NEC FUTURE

A Rail Investment Plan for the Northeast Corridor

Appendix BB – Technical Analysis on the Preferred Alternative

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1. Introduction

This document presents the technical analysis—service planning, ridership modeling, and capital and operations and maintenance cost estimating—of the Preferred Alternative performed for the Tier 1 Final Environmental Impact Statement (Tier 1 Final EIS) for the No Action Alternative and Preferred Alternative. The Preferred Alternative analysis is consistent with the iterative technical process for the Action Alternatives performed for the Tier 1 Draft Environmental Impact Statement (Tier 1 Draft EIS), as described in Volume 2, Appendix B. Updates and modifications to methodology on service planning, ridership modeling, capital and operations and maintenance cost estimates that were conducted for analysis of the Preferred Alternative are reflected in this document.

The Federal Railroad Administration (FRA) identified the Preferred Alternative through a comprehensive and collaborative evaluation process that reflects the Tier 1 Draft EIS evaluation of the Action Alternatives, extensive stakeholder and public comments, and the FRA policy objectives. Ultimately, the technical analysis and diverse perspectives led the FRA to a Preferred Alternative that defines a path forward to efficient passenger rail service that establishes a blueprint for corridor development for future generations. The process for identifying the Preferred Alternative is described in Volume 1, Chapter 4, along with a detailed description of the Preferred Alternative.

Section 2 of this document describes how the FRA developed the representative Service Plans for the No Action Alternative and Preferred Alternative. This section also identifies the station upgrades and expansions associated with the Preferred Alternative, as well as new stations served by the Preferred Alternative.

Section 3 describes the FRA's ridership forecasting process to identify and evaluate potential rail service improvements and investments in the NEC. For the Tier 1 Final EIS, the FRA adjusted the NEC FUTURE Interregional Model based on issues identified during the Tier 1 Draft EIS comment period and a reassessment of the overall model outcomes. Section 3.2 presents a detailed description of the reasoning for these adjustments, the process used, and a summary of the changes in the model results, compared to the results presented in the Tier Draft EIS. Section 3 also presents the results of the ridership forecasting including key findings, risks, and the sensitivity tests performed to further investigate model uncertainties.

Section 4 describes the adjustments made to the capital cost model for the Preferred Alternative. Section 5 documents the data sources, key assumptions, and approach used to prepare representative estimates of the costs associated with operations and maintenance (O&M) of the representative Service Plans for the No Action Alternative and Preferred Alternative. In conjunction with the capital cost estimates, the O&M cost estimates facilitate comparative cost analysis between the No Action Alternative and Preferred Alternative.

2. Service

As described in detail in Volume 1, Chapter 4, the FRA identified a Preferred Alternative based on the evaluation and findings presented in the Tier 1 Draft EIS, public and stakeholder comments, and the FRA policy objectives consistent with U.S. Department of Transportation strategic goals. Through this process, the FRA determined that the train service levels of the “grow” vision best accommodate and support future growth in population and employment in the Northeast; and thus, best meet national and regional goals for passenger rail transportation in the region.

Alternative 2 served as the foundation for the components of the Preferred Alternative. However, the FRA combined elements of all three Action Alternatives in terms of markets, representative route, service plan, and infrastructure elements in the Preferred Alternative. The Preferred Alternative representative routes and construction characteristics are the basis for the analysis in the NEC FUTURE Tier 1 EIS. They illustrate necessary improvements to achieve the Preferred Alternative representative Service Plan. As part of the Tier 1 process, the FRA has determined the necessity for new segments in particular geographic sections of the NEC in order to meet the Purpose and Need, and has identified a representative route for each potential new segment. The FRA or another federal agency providing funding for a particular project will evaluate specific locations for new segments as part of the Tier 2 project studies, prior to making any decision regarding new segment locations.

Over this assembled network, the FRA developed a new representative Service Plan. The FRA undertook additional service planning at specified nodes to provide improved transitions between infrastructure elements. The resulting Preferred Alternative provides a 4-track railroad for almost the entire length of the NEC, with the exception of final approaches to Washington, D.C., and Boston, and incorporates an electrified Hartford/Springfield Line into the NEC. The result is a significant capacity expansion on the NEC between central New Jersey and New Haven and through Penn Station New York, a one-seat ride service to and from Springfield, MA, and improved service to all NEC markets and additional service to selected new markets.

2.1 STATION IDENTIFICATION

For the Tier 1 Draft EIS, the FRA identified station upgrades and expansions, as well as new stations served by the Action Alternatives. This included both existing stations and potential new stations, required to accommodate market demands. The FRA defined general requirements for new and upgraded stations intended to serve as Intercity 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 methodology and results of this process are described in Volume 2, Appendix B.05. This process was used for the Tier 1 Final EIS with modifications noted below specific to the Preferred Alternative.

The level of analysis for a Tier 1 Environmental Impact Statement (Tier 1 EIS) is intended to be conceptual and should be considered as representative of future conditions for planning purposes.

The Tier 1 Final EIS does not include the engineering necessary to select specific new station sites or prescribe the extent or design of specific capital improvements at stations. However, it does include assumptions about where train stations generally are located and how they are served, as these assumptions are critical to the understanding of future travel behavior in the Study Area. The assumptions are used 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.

While Alternative 2 served as the foundation for the components of the Preferred Alternative, the FRA combined elements of all three Action Alternatives in terms of markets, representative route, and infrastructure elements in the Preferred Alternative. The station identification process, including upgrades and expansions, and new stations served by the Preferred Alternative is consistent with the representative route and infrastructure of the Action Alternative included in that portion of the Preferred Alternative. For example, between New Haven and Boston, the representative route is similar to Alternative 1. As such, the stations are also consistent with Alternative 1.

The next sections describe the FRA's station identification process. Section 2.1.1 provides a description of FRA's station typology used for NEC FUTURE, and Sections 2.1.2 and 2.1.3 provide a summary of the FRA's process to identify existing and new stations for the Preferred Alternative. Station identification included identifying station upgrades and expansions, as well as new stations served by the Preferred Alternative. A full description of the station identification process can be found in Volume 2, Appendix B.07.

In the Tier 1 Final EIS, the FRA analyzed transportation effects of the No Action Alternative and Preferred Alternative at a locally focused "stations" level. For this analysis, the FRA considered changes in travel modes within a metropolitan area with a focus on changes to local connectivity and passenger rail service, using the stations along the NEC as the focus of the analysis. The methodology for this analysis is described in Volume 2, Appendix B.05. The results of this analysis are presented in Volume 1, Chapter 5, Transportation.

2.1.1 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* in Volume 2, Appendix B.) This typology applies to existing stations and future stations included in each of the No Action Alternative and Action Alternatives, as well as the Preferred Alternative. 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 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 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 intermodal 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).
- 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).

2.1.2 Existing Stations

The FRA identified existing stations on the NEC and Hartford/Springfield Line that require station upgrades and expansion associated with implementation of the Preferred Alternative, based on previous work prepared on the Action Alternatives in the Tier 1 Draft EIS. Volume 2, Appendix B.07, describes this identification process, including the criteria the FRA used to identify stations that will need to be reclassified or upgraded to meet the service and infrastructure investments associated with the Preferred 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
- 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 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.

2.1.2.1 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[1] trains. Table 1 lists the existing stations included in the Preferred Alternative that meet the criteria for an upgrade, along with the primary reasons why these stations were initially selected.

[1] A new service concept that upgrades the level of Intercity-Corridor service provided on the NEC, 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 service.

Table 1: Selection Criteria for Existing Stations Proposed for Metropolitan Service with the Preferred Alternative

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	✓	✓	✓			✓				
Trenton, NJ	✓	✓		✓		✓	✓	✓		
Princeton Junction, NJ	✓						✓			
New Brunswick, NJ							✓			
Secaucus, NJ										
New Rochelle, NY	✓					✓	✓			
Greens Farms, CT		✓	✓			✓			✓	
Hartford, CT						✓	✓	✓	✓	
Springfield, MA						✓	✓	✓	✓	
Mystic, CT										✓
Westerly, RI										✓
T.F. Green, RI		✓	✓		✓					

Source: NEC FUTURE team, 2016

2.1.2.2 Expansion

Table 2 summarizes the type of work recommended at each of the stations associated with the Preferred 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 2: Station Expansion Associated with the Preferred Alternative

Station	Expansion Scope
Washington Union Station, DC	Station and terminal expansion**
New Carrollton, MD	Additional track, 2 additional platforms
Odenton, MD	Additional track, track/platform reconfiguration
BWI Airport, MD	Additional track, 2 additional platforms
Baltimore Penn Station, MD	Track and platform reconstruction, station expansion
Martin Airport, MD	Station relocation, track/platform reconfiguration
Aberdeen, MD	Station relocation, track/platform reconfiguration
Newark, DE	Station relocation, track/platform reconfiguration
Philadelphia 30th Street, PA	Station facilities, approach tracks
Cornwells Heights, PA	Track and platform reconfiguration
Metropark, NJ	Track and platform reconfiguration*
Newark Penn Station, NJ	Station capacity expansion
Secaucus, NJ	Additional platforms and station tracks connected to new Hudson River tunnels
Penn Station New York, NY	Station and terminal expansion
New Rochelle, NY	Track platform and station reconfiguration
Stamford, CT	New tracks and platforms on high-speed bypass*
Green's Farms, CT	Additional track, track/platform reconfiguration
New Haven Station, CT	Additional platform tracks on main level
Old Saybrook, CT	New tracks and platforms on high-speed new segment*
Hartford, CT	New lower level station and track relocation*
Kingston, RI	Additional track and platform capacity
T.F. Green Airport, RI	Additional track and platform capacity
Westwood/Rte 128, MA	Additional track and platform capacity
Readville, MA	Additional platform
Forest Hills, MA	Additional platform
Ruggles, MA	Additional platform
Boston South Station, MA	Station and terminal expansion

Source: NEC FUTURE team, 2016
* 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.

2.1.2.3 Relocation

Hartford Union Station in Hartford, CT, is the only major station relocation currently under consideration. The station is 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 under the Preferred Alternative. The need for station relocation due to the implementation of specific projects in the Preferred Alternative will be determined as part of future Tier 2 environmental review processes.

2.1.2.4 Partial Reconstruction

Under the Preferred Alternative, there are a number of existing stations that would need to be partially reconstructed to provide for additional main tracks within or adjacent to the existing right-of-way. These stations are typically served by Regional rail only, and their type or level of use would not change under the Preferred Alternative. As a result, they are not included as an upgraded or expanded station.

Examples include Seabrook and Bowie State in Maryland, where the addition of a fourth main line 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, as the Preferred Alternative is built out to a 4-track railroad along most of the NEC. This would impact 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 the Preferred 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).

2.1.3 New Stations

In addition to existing stations, the FRA identified new stations, including Regional rail stations, stations along the NEC and Hartford/Springfield Line that were previously unserved, stations on new segments, and high-speed express stations adjacent to existing stations. The analysis includes stations currently under planning by Regional 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 Regional rail operators, municipalities, or other transportation agencies
- Stations on the NEC or Hartford/Springfield Line
- Stations on new segments
- Stations serving new high-speed express tracks adjacent to existing stations

2.1.3.1 New Stations Planned by Regional Rail Operators

Most new stations along the NEC are Regional rail stations under development or included in the long-range plans of the Regional rail operators and planning agencies. Table 3 lists these planned stations, along with the selection criteria used to identify these stations, as part of the Preferred Alternative.

The FRA included these new stations in the Preferred Alternative generally as Regional rail (local) stations. These stations are anticipated to have ridership catchment areas that are more local in nature and best served by Regional rail. Stations that are under construction, funded, or in the capital plans of local agencies or rail operators are also included in the No Action Alternative.

Table 3: Selection Criteria for New Stations Planned by Regional Rail Operators

Name	Ridership Potential	Gap in Intercity or Regional Rail 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	✓					✓			
Barnum, CT	✓					✓		✓	
Orange, CT	✓			✓					
North Haven, CT	✓	✓							
Newington, CT	✓	✓		✓					
West Hartford, CT	✓	✓		✓					
Enfield, CT	✓			✓					
Pawtucket, RI	✓	✓		✓					

Source: NEC FUTURE team, 2016

Some of these planned new Regional rail stations represent candidates for Metropolitan service. Bayview, North Brunswick, and Morris Park fall into this category. These stations exhibit the following characteristics:

- Fills gap in Intercity 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

2.1.3.2 New Stations on the NEC and Hartford/Springfield Line

The FRA also identified new stations on the NEC and Hartford/Springfield Line that serve a purpose consistent with the vision of the Preferred Alternative. Table 4 identifies these new stations and the criteria used to identify them.

Baldwin, PA, and Cross-Westchester, NY, both provide highway access to the NEC and serve large suburban areas in the southwestern Philadelphia and northern New York City 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 the vision of the Preferred Alternative to grow the role of rail. The feasibility, practicality, and cost-effectiveness of these new stations should be assessed in future Tier 2 environmental analyses.

Table 4: Selection Criteria for New Stations on the NEC and Hartford/Springfield Line

Name	Ridership Potential	Gap in Intercity or Regional Rail Service	Highway Access	Transit Access	Airport Access	Population/Employment. Concentration	Activity Center	TOD/Regeneration Potential	New Intercity Route
Baldwin, PA	✓	✓	✓					✓	
Cross-Westchester, NY	✓		✓	✓					

Source: NEC FUTURE team, 2016

2.1.3.3 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 5. Select stations are also described in more detail below.

Table 5: Selection Criteria for New Stations on New Segments and Hartford/Springfield Line

Name	Ridership Potential	Gap in Intercity or Regional Rail Service	Highway Access	Transit Access	Airport Access	Population/Employment Concentration	Activity Center	TOD/Regeneration Potential	New Intercity Route
Philadelphia Int'l. Airport, PA	✓		✓		✓	✓	✓		✓
Mystic/New London, CT	✓								✓

Source: NEC FUTURE team, 2016

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/Southeastern Pennsylvania Transportation Authority (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 Mystic/New London station is located on the Old Saybrook CT-Kenyon RI new segment. The station is in a more suburban and rural area, but provides good access to population in zones that are relatively far from other Intercity stations.

2.1.3.4 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 NEC. Rather than being wholly new and separate stations, these stations function as a single integrated facility in terms of access and parking. Table 6 presents these stations, along with the criteria used to identify the station, for the Preferred Alternative.

Table 6: Selection Criteria for New Stations Adjacent to Existing Stations for the Preferred Alternative

Name	Ridership Potential	Gap in Intercity or Regional Rail Service	Highway Access	Transit Access	Airport Access	Population/Employment Concentration	Activity Center	TOD/Regeneration Potential	New Intercity Route
Metropark, NJ H.S.	✓		✓			✓	✓		
Stamford, CT H.S.	✓					✓	✓		

Source: NEC FUTURE team, 2016
H.S. = high speed

The evaluation presented in the Tier 1 Draft EIS did not demonstrate the need for a complete second spine. However, it is possible that in future decades there may be heightened need for additional capacity and performance improvement that could justify the construction of additional segments of a second spine to the existing rail network. The proposed Preferred Alternative is compatible with the later addition of new segments, including those adjacent to existing stations.

2.1.4 Summary

Table 7 contains a complete list of stations, their location, and station typology, and indication if the station is included in the No Action Alternative and Preferred Alternative. The FRA used the station ID (the third column of Table 7) to refer to each station in its assessment of station area Environmental Consequences for applicable resources. The station name and station ID is also a reference for information displayed in Chapter 7 of the Tier 1 Final EIS.

The Preferred Alternative provides service to 138 stations. Of these 138 stations, 116 exist today—109 on the NEC and 7 on the Hartford/Springfield Line. The improvements associated with the No Action Alternative provide service to an additional 9 stations, and the Preferred Alternative provides service to an additional 13 stations (for a total of 22, compared to existing service). Of the 22 stations, eight new stations are located in Connecticut, the most of any state within the Study Area. Four new stations are located on the Hartford/Springfield Line, in New Haven and Hartford Counties, followed by two in Fairfield County, one in New Haven County on the NEC, and one in New London County. There are five new stations in New York: four in Bronx County and one in Westchester County. Additional Tier 2 project analyses would address specific issues about new station location, layout, access, amenities, and connecting services. Chapter 5, Transportation, documents the effects to travel conditions related to these new stations.

Table 7: Stations in the No Action Alternative and Preferred Alternative

Geography	County	Station ID	Station Name	Station Typology	No Action Alternative	Preferred Alternative	Station Type
Existing NEC							
D.C.		1	Washington Union (WAS)[1]	Major Hub	X	X	Existing (Expanded)
MD	Prince George's	2	New Carrolton (NCR)	Hub	X	X	Existing
		3	Seabrook	Local	X	X	Existing
		4	Bowie State	Local	X	X	Existing
	Anne Arundel	5	Odenton	Hub	X	X	Modified
		6	BWI Airport (BWI)[1]	Major Hub	X	X	Existing (Expanded)
	Baltimore County	7	Halethorpe	Local	X	X	Existing
		15	Martin Airport	Local	X	X	Existing
	Baltimore City	10	Baltimore Penn Station (BAL)	Major Hub	X	X	Existing
		13	Bayview[2]	Hub	X	X	New
		8	West Baltimore	Local	X	X	Existing
	Harford	16	Edgewood	Local	X	X	Existing
		17	Aberdeen (NEC) (ABE)	Hub	X	X	Existing
	Cecil	22	Perryville	Local	X	X	Existing
		23	Elkton	Local		X	New
DE	New Castle	24	Newark, DE (NRK)	Hub	X	X	Existing
		25	Churchman's Crossing	Local	X	X	Existing
		26	Newport[2]	Local	X	X	New
		27	Wilmington Station (WIL)	Major Hub	X	X	Existing
		28	Edgemoor[2]	Local	X	X	New
		29	Claymont	Local	X	X	Existing

Source: NEC FUTURE team, 2015
Note: Existing Amtrak Station Codes provided in parenthesis where applicable
[1] Existing (Expanded) stations would be expanded in conjunction with the Preferred Alternative. The station typology of these stations would not change as a result of the Preferred Alternative.
[2] Stations that are included in the No Action Alternative, but are not yet operational are considered "new" for the purposes of this analysis. These stations are also included in the Preferred Alternative.

Table 7: Stations in the No Action Alternative and Preferred Alternative (continued)

Geography	County	Station ID	Station Name	Station Typology	No Action Alternative	Preferred Alternative	Station Type
Existing NEC (cont'd)							
PA	Delaware	30	Marcus Hook	Local	X	X	Existing
		31	Highland Avenue	Local	X	X	Existing
		32	Chester	Local	X	X	Existing
		33	Eddystone	Local	X	X	Existing
		34	Baldwin[2]	Hub	X	X	New
		35	Crum Lynne	Local	X	X	Existing
		36	Ridley Park	Local	X	X	Existing
		37	Prospect Park	Local	X	X	Existing
		38	Norwood	Local	X	X	Existing
		39	Glenolden	Local	X	X	Existing
		40	Folcroft	Local	X	X	Existing
		41	Sharon Hill	Local	X	X	Existing
		42	Curtis Park	Local	X	X	Existing
		43	Darby	Local	X	X	Existing
	Philadelphia	44	Philadelphia Airport[3]	Hub		X	New
		45	Philadelphia 30th St (PHL)	Major Hub	X	X	Existing
		47	North Philadelphia (PHN)	Hub	X	X	Existing
		48	Bridesburg	Local	X	X	Existing
		50	Tacony	Local	X	X	Existing
		51	Holmesburg Junction	Local	X	X	Existing
		52	Torresdale	Local	X	X	Existing
	Bucks	53	Cornwells Heights (CWH)	Hub	X	X	Existing
		54	Eddington	Local	X	X	Existing
		55	Croyton	Local	X	X	Existing
		56	Bristol	Local	X	X	Existing
		57	Levittown	Local	X	X	Existing

Source: NEC FUTURE team, 2015

Note: Existing Amtrak Station Codes provided in parenthesis where applicable

[2] Stations that are included in the No Action Alternative, but are not yet operational are considered "new" for the purposes of this analysis. These stations are also included in the Preferred Alternative.

[3] The airport is currently served by Regional rail service located off the NEC. The Philadelphia International Airport Station identified in the Preferred Alternative would be built as part of the NEC FUTURE and is a new station separate from the existing Regional rail station. The station area is co-located in Delaware County, PA.

Table 7: Stations in the No Action Alternative and Preferred Alternative (continued)

Geography	County	Station ID	Station Name	Station Typology	No Action Alternative	Preferred Alternative	Station Type
Existing NEC (cont'd)							
NJ	Mercer	58	Trenton (TRE)	Hub	X	X	Existing
		60	Hamilton	Local	X	X	Existing
		61	Princeton Junction (PJC)[4]	Local	X	X	Modified
	Middlesex	62	North Brunswick[4]	Hub	X	X	New
		63	Jersey Avenue	Local	X	X	Existing
		64	New Brunswick (NBK)[4]	Local	X	X	Modified
		65	Edison	Local	X	X	Existing
		66	Metuchen	Local	X	X	Existing
		67	Metropark (MET)	Major Hub	X	X	Existing
		68	Metropark H.S.	Major Hub		X	New
	Union	69	Rahway	Local	X	X	Existing
		70	Linden	Local	X	X	Existing
		71	Elizabeth	Local	X	X	Existing
		72	North Elizabeth	Local	X	X	Existing
	Essex	73	Newark Airport (EWR)	Hub	X	X	Existing
		74	Newark Penn Station (NWK)	Major Hub	X	X	Existing
	Hudson	76	Secaucus	Hub	X	X	Modified
NY	New York	77	Penn Station New York (NYP)[1]	Major Hub	X	X	Existing (Expanded)
	Bronx	78	Hunts Point	Local		X	New
		79	Parkchester/Van Ness	Local		X	New
		80	Morris Park	Hub		X	New
		81	Co-op City	Local		X	New
	Westchester	82	New Rochelle (NRO)	Hub	X	X	Existing
		83	Larchmont	Local	X	X	Existing
		84	Mamaroneck	Local	X	X	Existing
		85	Harrison	Local	X	X	Existing
		86	Rye	Local	X	X	Existing
		87	Cross-Westchester*	Hub		X	New
		88	Port Chester	Local	X	X	Existing

Source: NEC FUTURE team, 2015
Note: Existing Amtrak Station Codes provided in parenthesis where applicable
* Intercity services only
[1] Existing (Expanded) stations would be expanded in conjunction with the Preferred Alternative. The station typology of these stations would not change as a result of the Preferred Alternative.
[2] Stations that are included in the No Action Alternative, but are not yet operational are considered "new" for the purposes of this analysis. These stations are also included in the Preferred Alternative.
[4] Princeton Junction and New Brunswick stations are reclassified as Local stations, and a new Hub station is located in North Brunswick, midway between the two, to serve central New Jersey. The location for the Hub station in North Brunswick reflects NJ TRANSIT's plans for a new station (see Appendix B, No Action Report) as well as the existing constraints to expanding Princeton Junction or New Brunswick stations. The North Brunswick station, however, is representative and future decisions on a location for a Hub station would be as part of subsequent Tier 2 project-level studies.
H.S. = high speed

Table 7: Stations in the No Action Alternative and Preferred Alternative (continued)

Geography	County	Station ID	Station Name	Station Typology	No Action Alternative	Preferred Alternative	Station Type
Existing NEC (cont'd)							
CT	Fairfield	89	Greenwich	Local	X	X	Existing
		90	Cos Cob	Local	X	X	Existing
		91	Riverside	Local	X	X	Existing
		92	Old Greenwich	Local	X	X	Existing
		93	Stamford (STM)	Major Hub	X	X	Existing
		94	Stamford H.S.	Major Hub		X	New
		95	Noroton Heights	Local	X	X	Existing
		96	Darien	Local	X	X	Existing
		97	Rowayton	Local	X	X	Existing
		98	South Norwalk	Local	X	X	Existing
		99	East Norwalk	Local	X	X	Existing
		100	Westport	Local	X	X	Existing
		101	Greens Farms	Hub	X	X	Modified
		102	Southport	Local	X	X	Existing
		103	Fairfield	Local	X	X	Existing
		104	Fairfield Metro	Local	X	X	Existing
		105	Bridgeport (BRP)	Hub	X	X	Existing
		107	Barnum[2]	Local	X	X	New
		108	Stratford	Local	X	X	Existing
	New Haven	109	Milford	Local	X	X	Existing
		189	Orange	Local		X	New
		110	West Haven	Local	X	X	Existing
		111	New Haven Station (NHV)	Major Hub	X	X	Existing
		113	New Haven State Street	Local	X	X	Existing
		114	Branford	Local	X	X	Existing
		115	Guilford	Local	X	X	Existing
		116	Madison	Local	X	X	Existing
	Middlesex	117	Clinton	Local	X	X	Existing
		118	Westbrook	Local	X	X	Existing
		119	Old Saybrook (OSB)	Hub	X	X	Existing
	New London	121	New London (NLC)	Hub	X	X	Existing
		124	Mystic/New London H.S.*	Major Hub		X	New
		122	Mystic (MYS)*	Hub	X	X	Existing

Source: NEC FUTURE team, 2015
Note: Existing Amtrak Station Codes provided in parenthesis where applicable
* Intercity services only
[2] Stations that are included in the No Action Alternative, but are not yet operational are considered "new" for the purposes of this analysis. These stations are also included in the Preferred Alternative.
H.S. = high speed

Table 7: Stations in the No Action Alternative and Preferred Alternative (continued)

Geography	County	Station ID	Station Name	Station Typology	No Action Alternative	Preferred Alternative	Station Type
Existing NEC (cont'd)							
RI	Washington	123	Westerly (WLY)*	Hub	X	X	Existing
		125	Kingston (KIN)	Hub	X	X	Existing
		126	Wickford Junction	Local	X	X	Existing
	Kent	127	T.F. Green	Hub	X	X	Modified
	Providence	128	Providence Station (PVD)	Major Hub	X	X	Existing
		130	Pawtucket	Local		X	New
MA	Bristol	131	South Attleboro	Local	X	X	Existing
		132	Attleboro	Local	X	X	Existing
		133	Mansfield	Local	X	X	Existing
	Norfolk	134	Sharon	Local	X	X	Existing
		135	Canton Junction	Local	X	X	Existing
		136	Route 128 (RTE)	Major Hub	X	X	Existing
	Suffolk	137	Readville	Local	X	X	Existing
		138	Hyde Park	Local	X	X	Existing
		139	Forest Hills	Local	X	X	Existing
		140	Ruggles Street	Local	X	X	Existing
		141	Back Bay (BBY)	Major Hub	X	X	Existing
		143	Boston South Station (BOS) [1]	Major Hub	X	X	Existing (Expanded)
Existing Hartford/Springfield Line							
CT	New Haven	157	North Haven	Local		X	New
		184	Wallingford (WFD)	Hub	X	X	Existing
		185	Meriden (MDN)	Hub	X	X	Existing
	Hartford	160	Berlin (BER)	Hub	X	X	Existing
		161	Newington	Local		X	New
		186	West Hartford	Local		X	New
		163	Hartford (HFD)	Major Hub	X	X	Modified
		168	Windsor WND)	Hub	X	X	Existing
		169	Windsor Locks (WNL)	Hub	X	X	Existing
		187	Enfield	Local		X	New
MA	Hampden	170	Springfield (SPG)	Hub	X	X	Existing

Source: NEC FUTURE team, 2015
Note: Existing Amtrak Station Codes provided in parenthesis where applicable
* Intercity services only
[1] Existing (Expanded) stations would be expanded in conjunction with the Preferred Alternative. The station typology of these stations would not change as a result of the Preferred Alternative.
H.S. = high speed

2.2 REPRESENTATIVE SERVICE PLAN DEVELOPMENT

The FRA developed the representative Service Plan and associated outputs for the Preferred Alternative, including timetables, stringline charts (time-distance diagrams) and cumulative train operating data, at a sketch planning level of detail appropriate to a Tier 1 EIS.[2] The use of this modeling technique was introduced and described in Volume 2, Appendix B.05. As in the Tier 1 Draft EIS, the Preferred Alternative representative Service Plan is operator neutral and provides a technical basis to allow 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 assembled the network model of the Preferred Alternative by adapting the work previously performed for Alternatives 1, 2, and 3, to assist in the development of an end-to-end, conflict-free representative Service Plan. The technical assumptions guiding the development of the representative Service Plan, including train performance, schedule margin, station dwell times, and practical line headways were advanced from the Tier 1 Draft EIS service planning effort. These technical assumptions are detailed in Volume 2, Appendix B.05.

The development of the representative Service Plan for the Preferred Alternative followed a logical process of sequentially introducing trains to the modeled network and resolving any train movement conflicts in priority order. The process started with the schedule of Intercity-Express trains, which were routed on the express tracks, and maintaining the minimum dwell and schedule

NEC FUTURE Service Types

- **Intercity-Express —** premium intercity high-speed rail service offered on the NEC, making limited stops along the NEC and only serving the largest markets. 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.
- Intercity-Corridor — Intercity services that operate both on the NEC and on connecting corridors that reach markets beyond the NEC. These Metropolitan and Intercity-Corridor trains provide connectivity and direct one-seat service to large and mid-size markets on the NEC.
- Metropolitan — A new service concept that upgrades the level of Intercity-Corridor rail service provided on the NEC, 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 service.
- Intercity-Corridor-Other — Intercity-Corridor service that provides connectivity and direct one-seat service between non-electrified connecting corridors and the large and mid-size markets on the NEC (as opposed to Metropolitan service that can only operate only in electrified territory).
- 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.
- Regional Rail — service within a single metropolitan area to local markets. Regional rail trains provide local and commuter-focused service characterized by relatively low fares and a high percentage of regular travelers.

[2] The service planning effort for the NEC FUTURE Tier 1 Draft EIS and Tier 1 Final EIS used a combination of spreadsheet-based tools and planning level models developed using the Viriato software package.

margin for the entirety of their run. Intercity-Corridor service (both Metropolitan and Intercity-Corridor-Other trains) were then added into the network, followed by Regional rail trains.

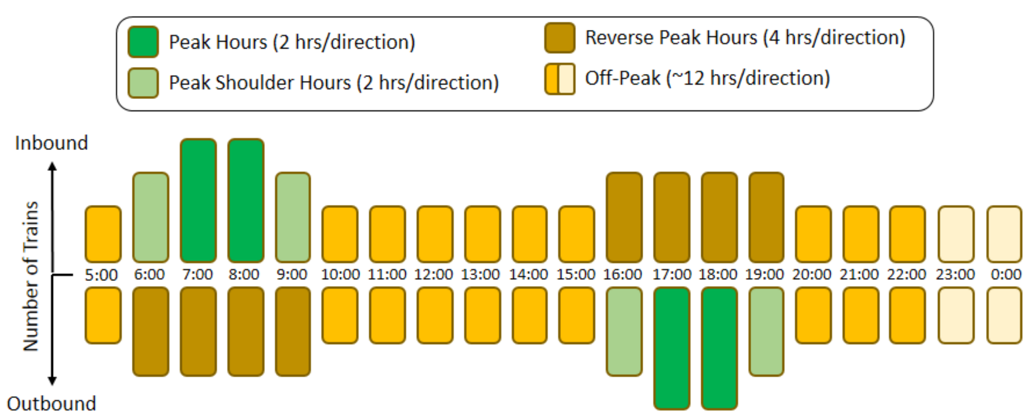
The development of peak and non-peak service specifications also mirrored the process used in the Tier 1 Draft EIS for the Action Alternatives. The FRA first scheduled trains into the peak hour, followed by fully integrating them into the representative Service Plan without conflicts. Then, the FRA adapted the peak service into a full-day representative Service Plan.

Overall the peak and off-peak train volumes in the Preferred Alternative representative Service Plan are similar to the Alternative 2 representative Service Plan. For Intercity service, maximum service was planned during the peaks for the intercity train types and then tapered along the service route based on time of day to reduce the volume of service during off-peak hours. To accomplish the tapering, the FRA tailored the volume of Intercity service to the business travel peak periods in Washington, D.C., New York City, and Boston by originating and terminating selected trains at key intermediate stations.

In addition to the three terminal stations in Washington, D.C., New York City, and Boston, the FRA used Philadelphia and New Haven to start and terminate trains during the early morning, midday, and evening. Due to their long travel distances and times, most Intercity trains do not fit comfortably into a single time slot along their entire run. Thus, Intercity non-peak periods cannot be simply subsets of the peak. In contrast, for Regional rail trains, the service levels for the reverse-peak, off-peak and shoulder hours are planned as a subset of peak service within each NEC region. Regional rail service specifications include total daily trains on a typical weekday, which are then broken out into the number of trains per hour for each service pattern in each of four standard time periods: (1) peak hour, peak direction, (2) peak shoulder hour, peak direction, (3) reverse-peak hour, and (4) typical off-peak hour.

Figure 1 illustrates the assumed fluctuation of Regional rail service levels within hourly time intervals through the course of a typical weekday. For a more detailed explanation of this approach, please see Volume 2, Appendix B.05.

Figure 1: 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).

2.3 SERVICE PLAN STRUCTURE

Between Philadelphia, PA, and New Haven, CT, the FRA built the representative Service Plan for the Preferred Alternative from the Service Plan for Alternative 2. Pulse-hub operations identified for the Alternative 2 Service Plan were included in the Preferred Alternative representative Service Plan at Philadelphia, PA, and New Haven, CT, where numerous rail services converge multiple times per hour allowing for coordinated timed transfers and service overtakes. 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 (see Volume 2, Appendix B.05 for a description of pulse-hub operations). South of Philadelphia and North of New Haven, the Preferred Alternative representative Service Plan incorporates elements of Alternative 1 and 3, and is based on the parameters set by the Preferred Alternative network configuration and service goals.

Operating speeds are primarily governed by track geometry. The representative Service Plans assume maximum operating speeds for tangent track; however, localized conditions limit speeds below these maximum speeds. As in the Alternative 2 representative Service Plan, the Preferred Alternative representative Service Plan limits top operating speeds between Philadelphia and New Haven to 160 miles per hour (MPH). South of Philadelphia and north of New Haven (to Boston), the Preferred Alternative Service Plan assumes operating speeds up to 220 MPH for Intercity-Express and Metropolitan trains on new segments in the network. For more details on speeds and railroad operational safety, see Volume 1, Chapter 7.18.

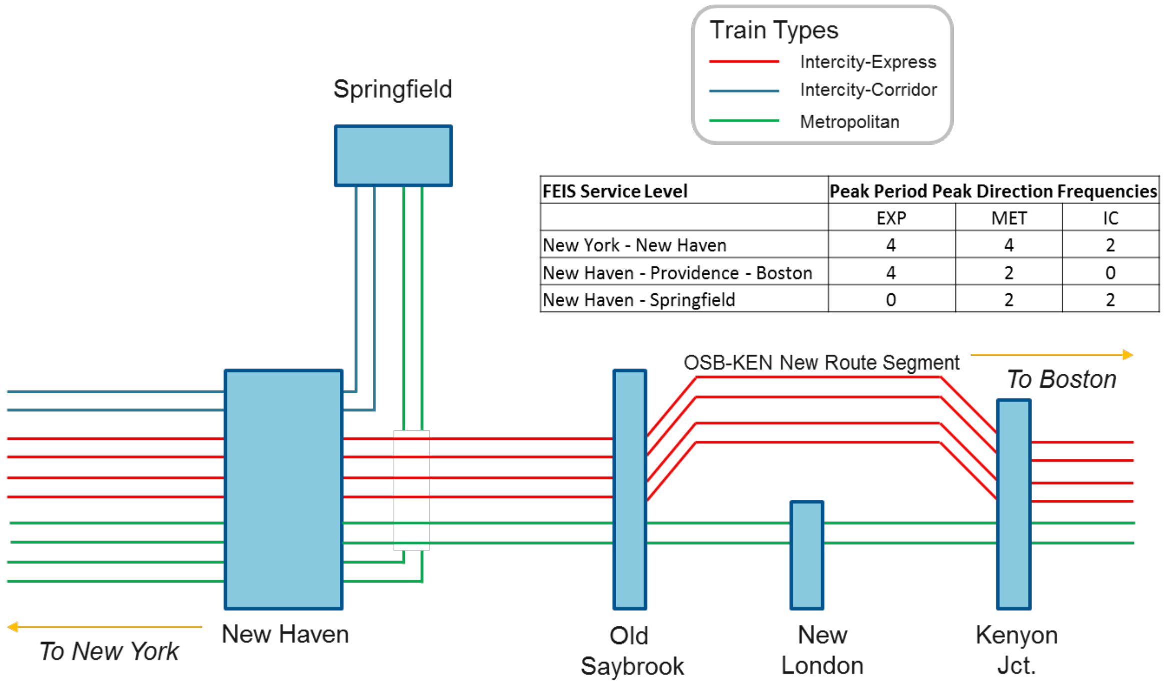
The FRA developed new Regional rail service specifications and new Regional rail ridership estimates for the Preferred Alternative in all regions of the Study Area, with the exception of Philadelphia. In the Tier 1 Draft EIS, the Delaware Valley Regional Planning Commission (DVRPC) provided the Regional rail ridership estimates for Philadelphia. The FRA determined there were not sufficient changes in this region to require new ridership model runs by DVRPC; thus, the specifications and estimates for the Philadelphia region remain unchanged from the Tier 1 Draft EIS. For each of the other major regions on the NEC – Washington, D.C., New Jersey-New York City, New York City-Connecticut, and Boston – the FRA developed new Regional rail service specifications that include Regional rail and Metropolitan service, and generated new ridership estimates[3].

