & Station	$7,600,000	$20,400,000	$6,100,000	$34,100,000	$3,600,000	$37,700,000
	Power Directors	$5,000,000	$8,000,000	$2,100,000	$15,100,000	$4,900,000	$20,000,000
*	Train Dispatching	$2,600,000	$5,200,000	$1,600,000	$9,400,000	$21,100,000	$30,500,000
*	Station Maintenance & Services	$43,000,000	$155,700,000	$48,300,000	$247,000,000	—	$247,000,000
Transportation Operations Costs							
*	Regional Transportation Ops	—	—	—	—	$515,900,000	$515,900,000
*	Maintenance of Equipment	$72,500,000	$116,800,000	$100,700,000	$290,000,000	—	$290,000,000
*	Onboard Services	$50,600,000	—	—	$50,600,000	—	$50,600,000
*	Trainmen & Enginemen	$45,800,000	$154,100,000	$47,000,000	$246,900,000	—	$246,900,000
*	Yard	$14,500,000	$21,400,000	$14,500,000	$50,400,000	—	$50,400,000
*	Fuel	$800,000	$1,300,000	$1,600,000	$3,700,000	—	$3,700,000
*	Other Transportation Ops	$20,200,000	$32,200,000	$11,700,000	$64,100,000	—	$64,100,000
Sales & Marketing, National Ops Costs							
*	Sales & Marketing	$63,100,000	$107,100,000	$21,200,000	$191,400,000	—	$191,400,000
*	Police, Security, Environmental	$8,600,000	$31,100,000	$5,300,000	$45,000,000	—	$45,000,000
G&A Costs							
*	G&A	$51,200,000	$78,900,000	$29,000,000	$159,100,000	—	$159,100,000
TOTAL O&M COSTS		**$527,300,000**	**$961,600,000**	**$350,800,000**	**$1,839,700,000**	**$736,800,000**	**$2,576,500,000**
** = Indicates above-the-rail (ATR) cost area*							
Net Contribution Cost Definition		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION		**$496,400,000**	**$155,500,000**	**$(4,500,000)**	**$647,400,000**		

Source: NEC FUTURE team, 2015

Table 13: Alternative 3.1 (via Central CT/Providence Route Option) O&M Cost Summary and Contribution Analysis

		INTERCITY SERVICES				REGIONAL SVCS	
Revenue		Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity	Commuter RRs	Total NEC
Ticket Revenue		$1,250,300,000	$1,184,000,000	$298,400,000	$2,732,700,000	—	$2,732,700,000
Food & Beverage Revenue		$50,000,000	—	—	$50,000,000	—	$50,000,000
(Assumed 4% of ticket revenue)							
TOTALREVENUE		**$1,300,300,000**	**$1,184,000,000**	**$298,400,000**	**$2,782,700,000**	**—**	**$2,782,700,000**
O&M Costs		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs							
*	Electric Propulsion	$106,500,000	$129,600,000	$25,900,000	$262,000,000	$76,900,000	$338,900,000
	Maintenance-of-Way	$63,300,000	$80,600,000	$16,800,000	$160,700,000	$95,100,000	$255,800,000
	Maintenance-of-Way - New	$66,800,000	$81,200,000	$16,200,000	$164,200,000	$50,300,000	$214,500,000
*	Police - Road, Yard, & Station	$12,300,000	$24,600,000	$5,700,000	$42,600,000	$5,500,000	$48,100,000
	Power Directors	$8,500,000	$10,300,000	$2,100,000	$20,900,000	$6,100,000	$27,000,000
*	Train Dispatching	$3,300,000	$5,400,000	$1,400,000	$10,100,000	$20,400,000	$30,500,000
*	Station Maintenance & Services	$52,800,000	$165,000,000	$41,600,000	$259,400,000	—	$259,400,000
Transportation Operations Costs							
*	Regional Transportation Ops	—	—	—	—	$580,500,000	$580,500,000
*	Maintenance of Equipment	$122,900,000	$151,000,000	$100,700,000	$374,600,000	—	$374,600,000
*	Onboard Services	$73,000,000	—	—	$73,000,000	—	$73,000,000
*	Trainmen & Enginemen	$71,700,000	$236,700,000	$74,000,000	$382,400,000	—	$382,400,000
*	Yard	$11,500,000	$26,000,000	$14,500,000	$52,000,000	—	$52,000,000
*	Fuel	$1,400,000	$1,700,000	$1,500,000	$4,600,000	—	$4,600,000
*	Other Transportation Ops	$34,300,000	$41,800,000	$11,400,000	$87,500,000	—	$87,500,000
Sales & Marketing, National Ops Costs							
*	Sales & Marketing	$79,500,000	$113,500,000	$18,300,000	$211,300,000	—	$211,300,000
*	Police, Security, Environmental	$10,500,000	$33,000,000	$4,600,000	$48,100,000	—	$48,100,000
G&A Costs							
*	G&A	$62,200,000	$78,800,000	$24,000,000	$165,000,000	—	$165,000,000
TOTAL O&M COSTS		**$780,500,000**	**$1,179,200,000**	**$358,700,000**	**$2,318,400,000**	**$834,800,000**	**$3,153,200,000**
** = Indicates above-the-rail (ATR) cost area*							
Net Contribution Cost Definition		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION		**$519,800,000**	**$4,800,000**	**$(60,300,000)**	**$464,300,000**		

