NEC FUTURE

A Rail Investment Plan for the Northeast Corridor

Tier 1 EIS Alternatives Report

August 2015

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Federal Railroad Administration

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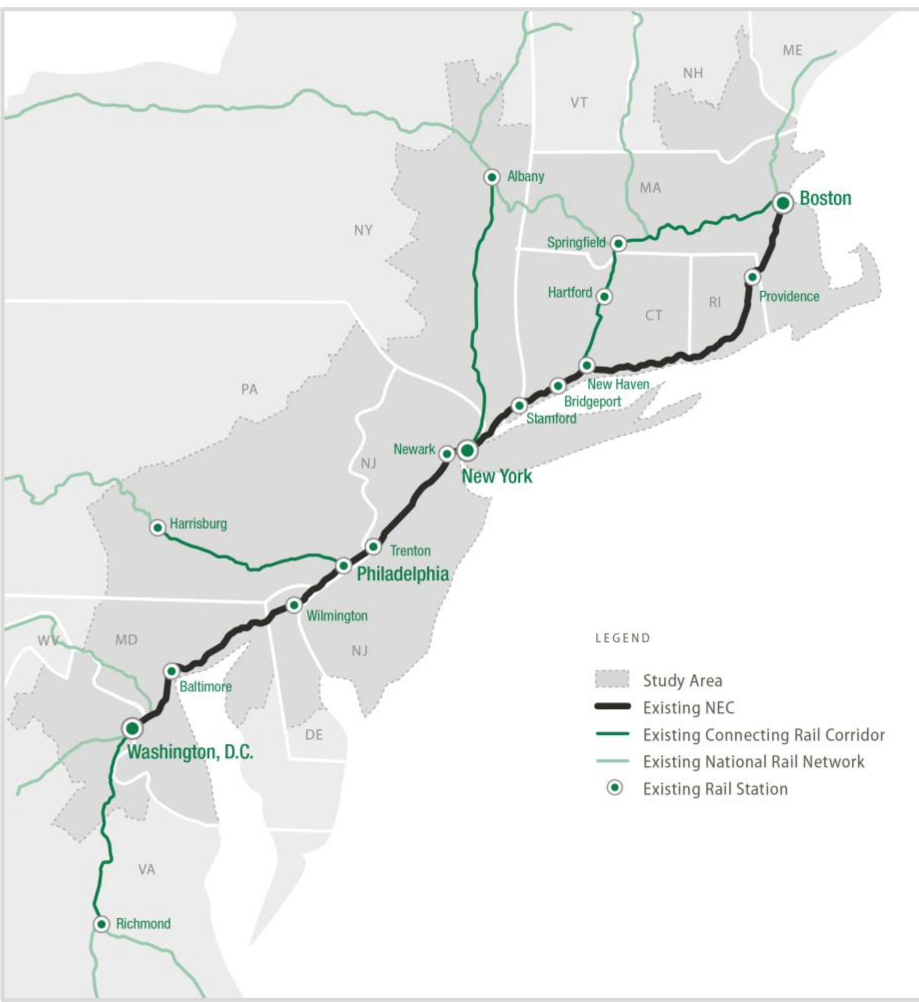
1. Introduction

NEC FUTURE is a comprehensive planning effort to consider the role of passenger rail service on the Northeast Corridor (NEC) within the regional multimodal transportation system and how it can meet current and future demand for Intercity and Regional rail service. As the lead federal agency for this planning effort, the Federal Railroad Administration (FRA) will determine a long-term vision and investment program, through the development of a Tier 1 Environmental Impact Statement (EIS) and Service Development Plan (SDP).

The NEC is the rail transportation spine in the Northeast of the United States and is a key component of the region's overall transportation system. It accommodates the operation of eight commuter-rail authorities and Amtrak—the Intercity rail service provider—as well as four freight railroads. The NEC FUTURE Study Area (Study Area) encompasses eight Northeast states and Washington, D.C., which are served directly by the NEC, plus those areas that can be reached directly by train or via a transfer from the NEC to connecting corridors. Figure 1 shows the Study Area, identifying the existing passenger rail network that comprises the NEC and connecting corridors.

Figure 1: Study Area



1.1 PURPOSE AND NEED

The 457-mile NEC and its connecting rail corridors[1] form the most heavily utilized rail network in the United States. The NEC ranks among the busiest rail corridors in the world, moving more than 750,000 passengers every day[2] on 2,200 trains.[3] Freight operators share the NEC with passenger railroads and move over 350,000 car loads of freight per year[4] on the NEC. This volume of traffic and diversity of service operate with capacity constraints that require scheduled and real-time trade-offs in passenger and freight service frequency, speed, and performance.

The congestion resulting from these capacity constraints, along with the NEC's aging infrastructure, further limit the opportunities to improve or expand passenger rail services. This infrastructure, in many cases built over 100 years ago, also does not provide the resiliency or redundancy necessary to respond to unanticipated natural disasters or other disruptive events. Additional details on the NEC's capacity constraints and aging assets are presented in the NEC FUTURE Scoping package (available on the NEC FUTURE website)[5] as well as the Northeast Corridor Infrastructure & Operations Advisory Commission (NEC Commission) *State of the NEC Region Transportation System* and *NEC Five-Year Capital Plan Fiscal Years 2016-2020*.[6]

An investment program to improve connectivity between passenger and freight rail markets and established and growing Northeast business centers is also critical to the economy. The Northeast is home to more than 51 million people[7] and includes four of the ten largest metropolitan areas in the United States. These major metropolitan areas, Washington, D.C., Philadelphia, New York City, and Boston, are among the top 25 largest metropolitan areas ranked by gross domestic product (GDP) in the world.[8] Approximately 20 percent of the nation's GDP comes from areas within the Study Area,[9] establishing the Northeast as an economic engine for the nation. In fact, if the Study Area were an independent country, it would represent the fifth-largest economy in the world.[10] The effectiveness and efficiency of that transportation system is critical to the continued economic growth and vitality of the Northeast.

As population and employment grow in the Northeast, however, even more demands are made on the existing transportation system. Traffic congestion and delays are routine across the transportation system

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

[2] Northeast Corridor Infrastructure and Operations Advisory Commission. (February 2014). *State of the Northeast Corridor Region Transportation System.* State of the Northeast Corridor Region Transportation System.

[3] Amtrak. (2014). *NEC Maps & Data: Growing Demand for Rail Services in the Northeast*. Retrieved January 2015, from Amtrak, The Northeast Corridor: *http://nec.amtrak.com/content/growing-demand-rail-services-northeast*

[4] Northeast Corridor Infrastructure and Operations Advisory Commission. (February 2014). *State of the Northeast Corridor Region Transportation System.*

[5] *www.necfuture.com*

[6] The referenced NEC Commission documents are available at *http://www.nec-commission.com*.

[7] U.S. Census Bureau. 2013. 1970–2012 Population Data. Washington, D.C.

[8] Brookings Institution. *Global MetroMonitor*. 2012. *http://www.brookings.edu/research/interactives/global-metro-monitor-3*

[9] United States Department of Commerce, Bureau of Economic Analysis. (2015). *Regional Economic Accounts*. Retrieved February 2015 from *http://www.bea.gov/regional/index.htm*

[10] Northeast Corridor Infrastructure and Operations Advisory Commission. (April 2014). *The Northeast Corridor and the American Economy.*

for highways and airports. By 2040, the Northeast is expected to add seven million new residents,[11] and no mode has sufficient new capacity to accommodate this growth. As growth continues and transportation demand exceeds the capacity of an already heavily used system, congestion will likely worsen.

Growth in population and employment in the Study Area combined with changes in travel preference will increasingly require a level-of-service and connectivity that is not supported by the existing NEC. Challenges to passenger rail travelers today include poorly coordinated transfers and inconvenient service frequencies, which make other travel choices and modes more attractive. A well-defined and coordinated investment program to support both preservation and enhancement of the NEC is essential to meet the needs of passenger and freight markets in the coming decades.

Moreover, there is national, regional, state, and local interest in how the transportation system, and in particular the rail network, can positively contribute to the overall environmental quality of the Northeast. It is, therefore, critical that improvements also consider environmental sustainability.

The ***purpose*** of the NEC FUTURE program is to upgrade aging infrastructure and to improve the reliability, capacity, connectivity, performance, and resiliency of future passenger rail service on the NEC for both Intercity and Regional rail trips, while promoting environmental sustainability and economic growth.

Overall ***needs*** addressed by the NEC FUTURE program include aging infrastructure, insufficient capacity, gaps in connectivity, compromised performance, lack of resiliency, environmental sustainability, and economic growth (Figure 2).

1.2 GUIDING PRINCIPLES

Given the unique complexities of alternatives development for the NEC, the FRA has drawn on international best practices, lessons learned in the development of the United States rail system, and stakeholder and public feedback to establish a set of “guiding principles” to help structure the planning process. These principles reflect agreed-upon policy objectives for the NEC FUTURE planning study to:

- Consider a Broad Range of Alternatives
- Develop Alternatives that Focus on Efficiency
- Structure Alternatives to Enable Incremental, Flexible Implementation

These principles and the related implications for the alternatives development process are described in the *Preliminary Alternatives Evaluation Report*, available on the NEC FUTURE website.

1.3 DOCUMENT PURPOSE

This Tier 1 EIS Alternatives Report presents the process for developing and refining the Tier 1 EIS Alternatives, which includes the No Action Alternative and Action Alternatives that will be analyzed in the Tier 1 Draft EIS. The alternatives development and refinement process, consists of service planning, ridership modeling, capital and operations and maintenance cost estimating, as well as stakeholder and

[11] Northeast Corridor Master Plan Working Group. (2010). *Northeast Corridor Infrastructure Master Plan*

public input. Furthermore, this document provides the complete definition and description of each alternative that will be presented in the Tier 1 Draft EIS.

Figure 2: NEC FUTURE Program Needs

State of Good Repair

Service quality currently falls short, due to the aging and obsolete infrastructure that has resulted from insufficient investment in maintaining a state of good repair on the existing NEC. Achieving and maintaining a state of good repair is needed to improve service.

Connectivity

The reach and effectiveness of the passenger rail network are limited by gaps in connectivity among transportation modes and between different rail services.

Capacity

Severe capacity constraints at critical infrastructure chokepoints limit service expansion and improvement, making it difficult to accommodate existing riders and growth in ridership.

Performance

In many markets, the trip times on passenger rail within the Study Area are not competitive with travel by air or highway. Improvements in travel times, frequency, or hours of service are needed to make passenger rail competitive with other modes.

Systemwide Resiliency

The NEC is vulnerable to the effect of severe storms. A more resilient and redundant passenger rail network is needed to enhance safety and the reliability of the region's transportation system.

Environmental Sustainability

Throughout the Study Area, energy use and emissions associated with transportation affect the built and natural environment. Passenger rail can help meet the region's mobility needs with fewer environmental impacts.

Economic Growth

A transportation system that provides options for reliable, efficient, and cost-effective movement of passengers and goods is needed for continued economic growth in the Northeast. The region's knowledge-based economic sector, including academic research and medical facilities, is especially reliant on access to convenient, reliable, and frequent rail service.

2. Alternatives Development Process Overview

There are many possible futures for the NEC. Some involve significant changes in the way passenger service is provided, while others focus on modifications to the existing system, keeping service much as it is today. Some options focus improvements only on the existing NEC, while others include service to new locations or different types of service. The FRA designed the NEC FUTURE alternatives development process to consider a broad array of distinct alternatives that address the program's Purpose and Need. With a set of guiding principles in mind (as listed in Section 1.2), the FRA progressively narrowed those alternatives to a smaller set that address the identified needs to varying degrees.

Because of the unique geographic, technical, and institutional complexity of the program, the FRA took an innovative approach developing the NEC FUTURE alternatives, organizing the process into three steps (Figure 3). The three-step process allowed for the preparation of corridor-wide service plans and infrastructure projects, and subsequent testing, refining, and optimizing of different service and geographic markets within the NEC. This process also provided the FRA with an understanding of how discrete elements perform relative to one another so that the strongest "package" of separate service, infrastructure, and route options could be crafted into different alternatives that meet the needs of various markets along the NEC.

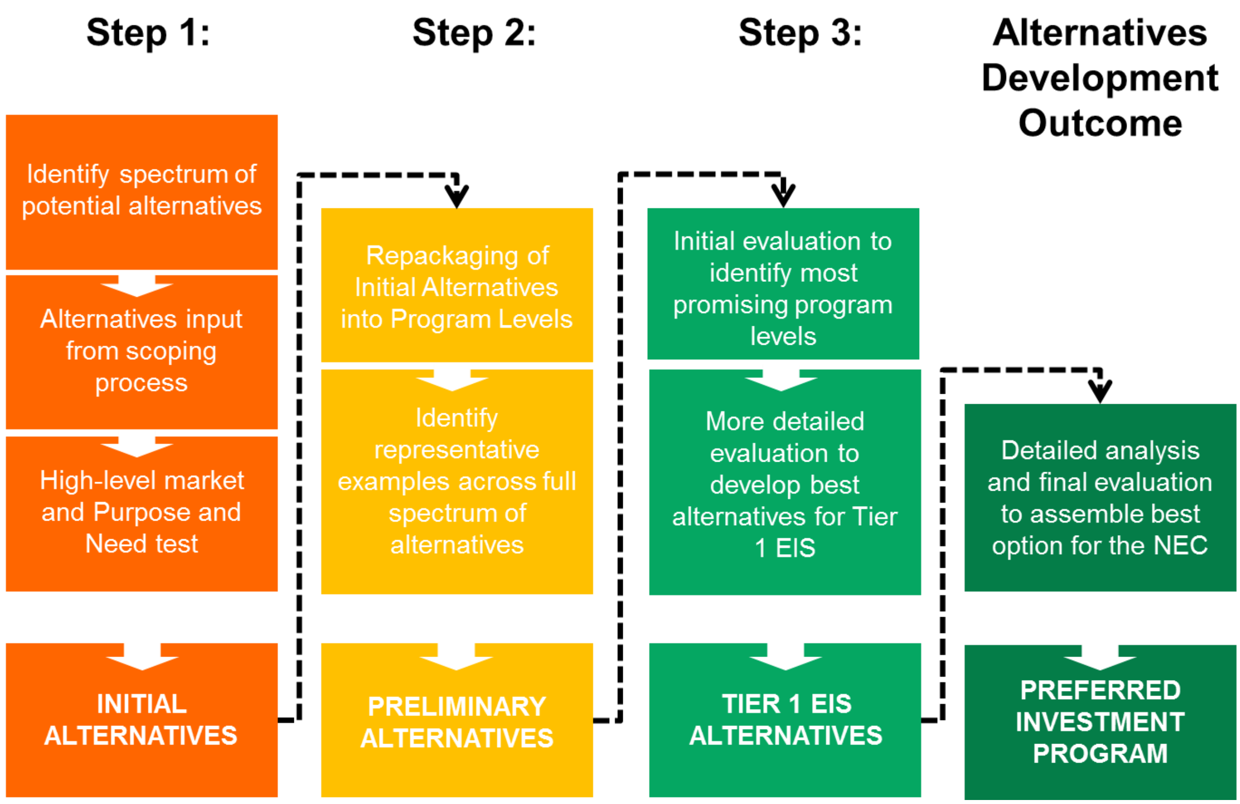
Decisions about the future of the NEC affect a wide range of stakeholders, from rail passengers, agencies, and service operators on the NEC to the residents, travelers, businesses, and communities potentially affected by the outcomes of NEC FUTURE. The FRA has been committed to an open and transparent engagement that involves these stakeholders in the alternatives development process. This engagement has entailed frequent coordination with state and railroad stakeholders, as well as federal and state environmental, transportation, and non-transportation officials. In addition, the FRA has conducted extensive public involvement and agency consultation activities including Scoping, consultation meetings, briefings, workshops, and presentations.

Each level of alternatives development is tied directly to the program's Purpose and Need and reflects the available level of detail from the supporting technical analysis. Similarly, alternatives and service concepts not meeting and addressing the Purpose and Need (Section 1.1) for NEC FUTURE were dismissed from further consideration.

In evaluating the alternatives, the FRA used a number of technical tools (as described in Section 0) to assess engineering feasibility, ridership, operational impacts, capital and operating costs, environmental impacts, and public benefits. The level of technical analysis and associated tools to develop applicable data becomes more detailed as the alternatives advance through the process. This approach was designed to allow for the refinement and the recombination of components of alternatives leading to FRA's identification of the Action Alternatives to be further analyzed and compared to a No Action Alternative in the Tier 1 Draft EIS.

The FRA defined and developed the Action Alternatives to a programmatic level, to focus on corridor-wide solutions within the Tier 1 Draft EIS. These alternatives establish a comprehensive, long-term vision for the corridor's future development and are defined by (1) a range of corridor-wide service options (Service Plans) required to meet varying degrees of projected growth and demand and (2) broad infrastructure needs to accommodate the service. Assumptions made at the Tier 1 level are representative and illustrative, to support analysis in both the alternatives development process and the Tier 1 Draft EIS. These service and infrastructure assumptions are not intended to be specific or prescriptive.

Figure 3: Alternatives Development Process



Source: NEC FUTURE team, 2015

The Action Alternatives provide the FRA and other stakeholders with a range of options and information over the No Action Alternative to determine the appropriate role of rail within the region's future transportation network. While focused on rail solutions (addressing the Purpose and Need), the alternatives have different implications for other transportation modes, including the region's airports, highways, and transit networks. In this way, they provide important information for policymakers to make decisions with this broader transportation system in mind.

The visions articulated by the Action Alternatives will take decades to fully implement. Additionally, improvements are likely to be implemented by multiple stakeholders across the NEC over many years, with specific timing dictated in part by availability of funding, local needs, and construction considerations.

As such, a key element of the NEC FUTURE planning process is to ensure improvements to the NEC are prioritized, integrated, and packaged for optimal service benefits across the entire rail network. The FRA developed the alternatives with the intent that they could be implemented in phases. Prioritization will be accomplished through phasing plans that define the necessary infrastructure and operational enhancements required to support various increments of new corridor-wide service. This phased implementation is described in Section 11.

2.1 INITIAL ALTERNATIVES

Developing a list of "Initial Alternatives" was the first step in the alternatives development process. To develop these alternatives, the FRA began with an analysis of Study Area travel demand and growth data to understand where people are traveling, where growth in population and employment is forecast to occur, and how travel patterns are likely to change in the coming decades. In addition, numerous route and service concepts were identified through input and data collected during Scoping. The FRA organized these ideas into a combination of "building blocks," including how trains will access the markets (network/route), the amount of service to provide to each market (investment level), and the type of service to be provided (service). Mixing and matching these building blocks provided the basis for testing and comparing multiple market, investment, and service options. Table 1 describes these three building blocks.

Table 1: Initial Alternatives Building Blocks

Building Blocks	Variations
Network/Route ■ How can markets be accessed by rail?	■ Existing NEC ■ Potential second-spine ■ Potential new right-of-way segments ■ Potential connecting corridor links
Investment Level ■ How robust is the program? ■ How much service can be provided? ■ Which new markets can be served?	■ Low (A): 2040 growth on existing NEC serving existing markets ■ Medium-low (B): Additional capacity on existing NEC to add new types of express, regional, and connecting corridor services ■ Medium-high (C): Targeted expansion of the NEC to serve new off-corridor markets and expand service options to NEC and connecting corridor markets ■ High (D): Extensive end-to-end expansion of the NEC to serve new markets and high-speed rail service
Service ■ How can markets be best served?	■ Standard service mix (services similar to today) ■ Enhanced service mix (new types of service and operations)

Source: NEC FUTURE team, 2015

Using these three building blocks, the FRA identified approximately 100 Initial Alternatives to address a broad spectrum of opportunities to upgrade and expand the NEC, serve existing and new markets both on and off the corridor, provide better connectivity to other rail markets, transit, and airports, and develop new high-speed rail service.[12] Some of the initial ideas proposed, such as modifying the existing NEC to serve markets off of the existing spine when those markets could be better served through existing and/or future connecting corridors did not advance. The FRA also dismissed less efficient routing options, such as New York City to Boston via Albany. (See the *Preliminary Alternatives Report* available on the NEC FUTURE website for a full description of the process.)

In December 2012, the FRA hosted a set of regional workshops.[13] These December Dialogues presented the market-based approach underpinning the alternatives development process, the results of Scoping, and the framework used to generate the Initial Alternatives. The feedback from participants at the December Dialogues underscored the importance of providing a range of investment scenarios for the

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[12] The definition of high-speed rail varies depending on context and purpose. For NEC FUTURE, high-speed rail consists of service provided by Intercity-Express trains operating at a range of speeds from 150 to 220 mph.
[13] A summary of this meeting is available on the NEC FUTURE website: *http://necfuture.com/get_involved/public_meetings.aspx*

NEC, as well as a flexible approach for the use of additional railroad capacity, allowing operators to respond to changing needs.

2.2 PRELIMINARY ALTERNATIVES

For the next step of the alternatives development process, the FRA organized the Initial Alternatives into four program levels to facilitate a comparison of the benefits and impacts of distinct levels of investment in the NEC. Some Initial Alternatives were not advanced into Preliminary Alternatives, particularly those alternatives that included specific engineering and alignment solutions not germane to a corridor-wide, Tier 1 NEPA planning process. These options can be appropriately considered in a project-level, Tier 2 NEPA process.

The four program levels (Table 2) differ by the level and types of rail service they provide to the region and support a broad range of options for the "role" that passenger rail can play on the NEC and in the Study Area, from upgrading the existing NEC to building a second-spine to support high-speed rail operations for existing and future markets. As program levels increase from A to D, larger investments in service and infrastructure are required.

Table 2: Preliminary Alternatives

Program Level	Alt.	Service Objective	Possible Service Option
A	1	Addresses state of good repair and provides some increase in service and capacity along existing NEC	Standard (financially constrained)
	2		Standard
	3		Enhanced (mixture of services)
B	4	Substantially increases service to existing and connecting markets along existing NEC with high capacity operations	Standard
	5		Enhanced: Maximum frequency of trains
	6		Enhanced: Maximum trip time savings
	7		Enhanced: Maximum service to connecting corridors
C	8	Targeted expansion of existing NEC to serve new markets, reduce trip time, and introduce robust Regional rail service	Standard
	9		Enhanced: Maximum frequency of trains
	10		Enhanced: Maximum trip time savings
	11		Enhanced: Maximum service to connecting corridors
D	12	Achieves world-class high-speed rail potential through the addition of new spine	Second-spine generally parallel to existing NEC
	13		Second-spine via Danbury-Hartford-Providence
	14		Second-spine via Ronkonkoma-Hartford-Worcester
	15		Second-spine via Delmarva and Nassau County-Stamford-Danbury-Springfield

Source: NEC FUTURE team, 2015

Within each program level, the FRA developed multiple alternatives to better understand and quantify key market and service dynamics, such as the trade-offs between frequency of service, trip time, and the convenience of one-seat end-to-end service. This allowed the FRA to test and compare different operating scenarios, or, in the case of the second-spine, different route options. In all, the FRA defined 15 Preliminary Alternatives (Table 2). Within Program Levels A, B, and C, the FRA developed two different service scenarios for testing and comparison:

- **Standard service** serves markets in much the same manner as they are served today, with Intercity trains stopping at major stations along the corridor and commuter trains taking passengers from suburban markets into urban centers.
- **Enhanced service** involves the evaluation and testing of new operating approaches and services that allow for more intensive use of existing or new infrastructure.