2.4 LEVEL OF SERVICE

Figure 2 and Figure 3 present the representative level-of-service north and south of New York City, respectively, for the Preferred Alternative. Table 8 lists the trains per hour by location for the existing, No Action Alternative, and Preferred Alternative.

[3] The final ridership estimates represent the average of two runs (one with and one without Metropolitan service). The FRA determined that these two runs were necessary to reflect that Metropolitan trains would carry Regional rail passengers, although Metropolitan service would not be offered at the same price point as traditional Regional rail service. Since fare was not explicitly adjusted in the ridership model, the FRA determined that a fair proxy for a higher priced Metropolitan service available to Regional rail riders was the average of runs with and without the service.

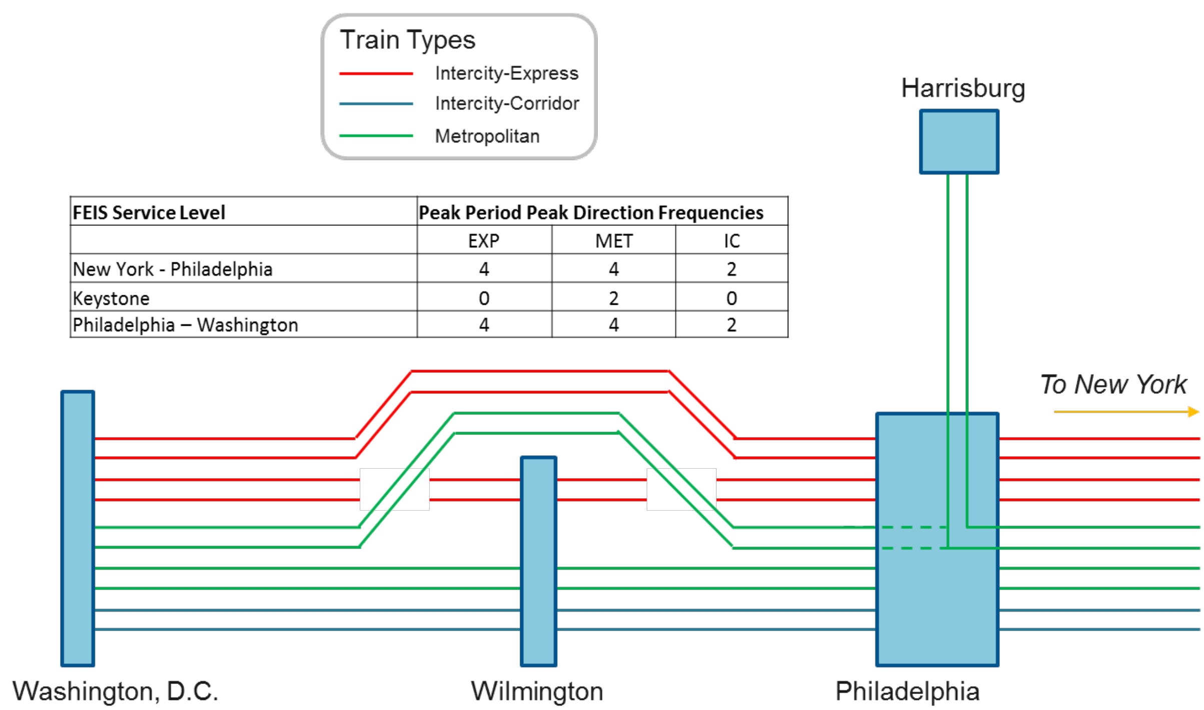
Figure 2: Preferred Alternative Standard Peak-Hour Service North of New York City



FEIS Service Level	Peak Period Peak Direction Frequencies		
	EXP	MET	IC
New York - New Haven	4	4	2
New Haven - Providence - Boston	4	2	0
New Haven - Springfield	0	2	2

Source: NEC FUTURE team, 2016

Figure 3: Preferred Alternative Standard Peak Hour Service South of New York City



FEIS Service Level	Peak Period Peak Direction Frequencies		
	EXP	MET	IC
New York - Philadelphia	4	4	2
Keystone	0	2	0
Philadelphia – Washington	4	4	2

Source: NEC FUTURE team, 2016

Table 8: Trains per Hour by Location for the Existing (2012), No Action Alternative, and Preferred Alternative (2040)

	Existing	No Action Alternative	Preferred Alternative
SOUTH END			
Intercity-Express	1	1	4
Intercity-Corridor			
Washington, D.C.-Philadelphia	1	1	2
Philadelphia-New York City	2	2	2
Metropolitan			
Washington, D.C.-Philadelphia	—	—	4
Philadelphia-New York City	—	—	4
NORTH END			
Intercity-Express	<1	<1	4
Intercity-Corridor			
New York City-New Haven	<1	<1	2
New Haven-Boston (Shore Line)	<1	<1	-
New Haven-Springfield	<1	<1	2
Metropolitan			
New York City-New Haven	—	—	4
New Haven-Boston (Shore Line)	—	—	2
New Haven-Springfield	—	—	2
CONNECTING CORRIDORS			
Keystone Corridor			
Intercity-Corridor	1	1	—
Metropolitan	—	—	2
Virginia	<1	<1	2
Empire Corridor	1	1	2
Knowledge Corridor	1*	1*	1*
Inland Route	—	<1	1

Source: NEC FUTURE team, 2016
*denotes trains per day
<denotes train frequencies less than one per peak hour (i.e., one train every two hours)

2.4.1 Intercity-Express

The Preferred Alternative provides additional capacity that allows improved Intercity-Express levels of service for all major markets, and reflects the level-of-service developed for Alternative 2. In the Tier 1 Draft EIS, different combinations of stopping patterns were tested, with two scenarios offering the best illustration of the tradeoffs and issues. This analysis (Volume 2, Appendix B.05) informed the determination of the express patterns and service levels for the Preferred Alternative.

Under the Preferred Alternative, throughout the NEC, four Intercity-Express trains are operated in each direction in the standard peak hour. Approximate Intercity-Express trip times are presented in Table 9. Within that service level envelope, service characteristics and patterns for Intercity-Express in the peak hour vary among the four NEC segments as follows.

Table 9: Best Intercity-Express Trip Times for Existing (2012) and Preferred Alternative (2040)

	Existing	Preferred Alternative
Boston–New York City	3:40	2:45
New York City–Washington, D.C.	2:45	2:10*

Source: NEC FUTURE team, 2016
* 2:10 for the service pattern that operates non-stop between Philadelphia and Washington, D.C. The representative Service Plan also includes Intercity-Express trains that make limited stops between Philadelphia and Washington, D.C. The travel time for this service pattern is 2:20.

2.4.1.1 South of Philadelphia

Two patterns of Intercity-Express trains are planned south of Philadelphia, each on 30-minute headways. One pair operates non-stop between Philadelphia and Washington, D.C. The other pair makes intermediate stops at Wilmington, Baltimore, and BWI Airport. The train that operates non-stop utilizes the new segment through the Wilmington area and saves approximately 10 minutes of trip time in this territory over the stopping train.

2.4.1.2 Philadelphia to New York City

In the Philadelphia to New York City territory, all four Intercity-Express trains are planned with the same pattern on regular 15-minute headways. Intermediate stops include, Metropark and Newark Penn Station. These two intermediate stops were assumed for ridership estimation purposes but represent placeholders pending further analysis. The patterns developed for this analysis remain feasible with other potential combinations of intermediate stations (including North Brunswick, Newark Airport, Trenton, Princeton Junction and/or New Brunswick), as long as the total number of intermediate stops equals two.

2.4.1.3 New York City to New Haven

In the New York City to New Haven, CT, territory, all four Intercity-Express trains are planned with the same pattern on regular 15-minute headways. Stamford is the only intermediate stop for Intercity-Express trains in this territory.

2.4.1.4 North of New Haven

Two patterns of Intercity-Express trains are planned between New Haven, CT, and Boston, MA, each on 30-minute headways. Unlike in the Philadelphia to Washington, D.C., territory in which the trip time differences between the patterns are significant, the deviations north of New Haven are minimal, and all four trains maintain an even 15-minute separation throughout the territory. Both patterns utilize the Old Saybrook–Kenyon new segment and serve the intermediate markets of Back Bay, Route 128, and Providence. One pattern also serves T.F. Green Airport, while the other serves a new station on the Old Saybrook–Kenyon new segment in Mystic/New London.

2.4.2 Metropolitan

Similar to the Intercity-Express patterns, the Metropolitan trains are planned with a single pattern at 15-minute headways between Philadelphia, PA, and New Haven, CT. These regular patterns feed the pulse-hub operations at these two locations. South of Philadelphia, both the Intercity-Express and Metropolitan trains deviate from regular 15-minute headways with multiple stopping patterns; north of New Haven the four Metropolitan trains operate over different routes, with two trains to Springfield via the Hartford/Springfield/Line and two to Boston via the NEC.

2.4.2.1 South of Philadelphia

Two patterns of Metropolitan trains are planned south of Philadelphia, each on 30-minute headways. Both pairs serve the intermediate markets of Newark, DE, Aberdeen, Bayview, Baltimore, BWI Airport, Odenton, and New Carrolton. One pair also serves Wilmington; the other utilizes the new segment in the Wilmington area, which circumvents the existing Wilmington train station. Use of the new segment reduces travel time by approximately seven minutes.

2.4.2.2 Philadelphia to New York City

In the Philadelphia to New York City territory, all four Metropolitan trains are planned with the same pattern on regular 15-minute headways. Intermediate stops include, Secaucus, Newark Penn Station, Newark Airport, Metropark, North Brunswick, Trenton, Cornwell's Heights, and North Philadelphia.

Two of these four trains operate through Philadelphia to Washington, D.C., as the pattern that stops at Wilmington. The other two trains are lined up in the same "slot" to feed either the Metropolitan trains that operate south of Philadelphia via the new route segment through Wilmington or the 30-minute frequency to Harrisburg via the Keystone Line. In the Preferred Alternative representative Service Plan, these trains are assumed to operate to Harrisburg and the second pair of Washington, D.C. Metropolitans originate in Philadelphia. However, based on the relative volumes and the time of day, these trains could operate in either "slot" west or south of Philadelphia.

2.4.2.3 New York City to New Haven

In the New York City to New Haven, CT, territory, all four Metropolitan trains are planned with the same pattern on regular 15-minute headways. Intermediate stops include Morris Park, New Rochelle, Port Chester, Stamford, Greens Farms, and Bridgeport.

2.4.2.4 North of New Haven

Of the four Metropolitan trains that feed the New Haven pulse-hub from the south in the peak hour, two are routed to Springfield via the Hartford/Springfield Line and two to Boston via the NEC. Intermediate stops to Boston include Old Saybrook, New London, Mystic, Westerly, Kingston, T.F. Green, Providence, Route 128, and Back Bay.

The pulse-hub at New Haven would allow for efficient transfer among the various services and routes. A passenger from Springfield or Hartford on a Metropolitan train has a four-minute transfer to a southbound or northbound Intercity-Express train. The transfer to the southbound Express is cross platform. Intercity-Express passengers transferring to a Metropolitan train will have either a 2 or 17-minute transfer to a Springfield or a Metropolitan train depending on which 15-minute pulse the Express train arrives in at New Haven. Hartford/Springfield Line and NEC Regional rail service also participate in the pulse-hub at New Haven, with approximately 6-minute transfer times to Metropolitan or Express trains.

2.4.3 Intercity-Corridor-Other

The service levels and stopping patterns for Intercity-Corridor-Other service have been incorporated directly from Alternative 2. The representative Service Plan for the Preferred Alternative accommodates up to four Intercity-Corridor-Other slots per hour in each direction, all day long on a typical weekday, between Washington, D.C., and New Haven, CT, and, by extension, on the Hartford/Springfield Line between New Haven, CT, and Springfield, MA. As discussed below, not all slots would be used.

The Intercity-Corridor-Other slots would be occupied by the following train services:

- Long-distance intercity trains operating between New York City and several destinations, including Miami, Savannah, New Orleans, Pittsburgh, and Chicago
- Intercity-Corridor trains that operate both on the NEC Spine and off-corridor, including:
  - Trains with destinations south of Washington, D.C., including Virginia and North Carolina
  - Trains headed north and east of Springfield, MA with destinations in Vermont via the Knowledge Corridor and Boston via the Inland Route

No more than two Intercity-Corridor-Other trains per hour are scheduled during any given hour on a typical weekday, and the number of hours during which two trains are scheduled are limited generally to peak travel periods. Unfilled slots are available for use by Intercity–Corridor-Other trains coming from off-corridor and operating behind schedule. This use of unfilled slots allows greater reliability for the NEC overall and minimizes the need for excessive schedule recovery time for these services at Washington, D.C., and Springfield, MA.

2.4.4 Regional Rail

The representative Service Plan for the Preferred Alternative represents a simplified version of existing Regional rail train schedules, appropriate for high-level corridor planning purposes (Table 10). The use of simplified service patterns, including regular clockface headways, are recommended as operational best practices. As in the Tier 1 Draft EIS, the Service Plans are operator neutral and provide a technical basis to allow 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.

In the Tier 1 Draft EIS, the FRA identified a broad array of Regional rail improvements, 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. For Alternative 2, a set of general service standards at Regional rail stations was used to guide the development of future service targets:

- 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.

In locations where Regional rail service is provided only as all-stop local service, the representative Service Plan creates service zones comprising groups of adjacent stations to enable the introduction of zone-express service at peak periods. Where zone-express service already exists, the FRA considered increasing the number of zones, in order to improve trip times for stations in the outer zones.

The Preferred Alternative includes Metropolitan service along the NEC 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 distributes passenger loads in certain Regional rail markets and represents a different service option for long Regional rail trips.

The representative Service Plan incorporates the “transit style” service included in the Alternative 1 representative Service Plan for Regional rail service between New Haven and New York City. This supports very frequent regional train service to local markets in Connecticut. In order to provide travel time benefits for intercity trains, as well as the option for some faster regional trains, the Preferred Alternative includes some 29 miles of new segments between New Rochelle, NY, and Green Farms, CT, which support overtakes and faster speeds.

Table 10: Regional Rail Service Volumes (2040)

	No Action				Preferred Alternative			
	Peak	Shoulder	Reverse Peak	Off Peak	Peak	Shoulder	Reverse Peak	Off Peak
WASHINGTON REGION								
Maryland Regional Rail								
NEC (Penn Line)	3	2.5	1.5	1.3	10	6	5	3
Camden Line	2	1	0.8	—	4	2	2	1
Brunswick Line	3	1.5	—	0.1	6	4	2	1
Virginia Regional Rail								
VA Regional Rail	6	1	0.2	0.1	8	5	3	3
PHILADELPHIA REGION								
NEC (North Side) Lines								
Trenton Line	4	1	2	1	6	3	4	2
Atlantic City	1	1	0.5	0.5	2	1	1	1
Chestnut Hill West	2	2	1.5	1	4	2	2	1
NEC (South Side) Lines								
Wilmington/Newark/Marcus Hook	3	2	1.5	1	12	6	6	2
Airport	2	2	2	2	2	4	4	5
Non-NEC Lines								
Chestnut Hill East Line	2.5	1.5	1	1.2	2.5	1.5	1	1.2
Cynwyd Line	1.5	1	0.8	0.2	1.5	1	0.8	0.2
Fox Chase Line	2.5	1	1.3	1.1	2.5	1	1.3	1.1
Doylestown Line	4	2	2	1.8	4	2	2	1.8
Norristown Line	3	1.5	1.3	1.2	3	1.5	1.3	1.2
Media/Elwyn Line	3.5	2	1.5	1.1	3.5	2	1.5	1.1
Paoli/Thorndale Line	6	3	2	1.8	6	3	2	1.8
Warminster Line	3	1.5	1	1.6	3	1.5	1	1.6
West Trenton	3	2	1.5	1.2	3	2	1.5	1.2
NEW YORK REGION								
New Jersey								
NEC/NJCL Trans Hudson	15	8	7	2.8	22	14	10	4
Other Regional Rail Trans Hudson	6	3	3	1.8	—	—	—	—
Standard Inner Branch Slots	—	—	—	—	20	14	10	8
New York (LI & Hudson)								
Long Island (to PSNY)	27	13	10	9	27	13	10	9
Hudson Line (to PSNY)	—	—	—	—	6	4	5	2
CT & Westchester County								
New Haven Line (PSNY & GCT)	22	16	12	3	34	26	16	15
New London - New Haven	2	2	1	0.4	3	2	1	1
Springfield - New Haven	0.5	0.5	0.5	0.5	2	1	1	1
BOSTON REGION								
NEC Lines								
Providence Line	2	1	1	0.8	4	4	4	1.5
Stoughton/South Coast	2	1	1	0.6	4	2	2	1.0
Needham Branch	2	1	1	0.6	2	2	2	1.0
Franklin Branch	3	1	1	0.6	2	2	2	1.0
Non-NEC Lines								
Worcester/Framingham Line	3	2	1	0.5	4	3	1	1
Fairmont Line	1.5	1.5	1.5	1.0	1.5	1.5	1.5	1
Greenbush Line	1.5	1	0.5	0.5	1.5	1	0.5	0.5
Kingston/Plymouth Line	1.5	1	0.5	0.5	1.5	1	0.5	0.5
Middleborough/Lakeville	1.5	1	0.5	0.5	1.5	1	0.5	0.5

Source: NEC FUTURE team, 2016

A key feature of the representative Service Plan is that Regional rail service participates in the New Haven pulse-hub operation. Regional rail trains arrive just ahead of Intercity trains and depart soon after Intercity trains in both directions. The New Haven Line limited-stop Regional rail train connects at the New Haven Hub to both the Hartford/Springfield Line Regional rail train and the Shore Line Regional rail train. This train could be operated as a single train between New York City and New Haven that splits (decouples) at New Haven with one-half traveling on to Springfield and the other half traveling on to Old Saybrook. Alternatively, the limited-stop New Haven Line train could operate through to Springfield, or Old Saybrook with the other service connecting at the New Haven Hub; or it could terminate in New Haven with both Springfield and Old Saybrook service connecting.

2.5 SUMMARY

2.5.1 No Action Alternative

As a baseline for comparison, consistent with NEPA requirements, the FRA defined and evaluated a No Action Alternative that included planned and programmed improvements to the Existing NEC. The No Action Alternative includes planned and programmed improvements to the Existing NEC, organized into three categories:

- Category 1: Funded projects or projects with approved funding plans
- Category 2: Funded or unfunded mandates
- Category 3: Unfunded projects necessary to keep the railroad running

The FRA also identified several ongoing independent rail projects located within the Study Area as Related Projects. Related Projects are fully or partially funded projects on a connecting corridor, but not on the NEC; unfunded projects with ongoing or completed NEPA/PE; and partially funded transit or freight projects located off of but connecting to the NEC. These Related Projects are not included in the No Action Alternative.

This Tier 1 Final EIS incorporates the No Action Alternative developed for the Tier 1 Draft EIS. Although projects have advanced and conditions have changed along the NEC since the release of the Tier 1 Draft EIS in November 2015, the assumptions about overall performance or capacity of the NEC in 2040 did not change. For that reason, and to maintain consistency throughout this evaluation, the No Action Alternative was not updated.

Since the release of the Tier 1 Draft EIS, progress has been made in advancing critical infrastructure projects on the NEC as well as connecting corridors. Some of these were identified as Related Projects to the No Action Alternative—projects with independent utility that are advancing under their own project development or NEPA processes or ones that are necessary 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. An example of recent progress is the initiation of the NEPA process for the Hudson Tunnel Project to preserve the current functionality of the NEC's Hudson River rail crossing between New Jersey and New York and strengthen the resilience of the NEC. The FRA and NJ TRANSIT are currently leading the NEPA process for the Hudson Tunnel Project. The Hudson Tunnel Project will create new track capacity so that the existing tracks in tunnel (referred to as the North River Tunnel) can be repaired. It is an urgently needed project that is necessary to bring the NEC to a state of good repair. 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 alternative selected in the Record of Decision.

Although the infrastructure improvements on the NEC were categorized differently than those on connecting corridors, the service improvements for both the NEC and connecting corridors were incorporated into the No Action Alternative representative Service Plan to ensure compatibility with the representative Service Plans for the Action Alternatives. Examples include services proposed south of Washington, D.C., between Philadelphia and Harrisburg on the Keystone Corridor, and on the Hartford/Springfield Line. Planned Regional services are also reflected in the No Action Alternative representative Service Plan.

Connecticut's *CTrail*[4] *Hartford Line* program includes a second track between New Haven and Hartford and increases Intercity and Regional rail service frequency on the Hartford/Springfield Line between New Haven, Hartford, and Springfield. These improvements to the Hartford/Springfield Line were included in the No Action Alternative as a Related Project. Therefore, the Service Plan for the No Action Alternative did not change for the Tier 1 Final EIS.

2.5.2 Preferred Alternative

The representative Service Plan for Preferred Alternative provides additional capacity to allow significant increases in peak and off-peak service frequency for all types of service across the entire NEC, as compared to the existing condition and to the No Action Alternative (including the Hartford/Springfield Line). The focus of service improvements and capital investment remains predominately on the NEC, although service improvements are realized on connecting corridors. In addition, an electrified Hartford/Springfield Line is incorporated into the NEC, providing for a significant expansion of service to and from Springfield, MA. The Preferred Alternative provides sufficient capacity to operate the following levels of service during the peak periods:

- Intercity-Express service at 4 trains per hour (tph)
- Metropolitanservice at 4 tph south of New Haven
- Metropolitan service at 4 tph north of New Haven, with two trains operating to Boston and two trains operating to Springfield
- Intercity-Corridor-Other service at up to 2 tph between Washington, D.C., and Springfield, MA
- Regional rail service at levels that significantly exceed the anticipated rate of regional population and employment growth within the Study Area

[4] The FRA approved the NHHS improvements in a Finding of No Significant Impact (FONSI) issued on August 9, 2012. The FONSI described a series of improvements to be implemented in phases. These improvements included constructing a second track for a portion of the corridor; installing improved train control systems; upgrading at-grade crossings and closing some at-grade crossings; repairing or replacing bridge and culvert structures; constructing a layover and light maintenance facility in the Springfield area; and development of new regional rail stations at Enfield, West Hartford, Newington, and North Haven.

Overall the Preferred Alternative provides for faster and more reliable passenger train operations on the NEC. It supports:

- Operation of up to 5 times as many trains as today and in the No Action Alternative
- Significant travel time savings, particularly for Intercity-Express service, including opportunities for super-express limited-stop Intercity-Express services
- Operation of "pulse hubs" in Philadelphia, PA, and New Haven, CT, where passengers will be able to transfer between a highly coordinated network of Intercity and Regional rail trains
- Operating efficiencies, included reduced dwell time at major terminals, clockface scheduling and regular headways and patterns
- Enhancements to the customer experience, including a common fare medium, coordinated and scheduled service between different providers, and easier transfers at stations

3. Ridership

As described in Volume 2, Appendix B.08, the FRA developed a ridership forecasting process to identify and evaluate potential rail service improvements and investments in the NEC. For the Tier 1 Final EIS, the ridership estimates and results were generated from representative Service Plans created for the No Action Alternative and the Preferred Alternative. The ridership model also used a series of assumptions regarding future fare policies and regional and corridor-wide estimates of growth. The Service Plan and fare policy for the Preferred Alternative were developed to represent the programmatic goals of the alternative, but were not strictly optimized to capture the maximum potential ridership at each station. Therefore, estimated ridership is representational and consistent with the level of detail inherent in a Tier 1 environmental study.

3.1 KEY INTERCITY RIDERSHIP DRIVERS

The primary drivers impacting the Intercity ridership results (Intercity-Express and Intercity-Corridor) include the following:

- Demographic forecasts
- Induced demand assumptions
- Current attitudes toward rail, incorporated through the use of the NEC FUTURE Household Survey
- Travel time, travel cost, and frequency sensitivity

The demographic forecasts used in the ridership modeling dictate the size of the total travel market and the geographic distribution of trips. The forecast used in the NEC FUTURE ridership modeling is the "base" forecast produced by Moody's Analytics, which provides the "most likely" case of the population and employment in the year 2040. A more detailed description of the demographic data is found in Section 3.3.1.

Induced demand refers to any forecasted trips beyond those based on the demographic forecast. Induced demand trips result from improved travel conditions that make travel easier, thus "inducing" people to make trips they otherwise would not have made. The NEC FUTURE Interregional Model incorporates induced demand in a typical formulation by including a term in the total demand model that links additional trips to the total level-of-service (LOS) across all modes for each zone pair. Induced demand contributes approximately 2.2 percent of the total rail ridership. This level of induced demand is somewhat lower than other high speed rail forecasts; high speed rail forecasts from Europe and California are in the range of 10 to 15 percent. However, there are important reasons for those differences.

In the case of California, high speed rail will be an entirely a new mode and current conventional rail service is quite limited. Comparatively, rail has a strong presence in the NEC. While the Preferred Alternative would grow the role of rail, it already has a strong mode share to build from. Therefore, it is expected that induced demand would not be as great as in a situation where rail is an entirely new mode. Europe has a long history of strong rail ridership and provides a different point of comparison than California. The European transportation system operates quite differently than the Northeast Corridor, particularly for auto travel. Auto ownership and use are less attractive options in Europe due in part to higher fuel costs and the greater availability of substitute transportation options such as local transit. As a result, it is problematic to directly compare rail ridership forecasts from the Northeast Corridor and Europe. However, to the extent Northeast Corridor conditions change in the future with respect to population and employment distribution, cost and ease of auto travel, and the availability of non-auto transportation, the level of induced demand could be higher than forecast.

The remaining four key drivers of the ridership forecasts are all derived from the NEC FUTURE household survey data; and therefore, represent potentially conservative responses toward Intercity rail, as they are tied to current ridership experiences. In particular, the Preferred Alternative offers Intercity service with increased frequencies, much reduced travel times, increased reliability, and much greater capacity which could shift overall perceptions of rail travel.

Current general attitudes toward rail are captured in the alternative specific constants (ASC) of the mode choice model, which indicate the order of preference of modes based on all the non-measured attributes with all other variables held equal (time, cost, and frequency). The NEC FUTURE Interregional Model uses a conservative approach by using the survey data for current Acela travel to estimate the improved Intercity-Express ASC. The comparison to Acela was made to give the respondent a reference point for service features other than those explicitly detailed (such as leg room, work space, etc.) and to communicate the premium nature of the service. To the extent that the future Intercity-Express service has non-measured attributes that are better than existing service (such as improved reliability), the expected ridership would be higher. However, it is not possible to estimate the extent of the higher ridership while utilizing the existing data. The FRA conducted multiple sensitivity analyses with the Interregional Model on the Preferred Alternative, including improving the rail ASCs. The results of this testing found that adjusting the Intercity-Express ASC to equal that of air, and similarly increasing the Intercity-Corridor ASC resulted in an increase of total rail ridership by approximately 20 percent. The details of this analysis can be found in Section 3.7.4.

The travel time sensitivity and travel cost sensitivities in the mode choice model are similarly estimated directly from the survey data, and are combined to calculate the value of time (VOT) for each trip purpose. A higher VOT indicates a higher sensitivity toward time, while a lower VOT indicates a higher sensitivity toward cost. Table 11 shows the value of time as well as the percentage of the total travel market for each trip purpose. The Business purpose has the highest VOT, and has similar values as other intercity models. One of the factors that could influence the lower VOT for the Non-Business purpose is the recent increase of intercity bus options in the market. By adding in a cheaper option, travelers' sensitivities toward cost can shift downward. The cost sensitivities derived from the Non-Business model drives the cost sensitivity of the overall forecast because Non-business trips comprise such a larger percentage (70 percent) of overall travel in the NEC. Fare sensitivity is an important factor driving ridership estimates and Section 3.7 describes the sensitivity testing relating to this issue.

Table 11: Mode Choice Model Value of Time

	Value of Time	Percentage of Total Travel
Commute	$28	12%
Business	$41–$92	18%
Non-Business	$6–$18	70%

Source: NEC FUTURE team, 2016

The final sensitivity taken from the survey data is the traveler response to frequency. In the model estimation phase, multiple formulations of frequency were tested, and the formulation that best fit the survey data was a dampened function, which reduces the impact of additional trains at higher frequency levels, with the ridership impact from additional trains tapering off around 50 trains per day or average 20 minute headways over the course of an entire day. This result suggests that travelers are not likely to switch to rail from another mode if additional trains are added above that level. The ridership forecasting process included an iterative process to evaluate load factors and adjust frequencies as necessary, to ensure that the representative Service Plan aligned with the anticipated ridership. Additional benefits could come about due to higher level frequencies, such as better integration with other modes, the ability of riders to show up at regular intervals and not have to check schedules, among others, but FRA believes these benefits fit better with the overall improvement of the rail system that is accounted for through the ASCs, as discussed above.

Further discussion of risks and uncertainties of the ridership forecast can be found in Section 3.6.

3.2 METHODOLOGY

This section outlines the methodology for the analysis of travel markets and the forecast of ridership and revenue associated with the 2040 No Action Alternative and Preferred Alternative, specifically, focusing on changes to the methodology for the evaluation of the Preferred Alternative. A full documentation of the ridership methodology can be found in Volume 2, Appendix B.08.

3.2.1 Interregional Model

The FRA developed the NEC FUTURE Interregional Model during the Tier 1 Draft EIS process. Prior to the Tier 1 Final EIS analysis of the Preferred Alternative, the FRA adjusted the Interregional Model to improve model functionality and utilize more appropriate data on air travel. This section describes the adjustments and the process used, and summarizes the changes in the model results compared to the Tier 1 Draft EIS results.

After the Tier 1 Draft EIS was finalized, the FRA found that the number of air trips generated in the ridership results appeared inflated. The cause was traced to the use of the FAA T-100 Market dataset which represents air trips by segment instead of the FAA DB1B dataset which represents air trips by ultimate origin and destination. In many instances, the FAA T-100 Market dataset has proven to be a reliable forecast of true origin to destination travel, but in this case there were a significant number of trips which were connected to other final destinations, but were analyzed as complete trips. The FAA DB1B database represents a 10 percent sample of actual travel and airlines are not required to report data for this database. Although this dataset represents a certain lack of precision as a result of the limited data reported, the FRA considered it to be a more appropriate source for analyzing air travel in the Study Area than the FAA T-100 Market dataset.

The FRA adjusted the base trip table by replacing the previous air trips with the DB1B database air trips. The FRA then applied the same methodology to distribute trips to the zone system as described in Volume 2, Appendix B.08. A summary of the trips by air for key markets and the entire corridor, for both the previous base trip table and the revised trip table, are shown in Table 12.

Table 12: Base Air Trip Table Adjustments

Origin Market	Destination Market	Original Air Trips	Revised Air Trips	Percentage Difference
Boston	New York City	2,911,222	1,415,775	-51%
	Philadelphia	1,347,578	678,786	-50%
	Baltimore	1,395,068	891,704	-36%
	Washington	2,717,932	1,787,143	-34%
Hartford	New York City	55,341	1,048	-98%
	Philadelphia	148,549	23,661	-84%
	Baltimore	171,871	75,851	-56%
	Washington	342,613	159,390	-53%
Providence	New York City	58,743	2,683	-95%
	Philadelphia	136,902	43,455	-68%
	Baltimore	163,063	87,955	-46%
	Washington	326,763	180,991	-45%
New York City	Philadelphia	828,899	16,751	-98%
	Baltimore	820,384	289,455	-65%
	Washington	1,996,075	732,503	-63%
Philadelphia	Baltimore	198,702	4,426	-98%
	Washington	464,782	12,592	-97%
Total Study Area		**16,667,448**	**7,266,190**	**-56%**

Source: NEC FUTURE, 2016

After taking a closer look at the base trip table, the FRA also found the previous analysis included some zones pairs that were less than 50 miles apart which is inconsistent with the Interregional model that was estimated using only trips that were 50 miles or longer. The FRA adjusted the base trip table to exclude these zone pairs. Some intra-regional trips still remain in the base trip table, as these regions are quite large.

Table 13 shows the effect that revising the air trip table and excluding trips less than 50 miles has on the total number of trips by market in the Tier 1 Draft EIS. The total number of trips was reduced by approximately 24 percent, presenting a more representative picture of intercity travel. As shown in Table 13, removing trips less than 50 miles does not impact the number of trips between the major markets, since the majority of the eliminated trips are within each market (i.e., New York City to New York City).