Source: NEC FUTURE team, 2015

Table 14: Alternative 3.2 (via Long Island/Providence Route Option) O&M Cost Summary and Contribution Analysis

Revenue		INTERCITY SERVICES				REGIONAL SVCS	Total NEC
		Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity	Commuter RRs	
Ticket Revenue		$1,216,900,000	$1,161,700,000	$292,800,000	$2,671,400,000	—	$2,671,400,000
Food & Beverage Revenue		$48,700,000	—	—	$48,700,000	—	$48,700,000
(Assumed 4% of ticket revenue)							
TOTALREVENUE		**$1,265,600,000**	**$1,161,700,000**	**$292,800,000**	**$2,720,100,000**	—	**$2,720,100,000**
O&M Costs		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs							
*	Electric Propulsion	$112,300,000	$138,100,000	$26,700,000	$277,100,000	$76,900,000	$354,000,000
	Maintenance-of-Way	$63,800,000	$82,000,000	$16,700,000	$162,500,000	$93,400,000	$255,900,000
	Maintenance-of-Way - New	$47,200,000	$58,100,000	$11,200,000	$116,500,000	$33,800,000	$150,300,000
*	Police - Road, Yard, & Station	$10,900,000	$23,000,000	$5,400,000	$39,300,000	$4,200,000	$43,500,000
	Power Directors	$9,000,000	$11,000,000	$2,100,000	$22,100,000	$6,100,000	$28,200,000
*	Train Dispatching	$3,300,000	$5,400,000	$1,400,000	$10,100,000	$20,400,000	$30,500,000
*	Station Maintenance & Services	$52,200,000	$164,300,000	$41,400,000	$257,900,000	—	$257,900,000
Transportation Operations Costs							
*	Regional Transportation Ops	—	—	—	—	$603,800,000	$603,800,000
*	Maintenance of Equipment	$129,400,000	$160,500,000	$100,700,000	$390,600,000	—	$390,600,000
*	Onboard Services	$66,600,000	—	—	$66,600,000	—	$66,600,000
*	Trainmen & Enginemen	$62,900,000	$196,200,000	$60,200,000	$319,300,000	—	$319,300,000
*	Yard	$11,500,000	$26,000,000	$14,500,000	$52,000,000	—	$52,000,000
*	Fuel	$1,500,000	$1,800,000	$1,600,000	$4,900,000	—	$4,900,000
*	Other Transportation Ops	$36,200,000	$44,500,000	$11,800,000	$92,500,000	—	$92,500,000
Sales & Marketing, National Ops Costs							
*	Sales & Marketing	$77,700,000	$112,100,000	$18,100,000	$207,900,000	—	$207,900,000
*	Police, Security, Environmental	$10,400,000	$32,800,000	$4,600,000	$47,800,000	—	$47,800,000
G&A Costs							
*	G&A	$61,800,000	$78,300,000	$23,600,000	$163,700,000	—	$163,700,000
TOTAL O&M COSTS		**$756,700,000**	**$1,134,100,000**	**$340,000,000**	**$2,230,800,000**	**$838,600,000**	**$3,069,400,000**
** = Indicates above-the-rail (ATR) cost area*							
Net Contribution Cost Definition		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION		**$508,900,000**	**$27,600,000**	**$(47,200,000)**	**$489,300,000**		

Source: NEC FUTURE team, 2015

Table 15: Alternative 3.3 (via Long Island/Worcester Route Option) O&M Cost Summary and Contribution Analysis