Because enhanced service, as defined, encompasses a broad range of potential new service options, the FRA developed separate alternatives in Program Levels B and C to focus on three different enhanced service objectives: maximizing the frequency of trains; providing the fastest express trip time; or maximizing service to connecting corridors. (Additional information about the Preliminary Alternatives can be found in the *Preliminary Alternatives Report* available on the NEC FUTURE website.)

In April 2013, the FRA hosted a second set of regional workshops to present the Preliminary Alternatives to the general public.[14] The feedback from participants at the April Dialogues confirmed the importance of preserving a range of program levels in the Tier 1 Draft EIS to reflect different visions for the future of the NEC. Participant feedback also highlighted the importance of evaluating multiple route options.

2.3 NO ACTION ALTERNATIVE AND ACTION ALTERNATIVES

In the final step of the alternatives development process, the FRA evaluated the 15 Preliminary Alternatives by comparing them to understand whether and how each met the Purpose and Need (Section 1.1), and analyzing their benefits in terms of ridership, travel time, and service quality. Similarly, among the different Program Level D second-spine route alternatives, the FRA compared performance (in terms of service and ridership) and environmental impacts.

To conduct the analyses of the 15 Preliminary Alternatives, the FRA developed evaluation criteria and associated performance measures derived from the Purpose and Need. This set of evaluation criteria are based on (i) best practices; (ii) results from models used in transportation investment programs of similar physical and programmatic magnitude, (iii) available data; and (iv) stakeholder input. Table 3 details the criteria and data used to evaluate the Preliminary Alternatives.

The FRA used the metrics and data for each criterion to compare Program Levels A through D, as well as to compare the separate alternatives within each program level. After evaluating the environmental impacts of the Preliminary Alternatives, the FRA determined that each was likely to result in environmental effects. Based on feedback received during the April Dialogues, the FRA dismissed the Delmarva routing in Preliminary Alternative 15, because of public concerns that the route was not viable for a variety of reasons, including the potential for environmental impacts as well as from a growth and market perspective.

Table 3: Preliminary Alternatives Evaluation Criteria

Evaluation Criteria	Metrics
Growth and Capacity Expansion	▪ Annual trips ▪ Annual passenger miles

[14] A summary of this meeting is available on the NEC FUTURE website: *http://necfuture.com/get_involved/public_meetings.aspx*

	■ Peak-hour passengers at major screenlines* ■ Peak-hour trains, Hudson River screenline
Aging Infrastructure	■ NEC in a state of good repair
Service Effectiveness and Performance	■ Express trip time savings ■ Maximum trains per hour ■ Peak-hour trains operating on NEC
Connectivity	■ Stations served by Intercity trains ■ Station-pairs served by Intercity trains ■ Airport stations
Environmental Consequences	■ Acres of environmental sensitivity

Source: NEC FUTURE team, 2015

* A screenline is an imaginary line used to count rail traffic at a specific location in the Study Area (e.g., the Hudson River, recognizing the capacity restrictions of the tunnels and/or to analyze certain defined types of service/markets).

The FRA's key findings during this stage of the alternatives development process were related to 1) defining service dynamics—evaluating passenger preferences for frequency of service, trip time, and one-seat-ride services; and 2) defining the role that rail can play in transporting travelers across the NEC region. Additional details on this process can be found in the *Preliminary Alternatives Evaluation Report* available on the NEC FUTURE website.

The FRA used this evaluation to repackage the Preliminary Alternatives into three distinct Action Alternatives that meet the Purpose and Need. The FRA also defined a No Action Alternative to establish a baseline for comparative purposes. Each alternative consists of 1) a set of geographic markets to be served by passenger rail; 2) a Representative Route (or footprint) that connects these markets; 3) assumptions about the level of passenger rail service that will be provided to these markets; and 4) infrastructure improvements that support this level-of-service.

The FRA further refined the No Action and Action Alternatives by adjusting and refining service and infrastructure needs based on input gained from over 200 meetings with stakeholders, including the NEC railroads; federal, state, and regional agencies; and other interested organizations and individuals. This refinement process is described in more detail in Section 0.

The following are brief descriptions of the No Action and Action Alternatives. A detailed definition for each alternative is provided in Sections 7, 8, 9, and 10.

- **No Action Alternative** is represented by the existing NEC[15] and maintains today's service levels, defined as the number of trains per hour by operator and existing types of service. It does not increase capacity, address gaps in connectivity, expand service to new markets, or achieve a state of good repair.
- **Alternative 1** maintains the role of rail within the transportation system of the Northeast as it is today, keeping pace with the level of rail service and investment required to support proportional growth in population and employment. For this alternative, the FRA used the projected service plans of NEC service operators as a starting point, and made adjustments to meet projected increases in travel demand. To keep pace with demand, Alternative 1 includes new rail services and investment to expand capacity, add tracks, and relieve key chokepoints, particularly through New Jersey, New York, and Connecticut. Intercity service grows south of New York City through the addition of one Intercity-Express train and one Intercity-Corridor train during periods of peak demand. North of New

[15] Including initiatives currently under construction or funded (e.g., LIRR East Side Access).

York City, the Intercity schedule is expanded to include one Intercity-Express train and one Intercity-Corridor train operating hourly in each direction. The capacity of Regional rail service is increased by a combination of lengthening existing peak trains, and adding trains in the peak period where growth is strong and line capacity is limited, especially on the lines feeding New York City.

- **Alternative 2** grows the role of rail, expanding rail service at a faster pace than the proportional growth in regional population and employment. South of New Haven, CT, service and infrastructure improvements are focused generally on the existing NEC, and north of New Haven, a new supplemental two-track route is added between New Haven and Hartford, CT, and Providence, RI, to increase resiliency, serve new markets, reduce trip time, and address capacity constraints. The existing NEC expands in most areas to four tracks, with six tracks through portions of New Jersey and southwestern Connecticut. Alternative 2 includes a new rail route to serve Philadelphia International Airport, and some Regional rail run-through service in New York City and Washington, D.C., to increase terminal throughput.

- **Alternative 3** transforms the role of rail, positioning rail as a dominant mode for Intercity travelers and commuters. Service and infrastructure improvements include upgrades on the NEC and the addition of a two-track second-spine that operates adjacent to the NEC south of New York City and extends the reach of NEC rail to new markets north of New York City. This new spine supports high-speed rail services between major markets and provides additional capacity for Intercity and Regional rail services on both the existing NEC and new spine. Alternative 3 supports a wide variety of new Intercity and Regional rail services, tailored to the needs of specific markets, including non-stop express trains, high-speed zone express trains serving the long-distance commute market, and new service to markets off the existing NEC.

  Alternative 3 includes new high-speed service between Washington, D.C., and Boston. From Washington, D.C., to New York City, this service mostly runs on a route closely parallel to the existing NEC, but it deviates from the existing route to shorten trip times and serve new stations in downtown Baltimore, Philadelphia International Airport, and downtown Philadelphia. Between New York City and Boston, in addition to the existing NEC, Alternative 3 includes several new route options that provide shorter trip times than the existing NEC. Each route option serves different intermediate markets in central Connecticut and on Long Island. These north end route options are described in Section 5. The Service Plans developed to analyze Alternative 3 assume that some Intercity trains operate end-to-end over the new route between Washington, D.C. and Boston, while other Intercity trains, as well as Regional rail trains, operate interchangeably over portions of the new route and the existing NEC.

3. Technology

In defining a long-term vision for the role of passenger rail on the NEC, FRA has actively sought stakeholder and public input via an early and proactive outreach process. The overwhelming message received is that the users of the NEC are seeking reliable, integrated, and expanded train service to meet both Intercity and Regional rail travel needs. Considering that over 90 percent of the users of the NEC are Regional rail customers, it is clear that near-term investments that prioritize responding to the interconnected travel needs of existing rail passengers have great public and institutional support.

The FRA developed the NEC FUTURE Purpose and Need (Section 1.1) to reflect key deficiencies in today's NEC, and subsequently focused on Action Alternatives that best meet that Purpose and Need by improving steel-wheel passenger train technology that is used today by all the railroads sharing the NEC, including both Intercity and Regional rail operations, as well as freight service. The FRA considered proven technological advances, and, where appropriate, incorporated use of international best practices that are compatible with existing steel-wheel train technology for the following reasons:

- **Aging Infrastructure**: The quality of rail service on the NEC – reliability, travel time, and ride quality – currently falls short due to aging and obsolete infrastructure. This is the result of insufficient investment in the rail line to maintain its infrastructure in a state of good repair. Aging infrastructure also increases the cost and complexity of continuing railroad operations. Focusing first on the renewal of existing rail lines using steel wheel technology will yield a significant positive return on transportation investment by improving the reliability and overall quality of current Intercity and Regional rail service for the more than 700,000 daily users of the NEC.
- **Gaps in Connectivity**: Expanding travel connections across the NEC, and making those connections easier and more seamless for the hundreds of millions of people riding Intercity and Regional rail trains each year is fundamental to achieving the purpose of NEC FUTURE. The Northeast is steadily transforming from multiple separate markets to a single region. Essential to this transformation is an integrated network of passenger rail service that connects Intercity and Regional rail markets across the NEC, meets diverse trip origins and destinations of the traveling public, and accommodates projected growth in regional population and employment. Today's NEC passenger rail network is limited by gaps in connectivity among transportation modes and between different rail services. Even with compatible rail technology, today's rail service between stations often requires lengthy layovers or difficult transfers, limiting mobility options for passengers. Expansion of service that incorporates interoperable steel wheel rail technologies within the existing infrastructure will offer travelers a wider choice of city-pair combinations and travel options. It also offers better connectivity through shared station infrastructure and easier cross-platform transfers between Intercity and Regional rail trains.
- **Insufficient Capacity**: Severe capacity constraints at critical infrastructure chokepoints limit service expansion and compromise the ability to recover from service disruptions, making it difficult to offer reliable service and accommodate growth in ridership. Given the broad range of Intercity and Regional rail services provided on the NEC, and the significant cost for adding capacity, the NEC FUTURE Action Alternatives are intended to maximize the transportation benefits of investments in additional capacity, both on the existing NEC and for new routes connecting to or supplementing the existing NEC. The use of interoperable train technology in the Action Alternatives facilitates the

incremental expansion of service across the corridor to address immediate needs on the NEC, keeping up with underlying growth in transportation demand while leveraging individual projects on the NEC to maximize the regional benefits of investments in service and infrastructure.

Given the accelerating pace of change in consumer technology, business practices and transportation patterns, application of future emerging and new technologies may help to support rail service on the NEC and meet other transportation needs across the region. These might include new information systems and services, new train propulsion and guideway systems, fare collection innovations, and safety enhancements. The FRA plays an important role in bringing new rail transportation approaches and technologies to market and demonstrating their specific capabilities and role in the broader transportation system. For example, the FRA has sponsored development of next-generation propulsion systems for locomotives and has explored the potential for use of magnetic levitation train technology.

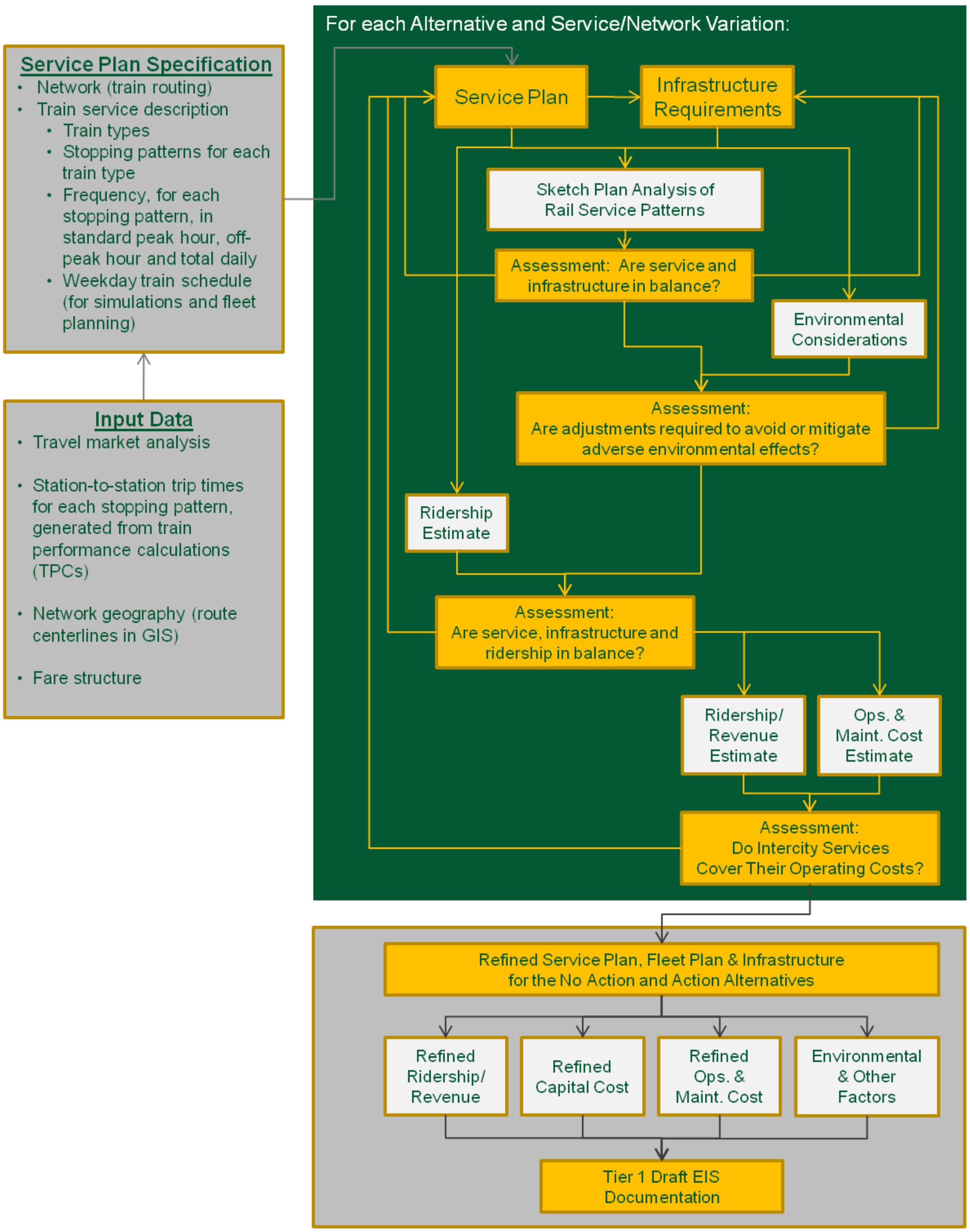
An advanced guideway system, such as magnetic levitation technology, could possibly be used to develop a second-spine or portions thereof as envisioned in Alternative 3. This would require separate stations, could not support run-through trains from connecting corridors, and does not offer proven integration efficiencies with today’s NEC infrastructure and operators. However, because advanced guideway technologies remain under development they are not incorporated in the Action Alternatives.

Such technologies could be studied separately, and are not precluded as a future transformative investment in the regional transportation system. Other potential applications of new technology transportation systems could support the NEC passenger rail network by connecting off-corridor markets to the NEC, or a major market to the NEC. This might include a connection between a specific airport (such as JFK International Airport) or other activity center to a downtown center located on the NEC, or connecting the NEC to Pittsburgh, PA or Richmond, VA (e.g., Long Island or parts of northern Virginia).

4. Alternatives Refinement

The FRA refined the Action Alternatives through a phased and iterative process that drew from multiple sources and types of information and work products. Figure 4 summarizes this process in a flow diagram. The refinement of the No Action Alternative also followed this process; however, the process did not require multiple iterations.

Figure 4: Alternatives Refinement Process



Source: NEC FUTURE team, 2015

The FRA developed Service Plans for each Action Alternative, building from the successful elements of the Preliminary Alternatives. While the FRA was developing analytic models for estimating ridership, capital costs, and annual operations and maintenance costs, the FRA tested and evaluated the specific elements of the Service Plans – service frequencies, stopping patterns, train routings, and rolling stock characteristics for each service type – to identify their ability to achieve efficient use of rail infrastructure capacity and meet the varying needs of each type of rail service. The FRA then refined the Service Plans in two broad steps as described below. Throughout this effort, the Service Plans remained consistent with the overall role of rail as defined for each of the Action Alternatives.

- The FRA modified the Service Plans to incorporate feedback and input from stakeholders and output from the initial ridership model. Additional refinements were made to balance the rail infrastructure associated with each Action Alternative and provide flexibility for the Regional rail operators, with an emphasis on the areas in and around major terminals.

- The FRA further refined the Service Plans using iterative work with the service planning, ridership, and cost modeling efforts. Interim conservative estimates of service levels were prepared and confirmed the reasonableness of the Representative Route[16] for each Action Alternative. The FRA compared results from the Interregional Model (Section 4.2) with the service levels, and subsequently adjusted the Service Plans to confirm that (1) capacity is reasonably in line with estimated ridership; and (2) the Intercity-Express and Metropolitan services, as defined in Section 4.1.2, generate revenues in excess of operations and maintenance costs in 2040.

For the No Action Alternative, the FRA developed a Service Plan identical to the existing service levels on the NEC, with one exception. The Long Island Rail Road East Side Access Project in New York City, which currently is under construction and therefore included within the No Action Alternative, will change the number of Regional rail trains and their service patterns crossing the East River between Manhattan and Queens, New York. As a result, the FRA incorporated future Regional rail service from Long Island to Manhattan identified in the East Side Access project's Record of Decision into the Service Plan for the No Action Alternative. Intercity service levels are assumed to remain the same as existing levels today.

4.1 SERVICE PLANNING

The FRA developed a sketch planning process for creating and analyzing Service Plans to enable the efficient testing of multiple service scenarios, encompassing:

- Train types, routings, service levels and stopping patterns (peak and off-peak)
- Scenarios covering the range of service levels and types being considered for each of the Action Alternatives
- Service pattern analysis – balancing service needs and infrastructure requirements.

[16] A Representative Route refers to a proposed route or potential alignment for an Action Alternative. It includes horizontal and vertical dimensions, which are based on prototypical cross sections and define its footprint. Prototypical cross sections identify construction methods (tunnel, viaduct, bridge, fly-over, bypass, track type, etc.) and right-of-way requirements for tracks, structures, ancillary facilities, and stations associated with each Action Alternative. (See Section 6.2.) The Representative Route is limited to the NEC Spine; and therefore, excludes connecting corridors and branch lines.

The FRA performed early rounds of analysis working with ranges of service levels. Service Plan scenarios were developed for the NEC network as a whole and also for key segments of the corridor. These scenarios were developed from a set of planning objectives directly related to the three visions (maintain, grow, transform) of the Action Alternatives.

In each Service Plan, the FRA considered:

- A mix of service types, including Intercity-Express, Intercity-Corridor (Metropolitan and Intercity-Corridor-Other), Long Distance, and Regional rail service (as defined in Section 4.1.2)
- Specific stopping patterns and rolling stock for each type of train service
- The calculation of trip times over the rail network for each train type and stopping pattern, based on train performance calculations, with reasoned assumptions about station dwell times, terminal layover time and overall schedule recovery time built into the scheduled trip times
- Future Regional rail frequency targets for each service type and stopping pattern:
  - Peak, at each station (e.g., provide slots for 2, 3, or 4 trains per hour [tph])
  - Off-Peak (e.g., provide slots for 1–2 tph)
- Infrastructure assumptions, including number of main tracks, location and configuration of rail junctions, track and platform configurations at stations, and the locations of train storage yards
- Assignment of trains (by type, stopping pattern and time of day) to available tracks in each segment of the corridor

Using stringline (time-distance) diagrams and train schedule information, the FRA aligned and overlaid a full set of train service patterns. The FRA adjusted train service patterns, schedule times, and track assignments interactively to eliminate operating conflicts. Adjustments to the rail infrastructure configuration were made, where necessary and appropriate to address conflicts that could not be resolved with operational and scheduling adjustments. The end result of this integrated process was a Service Plan and representative train timetable for each Action Alternative that is operationally feasible and fits within the available capacity of the rail infrastructure. This process is described in greater detail in Appendix A, *Service Plans and Train Equipment Options Technical Memorandum.*

4.1.1 SERVICE PLANS

The FRA developed Service Plans for the No Action and Action Alternatives to describe the types and levels of passenger train service operating on the NEC in 2040. These Service Plans are a representative train schedule for a typical future weekday, and include the train stops by station for both peak and non-peak periods. The Service Plans are operator-neutral and provide a technical basis that allows the FRA to estimate future ridership and capital investment needs and costs, as well as assess the environmental impacts associated with planned construction and future operations.

The FRA developed the Service Plans as a planning tool. They are not for purposes of actual implementation and are distinct from full detailed operating plans. The Service Plans do not include yarding and crewing assumptions, or specific track assignments at major stations and terminals. They are grounded in reasonable operational assumptions, driven by rigorous train performance calculations and informed by capacity analysis, supported by operations-related analysis at a level sufficient for the plan to be considered operationally feasible. Subsequent investment-grade simulation analyses generally will be required to support detailed decision-making and the development of actual operating plans and timetables.

4.1.2 SERVICE TYPES

For NEC FUTURE, the FRA organized the various types of passenger rail service into categories, based on travel distance, travel market, trip purpose, where and how the trains operate, and the service characteristics and amenities offered to passengers. The categories are used to represent the rail service that is provided in the No Action Alternative and Action Alternatives and correspond with the travel market definitions used for ridership estimating. These categories are aimed at best describing the full range of services provided in the Action Alternatives.

The top level categories are **Intercity** and **Regional rail.** Intercity service provides transportation between cities or metropolitan areas at speeds and distances greater than that of most Regional rail trips. Regional rail generally provides transportation within a single metropolitan region and serves more local markets. Regional rail service currently focuses largely, though not exclusively, on journey-to-work travel to the major central business districts within the Study Area. However, an increasing share of Regional rail trips are attributable to non-traditional commutes and non-work trip purposes. Moreover, reverse-peak and off-peak travel generally is growing at a faster rate than traditional commuting.

Intercity

For purposes of the travel demand analysis and ridership estimating, Intercity service is classified by market segment into two service types: **Intercity-Express** (serving the premium travel market composed largely of business travelers) and **Intercity-Corridor** (serving a broad market segment that includes a mix of business, personal, and leisure trips). Today's Amtrak's Acela Express and Northeast Regional services fit into these two service types, respectively. Ridership estimates were produced for these service types, as described in Section 4.1.2. These service types are described in greater detail in the *Service Plans and Train Equipment Options Technical Memorandum*.