Table 13: Total Trip Adjustments

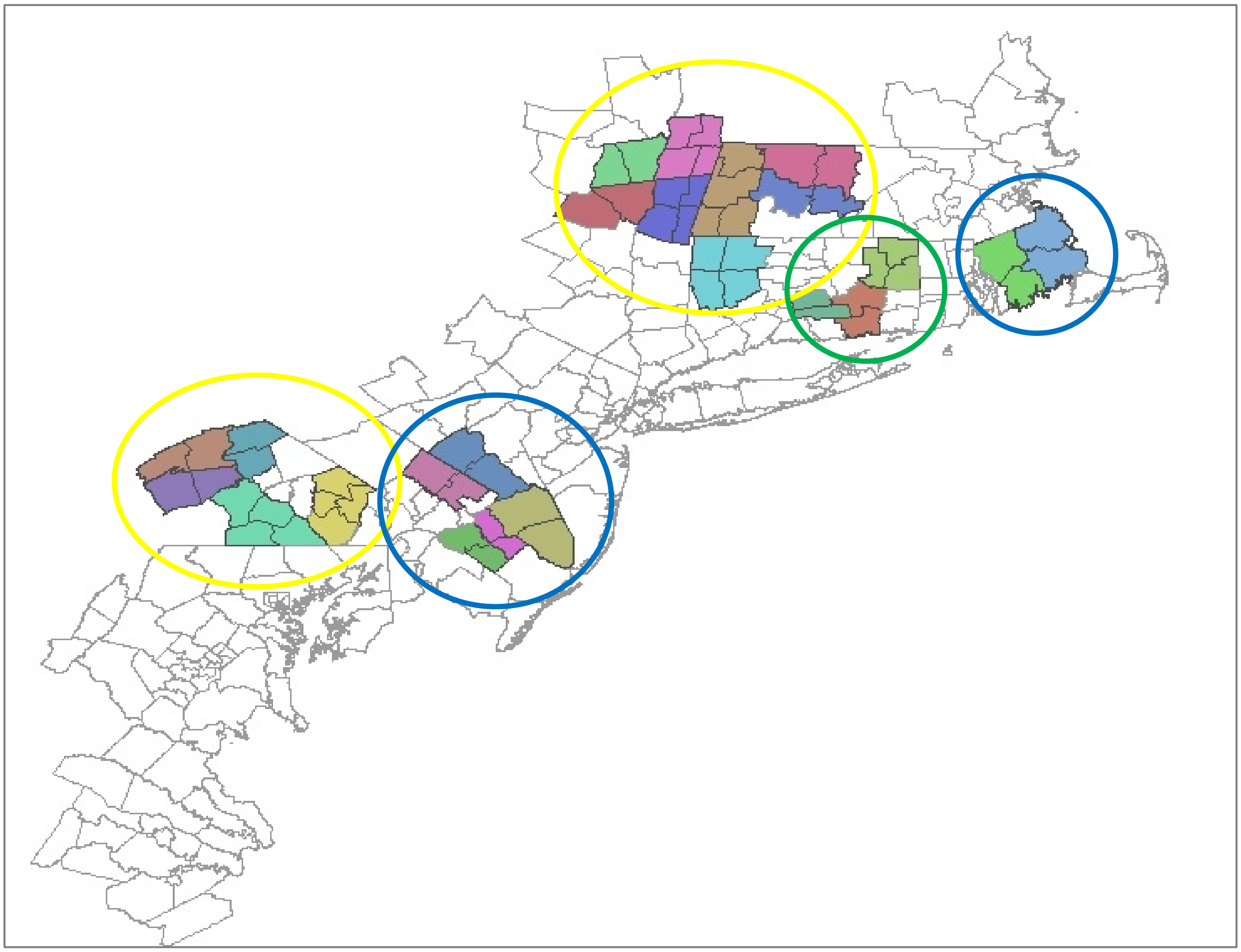
Origin Market	Destination Market	Tier 1 Draft EIS Total Trips	Revised Air Data Total Trips	Revised Air Data & 50 Mile Restriction Total Trips
Boston	New York City	38,358,321	36,862,895	36,831,092
	Philadelphia	4,489,000	3,823,004	3,825,810
	Baltimore	2,445,031	1,953,122	1,940,268
	Washington, D.C.	3,630,790	2,712,541	2,699,911
Hartford	New York City	12,595,662	12,541,317	11,443,043
	Philadelphia	1,533,993	1,407,135	1,408,192
	Baltimore	371,363	268,246	274,736
	Washington, D.C.	705,304	506,634	521,404
Providence	New York City	9,431,262	9,375,075	9,347,259
	Philadelphia	1,336,438	1,239,504	1,241,705
	Baltimore	2,008,046	1,923,579	1,932,396
	Washington, D.C.	484,469	319,813	337,795
New York City	Philadelphia	45,317,017	44,504,821	43,843,973
	Baltimore	7,249,429	6,717,733	6,707,300
	Washington, D.C.	14,913,999	13,648,849	13,645,083
Philadelphia	Baltimore	5,148,604	4,954,336	4,513,778
	Washington, D.C.	5,413,960	4,961,740	4,978,245
	Total Study Area	**434,590,368**	**425,189,158**	**316,514,176**

Source: NEC FUTURE, 2016

A third adjustment to the model involved splitting large zones into smaller zones to provide a finer level of detail and show a more distinctions between the Action Alternatives. The large zones aggregated trips to a level that did not adequately reflect access times and did not allow for close examination of differences between the alternatives with respect to ridership volumes. To correct this, several zones were split into smaller zones, as shown in Figure 4. Zones used previously are shown as a single color, with the revised zones shown by the dividing lines within each colored zone. The three types of zones that were split include:

- Off-corridor zones circled in yellow. These zones, which were typically an entire county, did not adequately communicate the differences between the Action Alternatives because of their large size.
- On-corridor zones circled in blue. These zones around Philadelphia and Providence were too large to provide an appropriate level of detail in the ridership forecast.
- On-corridor zones circled in green. These zones east of Hartford and Springfield were too large which made it difficult to assign stations and as a result, station assignment was not consistent across the Action Alternatives between the shoreline and the Springfield routings.

Figure 4: Split Zones



Source: NEC FUTURE, 2016

To accommodate the revised zone structure the input data was appropriately modified in terms of demographic inputs, station assignments, and service data such as highway travel times, both for the auto mode and access/egress characteristics for the other modes.

After these adjustments were made, the FRA recalibrated the base model run for 2013 to match the output trip table by mode to the actual trip table by mode by MSA pairs, as described in Volume 2, Appendix B.08. To test the differences in the revised forecast results versus the ridership results reported for the Tier 1 Draft EIS, the Action Alternatives were rerun using the revised model. For consistency purposes, trips for the zone pairs less than 50 miles were removed from the Draft EIS results. The resulting rail ridership and mode share for the total Study Area are shown in Table 14. Detailed results by all modes can be found in Appendix A of this document.

Using the revised model, the Intercity-Express ridership maintained a similar level across all Action Alternatives, and Intercity-Corridor increased by three to four million trips for each alternative. This change, combined with a reduced number of total trips, increased the rail mode share vis a vis air share across all alternatives. As a result of the re-calibration of the model the previous excess of air mode share was proportionally reassigned to the other modes. The modes with the largest number of travelers (auto and Intercity-Corridor) received the largest increases in travelers versus the previous results.

Table 14: Revised Model Results (2040)

		Intercity Service	Alt 1	Alt 2	Alt 3.1	Alt 3.2	Alt 3.3	Alt 3.4
Revised Model	Trips (in mil)	Express	5.09	6.38	6.72	7.87	7.60	6.75
		Corridor	29.72	32.54	32.35	33.33	33.94	32.95
	Mode Share	Express	1.2%	1.5%	1.6%	1.8%	1.8%	1.6%
		Corridor	6.9%	7.6%	7.5%	7.8%	7.9%	7.7%
Draft EIS Model	Trips (in mil)	Express	4.97	6.30	7.75	7.67	7.40	6.96
		Corridor	26.34	28.51	28.91	29.52	29.98	29.34
	Mode Share	Express	1.1%	1.4%	1.7%	1.7%	1.6%	1.5%
		Corridor	5.9%	6.3%	6.4%	6.5%	6.6%	6.5%

Source: NEC FUTURE, 2016

Table 15 shows the changes in rail trips and mode share for Alternative 2 in selected market pairs. A wide variety of distances were impacted in the changes, as most markets saw at least a nominal increase in rail mode share. The exception to this is rail trips to and from Springfield, which decreased with the revised model, primarily due to the zone splits that provide a more precise station assignment in that area.

Although the number of rail trips estimated for each of the Action Alternatives changed as a result of the revisions to the model, the conclusions made from the previous ridership estimates are still valid, given that each Action Alternative was affected similarly by the adjustments and the magnitude of overall ridership changes was not significant.

Table 15: Revised Model Results for Selected Major Markets in Alternative 2 (2040)

		Revised Model				Tier 1 Draft EIS Model				Total Diff in Rail Mode Share
		Trips		Mode Share		Trips		Mode Share		
		Express	Corridor	Express	Corridor	Express	Corridor	Express	Corridor	
Boston	Hartford	53,249	603,949	0.7%	8.2%	23,014	277,572	0.4%	4.3%	4.3%
	Springfield	4,022	34,023	0.4%	3.1%	1,250	26,649	0.1%	2.4%	1.0%
	New York City	1,936,497	3,888,896	4.1%	8.2%	1,746,376	3,797,730	3.5%	7.5%	1.4%
	Philadelphia	74,049	483,684	1.4%	9.2%	81,092	513,383	1.3%	8.3%	1.0%
	Baltimore	15,743	69,667	0.8%	3.6%	18,204	80,906	0.7%	3.2%	0.6%
	Washington, D.C.	46,640	332,128	1.2%	8.8%	44,719	299,256	0.9%	5.9%	3.2%
Springfield	New York City	44,788	275,591	0.8%	4.9%	37,859	375,037	0.6%	6.4%	-1.4%
	Philadelphia	12,535	17,604	2.3%	3.3%	13,248	61,272	2.1%	9.7%	-6.2%
	Baltimore	2,931	4,411	2.5%	3.8%	2,527	11,260	1.4%	6.1%	-1.1%
	Washington, D.C.	9,936	20,689	3.3%	6.9%	9,234	33,326	2.1%	7.5%	0.6%
Providence	New York City	347,129	1,176,320	1.9%	6.6%	351,783	1,514,769	1.9%	8.1%	-1.5%
	Philadelphia	20,564	202,220	0.8%	8.1%	22,835	224,337	0.8%	8.2%	-0.1%
	Baltimore	10,417	73,100	0.3%	2.0%	9,660	70,884	0.3%	1.9%	0.2%
	Washington, D.C.	15,292	109,788	2.1%	15.4%	14,294	109,842	1.3%	10.1%	6.1%
New York City	Philadelphia	618,695	4,625,589	1.1%	8.5%	836,210	4,332,032	1.4%	7.5%	0.7%
	Baltimore	357,486	1,792,740	3.9%	19.8%	408,938	1,661,043	4.1%	16.5%	3.1%
	Washington, D.C.	1,590,211	5,056,042	8.2%	26.0%	1,691,590	4,440,564	7.7%	20.2%	6.2%
Philadelphia	Baltimore	60,579	556,851	1.0%	8.9%	61,251	438,052	0.9%	6.6%	2.4%
	Washington, D.C.	255,273	1,645,295	2.9%	18.4%	254,325	1,252,490	2.6%	12.8%	5.8%
	Total Study Area	**6,382,931**	**32,534,796**	**1.5%**	**7.6%**	**6,303,115**	**28,514,010**	**1.4%**	**6.3%**	**1.3%**

Source: NEC FUTURE, 2016

3.2.2 Regional Models

As described in Volume 2, Appendix B.05, 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 were addressed by the following available regional models:

- Washington, D.C.: 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 Model
- New Jersey: NJ TRANSIT North Jersey Travel Demand Forecasting Model
- New York City – 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 where local models were not available. 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.

With the Hartford/Springfield Line as part of the Preferred Alternative, the FRA estimated regional ridership forecasts for the Hartford/Springfield area using previous forecasts available from the *Technical Paper for NHHS Line NEPA/CEPA Environmental Assessment/Environmental Impact Evaluation* (May 2011). The forecasts were updated using population and employment, and service elasticities based on the *TCRP Report 95: Transit Scheduling and Frequency – Chapter 9: Traveler Response to Transportation System Changes* (May 2004).

The FRA developed new Regional rail ridership estimates for the Tier 1 Final EIS, based on the Regional rail service specifications for the Preferred Alternative. As described in Section 2.3, Regional rail service specifications were developed for all regions of the Study Area, with the exception of Philadelphia. In the Tier 1 Draft EIS, the Delaware Valley Regional Planning Commission (DVRPC) provided the Regional rail ridership estimates for Philadelphia. The FRA determined there were not sufficient changes in this region to require new ridership model runs by DVRPC; thus, the specifications and estimates for the Philadelphia region remain unchanged from Alternative 2 in the Tier 1 Draft EIS. For each of the other major regions on the NEC – Washington, D.C., New Jersey-New York City, New York City-Connecticut, and Boston – the FRA developed new representative service plans that include Regional rail and Metropolitan service, and generated new ridership estimates.

3.2.3 Integration of the Interregional and Regional Forecasts

Using separate models, the FRA forecast interregional and regional ridership for the No Action Alternative and the Preferred Alternative, and combined these forecasts into an overall ridership forecast. Combining the forecasts involved the identification and application of the appropriate "model of record" for each NEC rail market. Table 16 summarizes the forecasting models used to evaluate the No Action Alternative and the Preferred Alternative for each region pair within the Study Area. Within each of the metropolitan regions (on the diagonal of the table), the associated regional model was used. The geographic coverage of each model is shown in Volume 2, Appendix B.08. The majority of region pairs were analyzed using the new Interregional Model.

Table 16: Models used to Evaluate NEC FUTURE Rail Markets

From/ To	Region	Boundaries	A	B	C	D	E	F	G–L
A	Washington, D.C. Metro	Northern Virginia to Patuxent River	R1	IR	IR	IR	IR	IR	IR
B	Baltimore Metro	Susquehanna River to Patuxent 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

In certain instances estimates of commuter-rail ridership were available from the regional models, and also from the Interregional Model. These instances primarily reflect long-distance commuting activity. Because all trips less than 50 miles in length were excluded from the Interregional Model, the FRA retained Regional rail ridership estimates both from the regional models and the Interregional Model, as the Interregional Model results represented commuter trips which used multiple commuter-rail systems and would not be captured by the regional models.

3.3 ALTERNATIVES DESCRIPTION

For analysis purposes, the FRA tested all alternatives using 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 Alternative and Preferred Alternative, which led to the forecasts described in Section 0.

3.3.1 Demographic Forecasts

The fundamental driver of growth in total trip-making in the NEC FUTURE Study Area is the forecast growth in population, employment, and income. Forecasts used as the basis for growth were extracted from Moody's Analytics June 2013 "base" demographic forecasts.[5] These forecasts were obtained on a county-level basis for the Study Area. The detailed county-level demographic forecasts are summarized in Appendix B included with this document.

Table 17 and Table 18 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 forecast results use the "base" (or most likely) condition. Population in the major metropolitan markets is projected to grow between 6.2 percent (Hartford) and 29 percent (Washington, D.C.). The low-high bounds are also fairly tightly bound to the "base" condition, generally plus or minus 5 percentage points of the base forecast.

The "base" forecasts shows employment growing slightly faster than population and the low-high bounds are much wider for employment than population suggesting larger uncertainty associated with future NEC employment. Moody's "low" scenario includes a contraction of the overall job market (as compared to today), and its "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.

[5] The FRA used Moody's data because U.S. Census Bureau forecast data are not available at the county-level required for the NEC FUTURE interregional model.

Table 17: 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 City	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, D.C.	*5,930,470*	*7,126,550*	*7,654,620*	*8,237,550*	*20.5%*	*29.1%*	*38.6%*

Source: NEC FUTURE team, 2016

Table 18: 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.	3,104,290	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 City	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, 2016

The Moody's Analytics demographic forecasts serve as the overall county-level control totals for growth. However, the forecasting process for NEC FUTURE required demographic data at the sub-county level, for both the regional models and the Interregional Model.

To develop the sub-county level demographic process for the regional models, the FRA employed a methodology in which:

- 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 followed a process using one consistent NEC wide source (Moody's) to forecast growth on the NEC, and used the local MPO forecasts as the basis for where growth occurs at the sub-county level. As a result localized development and redevelopment initiatives are reflected in the forecasts.

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, 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.

3.3.2 Service Level Forecasts (Non-Rail Modes)

For the No Action Alternative and Preferred Alternative, the FRA held non-rail modes constant in terms of frequency, travel time, and cost for both the regional and interregional models. The future year service characteristics for the non-rail modes in the regional models are unchanged from the source models.

3.3.3 No Action Alternative

The No Action Alternative represents the Year 2040 condition without the implementation of the Preferred Alternative, and serves as the basis of comparison to evaluate the impacts of the Preferred Alternative. This section discusses the elements used to establish the Year 2040 NEC FUTURE No Action Alternative forecasts.

3.3.3.1 Service Plan

For the Interregional Model and regional models, the basis for the No Action Alternative representative Service Plan was existing level-of-service. The infrastructure improvements included in the No Action Alternative are described in Volume 2, Appendix B.01. No Action Alternative infrastructure improvements included projects that have been funded or are 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.

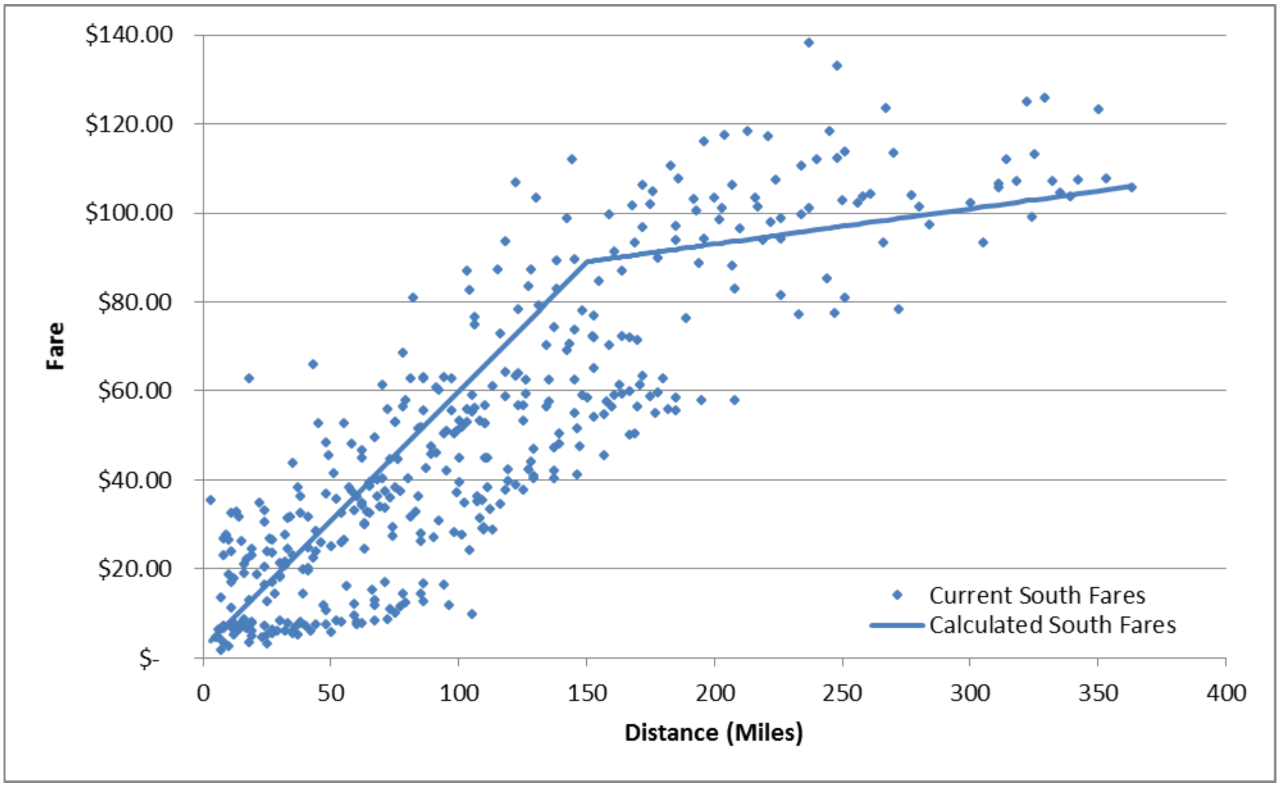
The only service change included in addition to today's service in the No Action Alternative is the completion of the LIRR East Side Access (ESA) project. The analysis assumed implementation of the LIRR ESA Operating Plan version 3.0 for the LIRR East Side Access. Otherwise, the No Action Alternative Service Plan for all other rail operators is identical to today's service. Intercity service in the No Action Alternative does not change from the existing condition. A more thorough discussion concerning the contents of the No Action Alternative is described in Volume 2, Appendix B.01 and Appendix B.05.

3.3.3.2 Rail Pricing

For the No Action Alternative, the FRA held Regional rail pricing constant through the analysis in real dollars. This results in Regional rail fares rising with inflation. For the Interregional Model, the FRA assumed that rail fares 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 City, trips north of New York City, and trips through New York City, to reflect that the current pricing structures were different in each of these 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 Preferred Alternative.

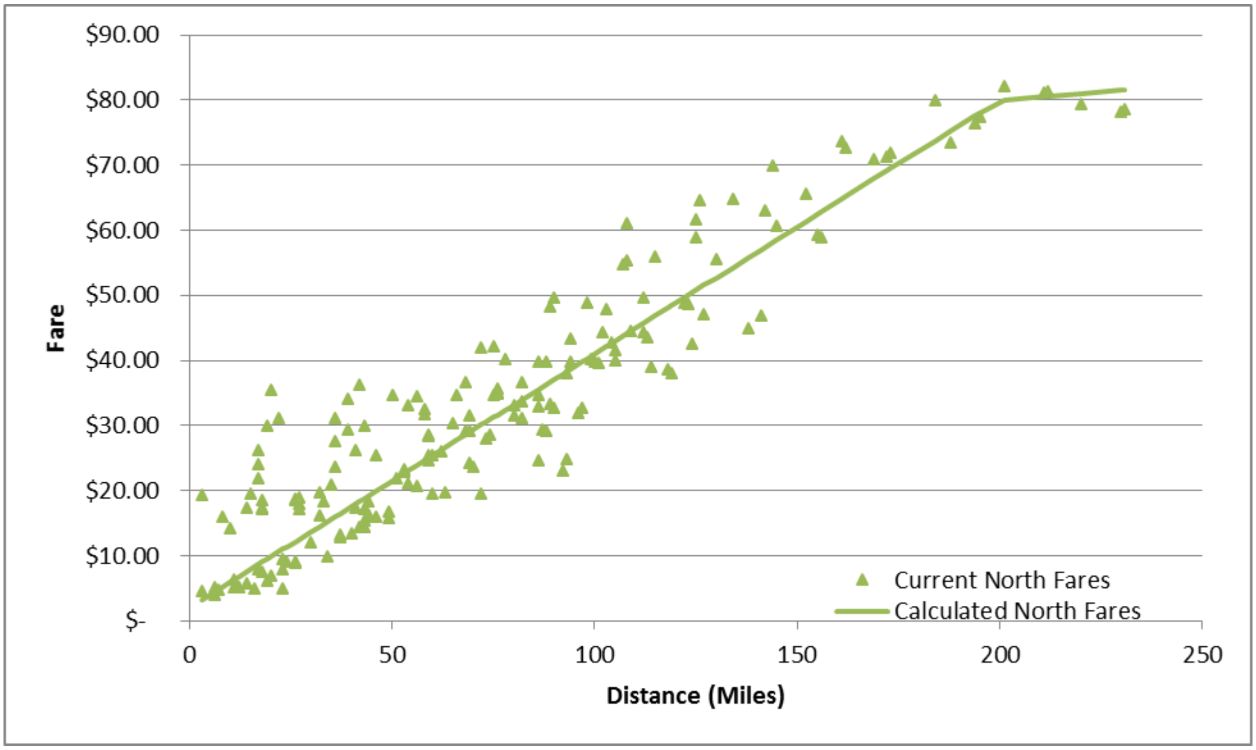
Figure 5 through Figure 8 show the current fares, as well as the calculated fares for each market. The fare equations were calculated by fitting a line to the current fare relationships and calibrating to closely match the large key markets. The geographic equations are similar for express and non-express rail. Markets entirely south of New York City show the highest rail fares, markets entirely north of New York City have the lowest fares, and the through New York City 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 5: Intercity-Corridor Distance-Based Fares for Trips South of New York City



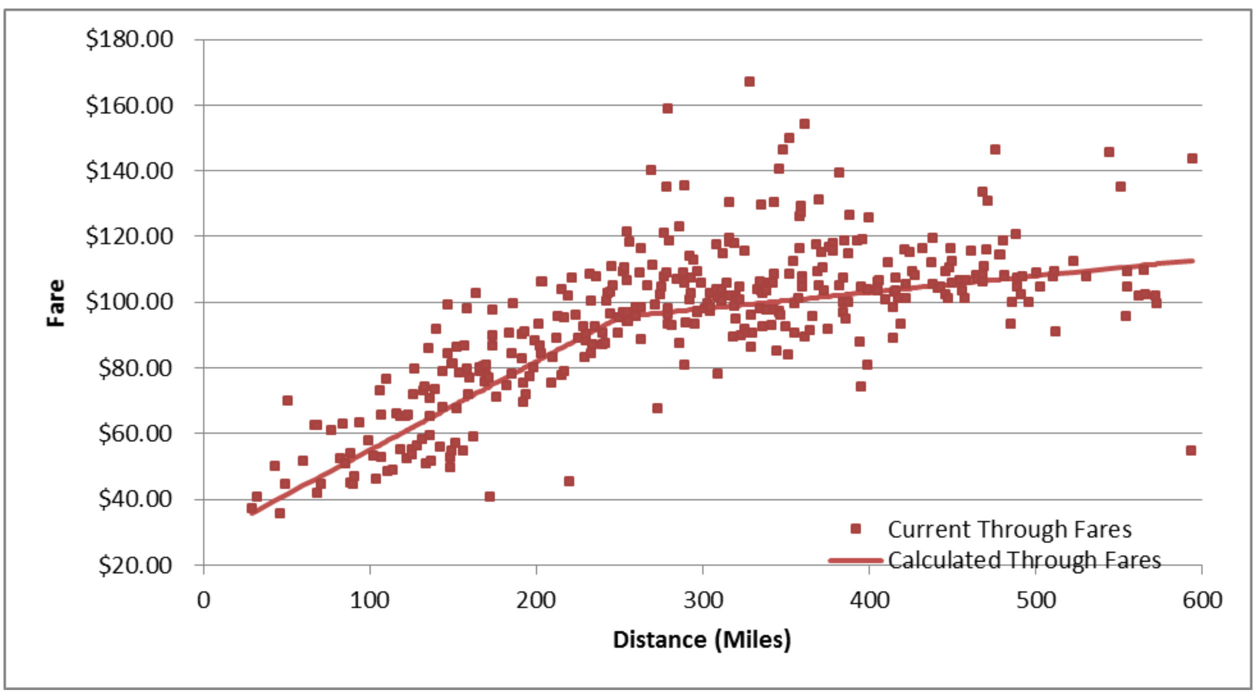
Source: NEC FUTURE team, 2016

Figure 6: Intercity-Corridor Distance-Based Fares for Trips North of New York City



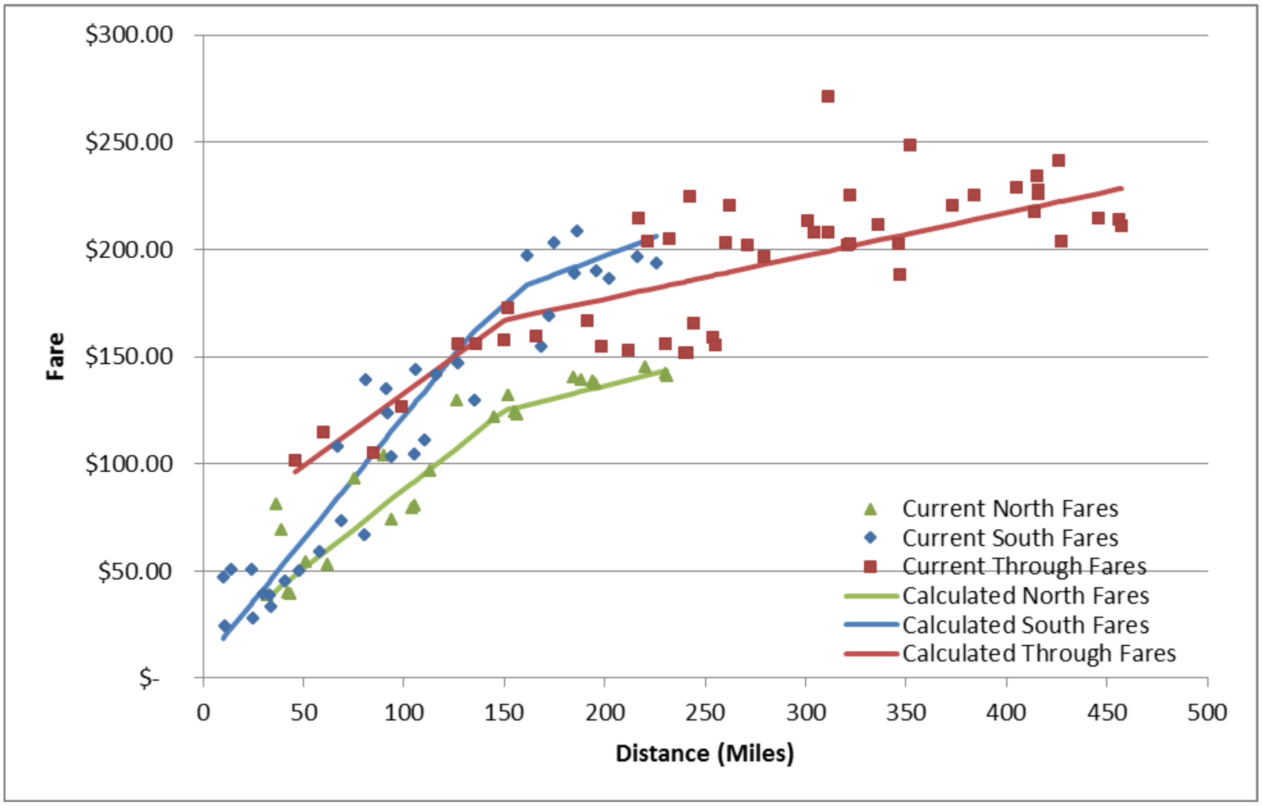
Source: NEC FUTURE team, 2016

Figure 7: Intercity-Corridor Distance-Based Fares for Trips through New York City



Source: NEC FUTURE team, 2016

Figure 8: Intercity-Express Distance-Based Fares



Source: NEC FUTURE team, 2016

3.3.4 Preferred Alternative

Inputs to the ridership model included elements of the Service Plan and rail pricing assumptions for the Preferred Alternative as described below.

3.3.4.1 Service Plan

The representative Service Plan for the Preferred Alternative is described in detail in Section 2. The key inputs into the Interregional Model include travel time (TT) and daily service frequencies (FREQ). A summary of these for the major city pairs are provided in Table 19.

The Regional rail Service Plans are summarized in Table 20. In all Regional rail markets, the Preferred Alternative offers increased service throughout the day, utilizing available capacity. Also included in the Service Plan for the Preferred Alternative is the new Metropolitan service. The Metropolitan trains were simulated as additional service frequency opportunities for travel within regions. Fares for Metropolitan were assumed to be consistent with commuter-rail fares for travel within regions. The regional models were run both with and without Metropolitan service, and the final ridership numbers are the average of the two runs. Essentially, the Preferred Alternative offers approximately 2.2 times greater service over the No Action Alternative.

Table 19: Selected Station Pairs Intercity Service Plan Summary – No Action Alternative and Preferred Alternative (2040)

Intercity-Express	Existing/No Action		Preferred Alternative	
Trip Pair	**FREQ**	**TT**	**FREQ**	**TT**
Boston–New York City	10	212	56	165
Boston–Philadelphia	10	293	49	228
Boston–Washington, D.C.	10	394	43	310
New York City–Philadelphia	16	68	63	55
New York City–Washington, D.C.	16	167	57	136
Philadelphia–Washington, D.C.	16	97	57	79
Intercity–Corridor	**Existing/No Action**		**Preferred Alternative**	
Trip Pair	**FREQ**	**TT**	**FREQ**	**TT**
Boston–New York City	9	253	38	221
Boston–Philadelphia	8	361	32	301
Boston–Washington, D.C.	8	482	30	410
New York City–Philadelphia	32	84	93	72
New York City–Washington, D.C.	22	204	79	177
Philadelphia–Washington, D.C.	22	116	81	99

Source: NEC FUTURE team, 2016

Table 20: Average Weekday Regional Rail Service Plan Summary (trains/hour)

	Existing/No-Action				Preferred Alternative			
	PK	SHD	REV	OPK	PK	SHD	REV	OPK
Washington Region								
MD Regional Rail	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	2.3	12	7	6	4
South Side Regional Rail	5	4	3.5	3	20	14	16	11
New York Region								
NJ-NEC/NJCL Trans-Hudson	15	8	7	3	22	14	10	4
NJ-Other Regional Rail	6	3	3	2	27	16	13	8
CT-Nhaven Line (PS&GCT)	22	16	12	3	34	26	16	15
Boston Region								
NEC Regional Rail	9	4	4	2.6	12	10	10	5
Other Regional Rail	3	2	1	0.5	4	3	1	1

PK - Peak Period, Peak Direction
SHD - Shoulder of Peaks
REV - Reverse Peak
OPK - Off-Peak

Source: NEC FUTURE team, 2016

3.3.4.2 Rail Pricing

As noted, the FRA held Regional rail pricing constant through the analysis in real dollars. For the Interregional Model, the FRA made adjustments to the Preferred Alternative pricing for the following reasons:

- Strong customer demand coupled with limited ability to add capacity during peak hours has led to higher fares on the NEC during the past decade
- Capacity constraints coupled with higher demand on the south end has led to significantly higher pricing on a per mile basis as compared the north end
- The NEC FUTURE household survey revealed NEC travelers making personal trips are quite sensitive to the cost of travel, and are generally more sensitive to trip cost 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.

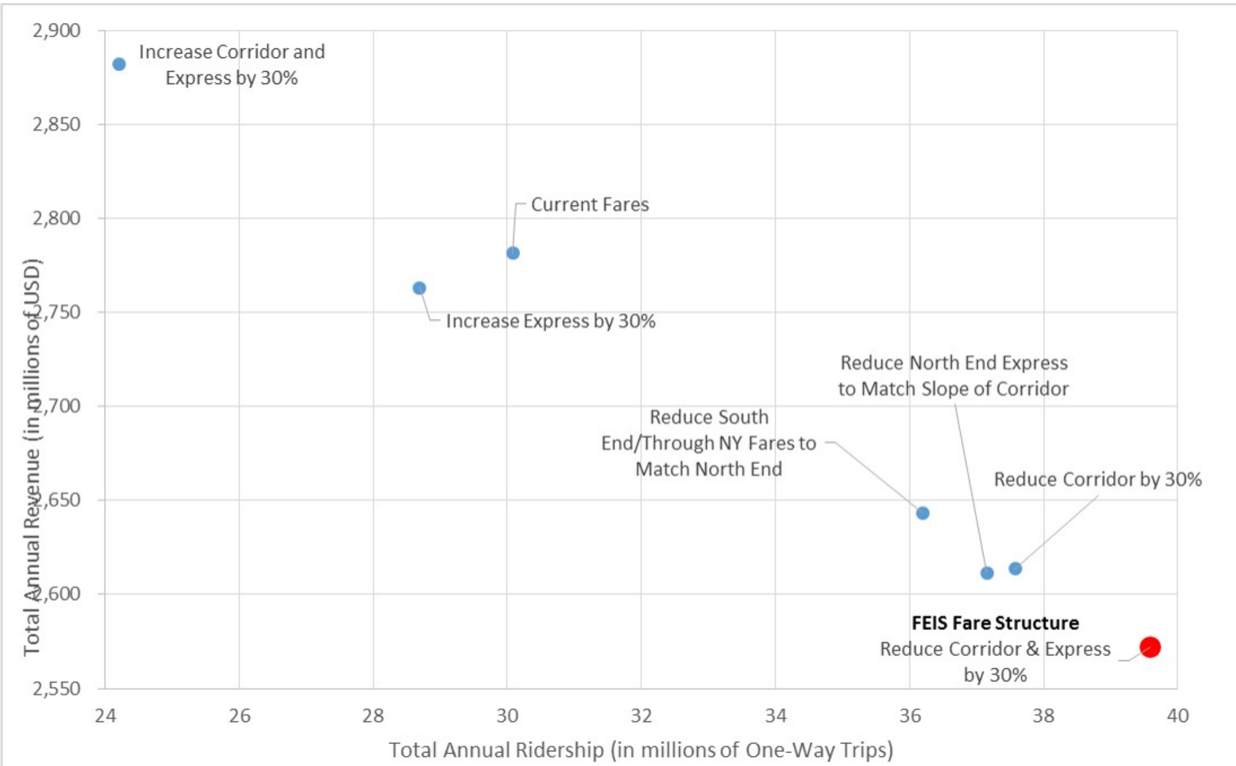
Although the FRA began the analysis with an assumption that current Intercity pricing levels would stay in place, it also evaluated the impact of lower fares. The purpose of the evaluation was to establish the model's sensitivity to pricing and understand the impacts associated with changing the fares for just one service (Intercity-Express or Intercity-Corridor), or both services at the same time. The FRA found that lower fare prices attracted higher overall levels of rail ridership while still providing sufficient revenue to fund operating and maintenance costs associated with the Preferred Alternative. This analysis demonstrated a modicum of flexibility for rail operators to utilize a variety of potential fare structures while maintaining the ability to cover operating expenses.

