Technical Monograph: Transportation Planning for the Richmond–Charlotte Railroad Corridor

January 2004

Appendix C
Operations Analysis To Support Project Goals

Federal Railroad Administration
United States Department of Transportation

Appendix C
OPERATIONS ANALYSIS TO SUPPORT PROJECT GOALS

2020 Traffic Level Operations—Monte Carlo™ Simulations

Conflicts are likely when several services coexist on the same trackage. The reliability of all services can be jeopardized by the time lost as a result of these conflicts. Simulation of the entire interrelated system of the SEC between Richmond and Charlotte is the only valid methodology that can measure the impact of these conflicts.

Therefore, in addition to the TPC model, a model using the LOGSIM and MONTE CARLO™ simulation packages was developed for the FRA and Amtrak and modified to include the projects initially considered necessary to achieve the trip time and reliability goals.

The purpose of the simulations was to provide information as to:

- Where delays may occur;
- Where schedule changes can eliminate conflicts; and
- Where facility changes can eliminate conflicts.

Throughout this section the term "delay" is used to describe the additional time required to move a train between two points over and above the theoretically perfect TPC run for that type of train. The term does not refer to a "delay" from a schedule or published timetable that includes an acceptable "pad," which is described later in this section.

The MONTE CARLO™ simulator provides a large number of tabular reports to assist in analysis of the simulation. In addition, string lines of the simulation can be plotted for each simulation run using Amtrak's plotting program. The string lines visually depict the each train's performance and delays.

LOGSIM™

LOGSIM™, a train simulation program embedded in MONTE CARLO™, was developed to evaluate train operations scenarios in the densely traveled Northeast Corridor, was utilized to simulate projected 2020 intercity passenger, commuter, and freight train operations between Richmond, Virginia and Charlotte, North Carolina. Desired frequencies and headways[1] were utilized to develop preliminary schedules, which were later modified to integrate with intercity and freight operations and eliminate obvious conflicts. The train simulation used MONTE CARLO™ to vary performance to more closely replicate real world operations.

A number of individual train performance simulations and preliminary train operations models were created using several different track configurations to determine where the problem areas were likely to be located. Then, the train operations

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[1] As provided by Virginia Department of Rail and Public Transportation (VDRPT), Amtrak, North Carolina Department of Transportation (NCDOT), and CSX Transportation (CSX). Norfolk Southern (NS) schedules were developed using the best available information.

model was run through a series of iterations with various modifications to the track configuration (crossover configurations, siding and passing track locations, platform locations, etc.) with the goal of improving the overall operating performance of freight, commuter and intercity passenger trains. When it appeared that the overall performance had stabilized with an economically feasible track configuration, a full 7 day MONTE CARLO™ simulation[2] was run to observe the impact of various trains deviating from their assigned schedule on a random basis (a reflection of real-world conditions).

Simulation Methodology

The starting point for the simulation was to encode the planned 2020 facility into the MONTE CARLO™ format. Year 2020 schedules were obtained from each entity (VDRPT, NCDOT, CSX, and Amtrak[3]) and encoded into the model.

Intercity trains enter into the models on their scheduled departure times. When each train enters the system, the model determines whether it will depart the terminal on time or late. If late, the model determines how late by sampling historical departure statistics. Before leaving the terminal, each train's road performance factor is determined, varying from the minimum running time to about 3 percent greater than the minimum. This technique accounts for minor differences in locomotive performances and train handling. Thus the operation of the same train on successive days probably varies, as they do in actual operations.

Long distance Amtrak passenger trains were allowed to enter according to a historical distribution developed from a previous analysis of Amtrak data.

Using the dispatching rules encoded in the model for that train or a group of trains (having the same stopping pattern, for example) simulated an actual dispatcher controlling the operation. The train could be routed on regularly assigned tracks or other tracks if the former were not available. If no track was available, or if an interlocking was blocked, the train waits until a route was available. Trains were kept from following each other too closely just as they actually were by the signaling system.

Every main track crossover and turnout was represented in the model. When a train uses a crossover, either to reach an assigned track or because of contingencies, the additional time, if any, to use the crossover was accounted for by the model. Each interlocking route was blocked for a designated amount of time to preclude conflicting trains from using it simultaneously. The time consumed making station stops also was simulated.

Charlotte to Concord trains commuter trains also entered the model on their scheduled times. These trains were sampled for lateness and performance, and were routed in the same manner as intercity trains.

CSX and NS through and local freight trains randomly entered the simulation ranging from 30 minutes early to 1½ hour late. This gives a wide range of entry for both services. If an intermodal train selects a departure time placing it immediately behind a

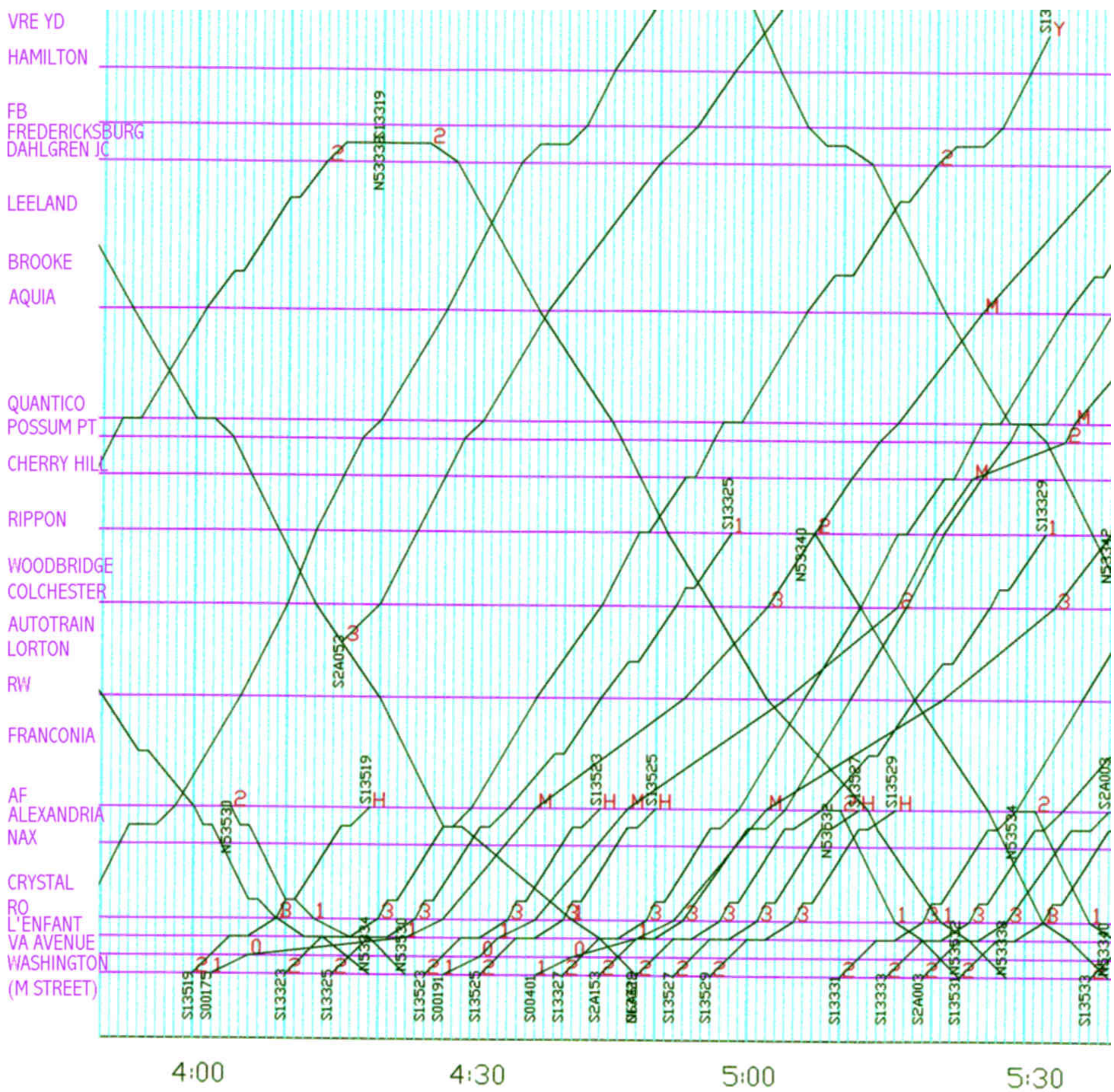
[2] Each scheduled train is entered into the model at the same time each day, but its entry into simulation is controlled by a random number generated within the simulator.

[3] NS did not provide schedule information.

regular freight train, the intermodal train was given priority at its origin, which a train dispatcher would normally do. These trains were sampled for lateness and performance, and were routed in a manner similar to intercity trains.

A typical plot of a simulation (drawn from the companion study of the Washington–Richmond Corridor) is shown in Figure C-1. Northbound trains departing the Fredericksburg area move from left to right down the page, while southbound trains departing Washington move from left to right up the page. The density of traffic southbound from Washington is clearly shown. The difference in speed of trains is shown by the variation in slope of the lines.

Figure C-1: Typical Simulation Stringline Plot



Simulation Results

Richmond to Charlotte

Seven days of simulated transit times of southward passenger trains operating between Richmond and Charlotte are displayed in Table C-1. The times included stops at Petersburg, Raleigh, Durham, Greensboro, and Charlotte I-485 for all trains. Each train was scheduled to have a three-minute dwell time at Raleigh, a two-minute dwell at Greensboro, and one-minute dwells at Petersburg, Durham, and Charlotte I-485. Trains NC06, NC07 and NC14, andNC15 stop at Henderson so their average times should be two to three minutes longer.

Table C-1

RICHMOND - CHARLOTTE

Trip times for Southbound Passenger Trains (hours: minutes)

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC07	4:09 (1)	4:23 (1)	4:12 (1)	4:08	4:13 (1)	4:20 (1)	4:08	4:13
NC11	4:03	4:09	4:22 (2)	4:19 (2)	4:18 (2)	4:07 (1)	4:09 (1)	4:12
NC15	4:19 (2)	4:15 (1)	4:26 (3)	4:23 (2)	4:08 (1)	4:10	4:22 (1)	4:17
NC17	4:13	4:11 (2)	4:24 (1)	4:15 (1)	4:13 (1)	4:18 (1)	4:17	4:15
								4:14

Notes: All trains stop at Petersburg, Raleigh, Durham, Greensboro, and I-485.

Trains NC07 and NC15 also stop at Henderson.

CHARLOTTE - RICHMOND

Trip times for Northbound Passenger Trains (hours:minutes)

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC02	4:13 (1)	4:13 (2)	4:19 (3)	4:30 (3)	4:26 (2)	4:14 (1)	4:27 (1)	4:20
NC06	4:22 (2)	4:24 (2)	4:17	4:17 (1)	4:22	4:13 (1)	4:17 (2)	4:18
NC10	4:15 (1)	4:13 (1)	4:11	4:28 (1)	4:25 (1)	4:19 (2)	4:18 (1)	4:18
NC14	4:22 (1)	4:37 (2)	4:12 (1)	4:20 (1)	4:18 (2)	4:26 (4)	4:27 (3)	4:23
								4:20

Notes: All trains stop at I-485, Greensboro, Durham, Raleigh, and Petersburg.

Trains NC06 and NC14 also stop at Henderson.

(#) Denotes the number of sidings entered.

The times indicate a wide variance in daily performance of the Richmond to Charlotte passenger trains. Northbound station-to-station times ranged from a minimum of four hours 11 minutes for five-stop NC10 on Day 3 to a maximum of four hours 37 minutes for six-stop NC14 on Day 14.

The results of a 49-day simulation also were analyzed to evaluate the reliability of the proposed timetable. The analysis indicated that the proposed four-hour 25-minute schedule for five-stop trains was attainable.

S Line- Richmond to Raleigh

Seven days of simulated transit times of southward passenger trains operating between Richmond and Raleigh are displayed in Table C-2. The times include a stop at Petersburg for all trains. Each train was scheduled to have a three-minute dwell time at Raleigh prior to departing for Greensboro. Trains NC07 and NC11 stop at Henderson so their average times should be two to three minutes longer. The “NC” trains operated at 110 mph MAS. The Star was operated at 90 mph because mail and express cars will be in the train, so their times will be greater.

Transit times were not the same each day. Even if trains receive no delay the times will not be the same for each run. All engineers do not operate their trains exactly the same and all locomotives, especially when being pushed to their limit, do not perform exactly the same way. Therefore before entering simulation each train randomly selects a performance factor - between zero and two percent greater than the minimum possible time. Therefore, if the minimum transit time was 100, minutes the time for a train having no delay en route can be expected to range between 100 and 102 minutes. Consequently, as in real life, the transit times were not consistent.

The simulated S Line was single track with passing siding spaced about fifteen miles center to center. When two trains of opposite directions approach each other one of the trains must slow down to enter one of the sidings to enable the trains to pass each other on the single-track line. The train that enters the siding runs through the length of the siding to the other end. If the other train has not passed the far end of the siding the train in the siding must stop and wait until the opposing train has passed. The length of time that the train in the siding waits was dependent upon the location of the other train, which varies from day to day. In the simulation the first train arriving at the siding was assumed to enter it. Therefore, when trains were scheduled to meet, one train may enter the siding on one day and the other may enter the siding the next day. Furthermore, even when trains were running close to their scheduled times, they may not meet at the same siding every day; they might meet at an adjacent siding.

Trains also may meet more than one train each day, therefore the number of sidings entered each day by each train is shown in parentheses in Table C-2. A (2) in the table signifies that the train that day entered two sidings. It can be expected that the transit times for trains that enter sidings will be as much as ten minutes per meet greater than trains that do not enter a siding. As a result a schedule that is based solely on the minimum possible time will be unreliable. An allowance must be added so the trains can make meets and be reliably on time.

The simulated time for northward trains also is shown in Table C-2. All trains stop at Petersburg and trains NC06, NC07, NC14and NC15 stop at Henderson.

The minimum transit times for freight trains are shown in Tables C-3. Four intermodal trains one-merchandise train were operated in each direction in each direction daily[4]. The intermodal trains perform no work between Fetner and Centralia. However it was assumed that the merchandise trains pick up and set off at Raleigh.

Table C-2

RICHMOND - RALEIGH

Trip times for Southbound Passenger Trains (hours:minutes)

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC07	1:58 (1)	1:58 (1)	1:57	1:53	1:53	1:59 (1)	1:53	1:55
NC11	1:50	1:56	1:58 (1)	1:55 (1)	2:00 (1)	1:56 (1)	1:51	1:55
NC15	1:58 (1)	1:59 (1)	2:06 (1)	1:53	1:53	1:55	1:53	1:56
NC17	1:59	1:50	1:59 (1)	1:57 (1)	1:59 (1)	2:00	2:00	1:57
								1:58
Silver Star (90 mph)	2:11 (1)	2:17 (1)	2:21 (1)	2:10	2:15 (1)	2:09	2:11	2:13

Note: NC07, NC15 stop at Henderson.

RALEIGH - RICHMOND

Trip times for Northbound Passenger Trains (hours:minutes)

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC02	1:53 (1)	1:52	1:58 (1)	2:00 (1)	1:58 (1)	1:52	1:58 (1)	1:55
NC06	2:00	1:59 (1)	1:54	1:55	1:56	1:55	1:59 (1)	1:56
NC10	1:57	1:53	1:53	2:01 (1)	2:07 (1)	2:01 (1)	2:00 (1)	1:58
NC14	2:04 (1)	2:00 (1)	1:54	2:02 (1)	1:54	2:08 (2)	2:09 (2)	2:01
								1:58
Silver Star (90 mph)	2:12	2:12	2:13	2:12	2:12	2:19	2:11	2:13

Note: NC06, NC14 stop at Henderson.

(1) Denotes the number of sidings entered.

[4] The trains enter the SEC at Fetner on the H line and exit the SEC at Centralia to the A Line.

Table C-3

RALEIGH - RICHMOND

Simulated Running Times For
CSX Freight Trains between Fetner and Centralia

Southbound

Train	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
CSX1	3:56	4:00	4:02	4:09	4:23	3:55	3:53	4:02
CSX3	4:52	4:33	4:45	5:41	5:33	5:05	4:20	4:58
CSX5	4:20	4:40	4:28	5:18	4:56	4:01	3:57	4:31
CSX7	5:04	5:15	4:48	4:45	5:01	4:52	4:38	4:54
ACHA	4:48	5:27	5:19	5:28	5:25	4:58	5:10	5:13
Average	4:36	4:47	4:40	5:04	5:03	4:34	4:23	4:44

RICHMOND - RALEIGH

Simulated Running Times For
CSX Freight Trains between Centralia and Fetner

Northbound

Train	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
CSX2	4:11	3:51	3:32	4:14	4:06	3:52	4:37	4:03
CSX4	4:19	5:07	3:45	3:47	3:33	4:30	*d.n.o*	4:10
CSX6	4:56	5:08	5:06	5:03	5:11	4:23	4:43	4:55
CSX8	2:54	3:26	3:27	3:26	3:35	3:27	3:32	3:23
HAAC	3:57	4:04	4:56	3:56	4:17	3:55	4:03	4:09
Average	4:03	4:19	4:09	4:05	4:08	4:01	4:13	4:08

The transit times for freight trains were highly variable. Freight trains meet passenger trains and other freight trains and were overtaken by passenger trains and other freight trains of the same direction. The simulation was programmed to ascertain that when two freight trains were to meet at a siding that two passenger trains would not meet at that siding too. Therefore, a freight train may stand in a siding to avoid this occurrence, which results in the larger variability in freight train transit times. The table indicates the number of sidings entered; however the reason for entering is not shown.

The daily usage of the S Line sidings during a seven-day period is displayed in Table C-4. Passenger train meets occurred exclusively between Burgess and Norlina, with the exception of the Silver Star, 0079 that used Greystone Siding once. Freight trains very seldom used Burgess Siding; almost exclusively passenger trains used it. The siding used each day by a passenger train varied widely, according to the amount of its lateness or the lateness of the passenger train it met. For example, NC14 on separate days used Burgess, Alberta, Bracey, or Norlina.

Unless a siding has a mid-siding crossover(s) three trains cannot be handled at the same siding. None of the sidings on the S Line were provided with mid-siding crossovers. Mid-siding crossovers may be installed as the number of freight trains increases or to improve the performance of freight trains, which would be held at distant sidings to avoid the stalemate that would result in three trains converging on a siding without a mid-siding crossover.