- **Intercity-Express** – the future premium Intercity high-speed rail service offered on the NEC, making limited stops along the NEC and only serving the largest markets. Amtrak's Acela Express currently provides such service on the NEC between Washington, D.C. and Boston, MA. For the Action Alternatives, this category of service is envisioned as analogous to the state of the art high-speed rail services currently operating in Europe and Asia. Intercity-Express service offers the shortest travel times for Intercity trips, with a higher quality of on board amenities, at a premium price, using state of the art high-speed trainsets, with top speeds in the range of 160 mph to 220 mph.
- **Intercity-Corridor** – the Intercity services that operate *both* on the NEC and on connecting corridors that reach markets beyond the NEC. Whereas Intercity-Express service is aimed at the business travel market, Intercity-Corridor trains serve the more price-sensitive end of the Intercity rail travel market, carrying both leisure and business travelers and stopping at a greater number of intermediate stations, compared with Intercity-Express trains.
  - **Metropolitan** – the future primary Intercity rail service on the NEC, a subset of Intercity-Corridor service, and the successor to the existing Amtrak Northeast Regional Service. Whereas Intercity-Express service is aimed at the business travel market, Metropolitan trains serve both leisure and

business travelers who are more price-sensitive. The FRA has chosen a new name for this service to emphasize its distinct characteristics and higher level of performance. Metropolitan trains use electric high-performance train equipment intended to operate at speeds up to 160 mph. They operate on regular schedules with high frequency (2-4 trains per hour) and are able to stop at more stations than the current Amtrak Northeast Regional service (including some stations that are only served today by Regional rail trains), due to faster speeds and high-performance operating characteristics. This allows Metropolitan trains to maintain competitive trip time while increasing the number of direct station-pair connections served by Intercity-Corridor trains. Metropolitan service also provides a travel choice for longer-distance commuters at stations served by both Metropolitan and Regional rail trains. In addition to providing service on the NEC Spine, Metropolitan trains provide service on the electrified Keystone Corridor in all three Action Alternatives and on the Hartford Line in the alternatives where this line is electrified (Alternatives 2 and 3).

- **Intercity-Corridor-Other** – Since Metropolitan service utilizes trainsets that can only operate in electrified territory, a separate Intercity-Corridor service is needed to provide connectivity and direct one-seat service between non-electrified connecting corridors and the large and mid-size markets on the NEC. These trains, along with the Metropolitans, are classified as Intercity-Corridor trains for purposes of ridership analysis, and they cater to similar market for Intercity service. These trains are assumed to have operating characteristics similar to today's Amtrak Northeast Regional trains, which will be dual-mode in the future – with top speeds of 125 mph on the NEC and up to 110 mph off of the NEC. The most prominent off-corridor routes served by these trains include Washington, D.C., to various points in Virginia and North Carolina, the Empire Corridor serving Upstate New York, the Knowledge Corridor serving central Massachusetts and Vermont, and the Inland Route corridor between Springfield, MA, and Boston.

- **Long Distance** – Intercity trains connecting the Study Area with other parts of the United States, generally entailing overnight travel with sleeping car and dining car service and handling checked baggage. This category includes existing Amtrak service to Florida, New Orleans, and Chicago. Since these trains operate over longer distances, they are subject to greater delays when operating off-corridor. As such, these trains are scheduled to operate on the NEC during off-peak periods. For NEC FUTURE, the FRA assumes that the level of long-distance train service on the NEC will remain constant through the 2040 horizon period—five round trips per day on the NEC between New York and Washington, D.C., and points south[17] plus the Capitol Limited and Lake Shore Limited, which connect with NEC services at Washington, D.C., New York City, and Boston.

Regional Rail

Regional rail encompasses all rail services that are concentrated within a single metropolitan region. Regional rail trains provide local and commuter-focused service characterized by relatively low fares and a high percentage of regular travelers. Regional rail includes the current services provided by Virginia Railway Express (VRE), Maryland Area Regional Commuter (MARC), Southeastern Pennsylvania Transportation Authority (SEPTA), NJ TRANSIT, Metropolitan Transportation Authority (MTA)-Long Island Rail Road (LIRR), MTA-Metro-North Railroad (MNR), Shore Line East, and Massachusetts Bay

[17] Represented by four existing overnight services (Silver Star, Silver Meteor, Crescent and Cardinal), plus the same-day Palmetto service to Savannah, GA.

Transportation Authority (MBTA). None of these railroads, with the exception of Shore Line East, operates exclusively on the NEC. Most include relatively extensive networks of multiple branch lines, which feed one or more major terminal stations. As a result, the NEC does not operate in a vacuum, but rather as a key element within a complex and interconnected rail transportation system. Regional rail services have multiple stopping patterns, which vary by location and among the Action Alternatives: all-stop local service, zone express service (typically a weekday peak service that stops at a group of adjacent stations and then operates express to the main terminal), and limited-stop service focusing on selected key stations.

4.1.3 ROLLING STOCK

The FRA made assumptions in the Service Plans about combinations of various types and configurations of rolling stock and associated traction power. In the Action Alternatives, passenger trains on the NEC comprise both integrated trainsets and locomotive-hauled coaches. Integrated trainsets are represented by electric multiple-unit trains operated by some Regional rail providers, as well as the high-speed trainsets that are used for both Intercity-Express and Metropolitan service. On the NEC, integrated trainsets operate on electric power drawn from the overhead catenary system. Locomotive-hauled trains are categorized by the traction capabilities of the locomotive, which can either be electric (also drawing power from the catenary), diesel, or dual-mode (with the ability to operate under electric or diesel power). Locomotive-hauled trains are used for Intercity-Corridor-Other and Regional rail service.

The Service Plans for the Action Alternatives are based on the use of electric traction by all passenger trains operating on the NEC– using intact trainsets, electric locomotives or high-performance dual-mode locomotives – since these equipment types provide the most consistent top speeds and accelerating and braking performance, which allows for the highest utilization of available capacity. Specific assumptions regarding Regional rail service and rolling stock vary among the Action Alternatives. The ultimate decisions about rolling stock procurement, including the configuration and maximum speed of trainsets, will be made subsequent to the completion of the programmatic Tier 1 EIS.

4.1.4 ENHANCED SERVICE CONCEPTS

In addition to identifying requirements for rail infrastructure investments in capacity needed to accommodate increased levels of train service, FRA also examined the potential to improve passenger rail operations through the adoption of enhanced service and precision operations concepts. These enhanced operating concepts represent national and international best practices, and are aimed at enhancing the attractiveness and convenience of train services, increasing the efficiency of operations, lowering the cost per capita of delivering rail service, and making the most efficient use of investments in new rail infrastructure. The FRA's focus in the development of the Action Alternatives was on concepts that take advantage of the elimination of chokepoints, the expansion of capacity and the standardization of rolling stock, so that the benefits of capital investment are maximized. Enhanced service concepts reach markets that are underserved or not served by existing service, while providing the rail operators the flexibility to deliver service that best meets the needs of the market in 2040. The new service concepts that the FRA applied and tested are discussed in the following sections, along with how and where these concepts are embedded within the Service Plans of the Action Alternatives.

Regular Clockface Headways

Service Plans for the three Action Alternatives provide for regular schedules for all train services operating on the NEC. Train schedules are headway-driven rather than load driven, as is the case today. In the Action Alternatives, virtually all NEC services operate at regular 15-, 30-, or 60-minute intervals, with local stations generally receiving 2 to 4 tph during peak periods and major stations often receiving more service. Peak shoulder hour, reverse-peak, and off-peak schedules retain the same operating patterns, but with a reduced number of trains per hour to match expected passenger demand. Individual service patterns repeat every hour (e.g., the local train stops each hour at 18 minutes and 48 minutes past the hour), though some patterns may only exist during peak periods.

An additional benefit of regular clockface headways is that they make it easy for passengers to make connections between rail and local transit services. For example, a bus route that runs on a regular clockface headway can be timed to meet connecting trains at a hub station[18]. This coordination increases ridership on both rail and other public transit services by reducing transfer time between modes. Additionally, a bus that is timed to meet the train can serve double duty – bringing passengers to the train as well as carrying passengers from the train on its onward journey. Transit agencies all along the NEC can choose to re-structure routes and schedules to take advantage of the regular clockface headway operation on the railroad.

Metropolitan Service

As described in Section 4.1.2, today's non-premium Intercity-Corridor service evolves into Metropolitan service, a new Intercity-Corridor service that provides frequent, regular service catering to the non-premium intercity market as well as the time-sensitive regional rail market. In all three Action Alternatives, Metropolitan service becomes the primary non-express Intercity service option for trips that begin and end on the NEC. A separate Intercity-Corridor-Other service remains to provide one-seat rides from NEC stations to markets beyond the NEC, including Virginia, North Carolina, and Vermont.

All of the Action Alternatives introduce Metropolitan service, although the level-of-service and the performance characteristics of the service varies among the alternatives. This variance is based on the railroad infrastructure and capacity that are provided in each alternative. In Alternative 1, Metropolitan trains share NEC slots with Intercity-Corridor-Other trains, operate mostly over existing NEC tracks, and service is limited to no more than two trains per hour in the peak periods. Metropolitan service is introduced to additional stations on the NEC, but the overall performance of Metropolitan and Intercity-Corridor-Other services is similar, and the principal travel benefits are derived from the improvement in the frequency of these combined services within the Intercity-Corridor category.

In Alternative 2, Metropolitan service effectively replaces the existing Northeast Regional service for the low or economy end of the Intercity travel market for trips within the NEC territory. The service utilizes the high-speed tracks that are built at various locations along the NEC, and it provides four trains per hour, at regular 15-minute intervals at all locations and in all time periods on the NEC where there is demand to

[18] Hub stations include smaller intermediate Intercity stations and key Regional rail stations, as well as new stations that have the potential to fill connectivity gaps, serve special trip generators, and/or provide important inter-modal connections. These stations are served by some Intercity service, although Intercity-Express service is more limited than the service levels offered at Major Hub stations. See Section 6.1.1.

support the service. Intercity-Corridor-Other trains supplement the Metropolitans, further increasing the effective service frequency for travel within the NEC.

Alternative 3 provides two different sets of Metropolitan services, each operating with four trains per hour in peak travel periods. One service operates via downtown Philadelphia and the second-spine between New York City and Boston, and the other service operates on the existing NEC between Philadelphia and New Haven, with extensions of service to Harrisburg, PA via the Keystone Corridor, to Boston, MA via the Shore Line, and to Springfield, MA via the Hartford Line.

Run-Through Service at Major Stations/Terminals

In Boston, New York City, and Washington, D.C., the various Regional rail operators terminate service at the major rail stations in the central business district (CBD). Philadelphia is the exception on the NEC where Regional rail currently operates through Center City Philadelphia with branch lines on one side linked with different branch lines on the other side.

Regional rail run-through service, particularly applicable to Washington, D.C., and New York City, links branch lines from the different service operators and provides continuous revenue service on both sides of the metropolitan region through the CBD. For example, a peak-direction Regional rail train that originates in New Jersey operates into Penn Station New York, then continues eastward in revenue service and offers reverse-peak service to Long Island. Based on early market analysis performed during the alternative development process, demand for this through-service is modest relative to the demand for service to the CBD, and run-through demand is unlikely to be the driver for the investment in infrastructure required to support such operations. However, with considerable investment in the major terminals and coordinated improvements to train fleets, run-through service has the potential to provide operational efficiencies and reduce train interference conflicts, thereby unlocking additional capacity at these congested stations.

Alternative 1, which maintains the role of rail as it is today, retains the existing Regional rail operations with terminating services at Washington, D.C., New York City, and Boston, although the volume of train movement activity increases over existing and No Action Alternative levels. Intercity trains remain the principal through-running trains at Washington, D.C., and New York City.

Alternative 2 requires capital investment at Washington, D.C., and New York City to facilitate the through running of both Intercity and Regional rail trains, including the widening of station platforms and the creation of storage yard facilities on the far side of the terminal for originating and terminating Regional rail services. Through running is assumed to occur at both Washington, D.C., and New York City in this alternative – supporting frequent Metropolitan service as well as high-density Regional rail service. Through running capability and associated capacity projects permit Metropolitan service to be extended through Washington, D.C., to northern Virginia. Similarly, expanded Regional rail services at both Washington, D.C., and New York City are assumed to operate through the Major Hub stations, feeding yard facilities on the far side of the hub station and also enabling (but not requiring) revenue run-through service between suburban branch lines on opposite sides of the region.

Alternative 3 similarly supports through-running operations, which permit the most efficient use of platform and track capacity at the Major Hub stations and enable the dramatic increases in total train volumes that are possible in this alternative.

Intercity-Corridor and Regional Rail Express Service using New High-Speed Tracks

In Alternative 3, the new dedicated high-speed tracks for Intercity-Express and Metropolitan service provide an opportunity to increase the utilization of this infrastructure through urban areas with select Regional rail trains taking advantage of available slots not used by intercity trains. Intercity-Express and these select Regional rail trains operate with high-performance trainsets capable of operating in blended service with high-speed express trains. They supplement or replace the outer zone express service in the major metro regions, or could be used to extend Regional rail service beyond the existing service territories. For example, in New Jersey, this service could replace the current Trenton-Hamilton-Princeton Junction zone express trains, providing significant trip time improvement for these trips. This service could also be used to extend the service territory south to Philadelphia, providing high-quality express Regional rail service between Philadelphia and Bucks County to New York City.

This enhanced service concept is a significant feature of Alternative 3, offering substantially faster commute times for longer-distance commute trips from the outer suburbs. Maryland outer zone Regional rail trains can use the high-speed tracks between Baltimore and Washington, D.C. Similarly, outer zone Regional rail trains in New Jersey can use the high-speed tracks on final approach to New York City to reduce trip times and relieve congestion on the local tracks. Alternative 3 also provide opportunities for up to six or eight commuter express trains per hour from either Long Island or the Upper Harlem Line to Penn Station New York, depending upon the route option.

Simplified Operations

The simplified operations category encompasses a range of possible concepts for operating passenger service on a multi-track rail line. Service concepts include normalizing stopping patterns (with fewer but more regular and better coordinated patterns), as opposed to having a lot of unique individual patterns, less switching of trains between tracks in multi-track territory, fewer branch lines feeding the NEC Spine, timed transfers for branch line passengers at main line hub stations, and/or higher and more regular service frequencies for the stopping patterns that remain on the existing NEC. The primary benefit of a simplified Service Plan is that it brings more predictability to both train operators and passengers.

For train operators, simplifying the train schedule and adopting regular, repeating and well-integrated train stopping patterns can allow the railroad to be run more automatically, without the variability and potential human error introduced by a system that generates a wide range of unique conflicts that require frequent dispatcher decisions and unique solutions. The system remains too complex for completely automated operation, and train dispatchers are still needed to monitor and resolve conflicts and errors that do occur. However, simplified operations can reduce the number and type of train interference conflicts that arise for train dispatchers and allow them to better respond to conflicts when they occur, and respond in a way that is more predictable. Consequently, simplified options should improve the overall reliability of the railroad as well as minimize the amount of redundant and parallel rail infrastructure necessary to support a more complex Service Plan.

For passengers, the regularity of a simplified plan makes planning trips easier, increasing the attractiveness of rail versus other modes. More reliable service and better connections with other rail services and transit modes are benefits that attract additional ridership. Drawbacks of this type of plan may include serving fewer markets with one-seat-rides and increased trip times for express trains between major markets.

Both Intercity and Regional rail stopping patterns in all three Action Alternatives are simpler and more regular than in the current operating plans. These modifications, along with the elimination of chokepoints and the restoration of the railroad to a state of good repair, result in more reliable service and more efficient use of infrastructure. The most dramatic application of simplified operations occurs in Alternative 1 on the New Haven Line. A transit-style service with a simpler system of express and skip-stop local services replaces the current complex overlay of multiple stopping patterns. This service concept delivers greater throughput capacity without major additions of new track.

Coordinated Endpoint and Branch Line Connections

Coordinated scheduling of Regional rail trains on systems that have multiple branch lines or multiple terminals, or where the outer ends of two regional systems meet at a common station (defined as endpoints), can provide for convenient passenger connections, extending the reach of the existing systems, substituting for costly extensions for one-seat-ride service, and providing a much more convenient transfer experience for rail travelers. More precise schedule coordination becomes easier to accomplish with clockface scheduling, simplified operations, and elimination of the chokepoints that contribute to train delays—all of which are characteristics of the Action Alternatives. Convenient transfer connections depend on train schedules that allow enough, but not too much, time for passengers to change trains. Convenience also is enhanced with cross-platform or same-platform transfers, and the integration of timetable and real-time train information, particularly where more than one operating authority is involved. Trenton, NJ, is an example of a location where endpoint connections currently are provided between SEPTA and NJ TRANSIT Regional rail trains.

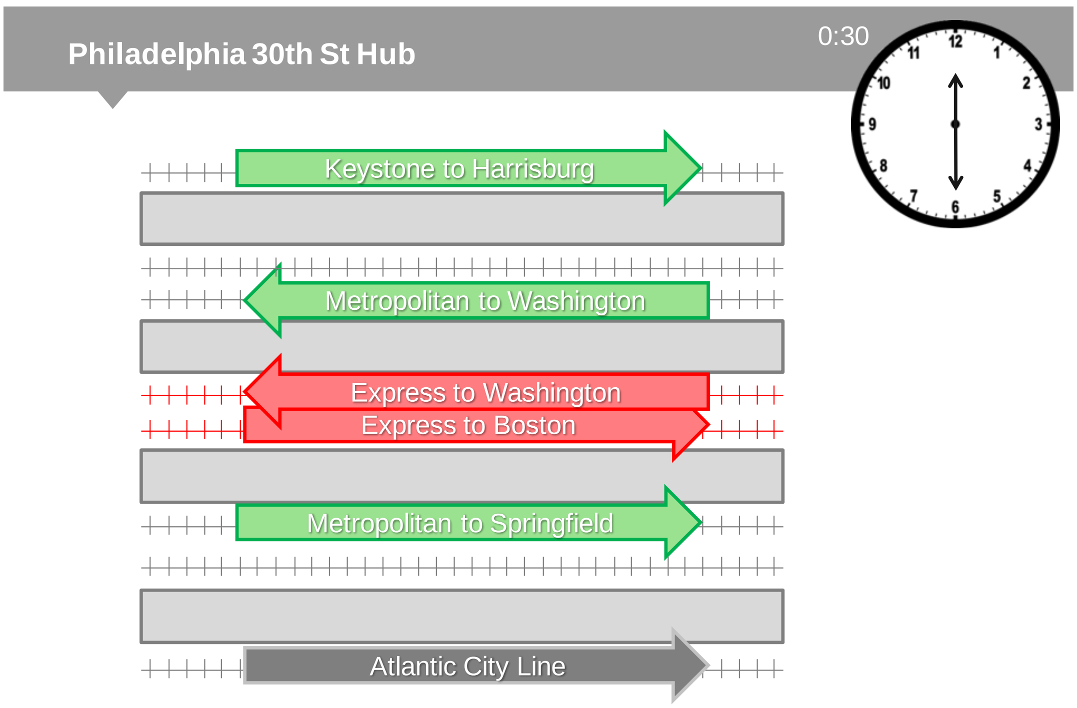
With clockface scheduling and regular, repeating service intervals, Alternatives 1, 2, and 3 take advantage of opportunities for better connected Regional rail service at several locations on the NEC, effectively closing the gaps that now exist in Regional rail connectivity from one system to another. As Maryland Regional rail service is extended to Newark, DE, schedules are coordinated with those of the Regional rail service to Philadelphia, enabling convenient passenger transfers. Modification of the track configuration near Trenton, NJ, allows timed cross-platform transfers between New Jersey and Philadelphia Regional rail trains in both directions. Also, the integration of Shore Line and Hartford Line Regional rail trains with New Haven Line service provides convenient cross-platform transfers at New Haven.

The Action Alternatives also improve connectivity between main line and branch line services at multiple locations. Intercity services can be better coordinated with Regional rail services at Philadelphia 30th Street with the normalization of train schedules. Similarly, NEC services can be better coordinated with train services to and from Hoboken, NJ, at the transfer station in Secaucus, NJ. The timing of Empire train arrivals and departures at Penn Station New York can be coordinated with Intercity-Express, Metropolitan, and Regional rail service on the NEC. And, in cases where simplified operations may reduce the number or frequency of direct train services from the NEC Spine to branch lines, shuttle services on the branch lines can be timed with convenient connections to and from NEC trains. This offers greater overall service frequency on the branch line, and a trip that remains convenient and time-competitive for the passenger making the transfer. The same principles apply to connecting transit services at hub stations. Regular clockface scheduling of rail services, coupled with reliable operating performance, allows local transit service providers to customize the arrival and departure timing connecting and feeder services to match the train schedules.

Pulse-Hub Operations

A pulse-hub is a special application of service coordination, where multiple trains converge on a single hub station concurrently or in close succession, dwell simultaneously for a period of time while passengers transfer from one service to another, and then depart toward their various destinations. A pulse-hub operation can be a key component in a simplified operation, but could also be featured in Service Plans with a wider variety of service offerings. Figure 5 illustrates one example of a pulse-hub operation at 30th Street Philadelphia. Several trains of different types and with various destinations have coordinated arrival and departure times, facilitating convenient transfers.

Figure 5: Philadelphia Pulse-Hub



Source: NEC FUTURE team, 2015

A pulse-hub operation offers opportunities to provide high-quality service to smaller markets that do not warrant one-seat-rides to a major market. For this system to work adequately, significant amounts of built infrastructure are needed at hub stations to facilitate the simultaneous movement of multiple trains through the station as well as the efficient movement of passengers between trains. Investment in station and rail infrastructure to enable easy passenger transfers is a prominent feature of pulse-hub operations. Investment in stations to facilitate high-quality passenger transfers, however, can also be a feature of Service Plans that do not rely exclusively on this type of operation, but selectively employ it at key stations on the network. Similarly, as with coordinated endpoint connections, this service enhancement works only if a transfer passenger can change trains without queuing and with the common practice of staging passengers on platforms.

The Service Plans for Alternatives 2 and 3 provide for pulse-hub operations on the lower level of Philadelphia 30th Street Station with Intercity-Express, Metropolitan, Keystone Corridor, and Atlantic City trains all connecting with universal transfer opportunities every 30 minutes during the peak periods. The Alternative 3 route option from Long Island through New Haven, CT, to Hartford, CT, also provides a timed pulse-hub at New Haven.

4.1.5 FREIGHT RAIL

While the purpose of NEC FUTURE focuses on passenger rail service, the NEC FUTURE Scoping process, along with input received from freight rail operators and state and regional stakeholders, identified the preservation of freight rail as an important objective. NEC FUTURE Service Plans for each of the Action Alternatives preserve freight access on the NEC and do not preclude future growth opportunities. The FRA relied on specific assumptions for the mixed operations of freight and passenger traffic on the same tracks and in the same right-of-way, consistent with the current FRA regulatory framework:

- Freight will not operate on high-speed tracks in mixed traffic with Intercity-Express passenger trains operating above 160 mph—this includes all new segments included in Alternative 3.
- Mixing of different types of passenger trains, including Intercity-Express and Metropolitan service using new high-performance equipment, are assumed to be permissible in the future on the existing NEC with passenger train speeds up to 160 mph—this applies mostly to the express tracks on the NEC where there are more than two main tracks, in all three Action Alternatives.
- New tracks generally will be built with sufficient separation from parallel tracks used by freight trains to permit simultaneous operation of freight and passenger traffic; however, temporal separation of freight traffic may be required for some portions of the NEC where existing express tracks are used by high-speed trainsets and are closely parallel to the existing local tracks, such as in Pennsylvania, New Jersey, and Massachusetts.[19]

4.2 RIDERSHIP

The NEC FUTURE ridership and revenue forecasting approach included two major components to address the most significant travel markets relevant to the NEC. These two components are listed below and described in the next sections:

- A new Interregional Model, which addressed travel between metropolitan market areas in the NEC, developed primarily from a new NEC household survey
- Existing regional models, which addressed travel within metropolitan market areas in the NEC (e.g., Washington, D.C., Baltimore, Philadelphia, New York City, Boston, etc.)