		INTERCITY SERVICES				REGIONAL SVCS	
	Revenue	**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Ticket Revenue		$1,172,700,000	$1,235,800,000	$306,500,000	$2,715,000,000	—	$2,715,000,000
Food & Beverage Revenue		$46,900,000	—	—	$46,900,000	—	$46,900,000
(Assumed 4% of ticket revenue)							
	TOTALREVENUE	**$1,219,600,000**	**$1,235,800,000**	**$306,500,000**	**$2,761,900,000**	**—**	**$2,761,900,000**
	O&M Costs	**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs							
*	Electric Propulsion	$110,800,000	$136,000,000	$26,700,000	$273,500,000	$80,700,000	$354,200,000
	Maintenance-of-Way	$62,900,000	$81,100,000	$16,700,000	$160,700,000	$95,100,000	$255,800,000
	Maintenance-of-Way - New	$45,400,000	$55,800,000	$11,000,000	$112,200,000	$34,500,000	$146,700,000
*	Police - Road, Yard, & Station	$10,600,000	$23,500,000	$5,500,000	$39,600,000	$4,400,000	$44,000,000
	Power Directors	$8,800,000	$10,800,000	$2,100,000	$21,700,000	$6,400,000	$28,100,000
*	Train Dispatching	$3,300,000	$5,500,000	$1,400,000	$10,200,000	$20,400,000	$30,600,000
*	Station Maintenance & Services	$50,300,000	$171,900,000	$42,600,000	$264,800,000	—	$264,800,000
Transportation Operations Costs							
*	Regional Transportation Ops	—	—	—	—	$608,000,000	$608,000,000
*	Maintenance of Equipment	$127,700,000	$158,300,000	$100,700,000	$386,700,000	—	$386,700,000
*	Onboard Services	$67,400,000	—	—	$67,400,000	—	$67,400,000
*	Trainmen & Enginemen	$65,600,000	$193,600,000	$60,200,000	$319,400,000	—	$319,400,000
*	Yard	$11,500,000	$26,000,000	$14,500,000	$52,000,000	—	$52,000,000
*	Fuel	$1,400,000	$1,800,000	$1,600,000	$4,800,000	—	$4,800,000
*	Other Transportation Ops	$35,700,000	$43,800,000	$11,800,000	$91,300,000	—	$91,300,000
Sales & Marketing, National Ops Costs							
*	Sales & Marketing	$74,800,000	$118,300,000	$18,800,000	$211,900,000	—	$211,900,000
*	Police, Security, Environmental	$10,100,000	$34,400,000	$4,700,000	$49,200,000	—	$49,200,000
G&A Costs							
*	G&A	$60,400,000	$80,300,000	$24,100,000	$164,800,000	—	$164,800,000
	TOTAL O&M COSTS	**$746,700,000**	**$1,141,100,000**	**$342,400,000**	**$2,230,200,000**	**$849,500,000**	**$3,079,700,000**
** = Indicates above-the-rail (ATR) cost area*							
	Net Contribution Cost Definition	**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
	NET CONTRIBUTION	**$472,900,000**	**$94,700,000**	**$(35,900,000)**	**$531,700,000**		

Source: NEC FUTURE team, 2015

Table 16: Alternative 3.4 (via Central CT/Worcester Route Option) O&M Cost Summary and Contribution Analysis