Dispatching Single Tracked Lines

Dispatching single tracked lines is often a difficult task for train dispatchers as speed differentials between trains create the biggest headache for dispatchers. The fastest of all trains were the passenger trains, which were to have preference over all other trains. The next in the speed ranking were the intermodal trains. Following the intermodal trains in speed were the merchandize trains. Next in the speed ranking were the drag freight and mineral freight trains. Last were the local freight trains, which often consume much time switching industries.

Siding lengths or lack of sidings also are a problem for dispatchers. Train lengths have often outgrown the length of many sidings. Meeting two trains at a siding that is not long enough to accept either train is a major mistake. The dispatcher's task is to weave all of the different train types through an often-inadequate facility to minimize delay to all classes. The faster trains are often delayed. The facility proposed for this study has been designed to ensure that a dispatcher has an adequate but not an excessive facility to work with.

Local freight trains must work between through-running trains. If sufficient time cannot be provided on a single track between through trains to accomplish the switching work, a non-signaled siding with hand-operated switches must be provided so the local freight train can switch industries without occupying the main track. Often local freight trains are scheduled to do their work when no or few through trains are operating. That may not always be acceptable to certain industries. In this study it was assumed that local freight trains would operate at the same time of day that they currently operate.

Long sidings to minimize delays and optimize train meets have been recommended. Through passenger and freight trains operating at three maximum speeds on the S Line were assumed: 110 mph high-speed passenger trains; the Silver Star at a maximum of 90 mph because it will be handling express cars and possibly Roadrailers; and CSX freight trains operating at 60 mph, grades and curves permitting. The manner in which single tracked lines were dispatched in the project simulations is presented in the following sections.

Table C-4

S Line Trains Using Sidings

By Location And Day

Location	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Avg.
Chester	ACHA	CSX2	CSX3	HAAC	CSX3	CSX4	ACHA	
	CSX2		CSX4				CSX4	
	CSX8							
Totals	3	1	2	1	1	1	2	1.57
Lynch	CSX4	CSX3	CSX3	ACHA	CSX3	ACHA	CSX3	
				CSX1	CSX5	CSX3		
				CSX3				

[Table C-4 continues on the next page . . .]

Table C-4 *[continued]*

S Line Trains Using Sidings

By Location And Day

Location	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Avg.
Lynch *[continued]*				CSX4				
				CSX5				
Totals	1	1	1	5	2	2	1	1.86
Burgess	NC06	CSX4	NC02	NC11	NC02	CSX8		
	NC07		NC11			NC11		
	NC14							
Totals	3	1	2	1	1	2	0	1.43
De Witt	CSX2	NC07	CSX4	CSX2	NC11	ACHA	CSX2	
	CSX4		NC17	CSX6	NC17	CSX4	NC02	
	CSX6			NC17		NC07	NC06	
Totals	3	1	2	3	2	3	3	2.43
Alberta	CSX7	CSX5	ACHA	CSX5	CSX5	ACHA	ACHA	
		CSX7	CSX3	CSX7		ACHA	NC14	
		NC06		NC02		CSX3		
		NC14				NC14		
Totals	1	4	2	3	1	4	2	2.43
Skelton	CSX2	ACHA	ACHA	CSX6	CSX1	CSX7	ACHA	
	CSX6	CSX3	CSX4	CSX7	CSX2		CSX2	
	CSX7	NC15	CSX7		CSX6		NC10	
	NC15				CSX7			
					NC10			
Totals	4	3	3	2	5	1	3	3.00
Bracey	ACHA	ACHA	0079	CSX1	0079	CSX2	CSX6	
	CSX7	CSX1	CSX2	CSX2	CSX4	CSX4	CSX7	
		CSX7	CSX6	CSX6	CSX6	NC10	NC14	
			CSX7					
			NC15					
Totals	2	3	5	3	3	3	3	3.14
Norlina	0079	ACHA	CSX1	CSX4	CSX2	CSX3	CSX1	
	CSX4	CSX5	CSX6	CSX7	CSX7	CSX6	CSX6	
	CSX5	CSX6	NC15	NC10		CSX7	CSX7	
		CSX7		NC14		NC14		
Totals	3	4	3	4	2	4	3	3.29
Greystone	CSX1	0079	CSX5	CSX3		ACHA		
	CSX6	CSX2	CSX7			CSX1		
		CSX7				F735		
Totals	2	3	2	1	0	3	0	1.57

[Table C-4 continues on the next page . . .]

Table C-4 *[continued]*

S Line Trains Using Sidings

By Location And Day

Location	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Avg.**
Kittrell	CSX2	CSX4	CSX3	CSX2	CSX3	ACHA	CSX2	
	CSX3	CSX6	CSX4	CSX3	CSX6	CSX3	CSX3	
	CSX6	CSX7	CSX6	CSX5	CSX7	CSX4	CSX5	
	F735		F735	F735		CSX5	CSX6	
				HAAC		CSX6	F735	
Totals	4	3	4	5	3	5	5	4.14
Youngsville	CSX3	CSX3	ACHA	F735	CSX1		ACHA	
	CSX5	CSX5	CSX5		CSX5		F735	
	CSX7	F735			HAAC			
	HAAC	HAAC						
Totals	4	4	2	1	3	0	2	2.29
Neuse	ACHA	ACHA	ACHA	ACHA	0079	ACHA	ACHA	
	CSX1	CSX1	CSX1	CSX1	ACHA	CSX1	CSX1	
	CSX3	CSX3	CSX3	CSX3	CSX1	CSX3	CSX3	
	CSX5	CSX5	CSX5	CSX5	CSX3	CSX5	CSX5	
	CSX7	CSX7	CSX7	CSX7	CSX5	CSX7	CSX7	
	F735	CSX8	CSX8	CSX8	CSX7	CSX8	CSX8	
		F711	F711	F711	F711	F711	F711	
		F735	F735	F735	F735	F735	F711	
					NC15		F735	
Totals	6	8	8	8	9	8	9	8.00

Southward Freight Train Dispatching - Southward Freight Train Approaching The North End Of De Witt Siding.[5]

Alberta siding is the next siding south of De Witt. The answers to the following questions determined whether the southward freight train could continue to Alberta. The answer to all of the questions had to be negative if the freight train was to continue. If the answer to any one of the several questions was affirmative the southward freight train must enter the De Witt siding

1. **Is an opposing (northward) train occupying the main track between the south end of Alberta siding and the north end of De Witt siding?** A yes answer would cause the southward train to be routed into the north end of the De

[5] For a more generalized, graphical presentation of this and similar dispatching situations, see the Annex at the conclusion of this Appendix.

Witt siding to prevent the two trains from attempting to occupy the single track between De Witt and Alberta.

2. **Is a northward opposing train occupying Alberta Siding?** A yes means that the next siding at Alberta was unavailable for southward train at De Witt, so the southward freight train will be routed into De Witt siding. Trains of the opposite direction cannot occupy the same siding unless a mid-siding crossover between the main track and the siding, which converts the siding into two sidings, was provided. A mid-siding crossover was not recommended at Alberta.
3. **Is a northward opposing passenger train, that will arrive at the south end of Alberta siding before the southward freight train at De Witt can run to and clear into Alberta Siding, at some point about 50 miles south of Alberta?** The purpose of the second question now becomes clearer. If the southward freight train at De Witt had been released when a northward freight train was in Alberta siding, the southward train would have had nowhere to go upon arrival at Alberta. The northward freight train would still be in Alberta siding waiting for the southward train, the northward passenger train would have arrived at Alberta and was standing on the main track beside the northward freight train and the southward freight train that had been released from De Witt was standing at the switch at the north end of Alberta siding facing both trains. This standoff cannot be allowed to occur. The option of routing the northward passenger train behind the freight train that was waiting to be overtaken was undesirable. Therefore, a yes answer to this question would cause the southward freight train to be routed into De Witt siding.
4. **Is a southward following passenger train, that would catch up to the southward freight train before it could run to and clear into Alberta siding, at some point about 20 miles north of De Witt?** A yes answer would cause the southward freight train to be routed into De Witt siding.

Referring to question 3, would a dispatcher actually route the southward freight train into De Witt siding because a northward passenger train was 50 miles away? At first the distance might seem excessive. The north end of De Witt siding was at MP S41 and the north end of the next siding at Alberta was near MP S55. The southward freight train would have to traverse those 14 miles plus another mile to clear into the Alberta siding before the northward passenger train arrives. The southward freight train will take 20 minutes at an average speed of 45 mph to cover the 15 miles. The northward passenger train must not be any closer than MP S60 or about 3 minutes from North Alberta Interlocking (MP S55) where the southward freight train would enter into the siding to avoid delaying the northward passenger train. Twenty minutes earlier a northward passenger train, averaging 90 mph, would have been at MP S90, thirty miles from MP S60, or 49 miles from North De Witt. Therefore, the dispatcher would have to route the southward freight train into De Witt siding when a northward passenger train was at MP S90, 50 miles away. If the average speed of the passenger train had been higher or the average speed of the freight train been lower, the distance would have been even greater, so 50 miles was the absolute minimum distance.

Referring to question 4, where must the northward passenger train be to enable the southward freight train to proceed to Alberta siding and clear the main track without delaying the southward passenger train? Again, the twenty-minute criterion applies. In this case, the southward passenger train can be no closer than MP S50 (five miles behind the southward freight train when it clears the main track at N De Witt, MP S55). Therefore, the southward passenger train would have to be at MP S20, thirty miles from MP S50, or twenty-one miles behind the northward freight train at De Witt. Again if the average speed of the passenger train had been higher or the average speed of the freight train been lower, the distance would have to be even greater, twenty-one miles was an absolute minimum distance.

Referring to question 2, if a northward freight train were in the Alberta siding for the northward passenger train described above, the southward freight train would enter De Witt Siding and wait for the passenger train to pass De Witt (possibly as long as 30 minutes). The southward freight train would also wait about 15 minutes to let the northward freight train to leave Alberta Siding and pass South De Witt.

The same four conditions that cause a southward freight train to enter De Witt siding also will hold the southward freight train in De Witt Siding until the answers to the questions were negative. The simulation model looks ahead of the freight train for opposing trains; behind the freight train for overtaking trains; and beside the freight train while waiting in the siding when making the decision whether to release a freight train.

Southward Passenger Train Dispatching

The simulation asks one question when a northward passenger train arrives at the south end of Alberta siding:

1. Is there an opposing (southward) passenger train occupying the main track between the north end of De Witt siding and the south end of Alberta Siding?
   - If the answer were yes the northward passenger train at the south end of Alberta siding was routed into Alberta siding to prevent the two passenger trains from occupying the single track between Alberta and De Witt.

The maximum delay for a meet between passenger trains was ten minutes.

What about an opposing freight train? Question 3 for freight trains at De Witt should prevent a southward freight train from being between De Witt and Alberta. If a southward freight train was proceeding between De Witt and Alberta, the northward passenger train would proceed to the north end of Alberta siding and wait for the southward freight train to clear into the siding at that point.

Existing CSX Operations at Raleigh

CSX operates two local freight trains per day north onto the S Line. The exact operating limits of the trains vary somewhat from day to day depending upon the workload. A typical pattern is described in the following paragraph below.

Train F735 leaves Raleigh first at about 9:00, runs to Henderson, works there for several hours, then serves industries between there and Norlina but rarely going as far as Norlina. At Norlina or some location short of Norlina Train F735 turns (changes direction of travel) and works back to Raleigh, spending a number of hours at Gill and Henderson. It arrives in Raleigh eight to eleven hours after departing Raleigh. Train F711 follows Train F735 from Raleigh at about 10:00 and works the industries short of Henderson, turns at about Wake Forest and returns to Raleigh, and arrives four to five hours after departure. Train F711 continues south from Raleigh working between Raleigh and Fetner and to Apex on the CSX and return. Train F745 departs Raleigh for Hamlet with cars from F735 and F711 at about 19:30, a number of hours after Trains F735 and F711 have arrived back in Raleigh. Train F745 returns from Hamlet at about 5:00 with cars for that day's F735 and F711.

Raleigh Station

Neither the present Raleigh station nor the old Seaboard station, located in North Raleigh on the S Line, will be used to support the recommended high-speed operation. Therefore, a new station to handle proposed intercity operations to be located west of existing Boylan Interlocking, the crossing with the old Norfolk Southern, will be required.

Proposed Operations Through Raleigh

Raleigh was one of the most complex dispatching locations in the entire route between Charlotte and Richmond. A detailed analysis of the proposed operation in the Raleigh area performed prior to developing the simulation model clearly indicated that the existing configuration would not support the proposed 2020 operations. It was concluded early in the analysis that the location of the proposed new intercity passenger station in Raleigh would result in train operations that could not be supported by the existing track configuration through downtown Raleigh. A revised configuration to support the proposed operation was developed.

Proposed CSX Operations

The 2020 NS and CSX freight trains are presented in Table C-5. CSX would operate two local freight trains per day north onto the S Line. The local freight trains would originate at Raleigh Yard in Raleigh. The exact operating limits of the local freight trains would vary somewhat from day to day depending upon the workload. The second local freight train turns at about Wake Forest and continues south from Raleigh working between Raleigh and Fetner and to Apex on the CSX Line and returns to Raleigh Yard. As initially scheduled the second local freight train received a large number of significant delays because of conflicts with daylight passenger and freight trains. Therefore, it was rescheduled to leave Raleigh at 1:00 a.m. when passenger trains were not operating.

A freight train departs Raleigh for Hamlet, NC with cars from the two local trains and returns to Raleigh Yard from Hamlet with cars for that day's local trains. A northward and a southbound merchandise train HAAC/CAHA (Hamlet/Acca) would operate between Fetner and Centralia; the trains would work at Raleigh.

Four northbound and four southbound CSX intermodal trains were assumed to operate uniformly during the day between Fetner and Centralia. The trains were assumed to randomly enter the corridor between the time entered and two hours later. These trains would not work at Raleigh.

Table C-5
CSX/NS Freight Trains Originating-Operating Through Raleigh

	Train	From	To	Type	
CSXT	CSX2	Fetner	Richmond	Intermodal	*Northbound*
CSXT	CSX4	Fetner	Richmond	Intermodal	*Northbound*
CSXT	CSX6	Fetner	Richmond	Intermodal	*Northbound*
CSXT	CSX6	Fetner	Richmond	Intermodal	*Northbound*
CSXT	HAAC	Fetner	Richmond		*Northbound*
NS	LINS	Linwood	Chocowinity		*Northbound*
NS	LIRA	Linwood	Raleigh		*Northbound*
NS	WSRA	Winston-Salem	Raleigh		*Northbound*
CSXT	ACHA	Richmond	Fetner		*Southbound*
CSXT	CSX1	Richmond	Fetner	Intermodal	*Southbound*
CSXT	CSX3	Richmond	Fetner	Intermodal	*Southbound*
CSXT	CSX5	Richmond	Fetner	Intermodal	*Southbound*
CSXT	CSX7	Richmond	Fetner	Intermodal	*Southbound*
NS	NSLI	Chocowinity	Linwood		*Southbound*
NS	RALI	Raleigh	Linwood		*Southbound*
NS	RAWS	Raleigh	Winston-Salem		*Southbound*
CSXT	F711	Raleigh	Norlina	Local	*Turn*
CSXT	F735	Raleigh	Wake Forest	Local	*Turn*
NS	LCL6	Raleigh	Pomona	Local	*Turn*

Proposed NS Operations At Raleigh[6]

Four southbound NS and three NS northbound trains were assumed to operate between Glenwood Yard and Greensboro daily.

A local freight train would work between Raleigh and Pomona Yard in Greensboro[7]. The train would serve industries on the branch between Glenn (on the H Line at MP H46.8) and Carrboro. This train was initially scheduled to work during daylight hours, but with the large number of passenger trains the local freight train would not reach Greensboro in less than twelve hours; therefore, its schedule was changed to depart Raleigh at five p.m.. Since nearly all of the industrial sidings between Raleigh and Greensboro are trailing[8] going west, an eastward counterpart local freight has not been scheduled. Local service to the few trailing switches going east was assumed to handled by a Linwood to Raleigh train.

Northbound and southbound trains (NSLI/LINS) would operate through Raleigh between Chocowinity (located on the original NS line south of Raleigh) and Linwood

[6] NS did not provide data on freight service schedules or the locations where trains work and the times that work is performed.

[7] Locations where this train works and the switching times have been assumed based on an inventory of sidings shown on NS track charts and an inspection of photographs, which indicated sidings that were presently being serviced. NS did not provide the manner in which NS actually operates its local service on the H Line.

[8] A phrase indicating that the turnout to the siding is located so that a local freight can back into the siding to set off and pick up cars.

Yard via Raleigh. Northbound and southbound trains (RAWS/WSRA) would operate between Raleigh and Roanoke via Winton-Salem. Northbound and southbound freight trains (RALI/LIRA) would operate between Raleigh and Linwood.

All of these trains randomly entered the system at the scheduled time up to two hours late.

Additional trains may leave Glenwood Yard but only daily northbound and southbound freight trains (RAFA/FARA) that operate between Raleigh and Varina/Fayetteville were simulated. Each train crossed the SEC and significantly impacted SEC train operations[9].

Raleigh Station

A new station to handle proposed intercity operations was located west of existing Boylan Interlocking, the crossing with the old Norfolk Southern to Varina. A new interlocking, Ashe (for Ashe Avenue) would facilitate train operations south of the new station. A low-level, 24-foot wide center-island platform was located between Tracks 2 and 4. A second platform was located adjacent to a new Track 1 between Ashe and Boylan. Track 4 would normally be a freight track but it also was used passenger trains. Track 4 may require that the existing stub ended siding south of Boylan Junction be relocated.

The rigid crossing frogs at Boylan Interlocking are recommended to be removed to enable adequate spirals and superelevation to be installed in the ten-degree curve between Boylan and Hargett Street on the S Line. Speed on the 10-degree curve was raised from the current 10 mph to 30 mph on tracks 1 and 2. The same progressive route that the crossing currently provides from Glenwood Yard through Raleigh to Varina on the original NS Railway was provided by:

1. The crossovers between Tracks 1 and 2 at Southern Junction, located on the S Line west of the entrance to Glenwood Yard, and
2. A new Track 4 between Boylan Interlocking and Southern Junction Interlocking.