As a sensitivity analysis during the Draft EIS analysis, the FRA tested multiple fare structures including:

- Use current fares for Corridor and Express
- Increase both Intercity-Corridor and Intercity-Express fares by 30 percent
- Increase Intercity-Express fares by 30 percent with current fares for Intercity-Corridor
- Reduce Intercity-Corridor fares by 30 percent with current fares for Intercity-Express (Tier 1 Draft EIS fare structure)
- Reduce both Intercity-Corridor and Intercity-Express fares by 30 percent (Tier 1 Final EIS fare structure)
- Set fares for all geographies (north of New York City, south of New York City, through New York City) equal to current north end fares
- Set fares for all geographies (north of New York City, south of New York City, through New York City) equal to current north end fares, but reduce the per mile component of north end Express fares

The total ridership and revenue (combining Intercity-Express and Intercity-Corridor) for each of these sensitivity tests is shown in Figure 9. These are not intended to be an exhaustive list of potential fare structures, but were evaluated to determine a reasonable range of cost sensitivities. The objective of the NEC FUTURE fare structure was for ticket revenues to cover operating and maintenance costs, while approximately sizing the rail network to accommodate potential growth.

Figure 9: Fare Structure Sensitivity Test Results



For the Tier 1 Final EIS analysis of the Preferred Alternative, the FRA selected the ridership results that reflect a 30 percent reduction in both Intercity-Express and Intercity-Corridor fares, compared to today's fare structure. This fare approach is not intended to provide either a revenue-maximizing or ridership-maximizing result; rather, it is intended to provide some balance between these goals while reflecting the potential of the Preferred Alternative to attract a large amount of riders. Additionally, FRA selected the lower fare pricing approach for the Tier 1 Final EIS to evaluate the potentially greater environmental impacts from higher utilization and operations than may occur with a revenue-maximizing approach. Rail operators and stakeholders implementing the Preferred Alternative will likely consider other pricing approaches including the use of refined commercial marketing strategies and refined operating plans.

3.4 FORECASTS

The ridership forecasts provide the basis for estimating the magnitude and incidence of benefits to users of rail services associated with the No Action Alternative and Preferred Alternative. The ridership forecasts are also the basis for estimating ancillary benefits to other travelers indirectly impacted by rail service changes in the NEC. The benefit measures associated with the Preferred

Alternative largely stem from predicted changes in travel behavior in response to new services and reduced and/or more reliable travel times provided. The representative Service Plan developed for the Preferred Alternative was intended to be demonstrative of possible future service and was not fully optimized for ridership or revenue potential. This section discusses the key measures associated with:

- Annual total rail-linked trips (trips from initial origin to ultimate destination, ignoring transfers)
- Rail passenger miles
- Non-rail-linked trips
- Automobile vehicle-miles of travel
- Peak-hour forecasted impacts at key screenline locations with an analysis of forecasted demand versus seat supply

The FRA constrained the forecasted ridership when it exceeded available seats for the No Action Alternative and Preferred Alternative. Instead of removing rail trips in excess of available capacity, the FRA iteratively ran the forecasting model (for both the 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 measures such as auto vehicle-miles traveled. However, this analysis did not apply capacity constraints to other modes. Capacity constraints for rail were evident only in the No Action Alternative, in which the most significant constraint was identified at the Hudson River screenline. At this screenline, 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 during the average weekday peak hour.

The remainder of this section provides discussion and findings related to the ridership forecasts for the Preferred Alternative. Region-to-region summaries of ridership trip tables by mode are provided in Appendix C (Intercity rail) and Appendix D (Regional rail).

3.4.1 Rail-Linked Trips

The number of rail-linked trips that the Preferred Alternative attracts is an important indicator of the value of proposed 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 those that force few transfers.

Table 21 provides the forecast annual estimate of rail-linked trips. The key findings include:

- The vast majority of existing and forecasted rail-linked trips are on regional rail services

- Approximately 73 percent of the forecasted Regional rail trips are concentrated in the New York City metropolitan area (see Appendix D)
- Although they comprise a relatively small share of the total rail travel, Intercity service linked trips are forecast to grow more rapidly than the Regional rail-linked trips
- Approximately 73 percent of Intercity linked trips have at least one trip end in the New York City metropolitan area (see Appendix C)

The growth in the No Action Alternative ridership compared to existing ridership (shown in Table 21) reflects organic growth due to demographic changes in the Study Area. However, the ridership estimates for the No Action Alternative are adjusted downward to reflect capacity constraints (for both Intercity and Regional rail). Based on regional estimates, growth of Regional rail exceeds growth of Intercity 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, as Intercity-Corridor existing demand is already close to capacity in contrast to Intercity-Express, which has more available seats. The No Action Alternative essentially maintains the same level-of-service as today, while the rail ridership forecasts have a significantly higher ridership, above and beyond what can be accommodated with the existing service. This growth of ridership demonstrates the need for improved and expanded rail service in the NEC, as defined with the Preferred Alternative.

Table 21: Annual Interregional and Regional Linked Rail Trips (in 1,000s of one-way trips)

Passenger Rail Trips	Existing	2040 No Action	2040 Preferred Alternative
Intercity-Express	3,400	5,100	9,700
Intercity-Corridor	11,500	14,400	30,400
Subtotal Interregional	14,900	19,500	40,100
Subtotal Regional	324,500	419,800	502,800
Total Rail Trips	339,400	439,300	542,900
Regional as a percentage of total trips	95.6%	95.6%	92.6%

Source: NEC FUTURE team, 2016

The Preferred Alternative forecast shows growth relative to the No Action Alternative in both Intercity-Express and Intercity-Corridor ridership, with 90 percent and 111 percent increases, respectively. Overall, Intercity ridership grows by 106 percent, and Regional rail ridership grows by 20 percent. These increases in ridership are the result of service changes associated with the Preferred Alternative, as well as the adjusted fare structure. The significant expansion in passenger capacity in the Preferred Alternative, plus lower ongoing operating and maintenance costs associated with new infrastructure and equipment allows for the lower fares used in the Final EIS analysis to still cover estimated operating expenses. The higher growth in the Intercity-Corridor ridership is primarily due to the lower fare structure used in the Final EIS and suggested improvements in service (for both frequency and travel time) for Intercity-Corridor service.

As described in the Volume 2, Appendix B.08, the dampened function of frequency used in the Interregional Model means the impact of frequency flattens out at approximately 50 trains per day, and further increases in frequency have minimal effect in attracting new passengers. As shown in

Table 19, for most key markets in the Preferred Alternative, Intercity-Express service reaches the 50 trains per day level. There are approximately 30 to 40 trains per day for Intercity-Corridor trains in the north end of the corridor, and 80 to 90 trains per day on the south end of the corridor. Travel times in the Preferred Alternative are also shorter than the No Action Alternative, with Intercity-Corridor travel times approaching the same travel times as Intercity-Express in the No Action Alternative. Therefore, rail passengers are able to travel with express-like speeds at the lower fares modeled for the Intercity-Corridor service. This is particularly attractive to non-business passengers (comprising approximately 70 percent of all rail passengers) who are more sensitive to trip cost as opposed to trip time.

In addition to absolute trip numbers, the distribution of trip-making patterns also plays a key role in the assessment of the Preferred Alternative. As mentioned above, both the Intercity and Regional rail trips are heavily focused on the New York City metropolitan region. To further examine the geography of the trips, Table 22 looks at the breakdown of the total Intercity trips by three segments:

- Trips from a major metropolitan region (Boston, New York City, Philadelphia, or Washington, D.C., as shown in Figure 10 and in Appendix C) to another major metropolitan region
- Trips from a major metropolitan region to a non-major region (all other regions in the Study Area)
- 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) is to provide access to formerly unserved or under-served markets, typically the non-major markets. Although rail services in these non-major markets more than double their mode shares in the Preferred Alternative relative to the No Action Alternative, ridership in these markets is 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.

In the major to/from non-major region market, the introduction of Metropolitan service more than doubles the Intercity-Corridor mode from 4.0 percent for the No Action Alternative to 8.2 percent for the Preferred Alternative. Similarly, the rail mode shares (both Intercity-Corridor and Intercity-Express) approximately double for the trips in the major to major region segment. The majority of rail trips are in the major to major region segment, but slightly higher 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 service improvements.

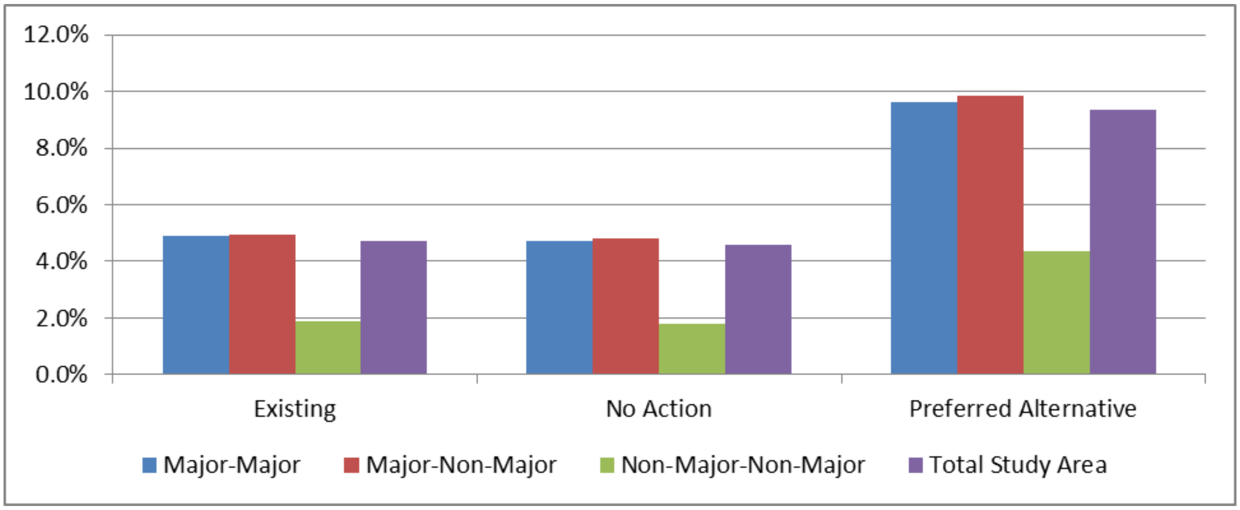
Table 22: Interregional Trips (1,000s of one-way) and Mode Share by Geographic Segment for Existing (2013) and the No Action Alternative and Preferred Alternative (2040)

		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	Major – Major	2,560	6,380	8,940	182,110	1.4%	3.5%	4.9%
	Major – Non-Major	800	4,760	5,560	112,350	0.7%	4.2%	4.9%
	Non-Major – Non-Major	50	330	380	20,190	0.2%	1.6%	1.9%
	Total Study Area	3,410	11,470	14,880	314,650	1.1%	3.6%	4.7%
No Action	Major – Major	3,840	7,870	11,710	247,500	1.6%	3.2%	4.7%
	Major – Non-Major	1,160	6,090	7,250	151,480	0.8%	4.0%	4.8%
	Non-Major – Non-Major	70	420	490	27,270	0.3%	1.5%	1.8%
	Total Study Area	5,070	14,380	19,450	426,250	1.2%	3.4%	4.6%
Preferred Alternative	Major – Major	7,010	17,000	24,010	249,140	2.8%	6.8%	9.6%
	Major – Non-Major	2,550	12,430	14,980	152,440	1.7%	8.2%	9.8%
	Non-Major – Non-Major	180	1,010	1,190	27,360	0.7%	3.7%	4.3%
	Total Study Area	9,740	30,440	40,180	428,940	2.3%	7.1%	9.4%

Source: NEC FUTURE team, 2016

Figure 10 illustrates the various allocations in Intercity rail mode shares across the alternatives. Capacity constraints limit the No Action Alternative's mode share in all geographic segments.

Figure 10: Intercity Mode Share (Intercity-Express + Intercity-Corridor) for Existing (2013) and No Action Alternative and Preferred Alternative (2040)



Source: NEC FUTURE team, 2016

In the Preferred Alternative, 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.

3.4.2 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 organized by service type. Generally, rail passenger miles exhibit the same patterns as seen for passenger trips. Although trips using Intercity services comprise a small percentage of total trips, they are typically much longer than trips made on Regional rail, and thus, account for a much larger percentage of total passenger miles.

As shown in Table 23, the Intercity passenger miles share increases from 21 percent in the No Action Alternative to 34 percent in the Preferred Alternative, accounting for approximately one-third of all passenger miles in the Study Area. In contrast, the Intercity passenger trips share increases from 4 percent to 7 percent in the Preferred Alternative. The Preferred Alternative has approximately 1.4 times the passenger rail miles compared to the No Action Alternative.

Table 23: Intercity and Regional Rail Passenger Miles (in 1,000s) for the No Action Alternative and Preferred Alternative (2040)

Service Type	No Action	Preferred Alternative
Intercity-Express	969,800	1,890,500
Intercity-Corridor	2,104,700	5,076,300
Regional	11,264,400	13,641,900
Total Passenger Miles	14,338,900	20,608,700
Regional as a percentage of total passenger miles	78.6%	66.2%
Percentage increase compared to No Action		43.7%

Source: NEC FUTURE team, 2016

3.4.3 Non-Rail-Linked Trips and Automobile Vehicle-Miles of Travel

Table 24 presents estimates of the number of trips diverted from other modes using the No Action Alternative as a baseline for the Preferred Alternative. Trips diverted from other modes include those diverted from other rail services (for example, from Intercity-Express to Intercity-Corridor). Compared to the No Action Alternative, 49 percent of the total Intercity trips estimated for the Preferred Alternative are diverted from other modes; of those diversions, the majority of diversions are auto diversions. Induced demand trips generated an additional 2.2 percent of trips over the No Action Alternative.

Table 24: Preferred Alternative Annual Intercity Trips Diverted from Other Modes as Compared to the No Action Alternative (2040)

Mode	Preferred Alternative Trips (1,000s)
Auto Diversions	16,700
Air Diversions	1,200
Intercity Bus Diversions	1,600
Induced Rail Trips	900
Total Rail Trips	40,100
% Trips Diverted from Other Modes	51%

Source: NEC FUTURE team, 2016

Table 25 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. Unlike the forecasts from the Interregional Model, the fixed trip table does not increase, and thus, no "induced" trips are generated. The percentage of total rail trips diverted from other modes is calculated by dividing the total diverted rail trips from the Preferred Alternative by the total rail trips of the No Action Alternative, as shown in Table 21 (420,000,000).

Table 25: Preferred Alternative Annual Regional Rail Trips Diverted from Other Modes Compared to the No Action Alternative (2040)

Mode	Preferred Alternative Trips (1,000s)
Auto Diversions	48,500
Other Transit Diversions (bus, subway, LRT)	34,500
Total Diverted Rail Trips	83,000
Total Rail Trips	502,800
% of Total Rail Trips Diverted from Other Modes	17%

Source: NEC FUTURE team, 2016

The effectiveness of the Preferred Alternative 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 26. This is a benefit to the remaining auto travelers, as it helps reduce congestion on the highway network. Increases in both Intercity and Regional rail ridership result in reduced VMT. In this metric, VMT reduced due to trips diverted to Intercity rail are approximately three times that of the VMT reduction associated with Regional rail for the Preferred Alternative due to longer trip lengths associated with Intercity rail trips.

Table 26: Annual Reduction in Automobile Vehicle-Miles Traveled Compared to the No Action Alternative (2040)

Market/Service Type	Preferred Alternative VMT Reduced (1,000s of miles)
Intercity Rail Market Automobile VMT Reduction	(3,023,000)
Regional Rail Market Automobile VMT Reduction	(1,001,600)
Total VMT Reduction	**(4,024,600)**

Source: NEC FUTURE team, 2016

3.4.4 Peak-Hour, Peak-Direction at Key Screenlines

For each of the 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 number of passengers seeking 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 27 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 as 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 because demand exceeds capacity for the No Action Alternative is the Hudson River screenline, with approximately 1,500 unserved riders per hour. The small amount of forecasted unserved demand at the Washington, D.C., screenline is a result of the Intercity service being over-subscribed in the No Action Alternative. The Preferred Alternative addresses the capacity constraints that are present in the No Action Alternative, and meets the forecasted demand. Considering potential for additional Intercity and Regional demand not captured by the forecasting tools, the greatest potential for unmet total rail demand with the Preferred Alternative is at the Hudson River screenline.

Table 27: Weekday AM Peak-Hour, Peak-Direction Volume/Capacity at Key Locations for the No Action Alternative and Preferred Alternative (2040)

Screenline	No Action Alternative	Preferred Alternative*
Washington, D.C., (north of Union Station)		
Total Practical Capacity (Slots/Hour)	12	20
Total Trains per Hour	6	20
Total-Practical Seats per hour (Intercity and Regional rail)	6,400	20,000
Total Constrained Ridership (passengers per hour)	6,697	9,912
Volume/Capacity Ratio	1.03	0.5
Total Ridership Unserved (passengers turned away per hour)	297	0
Hudson River		
Total Practical Capacity (Slots/Hour)	24	52
Total Trains per Hour	24	52
Total-Practical Seats per hour (Intercity and Regional rail)	28,850	63,035
Total Constrained Ridership (passengers per hour)	30,388	62,559
Volume/Capacity Ratio	1.05	0.99
Total Ridership Unserved (passengers turned away per hour)	1,538	0
East River		
Total Practical Capacity (Slots/Hour)	40	70
Total Trains per Hour	38	60
Total-Practical Seats per hour (Intercity and Regional rail)	38,260	56,338
Total Constrained Ridership (passengers per hour)	32,890	48,923
Volume/Capacity Ratio	0.86	0.87
Total Ridership Unserved (passengers turned away per hour)	0	0
Boston South		
Total Practical Capacity (Slots/Hour)	24	24
Total Trains per Hour	11**	18
Total-Practical Seats per hour (Intercity and Regional rail)	10,000	17,020
Total Constrained Ridership (passengers per hour)	8,236	12,718
Volume/Capacity Ratio	0.82	0.75
Total Ridership Unserved (passengers turned away per hour)	0	0

Source: NEC FUTURE team, 2016
Note: Ridership Values are both Intercity and Regional rail services, in the standard peak hour, year 2040.
*2040 Preferred Alternative peak ridership factored down from Annual estimates using the following factors: Annual to Daily - 275 days for Intercity-Express, 355 for Intercity-Corridor. Average Daily to Peak hour peak direction – Intercity-Express (9 percent), Intercity-Corridor (5.6 percent).
**Peak hour, peak direction service at the Boston South screenline for Existing Conditions and the No Action Alternative was updated for the Tier 1 Final EIS to two trains to capture those peak hours where one Intercity-Express and one Intercity-Corridor train operate in the same hour. This is an update from the Tier 1 Draft EIS.

3.5 KEY FINDINGS

The FRA selected a number of key results and findings from the ridership forecasting process, as summarized below.

3.5.1 Trip Characteristics and Travel Markets

The FRA identified two general findings describing the behavior of travelers in the NEC:

- In both the No Action Alternative and the Preferred Alternative, the majority of passenger rail ridership, as well as overall travel in the corridor, is focused on the New York City metropolitan area. Approximately 73 percent of both Intercity and Regional rail ridership trips have at least one trip end in the New York City metropolitan area.
- The majority of total travel (by all modes) in the interregional markets is for non-business purposes, making up approximately 70 percent of interregional travel. The rest of the interregional market is made up of 18 percent business travel and 12 percent commuter travel.

3.5.2 Market Responses

Rail travel demand in the Study Area continues to be dominated by Regional rail, which comprises 96 percent of all trips in the No Action Alternative and 93 percent in the Preferred Alternative. Intercity trips are typically much longer than Regional rail trips and in the Preferred Alternative, Intercity passenger miles comprise 34 percent of the total miles as compared to 21 percent in the No Action Alternative. The FRA identified two general findings regarding the market response to the service improvements in the Preferred Alternative.

- The Preferred Alternative demonstrates an overall increase in total rail trips over the No Action Alternative of 24 percent.
- The overall increase in passenger miles over the No Action Alternative is 44 percent for the Preferred Alternative. In the Preferred Alternative, 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.

3.5.3 Service Variable Sensitivities

The FRA identified five major findings associated with ridership demand sensitivity to service characteristics related to mode choice selection. The amount, frequency, and type of service that could accommodate future corridor ridership demand on the representative route drove the interactive process of developing the Service Plan for the Preferred 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 service. The critical service variables in the mode choice model include travel time, travel cost, and frequency of service.

The key findings related to ridership demand sensitivity to service characteristics in the NEC are:

- Travel time and travel cost typically have an inverse relationship in travel behavior, 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 NEC or for similar prior models. However, the non-business model demonstrated much lower values of time, ranging from around $6 to around $20 per hour (allowed to vary by total cost of the trip). These are lower values than represented on the NEC 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 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 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; although they comprise only 18 percent 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 train service is more frequent than every 20 to 30 minutes apart, the importance of increased frequency as a means to attract additional new passengers rapidly diminishes. The Preferred Alternative has daily frequencies around or above this saturation point.
- Investment in major improvements in Intercity rail service—travel time reductions, frequency increases, and price reductions—impact rail mode share, but may not significantly change the rail volumes for travel between metro areas that have only small overall demand. Thus, increases in rail volume are most dependent on mode share changes for travel between the large markets in the area (such as New York City, Boston, Philadelphia, and Washington, D.C.), which have already a large rail share. Where rail already has a large share of the travel market (Philadelphia-New York City, and to a slightly lesser extent Washington, D.C.-New York City), capturing additional rail share by further improving rail service is relatively difficult, as the remaining market share is primarily personal travel between suburban locations. In market pairs where there are multiple competing modes (such as New York City-Boston), significant improvements in rail service tend to result in a higher modal shift in favor of rail.
- The potential to grow Regional rail travel above the pace of demographic growth is achieved by investing in rail system capacity and operating additional Regional rail service. The Regional rail ridership growth rate of 20 percent estimated for the Preferred Alternative demonstrates the potential for increasing rail's share of regional travel markets, thereby growing the role of rail in Regional rail travel.

3.6 RISK AND UNCERTAINTY

A major source of the differences between the results of the NEC FUTURE Interregional Model and other high-speed rail forecasting tools is the uncertainty of model input values and how these inputs are used in the model. Many sources of uncertainty 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, the ridership forecasts reflect parameters established by the NEC FUTURE Service Plans, which are not prescriptive and do not necessarily reflect the future operating plans of the NEC railroads.

3.6.1 Data Inputs Uncertainty

For the NEC FUTURE representative Service Plans, many of the data inputs that contribute to uncertainty were held constant at current levels. However, these factors may change in the future and impact the relative attractiveness of rail. Specific sources of uncertainty for data inputs include:

- Demographics
  - Population, employment, income levels
  - Location/magnitude of changes in demographics
- Implementation
  - Physical scope: service extensions, station locations, intermodal 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 demand forecasts, which is the trip generation portion of the Interregional Model, is the demographic forecasts. The FRA had anticipated that the "base" forecast would represent a moderate and reasonable picture of future population, employment, and income. However, the "base" forecast contains some uncertainty. The actual demographics in 2040 may vary in both size and distribution. For example, as the largest trip generator in the corridor, differences between various sources and locations of growth in employment and population in the New York City metropolitan area greatly impact travel patterns, particularly commuter travel patterns. Intercity travel is also impacted with the shifting of origins and destinations within a metro area. For example, one of the features of the NEC FUTURE Service Plan is new intermediate stations, the area around which could potentially experience demographic growth and have higher ridership due to additional development. The demographic forecasts do not incorporate feedback loops to reflect 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 Preferred Alternative. The infrastructure investment represented in the Preferred Alternative could bring greater demographic growth than the No Action Alternative. However, by specifying exogenously the level of demographic growth, the model is not able to capture this potential additional growth.

The rail services form the second category of the data inputs that can foster uncertainty. The FRA examined a large Study Area currently served by multiple rail operators. 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 forecast 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. For the Preferred Alternative, 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. 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 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. Although other modes could be constrained in their physical or operational capacity to accommodate growth, the FRA could not determine a basis within the scope of NEC FUTURE to estimate the magnitude of such constraints. Thus, the non-rail modes were not capacity constrained in the Interregional Model and regional models.

3.6.2 Model Uncertainty

There are inherent uncertainties around any ridership model. For the NEC FUTURE model such uncertainties include:

- Un-modeled attributes, such as reliability, integrated fare collection systems, pulse-hub transfers, and other amenities
- Survey data used to estimate the model:
  - Stated preference data are based on theoretical experiments, not actual experience
  - Data are based on current attitudes, and do not account for unseen attributes changing, such as overall mode preferences or other attributes such as multimodal stations allowing for ease of transfer, future growth around stations, future rates of car ownership, etc.

While the Preferred Alternative creates an improved passenger experience through common ticketing, and more convenient schedules and connections, respondents base their answers on their current perception of how travel operates. Similarly, the model may not adequately reflect respondents' attitudes toward and knowledge of improved connections of the rail system to the transportation network. The Preferred Alternative allows for increased connectivity, including multimodal stations, rental car facilities, and other improvements that would make the rail system more accessible to passengers. Respondents of the household survey familiar with more limited options at rail stations today may not fully realize the advantages of this connectivity, and may not consider this influence in their response.

3.7 SENSITIVITY ANALYSIS

To further investigate the risks and uncertainties associated with the NEC FUTURE Interregional Model, the FRA undertook a series of four sensitivity tests. These four tests, which are described in detail in the next sections, include:

- Rail fare structure
- Reliability
- Air fare adjustment
- Alternative specific constants adjustment

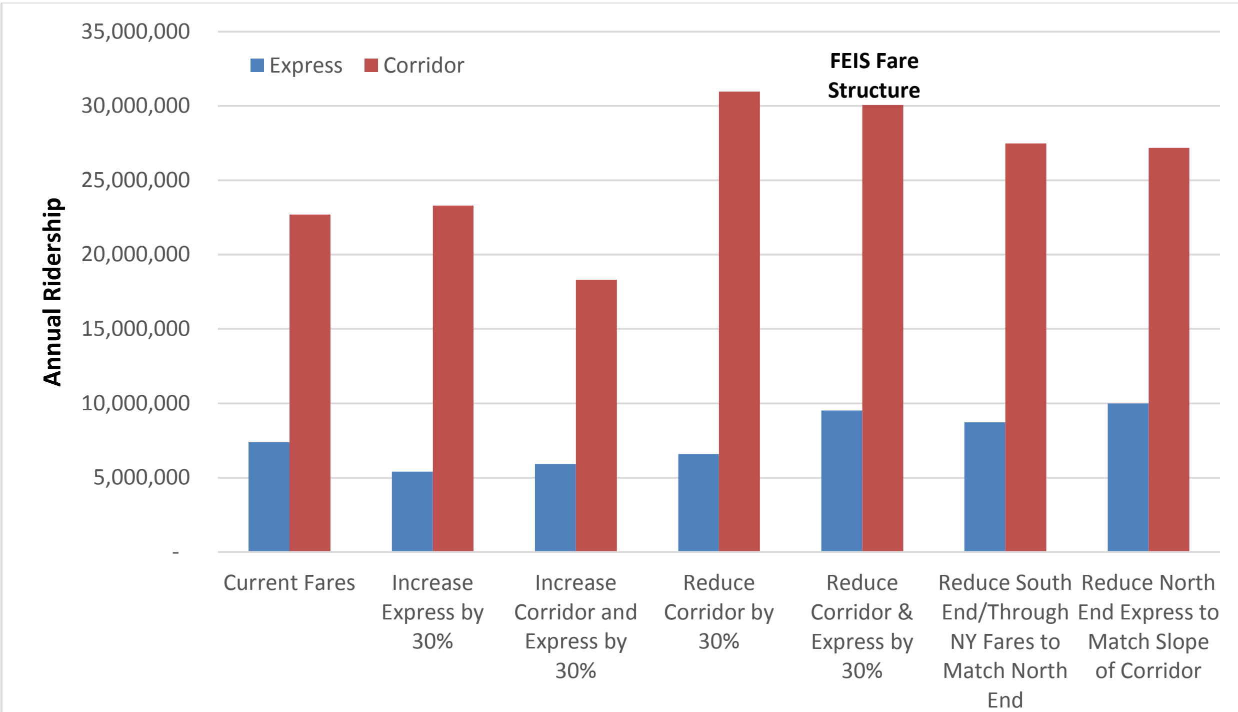
3.7.1 Rail Fare Structure

The FRA considered changes in Intercity pricing, based on proposed capacity increases and price sensitivities found in the NEC FUTURE household survey data. The fare structures tested including:

- Use current fares for Intercity-Corridor and Intercity-Express
- Increase both Intercity-Corridor and Intercity-Express fares by 30 percent
- Increase Intercity-Express fares by 30 percent with current fares for Intercity-Corridor
- Reduce Intercity-Corridor fares by 30 percent with current fares for Intercity-Express (Tier 1 Draft EIS fare structure)
- Reduce both Intercity-Corridor and Intercity-Express fares by 30 percent (Tier 1 Final EIS fare structure)
- Set fares for all geographies equal to current north end fares
- Set fares for all geographies equal to current north end fares, but reduce the per mile component of north end Intercity-Express fares

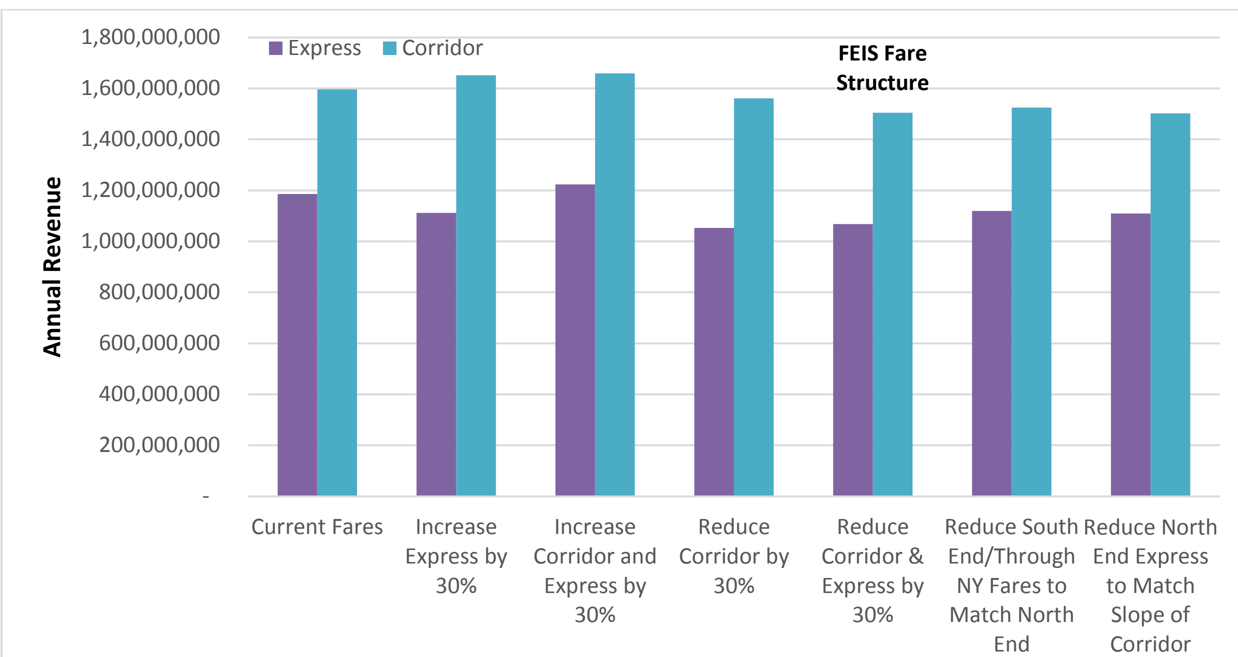
Figure 9 demonstrates that there is a clear relationship between the fare policy versus total revenue and total ridership, with higher fares resulting in higher revenue, but lower ridership. Figure 11 and Figure 12 break down the ridership and revenue for each fare structure by service type. The variation in ridership is primarily seen in the Intercity-Corridor service, while the Intercity-Express service contributes at least one-third of the total revenue for all fare structures.

Figure 11: Fare Structure Results-Ridership by Service Type



Source: NEC FUTURE team, 2016

Figure 12: Fare Structure Results-Revenue by Service Type



Source: NEC FUTURE team, 2016

3.7.2 Reliability

Reliability was not directly incorporated into the Interregional Model, but could potentially affect the ridership forecasts given the proposed increases in rail travel reliability in the Preferred Alternative. In order to capture this impact, the FRA adjusted the schedule pad that was included in the Preferred Alternative representative Service Plan time table to account for service reliability. The schedule pad is a constant 10 percent increase in the calculated travel time across the entire time table. The reliability sensitivity test looked at both removing the schedule pad (effectively reducing all travel times by 10 percent), as well as doubling the schedule pad. Table 28 shows the results of those tests, with a 5 to 6 percent increase in ridership due to a 10 percent decrease in travel time.

Table 28: Changes in Ridership due to Schedule Pad Adjustment

	Intercity-Express	Intercity-Corridor	Total Intercity
Base Line Haul Travel Time	9,742,000	30,441,000	40,183,000
Reduce Line Haul Travel Time by 10%	10,183,000	32,216,000	42,399,000
Percentage Change vs. Base	5%	6%	6%
Increase Line Haul Travel Time by 10%	9,313,000	28,776,000	38,089,000
Percentage Change vs. Base	-4%	-5%	-5%

Source: NEC FUTURE team, 2016

3.7.3 Air Fare Adjustment

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. Due to uncertainty about how service levels on other modes will evolve in the future, the service characteristics of the non-rail modes (auto, air and intercity bus), were held constant across the No Action Alternative and Preferred Alternative and were based on existing service. As air is highly competitive with rail in the corridor, a test was performed to show what the impact would be if air fares changed in the future. This test specifically increased air fare in all markets by 20 percent and decreased air fares the same amount. As can be seen in Table 29, the overall air market is reduced by approximately 17 percent with an increase in air fare, with the trips shifting to primarily to auto. There was a relatively small impact on the total Study Area trips, reducing the air mode share by less than 1 percentage point and increasing rail trips by approximately 300,000.

Some specific market pairs saw a bigger change in mode share. Those market pairs tended to have a strong market share for air, were typically longer distance, and had rail fares that were competitive with air fares. Table 30 and Table 31 show the mode shares for all market pairs with significant existing air mode share. All other market pairs in the Study Area had less than a 5 percent air mode share with the base air fare. The market pairs which had the greatest shift away from air and to rail were Boston–Washington, D.C., Boston-Baltimore, and Providence–Washington, D.C.

Table 29: Total Study Area Trips by Mode with Air Fare Adjustment (Preferred Alternative)

	Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips
Base Air Fares	362,553,000	9,062,000	10,660,000	9,742,000	30,441,000	6,481,000	428,939,000
Air Fares +20%	363,528,000	7,560,000	10,712,000	9,870,000	30,653,000	6,481,000	428,804,000
% Difference vs. Base	0.3%	-16.6%	0.5%	1.3%	0.7%	0.0%	0.0%
Air Fares -20%	361,351,000	11,274,000	10,590,000	9,592,000	30,194,000	6,481,000	429,482,000
% Difference vs. Base	-0.3%	24.4%	-0.7%	-1.5%	-0.8%	0.0%	0.1%

Source: NEC FUTURE team, 2016

Table 30: Major Market Pair Trips by Mode with Base Air Fare (Preferred Alternative)

MSA Pair	Auto	Air	Bus	Express Rail	Corridor Rail	Total Intercity Rail
Boston–Philadelphia	73.3%	16.1%	0.6%	2.3%	7.7%	10.0%
Baltimore–Boston	47.0%	48.4%	0.4%	1.3%	2.9%	4.2%
Boston–Washington, D.C.	28.3%	61.8%	0.4%	2.3%	7.2%	9.5%
Baltimore–Providence	85.2%	12.4%	0.1%	0.5%	1.8%	2.3%
Providence–Washington, D.C.	36.0%	45.6%	0.7%	3.5%	14.2%	17.7%
Baltimore–Hartford	66.0%	17.2%	2.0%	3.9%	10.9%	14.8%
Hartford–Washington, D.C.	56.2%	16.4%	2.7%	7.6%	17.1%	24.7%

Source: NEC FUTURE team, 2016

Table 31: Major Market Pair Trips by Mode with Air Fare Adjustment (Preferred Alternative)

MSA Pair	Auto	Air	Bus	Express Rail	Corridor Rail	Total Intercity Rail
Boston–Philadelphia	75.5%	13.5%	0.7%	2.4%	8.0%	10.4%
Baltimore–Boston	51.3%	43.6%	0.4%	1.4%	3.3%	4.7%
Boston–Washington, D.C.	32.3%	56.2%	0.5%	2.7%	8.4%	11.1%
Baltimore–Providence	87.3%	10.2%	0.1%	0.5%	1.9%	2.4%
Providence–Washington, D.C.	40.2%	39.2%	0.8%	3.8%	16.0%	19.8%
Baltimore–Hartford	68.0%	14.8%	2.1%	4.0%	11.1%	15.1%
Hartford–Washington, D.C.	58.5%	13.1%	2.8%	8.0%	17.6%	25.6%

Source: NEC FUTURE team, 2016

The changes in the air versus rail market in the total Study Area can be difficult to observe, due to the dominance of auto in the Study Area, which overwhelms the modes with smaller mode shares. Looking specifically at the air versus rail mode share, the changes are more visible, as seen in Table 32. Overall, there is a 2 percent mode share shift from air to rail, but in many large markets the shift is in the 4 to 7 percent range.