[19] Railroad operating characteristics and limitations on permissible maximum speeds and the mixing of freight and passenger traffic are described more fully in Appendix A, *Service Plans and Train Equipment Options Technical Memorandum*.

4.2.1 INTEGRATION OF THE INTERREGIONAL AND REGIONAL FORECASTS

The FRA estimated interregional and regional ridership forecasts in parallel processes using separate forecasting models. These forecasts were then combined to form overall ridership forecasts for the No Action Alternative and Action Alternatives. Combining the forecasts involved the identification and application of the appropriate "model of record" for each rail market. Table 4 summarizes the forecasting models used to evaluate the No Action Alternative and Action Alternatives for each region pair within the Study Area. Within the metropolitan regions (on the diagonal of the table), the appropriate regional models were used. Trips between regions were estimated using the new Interregional Model, for almost all pairs of regions. For the final rail results, there were very few interregional commuter-rail trips that were not captured using the regional models. Since the regional models were more robust in estimating commuter trips, as well as to avoid double-counting trips, the Regional rail ridership numbers were taken solely from the regional models as opposed to the Interregional Model commuter ridership.

Table 4: Models Used to Evaluate NEC FUTURE Rail Markets

From/ To	Market Area	Boundaries	A	B	C	D	E	F	G–L
A	Washington Metro	Northern Virginia to Pautuxent River	R1	IR	IR	IR	IR	IR	IR
B	Baltimore Metro	Susquehanna River to Pautuxent River	IR	R2	IR	IR	IR	IR	IR
C	Wilmington/ Philadelphia Metro	Susquehanna River to Trenton	IR	IR	R3	IR	IR	IR	IR
D	NY Metro, West of Hudson	Trenton to New York City	IR	IR	IR	R4	IR	IR	IR
E	NY Metro, East of Hudson	New York City, Long Island & Coastal Connecticut	IR	IR	IR	IR	R5	IR	IR
F	Providence/Boston Metro	Rhode Island to SE New Hampshire	IR	IR	IR	IR	IR	R6	IR
G	Empire Corridor	New York City to Albany	IR	IR	IR	IR	IR	IR	IR
H	Inland Connecticut, Massachusetts	New Haven to Springfield	IR	IR	IR	IR	IR	IR	IR
I	Virginia	Richmond to Washington D.C.	IR	IR	IR	IR	IR	IR	IR
J	Keystone	Philadelphia to Harrisburg	IR	IR	IR	IR	IR	IR	IR
K	Vermont	Vermont to Springfield	IR	IR	IR	IR	IR	IR	IR
L	Maine	Maine-New Hampshire	IR	IR	IR	IR	IR	IR	IR

Tools:

IR	NEC FUTURE Interregional Model
R1	Enhanced Washington Metropolitan Area Transit Authority Transit Post Processor of Metropolitan Washington Council of Governments Model
R2	Simplified Trips on Project Software (STOPS) Application for Baltimore Metropolitan Area
R3	Delaware Valley Regional Planning Commission Regional Forecasting Model
R4	NJ TRANSIT North Jersey Travel Demand Forecasting Model
R5	Metropolitan Transportation Authority Regional Transit Forecasting Model
R6	STOPS Application for Boston Metro/Rhode Island Area

Source: NEC FUTURE team, 2015

4.2.2 INTERREGIONAL MARKETS

The FRA's travel demand modeling and forecasting approach for interregional travel consisted of the development and application of a two-stage model system. The first stage modeled total interregional travel volume by origin-destination (OD) pair. The second stage predicted the share of intercity passengers expected to use each of the available intercity travel modes using a nested logit specification.

The two-stage model system was applied in reverse order (i.e., mode share before total travel demand) to allow mode share model results to be incorporated within the total demand model structure. This linkage provides the total travel model with sensitivity to changes in the level-of-service provided by all modes, allowing for the total number of trips to increase due to overall improvement in travel conditions.

Household Travel Survey

The development of the Interregional Model system was informed by the results of an extensive household survey conducted within the Study Area. Although existing survey data were available, the data were generally tied to specific existing models or forecasts focused exclusively on either interregional or certain regional sub-markets within the NEC. Moreover, these existing data sets and models did not provide a consistent integrated analysis and forecasting basis throughout the NEC. As such, the FRA conducted the NEC FUTURE Survey of Northeast Regional and Intercity Household Travel Attitudes and Behavior (Household Travel Survey) to provide data on travel patterns and mode choice within the Study Area for use in the mode choice models.

The new Household Travel Survey included only respondents who had made interregional trips between the respondent's home and eligible out-of-state locations were considered as qualifying trips. If a respondent took multiple qualifying trips, one was randomly selected to be the "reference trip" for the respondent. The actual mode chosen for the reference trip forms the basis for the revealed preference (RP) portion of the survey response. Respondents were then asked additional questions about this trip about attributes such as type of train service used, mode of access/egress, fare, estimated one-way travel time and cost, as well as trip purpose.

Six stated preference (SP) choice exercises represented the "core" of the survey and provided the primary basis for estimating the new mode-choice model. These SP questions asked respondents to think about the context of their reference trip and then choose from among three modes of travel with characteristics specified by the survey. These characteristics varied across the questions, according to an experimental design that minimized correlations among variables.

The specific SP trade-off questions reflected an experimental design to address an appropriate cross section of all the potential mode availability and service characteristic combinations. The detailed trip information obtained before the trade-off questions provided the context for the respondent's travel choices and a basis for defining trip-relevant service characteristics in the trade-off questions. The responses to the survey questions provided the basis for estimating key sensitivities to changes in the service characteristics, by market segment, for the new model. In addition to the SP questions, all qualifying respondents were asked demographic questions at the end of the survey.

Total Travel Demand Model

In the two-stage travel demand modeling approach, total travel demand models (one for each trip purpose) were required in conjunction with the mode share models (also one for each trip purpose). Total travel demand forecasts define the total market size to which the mode shares are applied to produce ridership forecasts by mode. In general, there are two major influences on the total travel demand between any two geographic areas; population and economic activity growth, and changes in the modal levels of service provided. The impact of population and economic activity contributes to organic growth, in that an increase in those measures will naturally generate more travel. The change of modal levels of service creates induced demand, as opposed to organic growth. Induced demand creates additional trips because overall travel between origins and destinations become more attractive, due to better travel conditions (such as reduced travel time or cost).

The FRA estimated total travel demand model using cross-sectional data that estimates the relationship between current levels of population, income, employment, and level-of-service and current observed demand. The modeling process then applies the observed relationships to forecasts of growth in population, income, employment, and changes in level-of-service.

Multimodal interregional passenger market data for the Study Area were assembled from a number of different sources. The sources are as follows:

- Auto market: NEC Automobile OD Study (2014), prepared by RSG for the NEC Commission
- Air market:
  - Air Carrier Statistics database (T-100 Domestic Market), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from *http://www.transtats.bts.gov/Fields.asp?Table_ID=258*
  - Airline Origin and Destination Survey (DB1B), 2012 Q3-Q4 and 2013 Q1-Q2, retrieved from *http://www.transtats.bts.gov/Fields.asp?Table_ID=247*
- Rail market: Amtrak Ridership and Ticket Revenue Data (FY 2013), provided by the Market Research and Analysis Department, Amtrak
- Bus market: Northeast Corridor Bus Schedule and Ridership Data (2014), prepared by RSG for the NEC Commission
- Demographic Data: Demographic Growth Forecasts provided by Moody's Economy.com (annual for years 2010 through 2040)

Using the data sources listed above, the FRA developed annual trip tables for each of the modes. Once the total trips were determined, the FRA then segmented them by purpose using the trip purpose percentage share calculated from the NEC FUTURE Household Travel Survey, segmented by mode and trip length. Table 5 presents the trips by mode and purpose, which shows that 70 percent of trips in the NEC market area are for non-business purpose. The final base trip table used in the Interregional Model was the total trips for each zone pair segmented by trip purpose.

Table 5: Summary of Existing (2013) Annual Person Trips by Mode and Purpose

Purpose	Auto	Air	Intercity-Express Rail	Intercity-Corridor Rail	Intercity Bus	Total
Business	63,195,000	8,717,000	1,725,000	2,698,000	1,031,000	77,366,000
Non-	274,272,000	7,951,000	1,423,000	7,126,000	6,991,000	297,763,000

Purpose	Auto	Air	Intercity-Express Rail	Intercity-Corridor Rail	Intercity Bus	Total
Business						
Commute	47,150,000	0	192,000	1,598,000	1,562,000	50,502,000

Source: NEC FUTURE team, 2015

Mode-Choice Model

The mode share models estimate the share of total person travel by mode. This model component addressed travel by the following modes:

- Auto (passenger car/truck/van)
- Air
- Intercity bus
- Train, addressing the following types of train service separately:
  - Intercity-Express
  - Intercity-Corridor rail
  - Regional rail
  - Metropolitan

Model Structure

The new model estimated shares among these as a function of the following key independent variables describing the service characteristics:

- Travel time
- Travel cost or fare, taking account of the cost implications of travel by group and individuals and also including parking charges
- Schedule of service provided by air, rail, and bus
- Alternative-specific constants reflecting the differences between modes not directly measured by other independent variables in the model (factors and traveler perceptions such as the comfort and convenience provided by each mode would be reflected here)

The FRA estimated three separate mode share models, to reflect trip purpose market segmentation (business, non-business/non-work, and commute). To reflect the differential substitution that exists between different modes of travel, the FRA used a nested logit (NL) structure. Using the NL model structure allows the modes in a common nest to exhibit a higher degree of similarity and competitiveness than modes outside of the nest.

Models of modal travel choice can be based on RP or SP data. Each type of data provides certain advantages over the other. RP data reflect actual behavior and take account of the real world conditions that respondents face. SP data takes account of a wider range of potential choices and attributes. The SP data reflect an experimental design that provides for explanatory variables that have a larger range of variability within and between alternatives and break the correlation between explanatory variables within each alternative. While models can be estimated with each type of data separately, the most robust models combine RP and SP data in order to take advantage of the unique characteristics of each type. Combining the two sets of data to estimate a single model can produce a model that retains the advantages of both RP and SP models and eliminate or dramatically reduce the disadvantages of each. The NEC FUTURE Household Travel Survey collected both types of data so for use in studying travel patterns and travel behavior along the NEC.

Modeling Metropolitan Trains

The SP questions in the Household Travel Survey presented four types of rail to respondents:

- High Speed Train (i.e., Intercity-Express)
- Regional Train (i.e., Intercity-Corridor)
- Commuter Train (i.e., Regional rail)
- Metropolitan Train (a new service)

At the time the survey was developed, Metropolitan service was envisioned as a mode that would be a level above the Regional rail services, but below the Intercity-Corridor rail, in terms of service quality. It would be moderately slower and cheaper than the Intercity-Corridor rail, while not having reserved seats (so potentially some riders may need to stand), and no amenities such as restrooms or food service. As the FRA developed the Service Plans for the No Action and Action Alternatives, Metropolitan service evolved to become similar to the Intercity-Corridor trains in terms of frequency and stopping patterns. In addition, the new equipment envisioned for use by the Metropolitan service allows for faster travel times for some Action Alternatives.

To include a new mode in a logit model, the modeler must assert that the new mode is independent from the other modes included in the model so that it does violate the independence from irrelevant alternatives (IIA) property of the model. While using an NL lessens the stringency of the IIA requirement, it does not eliminate it. Given that the more developed concept of Metropolitan service was similar to the existing Intercity-Corridor service in terms of speed, time, and cost parameters, the FRA decided to combine the Metropolitan with Intercity-Corridor for modeling purposes. The decision to estimate Metropolitan and Intercity-Corridor-Other service as a single rail mode does not mean that these services are identical, as there could be significant differences in on board amenities, reservations policy, and actual pricing. The combined service retained the label Intercity-Corridor. The daily frequencies for Metropolitan and Intercity-Corridor-Other were summed together and the travel times were averaged for each station-pair to account for any differences in the service.

As the naming convention of the rail modes differs across sections of the document, Table 6 provides a correspondence between the mode names.

Table 6: Intercity Rail Mode Naming Convention

Existing Name	Survey Name	Model Estimation Name	Model Application Name
Acela Express	High Speed Train	Intercity-Express Rail	Intercity-Express
Northeast Regional	Regional Train	Intercity-Corridor Rail	Intercity-Corridor

Existing Name	Survey Name	Model Estimation Name	Model Application Name
N.A.	Metropolitan Train	Metropolitan Rail	Intercity-Corridor

Source: NEC FUTURE team, 2015

Key Service Variable Sensitivities

The most important service variables in the mode-choice model include travel time, travel cost, and frequency of service. Travel time and travel cost typically have an inverse relationship, and can be used to calculate the Value of Time (VOT), or how much respondents are willing to pay to save additional travel time. The business and commute models had VOTs, which were similar to others seen in the corridor or for similar models, but the non-business model had much lower values of time, ranging from around $6 to around $20 (allowed to vary by total cost of the trip). These are lower values than have been seen in the Study Area in the past, and indicate that price is becoming a particularly important piece of the mode-choice decision, especially given that approximately 70 percent of travel in the Study Area is currently non-business. One reason for this shift in cost sensitivity could be the increased prevalence of low-cost intercity bus service that has occurred over the past several years, making travelers more aware of cheaper options in the interregional market. The market for Intercity-Express continues to appeal to business travelers who value time and are willing to pay for the service/time savings, but business travelers are only 18 percent of the total.

In all three mode choices of the Interregional Model (business, non-business, and commute), the FRA used a dampened function of frequency. This specification accounts for the expectation that additional departure options impact choice up until a certain saturation level, at which point travelers have enough options, and more frequency will not increase the utility of the mode. This saturation point in the models is around 50 trains per day, which indicates that once the trains are less than 30 minutes apart, the importance of frequency drops off.

4.2.3 REGIONAL MARKETS

The FRA conducted the regional forecasting process largely using existing ridership tools developed by the operators or the metropolitan planning organizations, with some modifications to accommodate the NEC FUTURE forecasting approach. Many of these tools have been used by Regional rail operators or other regional transit operators to plan Federal Transit Administration (FTA) New Starts investments and evaluate the implications of service and policy changes. By using existing tools to the maximum extent possible the NEC FUTURE team maintained consistency with local and future planning efforts, and ridership and growth estimates.

Shorter distance, regional travel markets that lie within a specific major region were addressed by the available regional models. Where local models were not available, the FRA used the FTA Simplified Trips on Project Software (STOPS)[20] module to estimate ridership demand.

The following lists the models used in the analysis of regional trip making:

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[20] STOPS is the FTA's national forecasting model, which relies on a combination of national experience and local market-based information to estimate transit project ridership. STOPS is a series of programs designed to estimate transit project ridership using a streamlined set of procedures that bypass the time-consuming process of developing and applying a regional travel demand forecasting model. It is quite similar in structure to regional models and includes many of the same computations of transit level-of-service and market share found in model sets maintained by metropolitan planning organizations and transit agencies.

- Washington: Metropolitan Washington Council of Governments/Washington Metropolitan Area Transit Authority Forecasting Model
- Baltimore: FTA STOPS implemented for the Baltimore metropolitan region
- Philadelphia: Delaware Valley Regional Planning Commission Model
- New Jersey: NJ TRANSIT North Jersey Travel Demand Forecasting Model
- New York: LIRR/MNR/Shore Line East: MTA Regional Transit Forecasting Model
- Boston: FTA STOPS implemented for Boston metropolitan region

4.2.4 MODEL INPUTS AND ASSUMPTIONS

For analysis purposes, the FRA used a forecast year of 2040 for the No Action Alternative and Action Alternatives. Travel demand forecasts are driven by demographics and service levels.

Demographic Forecasts

The fundamental driver of growth in total trip making in the Study Area comes from forecasted growth in population, employment, and income. Forecasts used as the basis for growth were extracted from Moody's Analytics June 2013 "base" demographic forecasts. These forecasts were obtained on a county-level basis for the Study Area.

Table 7 and Table 8 present the population and employment projections, and percentage change for the major NEC metropolitan areas as contained in Moody's Analytics June 2013 forecasts. Three forecasts were supplied by Moody's. They include "low", "base" and "high" conditions. All of the forecasted results use the "base" (or most likely) condition.

Table 7: NEC Population Forecasts

Market	Population				Percentage Change vs 2013		
	2013	2040 (Low)	2040 (Base)	2040 (High)	2040 (Low)	2040 (Base)	2040 (High)
Washington, D.C.	5,930,000	7,127,000	7,655,000	8,238,000	21%	29%	39%
Baltimore	2,774,000	3,000,000	3,145,000	3,299,000	8%	13%	19%
Philadelphia	6,600,000	6,874,000	7,108,000	7,352,000	4%	8%	11%
New York City	22,210,000	23,276,000	24,306,000	25,393,000	5%	9%	14%
Providence	970,000	982,000	1,036,000	1,094,000	1%	7%	13%
Hartford/Springfield	1,794,000	1,876,000	1,905,000	1,935,000	5%	6%	8%
Boston	6,450,000	6,602,000	6,888,000	7,188,000	3%	7%	11%

Source: NEC FUTURE team, 2015

Table 8: NEC Employment Forecasts

Market	Employment				Percentage Change vs 2013		
	2013	2040 (Low)	2040 (Base)	2040 (High)	2040 (Low)	2040 (Base)	2040 (High)
Washington, D.C.	3,104,000	2,781,000	3,858,000	4,801,000	-3%	24%	62%
Baltimore	1,363,000	1,279,000	1,679,000	2,023,000	2%	23%	55%

Philadelphia	3,007,000	2,680,000	3,576,000	4,323,000	-4%	19%	50%
New York City	10,077,000	8,810,000	11,827,000	14,660,000	-6%	17%	51%
Providence	426,000	352,000	476,000	560,000	-10%	12%	39%
Hartford/Springfield	873,000	729,000	963,000	1,145,000	-10%	10%	37%
Boston	3,275,000	2,756,000	3,736,000	4,599,000	-9%	14%	48%

Source: NEC FUTURE team, 2015

Table 7 shows that the populations in the major metropolitan markets are projected to grow between 6.2 percent (Hartford) to 29 percent (Washington, D.C.). The low-high bounds are also fairly tightly bound to the "base" condition, generally plus or minus 5 percent points of the base forecast.

Table 8 presents the employment forecasts. While the "base" forecasts shows employment growing slightly faster than population, the low-high bounds are much wider for employment. This is an important element of the demographic forecasts, as Moody's forecast suggests larger uncertainty associated with future NEC employment. Their "low" scenario includes a contraction of the overall job market (as compared to today), while their "high" scenario includes a full boom in economic activity with large scale growth in employment. This suggests that one of the significant risks to the forecasts is the strength of the regional employment market, as Moody's has placed a wide band on these forecasts.

Service Characteristics

The primary mode-choice input for both the Interregional Model and regional models were the service characteristics of all available modes

For the Interregional Model, the relevant service characteristics included travel time (access/egress and line haul), cost, and frequency of service. For the non-rail modes (auto, air and intercity bus), the service characteristics were held constant across all alternatives and were based on existing service, with the exception of introducing highway congestion into the auto and intercity bus travel times. The rail service travel times and frequencies were determined from the service planning process. The non-rail modes were assumed to be unconstrained with respect to their capacity to accommodate future growth.

For the rail fares in the Interregional Model, the FRA initially assumed the current pricing. Later, as described in Section 4.3, the FRA evaluated the impact of lower fares on resulting rail demand to establish the model's sensitivity to pricing and understand the impacts on ridership demand and operating costs. The FRA found that the operating costs associated with the Action Alternatives were lower than the associated passenger fare revenues, which indicates the flexibility for an operator to discount fares and still cover operating expenses.

While there were six separate regional forecasting models applied to evaluate the No Action Alternative and Action Alternatives, the key attributes that drove the magnitude of the ridership results included travel time (line haul and access/egress), number of transfers, frequency, and total cost. For the Regional models, the service characteristics for the non-rail modes were dealt with in the same manner as for the Interregional Model, by holding them constant across the No Action and Action Alternatives. The rail frequencies and travel times were similarly calculated from the potential service plans developed as part of the alternatives development process. The FRA held Regional rail pricing constant through the analysis in real dollars, meaning Regional rail fares were assumed to grow with inflation.

4.2.5 MODEL OUTPUTS

As described earlier in Section 4, for the alternatives refinement process the FRA ran both the interregional and regional models with numerous intermediate Service Plans. The resulting ridership projections were then compared with the volume of service provided at key locations along the corridor to estimate the extent to which seats on board trains would be filled during peak periods. Service levels then were adjusted either upward or downward as necessary to balance the provided service with the forecasted demand. The Interregional model provided ridership information at screenlines north of Washington, D.C., at the Hudson River and East River, at approaching Boston South Station. The initial ridership results from the Regional model included daily and peak passenger volumes at screenlines in the following locations:

- Potomac River South of Washington Union Station
- North of Washington Union Station
- Susquehanna River
- Keystone West of Philadelphia 30th Street Station
- North of Philadelphia (between Cornwells Heights and Trenton)
- Hudson River
- East River
- Harlem River/Empire Corridor
- South of Boston South Station

The FRA utilized these screenlines by comparing the peak-hour, peak-direction ridership with the available capacity, and adjusting service where there were large discrepancies. The goal was to provide an adequate amount of service to allow for growth, but not to provide excessive capacity.

The primary output of the model was trips by mode for each zonal pair, which can be formatted in multiple ways to support alternatives evaluation. The FRA used the following model outputs (from both the interregional and regional models):

- Annual trips by mode for two levels of geographic aggregation:
  - Metropolitan statistical areas (collectively do not cover entire Study Area)
  - Greater metropolitan area (collectively covers the entire Study Area)
- Annual rail passenger miles
- Annual and average weekday passengers at two levels:
  - Station boardings
  - Station-to-station ridership

The year 2040 ridership forecasts were constrained to the available seated capacity where forecasted demand exceeded available seats. Specifically, the FRA applied capacity constraints at specific locations and to specific train services where demand was projected to exceed seating capacity. In the No Action

Alternative, Intercity-Express, Intercity-Corridor, and New Jersey Regional rail service is capacity-constrained crossing the Trans-Hudson River screenline. In Alternative 1, New Jersey Regional rail crossing the Trans-Hudson screenline is capacity-constrained, but Intercity services have sufficient capacity to accommodate projected ridership. Alternatives 2 and 3 required no adjustments for capacity constraints, meaning that forecasted demand is accommodated by the amount of service offered by each alternative.