It was assumed that the single track between Crabtree and Edgeton on the S Line north of Raleigh Yard would remain because of a major bridge over Crabtree Creek, however double track was restored between Edgeton (actually south of the Edgeton curve (Curve S154.1)) and Southern Junction. The restoration of the double-track was essential if fluid trains operations are to be provided through Raleigh. The south entrance to Raleigh Yard, located south of MP S156, would have hand-operated switches but the lead to the NCDOT Yard off S Line Track 1, located at Peace Street, was interlocked to facilitate Charlotte to Richmond passenger trains moves. Northward trains to both Raleigh Yard and the NCDOT Yard would operate on Track 1 between Southern Junction and the switches leading to the Raleigh and NCDOT yards.

The complexity of rail operations through Raleigh was the result of the combination of:

- Passenger, through freight, and local freight train operations between Fetner on the H Line and Youngsville, on the S Line, 31 miles apart;

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[9] NS did not provide data on the freight service that operates between Raleigh and Goldsboro. It was assumed this service would not significantly impact SEC train operations; therefore, it was not simulated.

- Yard operations in the vicinity of the NS Glenwood Yard, and the CSX Raleigh Yard, and
- Raleigh passenger station.

A track configuration with the flexibility and capacity to enable the trains to operate reliably through the complex freight and passenger terminal location was recommended. The NS and CSX lines between Fetner and Southern Jct must be considered interchangeable to minimize train conflicts and facilitate access to and from the routes that converge at Raleigh.

The operation was further complicated by the need for CSX and NS dispatchers to coordinate the movement of trains between the various lines

Ashe Interlocking (H79.3)

Northward passenger and freight trains could be routed to six destinations from Ashe Interlocking:

1. NS freight trains to Glenwood Yard
2. CSX freight trains to Raleigh Yard
3. NS freight or Amtrak trains to the H Line toward Selma
4. CSX freight trains to north of Raleigh on the S Line
5. Amtrak trains to north of Raleigh on the S Line
6. Amtrak trains to the NCDOT Yard adjacent to CSX Yard at Raleigh.

NS and CSX Northward Freight Trains To Glenwood and Raleigh Yards

NS and CSX northward freight trains to Glenwood Yard and Raleigh Yard could not move from Ashe Interlocking to any track if a northward freight train was occupying any part of Ashe, Boylan, or Southern Junction Interlockings. A northward freight train could not move north of Ashe Interlocking to enter either yard if:

- Either a southward freight train was ready to depart from Glenwood Yard[10], or
- A southward passenger train was located between Youngsville (on the S Line) and Southern Junction, a distance of nineteen miles or approximately 15 minutes.

A northward freight train may enter Track 4 at Ashe between Ashe and Southern Junction provided that Track 4 was clear.

The fifteen minutes clearance time for southward passenger trains from Youngsville may seem excessive, but it was necessary to allow time for the following sequence of events:

1. Five minutes for the head of the freight train to operate between Ashe Interlocking and Southern Junction Interlocking, more than one mile (at about 20 mph.)
2. Six minutes to enable the rear of a mile-long freight train to pull clear of Southern Junction Interlocking at yard speed (10 mph.)
3. Four minutes to realign the switches and display a signal so that the distant signal to Southern Junction Interlocking to display its best aspect to the engineer of the passenger train.

[10] Raleigh Yard for northbound CSX freight trains.

Northward trains routed to Track 4 at Ashe or northward trains from the original NS Line at Boylan may operate into Glenwood Yard[11] at Southern Junction if the following conditions simultaneously exist:

1. No southward passenger train on the S Line was less than 10 minutes from Southern Junction;
2. No northward passenger train was located less than ten minutes from Southern Junction. Usually that was true when no northward passenger trains are by Fetner;
3. No southward train was ready to depart from Glenwood Yard or Raleigh Yard within 45 minutes.
4. A track in Glenwood Yard or Raleigh Yard was available to receive the train.
5. Glenwood and Raleigh Yards were beyond the limits of the model, so that assumption was necessary. It was assumed that holdouts[12] would not exist at Glenwood or Raleigh Yards or that trains would not have to double into the yard because of a track long enough to hold the entire train was not available[13].

Eastward H Line Freight Trains and Northward Freight Trains From The Original NS At Boylan To The H Line East Of Raleigh

Presently southward trains on the S Line do not impact Amtrak trains destined for the H Line east of Raleigh, the third destination for eastward freight trains from Ashe. After Amtrak trains are transferred to the restored S Line the potential for conflict would increase. Freight trains to the H Line at Ashe towards Selma must enter Track 4 at Ashe and it was necessary that:

1. Ashe and Boylan Interlockings were free of all northward trains
2. Track 4 was free between Boylan and Southern Junction (the rear of train between these two interlocking would block the dividing switch at Boylan).
3. There were no preceding or opposing trains on the H Line to Selma.

Northward freight trains from the original NS at Boylan to the H Line east must meet the same four conditions as the trains at Ashe.

Northward CSX Freight Trains to the S Line/Northward NS Freight Trains to Glenwood Yard

Southward trains would not affect northward S Line/NS freight trains at Ashe. Ashe, Boylan, and Southern Junction Interlockings must be clear of northward trains to enable these trains to proceed. The requirement that the segment of Track 2 (northward track) between Southern Junction and Edge Interlockings must be clear before a northward freight train receives a route at Ashe provides an added complexity to train operations in Raleigh. Northward CSX merchandise freight trains (HAAC) were assumed to make a pick up or setoff at Raleigh Yard from Track 2. Northward freight

[11] The same conditions must exist for a CSX freight train from Track 4 at Ashe to Raleigh Yard.

[12] Freight trains are not prevented from directly entering the yard upon arrival at the yard because of the lack of track space.

[13] Data has not been provided by Norfolk Southern to indicate that freight trains are regularly held out of Glenwood Yard.

trains also may have to wait on this segment for southward trains or to be overtaken by northward passenger trains. This may cause a complication that would arise when:

- A northward freight train was occupying Track 2 between Southern Junction and Edgeton, and
- A southward freight train also was occupying Track 1 between the same points at the same time because one or the other freight trains was waiting to be overtaken by a passenger train.

Holding the freight train on Track 2 between Fetner and Ashe creates a single track between Fetner and Ashe. Pulling the second freight train onto Track 2 between Ashe and Southern Junction beside the train on Track 4 was the better solution, if only one passenger train was involved. The second freight train blocks Track 2 at Raleigh station, creating either a one-mile single track between Ashe and Southern Junction on Track 1 or a two-mile single track between Ashe and Crab, depending upon the direction of the passenger train. If two passenger trains were involved, the best solution was to hold the second northward freight out of Raleigh altogether on one of the recommended passing sidings at Cary.

Southward Freight Trains to Fetner

A southward freight from Glenwood Yard to Fetner entered the corridor at Southern Junction Interlocking if five conditions[14] were satisfied:

1. A northward train was not on the southward track between Fetner and Ashe, this was the preferred route for northward passenger trains
2. A southward train, including a passenger train, was not between Southern Junction and the new Ashe Interlocking. The distance between the two points is 7000 feet; therefore, a long southward freight train with its head end at Ashe may not be clear of Southern Junction.
3. A southward train that has passed Crab Interlocking (on the S Line) but has not either passed Southern Junction Interlocking or cleared into the CSX Raleigh Yard
4. A southward passenger train would not pass Southern Junction in the next 30 minutes
5. A southward freight train was not waiting to be overtaken by the passenger train listed in Rule 4 on Track 1 between Edgeton and Peace Street.

Southward CSX freight train movements must satisfy only the first four conditions.

The distance between Edgeton and Peace Street was sufficient that most southward freight trains may stand between the two locations without the rear of a train blocking Edge. Therefore, southward passenger trains could use Track 2, provided that it was not occupied, between Edgeton and Southern Junction or Boylan to run around a southward CSX freight train. **Therefore, restoring the second track between Edgeton and Southern Junction was essential.**

[14] The same rules also would apply to a southward CSX train leaving the CSX Yard.

Simulation Of Raleigh Operations

The freight train delays in a seven-day simulation period are shown in Table C-6. The table includes the length of the delays and the reason for the delay. New track 4, north of Ashe Interlocking, provided a location for northward freight trains to stand while waiting for a route northward to NS Glenwood Yard, the CSX Raleigh Yard, or the S Line.

Track 4 between Southern Junction and Boylan was the normal route for trains RAFA and FARA, the NS Raleigh to Fayetteville turn. These trains were not delayed on Track 4 although Train FARA was held on the original NS line up to twenty-one minutes on four of the seven days before being allowed to enter Track 4. In each case the delay was to allow passenger trains to pass Southern Junction first.

On six of the seven days NS train WSRA was delayed entering Glenwood Yard awaiting NS trains RAWS and LCL6 to depart Glenwood Yard. On days 2, 3, and 4 passenger trains and CSX freight moves caused addition delays for WSRA. On day 7 NS train RALI into Glenwood Yard was delayed to allow NS train NSLI to depart from Glenwood Yard. On days 4 and 7 NS train LIRA was delayed to let Trains NC04 and NC07 pass Southern Junction. NS Local freight LCL6 was delayed each day to follow RALI.

CSX trains CSX6 and HAAC were delayed on Track 4 on various days so that they could follow passenger trains NC12 and NC16 north through Southern Junction. On day 1 CSX6 also waited for NC15 and CSX5 to come off the S Line. CSX local freight train F711 was routed to Track 4 at Ashe for a number of different reasons prior to entering CSX Yard. On Days 2 and 4 F711 was routed to Track 4 to let NC10 pass Southern Junction first and on Day 7 it was routed to Track 4 for NC15.

New Track 4 was used as intended in the simulations and was essential to support proposed future operations.

Thirteen Richmond-bound CSX freight trains were delayed on Track 2 between Southern Junction and Edgeton to permit southbound passenger and freight trains to clear the single-track between Crabtree and Edgeton. Restoration of Track 2 between Southern Junction and Edgeton was essential.

Five NS freight trains (RAWS) departing from Glenwood Yard were delayed to allow southward passenger trains to proceed up the grade to Fetner first. NS Local freight LCL6 was delayed each day to follow RAWS. CSX freight train F711 was delayed three days departing from Raleigh Yard to follow NC01 up the grade to Fetner. The delays departing from NS Glenwood and CSX Raleigh Yards were less than expected.

Table C-6

REASONS FOR FREIGHT TRAIN DELAYS AT RALEIGH

Day	Road	Train	From	To	Reasons
Track 4 - Boylan to Southern Junction					
1	CSX	F711	1623	1625	NC10 north
1	NS	WSRA	1731	1837	Waits for RAWS to depart from Glenwood Yard
1	NS	FARA	1912	1927	NC14 north
2	CSX	CSX6	1819	1849	NC15 south, NC12 north, CSX5 from S Line
2	NS	FARA	1846	1901	Off NS, waits for CSX6 blocking
2	NS	WSRA	2159	2414	NC17 south, Note 1, NC18 north, ACHA
3	NS	FARA	1829	1845	NC12 to NCDOT Yard
3	CSX	HAAC	2117	2132	NC16 to NCDOT Yard
3	NS	WSRA	2157	2408	NC17 south, Note 1, NC18 north, ACHA
4	NS	LIRA	1020	1058	NC04 to NCDOT Yard, NC07 south
4	CSX	F711	1623	1636	NC10 north
4	NS	WSRA	2204	2306	NC17 south, Note 1
5	NS	WSRA	2159	2341	NC17 south, Note 1, NC18 north
6	NS	LINS	1127	1227	NSLI from Glenwood, NC06 north
6	CSX	HAAC	2110	2135	NC16 to NCDOT Yard
6	NS	WSRA	2200	2302	Note 1
7	NS	LIRA	820	842	NC02 north
7	NS	LINS	1141	1227	NSLI from Glenwood, NC06 north
7	CSX	F711	1747	1756	NC15 south
7	CSX	CSX6	1813	1836	NC12 to NCDOT Yard
7	NS	FARA	1822	1843	From NS CSX6 blocking
7	NS	WSRA	2221	2304	Note 1
	Note 1: Waits for RALI and LCL6 to depart from Glenwood Yard before yarding.				
Track 2 - Southern Junction to Edgeton					
1	CSX	CSX6	1812	1854	NC15 and CSX5 off S Line
2	CSX	CSX4	1242	1321	CSX3 off S Line
2	CSX	HAAC	2102	2104	Silver Star off S Line
3	CSX	CSX6	1803	1843	CSX5 and F735 off S Line
3	CSX	HAAC	2203	2233	CSX7 off S Line
4	CSX	CSX2	755	812	CSX1 off S Line
4	CSX	CSX6	1754	1823	NC15 and F735 off S Line
4	CSX	HAAC	2245	2247	CSX7 off S Line
5	CSX	CSX2	858	923	CSX1 off S Line
5	CSX	CSX6	1739	1747	F735 off S Line

[Table C-6 continues on the next page.]

Table C-6 *[continued]*

REASONS FOR FREIGHT TRAIN DELAYS AT RALEIGH

Day	Road	Train	From	To	Reasons
6	CSX	CSX6	1802	1845	NC15, CSX5, F735 off S Line
6	CSX	HAAC	2202	2244	NC17, CSX7 off S Line
7	CSX	CSX2	854	912	CSX1 off S Line
Departing NS Glenwood Yard					
1	NS	RAWS	1756	1834	Follows NC15 up Fetner Hill
1	NS	LCL6	2215	2300	Follows RALI
2	NS	LCL6	2215	2312	Follows RALI
3	NS	RAWS	1745	1813	Follows NC15 up Fetner Hill
3	NS	LCL6	2215	2307	Follows RALI
4	NS	RAWS	1752	1808	Follows NC15 up Fetner Hill
4	NS	LCL6	2216	2303	Follows RALI
5	NS	LCL6	2215	2317	Follows RALI
6	NS	RAWS	1747	1813	Follows NC15 up Fetner Hill
6	NS	LCL6	2215	2259	Follows RALI
7	NS	RAWS	1752	1811	Follows NC15 up Fetner Hill
7	NS	LCL6	2216	2301	Follows RALI
Departing CSX Yard					
1,2,3					No delays
4	CSX	F711	532	601	NC01 goes south first
5	CSX	F711	538	601	NC01 goes south first
6	CSX	F711	548	601	NC01 goes south first
7					No delays

The One-Percent Ascending Grade to Fetner

A freight train would take approximately twenty-five minutes from the time from when the locomotive enters the main track at Southern Junction until the rear of the train passes Fetner. It would take at least five minutes for a mile long freight train to clear the yard tracks at Southern Junction. When the rear of the train clears Southern Junction the front of the train was at or by Ashe Interlocking. Normally a freight train would accelerate to track speed after clearing the yard track. However, at Southern Junction, a freight train was on an ascending one percent grade. TPC simulations indicated that freight trains close to their maximum tonnage accelerate to only 14 to 15 mph for the first four miles south of the yard track. A new passing siding located just south of Fetner Interlocking on the H Line enables a southward passenger train to overtake a southward freight train. If this new siding did not exist the freight train would have to run to Durham Yard ahead of a passenger train, and the window before the arrival of a southward passenger train at Southern Junction was much greater than 30 minutes, possibly as much as an hour.

Therefore, a freight train was held at Southern Junction until all five conditions were simultaneously met.

An NS freight train would not move from the H Line east of Boylan to Fetner unless the same five conditions were satisfied, however, a sixth condition was necessary:

- A northward train may not be between Fetner and Ashe on either track.

This conflict did not occur. An NS train moving from the H line east to the original NS Line at Boylan only required that Track 4 between Ashe and Southern Junction be clear.

Conclusion

Raleigh will be a busy and complex rail operation. The operation will be further complicated by the need for CSX and NS dispatchers to coordinate the movement of trains between the various lines.

H Line and Piedmont Main Line – Raleigh to Greensboro to Charlotte

Seven days of simulated transit times of southward passenger trains operating between Raleigh and Greensboro are shown in Table C-7. Seven days of simulated transit times of northward passenger trains between Greensboro and Charlotte are displayed in Table C-8. The times include a two-minute stop at Durham and Greensboro for all trains. Every Charlotte to Richmond and Charlotte to Raleigh trains was assumed to stop at the I485 beltway station in Charlotte so their average times should be two to three minutes longer.

H Line

The H Line is double tracked between Raleigh and Fetner, sidings have been provided at Cary, Durham, Funston, Efland, Graham, McLeansville, and English between Fetner and Greensboro to enable passenger trains to overtake freight trains or meet passenger or freight trains. The simulations results indicate that the schedule simulated resulted in numerous meets between passenger trains south of Durham.

Cary Siding

The simulation model assumed that northward passenger trains normally used the southward track (the existing CSX main track) from Fetner into Raleigh to avoid a diverging move at Fetner. If no southward trains are present at Raleigh a passenger train may use the platform located adjacent to the southbound main track. If this occurs a passenger train may not have to diverge until either entering the NCDOT Yard at Peace Street or crossing to the northbound S-Line Main track at Southern Junction to proceed northward to Richmond. Since the speed would be 30 mph around the ten-degree curve between Boylan and Southern Junction, a passenger train diverting at Southern Junction would not encounter a time penalty. A diverging move to access the northward platform at the relocated Raleigh Station was assumed to be made at Ashe Interlocking as a passenger train braked for a station stop at Raleigh. In the simulation

Table C-7

RALEIGH - GREENSBORO

Trip times for Southbound Passenger Trains (hours:minutes)

INTERSTATE

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC07	1:03	1:03	1:07 (1)	1:03	1:08 (1)	1:14	1:03	1:05
NC11	1:03	1:04	1:07 (1)	1:14 (1)	1:11 (1)	1:04	1:11 (1)	1:07
NC15	1:11 (1)	1:05	1:13 (2)	1:23 (2)	1:07 (1)	1:08	1:18 (1)	1:12
NC17	1:03	1:10 (2)	1:07	1:04	1:04	1:08 (1)	1:04	1:05
								1:07

Note: Includes dwells at Durham and Greensboro.

INTRASTATE

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC01	1:07	1:11	1:11	1:11 (1)	1:07	1:08	1:07	1:08
NC03	1:07	1:12 (1)	1:07	1:20	1:20	1:13 (1)	1:15 (2)	1:13
NC05	1:07	1:14 (2)	1:16 (1)	1:14 (2)	1:15 (2)	1:14 (2)	1:07	1:12
NC09	1:08	1:12 (1)	1:08	1:08	1:14 (2)	1:07	1:07	1:09
NC13	1:08	1:12	1:07	1:08	1:11	1:08	1:13 (1)	1:09
								1:10

Note: Includes dwells at Greensboro, Burlington, Durham, and Cary.