Table 32: Major Market Pair Air vs. Rail Mode Share (Preferred Alternative)

MSA Pair	Base Air Fare		Base Air Fare + 20%	
	Air	Total Rail	Air	Total Rail
Boston–New York City	21%	79%	17%	83%
Boston–Philadelphia	62%	38%	57%	43%
Baltimore–Boston	92%	8%	90%	10%
Boston–Washington, D.C.	87%	13%	84%	16%
Philadelphia–Providence	29%	71%	22%	78%
Baltimore–Providence	84%	16%	81%	19%
Providence–Washington, D.C.	72%	28%	66%	34%
Baltimore–Hartford	54%	46%	50%	50%
Hartford–Washington, D.C.	40%	60%	34%	66%
New York City–Washington, D.C.	9%	91%	7%	93%
Total Study Area	**18%**	**82%**	**16%**	**84%**

Source: NEC FUTURE team, 2016

3.7.4 Alternative Specific Constants Adjustment

One of the sources of uncertainty in the model is the limitation of basing the model on current attitudes, which comes from the survey responses. This can limit the ability of the model to forecast results in areas where modes may change dramatically and 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 toward rail over time. 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 multimodal 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 when responding to survey questions. In the mode choice model, all of these things are represented by the alternative specific constant (which captures all unmeasured attributes), but it does not vary across alternatives.

The alternative specific constant can be interpreted as the inherent preference for a mode given that all other measured attributes are equal, i.e., if travel time, cost, and other variables included in the model are the same for all modes. As such, the numerical order of the modal constants can indicate preference. However, in the NEC FUTURE Interregional Model, the modes can have a wide variance in travel characteristics, such as air versus bus travel time, and therefore it is difficult to make the simple assumption that it indicates order of preference.

The Study Area is large and covers a variety of rural and urban areas. Therefore, it is hard for a single number to convey all of those unseen attributes. Because of this, the mode choice models by trip purpose were calibrated at the MSA to MSA level, which attempts to refine the constants to more accurately reflect attributes at a closer geographic level, but still does not reflect any changes in preference due to a changing transportation system. Table 33 through Table 35 show the constants for major market pairs, as well as the base constants for the entire Study Area. The non-business trip purpose accounts for approximately 70 percent of all travel in the NEC, so this discussion will focus on the non-business coefficients, found in Table 34. In all of the major markets shown, auto has the most positive constant, which is to be expected given the prevalence of auto travel. Air typically has the next most positive coefficient, but also typically has the highest cost, which is a key variable in the mode choice model. Intercity-Express typically has a smaller ridership than Intercity-Corridor, and this is reflected in Intercity-Express having a more negative constant versus Corridor rail. Bus is often thought of a less preferred mode, but the findings in this analysis refute that assumption with bus looking more preferred to rail in some markets. It is possible that travelers may value certain characteristics of bus travel such as the flexibility to change departure times easily and at low cost.

Table 33: Alternative Specific Constants by Market Pair for Business Trip Purpose

	Auto	Air	Bus	Intercity-Express	Intercity-Corridor
Boston–New York City	0.51	-0.44	-1.61	-4.48	-1.88
Boston–Washington, D.C.	0.64	-0.16	-0.43	-9.58	-5.63
New York City–Washington, D.C.	1.28	0.42	-0.77	-2.38	1.03
Total Study Area	**0.00**	**-0.78**	**-0.22**	**-1.18**	**-1.18**

Source: NEC FUTURE team, 2016

Table 34: Alternative Specific Constants by Market Pair for Non-Business Trip Purpose

	Auto	Air	Bus	Intercity-Express	Intercity-Corridor
Boston–New York City	0.51	0.00	-2.15	-3.31	-2.20
Boston–Washington, D.C.	0.64	1.64	-2.62	-5.27	-3.16
New York City–Washington, D.C.	1.28	0.57	-1.42	-0.91	0.56
Total Study Area	**0.00**	**-1.22**	**-1.11**	**-1.54**	**-1.84**

Source: NEC FUTURE team, 2016

Table 35: Alternative Specific Constants by Market Pair for Commute Trip Purpose

	Auto	Air	Bus	Intercity-Express	Intercity-Corridor
Boston–New York City	0.51	1.05	0.42	2.04	0.51
Boston–Washington, D.C.	0.64	7.00	5.57	8.98	0.64
New York City–Washington, D.C.	1.28	4.36	5.20	7.35	1.28
Total Study Area	**0.00**	**-0.19**	**-2.20**	**-1.24**	**0.00**

Source: NEC FUTURE team, 2016

The proposed improvements in the Preferred Alternative will improve non-measured attributes of both Intercity-Express and Intercity-Corridor, such as reliability and connectivity. These improvements may potentially change travelers' modal preferences, which are reflected in the modal constants in the mode choice model. In order to test what the impact of changing preferences might be, a sensitivity test was conducted that looked at adjusting the ASCs for both Intercity-Express and Intercity-Corridor for the Preferred Alternative model run. To tie the constants to a reasonable value, the Intercity-Express constants were increased to be equal to the air constants, indicating that Intercity-Express service would be similarly perceived. Since both air and Intercity-Express are considered premium modes and have similar characteristics, this was deemed a realistic test. Intercity-Corridor would similarly have an increase in mode attractiveness, and the Intercity-Corridor constants were increased by the same increment as the Intercity-Express constants. The commute mode choice model does not include air as an available mode, so the adjustment increment from the Non-Business model was used to adjust both the Intercity-Express and Intercity-Corridor constants. This adjustment was done equally across the Study Area, and did not vary by market pair. Table 36 shows the rail constants before and after the adjustment.

Table 36: Adjusted Rail Alternative Specific Constants

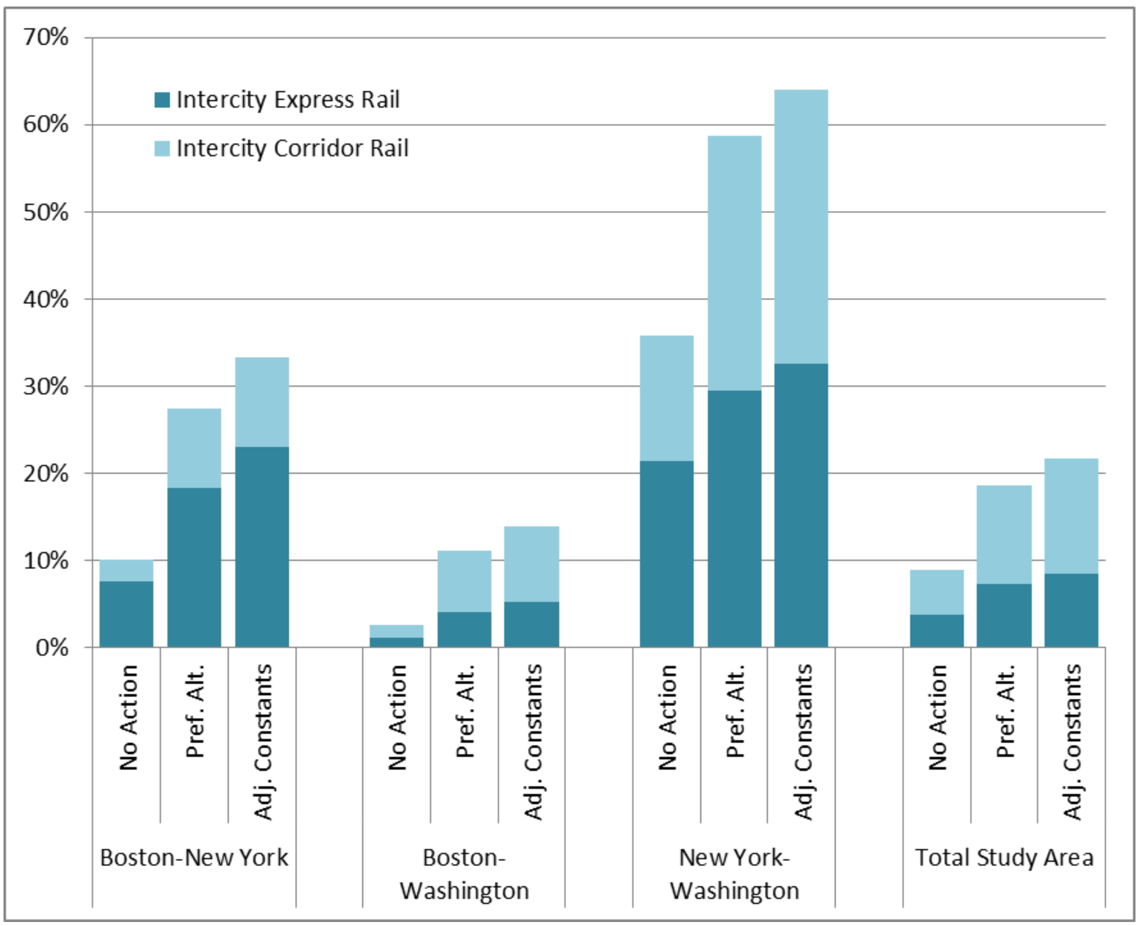
	Intercity-Express		Intercity-Corridor	
	Original	Adjusted	Original	Adjusted
Business	-1.18	-0.78	-1.18	-0.78
Non-Business	-1.54	-1.22	-1.84	-1.52
Commuter	-2.20	-1.88	-1.24	-0.92

Source: NEC FUTURE team, 2016

Table 37 through Table 40 provide the mode shares for the No Action Alternative, Preferred Alternative, and the Preferred Alternative with adjusted rail constants by trip purpose. The No Action Alternative and Preferred Alternative results share the same constants, and show the impact of improved rail service variables such as time, cost, and frequency. For all three trip purposes, both Intercity-Express and Intercity-Corridor mode shares double over the No Action Alternative with the proposed improvements for the total Study Area. Adding in the adjusted constants to account for changes in attitude toward rail, as well as other un-modeled improvements yields another 30 to 45 percent increase for Business and Non-Business trips, and another 20 percent for Intercity-Express trips and tripling Intercity-Corridor trips over the No Action Alternative. Because the rail constants were adjusted for the entire NEC and not geographically, the increase due to the adjusted rail constants is essentially equal across the markets.

Business trips, shown in Figure 13 and Table 37, have the largest rail mode shares for the No Action Alternative, Preferred Alternative, and Preferred Alternative with adjusted constants. Boston–Washington, D.C. has the smallest mode share, as it is currently a 6.5 hour ride with Intercity-Express, and decreases to a five hour Intercity-Express trip in the Preferred Alternative. The Intercity-Corridor trip is another 2 to 2.5 hours longer, but it also saw the largest percentage increase in trips of the major markets shown. Because of this long travel time, it is anticipated that the rail mode share would be small, with 2 percent in the No Action Alternative, increasing by almost four times in the Preferred Alternative. The adjusted constants yield another 3 percent rail mode share for the Boston–Washington, D.C. market. Boston–New York City also saw a large increase in the Business trip purpose, going from 11 percent total rail mode share in the No Action Alternative to 27 percent in the Preferred Alternative, increasing to one-third of all trips with the adjusted constants. New York City–Washington, D.C. has the largest business rail mode share in the NEC, with approximately one-third of all trips in the No Action Alternative, increasing to 58 percent in the Preferred Alternative, and gaining an additional 6 percent of the mode share with the adjusted rail constants.

Figure 13: Rail Mode Shares for Business Trips



Source: NEC FUTURE team, 2016

Table 37: Mode Shares for Business Trips

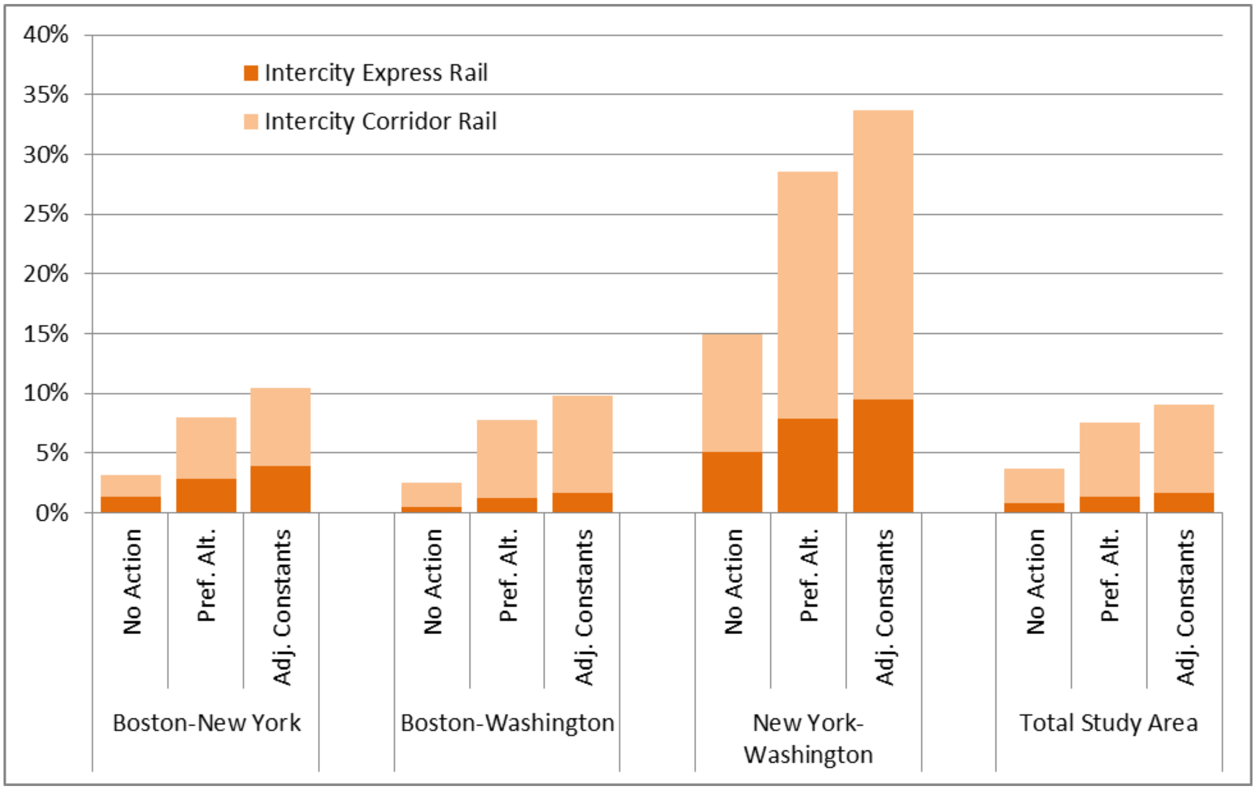
		Auto	Air	Intercity Bus	Intercity-Express Rail	Intercity-Corridor Rail
No Action	Boston–New York City	74%	13%	3%	8%	3%
	Boston–Washington, D.C.	5%	93%	0%	1%	1%
	New York City–Washington, D.C.	45%	15%	5%	21%	14%
	Total Study Area	**82%**	**7%**	**2%**	**4%**	**5%**
Preferred Alternative	Boston–New York City	60%	10%	2%	18%	9%
	Boston–Washington, D.C.	4%	85%	0%	4%	7%
	New York City–Washington, D.C.	30%	9%	3%	29%	29%
	Total Study Area	**74%**	**6%**	**1%**	**7%**	**11%**
Preferred Alternative - Adjusted ASCs	Boston–New York City	55%	9%	2%	23%	10%
	Boston–Washington, D.C.	4%	82%	0%	5%	9%
	New York City–Washington, D.C.	26%	8%	2%	33%	31%
	Total Study Area	**71%**	**6%**	**1%**	**9%**	**13%**

Source: NEC FUTURE team, 2016

The Non-Business trips make up 70 percent of all travel in the Study Area, but have the smallest rail mode shares of the trip purposes, likely due to the non-essential nature of the travel and auto dependence on at least one of the trip ends. Going from the No Action Alternative to the Preferred Alternative, the increases follow the same pattern of increase in rail mode share as seen in the Business trips, but with not quite as large of a shift overall toward rail. Major differences between the Business and Non-Business rail mode shares include:

- Overall rail shares are lower for Non-Business trips versus Business trips, by approximately half or less
- Intercity-Corridor Rail is more heavily utilized for Non-Business trips
- Boston–New York City has a much smaller rail share for Non-Business trips versus Business

Figure 14: Rail Mode Shares for Non-Business Trips



Source: NEC FUTURE team, 2016

Table 38: Mode Shares for Non-Business Trips

		Auto	Air	Intercity Bus	Intercity-Express Rail	Intercity-Corridor Rail
No Action	Boston–New York City	90%	2%	5%	1%	2%
	Boston–Washington, D.C.	40%	57%	0%	1%	2%
	New York City–Washington, D.C.	72%	3%	10%	5%	10%
	Total Study Area	**92%**	**2%**	**3%**	**1%**	**3%**
Preferred Alternative	Boston–New York City	86%	2%	4%	3%	5%
	Boston–Washington, D.C.	38%	54%	0%	1%	6%
	New York City–Washington, D.C.	61%	3%	8%	8%	21%
	Total Study Area	**88%**	**2%**	**3%**	**1%**	**6%**
Preferred Alternative - Adjusted ASCs	Boston–New York City	83%	2%	4%	4%	6%
	Boston–Washington, D.C.	38%	52%	0%	2%	8%
	New York City–Washington, D.C.	56%	2%	8%	9%	24%
	Total Study Area	**87%**	**2%**	**3%**	**2%**	**7%**

Source: NEC FUTURE team, 2016

Table 39 details the number of trips by mode for all trip purposes before and after the ASC adjustment. Overall, there is a 23 percent increase in rail trips due to the adjusted ASCs, indicating the Preferred Alternative could potentially see this sort of increase in ridership if perceptions of rail and the non-measured attributes increased over time.

Table 39: Comparison of Trips by Mode Before and After ASC Adjustment

Preferred Alternative					
	Auto	**Air**	**Bus**	**Intercity-Express Rail**	**Intercity-Corridor Rail**
Boston–New York City	40,489,000	1,646,000	2,098,000	2,769,000	3,228,000
Boston–Washington, D.C.	1,074,000	2,438,000	14,000	83,000	278,000
New York City–Washington, D.C.	10,839,000	770,000	1,508,000	2,616,000	4,980,000
Total Study Area	**362,553,000**	**9,062,000**	**10,660,000**	**9,742,000**	**30,441,000**
Preferred Alternative – Adjusted ASCs					
	Auto	**Air**	**Bus**	**Intercity-Express Rail**	**Intercity-Corridor Rail**
Boston–New York City	36,731,000	1,512,000	1,948,000	3,415,000	3,850,000
Boston–Washington, D.C.	1,049,000	2,293,000	14,000	105,000	336,000
New York City–Washington, D.C.	9,680,000	683,000	1,349,000	2,918,000	5,616,000
Total Study Area	**356,853,000**	**8,766,000**	**10,145,000**	**11,614,000**	**37,747,000**

Source: NEC FUTURE team, 2016

3.7.5 Summary

The sensitivity tests described above provide bounds to the official ridership forecast for the Preferred Alternative relative to the specific risk factors, including fare structures, reliability, responses of competitive modes like air, and traveler preferences. While changes to the service characteristics of the air mode did not have a major impact on the estimates of rail ridership for the Preferred Alternative, changing the rail fare structure and attitude toward rail as measured by the ASCs in the Interregional model, greatly influence the estimated ridership. The Preferred Alternative ridership results are in many was a conservative forecast given the many uncertainties surrounding the input data, such as demographic changes and the responses of other modes, as well as uncertainty inherent in the model related to future conditions.

4. Capital Costs

4.1 METHODOLOGY

The capital cost estimating methodology evolved through the alternatives development process, from initial concept planning and service development through concept design for the No Action Alternative and Action Alternatives evaluated in the Tier 1 Draft EIS. For the Tier 1 Final EIS, the FRA used the same methodology and cost library for generating capital costs that was used to determine the capital costs for the Action Alternatives (see Volume 2, Appendix B.6) with adjustments to several elements, including Unallocated Contingency, New Route Segments, and New Track.

4.1.1 Unallocated Contingency

Although the FRA did not include unallocated contingency in the estimate for the Tier 1 Draft EIS, the FRA recognized that the Preferred Alternative presented unknown and indefinite cost risks that often are addressed in cost models by applying an unallocated contingency. A primary purpose of the cost estimate for the Tier 1 Draft EIS was to facilitate a comparison between the No Action Alternative and Action Alternatives. Applying an unallocated contingency as a percentage of direct costs to each of the Action Alternatives would not have provided value for the comparative analysis. However, the primary purpose of the cost estimate for the Tier 1 Final EIS is to provide a documented and validated conceptual cost estimate for the Preferred Alternative commensurate with the level of detail required in a Tier 1 EIS. Accordingly, the FRA applied an unallocated contingency rate of 5 percent to the direct costs of each construction line item of new segment, new track, supporting infrastructure costs, and environmental mitigation in the cost estimate for the Preferred Alternative in the Tier 1 Final EIS.

4.1.2 New Segment

A new segment is a section of new track that would be constructed in new railroad right-of-way outside the NEC right-of-way. At the conceptual level, new segments are envisioned as being constructed according to one of 46 typical cross sections developed for NEC FUTURE. The Preferred Alternative representative routes and construction characteristics are the basis for the analysis in the NEC FUTURE Tier 1 EIS. They illustrate necessary improvements to achieve the Preferred Alternative representative Service Plan. As part of the Tier 1 process, the FRA has determined the necessity for new segments in particular geographic sections of the NEC in order to meet the purpose and need, and has identified a representative route for each potential new segment. The FRA or another federal agency providing funding for a particular project will evaluate specific locations for new segments as part of the Tier 2 project studies, prior to making any decision regarding new segment locations.

The FRA developed a new typical cross section for the Preferred Alternative to accommodate a four-track tunnel for the replacement of the Baltimore and Potomac (B&P) Tunnel in Baltimore. The FRA estimated the cost of this typical cross section by calculating the unit price of construction line items, similar to the typical cross sections used for the Tier 1 Draft EIS.

4.1.3 New Track

A new track represents additional track or systems improvements along the NEC. The FRA developed a new systems improvement—electric traction upgrade—for the Preferred Alternative to accommodate the conversion from diesel to electric operation along the Hartford/Springfield Line. The FRA estimated the cost of this upgrade by calculating the unit price of construction line items, similar to those identified for catenary and signal system improvements in the Tier 1 Draft EIS.

4.1.4 No Action Alternative

For the Tier 1 Draft EIS, the FRA calculated the cost estimate of the No Action Alternative by summing the total cost of the No Action Alternative Project List (see Volume 2, Appendix B). No Action Alternative projects were organized into three categories (costs in $2014 billions). This same process was used for the Tier 1 Final EIS.

- Category 1: Funded projects or projects with approved funding plans – Approximately $8 billion
- Category 2: Funded or unfunded mandates – Approximately $1 billion
- Category 3: Unfunded projects necessary to keep the railroad running – Approximately $11 billion

4.2 ANALYSIS

The NEC FUTURE capital cost model provides a documented and validated conceptual cost estimate for the Preferred Alternative commensurate with the level of detail required in a Tier 1 EIS. The appropriate level of detail was determined by the FRA and is a function of deliberation, analysis, and engineering assessments, and is consistent with a conservative approach to estimate capital costs of the Preferred Alternative.

Actual costs will differ after more-refined engineering and design work is completed. Actual costs will reflect value engineering, selection of construction and staging methodologies, and price inflation/deflation. The capital costs do not represent or include any specific implementation timelines, project delivery methods, funding sources, 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.

The FRA based the capital cost estimate of the Preferred Alternative on the representative network track schematic, using the infrastructure improvements defined for the Action Alternatives during the Tier 1 Draft EIS. The FRA used the infrastructure improvements that defined the cost estimate for the Action Alternatives as a base to estimate the capital cost of the Preferred Alternative. However, during the development of the Tier 1 Final EIS, the FRA made several refinements to the infrastructure improvements to accommodate the improvements associated with the Preferred Alternative. These refinements, which include constructability access, right-of-way acquisition, and rolling stock, are described in Sections 4.2.1 through 4.2.12. For a description of all infrastructure elements associated with the Preferred Alternative, refer to Volume 1, Chapter 4. Appendix E presents the track and construction type of the Preferred Alternative.

4.2.1 New Carrollton, MD to Halethorpe, MD New Track

The capital cost estimate for the Preferred Alternative includes new track of a construction type consistent with the NEC along the NEC between Bowie State University and the northeastern edge of the Patuxent Research Refuge North. The new track provides a continuous four-track NEC between Hanson Interlocking/New Carrolton station and Baltimore, MD, for the Preferred Alternative.

4.2.2 B&P Tunnel New Segment

The FRA adjusted the capital cost estimate for the new segment for the B&P Tunnel replacement that approaches Baltimore Penn Station from the west, consistent with the four-track tunnel typical section described in Section 4.1.2. In addition, the NEC, between Lafayette Avenue and North Avenue in Baltimore City would be retired from passenger rail service. As such, the FRA eliminated the infrastructure improvements in the capital cost estimate that included the rehabilitation of this existing track.

4.2.3 Wilmington New Segment

For the capital cost of the Preferred Alternative, the FRA included a new segment south of Newark, DE, that was not included in the cost estimate of the Action Alternatives. The new segment consists of a two-track infrastructure near Wilmington that shifts south of the NEC and east of I-95, continuing at-grade or on embankment east, crossing the Christina River, U.S. Route 13, and the Christina River again in succession. The new segment shifts north, running parallel to I-495, reconnecting with the NEC near Fox Point State Park in Edgemoor, DE.

4.2.4 Philadelphia New Segment – Baldwin, PA, to Philadelphia 30th Street Station via Philadelphia International Airport

The FRA included changes to construction type and route at the Baldwin, PA, to Philadelphia 30th Street Station via Philadelphia International Airport new segment south of Center City, Philadelphia, adjacent to the John Heinz National Wildlife Refuge. The new segment for the Preferred Alternative shifts south of the representative route of Alternative 2 on aerial structure and embankment.

4.2.5 Secaucus/Bergen Loop New Segment

In the capital cost estimate for the Preferred Alternative, the FRA included a new segment at the Secaucus rail station that was not included in the cost estimate of the Action Alternatives. The new segment consists of a two-track infrastructure that begins perpendicular to the NEC at the Secaucus rail station, parallel to NJ TRANSIT’s Main Line, under the NEC. The new segment follows the NJ TRANSIT Main Line at-grade before looping north and shifting to embankment, eventually becoming parallel to the NEC. The new segment continues parallel to the NEC on embankment or aerial structure to just east of Secaucus Road where it will connect to Allied Interlocking.

4.2.6 Old Saybrook-Kenyon New Segment

The FRA included changes to the construction type defined in Alternative 1 at a new segment beginning east of Old Saybrook Station, which provides a new two-track segment north of the NEC. The representative route of this new segment is unchanged from Alternative 1; however, the FRA changed the construction type and corresponding typical cross sections near Old Lyme. The new segment shifts north of the NEC east of the Connecticut River, crossing the Connecticut River in a tunnel under Old Saybrook and Old Lyme.

4.2.7 Branford, CT, to Guilford, CT New Track

The Preferred Alternative includes additional new track of a construction type consistent with the NEC between Branford and Guilford, CT. The new track provides two siding tracks, allowing overtakes between Branford and Guilford for the Preferred Alternative.

4.2.8 Pawtucket, RI, to Hebronville, MA New Track

The Preferred Alternative includes additional new track of a construction type consistent with the NEC between Pawtucket, RI, and Hebronville, MA. The new track provides two siding tracks allowing overtakes between Pawtucket and Hebronville for the Preferred Alternative.

4.2.9 Hartford/Springfield Line

The capital cost estimate for the Preferred Alternative includes improvements to the existing 60-mile Hartford/Springfield Line, which runs roughly parallel to I-91 between New Haven, CT, and Springfield, MA. The FRA included the following capital costs for infrastructure improvements to the Hartford/Springfield Line:

- Electric traction upgrade by route mile
- Signal system upgrade by route mile, including grade crossing improvements (i.e., quad-gates) from Hartford, CT, to Springfield, MA
- Connecticut River (Windsor Locks, CT) bridge crossing repairs to restore second track to service
- New track from Hartford to Springfield
- New Haven and Springfield yards
- Hartford viaduct replacement in kind
- Hartford Station improvements

4.2.10 Constructability Access

The cost estimates for constructability access reflect the costs necessary to implement railroad safety protection, and access/egress to the construction site, and the addition of other items such as run-around tracks, and fitting staging and laydown areas into constrained site locations for the Preferred Alternative. The FRA calculated the costs for constructability access for the Preferred Alternative consistent with Volume 2, Appendix B.06.

4.2.11 Right-of-Way Acquisition

The cost estimates for right-of-way acquisition reflect the cost of acquiring sufficient right-of-way to accommodate the infrastructure and rail service improvements of the Preferred Alternative. The FRA calculated the costs for right-of-way acquisition for the Preferred Alternative consistent with Volume 2, Appendix B.06.

4.2.12 Rolling Stock

The FRA determined that rolling stock costs should reflect the cost to acquire additional high-performance trainsets required to operate the Service Plans for the Preferred Alternative. The costs for rolling stock were calculated for the Preferred Alternative consistent with Volume 2, Appendix B.6.

4.3 RESULTS

Table 40 through Table 42 present the cost estimates generated by the capital cost model for the Preferred Alternative. Table 40 presents the total cost for the Preferred Alternative by the FRA standard cost category (SCC). Compared to the capital costs estimated for the Action Alternatives (see Volume 2, Appendix B.06), the total low and high cost estimates for the Preferred Alternative are closest to the estimates for Alternative 2. Table 41 presents the cost for new segments included in the total cost, and Table 42 presents the costs for new track included in the total cost.

Table 40: Preferred Alternative Cost Estimate

FRA SCC	Description	Low (millions)	High (millions)
10	Track Structures and Track	$51,580	$54,055
20	Stations, Terminals, Intermodal	$7,595	$7,940
30	Support Facilities	$915	$975
40	Site work, Right-of-Way, Land, Existing Improvements	$26,015	$26,815
50	Communications & Signaling	$2,410	$2,520
60	Electric Traction	$3,550	$3,715
70	Vehicles	$6,350	$6,350
80	Professional Services	$11,900	$12,505
90	Unallocated Contingency	$3,380	$3,390
NA	No Action Alternative Projects	$9,330	$9,330
	Total	$123,000	$128,000

Source: NEC FUTURE team, 2016
Note: Columns may not add to the total due to rounding; total costs are rounded to the nearest billion.

Table 41: Cost of the Preferred Alternative – New Segments by Construction Type

Construction Type	Cost (millions)	Construction Route Mileage
Tunnel	$15,820	35
Trench	$5,630	25
At-Grade	$2,350	40
Embankment	$7,985	95
Aerial	$6,335	45
Major Bridge	$2,490	15
Total	$40,605	250
Cost per Construction Route Mileage	$165	

Source: NEC FUTURE team, 2016
Note: Direct costs of new segments only, and does not include unallocated contingency, allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the total due to rounding.

Table 42: Cost of the Preferred Alternative – New Track by Construction Type

Construction Type	Cost (millions)	Construction Route Mileage
Additional Track	$5,785	121
Freight Track Upgrade	$535	35
Catenary System Upgrade	$530	165
Signal System Upgrade	$825	225
Electric Traction Upgrade	$235	35
Total	$8,000	

Source: NEC FUTURE team, 2016
Note: Direct costs of new track only, and does not include unallocated contingency, allocated contingency, environmental mitigation, or professional services costs. Columns may not add to the total due to rounding; total costs are rounded to the nearest billion.

5. Operations and Maintenance Costs

The FRA prepared representative estimates of the costs associated with operations and maintenance (O&M) of the representative Service Plans for the No Action Alternative and Preferred Alternative. The next sections document the data sources, key assumptions, and approach used to estimate these O&M costs for the NEC FUTURE program. The methodology produced high-level, order-of-magnitude estimates for O&M costs appropriate for a Tier 1 Final EIS level of review. In conjunction with the capital cost estimates, these O&M cost estimates facilitate comparative cost analysis between the No Action Alternative and Preferred Alternative, and, for Intercity services, assess whether the representative Service Plans are likely to generate an operating surplus in which revenues exceed costs.

Where available, the FRA used recent, actual Amtrak and commuter-rail O&M cost data 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 to provide a more comprehensive data set. To facilitate consistent application of cost estimates across all representative 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 Volume 2, Appendix B.05).

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 would be important baseline inputs to the O&M cost estimates. However, these data are proprietary business information 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 data use, and has presented only the summary-level results. 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 these 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), no other passenger rail operations in the United States share substantially similar operating characteristics to those proposed in the NEC FUTURE Preferred Alternative. Comparable international passenger rail data—in terms of unit O&M costs—are either governed by 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 was applied 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 these 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 available 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.

The next sections present the step-by-step process used to develop the O&M costs. Section 5.1 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 5.2 provides an overview of the model structure, and Section 5.3 describes model adjustments. Section 5.4 discusses the various data inputs and sources of information, and presents a discussion on the unit cost calculation and application. Section 5.5 describes the calculation of O&M unit costs and their application to projected levels of services for the No Action Alternative and Preferred Alternative. Section 5.6 presents the summary-level analytical results for the No Action Alternative and Preferred Alternative as well as a high-level contribution analysis comparing the alternatives.

5.1 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.[6] 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 service plan
- General and Administrative (G&A): management, marketing, sales and reservations, all general office expenses

[6] 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/sites/default/files/files/OIG-HSR-Best-Practice-Operating-Cost-Report.pdf*.

For the 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 the following key elements of the train Service Plans that contribute to estimating of O&M costs:

- 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 Plan elements provided the basis for calculating train hours and train miles—a critical input for estimating operating costs, 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. Additionally, the physical characteristics, such as the route operated and stations served, provided the basis for determining route and track distances (e.g., route and track miles) as well as ridership. Changes in physical characteristics directly affected 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 Alternative and Preferred Alternative. The FRA used Amtrak cost data as a baseline to project future costs for existing portions of the NEC, recognizing that the underlying NEC O&M costs would be a function of the corridor's extensive existing operations, unique infrastructure and equipment maintenance needs, and detailed labor agreements. The FRA also recognized the value of available 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.

To align the development of the O&M costs with the conceptual level of detail of the No Action Alternative and Preferred Alternative, the O&M cost modeling approach leveraged existing Amtrak financial data reports. One such report was the Amtrak Performance Tracking (APT) system report.

The cost analysis considered infrastructure-related costs (i.e., maintenance-of-way, train dispatching, propulsion, and physical plant maintenance) incurred throughout the territory covered by the NEC FUTURE Service Plans, including corridor-wide Intercity and Regional rail service, regardless of service or operator. Assembling these data from existing Amtrak reports was complicated by Amtrak's current allocation of O&M-related costs by business lines and services. Thus, the O&M cost model leveraged an analytical tool—the cost aggregation database—which was developed by the Northeast Corridor Commission (NEC Commission) that captured 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 addressed energy (i.e., propulsion power and maintenance), stations, and railroad cost areas mentioned in the OIG Report. Section 5.4.1 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 (i.e., 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 (i.e., 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 5.4.1 provides further information on the APT report.