4.3 OPERATIONS AND MAINTENANCE COSTS

The FRA prepared operations and maintenance (O&M) cost estimates to provide representative estimates of the costs to operate and maintain the proposed Service Plans for the No Action and Action Alternatives. The methodology produced high-level, order-of-magnitude estimates for O&M costs appropriate for a Tier 1 EIS level of review. In conjunction with the capital cost estimates (Section 4.4), these O&M estimates facilitate comparative cost analysis between the No Action Alternative and each Action Alternative, and, for Intercity services, help the FRA to assess whether the Service Plans are likely to generate an operating surplus, where revenues exceed costs.

Where available, the FRA used data on recent actual Intercity and Regional rail O&M costs as a starting point for the analysis. The availability of this information varied across the service types and cost categories, and the FRA supplemented it with additional cost estimates where needed to provide a more comprehensive data set. The FRA combined these data, which were also generalized across the corridor, to facilitate consistent application of cost estimates across the Service Plans, based on key assumptions about the characteristics of the service types (Section 4.1.2). The FRA then applied these unit O&M costs to projected level-of-service and physical characteristics information to produce O&M cost forecasts for the alternatives for each of the service types.

The FRA calibrated the ridership model for 2013 base trips using current fares to accurately match existing ridership. For the Action Alternatives that include new markets, the FRA calculated distance-based fare equations based on current fares for three types of rail trips: trips entirely south of New York City, trips north of New York City, and trips through New York City, to reflect market-based differences in the pricing structures for these trips today. The O&M costs associated with these existing fare scenarios were substantially lower than the associated revenues. Therefore, the FRA tested multiple fare discounts for the Intercity-Corridor service, while keeping the Intercity-Express fares at the existing level. For each Action Alternative, the FRA reduced the Intercity-Corridor fares by 30 percent compared to today. This reduction is neither fare-maximizing nor ridership-maximizing analysis; rather, it is intended only to demonstrate that the Service Plans operate profitably over multiple fare structures.

4.4 CAPITAL COSTS

The FRA developed a capital cost model to provide conceptual cost estimates for each Action Alternative commensurate with the level of detail necessary to provide for an accurate, well-documented cost comparison between the No Action and Action Alternatives. The FRA calculated the No Action Alternative cost by summing the total cost of the No Action Alternative Project List (see *No Action Alternative Report*). While the goal of the model is to reflect a conceptual level of detail, the model is based on a validated methodology that relies on data from actual construction projects. The model is sufficient to reasonably estimate the costs for end-to-end Action Alternatives from Washington, D.C., to Boston, MA. The model is not intended to estimate the costs of specific smaller scale projects or programs separately from the end-to-end routes of the Action Alternatives, such as individual bridge replacements, individual tunnel construction projects, or individual station projects. These detailed project-level cost estimates would be developed in later planning, engineering, and design states as the NEC FUTURE program is implemented.

To develop the cost model, the FRA completed more detailed analysis for typical right-of-way sections, station configurations, track configurations, rolling stock requirements, and maintenance and operations costs. The estimates address all major capital cost elements such as station development, grade crossing eliminations, vehicle and maintenance shop needs, supporting systems, right-of-way acquisition, and costs of linear or area-based infrastructure elements such as tunnel or aerial sections or embankment or retained fill areas.

4.4.1 LINEAR ELEMENTS

Linear element costs represent those costs that are measured by linear attributes, such as route-feet or track-feet. The FRA calculated these costs by multiplying lengths by a unit cost per route-foot. There are three types of linear elements that describe capital investment in rail infrastructure and which translate into capital cost line items for the Action Alternatives:

- **Curve Modification**: a shift or straightening of existing NEC track alignments to improve speeds, including straightening a curve or eliminating the curve entirely. Curve modifications address the compromised performance of the existing NEC by reducing, or eliminating speed restrictions at certain locations along the NEC.
- **New Track**: improvements that increase capacity or improve trip times, generally contained within the right-of-way of the existing NEC; typical upgrade projects include:
  - Signal system upgrade
  - Catenary and electrification system upgrade
  - One or two new tracks constructed within existing right-of-way—includes new track as well as all associated construction to enable new tracks to be utilized, including new or modified catenary, signaling, interlockings and civil and structural work
- **New Segment:** New-track construction on new right-of-way that does not follow the existing NEC. New segments diverge from and reconnect to the existing NEC, which expand the capacity of the railroad and/or relieve chokepoints.

Linear elements are mapped along the Representative Route of each alternative. The FRA estimated the capital costs of linear improvements by developing a unit cost of construction per linear mile or foot, and multiplying this unit cost by the length of the route segment over which the given set of linear element improvements are expected. Contingencies and other cost factors were added to the individual line items or totals as appropriate.

Two sets of right-of-way characteristics, which also are mapped along the Representative Route of each alternative, are used to develop the unit cost of construction and to understand the magnitude of potential environmental impacts associated with construction. These right-of-way characteristics are referred to as the ***construction type*** and the ***typical cross section***.

- **Construction Type** identifies the vertical profile characteristics of the existing or proposed new right-of-way, which is a function of the terrain through which the route passes and the extent to which natural features, land development, or highway/waterway/railroad crossings drive the need to change the grade of the railroad. All existing and proposed route segments are assigned one of the following construction types:
  - ***Tunnel*** is typically applied where the Representative Route is beneath a large body of water, such as the Hudson River; the topography is too steep to meet high-speed performance criteria, as is the case in northern Connecticut; and in densely developed areas where there is no room for above ground segments, as is the case in Baltimore, New York City, and Providence.
  - ***Trench*** is generally applied prior to and following a tunnel, where a tunnel transitions to at-grade or embankment construction types, and where local conditions permit the construction of an open trench to provide grade separation of the railroad and crossing roadways.
  - ***At-grade*** is generally applied where local vertical grade changes permit construction at-grade and where existing highway/roadway rights-of-way are grade separated on aerial structures. At-grade segments are common south of New York City where the topography is relatively flat. It is less common north of New York City where changes in topography occur more frequently.
  - ***Embankment*** is generally applied following an aerial structure construction type, indicating where the aerial structure returns to grade, and where local vertical grade changes do not permit construction at-grade. Embankments are common south of New York City where the topography is relatively flat.
  - ***Aerial Structure*** is generally applied in heavily urbanized areas where land available at-grade is scarce and requires an aerial structure above existing rail or roadway rights-of-way, and at river crossings, wetland areas, valleys, or crossings over existing highways/roadways where vertical grade changes below top of rail vertical alignment and/or where potential for significant environmental impacts do not permit construction at-grade.
  - ***Major Bridge*** is generally applied at river crossings, wetland areas, valleys, or crossings over existing highways/roadways where vertical grade changes do not permit construction at-grade. The major bridge construction type generally is associated with long-span aerial structures and with movable bridges.
- **Typical Cross Section** for construction on new track and new segments, the FRA developed representative typical cross sections that identify construction methods and right-of-way configurations for track and track structures. The purpose of these typical cross sections is to aid in the development and calculation of construction line-item quantities in the model. The typical cross sections define the requirements for major infrastructure components and provide for a quality control review of these quantities and a documentation source for how quantities were developed. The FRA developed quantities by calculating construction line items as they are depicted in the typical cross sections per route-foot. Each construction line item was assigned a unit cost, which was then multiplied by the quantity and summed to a total cost per route-foot for each typical cross section. There are 47 different typical cross sections, organized by interchangeability with the existing NEC,

based on the number of total tracks in the right-of-way, the horizontal and vertical location of the new tracks relative to existing tracks, the maximum speed of the route segment, and the construction type. A unique unit cost of construction was developed for each typical cross section.

4.4.2 SUPPORTING INFRASTRUCTURE

In addition to the linear elements, there are several types of rail infrastructure that are location-specific and are best represented in the cost estimate by a single location or point along the Representative Route. These supporting infrastructure costs are generally applied as a single discrete cost per facility or bundle of track work. The discrete cost includes any route-foot or track-foot elements needed to construct the facility or track work.

For purposes of environmental impact assessment, every location-specific element has a defined area of potential impact associated with it. The size and shape of the polygon defining this area of potential impact varies according to the type of element. Construction costs were estimated for location-specific projects based on a unit cost per element and a count of the number of elements constructed at a given location or along a segment of the route. Supporting Infrastructure fall into the following categories:

- **Stations and Station Areas**: station buildings, waiting areas, parking, and ancillary buildings. Existing local stations that are not slated for expansion or upgrading were omitted from the list of location-specific line items, since there are no incremental capital costs associated with these locations.
- **Junctions:** the construction of major track connections or interlockings[21] at points where tracks converge or diverge allowing trains to switch from one set of tracks to another. Junctions are identified at every point where a new route segment connects with the existing NEC, and at locations where grade-separated track connections provide relief to existing chokepoints. This category also includes the additional railroad infrastructure to provide station sidings at new or upgraded stations where stopping trains need to use platform tracks separate from the through tracks used by non-stop express trains. The footprint for these junctions or major connections can extend beyond the existing NEC rights-of-way (but stay within the Representative Route) to accommodate grade-separated, conflict-free movement between tracks or between the NEC and connecting corridors, Regional rail branch lines, and storage yards.
- **Storage and Maintenance Facilities**: support fleet requirements of NEC FUTURE. Horizontal dimensions could extend beyond the limits of the footprint defined for new segments, new tracks, or curve modifications. Right-of-way requirements for these facilities would be evaluated as more details become available, during the planning, engineering, and design stages when NEC FUTURE is implemented.

4.4.3 OTHER ELEMENTS

Other elements contributing costs to the overall needs of the NEC, but which are not part of the capital cost estimates for the Action Alternatives, include the following:

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[21] Interlockings are locations on multi-track rail lines where lines join together or where crossovers between tracks are placed to permit trains to change from one track to another. They are part of the signaling and train control system and are centrally controlled by train dispatchers on the NEC.

- Projects that are unfunded but necessary to keep the railroad running, including regular ongoing capital maintenance and improvements to basic infrastructure;
- Major backlog projects, including the rehabilitation or replacement of tunnels and movable bridges, which are currently unfunded; and
- Connecting corridor and off-corridor projects.

4.5 STAKEHOLDER AND PUBLIC OUTREACH

Throughout NEC FUTURE, the FRA has engaged numerous agencies and operators within the Study Area. This engagement has occurred as part of a Council on Environmental Quality Pilot Program,[22] Scoping, Section 106 consultation, as well as various key program milestones in the alternatives development process (Section 2), to promote transparency and facilitate an informed, efficient, and compliant planning and environmental review process. The knowledge, data, and input these agencies and organizations provided have been valuable to the NEC FUTURE planning process.

- **Federal and State Departments of Transportation** includes administrations within the U.S. DOT and state agencies that plan for and provide transportation infrastructure and/or services within the Study Area. Coordination with federal and state departments of transportation, including with the NEC Commission, comprising voting members from each of the NEC state departments of transportation, Amtrak, and the U.S. DOT is necessary to keep them informed about FRA transportation planning efforts. The FTA is a cooperating agency on the Tier 1 Draft EIS.
- **Other State Agencies** includes other select state agencies within the Study Area, such as planning and economic development agencies, as well as bi-state or multi-state agencies.
- **Railroad and Transit Operators** includes agencies that operate railroad and transit services along the NEC and its connecting corridors, as well as freight rail operators.
- **Metropolitan Planning Organizations (MPO)** within the Study Area play a prominent role in transportation planning throughout their respective regions and serve as representatives of their member municipalities and counties.
- **Tribal Nations:** The FRA coordinating with tribal governments with lands and/or resources in the Study Area as part of the consultation process for Section 106 of the National Historic Preservation Act of 1966.
- **Local Agencies** includes select counties and local agencies within the Study Area.
- **Technical Working Groups (TWG)** were created by the FRA to provide technical guidance in the service planning and environmental review processes. The TWGs include Alternatives Development, Environmental, Engineering and Capital Cost, Operations, and Ridership and Revenue. The TWGs include FRA representatives, as well as members from the stakeholder community to leverage their

[22] In January 2012, CEQ and FRA announced the selection of the NEC FUTURE Tier 1 Environmental Impact Statement (EIS) as a pilot project to promote early collaboration with federal and state environmental agencies for efficient environmental decision-making. The pilot was designed to help avoid the conflicts and delays often found in complex, multi-state transportation projects by engaging environmental resource and regulatory agencies early in the environmental review and assessment process.

considerable past work and expertise, as well as add to the general soundness and credibility of the analytical results.

4.5.1 STATE TRANSPORTATION AGENCIES AND RAILROAD OPERATORS

Throughout refinement of the Action Alternatives, the FRA held a variety of meetings and briefings with state transportation agencies and railroad operators to provide a dialogue and timely exchange of information. The meetings created opportunities to share information on the No Action and Action Alternatives and obtain input and feedback toward improving the NEC FUTURE process and integrity of findings.

4.5.2 PUBLIC OPEN HOUSES

The FRA hosted a series of public open house meetings in November 2014. The purpose of these meetings was to introduce the No Action and Action Alternatives developed for evaluation in the Tier 1 Draft EIS, and provide an informal opportunity for the public to learn about NEC FUTURE, ask questions, and provide comments. A related objective was to provide participants with a better understanding of what to expect from a Tier 1 level of analysis.

An open house meeting was held in each of the eight NEC states and Washington, D.C. A total of 377 participants attended the nine meetings. Discussion topics varied by location; however, some common themes included:

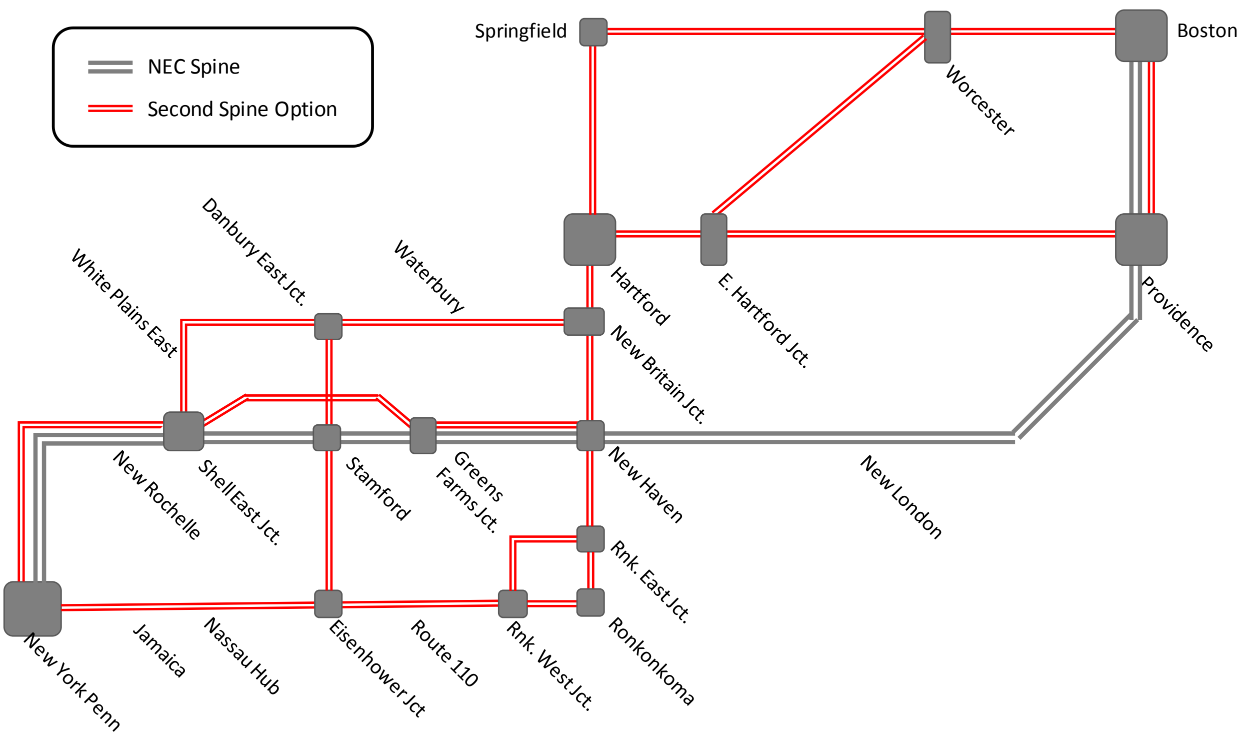
- The need to fix the existing NEC before expanding
- Importance of freight
- Questions about the feasibility of a Long Island route ("Could you really build it?")
- Relationship of NEC FUTURE to specific projects including Baltimore and Potomac (B&P) Tunnel, Gateway, New Haven-Hartford-Springfield Corridor; and overlap with plans for the Washington-Richmond corridor
- Cost of improvements
- Phasing – what improvements would be done when
- Continued questions about Tier 1 versus Tier 2
- Ability to mix and match alternatives
- Airport connections
- Fare prices, affordability compared to bus
- Climate change
- Importance to economy
- Potential for transit oriented development
- Importance of station areas and stations as destinations
- Seamless ticketing
- Need to accommodate bikes on board

- Millennials less likely to own cars; more will arrive to station by bike, walk, transit modes

5. North End Route Options Evaluation

The refinement of Alternative 3 included an examination of the range of potential options for establishing a new high-speed second-spine route to complement the existing NEC to provide rail service between New York City and Boston. The FRA identified several second-spine route options with potential to attract significant ridership and serve new markets – characteristics considered by the FRA to be essential for transforming the role of rail. Figure 6 shows diagrammatically the segments that comprise these route options. All of these route options deviate from the existing NEC at one or more points, providing direct Intercity service to new intermediate markets between New York City and Boston. Several of these route options touch the NEC only at the endpoints or for short distances. Other options run immediately parallel to or use portions of the existing NEC. Combining the various segments yields a total of 20 possible routing options between New York City and Boston. These options are arrayed in Table 9.

Figure 6: Segments Comprising the North End Route Options



Source: NEC FUTURE team, 2015

Table 9: Full Set of North End Route Options

<table>
<tr><th>No.</th><th colspan="6">North End Route Option</th></tr>
<tr><td>1</td><td rowspan="6">[NEC] New York City-New Rochelle-Stamford</td><td rowspan="3" colspan="2">[NEC] Stamford-New Haven</td><td rowspan="3">New Haven-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>2</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>3</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>4</td><td rowspan="3" colspan="2">Stamford-Danbury</td><td rowspan="3">Danbury-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>5</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>6</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>7</td><td rowspan="3">New York City-New Rochelle-Danbury</td><td rowspan="3" colspan="3">Danbury-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>8</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>9</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>10</td><td rowspan="11">New York City-Nassau Hub</td><td rowspan="4" colspan="2">Nassau Hub-Ronkonkoma-New Haven</td><td colspan="2">[NEC] New Haven-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>11</td><td rowspan="3">New Haven-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>12</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>13</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>14</td><td rowspan="7">Nassau Hub-Stamford</td><td rowspan="4">[NEC] Stamford-New Haven</td><td colspan="2">[NEC] New Haven-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>15</td><td rowspan="3">New Haven-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>16</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>17</td><td>Hartford-Springfield-Worcester</td></tr>
<tr><td>18</td><td rowspan="3">Stamford-Danbury</td><td rowspan="3">Danbury-Hartford</td><td>Hartford-Providence</td><td>[NEC] Providence-Boston</td></tr>
<tr><td>19</td><td>Hartford-Worcester</td><td rowspan="2">Worcester-Boston</td></tr>
<tr><td>20</td><td>Hartford-Springfield-Worcester</td></tr>
</table>

Source: NEC FUTURE team, 2015

Option number 1 in Table 9 was evaluated as Preliminary Alternative 12, which represented a second-spine parallel to the existing NEC from end-to-end. Following the development of the Preliminary Alternatives, the FRA dismissed Alternative 12 from further consideration for service, cost, constructability, and environmental sensitivity-related reasons, as follows:

- **Service**: the alternative provides no new markets north of New York City; and therefore, it performs the weakest in terms of ridership compared to other North End route options
- **Cost**: initial cost estimates indicated that this alternative accounts for the highest cost, as compared to the other second-spine route options
- **Constructability**: North of New York City, construction of a new two-track high-speed line adjacent to the existing NEC is challenging due to proximity to an operating railroad, dense populations, the existing capacity constraints, and bottlenecks across the numerous rivers in Connecticut
- **Environmental sensitivity**: the alternative has a greater proportion of the new right-of-way through environmentally-sensitive areas or through areas with greater environmental sensitivity, and through portions vulnerable to storm surge

In addition, Preliminary Alternative 12 largely overlaps with elements of other alternatives, including improvements between New York City and Hartford, new high-speed tracks between Old Saybrook and Kenyon, and new high-speed tracks between Providence and Boston.

The remaining combinations of route options all pass through Hartford CT. This provided the opportunity to split the analysis into two steps to first analyze and compare six route options for the territory between New York City and Hartford, and then analyze the three potential route options between Hartford and Boston. Figure 6 shows the six route options between New York City and Hartford and the three route options between Hartford and Boston.

5.1 METHODOLOGY

The FRA compared the service and ridership potential of sets of options north and south of Hartford. The objective of the analysis was to identify route options that best meet the NEC FUTURE Purpose and Need (Section 1.1) that can be further evaluated as Alternative 3.

In each step of the analytical process, the FRA prepared quantitative information about trip time, ridership, and capital cost, as well as information on distinguishing environmental factors, development and property impact, other local considerations, and the effects on transportation system connectivity. These characteristics were incorporated into evaluation matrices and used to compare the route options and identify those with greater potential to achieve the vision of Alternative 3.

The specific elements of the two-step process included:

- Step 1 – Assess New York City-Hartford route options [6 options]
  - Identify a limited number of representative New York City-to-Hartford route options with the potential to transform the role of rail, considering both New York City-to-Boston and intermediate markets, in terms of ridership potential, magnitude of expected capital cost, potential environmental effects, and extent of local support.

- Eliminate from further consideration those route options with lower ridership potential, higher cost, greater potential negative impacts, and/or less potential for transformational benefits.

- Step 2 – Assess Hartford-Boston route options [3 options]
  - Start with the selected representative New York City-to-Hartford route that offers the highest ridership potential.
  - Compare Providence, Worcester, and Springfield route options between Hartford and Boston.
  - Consider ridership effects of the full network, including dual spines (existing and a second-spine dedicated to high-speed rail) and connecting corridor service, as opposed to consideration of service on the second-spine route only.
    - Include Springfield, Knowledge Corridor, and Inland Route (Section 4.1.2)
    - Include Shore Line/Providence improvements in Worcester route options
  - Compare ridership potential, magnitude of expected capital cost, potential environmental effects and extent of local support, and identify representative New York City-to-Hartford route options with the greatest potential to transform the role of rail.
  - Eliminate from further consideration route options with lower ridership potential, higher cost, greater potential negative impacts, and/or less potential for transformational benefits.
  - Combine representative south-of-Hartford and north-of-Hartford route options, plus the Representative Route for a second-spine between Washington, D.C., and New York City, to create Representative Routes for Alternative 3 that span the full length of the NEC.