(#) Denotes the number of sidings entered.

only about half of the passenger trains operated into Raleigh from Fetner as assumed. The remaining trains found opposing trains occupying the southward track.

Brassfield Siding

This siding arrangement enabled:

- A freight train to be working at the yard and for two passenger trains to meet at the same time, or
- For a southward freight train to wait clear of the main track while a northward freight was working at Durham Yard.

A northward freight train waited at Funston Siding for a southward freight train to finish working at Durham Yard.

Table C-8

Charlotte (Downtown Station) - Greensboro

Trip times for Northbound Passenger Trains (hours:minutes)

INTERSTATE

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC02	1:10	1:10 (1)	1:10 (1)	1:10 (1)	1:22	1:10	1:21	1:13
NC06	1:11	1:11	1:08	1:10	1:09	1:08	1:06	1:09
NC10	1:06	1:10	1:17	1:09	1:15	1:06	1:08	1:10
NC14	1:12	1:18	1:09	1:13	1:10 (1)	1:06 (1)	1:12 (1)	1:11
								1:10

Note: Includes dwells at I-485 and Greensboro.

INTRASTATE

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
NC04	1:23	1:21	1:28	1:19	1:20	1:19	1:24	1:22
NC08	1:13	1:17	1:15	1:13	1:18	1:14	1:15	1:15
NC12	1:14	1:14	1:23	1:14	1:13	1:16	1:16	1:15
NC16	1:31 (1)	1:15	1:13	1:20	1:19 (1)	1:22 (1)	1:16 (1)	1:19
NC18	1:18 (1)	1:14	1:15	1:18	1:15	1:15 (1)	1:27	1:17
								1:17

Notes: Includes dwells at I-485, Kannapolis, Salisbury, High Point, and Greensboro.

Train NC16 used the Bowers center siding on Days 1 and 6.

WASHINGTON TRAINS (90 mph)

Train	Day1	Day2	Day3	Day4	Day5	Day6	Day7	Average
2	1:26	1:29	1:30	1:26	1:29	1:26	1:29	1:27
20	1:32	1:23	1:24	1:24	1:23	1:32	1:24	1:26
								1:26

Note: Includes dwells at I-485, Salisbury, and Greensboro.

(1) Meets on siding at Greensboro station.

Efland-Mebane Siding

Simulations indicated that two passenger trains and a freight train often met at this location. The long siding was advantageous because it also enabled a passenger train to meet one freight train and overtake another.

Center Sidings

The Funston-Glenn siding and the Efland-Mebane sidings would be constructed with a pair of mid-siding crossovers located at Glenn and Mebane, respectively. The crossovers facilitated meets at the sidings and enabled each siding to be operated as either two separate sidings or one long siding.

A southward passenger train approaching the Efland siding entered the north end of the siding at Efland for a meet with a northward passenger train unless:

- The northward passenger train was already in or entering the Mebane portion of the siding, or
- The Efland portion between Efland and Mebane was occupied by a southward freight train.
- In those cases the southward passenger train continued on the main track.

After entering the Efland siding a southward passenger train ran to the mid-siding crossover at Mebane and entered the Mebane portion of the siding, provided a northward opposing train was not occupying the Mebane portion of the siding, and exited at South Mebane to maximize the probability of creating a non-stop meet. If a northward freight train occupied the Mebane portion of the siding, the southward passenger train reentered the main track at the mid-siding crossover at Mebane after the northward passenger train had passed Mebane. Freight trains always reentered the main track at the mid-siding crossover.

Three-Train Meets

A three-way meet of a southward passenger train, a southward freight train, and a northward passenger train occurred as follows:

- The southward freight train occupied the Efland siding,
- The southward passenger train entered the Mebane portion of the siding at the mid-siding crossover at Mebane, unless
    - The train to be met has entered the siding or was entering it at South Mebane, in that case
    - The southward train continues on the main track to South Mebane.

The daily usage of the H Line sidings during a seven-day period is displayed in Table C-9. Six to seven passenger trains entered either the Efland-Mebane siding or the Funston-Glenn siding each day.

The schedule simulated determined the locations where passenger trains meet. The proposed schedule resulted in most meets passenger train meets occurring at either the Funston-Glenn Siding or the Efland-Mebane Siding. Because of the large number of meets at these sidings an evaluation was performed to determine whether to recommended that the north and south ends of both sidings be installed with Number

32 (80 mph) turnouts and that the Efland-Mebane siding have main track speed limits. A cost-effectiveness analysis, described in Appendix G, concluded that Number 20 turnouts should be installed and that the siding would not be realigned. A large portion of the Funston-Glenn siding would be on the original roadbed so it would have a lower speed. Number twenty crossovers also would be installed at the mid-siding locations.

Table C-9

H Line Trains Using Sidings

By Location And Day

Location	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Avg.
Boylan	F711	CSX6	F711	LIRA	WSRA	LINS	LIRA	
	WSRA	WSRA	HAAC	F711		WSRA	F711	
			WSRA	WSRA			CSX6	
							LINS	
							WSRA	
Totals	2	2	3	3	1	2	5	2.57
Cary	WSRA	LINS	LINS		LINS	LINS		
		LIRA	NC15					
Totals	1	2	2	0	1	1	0	1.00
Brassfield	NC15	NSLI	LIRA	LIRA	NSLI	LIRA	LIRA	
			NSLI	NSLI			NC15	
							NSLI	
Totals	1	1	2	2	1	1	3	1.57
Funston-Glenn	LINS	LINS	NC07	LINS	LINS	LINS	LINS	
	NC06	NC14	NC11	NC11	NC07	NC06	LIRA	
	NC10	NSLI	NC14	NC15	NC11	NC10	NC06	
	NC18	RALI	NSLI	NSLI	NC14	NC14	NC11	
	NSLI	RAWS	RALI	RALI	NSLI	NSLI	NSLI	
	RALI	WSRA	RAWS	RAWS	RALI	RALI	RALI	
	RAWS		WSRA	WSRA	RAWS	RAWS	RAWS	
	WSRA				WSRA	WSRA	WSRA	
Totals	8	6	7	7	8	8	8	7.43
Efland-Mebane	LINS	LIRA	LIRA	LIRA	LIRA	LIRA	LIRA	
	LIRA	NC02	NC02	NC01	NC02	NC02	NC03	
	NC02	NC05	NC08	NC02	NC05	NC05	NC08	
	NC08	NC06	NC15	NC05	NC09	NC08	NC13	

[Table C-9 continues on the next page.]

Table C-9 *[continued]*

H Line Trains Using Sidings

By Location And Day

Location	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Avg.
Efland-Mebane [continued]		NC09						
	NC12		NC18	NC06	NC12	NC12		
	RAWS	NC10	RAWS	NC08	NC15	NC17		
		NC12	WSRA	NC12	NC18	RAWS		
		NC17		NC15	RAWS			
				NC18	WSRA			
				RAWS				
				WSRA				
Totals	6	8	7	11	9	7	4	7.43
Haw River	NC04	WSRA	LINS	LINS	LINS	WSRA	NC04	
	NSLI		NC05				NC18	
			NC12					
Totals	2	1	3	1	1	1	2	1.57
McLeansville		LCL6	LCL6	LCL6	LCL6	LCL6	LINS	
		NC03	LINS	LINS	LINS	NC03	NSLI	
		NSLI	NSLI	LIRA	NSLI	NSLI	WSRA	
			WSRA	NSLI		WSRA	LCL6	
Totals	0	3	4	4	3	4	4	3.14
English	RALI	NC02	NSLI	NC02	RALI	LINS	LINS	
	RAWS	LINS	WSRA		WSRA		NC1	
			NC02		NC14			
Totals	2	2	3	1	3	1	2	2.00

English Siding

. This passing siding, located at the junction of these two lines, served several purposes. First, the siding provided a location where a freight train could be held without blocking passenger trains. For example, if the Piedmont Main Line did not have a track available to enable a southward freight train on the H Line to either enter Pomona Yard or to proceed southward to Linwood Yard. Second, the siding provided a location where a northward freight train headed to the single tracked H Line could be held until an oncoming (opposing) southward freight or passenger train passed. The siding also provided capacity to store a northward freight train, without occupying a Piedmont Line track, that may not be able to reach and enter the next siding at McCleansville on the H Line before a northward passenger train caught up to it.

Piedmont Line: Dispatching A Double Track Railroad

Traffic flow on a two-lane highway is analogous to the operation of a double tracked railroad. Automobiles (passenger trains) catch up to slower trucks (freight trains). Automobiles use the opposite lane to overtake or pass trucks when a break in the opposite traffic flow and sight distances permit. When traffic is heavy the breaks between oncoming cars are few and far between. Occasionally a third passing lane (a siding) is provided on hills or other locations to freely enable automobiles to pass the trucks. At the end of the passing lane (end of siding) the trucks must merge back into the automobile flow. At times when a lane is closed for repair work or other reasons (track maintenance or a local freight train) all traffic must use the remaining lane.

In two-lane highways, the locations where automobiles may cross to the opposite lane are unlimited, assuming adequate sight distances exist and a clear lane is available. However, railroads have fixed locations (crossovers) where trains may move to the opposite track and these locations may be many miles apart. Typically railroad crossovers are spaced five to ten miles apart, sometimes greater. Unlike automobile drivers and truck drivers, who make their own decisions when to use the opposite lane, train engineers are directed by train dispatchers when to use the opposite track.

Passenger Trains Overtaking Freight Trains[15]

How much "sight" or clear distance is needed for a passenger train moving at 100 mph (0.6 minutes per mile) to overtake a freight train moving at 50 mph (1.2 minutes per mile) by diverting to the opposite track and back? The time differential in this case is 0.6 minutes per mile. Once a freight train has cleared an interlocking a following passenger train, once it has diverted to the opposite track, must arrive at the next interlocking, divert back to the track it was on, and clear the interlocking in sufficient time to not delay the freight train. At a minimum, the freight train must gain nine minutes, which includes:

- Three minutes for the rear of the freight train to clear the first interlocking;
- 1.5 minutes for the passenger train to divert at the first interlocking;
- 1.5 minutes for the passenger train to divert at the second interlocking; and
- Three minutes for the rear of the passenger train to clear the second interlocking.

At 0.6 minutes per mile, it would take a passenger train fifteen miles to complete the pass. The time sequence of events of an ideal overtake of a freight train by a passenger train was as follows:

1. The rear of a freight train passes interlocking at Point 1 at time zero.
2. An opposing passenger train (B) may pass an unknown Point 3 at time zero
3. A passenger train (A) crosses to the other track at Point 1 to run around the freight train at time 3 minutes, with an deceleration/acceleration time loss (100 mph to 45 mph back to 100 mph) of about 1.5 minutes

[15] For a graphical presentation of this dispatching situation, see Annex 2 at the conclusion of this Appendix.

4. Passenger train A returns to original track ahead of the freight train at Point 2 fifteen miles from Point 1 at time 15 minutes, with another diversion delay of about 1.5 minutes.
5. The freight train may pass Point 2 at time 18 minutes, presumably without being slowed
6. Opposing train B also may pass Point 2 at time 18 minutes, presumably without being slowed.

If the opposing train was a passenger train it would have been at the unknown Point 3 eighteen minutes from Point 2 when the freight train passed Point 1. At 100 mph the opposing passenger train would have covered 30 miles in those eighteen minutes.

Therefore, a clear distance of 45 miles was needed for a passenger train moving at 100 mph to overtake a freight train moving at 50 mph - the sum of the distance of Point 3 to Point 2 (30 miles) and Point 2 to Point 1 (15 miles). Therefore, passenger train A cannot use the opposite track to overtake a freight train and avoid delaying an opposing passenger train B if opposing train B was within 45 miles of train A. If train B was within 45 miles of train A, and train A still uses the opposite track, train B was slowed or stopped to enable the passenger train to run around the freight train. However, if the opposing train was a slow moving freight train the dispatcher could not use the opposite track to overtake a freight train if the opposing freight train on the track was within 30 miles. If the interlockings were not ideally spaced, the required clear distances would be greater.

Operating approximately 50 trains daily between Greensboro and Charlotte in 2015 it would often be difficult to find forty-mile or thirty-mile clear opposing distances to enable overtakes to occur. Our analysis indicates that an eighteen-minute gap would not be available nearly 30 percent of the time. Consequently passenger trains may have to follow freight trains for many miles before a clear distance was available. The passenger train would lose 0.6 minutes per mile for each mile it followed a freight train.

Oncoming highway traffic generally does not slow down to create at gap to let a car pass a truck, but a train dispatcher can slow an opposing train to let a passenger train to pass a freight train.

If the distance between Point 1 and Point 2 in the example above was less than fifteen miles, the freight train being overtaken may have to be slowed or stopped to let the overtaking occur. It was possible that allowing a passenger train to overtake a freight train would result in three or more trains losing time or being required to operate at a reduced speed. The three trains was:

1. The freight train being overtaken,
2. The passenger train overtaking the freight train, and possibly
3. One or more opposing trains.

In the initial simulations of a double tracked system between Greensboro and Charlotte this situation occurred several times a day.

A very large number of trains can be operated on two tracks when the speed of the trains was uniform. For example, commuter agencies can operate well over 100 trains per day on two tracks. When the speed of trains was not uniform, the transit time differentials, not the number of trains create the need for overtakes.

Passenger-Freight Overtakes – Charlotte to Greensboro

A freight train can make the 85-mile run between Greensboro and Charlotte in about 2.25 hours. An intermodal train can make the run in slightly less time. It was anticipated that the high-speed passenger train would make the run in about one hour. Consequently, if a freight train departs Greensboro at any time less than 1.25 hours before a passenger train does, the passenger train would overtake the freight train before it arrives at Charlotte. In 2015 as many as nine freight trains each way per day may be operating, so there was fourteen 1.25-hour periods throughout the day that could require a passenger train to overtake a freight train somewhere between Greensboro and Charlotte. Assuming that freight trains can depart Greensboro at any time during the day (the likely NS requirement) it can be estimated based on queuing tables that about:

- 63 percent of the passenger trains can be expected to overtake at least one freight train,
- 16 percent of the passenger trains can be expected to overtake two freight trains, and
- 3 percent can be expected to overtake three freight trains.

The simulated northbound and southbound running times of intermodal trains between Charlotte and Greensboro are shown in Tables C-11 and C-12 respectively.

The Need for Additional Facilities – Charlotte to Greensboro

During the initial development of the model some trains overtook three freight trains, but this occurred rarely. The last simulation performed before additional facilities were added to the model to reduce the number of passenger train diversions indicated that eight of eleven southward passenger trains overtook a freight train or ran around a local freight train working on the main track. None of the eight diverted southward passenger trains overtook two trains. In three of the eight cases the overtaking passenger train required opposing passenger trains to be slowed or stopped to enable the pass to take place. In other words, an eighteen-minute operating window to enable a passenger train to bypass a freight train was not available. In one of the three cases one passenger train that was slowed was behind a freight train that was also slowed. Additionally, four of the eleven southward passenger trains had to follow a freight train prior to finding a clear track to make a diversion. A total of eight southward trains incurred diversion delays of 3 minutes, however the total delay was much more than that.

The same simulation also indicated that seven of eleven northward passenger trains diverted to overtake a freight train or a run around a local freight train. One passenger train overtook two freight trains, making a total of eight, but no train in this simulation overtook three freight trains. One of the eleven trains could not obtain a window to overtake a freight train and had to follow the freight train from Lake to Bowers, a distance of four miles. Two freight trains were held at AT&O Jct., in Charlotte, to enable a passenger train to operate ahead. If that had not been done two more overtakes would have occurred. In addition to that, four of the eleven trains diverted to Track 2 at Cox to enable four southward freight trains to work at Pomona Yard. That makes a total of twelve diversions. In one of the four cases a southward freight train was running around a working freight train at[6] Pomona and Track 2 was not available.

Densely Trafficked Double Tracked Rail Operations

The simulations clearly illustrated that a densely trafficked double track railroad with reverse signaling on both tracks does not adequately handle all the normal operations without slowing some, perhaps many, trains when great speed differentials exist. Short of having a separate track for every train some trains would have to be delayed. The major advantage of the reverse signaling is that it eliminates the time consuming practice of copying train orders, or their equivalent, when it is necessary to use the second track to run around slower trains, maintenance work, local freight trains or disabled trains. Reverse signaling does little to provide added capacity during normal operations. Consequently, railroads having very heavy passenger traffic, such as the New York Central, the Pennsylvania, and others, found it necessary to have multiple track sections in certain areas.

A continuous four-track or even a three-track system cannot be justified in this corridor. However, railroads have handled traffic that ranged from ten or more passenger trains each way per day and a similar number of freight trains on two tracks that were signaled in only one direction with speed differentials nearly as great as being proposed for this corridor. This is close to the volumes being projected for this corridor. How did they manage to operate that many trains?

In the earlier discussion comparing railroad operations to highway usage it was stated that passing lanes are required on highways when traffic becomes heavy enough that faster vehicles can no longer overtake the slower vehicles. Similarly, railroads must add sidings or additional tracks when traffic becomes heavy. In 1948 the Pennsylvania Railroad was operating fourteen passenger trains each way per day and about ten freight trains each way per day between Chicago and Fort Wayne on a double tracked line that was not reverse signaled. That meant that twenty-four trains per day operated on each track or one per hour on the average. At that time nearly all track work, except rail renewal, was done manually without track occupancy so the need for reverse signaling to run around maintenance work was not as great as it was today. Therefore, very little reverse running was done during normal operations.

The need for passing sidings

The PRR handled the overtake problem by installing directional 1.5 to 2.5 mile-long passing sidings with interlocked switches on both ends on each side of the main tracks at intervals of 15-25 miles. The same technique is proposed for this corridor except that, instead of directional sidings along each main track, bi-directional center sidings between the two main tracks are proposed. The need for two sidings simultaneously to handle overtakes was minimal, consequently, center sidings are recommended. Instead of using two-mile sidings four-mile sidings are proposed. The rationale for the four-mile long sidings is described in Appendix G.

Therefore, in the ninety miles between Greensboro and Charlotte three passing sidings approximately four-mile long are proposed. These sidings would enable freight trains to be passed by passenger trains when clear distances aren’t available on the other track. Normally, only one train was slowed or stopped.

Southward Freight Train At Thomas

The manner in which southward freight trains was handled at Thomas (MP 307), the north end of a siding located between MP 307 (south of Thomasville) and MP 311 (a relocated Bowers Interlocking) was as follows:

The dispatcher would check to see:

1. Is a southward passenger train by Pomona, about 12-15 minutes away?
2. If the answer was yes, was the Thomas-Bowers siding free of opposing trains?
1. If the answer was yes, the freight train would enter the siding to be overtaken
2. If the answer was no, the freight train would continue southward on Track 2.