O&M costs for segments of the existing NEC are based upon current Intercity costs in the corridor; however, the Preferred Alternative also includes new, off-corridor rights-of-way as well as different equipment types. Dedicated high-speed segments on new rights-of-way would be designed to current international standards, such as those proposed for the California High-Speed Rail project, and incur a different O&M cost profile than the existing NEC. In addition, new, multiple-unit, high-performance equipment would have a different maintenance cost experience than the current equipment in use on the NEC. The FRA determined that O&M costs of the new segments of the Preferred Alternative would be more closely aligned with costs associated with the proposed California system than with the existing NEC, and thus, for these new segments, O&M costs were based on the relevant unit costs for the proposed California system of new high-speed rail operations, including costs for new equipment (i.e., electric multiple-unit trainsets). The unit costs for new high-speed operations addressed the train maintenance and railroad cost areas mentioned in the OIG Report. Section 5.5 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 in this analysis in response to the lack of available O&M cost models from the commuter railroads. Although the NTD reports have 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 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 5.4.1 provides further information on the commuter-rail costs. Table 43 shows how each type of O&M

cost discussed above and identified for use in the O&M cost model addressed the cost areas mentioned in the OIG Report.

Table 43: 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, 2016

After the FRA assembled the relevant cost information, cost drivers were assigned to each cost group. The existing unit cost was calculated by dividing existing cost by the value of the existing cost driver. The unit cost was then applied to the projected cost-driver value to obtain the forecast O&M cost.

The Preferred Alternative representative Service Plan differs from the existing service, and the operating and physical characteristics associated with the Service Plan are likely to alter O&M cost experiences. Thus, the FRA evaluated certain potential 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 5.5.1.5 presents further discussion on these factors.

Generally, the service and infrastructure improvements associated with the Preferred Alternative would tend to reduce the costs associated with operations and maintenance compared to current experience. With a well-maintained railroad in a state of good repair, labor hours associated with the operation and maintenance of late trains would be reduced; wear and tear on the passenger equipment and the infrastructure (such as damage to wheels and flat spots, and impact damage on interlockings and bridge joints) would be reduced, saving both maintenance of equipment and maintenance of way costs. In addition, through-service, clock-face schedules, and reduced dwell time would result in more efficient use of trains and labor, further reducing costs. Maintenance and upgrade of the railroad could be better planned to address programmed needs rather than emergency repairs. These improvements in cost structure are not incorporated into the O&M cost model, but could be explored in further studies.

To confirm that proposed Intercity service would result 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 would be expected to exceed the O&M cost of the Service Plan. The FRA did not optimize the representative service plans to maximize ridership or net revenues.

5.2 MODEL STRUCTURE

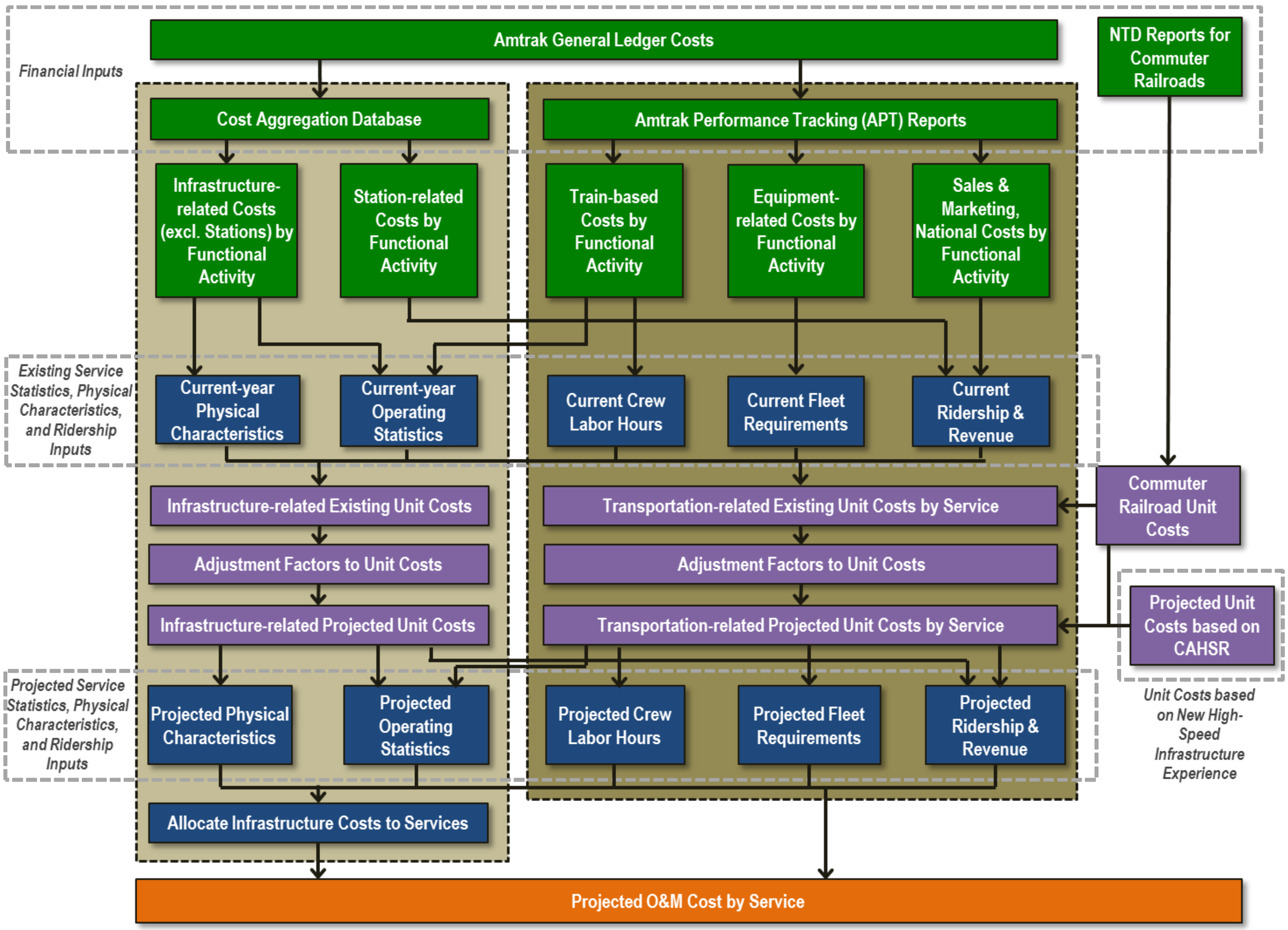
The O&M cost model is a Microsoft Excel–based spreadsheet model that compiled various data inputs from a number of sources. This model derived unit O&M costs through a transformation of the cost data and level-of-service information. Unit costs were generally derived function-by-function as a cost divided by either quantity of service or by 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 Alternative and Preferred Alternative for each of the proposed NEC FUTURE service types.

Figure 15 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 was 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 15: O&M Cost Model Structure



Source: NEC FUTURE team, 2016

The FRA structured the O&M cost model in a series of sheets within a single file to address 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 (i.e., the cost aggregation database, the APT reports, or the NTD reports) that represent the O&M costs forecasted in the Service Plans for the No Action Alternative and Preferred Alternative, 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 (i.e., by cost area) and by functional activity. Transportation- and equipment-related costs (i.e., costs from the APT reports) were also aggregated by existing service type (i.e., Acela Express, Northeast Regional). The FRA accepted this level of aggregation since it captured high-level costs related to major O&M activities that are driven by various cost drivers.
- **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 (i.e., 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 FRA used the O&M cost model to multiply 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 Alternative and Preferred Alternative, the FRA used the O&M cost model to multiply 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 5.4 describes the data input in detail, while Section 5.5 describes each of the four phases mentioned above in detail.

5.3 MODEL ADJUSTMENTS

Subsequent to the submission of the Tier 1 Draft EIS, the FRA made the following adjustments to the O&M cost analysis:

- Added the Hartford/Springfield Line between New Haven, CT, and Springfield, MA, to the analysis (previously, the analysis considered O&M costs related to service only on the NEC between Boston and Washington, D.C.)

- Updated ridership and revenue forecasts for the No Action Alternative
- Adjusted the speed of the Regional rail services to match existing Regional rail. (In the Tier 1 Draft EIS, the FRA's estimates for Regional rail speeds were calculated based on a collection of timetable and route network length data. For the Tier 1 Final EIS, the FRA used direct inputs of the existing Regional rail service speeds and applied the corresponding train miles to derive the adjusted revenue hours.)
- Developed ridership and revenue forecasts for the Preferred Alternative for all Intercity services
- Developed level-of-service forecasts for the Preferred Alternative for all Intercity services

5.4 DATA INPUTS

This section describes the four categories of data sources utilized in the O&M cost model. Section 5.4.1 describes financial inputs. Section 5.4.2 describes existing physical characteristics, services statistics, and ridership. Section 5.4.3 describes the projected physical characteristics, service statistics, and ridership for the No Action Alternative and Preferred Alternative.

5.4.1 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.[7] Application of the unit costs, discussed in Section 5.5, included a conversion to 2014 dollars using appropriate Association of American Railroads inflation indices.

5.4.1.1 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.

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 Alternative and Preferred Alternative within the NEC right-of-way. The FRA aggregated this confidential information from the Amtrak general ledger for development of shared infrastructure unit costs.

5.4.1.2 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, or "cost families," that align with the cost areas mentioned in the OIG

[7] 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.

Report. To be consistent with the cost data from the cost aggregation database, FY 2013 APT data were used in the O&M cost model.

5.4.1.3 National Transit Database (NTD) Reports

The FRA obtained the NTD reports for the 2012 reporting period[8] 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. Costs were inflated to FY 2014 dollars for use in the O&M cost model. Unit costs were developed by dividing the following:

- Vehicle operations costs by total vehicle revenue hours
- Vehicle maintenance costs by total vehicle revenue miles
- Non-vehicle maintenance costs by the number of track miles

5.4.2 Existing Physical Characteristics, Service Statistics, and Ridership

The FRA assigned five major cost-driver types to costs to derive unit costs: physical characteristics (i.e., track miles, route miles), operating statistics (i.e., 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

- 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

[8] 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 provided the existing crew labor hours and included information on the following:
  - Trainmen crews
  - Enginemen crews
  - Onboard service crews
- Amtrak's NEC Infrastructure and Investment Development (IID) 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.

5.4.3 Projected Physical Characteristics, Service Statistics, and Ridership

Engineering, service planning, and ridership data sources from the NEC FUTURE models were the sources of the projected values of the five major categories of cost-driver variables for the No Action Alternative and Preferred Alternative.

- 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 service planning data:
  - 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 service planning data.
- Projected ridership and ticket revenue were developed from ridership data.

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 Alternative and Preferred Alternative. Section 5.5.1 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 5.5.1.4 reviews the assignment of cost-driver variables to each cost area and functional activity. Section 5.5.1.5 discusses the derivation of unit costs and the adjustment factors applied to account for changes in productivity and technology. Section 5.5.1.6 discusses the application of the unit costs to the projected cost-driver variable values to obtain the projected O&M costs. The FRA did not reveal any actual costs or resulting unit costs because of the proprietary nature of the information. The numeric values were available and were reviewed by parties who signed a non-disclosure agreement.

5.5.1 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.

5.5.1.1 Infrastructure-Related Costs from the Cost Aggregation Database

Table 44 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.

Table 44: 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
		Station Police
Power Directors	Railroad	Power Directors & Load Dispatchers
Train Dispatching	Railroad	Blocks & Towers
		Control & Dispatch
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	Railroad	New Alignment – Track

Source: NEC FUTURE team, 2016

For this analysis, the FRA aggregated infrastructure-related costs at the level of detail outlined in Table 44 (i.e., corridor-wide by cost area and by functional activity). The FRA used the geographic or location-based information from the cost aggregation database to determine the NEC territory for which Service Plans for the Preferred Alternative applied. The analysis excluded infrastructure-related costs for the Harrisburg line west of Philadelphia.

5.5.1.2 Unit Costs Based on New High-Speed Segments

The FRA based the unit costs for maintenance of new high-speed segments and new high-speed multiple-unit equipment on unit costs derived from the O&M costing methodology applied for the California High-Speed Rail Authority. The FRA estimated high and low unit costs for maintenance of infrastructure per track mile and maintenance of equipment per train mile. The O&M cost model used the high estimates. The unit costs were derived from CHSRA estimates in 2014 dollars and were initially converted to 2013 dollars to be consistent with the unit costs derived from Amtrak cost data. The FRA subsequently converted combined unit costs (both Amtrak- and CHSRA-derived) to 2014 dollars in the application of the unit costs.

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 (i.e., patrols along the right-of-way), yard costs (i.e., patrols at the yard), and station costs (i.e., 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 Preferred Alternative. Thus, the station costs applied in the O&M cost model are only the Intercity (i.e., modeled on existing Amtrak) portion of the total station O&M cost. The FRA estimated these costs 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 44 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, and by cost associated with new alignment track.

5.5.1.3 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 45 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 45: 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, 2016

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 distinguished between MoE support costs (e.g., material handling and fleet engineering) and MoE multiple function costs that would 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. The FRA applied current Acela MoE costs 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 FRA included the cost for diesel train fuel in the fuel cost area of the O&M cost model. Functional activities for the other transportation operations cost areas represent costs for transportation-related administrative functions (i.e., 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 functional activities in the sales and marketing cost area distinguish between costs associated with sales, information and reservations, and marketing activities. The functional activities in the police, security, and environmental cost area 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 costs (e.g., payables, receivables, and payroll). 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.

5.5.1.4 Selection of Cost Drivers

This section introduces the cost drivers used to derive unit costs. The FRA transformed these cost drivers—assembled from the various inputs described in Section 5.4.2—to meet the requirements of this analysis, and assigned the cost drivers to cost areas 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. The FRA based cost-driver and allocation-driver assignments on industry knowledge and experience with changes in O&M costs as a result of changes in cost-driver values.

Cost Drivers and Allocation Drivers for Infrastructure-Related Costs

The FRA aggregated infrastructure-related O&M costs by territory regardless of the service operated, and assigned those costs a cost driver and an allocation driver. The unit cost resulting from the cost-driver element represents the change in O&M cost per change in service. The FRA selected the allocation driver as a method to distribute the costs on a consistent basis in the No Action Alternative and Preferred Alternative to the different NEC FUTURE service types.

The FRA assigned electrified train miles for both the cost driver and the allocation driver to each of the functional activities associated with electric propulsion and power. 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., 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 FRA assigned the number of track miles as the cost driver for all maintenance-of-way functional activities. Existing track miles were associated with existing maintenance-of-way costs. Any additional track miles along the NEC or new track miles off-corridor were assigned 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 5.5.1, since only the Intercity portion of station costs was included, Intercity ridership was used as the allocation driver.

Table 46 summarizes the assignment of cost driver and allocation driver to each infrastructure-related functional activity.

Table 46: 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
Electric Propulsion	Freq. Converter Maintenance	Electrified Train Miles	Electrified Train Miles
Maintenance-of-Way	Bridges	Existing Track Miles	Train Miles
Maintenance-of-Way	Comm. Systems	Existing Track Miles	Frequency
Maintenance-of-Way	Electric Traction	Existing Track Miles	Electrified Train Miles
Maintenance-of-Way	Equipment	Existing Track Miles	Train Miles
Maintenance-of-Way	Facilities	Existing Track Miles	Train Miles
Maintenance-of-Way	Signal & Interlocking	Existing Track Miles	Frequency
Maintenance-of-Way	Track	Existing Track Miles	Train Miles
Police – Road, Yard, & Station	Road	Total Route Miles	Train Miles
Police – Road, Yard, & Station	Yard	Total Route Miles	Train Miles
Police – Road, Yard, & Station	Station Police	NEC Intercity Ridership	NEC Intercity Ridership
Power Directors	Power Directors & Load Dispatchers	Electrified Train Miles	Electrified Train Miles
Train Dispatching	Blocks & Towers	Track Miles	Frequency
Train Dispatching	Control & Dispatch	Track Miles	Frequency
Station Maintenance & Services	Baggage & Express	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	First-Class Lounge	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	Porters	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	Station Maintenance	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	Station Operations	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	Stationmasters & Ushers	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	Ticketing	NEC Intercity Ridership	NEC Intercity Ridership
Station Maintenance & Services	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, 2016

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).

Maintenance of Equipment (MoE) and yard functional activity costs are largely driven by the equipment requirements to provide the level-of-service specified in the Service Plan. 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 trainmen and enginemen 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 based on 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 47 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 5.5.1.5 discusses the differences in projected unit costs by service.

Cost drivers for transportation-related costs associated with the NEC FUTURE Regional rail service are governed by the NTD reports for each of the existing commuter-rail operators on the NEC (see Section 5.4.1 for derivation).

Table 47: 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	
	MoE Support	
	MoE Multiple Functions	
	HSR Maintenance	
	Backshop	
Onboard Services	Crew	OBS Labor Hours
	Supplies - F&B	% of F&B Revenue
	Commissary/Management - F&B	
	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	
Yard	Train & Equipment	Train Sets
	Equipment Moves	
	Yard Direct	
	Terminal Rent/Yard Services	
Fuel	Train Fuel (Diesel)	Train Miles
Other Transportation Ops	Transportation – Multiple Functions	
	Transportation Support	
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	
	Environmental & Safety	
G&A	G&A Fixed	Fixed
	G&A Variable	Ticket Revenue

Source: NEC FUTURE team, 2016

Existing Cost Drivers

Table 48 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 48: Existing Cost-Driver Values

Statistic	INTERCITY			REGIONAL	NEC Total
	Acela Express	Northeast Regional	Intercity Total	All Services	
Annual Train Revenue Hours	51,000	97,000	148,000	276,000	424,000
Total Train Trips	10,000	20,000	29,000	329,000	358,000
Train Sets	20	28	48	—	48
Trainmen labor hours	165,000	629,000	794,000	—	794,000
Enginemen labor hours	85,000	241,000	326,000	—	326,000
Trainmen and Enginemen labor hours	249,000	910,000	1,160,000	—	1,160,000
OBS labor hours	234,000	178,000	412,000	—	1,160,000
Annual Train Revenue Miles	3,314,000	5,940,000	9,254,000	9,204,000	18,458,000
Electrified Train Miles	3,314,000	5,940,000	9,254,000	4,684,000	13,551,000
Ticket Revenue	$530,821,000	$580,689,000	$1,111,510,000	—	$1,111,510,000
Passenger Ridership	3,342,000	8,434,000	11,777,000	—	11,777,000

Source: NEC FUTURE team, 2016 Derivation of Unit Costs
Note: All cost driver values (with the exception of train sets) rounded to the nearest 1,000; totals may not add up, due to rounding

5.5.1.5 Unit Cost Calculation and Adjustment Factors

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.

Unit Cost Calculations

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 in the Preferred Alternative)
- **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.

Unit Cost Adjustment Factors

For projected future services, the FRA applied unit cost adjustment factors to address anticipated changes resulting from more-frequent service or from the implementation of next generation technologies. Table 49 lists the adjustment factors and the corresponding cost area and functional activity. The FRA based the adjustment factors for maintenance-of-way 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 would result in fewer and shorter available maintenance windows between trains. The FRA based the adjustment factor for Station Maintenance and Services on the expectation that passenger-handling costs associated with the Preferred Alternative would decrease by implementing automated passenger gates (similar to technology being installed at airports) and more vertical circulation facilities (e.g., elevators and escalators).

Table 49: Unit Cost Adjustment Factor

Cost Area	Functional Activity	Unit Cost Adjustment 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, 2016

The adjustment 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 × Adjustment

Factor = Projected Unit Cost per Track Mile

$50,000 per track mile × 1.25 = $62,500 per track mile

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, consistent with Volume 2, Appendix B.05.

Table 50 shows the association of cost drivers to the new Intercity services, and indicates 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 were based on existing Northeast Regional service, which are applied per trainset.

Table 50: 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			
MoE Support			
MoE Multiple			
HSR Maintenance			
Backshop			

Source: NEC FUTURE team, 2016

Projected Onboard Services Unit Costs by Service

The FRA assumed that the new Intercity-Express service includes onboard service 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.

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.

5.5.1.6 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, the FRA applied the unit costs to the projected cost-driver values for the No Action Alternative and Preferred Alternative to obtain the projected O&M costs.[9] 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.

Fare Strategy

See rail pricing in Section 3.3.3 for the fare strategy used for the No Action Alternative. See rail pricing in Section 0 for the fare strategy used for the Preferred Alternative.

5.6 RESULTS

This section presents the summary-level analytical results for the No Action Alternative and Preferred Alternative as well as a high-level contribution analysis comparing the alternatives.

5.6.1 Projected Cost-Driver Values

Table 51 and Table 52 show the projected cost-driver values for Intercity and Regional rail services for the No Action Alternative and Preferred Alternative.

[9] For a complete description of the alternatives, see Volume 2, Appendix B.05.

Table 51: No Action Alternative Cost-Driver Values

Statistic	INTERCITY SERVICE				Regional Rail	Total NEC
	Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity		
Annual Train Revenue Hours	51,000	—	97,000	148,000	276,000	424,000
Total Train Trips	10,000	—	20,000	29,000	329,000	358,000
Train Sets	20	—	28	48	—	48
Trainmen labor hours	165,000	—	629,000	794,000	—	794,000
Enginemen labor hours	85,000	—	241,000	326,000	—	326,000
Trainmen and Enginemen labor hours	249,000	—	910,000	1,160,000	—	1,160,000
OBS labor hours	234,000	—	178,000	412,000	—	412,000
Annual Train Revenue Miles	3,314,000	—	5,940,000	9,254,000	9,204,000	18,458,000
Electrified Train Miles	3,314,000	—	5,940,000	9,254,000	4,684,000	13,551,000
Ticket Revenue	$817,160,000	—	$845,618,000	$1,662,779,000	—	$1,662,779,000
Ridership	5,070,000	—	12,816,000	17,886,000	—	17,886,000

Source: NEC FUTURE team, 2016

Note: All cost driver values (with the exception of train sets) rounded to the nearest 1,000; totals may not add up, due to rounding

Table 52: Preferred Alternative Cost-Driver Values

Statistic	INTERCITY SERVICE				Regional Rail	Total NEC
	Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity		
Annual Train Revenue Hours	182,000	283,000	79,000	544,000	643,000	1,188,000
Total Train Trips	42,000	72,000	21,000	135,000	712,000	847,000
Train Sets	56	71	30	157	—	157
Trainmen labor hours	590,000	1,842,000	512,000	2,944,000	—	2,944,000
Enginemen labor hours	304,000	704,000	196,000	1,204,000	—	1,204,000
Trainmen and Enginemen labor hours	895,000	2,546,000	707,000	4,148,000	—	4,148,000
OBS labor hours	839,000	—	—	839,000	—	839,000
Annual Train Revenue Miles	16,016,000	18,593,000	4,973,000	39,582,000	21,640,000	61,223,000
Electrified Train Miles	16,016,000	18,593,000	4,973,000	39,582,000	21,033,000	60,616,000
Ticket Revenue	$1,087,721,000	$1,049,042,000	$298,257,000	$2,435,020,000	—	$2,435,020,000
Ridership	9,742,000	20,873,000	5,934,000	36,550,000	—	36,550,000

Source: NEC FUTURE team, 2016

Note: All cost driver values (with the exception of train sets) rounded to the nearest 1,000; totals may not add up, due to rounding

5.6.2 Summary of Revenue, O&M Costs, and Net Contribution

For the No Action Alternative and Preferred Alternative, 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)

The FRA performed an analysis of all projected O&M costs to determine if the Intercity services in the No Action Alternative and Preferred Alternative covered the full cost of operations from passenger revenues. The FRA calculated the net contribution by service type for each alternative to show a complete picture of revenues and costs. The FRA accounted for equipment cost recovery in the capital cost estimates. Table 53 and Table 54 present the summary results of revenue, O&M costs, and net contribution for the No Action Alternative and Preferred Alternative.

5.6.3 Contribution Analysis

Table 55 compares the revenue, O&M cost, and net contribution by service type across the No Action Alternative and Preferred Alternative. The analysis demonstrated that the Preferred Alternative is able to generate operating surpluses with a representative and generalized fare structure used for all market pairs. The FRA did not attempt to optimize operator revenue in its analysis as most choices about how to optimize revenues are dependent on future detailed service and operating choices made by railroad operators (e.g., types and number of classes of service, yield management practices). The analysis also demonstrated in following current trends, the No Action Alternative is able to generate operating surpluses. However, costs and revenues associated with the No Action Alternative were not adjusted to reflect the likely decrease in reliability and insufficient future capacity present in the No Action Alternative. Also, the No Action Alternative assumes the continuation of current Intercity fare structures, which are more tailored to specific markets than the Preferred Alternative. The financial performance of the No Action Alternative would likely be sensitive to these limitations; however, the extent and type of impacts are highly uncertain. Thus, the FRA did not attempt to model them at a Tier 1 level. Additional fare analysis and optimization could be performed during subsequent Tier 2 studies.

Table 53: No Action Alternative O&M Cost Summary and Contribution Analysis (Rounded to the Nearest 1,000)

Revenue	INTERCITY SERVICES Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity	Regional Rail	Total NEC
Ticket Revenue	$828,399,000	—	$857,248,000	$1,685,647,000	—	$1,685,647,000
Food & Beverage Revenue	$39,392,000	—	$16,383,000	$55,775,000	—	$55,775,000
(Assumed 4% of ticket revenue)						
TOTAL REVENUE	$867,791,000	—	$873,631,000	$1,741,422,000	—	$1,741,422,000
O&M Costs	**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs						
Electric Propulsion	$19,901,000	—	$33,347,000	$53,248,000	$28,132,000	$81,380,000
Maintenance-of-Way	$30,315,000	—	$54,335,000	$84,650,000	$113,051,000	$197,701,000
Maintenance-of-Way - New	-	—	—	—	—	$0
Police - Road, Yard, & Station	$4,326,000	—	$9,551,000	$13,877,000	$3,836,000	$17,713,000
Power Directors	$1,589,000	—	$2,663,000	$4,252,000	$2,246,000	$6,498,000
Train Dispatching	$1,129,000	—	$2,327,000	$3,456,000	$28,236,000	$31,692,000
Station Maintenance & Services	$33,289,000	—	$83,496,000	$116,785,000	—	$116,785,000
Transportation Operations Costs						
Regional Transportation Ops	-	—	—	—	$464,617,000	$464,617,000
Maintenance of Equipment	$72,560,000	—	$106,227,000	$178,787,000	—	$178,787,000
Onboard Services	$23,220,000	—	$18,176,000	$41,396,000	—	$41,396,000
Trainmen & Enginemen	$18,595,000	—	$63,608,000	$82,203,000	—	$82,203,000
Yard	$6,575,000	—	$19,686,000	$26,261,000	—	$26,261,000
Fuel	$237,000	—	$3,449,000	$3,686,000	—	$3,686,000
Other Transportation Ops	$5,894,000	—	$13,831,000	$19,725,000	—	$19,725,000
Sales & Marketing, National Ops Costs						
Sales & Marketing	$51,080,000	—	$46,190,000	$97,270,000	—	$97,270,000
Police, Security, Environmental	$6,747,000	—	$9,530,000	$16,277,000	—	$16,277,000
G&A Costs						
G&A	$57,703,000	—	$89,754,000	$147,457,000	—	$147,457,000
TOTAL O&M COSTS	$333,160,000	-	$556,170,000	$889,330,000	$640,118,000	$1,529,448,000
Net Contribution Cost Definition	**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION	$534,631,000	-	$317,461,000	$852,092,000		

Source: NEC FUTURE team, 2016

Table 54: Preferred Alternative O&M Cost Summary and Contribution Analysis (Rounded to the Nearest 1,000)

Revenue	INTERCITY SERVICES				Regional Rail	Total NEC
	Intercity-Express	Metropolitan	Intercity-Corridor	Total Intercity		
Ticket Revenue	$1,102,681,000	$1,063,469,000	$302,359,000	$2,468,509,000	—	$2,468,509,000
Food & Beverage Revenue	$44,107,000	—	—	$44,107,000	—	$44,107,000
(Assumed 4% of ticket revenue)						
TOTAL REVENUE	$1,146,788,000	$1,063,469,000	$302,359,000	$2,512,616,000	—	$2,512,616,000
O&M Costs	**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
Shared Infrastructure Costs						
Electric Propulsion	$96,184,000	$111,662,000	$29,863,000	$237,709,000	$75,938,000	$313,647,000
Maintenance-of-Way	$59,061,000	$71,598,000	$19,307,000	$149,966,000	$110,394,000	$260,360,000
Maintenance-of-Way — New	$23,618,000	$27,419,000	$7,333,000	$58,370,000	$19,542,000	$77,912,000
Police — Road, Yard, & Station	$8,940,000	$14,987,000	$4,178,000	$28,105,000	$3,512,000	$31,617,000
Power Directors	$7,681,000	$8,917,000	$2,385,000	$18,983,000	$6,064,000	$25,047,000
Train Dispatching	$2,045,000	$3,524,000	$1,003,000	$6,572,000	$25,120,000	$31,692,000
Station Maintenance & Services	$62,987,000	$134,951,000	$38,090,000	$236,028,000	—	$236,028,000
Transportation Operations Costs						
Regional Transportation Ops	—	—	—	—	$988,689,000	$988,689,000
Maintenance of Equipment	$101,799,000	$119,752,000	$112,853,000	$334,404,000	—	$334,404,000
Onboard Services	$65,879,000	—	—	$65,879,000	—	$65,879,000
Trainmen & Enginemen	$66,674,000	$185,878,000	$51,646,000	$304,198,000	—	$304,198,000
Yard	$18,411,000	$23,342,000	$21,092,000	$62,845,000	—	$62,845,000
Fuel	$1,144,000	$1,328,000	$3,128,000	$5,600,000	—	$5,600,000
Other Transportation Ops	$28,485,000	$33,069,000	$12,544,000	$74,098,000	—	$74,098,000
Sales & Marketing, National Ops Costs						
Sales & Marketing	$74,605,000	$97,299,000	$18,315,000	$190,219,000	—	$190,219,000
Police, Security, Environmental	$12,965,000	$27,777,000	$4,413,000	$45,155,000	—	$45,155,000
G&A Costs						
G&A	$60,699,000	$73,143,000	$27,121,000	$160,963,000	—	$160,963,000
TOTAL O&M COSTS	$691,177,000	$934,646,000	$353,271,000	$1,979,094,000	$1,229,259,000	$3,208,353,000
Net Contribution Cost Definition	**Intercity-Express**	**Metropolitan**	**Intercity-Corridor**	**Total Intercity**	**Commuter RRs**	**Total NEC**
NET CONTRIBUTION	$455,611,000	$128,823,000	$(50,912,000)	$533,522,000		

Source: NEC FUTURE team, 2016

Table 55: No Action Alternative and Preferred Alternative Summary (Rounded to the Nearest 1,000)

Alternative	Service*	Revenue	O&M Cost	Net Contribution
No Action Alternative	EXP	$867,791,000	$333,160,000	$534,631,000
	MET/IC	$873,631,000	$556,170,000	$317,461,000
	TOTAL	$1,741,422,000	$889,330,000	$852,092,000
Preferred Alternative	EXP	$1,146,788,000	$691,177,000	$455,611,000
	MET/IC	$1,365,828,000	$1,287,917,000	$77,911,000
	TOTAL	$2,512,616,000	$1,979,094,000	$533,522,000

Source: NEC FUTURE team, 2016

* EXP = Intercity-Express, MET/IC = combined Metropolitan and Intercity-Corridor services

Appendix A – Revised Interregional Model Ridership Results Comparison

TABLE A-1: COMPARISON OF ALTERNATIVE 1 RIDERSHIP FORECASTS

		Revised Model Results							DEIS Model Results						
		Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips	Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips
Boston	Hartford	6,676,960	15,393	271,000	36,719	339,733	—	7,339,804	5,983,642	879	297,503	15,513	155,916	—	6,453,454
Boston	Springfield	973,144	-	83,547	3,040	25,601	—	1,085,331	1,025,803	—	46,743	1,886	19,538	—	1,093,970
Boston	New York	38,251,679	1,692,689	2,118,553	1,515,510	3,416,866	—	46,995,296	38,834,168	3,589,776	3,073,146	1,348,300	3,335,179	—	50,180,569
Boston	Philadelphia	3,901,103	851,063	33,262	59,476	382,225	—	5,227,129	3,909,723	1,710,597	36,738	61,879	412,308	—	6,131,245
Boston	Baltimore	910,790	936,608	7,834	11,406	55,691	—	1,922,329	990,200	1,483,289	2,263	13,153	64,673	—	2,553,579
Boston	Washington	1,093,040	2,373,372	15,493	35,346	263,742	—	3,780,994	1,026,239	3,725,041	2,861	31,876	235,374	—	5,021,391
Hartford	New York	22,615,552	1,916	439,226	119,755	777,751	93,351	24,047,550	19,042,669	48,261	923,782	201,790	2,213,388	130,903	22,560,793
Hartford	Philadelphia	3,296,084	64,979	38,815	25,727	161,188	—	3,586,793	1,938,673	324,906	5,764	16,695	221,499	—	2,507,538
Hartford	Baltimore	511,519	134,796	16,084	11,740	78,736	—	752,874	380,946	268,388	6,254	7,792	80,227	—	743,607
Hartford	Washington	865,552	258,770	43,173	51,657	240,617	—	1,459,769	595,301	516,016	6,356	22,965	169,459	—	1,310,098
Springfield	New York	5,224,699	721	172,543	11,005	224,506	—	5,633,474	5,334,614	26,962	160,499	12,928	288,045	—	5,823,049
Springfield	Philadelphia	521,011	-	-	3,524	15,956	—	540,491	569,412	—	—	3,616	54,614	—	627,641
Springfield	Baltimore	77,568	33,166	-	607	4,174	—	115,515	82,759	90,594	—	588	9,736	—	183,677
Springfield	Washington	182,178	96,376	-	2,433	19,933	—	300,919	187,497	222,312	—	2,348	31,055	—	443,212
Providence	New York	16,349,923	19,243	204,875	257,662	1,074,535	—	17,906,238	16,399,702	122,460	432,497	252,000	1,336,227	—	18,542,886
Providence	Philadelphia	2,220,365	86,954	10,897	15,732	164,438	—	2,498,386	2,237,886	284,263	6,636	16,225	182,197	—	2,727,207
Providence	Baltimore	3,053,614	443,360	5,078	7,707	62,636	—	3,572,395	2,977,014	721,903	2,376	6,560	59,277	—	3,767,130
Providence	Washington	262,963	334,904	5,555	12,097	93,921	—	709,439	288,704	684,922	3,100	9,830	91,886	—	1,078,441
New York	Philadelphia	46,436,792	20,280	1,744,986	535,545	4,218,981	1,524,589	54,481,173	47,269,775	1,063,452	2,436,728	712,532	4,071,731	2,340,474	57,894,692
New York	Baltimore	6,140,887	325,434	548,471	299,232	1,696,140	—	9,010,165	6,437,269	961,720	679,096	340,118	1,577,915	—	9,996,117
New York	Washington	10,653,096	837,287	1,575,077	1,330,441	4,970,575	—	19,366,476	11,095,389	2,517,171	2,457,655	1,400,991	4,366,993	—	21,838,199
Philadelphia	Baltimore	5,573,732	5,386	74,208	54,981	524,844	4,160	6,237,311	5,783,328	228,068	109,387	54,252	416,352	43,495	6,634,881
Philadelphia	Washington	6,993,613	15,028	111,936	230,656	1,565,306	—	8,916,538	7,373,441	812,175	126,479	226,005	1,190,566	—	9,728,666
Total Study Area	**Trips**	**366,188,662**	**9,363,083**	**10,960,540**	**5,088,008**	**29,715,854**	**6,527,643**	**427,843,789**	**369,344,362**	**21,880,603**	**16,766,105**	**4,968,430**	**26,342,729**	**9,958,672**	**449,260,900**
	Mode Share	**85.6%**	**2.2%**	**2.6%**	**1.2%**	**6.9%**	**1.5%**	**100%**	**82.2%**	**4.9%**	**3.7%**	**1.1%**	**5.9%**	**2.2%**	**100%**