		INTERCITY SERVICES				REGIONAL SVCS	
Revenue		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Ticket Revenue		$1,105,100,000	$1,198,500,000	$304,500,000	$2,608,100,000	—	$2,608,100,000
Food & Beverage Revenue		$44,200,000	—	—	$44,200,000	—	$44,200,000
(Assumed 4% of ticket revenue)							
TOTALREVENUE		**$1,149,300,000**	**$1,198,500,000**	**$304,500,000**	**$2,652,300,000**	—	**$2,652,300,000**
O&M Costs		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs							
*	Electric Propulsion	$108,200,000	$130,900,000	$26,700,000	$265,800,000	$80,700,000	$346,500,000
	Maintenance-of-Way	$62,900,000	$79,700,000	$17,000,000	$159,600,000	$96,200,000	$255,800,000
	Maintenance-of-Way - New	$43,400,000	$52,500,000	$10,700,000	$106,600,000	$33,700,000	$140,300,000
*	Police - Road, Yard, & Station	$10,100,000	$22,800,000	$5,400,000	$38,300,000	$4,400,000	$42,700,000
	Power Directors	$8,600,000	$10,400,000	$2,100,000	$21,100,000	$6,400,000	$27,500,000
*	Train Dispatching	$3,300,000	$5,400,000	$1,400,000	$10,100,000	$20,400,000	$30,500,000
*	Station Maintenance & Services	$47,300,000	$167,200,000	$42,500,000	$257,000,000	—	$257,000,000
Transportation Operations Costs							
*	Regional Transportation Ops	—	—	—	—	$584,700,000	$584,700,000
*	Maintenance of Equipment	$124,800,000	$152,400,000	$100,700,000	$377,900,000	—	$377,900,000
*	Onboard Services	$66,200,000	—	—	$66,200,000	—	$66,200,000
*	Trainmen & Enginemen	$66,000,000	$196,000,000	$60,200,000	$322,200,000	—	$322,200,000
*	Yard	$11,500,000	$26,000,000	$14,500,000	$52,000,000	—	$52,000,000
*	Fuel	$1,400,000	$1,700,000	$1,600,000	$4,700,000	—	$4,700,000
*	Other Transportation Ops	$34,900,000	$42,200,000	$11,800,000	$88,900,000	—	$88,900,000
Sales & Marketing, National Ops Costs							
*	Sales & Marketing	$70,500,000	$114,900,000	$18,700,000	$204,100,000	—	$204,100,000
*	Police, Security, Environmental	$9,500,000	$33,400,000	$4,700,000	$47,600,000	—	$47,600,000
G&A Costs							
*	G&A	$58,700,000	$79,300,000	$24,400,000	$162,400,000	—	$162,400,000
TOTAL O&M COSTS		**$727,300,000**	**$1,114,800,000**	**$342,400,000**	**$2,184,500,000**	**$826,500,000**	**$3,011,000,000**
** = Indicates above-the-rail (ATR) cost area*							
Net Contribution Cost Definition		**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION		**$422,000,000**	**$83,700,000**	**$(37,900,000)**	**$467,800,000**		

Source: NEC FUTURE team, 2015

Table 17: No Action and Action Alternatives Summary

Alternative	Service*	Revenue	O&M Cost	Net Contribution
No Action	EXP	$964,100,000	$358,300,000	$605,800,000
	MET/ IC	$935,400,000	$548,300,000	$387,100,000
	TOTAL	**$1,899,500,000**	**$906,600,000**	**$992,900,000**
Alternative 1	EXP	$803,900,000	$331,000,000	$472,900,000
	MET/ IC	$1,369,400,000	$995,900,000	$373,500,000
	TOTAL	**$2,173,300,000**	**$1,326,900,000**	**$846,400,000**
Alternative 2	EXP	$1,023,700,000	$527,300,000	$496,400,000
	MET/ IC	$1,463,400,000	$1,312,400,000	$151,000,000
	TOTAL	**$2,487,100,000**	**$1,839,700,000**	**$647,400,000**
Alternative 3.1 (via Central CT/Providence route option)	EXP	$1,300,300,000	$780,500,000	$519,800,000
	MET/ IC	$1,482,400,000	$1,537,900,000	$(55,500,000)
	TOTAL	**$2,782,700,000**	**$2,318,400,000**	**$464,300,000**
Alternative 3.2 (via Long Island/Providence route option)	EXP	$1,265,600,000	$756,700,000	$508,900,000
	MET/ IC	$1,454,500,000	$1,474,100,000	$(19,600,000)
	TOTAL	**$2,720,100,000**	**$2,230,800,000**	**$489,300,000**
Alternative 3.3 (via Long Island/Worcester route option)	EXP	$1,219,600,000	$746,700,000	$472,900,000
	MET/ IC	$1,542,300,000	$1,483,500,000	$58,800,000
	TOTAL	**$2,761,900,000**	**$2,230,200,000**	**$531,700,000**
Alternative 3.4 (via Central CT/Worcester route option)	EXP	$1,149,300,000	$727,300,000	$422,000,000
	MET/ IC	$1,503,000,000	$1,457,200,000	$45,800,000
	TOTAL	**$2,652,300,000**	**$2,184,500,000**	**$467,800,000**

* EXP = Intercity-Express, MET/ IC = combined Metropolitan and Intercity-Corridor services
Source: NEC FUTURE team, 2015