If the Thomas-Bowers Siding was not free of opposing trains, passenger trains would have to overtake the freight train by crossing to the opposite track[16] The effect of the addition of the siding was that the dispatcher would no longer try to thread passenger trains through and around freight trains, instead the freight trains would enter the siding to create a route so that the passenger trains would not be diverted. Ultimately, the siding contributes to improved reliability of the passenger schedules.

Center Sidings on the Piedmont Line

Three center sidings have been provided on the Piedmont Main Line to enable passenger trains to overtake freight trains. The simulation results indicate that the sidings do not eliminate the possibility that passenger trains may have to divert to the opposite track to overtake freight trains. Sometimes a freight train was unable to use a siding because another freight train of the opposite direction was occupying it. When this occurs the freight train proceeds on the same track and the passenger train follows it at a reduced speed until it reaches a location (interlocking) where the simulation determines that the opposite track was clear. The passenger train then diverted to the opposite track to overtake the freight train. In the model freight trains were not diverted to the other track to be overtaken by a passenger train. If the freight train diverted it would occupy the opposite track longer than a passenger train would, thereby reducing capacity.

The number of times each day that the three center sidings were used by freight trains is shown in Table C-10. Each time a siding was used it was safe to assume that a passenger train did not have to divert, saving a minimum of about three minutes for a passenger train each time it did not have to divert. However, a passenger train may have been following a freight train for a number of miles before the second track became available, therefore, the delay to the passenger train can be significantly greater than the three minutes lost in diverting from one track to another.

The simulation results indicate that numerous passenger trains diverted to the opposite track to overtake freight trains. Certain trains have a greater chance of diverting than others. To a great extent that depends on when freight trains operate, but local freight trains cause the most diversions.

[16] If the diversion to the opposite track had caused too much delay in the simulation, the siding would have been assumed to have mid-siding crossovers that would enable freight trains of the opposite direction to occupy the same siding. The delays at Thomas-Bowers Siding were not that great and mid-siding crossovers are not recommended.

In a prior seven-day simulation, northward Train NC02 leaving Charlotte at 0600 was the most frequently delayed passenger train. On a typical day NC02 may divert three times (change tracks six times) between Charlotte and Greensboro. On one day:

- NC02 operated on the left hand track going north (track 2) between Charlotte and Junker to overtake a freight train that had changed crews on Track 1 at Charlotte.
- NC02 crossed to Track 1 at Junker ahead of the freight train, and then met a southward commuter train on Track 2 at Shamrock.
- NC02 continued on Track 1 to Sumner where it crossed to Track 2 to run around a local freight train working between Sumner and Salisbury.
  - Since NC02 does not stop at Salisbury moving the passengers to the right platform was not a problem.
- NC02 returned to Track 1 at Salisbury Junction and met a southward freight train on Track 2 between there and Duke.
- NC02 crossed back over to Track 2 At Maybelle to run around a local freight train working at Lexington.
- NC02 overtook a northward freight train on Track 1 between Thomasville and Varner.
  - This freight train had also used Track 2 to run around the local train and it had cleared into the Bowers-Thomasville siding only six minutes before NC02 arrived at Bowers.
- Since no southward trains were on Track 2 NC02 continued north on Track 2 to Varner where it returned to Track 1 ahead of the freight train.
- NC02 met a southward freight train on Track 2 at Jamestown.

NC02 departed Greensboro at 0725. Had no crossover moves been made NC02 could have departed Greensboro at about 0713; therefore, NC02 lost twelve minutes. On another day NC02 had no diversions.

On the same day as NC02 described above NC04 departed Charlotte on Track 1 at 0800. At Junker NC04 crossed to Track 2 to overtake a freight train on Track 1. NC04 stopped at the southward platform at the I485 Station; therefore, passengers would have had to be notified to cross over from the northbound platform[17]. Train NC04 returned to Track 1 at Shamrock and met southward NC01 and a southward freight train behind it between Shamrock and Adams. Train NC01 was delayed two minutes at Shamrock to let NC04 clear Track 2.

[17] This could have been avoided if the freight train had been held in Charlotte Yard for about twenty minutes.

Table C-10

Piedmont Line Trains Using Sidings

By Location And Day

Location	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Avg.
Thomas-Bowers	ATIP	ATCX	ATIP	ATDH	ATNJ	ATNJ	ATNJ	
	LCL1	ATNJ	ATNJ	ATNJ	LCL1	EMTY	IPAT	
	NC16	BVLI	LCL1	BANO	LIHA	ERAT	LCL1	
	NOBA	ERAT	OILI	CXAT	LINF	LCL1	LINF	
	RRER	LCL1		LCL1		NC16	LIWA	
				LINF				
				LIWA				
				OILI				
Totals	5	5	4	8	4	5	5	5.14
Yad-Sal Jct.	ATCX	ATDH	ATWA	CALI	ATWA	ATIP	ATIP	
	KNLI	BANO	CALI	CALI	BANO	ATNJ	CALI	
	LCL2	BHLI	KNLI	KNLI	CALI	BANO	KNLI	
	LCL3	CALI	LCL2	LCL2	KNLI	CALI	LCL2	
		CHLI	LCL3	LCL3	LCL2	CHLI	LCL3	
		CXAT	RRAT	LCL3	LCL3	KNLI	MALI	
		KNLI	SHLI	MALI		LCL2	SVLI	
		LCL2		NOBA		LCL3		
		LCL3		RRAT		NOBA		
						RRNJ		
Totals	4	9	7	9	6	10	7	7.43
Kannapolis	LCL4	ATIP	EMTY	BANO	LCL4	LCL4	ATCX	
	LICH	ATWA	ERAT	IPAT	LISV	LICH	BHLI	
	LIMA	EMTY	LCL4	LCL4	NJAT		LCL4	
	LISV	LCL4	LIAT	LISH	NOBA		LIAT	
	MALI	LISH	LIBI	LISV	RRER		NJAT	
	NOBA	RRAT	LISH	NOBA			WAAT	
			NOBA	WAAT				
			RRNJ					
Totals	6	6	8	7	5	2	6	5.71

NC04 overtook a freight train standing in the Yad-Sal siding. This freight, which was going to Linwood Yard, had entered the siding to clear NC04 but it had to remain in the siding for NC03, after which it used Track 2 to enter the yard. NC04 met NC03, which was operating on Track 2 between Duke and Sharp.

At Bowers NC04 crossed to Track 2 to run around the same local freight train that NC02 had run around at Lexington, but which now was working at Thomasville. NC04 returned to Track 1 at Varner. It met another southward freight on Track 2 at Cox and departed Greensboro at 0926. Because of the stopping pattern of this train the best departure time it could have made with no diversions was 0917, so NC04 lost nine minutes.

Not all trains make the same diversions each day and not every train diverts every day; but when making a schedule, additional time must be allocated as if they were to divert. If this was not done trains would be late on many days, but on days when the trains did not divert trains would become ahead of time and must wait at some station. One way of handling this situation was to allow more time at a station than was really needed to allow trains to be on time. The added time is often called pad.

Table C-11

Simulated Running Times (hours:minutes)
NORTHBOUND NS Intermodal Trains
Charlotte to Pomona

Train	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
ATCX	2:23	2:27	2:08	2:10	2:09	2:24	2:24	2:17
ATIP	2:27	2:36	2:32	2:08	2:08	2:25	2:20	2:22
ATNJ	2:16	2:43	2:48	2:20	2:33	2:32	2:16	2:29
ATWA	2:08	2:17	2:24	2:15	2:33	2:24	2:09	2:18
NOBA	2:44	2:09	2:19	2:43	2:49	2:22	2:09	2:27
RRER	2:22	2:08	2:08	2:09	2:17	2:09	2:08	2:11
RRNJ	2:35	2:27	2:26	2:23	2:28	2:33	2:23	2:27
Average	2:25	2:23	2:23	2:18	2:25	2:24	2:15	2:22

Table C-12

Simulated Running Times (hours:minutes)
SOUTHBOUND NS Intermodal Trains
Pomona to Charlotte

Train	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
IPAT	2:00	2:19	1:59	2:23	2:04	1:59	2:22	2:09
CXAT	1:52	2:10	1:53	2:04	2:04	1:53	1:53	1:58
NJAT	2:07	2:15	2:02	2:28	2:48	2:29	2:56	2:26
WAAT	2:02	2:00	2:19	2:14	2:03	2:06	2:18	2:08
BANO	2:18	2:20	2:01	2:44	2:08	2:17	2:00	2:15
ERAT	2:39	2:40	2:49	2:31	2:24	2:37	2:26	2:35
RRAT	2:18	2:13	2:10	2:17	2:07	2:00	2:01	2:09
Average	2:10	2:16	2:10	2:23	2:14	2:11	2:16	2:14

Pomona Yard

Analyses performed while developing the simulation model through Greensboro and the Pomona Yard area indicated that trains working[18] at Pomona Yard potentially could be a serious bottleneck when frequent passenger service is being operated. Experience has shown that a clear track should always be available to operate the passenger trains and non-working freight trains around working freight trains. Between Cox Interlocking and Elm Interlocking this would require single tracking the passenger and non-working freight trains on one track when a working train occupied one of the main tracks. Even this could subject trains to some delay, therefore, the possibility of establishing four tracks between Pomona and Elm was explored. It was concluded that the cost of installing a fourth track would be prohibitive, and that the track was infeasible for a number of reasons. Therefore, options, including operational changes, to provide the open track for passenger trains and non-working freight trains were evaluated.

Existing Operation and Facilities

The existing Greensboro Station is located to the west of the north-south NS Main Line[19]. Pomona Yard is located to the east of the NS Piedmont Main Line about two miles south of Greensboro. Tracks 1 and 2 are the main tracks; Track 2 is the

[18]A phrase used to denote a through-freight train stopping at a yard or wayside location to set-off and/or pick-up freight cars.

[19] The NS Main Line extends between AF Interlocking in Alexandria, VA to Atlanta, GA, approximately 610 miles. It consists of the Washington, Danville, and Piedmont Subdivisions. The Danville District ends at Spencer and the Piedmont Subdivision extends through Charlotte.

southward track and Track 1 is the northward track. The existing passenger station/platform is located adjacent to Track 2.

Elm Interlocking, at the north end of Greensboro, is located at the intersection of the H Line to/from Raleigh and Goldsboro and the NS Piedmont Main Line. Passenger trains to/from Raleigh/Goldsboro use the crossovers at Elm Interlocking to access Track 2. Cox Interlocking is located 2.5 miles south of the existing Greensboro station.

Current Freight Operations

The Aycock Street and Pomona hand-operated crossovers are located at the north and south ends of Pomona Yard, respectively. A southward freight train on Track 2, which is to work at Pomona Yard, pulls south to the hand-operated Pomona crossovers, just south of Pomona Station and yard office, to make a pick-up, a set-off or both. The hand-operated crossovers provide access to the yard by enabling the train to cross Track 1[20]. This move requires that no northward through running trains are approaching on Track 1. At the same time a northward freight train can be working on Track 1 near Aycock Street provided that the northward freight train is less than about 5,000 feet long. The northward freight train on Track 1 stops at the Aycock hand-operated crossovers to access the yard[21]. Long southward trains on Track 2 do not block the Aycock Street crossovers. A long northward freight train stopped at Aycock Street will block the switches at Pomona unless a cut (uncoupling) is made to provide access across Track 1 for a southward freight train. However, making a cut greatly increases the working time of the northward freight train on Track 1 and adds to the track occupancy time. The object of the operational analysis performed by the study team was to reduce track occupancy times by developing more efficient operations or facilities. In today's configuration northward freight trains can neither access Track 3 nor enter the yard except by using hand-operated switches. (Track 3 is a name arbitrarily given to the yard track east of and adjacent to Track 1.) Track 3 extends from Elm to a location south of the intermodal facility near MP 288, where it dead-ends. Unless a utility person is on duty to throw the switches, it is unlikely that long northward freight trains working at Pomona normally use hand-operated turnouts to pull the entire freight train into Track 3 to work. Once the move to Track 3 was completed the turnouts would have to be manually restored by the train crew; the time consumed in these manual operations make this a slow, inefficient operation. Therefore, it seems almost certain that northward freight trains work from Track 1 in today's operation. Southward freight trains having crossed over from Track 2 at Elm Interlocking also may work from Track 1. They would be able to return to Track 2 using the number 20 crossover at Pomona Interlocking; however, that violates Condition 2.

Freight trains operating between the Winston-Salem line and Pomona Yard use hand-operated switches to enter or leave the yard. A large industrial complex has grown on the Winston-Salem line west of Pomona. It was therefore assumed that the industrial complex is served from Pomona Yard. It also was assumed that through

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[20] A southward freight train accesses the yard by moving clear of the Pomona crossovers on Track 2 and backing into the yard.

[21] A northward freight train accesses the yard by moving clear of the Aycock Street crossovers on Track 1 and backing into the yard.

freight trains also operate to and from that line and use hand-operated switches to access/depart Pomona Yard[22].

Proposed Freight Operations

One of the questions the operations analysis was designed to answer was:

How often would two freight trains be working at Pomona at the same time?

The analysis indicated that at least ten freight trains in each direction are projected to work at Pomona daily. The average track occupancy for each working freight trains was assumed to be 45 minutes (the working time includes total occupancy, work, delay, and running between Elm and Pomona Interlockings). Therefore, freight trains worked approximately fifteen hours per day at Pomona, or 62 percent of the time. If all freight trains worked from Track 1, to keep Track 2 open for passenger trains, it was highly probable that a second working freight train would arrive before the previous working freight train has finished work. An analysis indicated that about 50 percent, or more, of the time a working freight train would arrive while another freight train was still working, therefore, nearly 10 freight trains per day would have to wait their turn, if all freight trains worked off the same track. It was concluded that this percentage was high enough that one working track for freight trains would not suffice.

Therefore, two requirements were considered necessary:

1. An open track (Track 2) between Pomona and Elm Interlocking for passenger and non-working freight moves while the second main track (Track 1) was occupied by a working freight train. Working freight trains would not use track 2.
2. Separate locations where southward and northward freight trains could work at Pomona simultaneously without conflicting with each other.

Condition 2 partially exists today, when freight trains are short enough, but both main tracks are used to accomplish this requirement. This operation would not satisfy the first condition and therefore would be unacceptable for future increased levels of passenger train operations and long freight trains.

Proposed Operating Plan

The new turnout to Track 3 at Cox would enable northward working freight trains to use Track 3 to set-off and pick-up. Southward freight trains would work off of Track 1. This configuration and operation would accomplish the first requirement of always having an open track (Track 2) for passenger train and through freight train operations, while freight trains work at Pomona. However, the turnout would not satisfy the second requirement of having the ability to work a northward and a southward freight train at the same time. Long northward freight trains would still block the switches at Pomona, and could potentially delay southward freight trains.

If two long freight trains arrived at approximately the same time the northward freight could delay the southward freight train from beginning to work by as much as 45 minutes. Thus, in a worst-case situation, the southward freight train could occupy Main Track 1 for nearly 1.5 hours. That would be unacceptable.

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[22]Data indicates that a Roanoke to Raleigh freight train (WSRA) operates each way through Winston-Salem and Pomona. A Raleigh to Winston-Salem train (RAWS) also operates.

A configuration and operating plan that would prevent long working freight trains from blocking other working freight trains was therefore developed. The recommended concept is as follows.

A new "Pomona Running Track" between the Intermodal Terminal and Aycock Street would be less than a main track but more than a yard track and it would be controlled by the yardmaster at Pomona.

Northward working freight trains would enter Track 3 at the relocated Cox Interlocking and proceed to the Intermodal Terminal, where they would enter the new running track at about MP 287.15. The normal position of the switches would be from Track 3 to the Pomona Running Track so that the northward move can be made, at yard speed, without stopping. Between MP 287.15 and Pomona. The Pomona Running Track would be the track immediately east of Track 3. A determination would have to be made whether the switches should be locked in their normal positions, except when yard-switching crews were using them. At Pomona this track is currently aligned directly into a thoroughfare track through the body of the yard to Chapman Street. Going northward from Chapman Street to Aycock the thoroughfare track would be aligned directly to Track 3. Track 3 is not continuous today and would continue to end just south of Aycock.

The running track would enable intermodal trains to make set-offs directly into the Intermodal Terminal and/or pick-ups from the track east of the Pomona Running Track or the Intermodal Terminal. Other working freight trains would pull north to approximately Aycock Street to ensure that the rear of the intermodal train cleared the Intermodal Terminal.

If the pick-up or set-off involved the east portion of the yard (to the left of the running track) the intermodal train would stop at Chapman Street. The first yard track east of the Pomona Running Track should be removed to enable freight train crews to have an open space to walk, inspect, couple, and uncouple cars.

Long northward freight trains would still block access to the east (left) portion of the yard at Pomona while working, but the west portion of the yard (to the right of the running track) would be open for switching and access by southward working freight trains on Main Track 1.

The Pomona Running Track also would enable southward freight trains of any length to work clear of both main tracks and enable northward and southward freight trains to work independently and in parallel without conflict. Accessing the Running Track would require that Track 1 be crossed at both Cox and Elm Interlockings. However, the crossing freight trains would occupy Track 1 significantly less than a southward freight train working from it.

Therefore, freight trains of both directions would work off the running track, unless the Running Track was in use by another working freight train. In that case the second freight train would work from Track 1

Two additional crossovers at Chapman Street would enable northward freight trains to work on Track 1 without being blocked by a long southward freight train standing on the switches at Aycock Street. The crossovers at Chapman Street would enable two long freight trains of any length to work simultaneously without conflicting with each other.

Pomona Interlocking would provide interlocked access to Track 3. The entry to the Winston-Salem line does not require a 45 mph turnout because the speed on the Wye track behind the frog apparently is restricted to 10 mph and apparently the signal aspect leading to the line is slow speed, therefore number 10 crossovers would be installed. The crossovers would not adversely impact southward Winston Salem-bound freight trains. The interlocked crossovers should reduce the time to access the Winston Salem Line from Pomona Yard. The right hand 45 mph crossover from Track 1 to Track 2 would be retained.