Table A-2: Comparison of Alternative 2 Ridership Forecasts

		Revised Model Results							DEIS Model Results						
		Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips	Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips
Boston	Hartford	6,467,102	14,772	254,289	53,249	603,949	—	7,393,362	5,898,130	861	288,729	23,014	277,572	—	6,488,306
Boston	Springfield	964,703	—	82,999	4,022	34,023	—	1,085,747	1,021,641	—	46,259	1,250	26,649	—	1,095,799
Boston	New York	37,657,714	1,617,598	2,053,056	1,936,497	3,888,896	—	47,153,761	38,448,323	3,464,907	2,993,507	1,746,376	3,797,730	—	50,450,843
Boston	Philadelphia	3,811,508	834,638	31,957	74,049	483,684	—	5,235,836	3,845,918	1,694,183	35,739	81,092	513,383	—	6,170,315
Boston	Baltimore	902,371	927,950	7,641	15,743	69,667	—	1,923,371	982,571	1,475,804	2,105	18,204	80,906	—	2,559,591
Boston	Washington	1,071,456	2,324,571	14,737	46,640	332,128	—	3,789,533	1,015,450	3,682,830	2,197	44,719	299,256	—	5,044,452
Hartford	New York	22,441,195	1,869	424,691	175,007	923,725	92,632	24,059,119	18,963,033	45,757	918,169	309,427	2,210,440	128,043	22,574,869
Hartford	Philadelphia	3,253,209	63,387	37,962	36,261	198,503	—	3,589,321	1,918,251	318,485	5,586	36,152	238,861	—	2,517,336
Hartford	Baltimore	506,238	131,323	15,722	20,982	78,827	—	753,093	377,873	263,171	6,123	18,173	80,881	—	746,221
Hartford	Washington	850,349	246,723	41,484	77,119	249,966	—	1,465,642	589,114	497,476	6,031	50,062	174,972	—	1,317,654
Springfield	New York	5,154,598	675	167,903	44,788	275,591	—	5,643,554	5,263,755	25,126	155,391	37,859	375,037	—	5,857,168
Springfield	Philadelphia	510,839	—	—	12,535	17,604	—	540,978	557,978	—	—	13,248	61,272	—	632,498
Springfield	Baltimore	76,256	32,109	—	2,931	4,411	—	115,706	81,273	89,564	—	2,527	11,260	—	184,625
Springfield	Washington	178,845	92,346	—	9,936	20,689	—	301,816	185,578	217,648	—	9,234	33,326	—	445,786
Providence	New York	16,194,653	18,555	202,558	347,129	1,176,320	—	17,939,215	16,239,919	119,250	408,095	351,783	1,514,769	—	18,633,816
Providence	Philadelphia	2,184,018	83,908	10,653	20,564	202,220	—	2,501,365	2,209,620	280,201	6,428	22,835	224,337	—	2,743,421
Providence	Baltimore	3,045,274	440,631	5,020	10,417	73,100	—	3,574,442	2,969,190	719,784	2,268	9,660	70,884	—	3,771,786
Providence	Washington	257,474	326,413	5,297	15,292	109,788	—	714,265	282,911	676,126	2,870	14,294	109,842	—	1,086,043
New York	Philadelphia	46,067,366	19,974	1,728,030	618,695	4,625,589	1,509,362	54,569,017	47,050,736	1,051,607	2,414,950	836,210	4,332,032	2,326,654	58,012,190
New York	Baltimore	6,056,238	316,374	539,454	357,486	1,792,740	—	9,062,293	6,371,165	940,150	669,041	408,938	1,661,043	—	10,050,338
New York	Washington	10,486,516	802,805	1,543,079	1,590,211	5,056,042	—	19,478,653	10,976,322	2,448,895	2,416,627	1,691,590	4,440,564	—	21,973,997
Philadelphia	Baltimore	5,546,306	5,348	73,651	60,579	556,851	4,124	6,246,859	5,766,207	226,029	108,679	61,251	438,052	43,489	6,643,706
Philadelphia	Washington	6,917,221	14,856	110,426	255,273	1,645,295	—	8,943,071	7,325,156	802,086	124,560	254,325	1,252,490	—	9,758,617
Total Study Area	**Trips**	**363,305,926**	**9,127,807**	**10,764,792**	**6,382,931**	**32,534,796**	**6,500,419**	**428,616,672**	**367,549,326**	**21,505,752**	**16,541,853**	**6,303,115**	**28,514,010**	**9,936,673**	**450,350,729**
	Mode Share	**84.8%**	**2.1%**	**2.5%**	**1.5%**	**7.6%**	**1.5%**	**100.0%**	**81.6%**	**4.8%**	**3.7%**	**1.4%**	**6.3%**	**2.2%**	**100.0%**

Table A-3: Comparison of Alternative 3.1 Ridership Forecasts

		Revised Model Results							DEIS Model Results						
		Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips	Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips
Boston	Hartford	6,536,453	18,151	258,304	30,922	546,493	—	7,390,322	5,902,658	859	289,025	25,178	269,046	—	6,486,766
Boston	Springfield	965,631	—	83,230	4,223	32,433	—	1,085,518	1,021,685	—	46,257	1,323	26,512	—	1,095,777
Boston	New York	37,587,360	1,568,531	2,032,949	1,999,279	4,092,030	—	47,280,149	38,191,760	3,349,441	2,949,635	2,099,518	4,063,960	—	50,654,314
Boston	Philadelphia	3,794,521	831,888	32,430	86,353	493,689	—	5,238,881	3,837,145	1,701,274	36,085	101,204	492,006	—	6,167,715
Boston	Baltimore	894,007	915,984	7,475	20,045	87,830	—	1,925,341	975,851	1,464,949	1,986	23,562	100,302	—	2,566,650
Boston	Washington	1,050,905	2,261,788	14,311	73,605	401,495	—	3,802,104	1,005,730	3,627,512	1,934	72,417	363,452	—	5,071,044
Hartford	New York	22,384,131	1,852	421,162	179,731	986,322	92,827	24,066,024	18,852,139	44,934	905,035	332,973	2,380,899	128,617	22,644,598
Hartford	Philadelphia	3,273,397	63,252	38,772	37,083	176,082	—	3,588,586	1,916,705	317,747	5,562	42,855	234,546	—	2,517,415
Hartford	Baltimore	525,308	129,867	17,415	20,461	61,689	—	754,740	370,317	258,501	5,954	23,570	94,084	—	752,426
Hartford	Washington	923,412	246,595	58,271	67,434	167,584	—	1,463,296	575,189	479,297	5,779	70,419	203,175	—	1,333,858
Springfield	New York	5,144,192	670	167,392	47,000	285,892	—	5,645,147	5,251,213	24,920	154,753	43,065	388,372	—	5,862,323
Springfield	Philadelphia	508,223	—	—	12,678	20,283	—	541,185	553,444	—	—	14,147	67,466	—	635,057
Springfield	Baltimore	75,821	31,552	—	4,022	4,479	—	115,874	80,868	88,968	—	3,451	11,728	—	185,014
Springfield	Washington	177,424	90,229	—	14,758	20,130	—	302,540	184,871	215,442	—	13,802	32,712	—	446,827
Providence	New York	16,130,696	17,968	200,143	345,417	1,272,112	—	17,966,336	16,126,968	115,354	395,435	381,570	1,684,662	—	18,703,988
Providence	Philadelphia	2,188,772	85,227	10,840	23,700	193,135	—	2,501,673	2,211,610	282,851	6,495	29,830	209,191	—	2,739,978
Providence	Baltimore	3,032,282	436,194	4,936	12,625	90,072	—	3,576,109	2,959,423	716,059	2,174	12,906	87,385	—	3,777,947
Providence	Washington	250,027	313,339	5,067	19,474	133,509	—	721,416	276,598	661,280	2,728	20,236	136,050	—	1,096,893
New York	Philadelphia	46,188,325	19,985	1,731,394	662,169	4,427,554	1,513,552	54,542,979	47,037,156	1,048,433	2,414,291	986,786	4,207,291	2,325,760	58,019,718
New York	Baltimore	6,071,414	315,482	537,750	342,728	1,822,321	—	9,089,694	6,339,378	927,134	664,128	485,353	1,664,921	—	10,080,914
New York	Washington	10,501,260	777,724	1,533,265	1,837,414	4,939,665	—	19,589,328	10,877,111	2,351,827	2,375,840	2,242,186	4,266,989	—	22,113,954
Philadelphia	Baltimore	5,560,500	5,372	73,982	54,074	544,095	4,126	6,242,149	5,771,157	225,871	108,827	57,585	434,080	43,489	6,641,010
Philadelphia	Washington	6,940,946	14,703	110,420	288,373	1,588,391	—	8,942,833	7,316,728	796,993	123,855	290,557	1,237,028	—	9,765,161
Total Study Area	**Trips**	**363,572,370**	**8,967,478**	**10,761,765**	**6,721,646**	**32,351,870**	**6,505,742**	**428,880,872**	**366,779,326**	**21,158,658**	**16,433,362**	**7,752,853**	**28,907,375**	**9,938,168**	**450,969,742**
	Mode Share	**84.8%**	**2.1%**	**2.5%**	**1.6%**	**7.5%**	**1.5%**	**100.0%**	**81.3%**	**81.3%**	**81.3%**	**81.3%**	**81.3%**	**81.3%**	**81.3%**

Table A-4: Comparison of Alternative 3.2 Ridership Forecasts

		Revised Model Results							DEIS Model Results						
		Auto	**Air**	**Bus**	**Express Rail**	**Corridor Rail**	**Commuter Rail**	**Total Trips**	**Auto**	**Air**	**Bus**	**Express Rail**	**Corridor Rail**	**Commuter Rail**	**Total Trips**
Boston	Hartford	6,465,751	15,058	253,745	56,033	605,794	—	7,396,380	5,897,066	862	288,416	24,654	277,967	—	6,488,964
Boston	Springfield	966,827	—	82,968	4,431	31,429	—	1,085,655	1,023,660	—	46,520	1,408	23,209	—	1,094,797
Boston	New York	37,241,077	1,547,576	2,009,546	2,325,730	4,172,319	—	47,296,248	38,192,413	3,353,284	2,940,088	2,078,899	4,086,987	—	50,651,671
Boston	Philadelphia	3,817,771	835,529	32,703	97,563	450,965	—	5,234,531	3,850,424	1,701,483	36,204	110,393	462,704	—	6,161,208
Boston	Baltimore	896,239	918,993	7,522	20,852	81,161	—	1,924,767	977,721	1,467,535	2,022	24,531	92,966	—	2,564,776
Boston	Washington	1,056,179	2,273,711	14,403	75,242	379,308	—	3,798,843	1,008,387	3,637,647	1,998	73,631	343,583	—	5,065,245
Hartford	New York	22,333,683	1,851	419,674	199,003	1,021,057	92,448	24,067,715	18,809,651	44,825	898,668	332,437	2,454,419	127,232	22,667,233
Hartford	Philadelphia	3,251,519	63,140	38,088	46,439	189,454	—	3,588,641	1,917,132	317,142	5,542	44,680	233,028	—	2,517,523
Hartford	Baltimore	500,550	128,474	15,522	25,345	86,530	—	756,421	369,970	258,901	5,951	23,477	94,294	—	752,593
Hartford	Washington	833,316	236,411	40,911	98,386	267,954	—	1,476,978	575,006	480,216	5,795	69,787	203,090	—	1,333,893
Springfield	New York	5,124,026	661	166,378	49,767	306,928	—	5,647,760	5,235,510	24,608	153,640	41,395	414,958	—	5,870,112
Springfield	Philadelphia	507,052	—	—	13,297	20,971	—	541,320	551,495	—	—	14,425	70,250	—	636,169
Springfield	Baltimore	75,931	31,649	—	4,033	4,226	—	115,839	81,082	89,145	—	3,485	11,109	—	184,822
Springfield	Washington	177,617	90,419	—	14,650	19,722	—	302,409	184,954	215,618	—	13,681	32,441	—	446,695
Providence	New York	16,084,191	18,011	199,226	394,728	1,265,535	—	17,961,692	16,133,215	116,139	396,809	391,388	1,658,059	—	18,695,609
Providence	Philadelphia	2,198,444	85,462	10,870	26,502	179,093	—	2,500,371	2,219,197	283,270	6,513	30,411	197,961	—	2,737,352
Providence	Baltimore	3,035,845	437,503	4,957	13,175	84,192	—	3,575,672	2,961,918	717,065	2,195	13,205	81,901	—	3,776,285
Providence	Washington	251,537	316,023	5,111	20,010	127,095	—	719,776	277,838	664,205	2,751	20,496	129,324	—	1,094,615
New York	Philadelphia	45,795,132	19,739	1,724,623	803,899	4,764,862	1,505,884	54,614,139	46,845,895	1,042,285	2,389,806	1,057,385	4,465,183	2,324,378	58,124,933
New York	Baltimore	5,978,047	300,687	533,206	413,251	1,892,521	—	9,117,711	6,316,528	911,918	658,671	471,163	1,743,792	—	10,102,072
New York	Washington	10,200,037	722,790	1,496,225	2,121,387	5,172,720	—	19,713,158	10,806,142	2,308,430	2,341,132	2,202,935	4,541,987	—	22,200,627
Philadelphia	Baltimore	5,553,465	5,329	73,666	53,403	555,292	4,126	6,245,282	5,770,778	225,828	108,811	57,410	434,927	43,489	6,641,242
Philadelphia	Washington	6,922,642	14,559	109,587	282,909	1,619,565	—	8,949,262	7,315,857	796,766	123,792	289,589	1,239,848	—	9,765,852
Total Study Area	**Trips**	**361,961,236**	**8,879,105**	**10,652,599**	**7,870,452**	**33,333,948**	**6,478,824**	**429,176,164**	**366,549,161**	**21,132,518**	**16,346,289**	**7,668,175**	**29,516,039**	**9,931,721**	**451,143,903**
	Mode Share	**84.3%**	**2.1%**	**2.5%**	**1.8%**	**7.8%**	**1.5%**	**100.0%**	**81.2%**	**4.7%**	**3.6%**	**1.7%**	**6.5%**	**2.2%**	**100.0%**

Table A-5: Comparison of Alternative 3.3 Ridership Forecasts

		Revised Model Results							DEIS Model Results						
		Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips	Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips
Boston	Hartford	6,439,916	15,454	252,776	49,653	646,903	—	7,404,703	5,889,741	861	287,656	22,448	291,475	—	6,492,182
Boston	Springfield	955,100	—	82,014	3,132	47,633	—	1,087,880	1,020,219	—	46,114	1,080	28,997	—	1,096,411
Boston	New York	36,816,897	1,534,676	1,979,320	2,210,155	4,863,055	—	47,404,102	37,980,933	3,334,673	2,909,733	1,970,736	4,572,754	—	50,768,830
Boston	Philadelphia	3,769,447	831,808	32,348	83,185	521,900	—	5,238,688	3,826,607	1,701,724	35,969	95,689	511,444	—	6,171,432
Boston	Baltimore	892,264	917,293	7,427	19,304	88,693	—	1,924,980	973,994	1,467,607	1,958	22,532	100,478	—	2,566,568
Boston	Washington	1,034,798	2,251,370	14,001	70,490	437,826	—	3,808,483	993,623	3,622,979	1,744	67,767	395,931	—	5,082,045
Hartford	New York	22,312,993	1,846	418,048	201,332	1,044,106	92,421	24,070,746	18,792,126	44,567	896,899	360,115	2,457,429	127,144	22,678,281
Hartford	Philadelphia	3,250,703	63,103	38,107	46,440	190,433	—	3,588,787	1,912,907	316,995	5,545	44,047	239,916	—	2,519,410
Hartford	Baltimore	499,975	128,018	15,497	25,820	87,220	—	756,529	369,711	258,319	5,941	24,562	94,398	—	752,931
Hartford	Washington	831,693	234,906	40,866	100,435	270,168	—	1,478,069	574,450	478,402	5,779	73,463	202,548	—	1,334,643
Springfield	New York	5,122,977	662	166,253	49,113	307,850	—	5,646,855	5,233,084	24,549	153,557	39,305	420,439	—	5,870,934
Springfield	Philadelphia	506,766	—	—	12,951	21,659	—	541,376	551,746	—	—	14,119	70,221	—	636,086
Springfield	Baltimore	75,759	31,372	—	4,046	4,766	—	115,943	81,046	89,059	—	3,471	11,304	—	184,881
Springfield	Washington	177,046	89,473	—	14,974	21,394	—	302,887	184,756	215,221	—	14,094	32,908	—	446,979
Providence	New York	16,324,411	19,482	205,801	291,902	1,065,086	—	17,906,682	16,311,509	123,913	405,074	262,972	1,501,694	—	18,605,162
Providence	Philadelphia	2,223,501	88,213	11,001	17,918	157,747	—	2,498,378	2,229,578	286,373	6,610	17,976	191,500	—	2,732,037
Providence	Baltimore	3,054,387	444,006	5,062	9,482	61,918	—	3,574,855	2,973,427	722,270	2,248	7,802	64,269	—	3,770,015
Providence	Washington	258,225	333,724	5,391	15,550	100,256	—	713,145	280,375	682,262	2,908	12,118	108,367	—	1,086,030
New York	Philadelphia	45,813,395	19,747	1,725,768	810,624	4,730,778	1,507,184	54,607,496	46,837,700	1,042,110	2,388,084	1,057,683	4,483,093	2,325,151	58,133,822
New York	Baltimore	5,974,216	300,370	533,173	413,069	1,900,555	—	9,121,383	6,313,634	911,179	658,474	471,083	1,750,522	—	10,104,892
New York	Washington	10,191,527	721,840	1,495,317	2,124,741	5,188,948	—	19,722,373	10,800,402	2,306,359	2,339,210	2,207,619	4,554,564	—	22,208,154
Philadelphia	Baltimore	5,554,369	5,331	73,690	53,346	554,094	4,126	6,244,956	5,771,269	225,894	108,831	57,299	434,183	43,489	6,640,964
Philadelphia	Washington	6,923,468	14,563	109,607	282,700	1,618,563	—	8,948,901	7,316,162	796,867	123,813	289,219	1,239,532	—	9,765,592
Total Study Area	**Trips**	**361,723,084**	**8,862,410**	**10,622,724**	**7,599,107**	**33,943,939**	**6,479,805**	**429,231,070**	**366,461,047**	**21,126,553**	**16,315,946**	**7,395,336**	**29,982,592**	**9,932,286**	**451,213,759**
	Mode Share	**84.3%**	**2.1%**	**2.5%**	**1.8%**	**7.9%**	**1.5%**	**100.0%**	**81.2%**	**4.7%**	**3.6%**	**1.6%**	**6.6%**	**2.2%**	**100.0%**

Table A-6: Comparison of Alternative 3.4 Ridership Forecasts

		Revised Model Results							DEIS Model Results						
		Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips	Auto	Air	Bus	Express Rail	Corridor Rail	Commuter Rail	Total Trips
Boston	Hartford	6,505,700	18,156	257,276	29,795	587,780	—	7,398,708	5,894,804	858	288,217	22,823	283,394	—	6,490,097
Boston	Springfield	955,072	—	82,012	3,116	47,692	—	1,087,893	1,020,213	—	46,114	1,076	29,012	—	1,096,415
Boston	New York	37,130,888	1,546,191	2,004,337	2,035,534	4,675,160	—	47,392,110	38,073,306	3,339,281	2,929,870	1,918,461	4,476,737	—	50,737,654
Boston	Philadelphia	3,755,685	828,974	32,203	86,020	537,890	—	5,240,772	3,815,957	1,698,989	35,828	100,276	526,823	—	6,177,873
Boston	Baltimore	890,590	915,146	7,405	20,732	91,459	—	1,925,333	972,621	1,465,785	1,941	24,198	103,281	—	2,567,826
Boston	Washington	1,031,401	2,242,234	13,947	74,301	449,124	—	3,811,006	991,783	3,614,320	1,722	72,505	406,050	—	5,086,380
Hartford	New York	22,347,971	1,845	418,827	202,484	1,004,992	92,797	24,068,915	18,821,421	44,535	901,635	376,717	2,391,050	128,572	22,663,929
Hartford	Philadelphia	3,267,935	62,971	38,696	41,071	178,225	—	3,588,897	1,912,178	316,611	5,535	47,912	237,725	—	2,519,962
Hartford	Baltimore	524,623	129,380	17,396	22,930	60,615	—	754,943	369,445	257,839	5,943	26,712	93,264	—	753,203
Hartford	Washington	921,336	245,066	58,158	74,788	164,952	—	1,464,300	573,153	476,804	5,757	79,135	201,234	—	1,336,082
Springfield	New York	5,138,476	666	166,992	51,481	288,184	—	5,645,799	5,246,052	24,765	154,557	43,594	395,424	—	5,864,392
Springfield	Philadelphia	506,609	—	—	14,082	20,761	—	541,453	552,454	—	—	15,670	67,281	—	635,405
Springfield	Baltimore	75,552	31,162	—	4,368	4,932	—	116,014	80,822	88,781	—	3,739	11,758	—	185,100
Springfield	Washington	176,669	88,949	—	16,047	21,442	—	303,107	184,587	214,700	—	15,159	32,785	—	447,230
Providence	New York	16,320,041	19,457	205,696	296,871	1,066,042	—	17,908,108	16,315,198	123,823	404,915	266,977	1,495,267	—	18,606,181
Providence	Philadelphia	2,220,533	87,869	10,968	19,355	159,849	—	2,498,574	2,227,726	285,834	6,600	19,384	193,209	—	2,732,754
Providence	Baltimore	3,053,307	443,713	5,050	10,143	62,856	—	3,575,070	2,972,553	722,012	2,234	8,398	65,369	—	3,770,566
Providence	Washington	257,653	332,656	5,368	16,357	101,718	—	713,751	279,810	681,135	2,889	12,930	110,195	—	1,086,960
New York	Philadelphia	46,182,283	19,980	1,731,138	667,877	4,429,164	1,513,205	54,543,648	47,059,644	1,049,388	2,415,210	924,901	4,237,158	2,325,930	58,012,231
New York	Baltimore	6,059,607	315,319	537,240	351,982	1,827,415	—	9,091,563	6,362,350	934,595	665,959	433,643	1,672,689	—	10,069,236
New York	Washington	10,490,026	777,085	1,531,596	1,832,419	4,963,041	—	19,594,166	10,970,196	2,394,994	2,398,692	1,993,332	4,293,084	—	22,050,297
Philadelphia	Baltimore	5,553,023	5,329	73,661	54,239	554,985	4,125	6,245,361	5,770,409	225,804	108,802	58,147	434,702	43,488	6,641,352
Philadelphia	Washington	6,921,444	14,555	109,588	285,035	1,618,775	—	8,949,397	7,314,863	796,619	123,784	291,680	1,239,275	—	9,766,221
Total Study Area	**Trips**	**363,098,500**	**8,942,939**	**10,725,713**	**6,745,196**	**32,952,172**	**6,505,226**	**428,969,746**	**366,975,911**	**21,228,685**	**16,440,596**	**6,964,870**	**29,339,395**	**9,938,581**	**450,888,038**
	Mode Share	**84.6%**	**2.1%**	**2.5%**	**1.6%**	**7.7%**	**1.5%**	**100.0%**	**81.4%**	**4.7%**	**3.6%**	**1.5%**	**6.5%**	**2.2%**	**100.0%**

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 – MSA-to-MSA Level Interregional Trips by Mode for each Alternative

Table C-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	50,700	1,178,300	266,400	321,300	29,500	701,100	217,700	20,000	33,300	120,300	66,600	15,300	48,800	4,700	3,074,000
Greater Washington Area	1,178,300	3,372,700	1,402,400	2,549,300	277,400	4,028,600	1,308,500	146,000	146,600	197,200	335,700	103,300	411,200	67,800	15,525,000
Greater Baltimore Area	266,400	1,402,400	337,500	2,076,200	174,500	2,405,100	600,300	93,500	124,300	269,700	200,700	1,107,400	338,400	29,400	9,425,800
Greater Philadelphia Area	321,300	2,549,300	2,076,200	1,822,100	476,400	17,741,100	1,547,800	65,900	166,100	245,300	1,263,100	869,800	1,509,000	199,700	30,853,100
Leigh Valley Area	29,500	277,400	174,500	476,400	15,600	4,521,800	212,700	22,900	50,100	32,600	287,100	194,000	484,000	51,300	6,829,900
New York - North Jersey Area	701,100	4,028,600	2,405,100	17,741,100	4,521,800	71,829,100	681,300	2,031,900	2,717,600	2,002,000	8,868,300	6,457,000	14,865,600	2,049,300	140,899,800
South Central PA Area	217,700	1,308,500	600,300	1,547,800	212,700	681,300	120,800	70,300	100,700	135,500	170,400	63,700	106,700	55,000	5,391,400
Atlantic City Area	20,000	146,000	93,500	65,900	22,900	2,031,900	70,300	-	38,700	45,000	199,700	21,400	31,800	28,700	2,815,800
Poughkeepsie-Newburgh-Middletown Area	33,300	146,600	124,300	166,100	50,100	2,717,600	100,700	38,700	113,300	248,700	355,100	176,600	497,900	151,500	4,920,500
Greater Albany Area	120,300	197,200	269,700	245,300	32,600	2,002,000	135,500	45,000	248,700	208,700	498,500	282,200	875,100	286,200	5,447,000
Greater Hartford Area	66,600	335,700	200,700	1,263,100	287,100	8,868,300	170,400	199,700	355,100	498,500	1,201,800	992,600	2,626,200	184,200	17,250,000
Greater Providence Area	15,300	103,300	1,107,400	869,800	194,000	6,457,000	63,700	21,400	176,600	282,200	992,600	159,100	186,100	37,100	10,665,600
Greater Boston Area	48,800	411,200	338,400	1,509,000	484,000	14,865,600	106,700	31,800	497,900	875,100	2,626,200	186,100	443,600	377,600	22,802,000
Springfield Area	4,700	67,800	29,400	199,700	51,300	2,049,300	55,000	28,700	151,500	286,200	184,200	37,100	377,600	600	3,523,100
Total Trips	**3,074,000**	**15,525,000**	**9,425,800**	**30,853,100**	**6,829,900**	**140,899,800**	**5,391,400**	**2,815,800**	**4,920,500**	**5,447,000**	**17,250,000**	**10,665,600**	**22,802,000**	**3,523,100**	**279,423,000**

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	—	600	300	11,200	200	77,600	—	—	1,400	2,400	6,300	2,800	92,000	—	194,800
Greater Washington Area	600	—	—	6,100	300	343,100	—	—	3,400	48,200	98,200	126,300	859,000	35,800	1,521,000
Greater Baltimore Area	300	—	—	2,200	300	135,500	—	—	2,700	32,300	50,700	146,900	345,500	12,500	728,900
Greater Philadelphia Area	11,200	6,100	2,200	—	—	8,200	300	—	—	7,700	24,800	32,700	321,600	—	414,800
Leigh Valley Area	200	300	300	—	—	200	200	—	—	—	200	100	9,200	—	10,700
New York - North Jersey Area	77,600	343,100	135,500	8,200	200	—	100	—	—	1,500	700	7,400	680,200	300	1,254,800
South Central PA Area	—	—	—	300	200	100	—	—	—	200	700	400	1,500	—	3,400
Atlantic City Area	—	—	—	—	—	—	—	—	—	—	—	—	9,600	—	9,600
Poughkeepsie-Newburgh-Middletown Area	1,400	3,400	2,700	—	—	—	—	—	—	—	—	—	2,800	—	10,300
Greater Albany Area	2,400	48,200	32,300	7,700	—	1,500	200	—	—	100	300	100	100	—	92,900
Greater Hartford Area	6,300	98,200	50,700	24,800	200	700	700	—	—	300	—	100	6,300	—	188,300
Greater Providence Area	2,800	126,300	146,900	32,700	100	7,400	400	—	—	100	100	—	—	—	316,800
Greater Boston Area	92,000	859,000	345,500	321,600	9,200	680,200	1,500	9,600	2,800	100	6,300	—	—	—	2,327,800
Springfield Area	—	35,800	12,500	—	—	300	—	—	—	—	—	—	—	—	48,600
Total Trips	**194,800**	**1,521,000**	**728,900**	**414,800**	**10,700**	**1,254,800**	**3,400**	**9,600**	**10,300**	**92,900**	**188,300**	**316,800**	**2,327,800**	**48,600**	**7,122,700**

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	—	3,300	26,900	13,800	2,300	91,300	4,000	1,600	1,300	—	3,900	700	2,500	—	151,600
Greater Washington Area	3,300	11,300	43,200	44,700	9,900	647,100	8,600	2,100	3,200	—	18,200	2,200	5,900	—	799,700
Greater Baltimore Area	26,900	43,200	1,200	28,600	11,200	219,800	10,900	700	900	—	6,300	1,700	2,900	—	354,300
Greater Philadelphia Area	13,800	44,700	28,600	20,600	3,900	672,200	37,600	300	900	1,800	15,300	4,000	12,500	—	856,200
Leigh Valley Area	2,300	9,900	11,200	3,900	—	97,500	7,400	100	100	1,000	2,700	1,000	8,900	300	146,300
New York - North Jersey Area	91,300	647,100	219,800	672,200	97,500	565,400	37,700	41,800	36,100	304,800	165,800	78,300	824,000	64,900	3,846,700
South Central PA Area	4,000	8,600	10,900	37,600	7,400	37,700	—	1,400	400	—	200	—	—	—	108,200
Atlantic City Area	1,600	2,100	700	300	100	41,800	1,400	—	100	100	1,100	100	200	—	49,600
Poughkeepsie-Newburgh-Middletown Area	1,300	3,200	900	900	100	36,100	400	100	—	1,600	400	200	5,200	2,600	53,000
Greater Albany Area	—	—	—	1,800	1,000	304,800	—	100	1,600	—	2,400	—	29,000	20,000	360,700
Greater Hartford Area	3,900	18,200	6,300	15,300	2,700	165,800	200	1,100	400	2,400	2,500	700	107,200	40,400	367,100
Greater Providence Area	700	2,200	1,700	4,000	1,000	78,300	—	100	200	—	700	—	42,800	5,100	136,800
Greater Boston Area	2,500	5,900	2,900	12,500	8,900	824,000	—	200	5,200	29,000	107,200	42,800	67,200	31,300	1,139,600
Springfield Area	—	—	—	—	300	64,900	—	—	2,600	20,000	40,400	5,100	31,300	—	164,600
Total Trips	**151,600**	**799,700**	**354,300**	**856,200**	**146,300**	**3,846,700**	**108,200**	**49,600**	**53,000**	**360,700**	**367,100**	**136,800**	**1,139,600**	**164,600**	**8,534,400**

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	—	3,000	300	800	—	2,700	500	—	500	100	400	300	500	—	9,100
Greater Washington Area	3,000	2,900	13,000	90,200	2,900	531,100	2,800	11,000	8,500	900	16,800	3,600	10,000	800	697,500
Greater Baltimore Area	300	13,000	600	18,600	1,100	110,700	1,200	1,600	2,200	—	3,800	2,200	3,200	200	158,700
Greater Philadelphia Area	800	90,200	18,600	10,500	1,600	202,000	3,100	900	900	700	8,100	4,200	16,700	1,000	359,300
Leigh Valley Area	—	2,900	1,100	1,600	—	5,600	500	200	—	200	300	900	5,800	—	19,100
New York - North Jersey Area	2,700	531,100	110,700	202,000	5,600	14,500	1,800	39,800	600	6,000	26,700	68,100	412,800	3,400	1,425,800
South Central PA Area	500	2,800	1,200	3,100	500	1,800	100	300	100	100	400	200	100	100	11,300
Atlantic City Area	—	11,000	1,600	900	200	39,800	300	—	400	100	2,100	200	300	200	57,100
Poughkeepsie-Newburgh-Middletown Area	500	8,500	2,200	900	—	600	100	400	—	—	200	800	4,800	—	19,000
Greater Albany Area	100	900	—	700	200	6,000	100	100	—	—	400	100	800	—	9,400
Greater Hartford Area	400	16,800	3,800	8,100	300	26,700	400	2,100	200	400	3,100	2,600	10,500	300	75,700
Greater Providence Area	300	3,600	2,200	4,200	900	68,100	200	200	800	100	2,600	300	6,600	100	90,200
Greater Boston Area	500	10,000	3,200	16,700	5,800	412,800	100	300	4,800	800	10,500	6,600	2,400	1,200	475,700
Springfield Area	—	800	200	1,000	—	3,400	100	200	—	—	300	100	1,200	—	7,300
Total Trips	**9,100**	**697,500**	**158,700**	**359,300**	**19,100**	**1,425,800**	**11,300**	**57,100**	**19,000**	**9,400**	**75,700**	**90,200**	**475,700**	**7,300**	**3,415,200**

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	500	86,900	13,100	21,900	1,300	83,200	1,700	1,500	700	400	1,200	900	2,000	—	215,300
Greater Washington Area	86,900	125,000	122,700	345,800	15,100	931,800	44,600	18,000	16,300	16,500	36,200	14,100	35,200	2,500	1,810,700
Greater Baltimore Area	13,100	122,700	4,800	115,800	8,500	319,800	19,600	3,300	2,700	800	13,000	8,000	6,400	500	639,000
Greater Philadelphia Area	21,900	345,800	115,800	319,100	18,800	877,100	190,600	10,100	2,300	14,200	19,400	19,100	48,100	2,100	2,004,400
Leigh Valley Area	1,300	15,100	8,500	18,800	—	151,500	13,300	200	200	1,000	2,400	2,600	8,600	300	223,800
New York - North Jersey Area	83,200	931,800	319,800	877,100	151,500	456,300	54,700	57,600	101,800	347,900	124,800	167,900	487,900	41,900	4,204,200
South Central PA Area	1,700	44,600	19,600	190,600	13,300	54,700	12,900	5,800	1,100	3,100	1,000	600	900	—	349,900
Atlantic City Area	1,500	18,000	3,300	10,100	200	57,600	5,800	—	200	500	1,500	400	700	200	100,000
Poughkeepsie-Newburgh-Middletown Area	700	16,300	2,700	2,300	200	101,800	1,100	200	1,400	11,300	1,800	800	2,200	700	143,500
Greater Albany Area	400	16,500	800	14,200	1,000	347,900	3,100	500	11,300	1,400	5,300	1,700	4,000	900	409,000
Greater Hartford Area	1,200	36,200	13,000	19,400	2,400	124,800	1,000	1,500	1,800	5,300	3,600	12,300	46,400	1,100	270,000
Greater Providence Area	900	14,100	8,000	19,100	2,600	167,900	600	400	800	1,700	12,300	9,300	68,500	200	306,400
Greater Boston Area	2,000	35,200	6,400	48,100	8,600	487,900	900	700	2,200	4,000	46,400	68,500	30,900	3,800	745,600
Springfield Area	—	2,500	500	2,100	300	41,900	—	200	700	900	1,100	200	3,800	—	54,200
Total Trips	**215,300**	**1,810,700**	**639,000**	**2,004,400**	**223,800**	**4,204,200**	**349,900**	**100,000**	**143,500**	**409,000**	**270,000**	**306,400**	**745,600**	**54,200**	**11,476,000**