5.2 ROUTE OPTIONS BETWEEN NEW YORK CITY AND HARTFORD

The first step in the evaluation process considered the six route options between New York City and Hartford as follows:

- New York City-Nassau Hub-Ronkonkoma-New Haven-Hartford
- New York City-Nassau Hub-Stamford-Danbury-Hartford
- New York City-Nassau Hub-Stamford-New Haven-Hartford
- New York City-New Rochelle-Stamford-Danbury-Hartford
- New York City-New Rochelle-Stamford-New Haven-Hartford
- New York City-New Rochelle-White Plains-Danbury- Hartford

The FRA calculated trip times between New York City and various other stations for each of these route options, for both Intercity-Express and Intercity-Corridor service (Table 10 and Table 11). For comparative purposes in conducting this initial step of analysis, which analyzed the New York City-to-Hartford route options, all of these route options were assumed to reach Boston from Hartford via a new route through Providence. The best Intercity-Express trip times were achieved in options 1 and 6, the two options that build a dedicated new high-speed line all the way between New York City and Hartford and avoid the existing New Haven Line. Ridership potential (Table 12) is greatest for the routes via Long Island (route options 1, 2, and 3).

Table 10: Trip Times – Selected Intercity-Express Markets – New York City-to-Hartford

Trip Times by Option	Existing	Limited-stop Intercity-Express					
Penn Station New York	Acela	Run 1: PSNY>RNK> HFD>PVD> BOS	Run 2: PSNY>NAS> STM>DAN> HFD>PVD> BOS	Run 3: PSNY>NAS> STM>NHV> HFD>PVD> BOS	Run 4: PSNY>NRO> STM>DAN> HFD>PVD> BOS	Run 5: PSNY>NRO> STM>NHV> HFD>PVD> BOS	Run 6: PSNY>WHP > DAN>HFD> PVD>BOS
Boston South Station	3:40	1:37	1:46	1:52	1:55	2:00	1:32
Penn Station New York	**Existing**	**Express**					
Boston South Station	3:40	1:55	2:02	2:10	2:11	2:17	1:51
Providence Station	2:45	1:31	1:38	1:46	1:47	1:53	1:27
Hartford	--	1:04	1:11	1:19	1:20	1:27	1:00
New Haven Station	1:30	0:45	0:59	1:00	1:08	1:08	1:08
Stamford	0:45	0:38	0:29	0:29	0:38	0:38	0:38
Waterbury South	--	--	1:00	--	1:09	--	0:49
Danbury	--	--	0:51	--	1:00	--	0:41
Ronkonkoma	--	0:28	--	--	--	--	--
Nassau Hub	--	0:13	0:13	0:13	--	--	--
White Plains East	--	--	--	--	--	--	0:21

PSNY- New York Penn Station; NAS - Nassau Hub, RNK - Ronkonkoma; WHP - White Plains STM Stamford;
NHV - New Haven; NRO - New Rochelle; DAN - Danbury; HFD - Hartford; PVD - Providence; BOS - Boston

Source: NEC FUTURE team, 2015

Table 11: Trip Times – Selected Intercity-Corridor Markets – New York City-to-Hartford

Trip Times by Option	Existing	Metropolitan					
Penn Station New York	Regional	Run 1: PSNY>RNK> HFD>PVD> BOS	Run 2: PSNY>NAS> STM>DAN> HFD>PVD> BOS	Run 3: PSNY>NAS> STM>NHV> HFD>PVD> BOS	Run 4: PSNY>NRO> STM>DAN> HFD>PVD> BOS	Run 5: PSNY>NRO> STM>NHV> HFD>PVD> BOS	Run 6: PSNY>WHP > DAN>HFD> PVD>BOS
Boston South Station	4:10	2:13	2:18	2:28	2:27	2:35	2:10
Providence Station	3:20	1:46	1:51	2:01	2:00	2:08	1:43
Hartford	2:50	1:15	1:20	1:30	1:29	1:37	1:12
New Haven Station	1:40	0:52	1:12	1:07	1:21	1:14	1:14
Stamford	0:50	0:45	0:33	0:33	0:41	0:41	0:45
Waterbury South	--	--	1:07	--	1:16	--	0:59
Danbury	--	--	0:56	--	1:05	--	0:48
Ronkonkoma	--	0:34	--	--	--	--	--
Nassau Hub	--	0:15	0:15	0:15	--	--	--
White Plains East	--	--	--	--	--	--	0:23

PSNY - New York Penn Station; NAS - Nassau Hub, RNK - Ronkonkoma; WHP - White Plains STM Stamford;
NHV - New Haven; NRO - New Rochelle; DAN - Danbury; HFD - Hartford; PVD - Providence; BOS - Boston

Source: NEC FUTURE team, 2015

Table 12: Estimated 2040 Ridership – Intercity markets – New York City-to-Hartford

Route Option-->	1	2	3	4	5	6
	Nass Ronk NewHvn Hart Prov	Nass Stam Danb Hart Prov	Nass Stam NewHvn Hart Prov	NewRoc Stam Danb Hart Prov	NewRoc Stam NewHvn Hart Prov	NewRoc WhPlns Danb Hart Prov

Total Annual Intercity Trips (M)	1	2	3	4	5	6
Intercity-Express	2.4	2.4	2.4	1.7	1.7	1.9
Intercity-Corridor-Other/Metropolitan	4.2	3.9	3.6	2.7	2.4	3.0
Total Intercity	6.6	6.3	6.0	4.4	4.1	4.9

Common Station Pairs*	1	2	3	4	5	6
Intercity-Express	1.7	1.6	1.8	1.5	1.7	1.5
Intercity-Corridor-Other/Metropolitan	2.6	2.3	2.4	2.2	2.4	2.3
Total Intercity	4.3	3.9	4.2	3.7	4.1	3.8

Millions of annual intercity trips

*BSS,RTE,PRV,HFD,NHV,STM,NYP,PHL,BAL,WAS

Top-performing options (green)

Top-performing options not including LI Sound crossing (yellow)

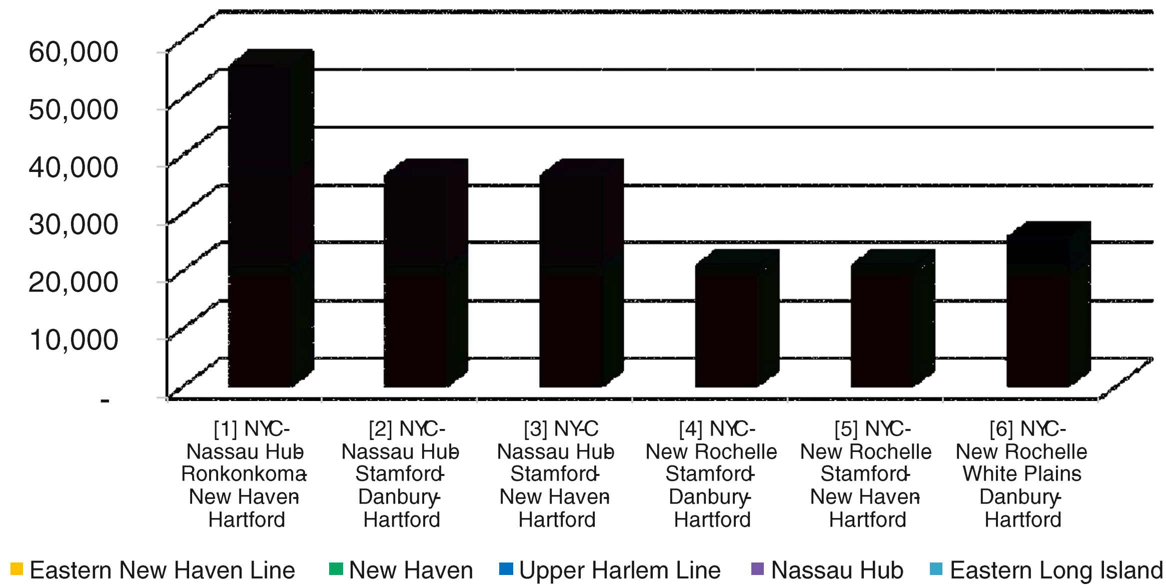
Source: NEC FUTURE team, 2015

A second measure of ridership potential exists in the New York City market. Construction of a new high-speed route via either Long Island, Central Connecticut, or parallel to the New Haven Line significantly decreases trip times for Regional rail services in the outer commuting zones of the New York City market, because these trains could utilize portions of the new high-speed route. Figure 7 presents the relative ridership potential of the six New York City-to-Hartford route options. When both interregional and regional ridership potential are considered together, the New York City-Long Island-New Haven route emerges as the one with the best ridership potential. This is consistent with the Regional rail time savings for outer zone commuting to New York City (Table 13), which also shows the Long Island route to be superior.

Rough order-of-magnitude capital costs for new route construction were estimated for the six route options. Their relative cost and degree of construction difficulty were compared by estimating the extent of the various types of construction needed to create a new two-track right-of-way (Figure 8). The Long Island route is the most expensive, with a long tunnel crossing of Long Island Sound;[23] however, each of the route options have high costs because they require new right-of-way and entail significant amounts of tunneling.

[23] Tunnels were selected over bridges, where possible and appropriate, primarily, because they are easier to align for the straightest possible route (which supports top speeds) and generally because they generate fewer adverse impacts.

Figure 7: Ridership – New York City Regional Rail Market – Existing AM Peak Regional Rail Trips with Improvements to New Haven Line Capacity



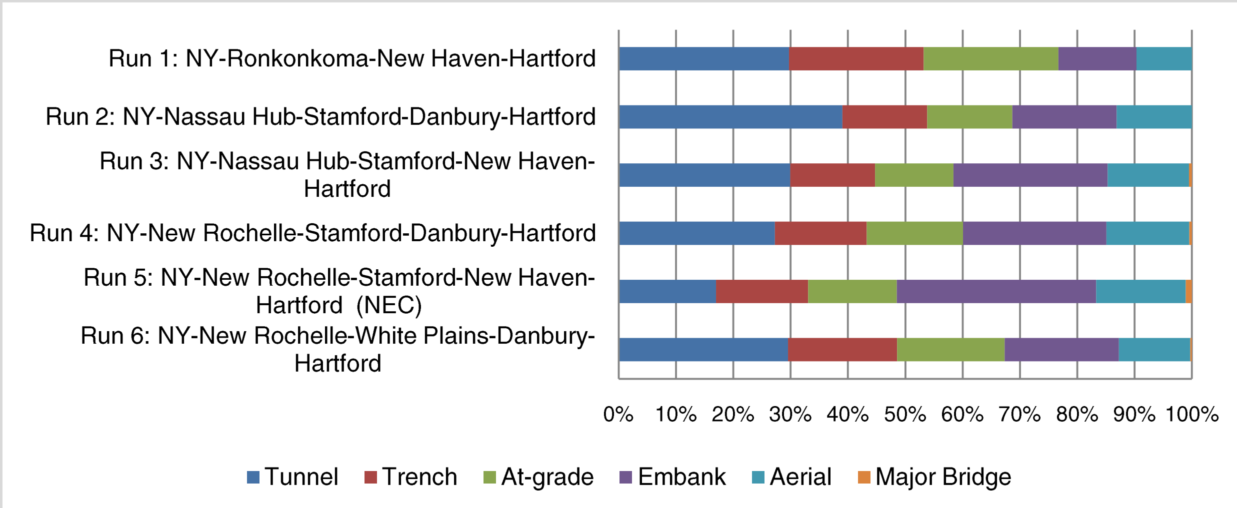
Source: NEC FUTURE team, 2015

Table 13: Time Savings Potential – New York City Regional Rail Minutes Saved per Trip with Outer Zone Express Service Utilizing High-Speed Second-Spine Route – AM Peak Period, with Improvements to New Haven Line Capacity

	New York City-Nassau Hub-Ronkonkoma-New Haven-Hartford	New York City-Nassau Hub-Stamford-Danbury-Hartford	New York City-Nassau Hub-Stamford-New Haven-Hartford	New York City-New Rochelle-Stamford-Danbury-Hartford	New York City-New Rochelle-Stamford-New Haven-Hartford	New York City-New Rochelle-White Plains-Danbury-Hartford
Eastern Long Island	30	—	—	—	—	—
Nassau Hub	25	25	25	—	—	—
Eastern New Haven Line	10	15	15	10	15	10
New Haven	50	25	30	20	25	10
Upper Harlem Line	—	—	—	—	—	20
TOTAL	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

Source: NEC FUTURE team, 2015
Note: Column headers refer to the route options between New York City and Hartford, as listed in Table 9.

Figure 8: Relative Construction Type by Route Option, New York City-to-Hartford



Source: NEC FUTURE team, 2015

When all of these factors are considered together, the route options that utilize the relatively low-speed existing New Haven Line, as well as the route from Long Island to Danbury via Stamford, which has significant curvature and relatively lower speeds, do not perform as well as the other options and were eliminated from further consideration as routes for a second-spine. The New York City-Long Island-New Haven route shows the best ridership potential and was retained. Because of the high cost and the risks inherent in the proposed Long Island Sound tunnel crossing, the route option without a Long Island Sound crossing that had the best ridership potential was also retained – the Central Connecticut route via New Rochelle and Danbury.

5.3 ROUTE OPTIONS BETWEEN HARTFORD AND BOSTON

The second step in the evaluation looked at the three route options between Hartford and Boston:

- Hartford-Providence-Boston
- Hartford-Worcester-Boston
- Hartford-Springfield-Worcester-Boston

These route options are designated with letters rather than numbers to distinguish them from the New York City-to-Hartford route options. A complete New York City-to-Boston route option can be represented by the combination of a number and letter (e.g., option 1B for the route that links New York City, Ronkonkoma, New Haven, Hartford, Worcester, and Boston). The FRA compared trip times, ridership, and capital costs for the three route options between Hartford and Boston. Each of these comparisons used option 1 (the Long Island route via Ronkonkoma) as the assumed second-spine between New York City and Hartford, because this route option had the highest level of ridership in the Step 1 comparison, which served to amplify the differences among the Hartford-Boston route options. This was done to provide a basis for comparing the northern route options, and did not represent a preference.

Table 14 compares the relative Intercity-Express and Intercity-Corridor trip times for the resulting three Hartford-to-Boston route options. The Providence (1A) and Worcester (1B) route options produced very similar trip times; the route via Springfield was considerably longer in terms of both distance and time.

Table 14: Trip Times – Selected Intercity Markets – Hartford-to-Boston

Trip Times by Option

Penn Station New York	Existing	Super Express		
	Acela	Run 1A: NYP>RNK> HFD>PVD> BOS	Run 1B: NYP>RNK> HFD>WOR> BOS	Run 1C: NYP>RNK> HFD>SPG> WOR>BOS
Boston South Station	3:40	1:37	1:37	1:43

Penn Station New York	Existing	Express			Existing	Metropolitan		
	Acela	1A	1B	1C	NE Regional	1A	1B	1C
Boston South Station	3:40	1:55	1:56	2:05	4:10	2:13	2:15	2:27
Providence Station	2:45	1:31	2:13	2:13	3:20	1:46	2:31	2:31
Hartford	--	1:04	1:04	1:04	2:50	1:15	1:15	1:15
New Haven Station	1:30	0:45	0:45	0:45	1:40	0:52	0:52	0:52
Stamford	0:45	0:38	0:38	0:38	0:50	0:41	0:41	0:41
Waterbury South					--	--	--	--
Danbury					--	--	--	--
Ronkonkoma					--	0:34	0:34	0:34
Nassau Hub					--	0:15	0:15	0:15
White Plains East					--	--	--	--

NYP - New York Penn Station; RNK - Ronkonkoma; HFD - Hartford; PVD - Providence; WOR - Worcester; SPG - Springfield; BOS - Boston

Source: NEC FUTURE team, 2015

The FRA compared the ridership potential of these three route options. The comparison yielded little difference in the magnitude of ridership potential (Table 15). The relative size of the Worcester and Providence markets, including the large swath of Boston suburbs lying to the west and south of Boston, is similar for Routes 1A and 1B. The Springfield market compensated for the loss in through ridership to and from Boston resulting from longer trip times. The Springfield route, however, by virtue of its extra length and the difficult topography to be traversed between Springfield and Worcester, requires extensive tunneling and was found to be considerably more costly than the two more direct routes, based on route-level cost estimates and the relative magnitude of the various types of required construction (Figure 9).

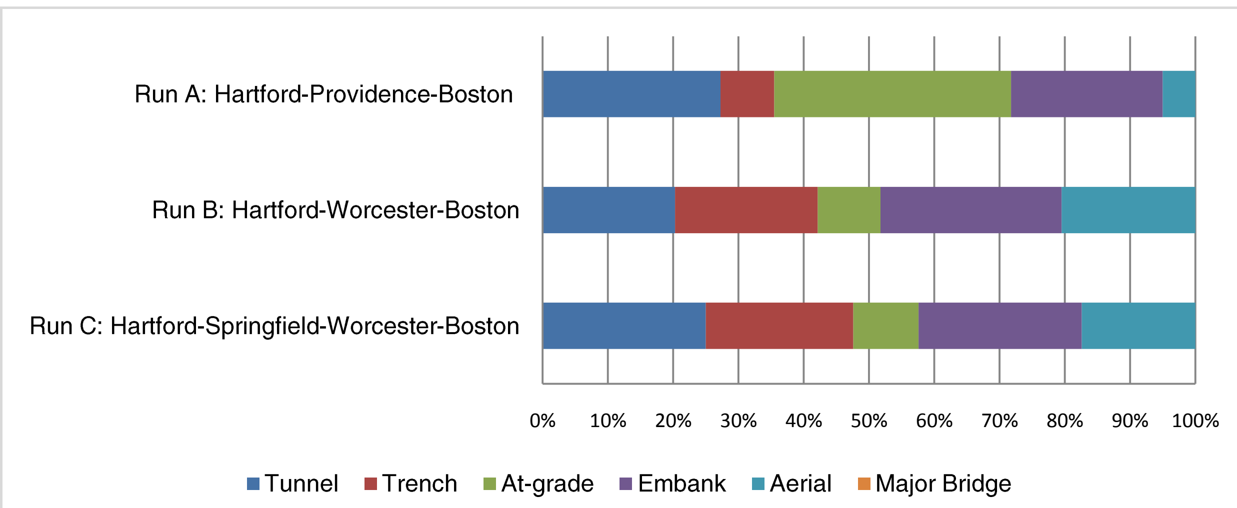
In addition to ridership potential and construction difficulty, the FRA considered the strength of potential connecting corridor service as a third factor to evaluate the route options. Springfield retains rail links to both New York City and Boston even in the options that do not provide direct high-speed service through Springfield – via connections at Hartford. The Hartford Line provides a 25-mile long connection from Springfield to Hartford, where a convenient transfer can be made to either Intercity-Express or Metropolitan trains running on the high-speed second-spine toward either New York City or Boston. The Inland Route, between Springfield, MA and Boston, MA, also offers a direct rail connection between Springfield and Boston that is not high-speed, but which is planned for improvements that offer reasonable service frequencies and trip times.

Table 15: Estimated 2040 Ridership – Intercity Markets – Hartford-to-Boston

Route Option-->	1A			1B			1C		
	Hartford-Providence-Boston			Hartford-Worcester-Boston			Hartford-Springfield-Worcester-Boston		
	Express	Corridor/ Metrop	Total	Express	Corridor/ Metrop	Total	Express	Corridor/ Metrop	Total
Total Annual Intercity Trips (M)									
Total North End Trips	3.0	4.2	**7.2**	2.8	4.4	**7.2**	2.9	4.4	**7.3**
Trips Between Common Station Pairs (NEC Spine plus Hartford)	2.5	3.5	**6.0**	2.0	3.4	**5.4**	2.0	3.4	**5.4**
Trips with end points in Greater Boston or New York & South	2.6	3.9	**6.5**	2.5	4.0	**6.5**	2.6	4.0	**6.6**
Percent of total north end trips			***89.7%***			***90.4%***			***90.1%***
Trips between Intermediate Markets	0.4	0.4	**0.8**	0.3	0.4	**0.7**	0.3	0.4	**0.7**
Percent of total north end trips			***10.3%***			***9.6%***			***9.9%***
Total Annual Intercity Trips (000)									
Trips between Greater Boston and New York & South	749	608	**1357**	701	697	**1397**	688	678	**1366**
Percent of total north end trips			***18.7%***			***19.3%***			***18.8%***

Source: NEC FUTURE team, 2015

Figure 9: Relative Construction Type by Route Option, Hartford-to-Boston



Source: NEC FUTURE team, 2015

On the other hand, the same cannot be said for Worcester or Providence, which must be on the high-speed second-spine in order to realize significant trip time and service frequency benefits relative to the No Action Alternative for travel to and through New York City. Without the high-speed second-spine, trip times from Worcester to New York City are significantly longer than via the existing Inland Route. Similarly, if the Providence route option is not selected, Providence retains Intercity-Express and Intercity-Corridor service, but the follows the existing NEC, and trip times to New York City are considerably longer. Moreover, through the various stakeholder and public meetings, the FRA received a greater amount of support for the Providence and Worcester route options, compared with Springfield.

In light of these considerations, the second-spine route option via Springfield was dropped from further consideration, but both of the other more direct route options (via Providence and via Worcester) were retained for further analysis. The service-related negative consequences of eliminating the direct route through Springfield are mitigated by the good connections that available at Hartford to both New York City and Boston with the two route options that are retained.

5.4 **FINDINGS**

Table 16 summarizes the disposition of the 20 unique north end route options with respect to documentation in the Tier 1 Draft EIS. Eight of the 20 routes are included among the Action Alternatives, either as the NEC or as connecting corridors. The FRA also retained the New Haven Line and Shore Line route as a route for through Intercity trains and Regional rail services in each of the Action Alternatives. In addition, the Stamford-Danbury corridor remains connected to the NEC as a Regional rail branch line. The further analysis and documentation of the Action Alternatives provides additional information on ridership, capital cost, environmental effects and other benefits, that will be used to inform identification of a Preferred Alternative.