Simulation Results

Delays to northbound trains at Pomona caused by trains working ahead during a seven-day simulation of the proposed operation are shown in Table C-13. These northbound train delays occurred on new Track 3 between Cox and Pomona. Delays to southbound trains at Pomona caused by trains working ahead of a freight train during a seven-day simulation are shown in Table C-14. These southbound trains were delayed on Main Track 1 between Elm and Aycock Street.

Conclusion

The simulation indicated that the recommended configuration and operations achieved the desired objective of enabling northward and southward freight trains to work at Pomona Yard with out interfering with passenger train and through-freight train operations.

High Point

A local freight train serving the M Line to Asheboro apparently originates at High Point[23]. A small yard is located east of the siding at about MP 300.5. The manner in which High Point is serviced by NS is not known, so it was assumed that an early morning train originating at Linwood sets off cars for the originating local and a late afternoon train picks up cars from High Point to be delivered to Linwood. This operation enabled inbound cars to High Point to be placed the same day they depart Linwood and the cars picked up by the High Point local to be delivered to Linwood on the same day they are picked up. The High Point, Thomasville and Denton Railroad (a CSX property) Freight also serves High Point. It is not known if the railroad interchanges cars with NS.

The left hand and right hand crossovers between Tracks 1 and 2 recently have been removed. Consequently, a northward local on Track 2 must serve the active industry at MP 301 and another industry at MP 298.5. These industries have facing point switches going south. It is not recommended that these apparently removed crossovers be replaced.

[23] The NS timetable shows that a train register for originating and terminating trains exists at High Point.

Table C-13

Delays To NORTHBOUND NS Trains At Pomona Caused By Other NS Trains Working Ahead

Day	Train	Arrived	*Departed*	Delay (mins.)
Day 1	LIOI	5:00	5:26	0:26
	LINF	6:08	6:14	0:06
	ATNJ	6:31	7:13	0:42
	NOBA	13:44	14:17	0:33
Day 2	LINS	5:33	6:01	0:28
	LIOI	6:20	7:13	0:53
	ATNJ	7:30	8:00	0:30
Day 3	LINS	5:04	5:42	0:38
	LINF	6:09	6:29	0:20
	ATNJ	6:58	7:14	0:16
	LIHA	14:15	14:24	0:09
	ATCX	14:45	15:32	0:47
Day 4	LINS	4:27	5:06	0:39
	LINF	7:03	7:28	0:25
	ATWA	17:03	17:31	0:28
Day 5	LIOI	5:28	6:05	0:37
	LINF	6:53	6:56	0:03
	ATNJ	7:13	7:50	0:37
	NOBA	13:56	14:33	0:37
Day 6	LINS	5:34	5:58	0:24
	LIHA	14:09	14:20	0:11
	ATCX	16:48	16:57	0:09
Day 7	LINS	5:31	5:43	0:12
	ATNJ	7:02	7:06	0:04
	NOBA	14:20	14:21	0:01
	ATWA	16:34	16:49	0:15

Note: These delays occur on new Track 3 between Cox and Pomona.

Table C-14

Delays To SOUTHBOUND NS Trains At Pomona Caused By Other NS Trains Working Ahead

Day	Train	Arrived	Departed	Delay (min.)
Day 1	WALI	3:26	3:37	0:11
	NJAT	4:32	4:38	0:06
	BANO	12:08	12:29	0:21
	HALI	19:48	19:59	0:11
Day 2	NJAT	3:50	4:13	0:23
	BANO	12:58	13:15	0:17
	HALI	20:04	20:13	0:09
Day 3	NJAT	3:46	4:16	0:30
	BANO	12:14	12:43	0:29
	HALI	20:55	21:12	0:17
	RAWS	21:40	22:13	0:33
Day 4	WALI	2:27	2:48	0:21
	NJAT	3:39	4:06	0:27
	RAWS	21:46	22:16	0:30
	OILI	23:19	23:29	0:10
Day 5	NJAT	5:03	5:06	0:03
	WAAT	20:31	20:59	0:28
	RAWS	21:45	21:48	0:03
Day 6	NJAT	4:06	4:16	0:10
	WAAT	20:24	20:25	0:01
Day 7	NJAT	4:06	4:51	0:45
	IPAT	11:27	12:38	1:11
	BANO	12:18	13:41	1:23
	WAAT	20:54	21:36	0:42
	RAWS	22:24	22:26	0:02

Note: These trains are delayed on Main Track 1 between Elm and Aycock Street.

Linwood Yard

Spencer Yard at Linwood, NC is alternately referred to as Spencer Yard or Linwood Yard. Linwood is a major freight classification Yard for the Norfolk Southern system. Trains from distant points arrive at Linwood and have their cars sorted (classified) for other points on the system. Linwood performs as a hub. For example, cars going to Charleston, SC may arrive on inbound trains from Norfolk, Roanoke, Knoxville, TN or other distant points such as Binghamton, NY. The cars to Charleston are grouped together for a train going to Charleston or other points, north of Charleston. About twelve inbound trains daily arrive from the north or south to have their cars classified to about the same number of outbound trains.

Sharp Interlocking at MP 324.6 consists of two crossovers between the main tracks and a turnout, which is used by trains to enter the receiving yard at Spencer Yard.

Duke, located at the south end of Spencer Yard, consists of inbound and outbound yard leads. The inbound lead is the entry to the receiving yard and the outbound lead is the exit from the departure yard. The leads are arranged in parallel to permit outbound (southward) trains to leave the yard to Track 2 (south crossover) while inbound (northward) trains enter the yard from Track 1 (north crossover).

Local Freight Trains From Linwood

Linwood serves as a distribution point for local freight trains that switch industries along the Piedmont Main Line, however NS did not provide the schedule for local freight trains. It was therefore necessary to generate an operating plan by making assumptions as to how often industries are served and how long it takes to switch.

A video of the territory between Pomona and Charlotte was reviewed to determine where local trains might work with regularity. An earlier simulation performed for NCDOT provided data on the local freight trains that may be operating. The simulation did not provide data on track occupancy and apparently did not include service to all industries having local freight service. Therefore a local service schedule that served the points that have active industries was developed.

The following local schedules were simulated.

LCL1. A local train named LCL1 for modeling purposes originated at Linwood at 5:00 am[24]. The train carried cars for the same day local originating at High Point.

This train operated northward on Track 2 (left handed) serving the industries between Maybelle and Lee, which have trailing switches for northward travel. The train arrived on the right hand track at Lexington at approximately 06:00. Between 06:00 and 08:00 the train sorted the WSSB interchange and served industries at Lexington including those off Track 2. Any cars received from the WSSB interchange that were destined to High Point as well as those from Linwood, were delivered by this local to High Point for placement by the High Point local on the same day. This local also carried any cars destined to points between High Point and Pomona.

It was assumed that this train would arrive at Thomasville at approximately 08:15 and would switch the one trailing point track north of Thomasville. The train finished at Thomasville at approximately 08:45 and arrived at High Point at 09:00.

[24] There should be a four-hour gap between northward freight trains and no passenger trains at that time.

High point cars were set off. Cars picked up between Linwood and High Point that were to be taken to Linwood for classification may, were set off at High Point, rather than being carried through to Pomona, if yard space permitted. Cars from the High Point local or the HPT&D going north were picked up. It was assumed that work at High Point was finished at 10:00.

LCL1 switched the trailing point industries between Hoskins and Cox. It was assumed that LCL1 would arrive at Pomona at approximately 11:00. At Pomona, cars for Pomona were set off; some cars remained with the train for the return trip; and cars for High Point and other points south of High Point were picked up.

At this time the crew would have been on duty seven or more hours, so it was assumed a new crew was called at approximately 10:00 at Linwood. The new crew was driven to Pomona, and the on-duty crew was driven back to Linwood to sign-off. It was assumed that the new crew would leave Pomona at 14:00.

LCL1 switched the trailing point industries between Cox and Hoskins and arrived at High Point at 15:00. The train operated left-handed on Track 1 from Hoskins to facilitate, picking up or setting off at High Point. This train cleared the main track in the long siding, and picked up the Linwood cars dropped off on the northward trip as well as the Linwood cars produced that day by the High Point local. At High Point, this train ran to MP 302.5 and back to serve the industry located adjacent to Track 1 as well as the two industries adjacent to Track 2. It was assumed that the work at High Point finished at 18:00, approximately when the High Point local went off duty, if it worked the full ten hours allocated to it.

LCL1 local continued south on Track 1 to work the industries having a facing point in the northward direction at Thomasville. Even though it appears many of these tracks are unused, it was assumed that some work was done there. The train finished Thomasville at 19:00 and arrived at Lexington on Track 1 at 19:30, assuming that there was cars to be set-off at the WSSB interchange. Carrying these cars through to Linwood and back the next day would have delayed them a day. At High Point, the WSSB cars, if any, were arranged to be on the head end of the train. They were moved onto the run-around track off Track 1 and placed into the interchange track. These tasks should have been completed by 20:00, after which the train ran to Linwood to an assumed 21:00 sign off, after being on duty eleven hours.

LCL2. A local train, named LCL2 for modeling purposes, was originated at Linwood at 03:00 and served two industries on Track 2 between Linwood and Salisbury. At Salisbury the local worked outside the limits of the model doing unknown work until it reappeared seven hours later to return to Linwood.

LCL3. Local train LCL3 originated at Linwood at 07:00, ran to Yadkin Junction, and served the N Line to Albemarle. LCL3 was assumed to return to Yadkin Junction at about 14:45 and returned to Linwood.

LCL4. It was assumed that local LCL4 originated in Linwood at 21:30, traveled to Charlotte and returned. The local passed Salisbury at 22:00. Industries with trailing switches for southward moves between Reid and Kannapolis were served and LCL4 arrived at Kannapolis at 22:15. All industrial switches in Kannapolis are facing for southward moves so Kannapolis cars were set-off on the siding for placement on the return trip. The train departed Kannapolis at approximately 22:45.

There are no trailing switches through Concord. The industries between Haydock and Junker were served between 23:01 and 23:59. It was assumed that Charlotte yard crews would serve the industries between Junker and AT&O Junction.

The train turned in Charlotte Yard and was ready to return at 01:30. Industries between Junker and Adams, including Concord, were switched, and LCL4 arrived at Adams at 03:00. At Adams the local operated left-handed to Kannapolis, departing from Kannapolis at 04:00. Left-handed operation continued to Reid to serve Sumner. Industries between Adams and Salisbury were switched with an anticipated 05:30 departure from Salisbury. The crew then ran to Linwood and signed-off at 06:00, after nine hours on duty. Initially LCL4 was scheduled to operate during daylight hours but the large number of passenger trains did not provide sufficient working time and created numerous diversions for passenger trains.

Salisbury Configuration And Operation

Four miles south of Duke, a mostly unused Salisbury Yard extends along Track 2 to Salisbury Interlocking, where trains to/from Asheville (the NS Asheville Line) leave/enter the Piedmont Main Line on a double-tracked Wye. The Wye tracks joining the Main Tracks at Salisbury are called the north Wye and are arranged so that northward trains from the Asheville Line can cross Track 2 to access Track 1 while a southward train is also entering the Asheville Line from Track 2. The speed of trains on the Wye is restricted to 15 mph and this may cause long freight trains to occupy the interlocking at Salisbury five to eight minutes, depending upon whether the train is stopped or not. The double track of the Asheville Line extends 2.1 miles to Majolica where the line becomes single track at a spring switch. The track between Salisbury and Majolica has automatic block signals for unidirectional flow only. Therefore, trains arriving at Salisbury on the left-hand track of the Asheville Line should be rare. About four trains in each direction use the Asheville Line each day to and from Spencer Yard.

Since a south Wye also joins the Piedmont Main Line from the Asheville Line, the interlocking joining the north Wye and the Piedmont Main Line at MP 333 has been named Saljct for modeling purposes.

Operations Analysis: Duke to Salisbury Junction

Several curves in Salisbury have highway crossings in them. It is proposed to maintain the current superelevation and alignment in the curves and restrict the speed to 70 mph through the city of Salisbury.

The initial operating analysis indicated that with the anticipated level of train service on the Piedmont Main Line that trains coming from the Asheville Line most likely would not be able to:

1. Cross the flow of southward trains on Track 2 to go onto Track 1 at Saljct,
2. Operate on Track 1 six miles north to Duke, and
3. Cross from Track 1 to Track 2 to access the turnout on Track 2 leading to the Spencer Yard arrival yard.

The following requirements would have to be satisfied to enable a Spencer Yard-bound freight train to cross Track 2 to access Track 1 at Saljct without delaying a southward train on Track 2.

1. A gap of about ten minutes between southward trains
2. A simultaneous ten-minute clear window ahead of each northward freight train on Track 1 at Saljct, and
3. A fifteen-minute clear window ahead of each passenger train on Track 1 at Saljct.

The last two requirements would ensure that northward trains are not delayed by the freight train clearing in Spencer Yard.

Upon arrival at Duke another ten-minute gap between southward trains is needed to let the Asheville Line train enter the yard from Track 1.

Is a fifteen-minute gap before a northward passenger train adequate? The fifteen-minute gap ahead of a passenger train would begin when the signal is displayed to the Asheville Line train at Saljct. It is estimated that it would take at least five minutes to start the train and pull the entire train onto the main track at 15 mph[25]. The northbound freight train would then accelerate to whatever speed it could achieve before it must begin to slow down to crossover at Duke Interlocking to enter the yard-. Eight minutes for the head end to traverse the four miles to Duke Interlocking is a good estimate. It would take at least another four minutes for freight train to cross to Track 2 and into the arrival yard and for the rear of the train to clear the main track. If a passenger train is not to be delayed, it must not have passed the distant signal for Duke. Therefore, the passenger train must be at least three minutes away from Duke Interlocking. Therefore about twenty minutes (5+8+4+3) after the signal is displayed by for the Asheville Line freight train at Saljct a following passenger train could pass Duke Interlocking.

Since the time reference started at Saljct, by deducting the four minute non-delay running time for the passenger train to run between Saljct and Duke, a sixteen minute gap would be needed at Saljct. The 16 minutes optimistically assumed that the freight train could enter the yard without being delayed by conditions in the yard (filled receiving tracks) or by southward trains at Duke. If a southward freight train were approaching Duke the Asheville Line freight train would likely enter the yard first to prevent a delay to a following passenger train. If the southward train were a passenger train, a determination would need to be made as to which passenger train was to be delayed. Therefore the fifteen-minute gap ahead of northward passenger at Saljct was quite conservative.

An alternative would be to operate northward Asheville Line freight trains between Salisbury and Duke on Track 2 rather than Track 1. Northward traffic on the Piedmont Main Line would not be impacted at all if this alternative were selected. This concept has two drawbacks. First, a twenty-five to thirty-minute window at Saljct would be needed to make the move from Saljct to Duke between southward trains on Track 2. Secondly, this move would block an outbound train from Spencer Yard from leaving until the Asheville Line freight train was yarded.

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[25] The Wye track speed on the Asheville Line is 15 mph

Center Siding Yadkin to Salisbury Junction

A new third track west of Track 2 between Duke and Saljct would let Asheville Line freight trains operate in both directions totally independently of Piedmont Main Line traffic between Duke and Saljct. Windows on either Tracks 1 or 2 would not be needed for through running trains; however parallel moves into or out of the yard would not be possible. The third track would require a large 639-foot third-track bridge over the Yadkin River, which lessens the viability of that option.

Scaling back the third track to the south end of the bridge over Yadkin River would appear to be a reasonable, less-expensive compromise. The time that Track 2 would be occupied would be shortened - since the Yadkin River is about one-mile from Duke, compared to five miles from Saljct. However a new third track west of Track 2 would have little value for Piedmont Main Line trains. Therefore, it was concluded that the third track, if it were to be built, would provide the maximum utility if it were constructed between Tracks 1 and 2.

The center siding north of Saljct would be one of the three center sidings that would be constructed between Greensboro and AT and O Jct

The yard track west of and adjacent to Track 2 would be upgraded to create a new track from Saljct at MP 333 to MP 330.7 and a new track would be built from MP 330.7 to MP 328.5 at the south end of a 1.7-degree curve. The new track would best be built adjacent to Track 1 north of Salisbury Yard. Yad interlocking would be installed south of the Yadkin River; it would actually be an extension of Duke. It is simulated in that way. Cut and throws would be necessary at MP 330.7. The new track would be aligned so that it is the northward main Track 1 at Yad. The current Track 2 would become a signaled center siding equivalent to a main track. The current Track 2 would remain Track 2. Number twenty turnouts would connect the siding Tracks 1 and 2 at Yad; these would enable a northward train on the siding to enter either track at 45 mph. In addition a right-hand number twenty crossover would be placed between the siding and Track 2 to enable trains to crossover from Track 2 to the siding to Track 1 at Yad/Duke.

The center siding operated in the following manner. Northward freight trains that enter Spencer Yard entered the center track at Saljct unless it was known that they could continue on Track 1 and enter the yard without being delayed at Duke or delaying a train behind it. Northward Asheville Line trains entered the center track unless it was known that they could operate against the flow on Track 2 to Duke and enter Spencer Yard without being delayed or delaying other trains. Asheville Line trains entering the center siding required a ten-minute gap on Track 2 between southward trains. Northbound Asheville Line freight trains entering at Saljct could not avoid interfacing with southward Piedmont Main Line trains.

The center siding eliminated:

1. Any conflict of northbound Asheville Line freight trains with northward through-running trains on Track 1, and
2. The need for the simultaneous windows on Tracks 1 and 2 to access Track 1 from the Wye at Saljct.

The center siding provided northward freight trains at Yad a location to wait clear of through running trains on Tracks 1 and 2 if they could not immediately enter Spencer Yard. Trains on the center siding at Yad had two routing choices. The first choice would be to use Track 2 between Yad and Duke to enter Spencer Yard without regard to northward trains on Track 1 if the following three conditions were met:

1. No outbound train was ready to leave or was leaving the yard,
2. A gap of fifteen minutes between southward trains existed, and
3. Room was available in the receiving yard.

If the first condition was not met, the alternative was to use Track 1 and the train could enter the yard in parallel to the outbound train if the following three conditions were met:

1. A gap of fifteen minutes between southward trains existed,
2. A gap of fifteen minutes between northward trains existed, and
3. Room was available in the receiving yard.

Southward freight trains normally operated on Track 2 south of Yad but they also may use the center siding to be overtaken by southward passenger trains when the siding was available. Passenger trains normally did not use the siding.