Annual Intercity Commuter 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	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater Baltimore Area	—	—	—	1,600	—	—	—	—	—	—	—	—	—	—	1,600
Greater Philadelphia Area	—	—	1,600	100	13,100	578,000	—	—	—	—	—	—	—	—	592,800
Leigh Valley Area	—	—	—	13,100	700	205,400	—	—	—	—	400	—	—	—	219,600
New York - North Jersey Area	—	—	—	578,000	205,400	2,826,600	—	76,700	10,300	—	35,100	—	—	—	3,732,100
South Central PA Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Atlantic City Area	—	—	—	—	—	76,700	—	—	—	—	—	—	—	—	76,700
Poughkeepsie-Newburgh-Middletown Area	—	—	—	—	—	10,300	—	—	—	—	—	—	—	—	10,300
Greater Albany Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater Hartford Area	—	—	—	—	400	35,100	—	—	—	—	—	—	—	—	35,500
Greater Providence Area	—	—	—	—	—	—	—	—	—	—	—	17,600	—	—	17,600
Greater Boston Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Springfield Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Trips	**—**	**—**	**1,600**	**592,800**	**219,600**	**3,732,100**	**—**	**76,700**	**10,300**	**—**	**35,500**	**17,600**	**—**	**—**	**4,686,200**

Source: NEC FUTURE team, 2016

Table C-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	67,800	1,693,400	374,100	445,200	41,900	952,700	302,600	27,000	45,800	169,900	87,700	19,900	60,100	6,300	4,294,400
Greater Washington Area	1,693,400	5,178,200	2,116,200	3,764,500	423,300	6,010,400	1,904,300	211,600	213,900	286,700	480,300	142,400	574,800	94,900	23,094,900
Greater Baltimore Area	374,100	2,116,200	509,300	2,867,800	251,600	3,363,000	845,300	127,600	174,300	392,300	272,800	1,543,600	466,200	39,700	13,343,800
Greater Philadelphia Area	445,200	3,764,500	2,867,800	2,564,600	629,300	23,965,700	2,096,800	91,300	227,200	341,900	1,704,700	1,165,100	2,062,900	266,500	42,193,500
Leigh Valley Area	41,900	423,300	251,600	629,300	20,400	6,130,100	304,300	28,900	64,400	44,300	387,900	264,000	665,900	68,000	9,324,300
New York - North Jersey Area	952,700	6,010,400	3,363,000	23,965,700	6,130,100	95,119,400	933,000	2,721,800	3,564,100	2,660,400	11,568,600	8,524,300	20,128,500	2,672,500	188,314,500
South Central PA Area	302,600	1,904,300	845,300	2,096,800	304,300	933,000	165,000	94,100	138,200	189,700	232,100	86,800	150,700	75,300	7,518,200
Atlantic City Area	27,000	211,600	127,600	91,300	28,900	2,721,800	94,100	—	51,600	61,400	265,200	28,100	42,000	38,000	3,788,600
Poughkeepsie-Newburgh-Middletown Area	45,800	213,900	174,300	227,200	64,400	3,564,100	138,200	51,600	148,100	332,100	460,300	231,900	665,800	194,400	6,512,100
Greater Albany Area	169,900	286,700	392,300	341,900	44,300	2,660,400	189,700	61,400	332,100	290,100	657,200	379,700	1,190,300	377,700	7,373,700
Greater Hartford Area	87,700	480,300	272,800	1,704,700	387,900	11,568,600	232,100	265,200	460,300	657,200	1,505,500	1,257,700	3,432,000	233,700	22,545,700
Greater Providence Area	19,900	142,400	1,543,600	1,165,100	264,000	8,524,300	86,800	28,100	231,900	379,700	1,257,700	202,600	240,800	46,700	14,133,600
Greater Boston Area	60,100	574,800	466,200	2,062,900	665,900	20,128,500	150,700	42,000	665,800	1,190,300	3,432,000	240,800	587,400	493,000	30,760,400
Springfield Area	6,300	94,900	39,700	266,500	68,000	2,672,500	75,300	38,000	194,400	377,700	233,700	46,700	493,000	700	4,607,400
Total Trips	**4,294,400**	**23,094,900**	**13,343,800**	**42,193,500**	**9,324,300**	**188,314,500**	**7,518,200**	**3,788,600**	**6,512,100**	**7,373,700**	**22,545,700**	**14,133,600**	**30,760,400**	**4,607,400**	**377,805,100**

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	—	900	400	16,500	200	117,400	—	—	1,800	3,600	9,700	4,500	128,500	—	283,500
Greater Washington Area	900	—	—	9,000	300	515,900	100	—	4,600	68,700	140,400	183,600	1,246,200	51,100	2,220,800
Greater Baltimore Area	400	—	—	2,900	300	188,900	—	—	3,400	43,300	70,200	226,000	478,100	17,200	1,030,700
Greater Philadelphia Area	16,500	9,000	2,900	—	100	11,000	400	—	—	10,100	33,800	48,500	446,500	—	578,800
Leigh Valley Area	200	300	300	100	—	300	200	—	—	—	200	200	12,700	—	14,500
New York - North Jersey Area	117,400	515,900	188,900	11,000	300	—	200	—	—	2,100	1,000	11,400	968,900	400	1,817,500
South Central PA Area	—	100	—	400	200	200	—	—	—	300	1,100	700	2,400	—	5,400
Atlantic City Area	—	—	—	—	—	—	—	—	—	—	—	—	13,000	—	13,000
Poughkeepsie-Newburgh-Middletown Area	1,800	4,600	3,400	—	—	—	—	—	—	—	—	100	3,500	—	13,400
Greater Albany Area	3,600	68,700	43,300	10,100	—	2,100	300	—	—	100	400	100	200	—	128,900
Greater Hartford Area	9,700	140,400	70,200	33,800	200	1,000	1,100	—	—	400	—	200	8,400	—	265,400
Greater Providence Area	4,500	183,600	226,000	48,500	200	11,400	700	—	100	100	200	—	—	—	475,300
Greater Boston Area	128,500	1,246,200	478,100	446,500	12,700	968,900	2,400	13,000	3,500	200	8,400	—	—	—	3,308,400
Springfield Area	—	51,100	17,200	—	—	400	—	—	—	—	—	—	—	—	68,700
Total Trips	**283,500**	**2,220,800**	**1,030,700**	**578,800**	**14,500**	**1,817,500**	**5,400**	**13,000**	**13,400**	**128,900**	**265,400**	**475,300**	**3,308,400**	**68,700**	**10,224,300**

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	—	4,500	37,900	19,200	3,200	125,900	5,300	2,100	1,800	—	5,500	1,000	3,400	—	209,800
Greater Washington Area	4,500	16,300	63,300	67,200	14,500	969,200	12,500	3,000	4,200	—	27,100	3,300	8,900	—	1,194,000
Greater Baltimore Area	37,900	63,300	1,700	39,300	15,700	307,600	15,600	900	1,200	—	9,300	2,800	4,400	—	499,700
Greater Philadelphia Area	19,200	67,200	39,300	29,900	5,000	933,200	52,000	500	1,100	2,400	21,300	6,300	19,400	—	1,196,800
Leigh Valley Area	3,200	14,500	15,700	5,000	—	142,600	10,500	100	100	1,200	3,800	1,500	12,700	300	211,200
New York - North Jersey Area	125,900	969,200	307,600	933,200	142,600	772,700	54,600	56,700	49,700	428,600	234,100	115,000	1,187,200	90,900	5,468,000
South Central PA Area	5,300	12,500	15,600	52,000	10,500	54,600	—	1,900	500	—	300	—	—	—	153,200
Atlantic City Area	2,100	3,000	900	500	100	56,700	1,900	—	200	100	1,400	100	300	—	67,300
Poughkeepsie-Newburgh-Middletown Area	1,800	4,200	1,200	1,100	100	49,700	500	200	100	1,900	500	200	6,900	3,400	71,800
Greater Albany Area	—	—	—	2,400	1,200	428,600	—	100	1,900	—	3,100	—	40,600	26,600	504,500
Greater Hartford Area	5,500	27,100	9,300	21,300	3,800	234,100	300	1,400	500	3,100	3,100	900	142,800	51,100	504,300
Greater Providence Area	1,000	3,300	2,800	6,300	1,500	115,000	—	100	200	—	900	—	56,600	6,500	194,200
Greater Boston Area	3,400	8,900	4,400	19,400	12,700	1,187,200	—	300	6,900	40,600	142,800	56,600	88,500	42,800	1,614,500
Springfield Area	—	—	—	—	300	90,900	—	—	3,400	26,600	51,100	6,500	42,800	—	221,600
Total Trips	**209,800**	**1,194,000**	**499,700**	**1,196,800**	**211,200**	**5,468,000**	**153,200**	**67,300**	**71,800**	**504,500**	**504,300**	**194,200**	**1,614,500**	**221,600**	**12,110,900**

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	—	4,000	400	1,000	100	3,700	700	—	700	100	600	300	500	—	12,100
Greater Washington Area	4,000	4,400	19,900	133,800	4,100	816,100	4,200	16,100	11,800	1,400	25,500	5,400	15,400	1,100	1,063,200
Greater Baltimore Area	400	19,900	800	24,900	1,400	158,200	1,600	2,100	2,900	—	5,800	3,800	5,000	300	227,100
Greater Philadelphia Area	1,000	133,800	24,900	14,300	2,000	278,200	3,900	1,100	1,200	900	11,700	7,100	28,200	1,500	509,800
Leigh Valley Area	100	4,100	1,400	2,000	—	8,000	600	200	—	200	400	1,300	8,400	100	26,800
New York - North Jersey Area	3,700	816,100	158,200	278,200	8,000	19,500	2,400	52,100	700	7,300	39,600	108,600	625,900	5,100	2,125,400
South Central PA Area	700	4,200	1,600	3,900	600	2,400	100	400	100	100	500	200	200	100	15,100
Atlantic City Area	—	16,100	2,100	1,100	200	52,100	400	—	500	100	3,000	300	500	300	76,700
Poughkeepsie-Newburgh-Middletown Area	700	11,800	2,900	1,200	—	700	100	500	—	—	300	1,100	6,000	—	25,300
Greater Albany Area	100	1,400	—	900	200	7,300	100	100	—	—	500	200	900	—	11,700
Greater Hartford Area	600	25,500	5,800	11,700	400	39,600	500	3,000	300	500	3,500	3,100	13,600	300	108,400
Greater Providence Area	300	5,400	3,800	7,100	1,300	108,600	200	300	1,100	200	3,100	300	8,200	100	140,000
Greater Boston Area	500	15,400	5,000	28,200	8,400	625,900	200	500	6,000	900	13,600	8,200	2,800	1,500	717,100
Springfield Area	—	1,100	300	1,500	100	5,100	100	300	—	—	300	100	1,500	—	10,400
Total Trips	**12,100**	**1,063,200**	**227,100**	**509,800**	**26,800**	**2,125,400**	**15,100**	**76,700**	**25,300**	**11,700**	**108,400**	**140,000**	**717,100**	**10,400**	**5,069,100**

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	500	102,900	16,300	26,500	1,500	100,200	2,100	1,800	800	500	1,600	1,200	2,400	—	258,300
Greater Washington Area	102,900	148,100	147,900	418,100	17,100	1,158,000	52,500	20,600	18,700	20,000	43,700	16,300	41,300	3,000	2,208,200
Greater Baltimore Area	16,300	147,900	7,100	160,400	11,700	418,100	28,200	4,500	3,900	1,100	14,500	8,900	6,500	500	829,600
Greater Philadelphia Area	26,500	418,100	160,400	449,300	26,300	1,168,500	257,400	13,500	3,100	19,000	20,600	20,600	52,300	2,200	2,637,800
Leigh Valley Area	1,500	17,100	11,700	26,300	—	216,400	18,600	300	200	1,300	2,500	2,700	9,000	200	307,800
New York - North Jersey Area	100,200	1,158,000	418,100	1,168,500	216,400	506,700	73,400	73,100	141,400	485,300	132,600	178,800	522,900	47,100	5,222,500
South Central PA Area	2,100	52,500	28,200	257,400	18,600	73,400	17,400	7,500	1,400	4,200	1,200	700	1,100	100	465,800
Atlantic City Area	1,800	20,600	4,500	13,500	300	73,100	7,500	—	200	600	1,400	400	700	200	124,800
Poughkeepsie-Newburgh-Middletown Area	800	18,700	3,900	3,100	200	141,400	1,400	200	1,700	14,000	2,400	1,000	2,900	800	192,500
Greater Albany Area	500	20,000	1,100	19,000	1,300	485,300	4,200	600	14,000	2,000	6,900	2,300	5,500	1,200	563,900
Greater Hartford Area	1,600	43,700	14,500	20,600	2,500	132,600	1,200	1,400	2,400	6,900	4,600	15,800	61,900	1,400	311,100
Greater Providence Area	1,200	16,300	8,900	20,600	2,700	178,800	700	400	1,000	2,300	15,800	12,100	89,300	200	350,300
Greater Boston Area	2,400	41,300	6,500	52,300	9,000	522,900	1,100	700	2,900	5,500	61,900	89,300	40,700	5,200	841,700
Springfield Area	—	3,000	500	2,200	200	47,100	100	200	800	1,200	1,400	200	5,200	—	62,100
Total Trips	**258,300**	**2,208,200**	**829,600**	**2,637,800**	**307,800**	**5,222,500**	**465,800**	**124,800**	**192,500**	**563,900**	**311,100**	**350,300**	**841,700**	**62,100**	**14,376,400**

Annual Intercity Commuter 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	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater Baltimore Area	—	—	—	2,200	—	—	—	—	—	—	—	—	—	—	2,200
Greater Philadelphia Area	—	—	2,200	100	16,900	805,400	—	—	—	—	—	—	—	—	824,600
Leigh Valley Area	—	—	—	16,900	1,000	298,500	—	—	—	—	500	—	—	—	316,900
New York - North Jersey Area	—	—	—	805,400	298,500	4,048,100	—	112,800	14,100	—	47,100	—	—	—	5,326,000
South Central PA Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Atlantic City Area	—	—	—	—	—	112,800	—	—	—	—	—	—	—	—	112,800
Poughkeepsie-Newburgh-Middletown Area	—	—	—	—	—	14,100	—	—	—	—	—	—	—	—	14,100
Greater Albany Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater Hartford Area	—	—	—	—	500	47,100	—	—	—	—	—	—	—	—	47,600
Greater Providence Area	—	—	—	—	—	—	—	—	—	—	—	22,800	—	—	22,800
Greater Boston Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Springfield Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Trips	**—**	**—**	**2,200**	**824,600**	**316,900**	**5,326,000**	**—**	**112,800**	**14,100**	**—**	**47,600**	**22,800**	**—**	**—**	**6,667,000**

Source: NEC FUTURE team, 2016

Table C-3: Trip Tables by Mode and MSA pair: Preferred 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	67,300	1,610,000	347,900	415,800	39,700	835,800	297,600	24,600	44,400	168,900	83,500	19,100	57,800	6,100	4,018,500
Greater Washington Area	1,610,000	5,033,400	2,007,800	3,407,100	405,200	5,083,200	1,843,600	189,500	190,000	270,000	415,200	128,400	536,200	87,600	21,207,200
Greater Baltimore Area	347,900	2,007,800	501,800	2,759,800	244,700	2,988,100	826,900	123,800	167,600	390,600	250,100	1,523,100	451,900	37,500	12,621,600
Greater Philadelphia Area	415,800	3,407,100	2,759,800	2,406,900	617,000	22,956,300	2,003,000	86,900	221,200	334,200	1,618,700	1,096,400	1,918,800	251,500	40,093,600
Leigh Valley Area	39,700	405,200	244,700	617,000	20,400	6,025,000	298,400	28,600	64,300	43,200	379,900	255,500	634,700	66,700	9,123,300
New York - North Jersey Area	835,800	5,083,200	2,988,100	22,956,300	6,025,000	94,442,200	834,700	2,648,800	3,524,100	2,463,500	11,206,300	8,082,400	18,780,300	2,566,900	182,437,600
South Central PA Area	297,600	1,843,600	826,900	2,003,000	298,400	834,700	159,500	91,100	135,100	187,900	217,000	80,400	139,500	71,700	7,186,400
Atlantic City Area	24,600	189,500	123,800	86,900	28,600	2,648,800	91,100	—	50,900	60,900	256,200	26,700	40,400	36,100	3,664,500
Poughkeepsie-Newburgh-Middletown Area	44,400	190,000	167,600	221,200	64,300	3,524,100	135,100	50,900	147,600	326,700	457,300	227,200	649,400	193,600	6,399,400
Greater Albany Area	168,900	270,000	390,600	334,200	43,200	2,463,500	187,900	60,900	326,700	289,600	650,100	374,500	1,175,700	377,100	7,112,900
Greater Hartford Area	83,500	415,200	250,100	1,618,700	379,900	11,206,300	217,000	256,200	457,300	650,100	1,485,200	1,218,700	3,306,600	231,300	21,776,100
Greater Providence Area	19,100	128,400	1,523,100	1,096,400	255,500	8,082,400	80,400	26,700	227,200	374,500	1,218,700	197,800	225,400	46,300	13,501,900
Greater Boston Area	57,800	536,200	451,900	1,918,800	634,700	18,780,300	139,500	40,400	649,400	1,175,700	3,306,600	225,400	556,500	481,800	28,955,000
Springfield Area	6,100	87,600	37,500	251,500	66,700	2,566,900	71,700	36,100	193,600	377,100	231,300	46,300	481,800	700	4,454,900
Total Trips	**4,018,500**	**21,207,200**	**12,621,600**	**40,093,600**	**9,123,300**	**182,437,600**	**7,186,400**	**3,664,500**	**6,399,400**	**7,112,900**	**21,776,100**	**13,501,900**	**28,955,000**	**4,454,900**	**362,552,900**

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	—	800	300	13,800	200	87,000	—	—	1,300	3,500	8,700	4,400	124,500	—	244,500
Greater Washington Area	800	—	—	7,200	300	374,300	100	—	3,100	68,700	121,100	162,800	1,169,800	44,300	1,952,500
Greater Baltimore Area	300	—	—	2,600	300	154,200	—	—	2,900	42,700	65,200	220,800	465,200	15,600	969,800
Greater Philadelphia Area	13,800	7,200	2,600	—	100	9,900	400	—	—	10,000	31,600	42,700	420,300	—	538,600
Leigh Valley Area	200	300	300	100	—	200	200	—	—	—	200	200	11,000	—	12,700
New York - North Jersey Area	87,000	374,300	154,200	9,900	200	—	200	—	—	1,800	900	9,300	797,600	300	1,435,700
South Central PA Area	—	100	—	400	200	200	—	—	—	300	900	500	2,000	—	4,600
Atlantic City Area	—	—	—	—	—	—	—	—	—	—	—	—	12,900	—	12,900
Poughkeepsie-Newburgh-Middletown Area	1,300	3,100	2,900	—	—	—	—	—	—	—	—	100	3,300	—	10,700
Greater Albany Area	3,500	68,700	42,700	10,000	—	1,800	300	—	—	100	300	100	200	—	127,700
Greater Hartford Area	8,700	121,100	65,200	31,600	200	900	900	—	—	300	—	200	7,400	—	236,500
Greater Providence Area	4,400	162,800	220,800	42,700	200	9,300	500	—	100	100	200	—	—	—	441,100
Greater Boston Area	124,500	1,169,800	465,200	420,300	11,000	797,600	2,000	12,900	3,300	200	7,400	—	—	—	3,014,200
Springfield Area	—	44,300	15,600	—	—	300	—	—	—	—	—	—	—	—	60,200
Total Trips	**244,500**	**1,952,500**	**969,800**	**538,600**	**12,700**	**1,435,700**	**4,600**	**12,900**	**10,700**	**127,700**	**236,500**	**441,100**	**3,014,200**	**60,200**	**9,061,700**

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	—	4,400	37,700	19,200	3,100	125,900	5,300	2,100	1,800	—	5,300	900	3,300	—	209,000
Greater Washington Area	4,400	15,500	56,300	54,000	13,200	735,200	11,400	2,500	3,100	—	20,100	2,600	7,400	—	925,700
Greater Baltimore Area	37,700	56,300	1,700	36,500	15,100	263,100	15,100	900	1,100	—	7,700	2,500	3,800	—	441,500
Greater Philadelphia Area	19,200	54,000	36,500	26,400	4,800	857,600	48,000	400	1,100	2,300	18,900	5,400	16,200	—	1,090,800
Leigh Valley Area	3,100	13,200	15,100	4,800	—	133,100	10,200	100	100	1,200	3,400	1,400	11,500	300	197,500
New York - North Jersey Area	125,900	735,200	263,100	857,600	133,100	745,700	48,600	53,900	46,300	381,600	213,200	100,200	1,024,600	83,500	4,812,500
South Central PA Area	5,300	11,400	15,100	48,000	10,200	48,600	—	1,800	500	—	300	—	—	—	141,200
Atlantic City Area	2,100	2,500	900	400	100	53,900	1,800	—	100	100	1,300	100	200	—	63,500
Poughkeepsie-Newburgh-Middletown Area	1,800	3,100	1,100	1,100	100	46,300	500	100	100	1,800	500	200	6,400	3,400	66,500
Greater Albany Area	—	—	—	2,300	1,200	381,600	—	100	1,800	—	2,900	—	39,400	26,500	455,800
Greater Hartford Area	5,300	20,100	7,700	18,900	3,400	213,200	300	1,300	500	2,900	2,800	700	133,400	50,700	461,200
Greater Providence Area	900	2,600	2,500	5,400	1,400	100,200	—	100	200	—	700	—	45,900	6,500	166,400
Greater Boston Area	3,300	7,400	3,800	16,200	11,500	1,024,600	—	200	6,400	39,400	133,400	45,900	83,800	41,300	1,417,200
Springfield Area	—	—	—	—	300	83,500	—	—	3,400	26,500	50,700	6,500	41,300	—	212,200
Total Trips	**209,000**	**925,700**	**441,500**	**1,090,800**	**197,500**	**4,812,500**	**141,200**	**63,500**	**66,500**	**455,800**	**461,200**	**166,400**	**1,417,200**	**212,200**	**10,661,000**

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	—	5,700	500	1,400	100	900	900	100	800	100	1,200	600	1,700	100	14,100
Greater Washington Area	5,700	7,700	28,600	191,700	6,600	1,262,800	5,300	24,500	20,700	8,400	56,000	12,400	42,700	8,000	1,681,100
Greater Baltimore Area	500	28,600	1,300	41,800	2,300	262,700	2,400	3,500	5,600	300	14,700	8,600	12,400	2,200	386,900
Greater Philadelphia Area	1,400	191,700	41,800	18,600	3,200	477,100	5,600	1,500	2,200	1,600	25,800	17,300	60,500	9,100	857,400
Leigh Valley Area	100	6,600	2,300	3,200	—	14,000	1,000	300	—	700	1,300	3,400	19,800	500	53,200
New York - North Jersey Area	900	1,262,800	262,700	477,100	14,000	46,400	3,000	99,000	1,400	78,200	126,100	277,800	1,430,800	29,200	4,109,400
South Central PA Area	900	5,300	2,400	5,600	1,000	3,000	200	600	200	300	1,600	500	200	500	22,300
Atlantic City Area	100	24,500	3,500	1,500	300	99,000	600	—	1,000	200	7,200	1,000	1,300	1,700	141,900
Poughkeepsie-Newburgh-Middletown Area	800	20,700	5,600	2,200	—	1,400	200	1,000	—	300	700	2,300	12,700	100	48,000
Greater Albany Area	100	8,400	300	1,600	700	78,200	300	200	300	100	1,400	300	1,800	100	93,800
Greater Hartford Area	1,200	56,000	14,700	25,800	1,300	126,100	1,600	7,200	700	1,400	17,300	9,000	34,000	900	297,200
Greater Providence Area	600	12,400	8,600	17,300	3,400	277,800	500	1,000	2,300	300	9,000	3,100	11,700	100	348,100
Greater Boston Area	1,700	42,700	12,400	60,500	19,800	1,430,800	200	1,300	12,700	1,800	34,000	11,700	3,400	1,900	1,634,900
Springfield Area	100	8,000	2,200	9,100	500	29,200	500	1,700	100	100	900	100	1,900	—	54,400
Total Trips	**14,100**	**1,681,100**	**386,900**	**857,400**	**53,200**	**4,109,400**	**22,300**	**141,900**	**48,000**	**93,800**	**297,200**	**348,100**	**1,634,900**	**54,400**	**9,742,700**

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	1,100	190,000	42,700	61,200	3,900	271,200	7,100	4,200	2,900	1,500	7,200	2,400	7,800	300	603,500
Greater Washington Area	190,000	293,200	269,600	831,300	36,100	2,392,400	119,300	39,100	41,100	32,800	126,300	50,800	137,200	11,800	4,571,000
Greater Baltimore Area	42,700	269,600	14,700	286,500	19,800	887,200	51,600	7,400	8,900	3,300	41,200	31,900	28,200	2,700	1,695,700
Greater Philadelphia Area	61,200	831,300	286,500	693,100	42,200	2,256,300	396,200	19,700	8,300	28,800	100,300	88,400	200,400	10,400	5,023,100
Leigh Valley Area	3,900	36,100	19,800	42,200	—	337,500	27,100	500	300	2,100	10,200	9,400	32,300	1,200	522,600
New York - North Jersey Area	271,200	2,392,400	887,200	2,256,300	337,500	1,210,000	202,400	118,800	192,400	720,300	434,200	495,800	1,541,400	142,600	11,202,500
South Central PA Area	7,100	119,300	51,600	396,200	27,100	202,400	25,600	11,000	4,500	6,500	16,400	7,400	13,200	3,500	891,800
Atlantic City Area	4,200	39,100	7,400	19,700	500	118,800	11,000	—	400	1,100	6,500	1,400	2,100	700	212,900
Poughkeepsie-Newburgh-Middletown Area	2,900	41,100	8,900	8,300	300	192,400	4,500	400	2,200	19,600	5,100	4,500	13,900	1,600	305,700
Greater Albany Area	1,500	32,800	3,300	28,800	2,100	720,300	6,500	1,100	19,600	2,600	14,700	7,500	20,600	2,000	863,400
Greater Hartford Area	7,200	126,300	41,200	100,300	10,200	434,200	16,400	6,500	5,100	14,700	15,100	58,800	192,600	4,000	1,032,600
Greater Providence Area	2,400	50,800	31,900	88,400	9,400	495,800	7,400	1,400	4,500	7,500	58,800	15,900	127,100	500	901,800
Greater Boston Area	7,800	137,200	28,200	200,400	32,300	1,541,400	13,200	2,100	13,900	20,600	192,600	127,100	81,000	18,000	2,415,800
Springfield Area	300	11,800	2,700	10,400	1,200	142,600	3,500	700	1,600	2,000	4,000	500	18,000	—	199,300
Total Trips	**603,500**	**4,571,000**	**1,695,700**	**5,023,100**	**522,600**	**11,202,500**	**891,800**	**212,900**	**305,700**	**863,400**	**1,032,600**	**901,800**	**2,415,800**	**199,300**	**30,441,700**

Annual Intercity Commuter 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	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater Baltimore Area	—	—	—	2,100	—	—	—	—	—	—	—	—	—	—	2,100
Greater Philadelphia Area	—	—	2,100	100	15,400	748,300	—	—	—	—	—	—	—	—	765,900
Leigh Valley Area	—	—	—	15,400	1,000	292,900	—	—	—	—	400	—	—	—	309,700
New York - North Jersey Area	—	—	—	748,300	292,900	4,022,600	—	97,800	14,100	—	46,400	—	—	—	5,222,100
South Central PA Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Atlantic City Area	—	—	—	—	—	97,800	—	—	—	—	—	—	—	—	97,800
Poughkeepsie-Newburgh-Middletown Area	—	—	—	—	—	14,100	—	—	—	—	—	—	—	—	14,100
Greater Albany Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater Hartford Area	—	—	—	—	400	46,400	—	—	—	—	—	—	—	—	46,800
Greater Providence Area	—	—	—	—	—	—	—	—	—	—	—	22,600	—	—	22,600
Greater Boston Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Springfield Area	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Trips	**—**	**—**	**2,100**	**765,900**	**309,700**	**5,222,100**	**—**	**97,800**	**14,100**	**—**	**46,800**	**22,600**	**—**	**—**	**6,481,100**

Source: NEC FUTURE team, 2016

Appendix D – MSA-to-MSA Level Regional Rail Trips for each Alternative

Table D-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 D-2: Regional Rail Linked Trips by MSA pair: Year 2040 Preferred 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	31,927,760	6,636,835	0	0	0	0	0	0	0	0	0	0	0	38,564,594
Greater Baltimore Area	6,636,835	454,682	0	0	0	0	0	0	0	0	0	0	0	7,091,516
Greater Philadelphia Area	0	0	36,386,392	0	0	1,293,816	12,580	0	0	0	0	0	0	37,692,788
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	174,420	0	0	0	0	0	0	0	174,420
New York - North Jersey Area	0	0	1,293,816	0	174,420	356,273,504	0	3,386,724	0	0	0	0	0	361,128,464
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	3,386,724	0	172,216	0	0	0	0	0	3,558,940
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	3,771,428	4,237,675	0	8,009,103
Greater Boston Area	0	0	0	0	0	0	0	0	0	0	4,237,675	42,288,988	0	46,526,663
Springfield Area	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**38,564,594**	**7,091,516**	**37,692,788**	**0**	**174,420**	**361,128,464**	**12,580**	**3,558,940**	**0**	**0**	**8,009,103**	**46,526,663**	**0**	**502,759,067**

Source: NEC FUTURE team, 2016

Appendix E – Track and Construction Type of the Preferred Alternative

Table E-1: Track and Construction Type of the Preferred Alternative

From	To	Approx. Distance (miles)	Total Number of Tracks (New Tracks)	Preferred Alternative Improvements	Predominant Construction Types
Existing NEC					
Washington Union Station	New Carrollton Station	9	2	Station: Washington Union Station Master Plan Improvement (Related Project) Chokepoint Relief: New Carrollton Station Systems Upgrade: High Density Signaling	At-grade and embankment; major bridge over Anacostia River
New Carrollton	Halethorpe Station	24	4 (1)	Chokepoint Relief: Odenton Station, BWI Station (Related Project) New Track: New Carrollton to Halethorpe System Upgrade: Seabrook, MD to Halethorpe, MD	At-grade through Prince George's County, MD; Embankment adjacent to Patuxent NWR; at-grade between Patuxent NWR and Halethorpe
Halethorpe Station	West Baltimore Station	4	4	System Upgrade: Halethorpe, MD to West Baltimore, MD	Trench, at-grade, embankment, and aerial structure
West Baltimore Station	Baltimore Penn Station	3	4 (2)	New Segment: New Baltimore Tunnel (Related Project)	Tunnel
Baltimore Penn Station	Bayview, MD	4	4	New Track: Union Tunnel System Upgrade: Broadway to Bayview Curve Mod: near Baltimore Penn Station	Tunnel, embankment, and aerial structure
Bayview, MD	Newport, DE	60	4-6 (2)	Chokepoint Relief: Newark, DE Station New Segment: Bayview to Newport New Track: Aberdeen to Havre de Grace, Newark to Newport Bridge Replacement: Bush River, Gunpowder River, Susquehanna (Related Project) System Upgrade: Bayview, MD to Gunpowder River; Bush River to Aberdeen, MD; Perryville, MD to Newport, DE	At-grade, embankment, aerial structure, trench, and tunnel through MD; at-grade through western New Castle County, DE; major bridges over Susquehanna, Bush and Gunpowder rivers.
Newport, DE	Edgemoor, DE	7	6 (2)	New Segment: Wilmington Segment	At-grade, embankment and aerial structure
Edgemoor, DE	Baldwin, PA	11	4	System Upgrade: Edgemoor, DE to Baldwin, PA	At-grade and embankment
Baldwin, PA	Philadelphia 30th St Station	13	6 (2)	Chokepoint Relief: Philadelphia 30th Street – Penn Interlocking New Segment: Philadelphia Segments: Baldwin, PA, to Philadelphia 30th Street Station; Philadelphia International Airport Station	At-grade and embankment
Philadelphia 30th St Station	Bridesburg, PA	12	6 (2)	New Segment: Philadelphia Segments: Philadelphia 30th Street Station to Bridesburg, PA System Upgrade: North Philadelphia, PA Curve Mod: near Bridesburg Rail Station	At-grade, embankment, major bridge and aerial structure
Bridesburg, PA	North Brunswick, NJ	40	4	Chokepoint Relief: Trenton Station and Yard Access System Upgrade: Bridesburg, PA to Trenton, NJ Curve Mod: near Holmesburg Rail Station	At-grade, embankment and aerial structure
North Brunswick, NJ	Secaucus, NJ	29	6 (2)	Chokepoint Relief: Metropark Station, Hunter Flyover (Related Project), Westbound Waterfront Connection New Segment: New Brunswick to Secaucus System Upgrade: North Brunswick, NJ to Secaucus, NJ	At-grade, embankment, aerial structure, tunnel, major bridge
Secaucus, NJ	Penn Station New York	8	4 (2)	New Segment: Secaucus/Bergen Loop, Hudson River Tracks (Related Project) System Upgrade: North Secaucus, NJ to Jersey City, NJ	Tunnel, embankment
Penn Station New York	Woodside, NY	6	6 (2)	Station: Expanded Penn Station New York New Segment: East River Tracks Curve Mod: Bronx County, near the I-95 and I-895 interchange; and near Pelham Bay Park	Tunnel, trench
Woodside, NY	New Rochelle, NY	12	4 (2)	Chokepoint Relief: New Rochelle (Shell Junction) New Track: Hell Gate Line between Queens and Bronx Counties System Upgrade: Woodside, NY to New Rochelle, NY Curve Mod: near New Rochelle Rail Station	Embankment and aerial structure
New Rochelle, NY	Greens Farms, CT	29	6 (2)	Bridge Replacement: Cos Cob, Norwalk River, and Saugatuck Movable Bridges New Segment: New Rochelle to Greens Farms System Upgrade: New Rochelle to Norwalk	At-grade, embankment, and aerial structure
Greens Farms, CT	Mill River, CT	30	4	Bridge Replacement: New Devon Bridge (Related Project) Chokepoint Relief: New Haven Station	At-grade; embankment, aerial structure and major bridge
Mill River, CT	Branford, CT	8	2	None	At-grade, embankment
Branford, CT	Guilford, CT	8	4 (2)	New Track: Branford to Guilford	Embankment

Table E-1: Track and Construction Type Profile of the Preferred Alternative

From	To	Approx. Distance (miles)	Total Number of Tracks (New Tracks)	Preferred Alternative Improvements	Predominant Construction Types
Existing NEC (continued)					
Guilford, CT	Old Saybrook, CT	15	2	Bridge Replacement: Shaw's Cove Movable Bridge	At-grade, embankment; major bridge crossings over Connecticut, Niantic, Thames, Mystic, Rivers
Old Saybrook, CT	Kenyon, RI	50	4 (2)	Bridge Replacement: Connecticut River Bridge New Segment: Old Saybrook-Kenyon	Tunnel, at-grade, embankment
Kenyon, RI	Davisville, RI	14	3 (1)	New Track: Kenyon to Davisville	Tunnel, at-grade, embankment
Davisville, RI	East Greenwich, RI	3	2	None	Embankment
East Greenwich, RI	Warwick, RI	4	4 (2)	New Track: East Greenwich to Warwick	At-grade and embankment
Warwick, RI	Pawtucket, RI	13	3	None	At-grade and embankment
Pawtucket, RI	Sharon, MA	6	4 (2)	New Track: Pawtucket, RI to Sharon, MA	At-grade and embankment
Sharon, MA	Hyde Park, MA	20	4 (2)	Chokepoint Relief: Canton Junction to Readville track and junction improvements New Segment: Neponset	At-grade and embankment
Hyde Park, MA	Boston South Station	12	3	Station: Boston South Station Expansion	Tunnel, trench, at-grade, embankment
Hartford/Springfield Line					
Mill River, CT	Quinnipiac River, CT	10	2	None	At-grade
Quinnipiac River, CT	Hartford, CT	20	2 (1)	New Track: New Haven to Hartford, CT (2 tracks (existing) electrification)	At-grade
Hartford, CT	Springfield, MA	30	2 (1)	New Track: Hartford, CT to Springfield, MA (2 tracks, electrification, track upgrades)	At-grade

Source: NEC FUTURE team, 2016
See Volume 1, Chapter 4 for additional information on the description and function of the Preferred Alternative improvements.