The evaluation of the north end route options did not reveal a single superior route. Instead, the FRA identified two viable candidate routes between New York City and Hartford, and two between Hartford and Boston. Consequently, the FRA determined to carry forward the following four potential route options for the second-spine between New York City and Boston in Alternative 3 (Figure 10):

- Alternative 3.1 – Central Connecticut/Providence
- Alternative 3.2 – Long Island/Providence
- Alternative 3.3 – Long Island/Worcester
- Alternative 3.4 – Central Connecticut/Worcester

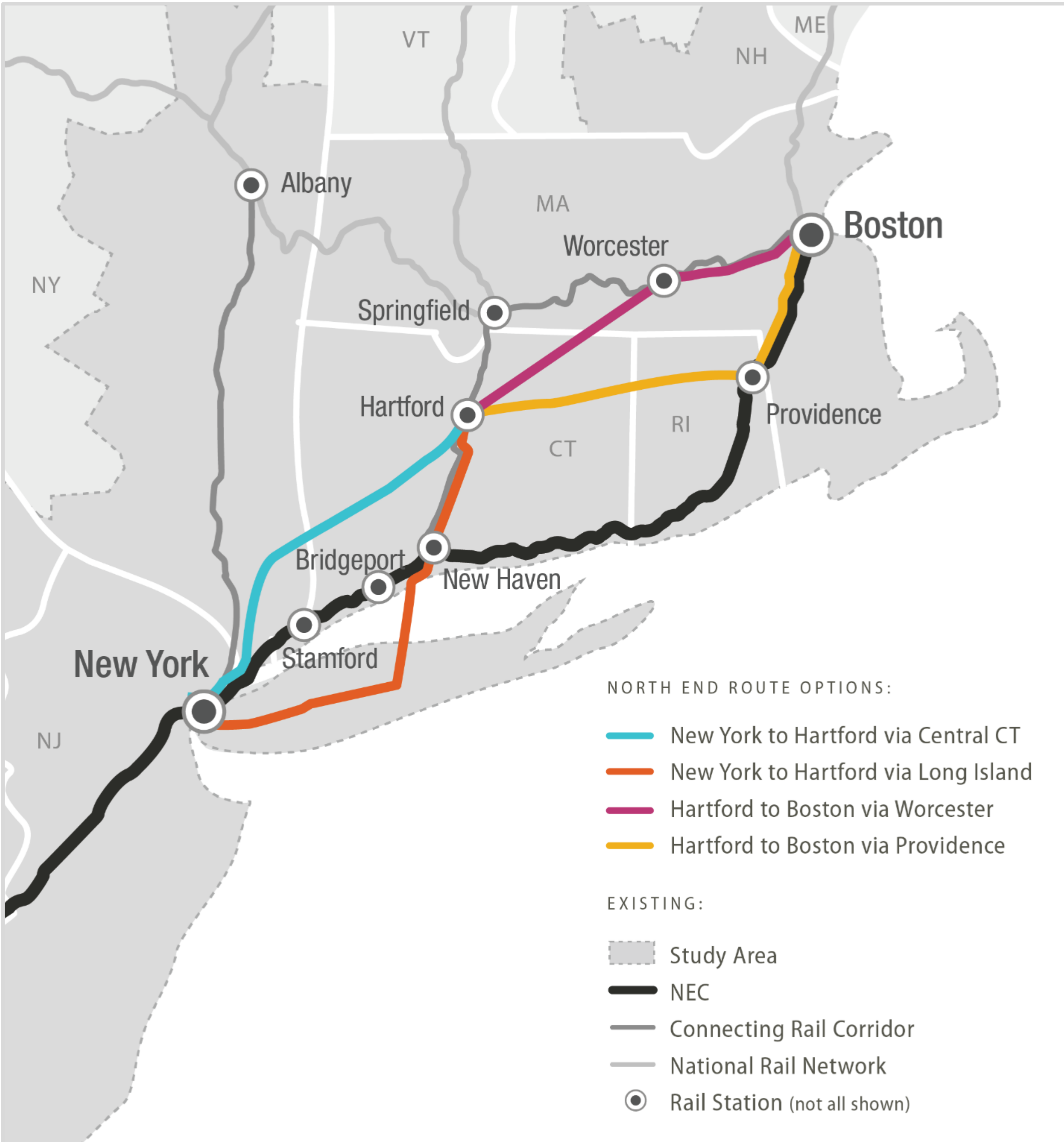
All four route options operate between Washington, D.C., and Boston, and join with common infrastructure improvements and rail services on the south end of the NEC, between Washington, D.C., and New York City. These route options are documented in the Tier 1 Draft EIS as part of Alternative 3.

Table 16: North End Routing Options Evaluation Summary, New York City to Boston

No.	North End Route Option						Disposition
1	[NEC] New York City-New Rochelle-Stamford	[NEC] Stamford-New Haven		New Haven-Hartford	Hartford-Providence	[NEC] Providence-Boston	Alt. 2
2					Hartford-Worcester	Worcester-Boston	X
3					Hartford-Springfield-Worcester		CC
4		Stamford-Danbury		Danbury-Hartford	Hartford-Providence	[NEC] Providence-Boston	X
5					Hartford-Worcester	Worcester-Boston	X
6					Hartford-Springfield-Worcester		X
7	New York City-New Rochelle-Danbury	Danbury-Hartford			Hartford-Providence	[NEC] Providence-Boston	Alt. 3.1
8					Hartford-Worcester	Worcester-Bos	Alt. 3.4
9					Hartford-Springfield-Worcester		CC
10	New York City-Nassau Hub	Nassau Hub-Ronkonkoma-New Haven		[NEC] New Haven-Providence		[NEC] Providence-Boston	X
11				New Haven-Hartford	Hartford-Providence	[NEC] Providence-Boston	Alt. 3.2
12					Hartford-Worcester	Worcester-Boston	Alt. 3.3
13					Hartford-Springfield-Worcester		CC
14		Nassau Hub-Stamford	[NEC] Stamford-New Haven	[NEC] New Haven-Providence		[NEC] Providence-Boston	X
15				New Haven-Hartford	Hartford-Providence	[NEC] Providence-Boston	X
16					Hartford-Worcester	Worcester-Boston	X
17					Hartford-Springfield-Worcester		X
18			Stamford-Danbury	Danbury-Hartford	Hartford-Providence	[NEC] Providence-Boston	X
19					Hartford-Worcester	Worcester-Boston	X
20					Hartford-Springfield-Worcester		X

X = This route was dropped from further consideration as a second-spine for the Action Alternatives.
CC = This route was included as connecting corridor service in various alternatives with second-spine via other route options.

Figure 10: Alternative 3 Route Options



6. Characteristics of the No Action and Action Alternatives

Each Action Alternative represents a different long-term vision for improving passenger rail service that will enhance mobility options, improve performance, and better serve existing and new markets that support future population and employment growth in the Study Area. All three Action Alternatives provide substantially more and better rail service than the No Action Alternative, along the entire length of the NEC. While the three Action Alternatives are distinct in their service and physical characteristics, they include several common elements. Despite differences in how they achieve these elements, each of the three Action Alternatives:

- Maintains and improves service on the existing NEC.
- Brings the NEC to a state of good repair by replacing or renewing aging infrastructure on the existing NEC and eliminating the backlog of infrastructure requiring replacement, so that future capital upgrades are planned and implemented according to a regular replacement cycle.
- Addresses the most pressing capacity and service chokepoints that constrain capacity on the existing NEC.
- Protects freight rail access and the opportunity for future expansion.
- Incorporates appropriate passenger rail enhanced service concepts and operational “best practices” consistent with integrated service and infrastructure planning to address capacity constraints, broaden the mix of station-pairs served, improve performance, and generate operating cost efficiencies.

The FRA developed a range of Action Alternatives to help better understand and quantify key rail market and service dynamics, such as the trade-offs between frequencies of service, trip time, and the convenience of one-seat service between markets. The Action Alternatives provide the FRA, the region, and other stakeholders with a broad range of options and sufficient information to evaluate future visions and make reliable, long-term decisions about the appropriate role rail plays in the region’s multimodal transportation network. The investment program for each Action Alternative consists of 1) a set of geographic markets to be served by passenger rail; 2) a Representative Route (or footprint) that connects these markets; 3) assumptions about the level of passenger rail service that will be provided to these markets; and 4) infrastructure improvements that support this level-of-service. These characteristics are also used to describe the No Action Alternative.

6.1 MARKETS

The FRA took a market-based approach to develop Action Alternatives, first identifying current travel patterns, how they have changed over the past three to four decades, and potential new rail markets. The four primary geographic markets on the existing NEC are Washington, D.C., Philadelphia, Boston, and New York City. These four markets are distinguished by existing regional and state travel demand and population growth data, ridership projections made by Amtrak and the commuter-rail operators, data and discussions with states and planning organizations, and public and agency comments made during Scoping and other public meetings.

The data also show that there are other strong Northeast travel markets, both on and off the existing NEC. The Study Area includes a number of smaller intermediate cities and urbanized areas. Some of these are located directly on the NEC, such as Baltimore, Wilmington, and Providence. Others are located away from the NEC, such as Hartford, CT, or Worcester, MA. A significant number of interregional trips[24] include travel from these intermediate cities to the primary metro regions, or between two intermediate cities.

A third category of geographic markets within the NEC Study Area can be characterized as suburban areas, located within the general realm of one or more of the primary regions but without easy access to a large downtown train station. These areas are served by NEC stations with both intercity and commuter trains. For example, the Maryland suburbs of Washington, D.C., and Baltimore are served today by the New Carrollton and BWI Airport stations. A broad swath of New Jersey is linked by highway to the Metropark station. Westchester (NY) and Fairfield (CT) Counties are served today by multiple stations along the New Haven Line, and the southern and western suburbs of Boston have good highway access to the Route 128 station.

6.1.1 STATIONS

For NEC FUTURE, the FRA developed a hierarchy of station types, based on the size of the geographic market and type and quantity of rail service offered. This typology applies to existing stations and future stations included in the No Action and Action Alternatives. Stations are grouped based on similar characteristics into one of three categories:

- **Major Hub stations** serve the largest markets in the Study Area and have the full complement of rail services types. Major Hub stations serve the four primary markets: Washington, D.C., Philadelphia, New York City, and Boston, as well as other major markets within the Study Area, including but not limited to Baltimore, MD; Stamford, CT; and Providence, RI. Major Hub Stations are located in the most populous and densely developed metropolitan areas along the NEC, serving Intercity and Regional rail travel to these major population and employment centers.
- **Hub stations** offer some Intercity service, although the Intercity-Express service is more limited than the service levels offered at Major Hub stations. Hub stations include the existing smaller intermediate Amtrak stations, as well as selected key Regional rail stations and new stations that have the potential to fill connectivity gaps in the existing passenger rail network, serve special trip generators, and/or provide important inter-modal connections.
- **Local stations** are served almost exclusively by Regional rail trains, on the portions of the NEC where Regional rail service is offered. Examples of local stations include Halethorpe, MD; Claymont, DE; Torresdale, PA; Edison, NJ; Larchmont, NY; Westport, CT; Wickford Jct., RI; and Attleboro, MA. There are a limited number of locations on the NEC outside of Regional rail territory where the existing Amtrak stations are best classified as local stations (e.g., Mystic and Westerly stations). Similarly, smaller stations on connecting corridors beyond the NEC are considered local stations (e.g., Ashland, VA; Mt. Joy, PA; Rhinecliff, NY; Wallingford, CT).

[24] Trips that that start and end in different metropolitan areas.

6.2 REPRESENTATIVE ROUTE

The Representative Route refers to the physical path of a proposed Action Alternative, including horizontal and vertical dimensions. The Representative Route is defined by the broad physical limits (or footprint) of an alternative, and is used to assess the potential environmental effects of the Action Alternatives. At the Tier 1 level, the footprint is only representative of where the physical route might be located and are not a prediction of future preferences or decisions. For purposes of footprint-related environmental effects analysis, a relatively wide buffer is drawn around the Representative Route centerline to understand the resources and potential impacts in the general zone within which the actual right-of-way might be located. The width of the buffer area varies by type of construction and is larger for new segments than for new tracks that follow the existing NEC. Recognizing the uncertainty that exists at this early stage of planning, the Representative Routes provide a sound basis for programmatic evaluation of the environmental effects of each Action Alternative.

6.3 SERVICE PLAN

The utility of the current passenger rail network is limited by gaps in connectivity with other transportation modes and minimal coordination between different rail services. Railroads operating on the NEC today share fixed infrastructure but operate separate rail services with different equipment with different performance capabilities. Infrastructure (track configuration, power source) and equipment constraints (diesel, electric) further limit the ability to provide passengers with coordinated and direct service for many city pairs along the existing NEC and connecting corridors.

The Service Plans (Section 4.1.1) for the Action Alternatives incorporate operational improvements that better integrate train service across today's separate markets, and explore opportunities free from institutional and jurisdictional operating constraints. These improvements (Section 4.1.4) include "through-service" at major stations to provide operational efficiency and improved capacity utilization; clockface (service at regular intervals) train departures and standard stopping patterns to improve efficiency; integrated ticketing and fares across the NEC to improve passenger convenience; and decreased dwell time at stations to reduce travel time. In addition, some stations could be enhanced to accommodate multiple service types, and train schedules could be integrated across the NEC to provide easier transfers between trains, resulting in an increase in travel options and service frequencies to additional markets. Other operational improvements include:

- Development of Regional rail slot catalogues, in which schedule slots are assigned to services where and when demand is greatest and not assigned to a specific operator.
- Scheduling options for accommodating less reliable off-corridor operations to reduce their effect on NEC operations (e.g., extended dwells at NEC entry point, phantom slots, etc.).

6.4 INFRASTRUCTURE ELEMENTS

As described in the Purpose and Need, the Action Alternatives use existing and proposed infrastructure to support the operations necessary to meet market growth and the specific vision of that alternative. All of the Action Alternatives can accommodate different types of trains; however, some route segments in Alternatives 2 and 3 will be dedicated to high-performance trainsets. This integrated approach to operations and train schedules, requires a smaller infrastructure footprint compared to today's independently planned operations.

Individual infrastructure elements make up an Action Alternative's path and describe the type of the physical infrastructure improvement relative to the No Action Alternative. These discrete elements, including both linear elements and supporting infrastructure (Section 4.4), facilitate a modular approach to analyzing the alternatives. Infrastructure Elements that make up the Action Alternatives consist of the following:

- Curve Modification
- New Track
- New Segment
- Station Area
- Junction
- Storage and Maintenance Facility

7. No Action Alternative

The No Action Alternative represents future conditions if no rail investment program is advanced. It assumes planned and programmed improvements to highway, freight rail, transit, air, and maritime modes that will be completed by 2040. Interregional and regional travel demand is affected by the availability, price, and reliability of all transportation modes. Therefore, inclusion of improvements of these other modes is necessary to represent the reasonably foreseeable future transportation conditions in the NEC Study Area. The No Action Alternative serves as a baseline for the purpose of comparing the outcomes of the Action Alternatives in terms of ridership, revenue, cost, and train operations.[25]

The No Action Alternative represents a snapshot in time and has been developed using current information compiled from federal, state, and regional transportation planning documents. As the NEC FUTURE program progresses, assumptions regarding which projects are included as part of the No Action Alternative may be revised based upon available funding, urgency of needs, and changes or updates to the region's transportation plans.

Upon reviewing planning lists of projects across all transportation modes, the FRA used the following methodology for selecting projects for inclusion in the No Action Alternative:

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

The FRA assumes that sufficient funding will be made available to maintain current service levels with the No Action Alternative; however, if this is not available, the reliability, capacity, and service quality of the NEC will decline. In fact, historic funding levels are not sufficient to make the improvements and maintain service in the No Action Alternative. Because the implications of continuing current funding levels on service are hard to predict, it is assumed that sufficient funding will be made available for the No Action Alternative. Forecasting the implications of insufficient funding on the performance of the eight commuter railroads and Amtrak would be subjective given the uncertainty of what might or might not be funded and the resulting performance implications. Therefore, the FRA decided to separate evaluation of the No Action Alternative from the discussion of historic or future funding trends and the implications of insufficient funding.

The FRA assumes that the No Action Alternative projects necessary to maintain existing service levels along the NEC will be funded through 2040. However, the funding levels necessary for the No Action Alternative exceeds historic levels of capital funding from federal, state, and local sources made available to all of the owners/operators on the NEC. Historic funding levels have averaged $600 million per year over the last ten years.[26] If sufficient funding to meet the requirements of the No Action Alternative is not made available, the consequence of continuing past patterns of disinvestment in the NEC would be

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[25] For additional information on the No Action Alternative, please see the NEC FUTURE *No Action Alternative Report* on the NEC FUTURE website, *www.necfuture.com*.
[26] NEC Infrastructure and Operations Advisory Commission. *NEC Capital Needs Assessment FY15-19 (September 2014)*

degradation of the reliability, capacity, and quality of service on the NEC with potential outcomes as summarized below.

- Reliability would decline, resulting in more frequent and longer delays, and reduced on-time performance of train service. This reduction in reliability would result from unscheduled delays, as well as “scheduled” delays required periodically (and randomly to allow engineering crews to access the railroad to make remedial repairs).
- Scheduled trip times would increase as the deteriorating condition of NEC infrastructure—particularly rail, bridge, and subgrade—would necessitate slow orders to reduce the impact of train operations on sensitive infrastructure and to ensure safety.
- Operating costs for infrastructure maintenance would rise in response to the need for more frequent maintenance and unscheduled and sometimes substantial repairs.
- Costs for train operations would increase as longer cycle times for equipment would require greater fleet sizes and more crew time and overtime.
- Ridership would decline in response to the reduced level and quality of service leading to declines in revenue such that current levels of operating profit for Intercity services would diminish and operating losses would occur.

However, as mentioned earlier, FRA has decided that, for the purposes of providing a baseline for comparison against the Action Alternatives, the FRA presumes sufficient funding to maintain current service levels are made available for the No Action Alternative.

7.1 MARKETS

The No Action Alternative serves existing geographic markets along the NEC. Table 17 identifies the stations served under the No Action Alternative.

7.2 REPRESENTATIVE ROUTE

The Representative Route of the No Action Alternative is the existing NEC between Washington Union Station and Boston South Station. It includes the MTA East Side Access Project currently under construction in New York City.

7.3 SERVICE PLAN

The Service Plan under the No Action Alternative is described by type and levels of passenger rail service at selected screenlines along the NEC (Table 18). Screenlines were used to measure the volume of passenger rail traffic at key locations along the NEC, particularly where capacity or utilization might change. Screenlines are drawn across a rail right-of-way usually associated with a particular geography in order to standardize the location at which the frequency and type of rail service are measured, evaluated, and compared. The volume of passenger rail traffic is expressed as trains per hour, per direction, by service type at the following points along the NEC: Washington, D.C.; Philadelphia, PA; the Hudson River and East River in the New York metropolitan region; New Rochelle, NY; and Boston, MA. For comparison purposes, existing (2012) service levels are compared to the No Action Alternative service levels for the peak-hour, peak direction.

Table 17: Existing Stations (excluding Connecting Corridors) Served Under the No Action Alternative

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

Source: NEC FUTURE team, 2014

Table 18: 2040 Standard Peak-Hour Trains, Peak Direction – No Action Alternative

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

Source: NEC FUTURE team, 2015

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

** Excludes MTA-Long Island Rail Road access to Grand Central Terminal.

In the No Action Alternative, passenger rail service on the NEC operates similarly to and at the same approximate level as today's services. The No Action Alternative assumes the same types of Amtrak Intercity services, including Intercity-Express (Acela), Intercity-Corridor (Regional), and connecting corridors (i.e., Springfield, Keystone, and Empire). The No Action Alternative also assumes the same types of regional services offered by the eight commuter railroads operating on the NEC: MBTA, Connecticut DOT, MNR, LIRR, NJ TRANSIT, SEPTA, MARC, and VRE. East Side Access, currently under construction and thus part of the No Action Alternative, includes new LIRR service into Grand Central Terminal in New York City. While the types of service are assumed to be similar going forward, greater demand in the future could affect overall performance.

7.4 INFRASTRUCTURE ELEMENTS

The No Action Alternative represents the condition of the Northeast region's multimodal transportation system in 2040 assuming general continuation of infrastructure conditions. The No Action Alternative includes the completion of transportation projects already planned and programmed, or in-progress by 2040. Beyond specific named projects, the No Action Alternative assumes that right-of-way owners individual railroad operators will continue to maintain the NEC through their annual maintenance programs for key elements such as track, signals and communications, and structures, and that the individual railroad operators will continue to maintain their rolling stock and yard facilities. Capital replacement or upgrading of infrastructure assets is assumed be undertaken as necessary to maintain railroad operations at current levels, based on the condition of the assets. This includes some—but only a modest proportion—of the significant backlog of work associated with bringing the NEC to a state of good repair. The No Action Alternative does not bring the NEC to a state of good repair.

8. Alternative 1

Alternative 1 maintains the role of rail, with the level and capacity of rail service to keep pace with proportional growth in population and employment. For this alternative, the FRA used the projected service plans of NEC service operators as a starting point, and made adjustments to meet projected increases in travel demand. Alternative 1 includes new rail services and commensurate investment in the NEC to expand capacity, add tracks, and relieve key chokepoints, particularly through northern New Jersey, New York, and Connecticut (Figure 11). This includes a 60-mile bypass between Old Saybrook, CT, and Kenyon, RI, that adds capacity, improves travel time, and provides an alternative for most intercity trains to avoid five existing movable bridges along Long Island Sound and numerous sharp curves.

8.1 MARKETS

Alternative 1 primarily serves existing NEC travel markets. There are several suburban Regional rail branch lines that are able to obtain one-seat ride service to Manhattan in this alternative, including the Raritan Valley Line corridor, Bergen County in northern New Jersey, Rockland and Orange counties on the west bank of the Hudson River in New York State, and the Waterbury Line corridor in Connecticut. Where Metropolitan service is introduced, the accessibility of these areas to NEC Intercity service is significantly improved. The stations with Metropolitan service generally are those with significant local development and economic activity and/or excellent regional highway access.

8.2 REPRESENTATIVE ROUTE

The Representative Route of Alternative 1 closely follows the existing route of the NEC. In all but a few locations, the Representative Route is confined to the existing NEC. Exceptions include locations where infrastructure is added to provide chokepoint relief or add capacity, as described above.

8.3 SERVICE PLAN

The Service Plan for Alternative 1 offers a moderate expansion in service compared to the No Action Alternative, to accommodate underlying growth in both the Intercity and Regional rail markets by 2040. In the standard peak hour, Intercity-Express service increases to two trains per hour, on both the South End and North End. Intercity-Corridor service also increases. In the standard peak hour, two trains per hour operate between Washington, D.C., and New Haven, CT, providing a one-seat ride from the NEC to off-corridor markets on the connecting corridors. In addition to these trains, new Metropolitan service is introduced, with two trains in the standard peak hour running between Washington, D.C., and Boston, and an additional train serving the Keystone Corridor and running on the NEC between Philadelphia and New York City.

Major NEC cities see an increase in total trains per hour in the standard peak hour from combined service of Intercity-Express, Intercity-Corridor, and Metropolitan services:

- Washington, D.C.: 6 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 2 Metropolitan)
- Philadelphia, PA: 7 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 3 Metropolitan)

- Newark, NJ: 7 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 3 Metropolitan)
- New Haven, CT: 6 tph (2 Intercity-Express, 2 Intercity-Corridor-Other, and 2 Metropolitan)
- Boston, MA: 4-5 tph (2 Intercity-Express, up to 1 Intercity-Corridor-Other[27], and 2 Metropolitan)

Expansion of trainset lengths, where possible, and increases in peak period service frequencies to provide more capacity, enables future Regional rail service to continue to carry its current share of journey-to-work trips to and from the major metropolitan CBDs, such as across the Hudson River screenline. Reverse-peak and off-peak service continues to be operated where it is provided today.

8.4 INFRASTRUCTURE ELEMENTS

Alternative 1 supports increases in Regional rail and Intercity services by bringing the existing NEC to a state of good repair, eliminating key chokepoints along the corridor, and increasing capacity at selected locations by adding additional track within the existing NEC and through new segments parallel to and outside the existing NEC right-of-way.