Charlotte Yard

Existing Configuration/Operations

Charlotte Yard, like Pomona Yard, is located east of the Main Tracks. Crossovers access the yard from the Main Tracks. Again like Pomona, long trains can block trains of the opposite direction from working at the yard. Long trains were not a problem when the yard was originally built, because trains of that era could fit between the crossovers.

About ten trains per day in each direction would work at Charlotte. Therefore, the potential of having trains conflicting with each other is about the same as at Pomona.

However, unlike Pomona, it is possible to remove all working freight trains from both of the two Main Tracks, so working trains would not interfere with passenger trains and non-working freight trains. A configuration that would enable two long freight trains of the opposite direction to set-off and pickup without conflicting with each other also was developed.

AT&O Jct.: A Problem Area

AT&O Jct. Interlocking is partially located on a 1.8-degree curve with two inches of superelevation in the main tracks. Consequently, some turnouts may have negative superelevation. All turnouts and crossovers are number 10s, which limits train speeds into and out of the yard or to the O Line to 10 mph, so a configuration that would permit greater entry or departure speeds to/from the proposed freight tracks is desirable. Slow entry/departure speeds result in freight trains tying up AT&O interlocking for significantly periods of time. Therefore, it is necessary to modify AT&O Jct.

The NS crosses the CSX at Graham on a curve. Currently two NS tracks cross one CSX track. It is recommended that two additional NS tracks be added to separate the freight and passenger operations in Charlotte.

The Northward Freight Track

Creating a working track for northward freight trains independent of Main Tracks would be relatively straightforward. The yard track adjacent to Main Track 1, called Track 3 for convenience, would be upgraded to serve as the northward freight-working track. Northward trains would enter Track 3 at a new interlocking (named **Stadium** because of its location next to Erickson Stadium) immediately south of the proposed new passenger station. Northward freight trains, after entering the new Track 3, would proceed to their working location near MP 375.5 without interference from or interfering with other NS freight trains or passenger trains. However, the freight trains would have to cross the CSX tracks at grade at Graham Interlocking. The northward freight train working location would be about 7,500 feet from the CSX crossing so nearly all trains should be able to work with the rear of the train clear of the CSX at-grade crossing. However, Lidell Street may be blocked. The potential of closing this crossing should be evaluated. Northward working freight trains that arrive before the previous working train has departed would wait south of the CSX crossing, leaving the crossing clear for CSX trains. Over 25 CSX moves per day, including yard moves, would use the crossing.

Upon completing work, northward freight trains would access Track 1 to proceed northward. Entering the main track over the existing number 10 mph crossovers, if AT&O Junction remains un-reconfigured, would be slow. Therefore a new interlocked left hand number 15 or number 20 crossover from Track 3 to Track 1 would be installed just south of the AT&O curve so that trains could depart at 30 mph.

The new interlocked crossover from Track 3 to Track 1 would replace an existing hand operated crossover between Track 3 and Track 1 and the existing crossover would be removed. Two right-hand crossovers between Tracks 3 and 1 and Tracks 1 and the yard track adjacent to Track 3 also would be removed. Since northward working freight trains would no longer be occupying the Main Tracks, these crossovers would no longer serve a useful purpose. A pair of crossovers, located between Tryon Street and Lidell Street, between the same tracks would remain for emergency use.

Simulation Results

The number of northbound trains delayed at Charlotte caused by other NS trains working ahead of them during a seven-day simulation is shown in C-15. These trains were delayed on new Track 3 between Stadium and CSX Graham crossing. A portion of the delay for these trains occurred between Charlotte Jct. and Stadium.

Table C-15:
Delays To NORTHBOUND NS Trains At Charlotte
Caused By Other NS Trains Working Ahead

Day	Train	Arrived	Departed	Delay (min.)
Day 1	BHLI	10:27	11:00	0:33
	CHLI	12:57	13:22	0:25
Day 2	NOBA	10:16	10:57	0:41
	ATCX	11:44	12:10	0:26
Day 3	RRNJ	7:58	8:24	0:26
	BHLI	9:08	9:39	0:31
	NOBA	9:41	10:47	1:06
Day 4	RRNJ	7:19	7:26	0:07
	BHLI	8:34	8:35	0:01
Day 5	NOBA	9:16	10:13	0:57
	BHLI	10:15	11:07	0:52
	CHLI	13:28	14:10	0:42
Day 6	RRNJ	7:29	8:10	0:41
	BHLI	8:58	9:17	0:19
	NOBA	10:11	10:32	0:21
	CHLI	13:34	14:24	0:50
	ATWA	14:26	15:17	0:51
	SVLI	20:56	21:13	0:17
Day 7	NOBA	10:27	11:19	0:52
	CHLI	13:03	13:37	0:34

Notes: These trains are delayed on new Track 3 between Stadium and CSX Graham crossing.

Some of the above trains may have also incurred some delay between Stadium and the CSX crossing at Graham

The Southward Freight Track

The southward freight track would require more extensive changes. A third track, new Track 4, would be installed between MP 372 at Junker Interlocking and AT&O Jct. **Junker Interlocking** would be configured to enable southward freight trains to enter

Track 4 at 45 mph. Track 4 also would provide a holding location for a southward freight train to wait short of the yard without blocking Track 2. Avoiding freight trains blocking Track 2 is essential to facilitate the operation of 17 daily southward passenger trains; including seven morning commuter trains from Concord. The new Track 4 would be placed through the east opening under 30th Street overhead bridge. A new connecting track would parallel the switching ladder at the north end of the yard so that standing or arriving working freight trains would not block switching operations.

This new connecting track may require straightening the small stream parallel to the switching ladder and a retaining wall may be required to support the track.

The new connecting track would tie into the existing easternmost track in the yard, which is adjacent to the Intermodal Terminal, and would be upgraded to become a new running Track 4 between AT&O Jct. and Tryon Street. This track apparently is used as a thoroughfare track today. Track 4 has access to the north and south entrances to the Intermodal Terminal, therefore intermodal trains could use Track 4 to directly set off or pick up to/from the Intermodal Terminal. However, as previously described, it has been assumed that this work would be normally accomplished from Track 3.

The new Track 4 would become parallel to the Piedmont Main Line at Tryon Street. Southward pick-ups and set-offs would be made using the switches from Track 4 to the yard at Tryon Street. Alternatively, the switches located near the south end of the intermodal terminal could be used.

The rear of long southward freight trains working at Charlotte Yard would be at or north of AT&O Junction; which is the reason that Track 4 would be isolated from the switching lead. Track 4 would reenter the Piedmont Main Line at Stadium Interlocking south of the proposed Charlotte passenger station. In emergency situations the hand-operated crossovers at Tryon Street would provide access to the Main Tracks at that location.

The configurations described would enable northward and southward freight trains to set-off and pick-up at Charlotte without conflicting with each other and the goal of enabling passenger trains and non-working freight trains to have their own tracks would be achieved.

Tracks 3 and 4 would be signaled between Stadium Interlocking and Tryon Street. Track 3 would have a 30 mph maximum speed between Stadium Interlocking and AT&O Junction. The hand-operated crossovers south of Tryon Street would be electrically locked. All switches on Northward Freight Track 3 between Tryon Street and AT&O Junction would have switch locks installed to enable the 30 mph MAS to be established between Tryon Street and AT&O Jct. Eliminating the yard speed on Track 3 and increasing it to 30 mph would enable long trains that have finished work to accelerate to 30 mph prior to accessing the Piedmont Main Line.

Track 4 would have a 30 mph maximum speed between Tryon Street and Stadium Interlocking. Switch locks would be installed on the numerous switches between Tryon Street and AT&O Jct. to eliminate the restricted yard speed between those points. Track curvature near the intermodal terminal may restrict speed to that level anyway. It was assumed that timetable instructions would say that the normal position of switches would be for movement on Track 4 and that they would be locked except when being used for switching moves.

Simulation Results

The number of southbound freight trains delayed at Charlotte by other NS freight trains working ahead of them during a seven-day simulation is shown in Table C-16. These trains were delayed on the new Track 4 between Junker and ATO Jct.

Table C-16

Delays To SOUTHBOUND NS Trains At Charlotte Caused By Other NS Trains Working Ahead

Day	Train	Arrived	Departed	Delay (mins.)
Day 1	WAAT	22:01	22:58	0:57
Day 2	LIAT	7:54	7:57	0:03
	LICH	14:15	14:28	0:13
	RRAT	21:03	21:43	0:40
	WAAT	22:13	22:49	0:36
Day 3	LICH	13:30	13:39	0:09
Day 4	LIAT	7:58	8:05	0:07
	LICH	13:44	13:55	0:11
	RRAT	21:05	21:17	0:12
Day 5	IPAT	13:12	13:57	0:45
	BANO	14:15	14:22	0:07
Day 6	LICH	13:43	13:49	0:06
Day 7	LIAT	9:09	9:29	0:20
	BANO	16:15	16:37	0:22
	LISV	17:07	17:46	0:39
	RRAT	20:37	21:14	0:37

Note: These trains are delayed on the new Track 4 between Junker and ATO Jct.

CSX Delays at Graham Interlocking

The large increase in passenger trains operating over the CSX crossing at Graham interlocking resulted in approximately 50 percent of the 28 CSX trains per day being delayed. Presently, only two passenger trains per day operate over the CSX crossing. Twenty-two inter-city trains and 18 commuter trains would operate over the CSX crossing in 2015. The passenger trains should have priority while NS and CSX freight trains would use the crossing on a first come-first served basis. CSX train freight trains would not be permitted to enter the crossing for a period of about ten minutes before the arrival of each passenger train. Eight minutes per freight movement has been assumed, so that leaves only two minutes to display a signal for passenger trains.

The CSX Charlotte Subdivision is single tracked and therefore a window for NS trains following a CSX train always existed. It was assumed that successive CSX moves would be fifteen or minutes apart. Therefore NS delays were small.

The delays to CSX freight trains for a seven-day period are shown in Table C-17.

Table C-17

Delays to CSX Transportation trains at Graham crossing in Charlotte, caused by Norfolk Southern freight trains and passenger trains

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Number of trains delayed	15	14	12	12	16	13	14
Maximum delay in minutes	46	24	37	32	21	24	38
Total delay in minutes	186	150	176	128	126	144	159
Average delay (mins.)	12.4	10.7	14.7	10.7	7.9	11.1	11.4

Charlotte Passenger Tracks And Passenger Station

Charlotte Station, located at MP 377.9, would consist of three tracks west of Track 3. Tracks 1 and 2 between AT&O Junction and Stadium would be the passenger tracks through Charlotte. A pair of number fifteen interlocked crossovers between Tracks 1 and 2 would be located at 6th Street (MP 377.5). **6th Street** is a new interlocking at the north end of Charlotte Station. A number fifteen turnout off Track 1 would lead to a third station track. At this time, only three station tracks are planned.

Two additional station tracks may later be placed east of Track 4 for a possible commuter service from the CSX. A single-track lead parallel to and east of Track 4 between the CSX at Graham (MP 377.1) and Stadium would provide access to these tracks. In addition a second at grade crossing over the CSX at Graham may be restored to provide access to the former O Line for additional commuter service.

Freight trains that do not work at Charlotte nor terminate at Linwood would change crews at Charlotte. These trains could operate on Tracks 1 and 2 through Charlotte Station and exchange crews at a convenient location between Stadium and AT&O Junction. It was assumed the exchange would take about ten minutes. Freight trains that pick up or set off at Charlotte would not use the passenger tracks.

Stadium interlocking, just south of Charlotte Station, would initially consist of three number twenty crossovers and three number fifteen turnouts. The crossovers would be arranged so that freight trains can move in parallel to and from Tracks 3 and 4. It was assumed that most southward freight trains going to Columbia would operate left handed between Stadium and Charlotte Junction.

Charlotte Station to Charlotte Airport

A servicing and storage yard would be constructed south of the Airport Station, adjacent to the Airport Freeway. Just south of Little Rock Road a loop track would diverge westward from the southbound main track, passing over both main tracks and becoming parallel to the northbound main track. The new passenger storage and servicing tracks would be just south of Little Rock Road east of the northbound main track. Three equipment sets will layover at night at the Airport.

Two trains to Atlanta originated each day at Washington and re-entered the SEC at Greensboro. These trains stopped at the Airport.

Three of the seven commuter trains from Concord each morning turned back to Concord for a second trip. Thirty-minute headways from Concord for this service were assumed. If these trains operated to the Airport they would not be able to return to Concord for a second trip. Layover facilities in Charlotte for day storage of commuter trains have not yet been identified. It was assumed that overnight facilities will be provide somewhere near Adams Interlocking.

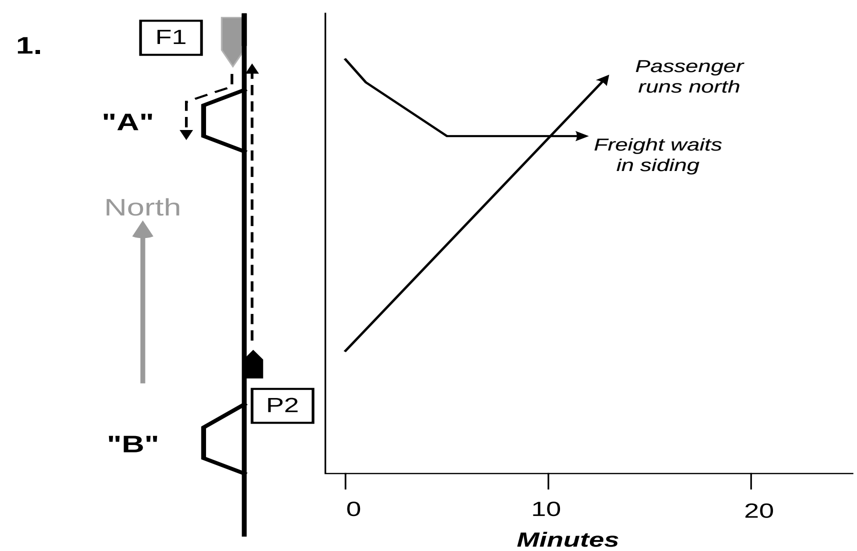
ANNEX TO APPENDIX C:
Graphical Presentation of Dispatching Situations

For readers interested in an alternative explanation of the complex dispatching situations discussed in Appendix C, this annex provides a generalized, graphical presentation.

Meets and Overtakes Involving Three or More Trains

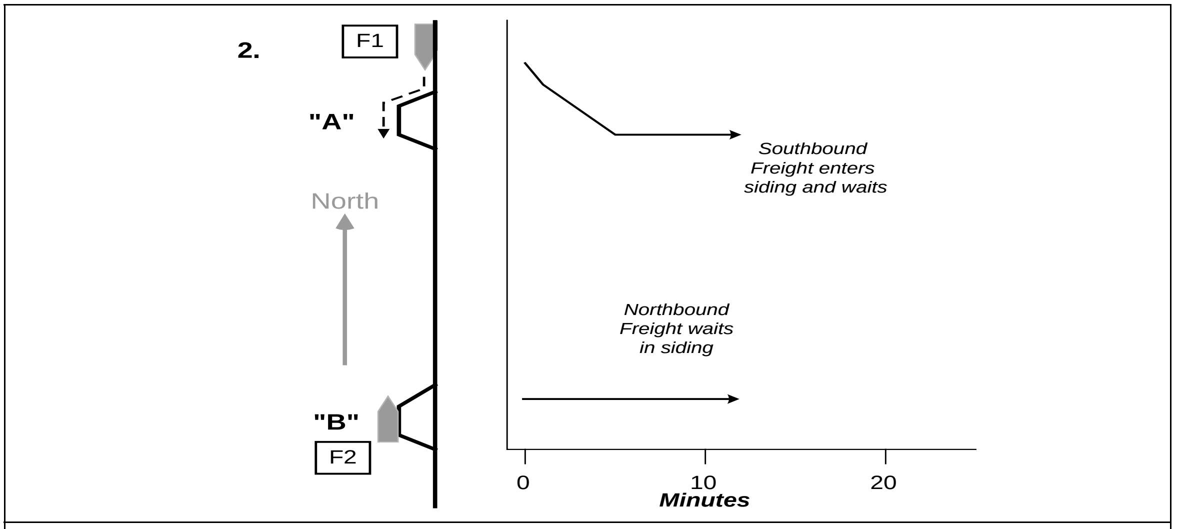
When evaluating the status of southward freight train approaching the north end of Siding A and making the decision whether to release the southward freight train (F1), a train dispatcher would:

- Look ahead of the southward freight train (F1) for opposing northward freight or passenger train (F2);
- Look behind the southward freight train for an overtaking southward passenger train (P1); and
- Look beside the freight train while it is waiting in a siding.



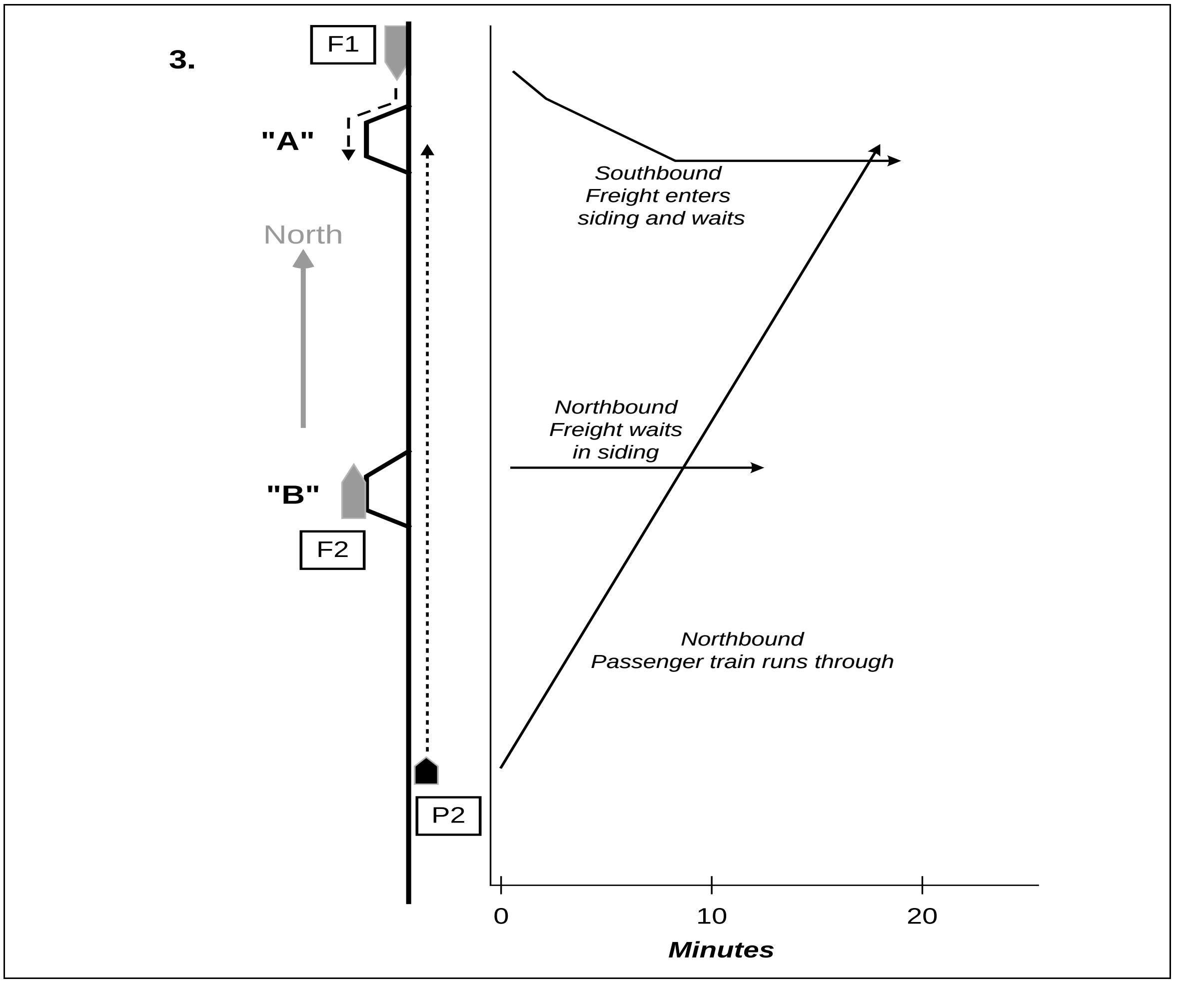
1. Is an opposing (northward) train occupying the main track between the north end of Siding B *and the north end of* Siding A*?*

***If** Yes**, the southward freight train enters the north end of Siding A to avoid a conflict between locations** B **and** A.*



2. Is a northward opposing train occupying Siding B*?*

***If** Yes**, the southward freight train will be routed into** Siding A **because** Siding B **is unavailable for the southward freight train at location** A.*



3.Is there a northward opposing passenger train at some point about 50 miles south of location B that will arrive at the south end of Siding B *before the southward freight train at location A can run to and clear into* Siding B*?*
The rationale for the second question now becomes clearer: a. The southward freight train would have had nowhere to go upon arrival at *Siding B*. b. The northward freight train would still be in *Siding B* waiting for the southward train. c. The northward passenger train would have arrived at *Siding B* and would be standing on the main track beside the northward freight train, and d. The southward freight train that had been released from *Siding A* would be standing at the switch at the north end of *Siding B* facing both trains. The option of routing the northward passenger train behind the northward freight train in *Siding B* would be undesirable[26]. Therefore, the southward freight train would be routed into *Siding A*.
The rationale for the southward freight train being routed into *Siding A*, if a northward passenger train was a minimum of 50 miles away is as follows: • If the north end of *Siding A* were 14 miles north of the north end of Siding B, the southward freight train would have to: o Traverse those 14 miles, and o At least one train length to clear into *Siding B.* The CTC would have to restore the turnout to enable the northward passenger train to receive a clear signal to proceed on the main track.

Location of the first locomotive of the southward freight train	***Location of the first locomotive of the northward passenger train***
At time 0	
Passes the turnout at the north end of *Siding A*.	Passes a point 50 miles south of the south end of *Siding B*.
At time 18[27]	
Arrives at the north end of Siding B, and begins to enter *Siding B* at 45 mph.	Has traveled 27 miles at an average speed of 90 mph.
At time 21	
Has entered into *Siding B*, and ▪ The rear of the train would just have cleared the turnout at the north end of the siding, the switch had been reset, and the northward signal set to clear.	Has traveled 32 miles at an average speed of 90 mph, and: ▪ Would be passing the south end of *Siding B* with a clear signal.
At time 24	
Stopped at the south end of Siding B.	Has traveled 36 miles and is passing the north end of *Siding B*.

[26] The northward passenger train would either have to back out of Siding B to proceed ahead of the northward freight train or follow the northward freight train north of Siding B at a reduced speed.

[27] Time rounded to nearest minute.

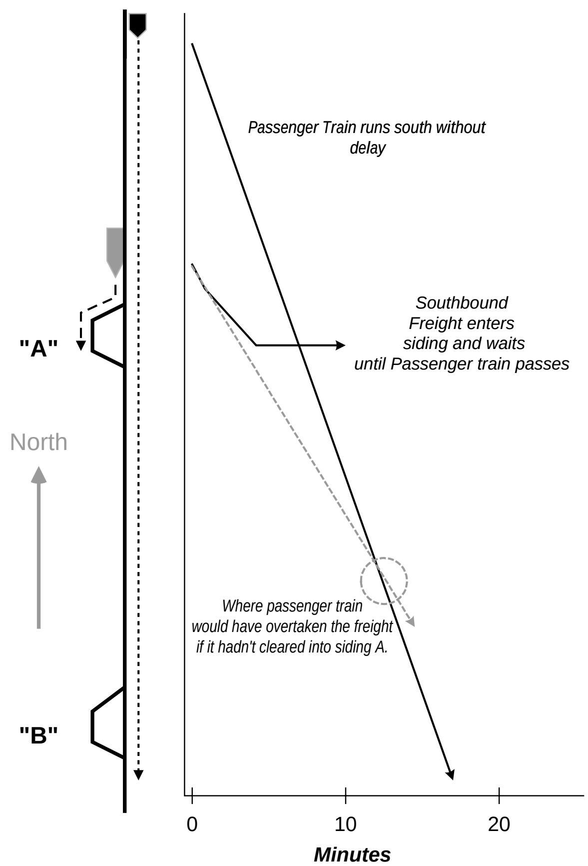
The northward passenger train, averaging 90 mph, must not be any closer than 24 minutes/36 miles from north end of Siding B to ensure time separation between trains at siding B.

Therefore, the northward passenger train, averaging 90 mph, would have to be a minimum of 49 miles south of the north end of Siding A to enable the southward freight train to proceed beyond the north end of Siding A. This distance would enable the northward passenger train to maintain suitable spacing and not have to decelerate approaching the north end of Siding B. **Fifty miles is the absolute minimum distance.** The southward freight train would be routed into Siding A when:

- A northward passenger train was 50 miles away, or closer, or
- An opposing freight train was already in or routed to Siding B.

The northward passenger would have to be more than 50 miles south of Siding B if the average speed of the northward passenger train had been higher, or the speed of the southward freight train lower.

4.



4. Is there a southward following passenger train at some point about 21 miles north of Siding A *that would catch up to the southward freight train before it could run to, and clear, into* Siding B*?*

If Yes - The southward freight train would be routed into *Siding A*.

The 21-mile criterion applies to the determination of the distance the southward passenger train would have to be behind the southward freight train, to enable the freight train to proceed to *Siding B* and clear the main track without delaying the southward passenger train. The rationale for the 21 miles is as follows:

Location of the first locomotive of the southward freight train	***Location of the first locomotive of the southward passenger train***
At time 0	
Passes the turnout at the north end of *Siding A*.	Passes a point 21 miles north of the north end of *Siding A*.
At time 18[28]	
Arrives at the north end of *Siding B*, and begins to enter *Siding B* at 45 mph.	Has traveled 26 miles at an average speed of 90 mph and is on the single-track between Sidings A and B.
At time 21	
Has passed into *Siding B*, and • The rear of the train would just have cleared the turnout at the north end of the siding; and • The CTC system has restored the turnout to enable the southward passenger train to receive a clear signal to proceed on the main track.	Has traveled 32 miles at an average speed of 90 mph, and: • Would be 3 miles from the north end of *Siding B*, and • Within 40 seconds (1 mile) would have to begin to decelerate approaching *Siding B*, ***if a clear signal had not yet been displayed***.

The southward passenger train would have traveled 32 miles, at an average speed of 90 mph, in the time it took the southward freight train, at an average of 45 mph, to travel 16 miles into the clear at *Siding B*.

Therefore, the southward passenger train would have to be:

- At least 36 miles north of *Siding B*, or
- A minimum of twenty-one miles behind the northward freight train when it passed *Siding A*, to be able to maintain suitable spacing and not have to decelerate approaching *Siding B*.

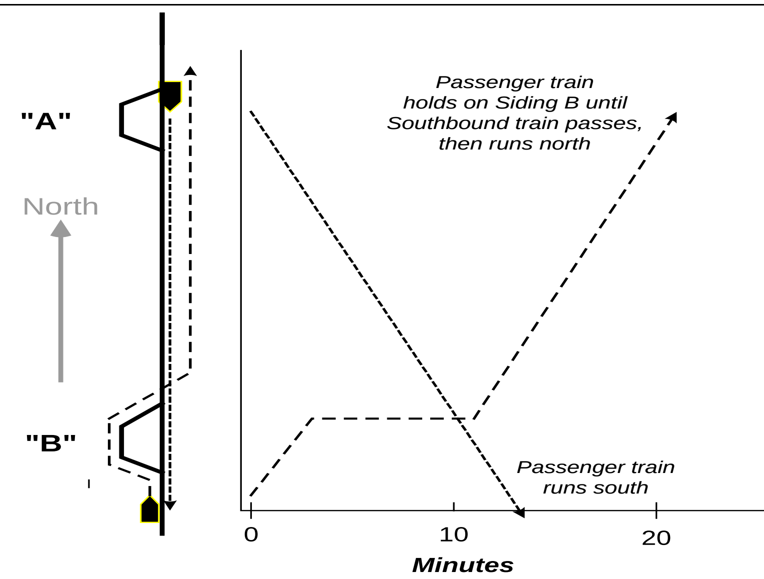
Twenty-one miles is the absolute minimum distance. If the average speed of the southward passenger train had been higher, or the average speed of the southward freight train been lower, the southward passenger would have to be even farther north of *Siding A*.

[28] Time rounded to nearest minute.

Referring to Question 2 above, if a northward freight train were located in *Siding B*, the southward freight train north of Siding A would enter the siding and wait for both the northward passenger train and the northward freight train to pass the south end of *Siding A*, before exiting the siding to head towards *Siding B*. The time sequence of the train moves would be as follows:

Location of the first locomotive of northward freight train B	**Location of the first locomotive of the northward passenger train**	**Location of the first locomotive of southward freight train A**
Time 0		
North end of *Siding B*	Passes a point 50 miles south of the north end of *Siding A*.	North of *Siding A*, on main track
Time 24 minutes		
North end of *Siding B*	Passes south end of *Siding B*	Standing at south end of *Siding A*
Time 29 minutes		
Leaves Siding B, following the northward passenger train	North of Siding B	Standing at south end of Siding A
Time 50 minutes		
Head end clears south end of *Siding A*	20 miles north of the north end of *Siding A*	Standing at south end of *Siding A*
Time 55 minutes		
Approaching north end of Siding A	28 miles north of the north end of *Siding A*	Leaves south end of Siding A
A southward freight train, having entered Siding A, would not depart the siding until the answers to the four questions are negative.		

There are times that a passenger train would take a siding. For example:



Location of southward passenger train[29]	Location of northward passenger train
Time 0	
On the main track passing the north end of *Siding A*	On the main track south of the south end of *Siding B*
Time 5 minutes	
Four miles south of the south end of *Siding A*	On *Siding B*, at the south end of the siding
Time 10 minutes	
Passing south end of the north end of *Siding B*	North end of *Siding B*, preparing to depart
Time 15 minutes	
Seven miles south of the south end of the north end of *Siding B*	On main track, between *Siding B* and *Siding A*

The amount of delay encountered by the northward passenger train would vary according to how far south of the south end of *Siding B* at Time 0.

Double-Track Railroad: Passenger Trains Overtaking Freight Trains

A train dispatcher evaluating the status of a northward passenger train (P1) following a northward freight train (F1) would look ahead of the trains for southward freight/passenger trains on the opposing track to determine whether the northward passenger train (P1) would be allowed to pass the northward freight train (F1). The amount of clear distance[30] a northward passenger train (P1), moving at 100 mph (0.6 minutes per mile), requires to overtake a northward freight train (F1), moving at 50 mph (1.2 minutes per mile), by diverting to the opposite (southward) track and back is:

[29] Both trains assumed to be averaging 90 mph.

[30] The equivalent to "sight distance" in the highway analogy.

- 30 miles, if the southward train approaching on the opposite track is a freight train, and
- 45 miles, if the southward train approaching on the opposite track is a passenger train.

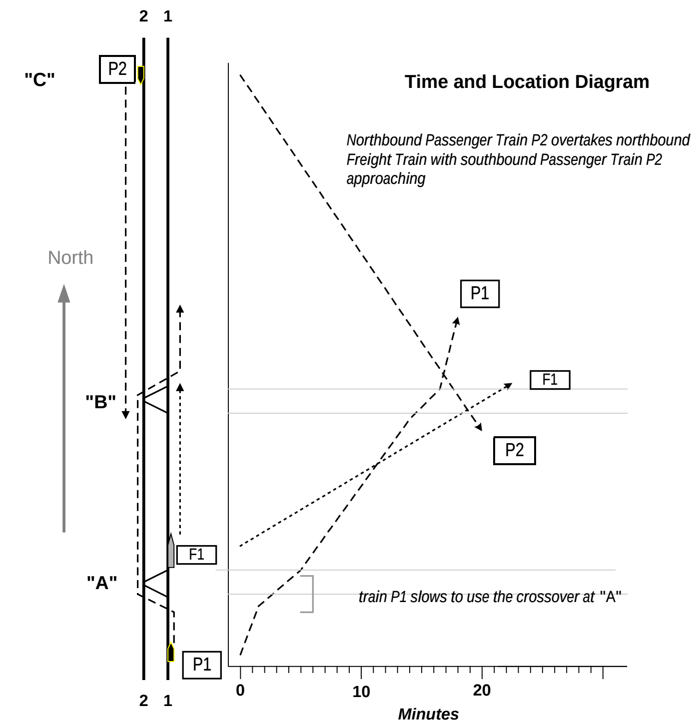
The minimum distance required by the northward passenger train (P1) to ideally overtake and pass a preceding freight is determined by the time to accomplish a number of moves, including:

- 3 minutes - The time separation between the northward freight (F1) and the northward passenger train (P1) to ensure that the northward passenger train (P1) obtains an optimal signal to crossover over to the opposite (southward) track at location A;
- 1.5 minutes - The time for the northward passenger train (P1) to crossover to the opposite track and accelerate to MAS (100 mph to 45 mph back to 100 mph);
- 1.5 minutes - The time for the northward passenger train (P1) to decelerate and cross back to its original track at location B; and
- 3 minutes - The time separation between the northward passenger train (P1) and the northward freight train (F1), which is now behind it, to ensure that the northward freight train (F1) obtains an optimal signal to proceed without slowing down and thereby being delayed.

Consequently, at a minimum, the northward passenger train (P1) must gain nine minutes relative to the freight train. At 0.6 minutes per mile, it would take a northward passenger train (P1) a minimum of fifteen miles to complete the pass of a northward freight train (F1).

Meets and Overtakes Involving Three Trains: Northward Passenger Train (P1) Overtaking Northward Freight Train (F1), and Approaching Southward Passenger Train (P2)

The time sequence of events of an ideal overtake of northward freight train (F1) by northward passenger train P1, being approached by southward passenger train P2, is as follows:

Time zero - Rear of northward freight train (F1) passes interlocking 1 on track 1; Southward passenger train (P2) may pass Point C on track 2, eighteen minutes north of Point B; **Time 3 minutes –** Passenger train (P1) crosses from track 1 to track 2 at Point A to run around the freight train; **Time 15 minutes –** Passenger train (P1) returns to track 1 ahead of the freight train at Point B fifteen miles north of Point A; **Time 18 minutes –** The freight train may pass Point B on track 1, presumably without being slowed; Opposing southward passenger train (P2) also may pass Point B on track 2, presumably without being slowed. At 100 mph the passenger train would have covered 30 miles in eighteen minutes.	

As the table indicates, a clear distance of 45 miles is needed for a northward passenger train (P1) moving at 100 mph to overtake a northward freight train (F1) moving at 50 mph –

- The sum of the distance of
  - i. Point C to Point B (30 miles), and
  - ii. Point B to Point A (15 miles).

If southward passenger train (P2) is within 45 miles of northward passenger train (P1), and northward passenger train (P1) still uses the opposite track, southward passenger train (P2) would be slowed or stopped to enable the northward passenger train (P1) to run around the northward freight train (F1).

Southward Train is a Freight Train (F2)

If the opposing train was a southward freight train (F2), it would cover 15 miles in 18 minutes, and a clear distance of 30 miles would be needed for a northward passenger train (P1) moving at 100 mph to overtake a northward freight train (F1) moving at 50 mph –

- The sum of the distance of
  - i. Point C to Point B (15 miles), and
  - ii. Point B to Point A (15 miles).

Thus, if southward freight train (F2) is within 30 miles of northward passenger train (P1), and northward passenger train (P1) still uses the opposite track, southward freight train (F2) would be slowed or stopped to enable the northward passenger train (P1) to run around the northward freight train (F1). If the interlockings were not ideally spaced, the required clear distances would be greater.

More Detailed Rationale for Passing Sidings, Greensboro–Charlotte

With approximately 50 trains projected to operate daily between Greensboro and Charlotte in 2020 it will be difficult to find forty-mile, or even thirty-mile, clear “gaps” in opposing trains to enable overtakes to occur. An eighteen-minute gap would not be available nearly 30 percent of the time. Consequently if further improvements were not implemented, passenger trains would have to follow freight trains for many miles before a clear distance would be available. The following passenger train would lose 0.6 minutes per mile for each mile it followed a freight train.

Oncoming highway traffic generally does not slow down to create at gap to let a car pass a truck, but a train dispatcher, having overall control of the traffic, **can** slow the opposing train to enable a passenger train to pass a freight train.

If the distance between Point A and Point B in the example above is less than fifteen miles, the freight train being overtaken may have to be slowed or stopped to let the passenger train overtake it. It is possible that allowing a passenger train to overtake a freight train would result in three or more trains losing time or being required to operate at a reduced speed. The three trains would be:

1. The freight train being overtaken,
2. The passenger train overtaking the freight train, and possibly
3. One or more opposing trains.