8.4.1 CHOKEPOINT RELIEF PROJECTS

Alternative 1 includes a set of location-specific capital projects to provide relief of train movement congestion and increase railroad capacity at several existing chokepoints. These projects are spread across the NEC, but are concentrated at locations that are currently congested and where train interference causes delays today—primarily south of New York City and on the New Haven Line in New York City and Connecticut. These chokepoint relief projects are located at stations, branch line junctions, and yard locations where trains lay over and change direction. They are listed below in geographic order from south to north, and their locations are identified in Figure 11:

- New Carrollton Station, 4 platform tracks, to permit express and local trains to operate on separate tracks
- Newark, DE, station relocation and track reconfiguration, to provide for smoother Intercity, Regional rail and freight train movements
- Holly Interlocking reconfiguration, DE, to separate local and express train traffic
- Philadelphia flyover, to facilitate regional rail local train movements
- Trenton Station and yard access, to facilitate Regional rail terminal operations
- Mid-Line Loop, to facilitate turning of regional rail zone express trains
- Metropark Station platforms on express tracks, to permit Intercity-Express and Intercity-Corridor trains to stop at this station without switching to the local tracks
- Hunter flyover and Westbound Waterfront Connection, improving access to the NEC from the Raritan Valley Line and from Hoboken Terminal
- New Rochelle (Shell Junction) grade separation, to provide smoother train flows between the Hell Gate Line and New Haven Line
- South Norwalk and Devon junction improvements, to facilitate Danbury and Waterbury Regional rail branch line train movements
- East Bridgeport yard access and turnback track, to facilitate turning of local Regional rail services

[27] The Intercity-Corridor-Other train at Boston would operate on the Inland Route (via Hartford, Springfield, and Worcester) and would operate at less than hourly service frequencies.

8.4.2 NEW TRACK

New-track projects are identified as linear elements along portions of the existing NEC that include associated junctions and interlockings required to access the new tracks. Six new-track projects are built in Alternative 1. Four are located south of New York City, two of which are in Maryland, which is currently a two- and three-track right-of-way. There are two new-track projects north of New York City. Two tracks are added to the Hell Gate Line in Queens County and one or two tracks are added near Route 128 station in Massachusetts. New-track projects are shown on the map in Figure 11 and include the following locations:

- Odenton, MD, to West Baltimore, MD, 4th track
- Bayview, MD, to Newark, DE, additional track(s)
- Elizabeth, NJ, to Newark Airport, NJ, additional track(s)
- Hell Gate Line, Bronx, NY, 4 tracks
- East Greenwich, RI-Warwick, RI, additional track(s)
- Canton Jct., MA, to Westwood/Route 128, MA, additional track(s)

8.4.3 NEW SEGMENT

Alternative 1 adds three new segments,[28] parallel to and outside of the existing NEC right-of-way. Two new segments are located south of New York City: a new tunnel near Baltimore Penn Station and a third and fourth tunnel under the Hudson River between New Jersey and New York. These new segments are listed below (with their approximate length in parentheses) and are also identified on the map in Figure 11:

- Baltimore Tunnel (~2 miles)
- Hudson River third and fourth tunnels (~3 miles)
- Old Saybrook, CT-Kenyon, RI (~50 miles)

All of these are locations for new segments are where the railroad is capacity-constrained, where expanding capacity within the existing right-of-way is difficult or impractical, or, in the case of the Baltimore Great Circle Tunnel, where existing facilities require life-cycle replacement.

This alternative also includes one long parallel new segment in southeastern Connecticut, the Saybrook-Kenyon bypass. This new route, approximately 50 miles long, provides a more direct and faster route than the circuitous existing Shore Line, and it circumvents the existing movable bridges over navigable waterways connected to Long Island Sound, over which daily train movements are capped by current agreements and where approval for significant increases in future train traffic will be difficult to obtain. Operating Intercity-Express and Metropolitan service on this bypass route saves approximately 30 minutes of travel time compared with the existing Shore Line route and frees up capacity on the existing route for anticipated growth in Regional rail and freight service. A new station for Intercity-Express and/or Metropolitan services could be built on the bypass route in the New London-Mystic area. The existing stations serving the downtown areas of New London, Mystic and Westerly continue to be served by trains running on the existing Shore Line.

[28] New segments contribute to the Representative Route of an alternative, as described in Section 8.1

Figure 11: Alternative 1

Source: NEC FUTURE team, 2015

9. Alternative 2

Alternative 2 grows the role of rail, expanding rail service at a faster pace than the proportional growth in regional population and employment. During the business travel peak periods, very frequent Intercity-Express service is provided along the entire NEC, with Intercity-Express trains operating at 4 tph. Metropolitan service also is operated on the NEC at a frequency of a train every 15 minutes, providing a level-of-service resembling that of transit. In all regions of the NEC, Regional rail service frequencies also are increased significantly above No Action Alternative levels. As shown in Figure 12, south of New Haven, CT, infrastructure improvements focus on the existing NEC right-of-way with some variations in the route to improve train speeds in areas with speed-limiting curves, address capacity constraints, and serve selected new markets. North of New Haven, Alternative 2 provides a new route segment between New Haven, Hartford, and Providence, improving performance for express trains operating between Boston and New York City while providing better connections for markets in the Connecticut River Valley. Alternative 2 also brings the existing NEC to a state of good repair and implements operational best practices to obtain the highest practical utilization of the infrastructure capacity that is created.

9.1 MARKETS

Alternative 2 greatly improves the level-of-service available to all of the existing NEC markets and selectively taps potential new travel markets that are not served currently or are not well served by the NEC. This includes the New Haven-Hartford-Springfield corridor, now known as the Hartford Line. Hartford becomes a market on the NEC Spine rather than part of a connecting corridor. Other locations along this line have improved trip times and service offerings by virtue of the new high-speed line between New Haven and Hartford featured in this alternative, and the greatly improved accessibility of Providence and Boston by rail.

A second market that receives greatly improved rail service is Philadelphia International Airport, which has a station directly on the NEC in this alternative, with frequent Intercity-Express, Metropolitan, and Regional rail service up and down the NEC as well as to the Keystone Corridor and the rest of the SEPTA Regional rail network.

A third market with significantly increased NEC rail service is located on the south side of Washington, D.C. Improvements to the Long Bridge corridor between Washington, D.C., and Alexandria, VA, coupled with improvements at Washington Union Station, permits Metropolitan service and selected Regional rail trains to run through Union Station, effectively extending the reach of the NEC to this heavily populated part of greater Washington, D.C., and to Ronald Reagan Washington National Airport.

Figure 12: Alternative 2

Source: NEC FUTURE team, 2015

9.2 REPRESENTATIVE ROUTE

Much of the Representative Route of Alternative 2 follows the existing NEC between Washington, D.C., and New Haven, CT, with some exceptions where infrastructure is added or modified to provide chokepoint relief or improve capacity and performance. These infrastructure elements are described Section 9.4. North of New Haven, a new route is provided for Intercity-Express and Metropolitan trains running between New York City and Boston. The new route runs on new tracks between New Haven and Meriden, CT, shares the existing Hartford Line between Newington, CT and Hartford, CT, and runs on new tracks between Hartford, CT and Providence, RI.

9.3 SERVICE PLAN

Alternative 2 significantly grows Intercity service on the NEC through improved service to all existing markets and additional service to selected new markets. In the standard peak-hour, Intercity-Express service increases to four trains per hour compared to the No Action Alternative, where there is never more than one train per hour operating on any segment of the NEC. Intercity-Corridor-Other service increases to 2 tph between Washington, D.C., and New Haven. Metropolitan service provides 4 tph, during peak travel periods, between Washington, D.C. and New Haven.

Major NEC cities see an increase in the total number of Intercity trains in the standard peak hour:

- Washington, D.C.: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other, and 4 Metropolitan)
- Philadelphia, PA: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other, and 4 Metropolitan[29])
- Newark, NJ: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other, and 4 Metropolitan)
- New Haven, CT: 10 tph (4 Intercity-Express, 2 Intercity-Corridor-Other[30], and 4 Metropolitan[31])
- Boston, MA: 8–9 tph (4 Intercity-Express, up to 1 Intercity-Corridor-Other[32], and 4 Metropolitan)

Regional rail service on the NEC is provided with peak service frequencies at most NEC stations based on 15-mintue headways, which represents an increase in service at a majority of stations, compared with the No Action Alternative. In areas with heavy Regional rail demand, additional service zones are created to increase peak zone express service and reduce average trip times. In addition, service to branch lines is increased where sufficient capacity exists.

[29] Service at 4 tph is provided in the direction of both New York City and Washington, D.C. Metropolitan service in the standard peak hour at Philadelphia consists of 2 trains running between Washington, D.C., and Boston, 2 trains running between Harrisburg and Boston, and 2 trains running between Philadelphia and Washington, D.C.

[30] The Intercity-Corridor-Other trains operate via the Hartford Line to Springfield, with selected trains extended to Vermont via the Knowledge Corridor and to Boston via the Inland Route.

[31] Metropolitan services at 4 tph from New York City splits at New Haven, with 2 tph continuing on the Shore Line to Boston, and 2 tph operating via the new route segment to Boston via Hartford and Providence.

[32] The Intercity-Corridor-Other train at Boston operates on the Inland Route (via Hartford, Springfield and Worcester) and at less than hourly service frequencies.

9.4 INFRASTRUCTURE ELEMENTS

Alternative 2 maximizes the capacity of the existing NEC, focusing on where future demand is greatest. Alternative 2 includes chokepoint relief projects necessary to provide for smooth-flowing operations, and new-track projects and new segments improve trip times through increases in allowable speeds or bypassing the slowest-speed portions of the existing NEC in and around the major urban areas, on antiquated bridges, and in southeast Connecticut.

9.4.1 CHOKEPOINT RELIEF PROJECTS

Alternative 2 includes capital projects at specific locations to relieve chokepoints on the existing NEC. Most of the chokepoint projects in Alternative 2 are the same as those identified for Alternative 1, addressing chokepoints near stations, at railroad junctions, and at yard locations where trains lay over and change direction. The inclusion of new segments or new tracks at certain locations obviates the need for a separate chokepoint project. The Philadelphia Flyover is one such project, where the new segment via Philadelphia International Airport reduces the severity of train movement conflicts at the location of the potential flyover. The chokepoint projects identified in Alternative 2 include:

- New Carrollton Station, 4 platform tracks, to permit express and local trains to operate on separate tracks
- Odenton Station island platforms, to enable Metropolitan trains to stop at this station on the express tracks
- Newark, DE, station relocation and track reconfiguration, to provide for smoother intercity, regional rail and freight train movements
- Wilmington, DE, express bypass tracks, to enable non-stopping trains to pass or overtake stopping trains, and to reduce trip times for non-stopping trains
- Philadelphia 30th Street – Penn Interlocking – 4-track approaches, to enable the station to operate as a pulse-hub with coordinated transfers between train services at timed intervals
- Trenton Station and yard access, to facilitate regional rail terminal operations
- Mid-Line Loop, to facilitate turning of regional rail zone express trains
- Metropark Station platforms on express tracks, to enable Intercity-Express and Intercity-Corridor trains, including Metropolitan trains, to stop at this station on the express tracks
- Hunter Flyover and Westbound Waterfront Connection, improving access to the NEC from the Raritan Valley Line and from Hoboken Terminal
- New Rochelle (Shell Junction) grade separation, to provide smoother train flows between the Hell Gate Line and New Haven Line
- New Haven Station, to facilitate the smooth movement of Intercity and Regional rail trains into and out of the station

9.4.2 NEW TRACK

Alternative 2 includes the construction of several new-track projects. Three are located in Maryland where the existing NEC is currently a two- and three-track railroad. Two are located north of New York City, including adding two tracks to the Hell Gate Line in Queens.

- Washington, D.C., to New Carrollton, MD, 3rd Track
- New Carrollton, MD to West Baltimore, MD, 4th Track
- Bayview, MD to Perryville, MD, 4-track railroad
- Hell Gate Line, Bronx, NY, 4 tracks
- Providence, RI to Hyde Park, MA, 4 tracks

9.4.3 NEW SEGMENT

Alternative 2 includes 10 new segments parallel to and outside of the existing NEC right-of-way at the following locations (with the approximate length of the new segments shown in parentheses):

- Baltimore Tunnel (~2 miles)
- Aberdeen, MD, to Newark, DE (~23 miles)
- Wilmington, DE Bypass (~8 miles)
- Baldwin, PA, to Philadelphia 30th Street Station via Philadelphia International Airport (~10 miles)
- Baltimore 30th Street Station to Bridesburg, PA through North Philadelphia, PA (~8 miles)
- North Brunswick, NJ, to Colonia, NJ (~16 miles)
- Elizabeth, NJ, to Secaucus, NJ (~12 miles)
- Secaucus, NJ, to Hell Gate Viaduct, Queens, NY, via new Hudson and East River Tunnels and expanded Penn Station New York (~8 miles)
- New Rochelle, NY, to Westport, CT (~29 miles)
- Sharon, MA to Canton Jct., MA (~3 miles)

The biggest change in the Representative Route between Alternatives 1 and 2 is in the New Haven-to-Providence territory. Alternative 2 provides new route segment that runs all the way from New Haven to Providence via Hartford. This new route via Hartford is estimated to save approximately 15-20 minutes of run time, compared with service via the New Haven-Saybrook-Kenyon-Providence route, which was included in Alternative 1. It removes Intercity-Express trains from 120 miles of the Shore Line route between New Haven (Mill River, CT) and Providence (Hebronville, MA), a route that includes capacity-limited, movable bridges and over which Providence and Worcester freight trains operate in addition to Shore Line East and MBTA Regional rail services.

10. Alternative 3

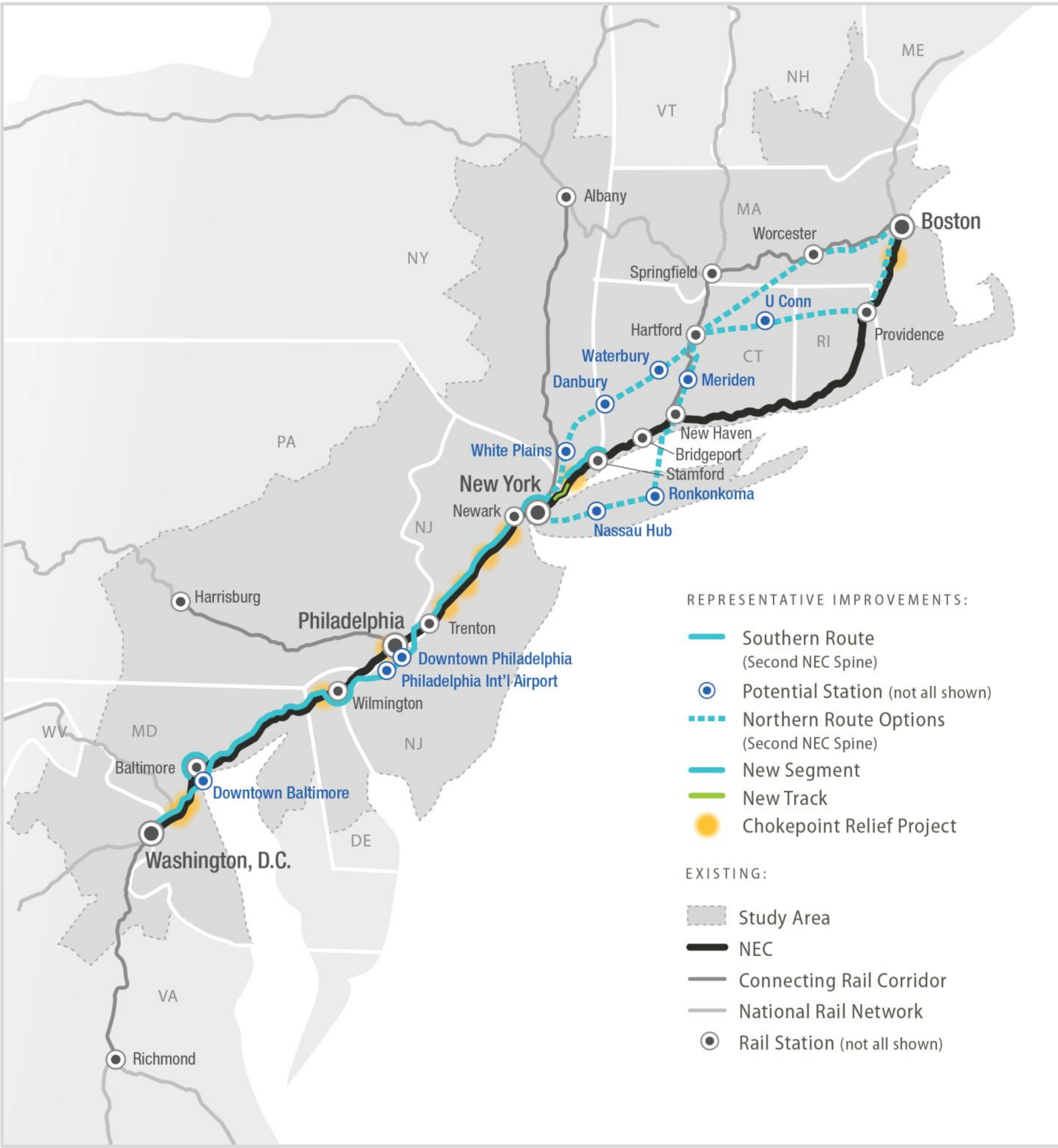
Alternative 3 is intended to enable transformation of the role of rail within the transportation network, positioning rail as the dominant mode for intercity travel within the NEC and a more competitive mode for all types of tripmaking within the metropolitan regions of the NEC. This alternative provides a major increase in the capacity of the NEC compared with the No Action Alternative and, consequently, offers the potential for considerably more rail service and the introduction of new types of service – both to existing and new markets within the Study Area. Infrastructure improvements include upgrades on the NEC and the addition of a two-track second-spine that operates adjacent to the existing NEC south of New York City and expands the reach of the NEC to new markets north of New York City (Figure 13). This new spine supports high-speed rail services between major NEC markets and provides additional capacity for Intercity and Regional rail services on both the existing NEC and the new spine. The FRA identified several potential routes for the new spine between New York City and Boston (Figure 13).

10.1 MARKETS

The additional NEC rail capacity, coupled with the faster trip times that are possible between the major NEC cities, can be used in this alternative to expand the physical reach of the NEC. The routes that are created parallel to the existing corridor improve the rail system's coverage within the NEC Study Area. Several new geographic markets become part of the NEC and are provided with direct and frequent NEC rail service – including Intercity-Express, Metropolitan and, in some cases, express Regional rail trains:

- Downtown Baltimore
- Downtown Philadelphia
- Central Connecticut Corridor, including White Plains, NY, and Danbury and Waterbury, CT, (Alternatives 3.1 and 3.4 route options)
- Long Island (Nassau and Suffolk Counties) and Jamaica, Queens (Alternatives 3.2 and 3.3 route options)
- Hartford, CT, and Springfield, MA
- The Hartford-Providence Corridor (Alternatives 3.1 and 3.2 route options)
- The Hartford-Worcester-Boston Corridor (Alternatives 3.1 and 3.4 route options)

Figure 13: Alternative 3



Source: NEC FUTURE team, 2015

Alternative 3 provides sufficient capacity to enable Intercity service from connecting corridors onto the NEC to be offered at a volume of up to four trains per hour. This enables an increase in service on existing connecting corridors, as well as the introduction of one-seat ride service onto the NEC from new connecting corridor markets. Connecting corridors that potentially could benefit from the additional capacity in Alternative 3 include:

- Washington-Richmond corridor and the Southeast High-Speed Rail corridor (to Richmond, Newport News, Norfolk and Charlotte, NC)
- Washington-Charlottesville-Lynchburg-Roanoke, VA
- Keystone Corridor extended (Philadelphia-Harrisburg-Pittsburgh)
- Empire Corridor extended (New York City-Albany-Buffalo-Cleveland, plus potential links with faster trip times from New York City to Montreal and Toronto)
- Delmarva Peninsula (Newark, DE-Dover-Ocean City, MD)
- Atlantic City (New York City-Atlantic City, Philadelphia-Atlantic City, NJ)
- Lehigh Valley (New York City-Raritan, NJ-Easton-Allentown, PA)
- Scranton (New York City-Dover, NJ-Scranton, PA)
- Eastern Long Island (New York City-Montauk)
- White Plains-Brewster-Albany-Montreal (as a branch off of the route options 3.1/3.4, with significantly faster trip times between New York City and Albany than are possible along the Hudson River)
- Knowledge Corridor extended (Springfield-Burlington, VT-Montreal)
- Cape Cod (Attleboro-Fall River-New Bedford-Cape Cod)
- Boston-Concord, NH-Burlington-Montreal
- Downeaster Corridor (Boston-Portland-Brunswick, ME).

Additional capacity exists in this alternative to offer new or improved service to combinations of the above markets while also providing superior service to existing Intercity and Regional rail markets on the NEC. There is not sufficient capacity on the railroad to provide new or greatly improved service to all of these markets simultaneously, even in Alternative 3, requiring trade-off analysis subsequent to NEC FUTURE, to identify which of these corridors, if any, warrant direct service based on their cost-effectiveness or economic benefits. However, slots are provided in Alternative 3 for Intercity-Express and/or Intercity-Corridor trains to operate along portions of the NEC to connect these markets to Boston, New York City, Philadelphia, and/or Washington, D.C. The FRA did not include any particular combination of the above services in the Alternative 3 Service Plan. Rather, the Service Plan provides extra or "phantom" Intercity-Corridor slots on the existing NEC at regular 15-minute intervals. These could be filled by trains serving any combination of these off-corridor markets.

Alternative 3 also provides additional capacity that can be used to offer Regional rail service in new corridors or to offer one-seat ride service to NEC destinations on Regional rail lines that do not currently offer direct service or have only limited direct service. However, considerable investment in railroad infrastructure, stations, fleet and/or yard facilities are required in locations outside the NEC to take advantage of this new service. The scope of NEC FUTURE does not encompass these potential branch line initiatives – either the required investments or their environmental consequences – although the potential benefits of expanding Regional rail network connections to the NEC will be assessed qualitatively. In Alternative 3, the future sponsors and operators of Regional rail and Intercity-Corridor service have great discretion to develop and implement service concepts that meet market demands for rail travel as they emerge. Some potential Regional rail concepts are summarized below, without any judgment as to their efficacy or practicality, but as examples of the types of service improvements that could be possible.

In New Jersey, there have been several prior studies for the potential re-use of former rail lines or current rail freight corridors for expanded Regional rail. These include the New York, Susquehanna & Western corridor serving western Bergen County, the West Shore corridor, and the Monmouth-Ocean-Middlesex corridor. Direct service to Manhattan with reasonable levels of service is possible in Alternative 3, which could make some of these corridors viable or more cost-effective.

In Connecticut, displacing some of the NEC Intercity-Express service from the New Haven Line to new high-speed lines could free up capacity that could be used to expand the level-of-service on the existing Danbury and Waterbury branch lines. The new high-speed line through central Connecticut in route option 3.1 presents the potential to make connections to this line from the northern end of the Danbury and Waterbury branches or to extend rail service to northwestern Connecticut or southwestern Massachusetts. It also offers the potential to build a short connection to the Metro-North upper Harlem Line in order to offer peak period express commuter service from upper Westchester and eastern Putnam and Dutchess Counties via the high-speed line to Penn Station New York.

On Long Island, with additional investment in main line capacity and yard facilities, rail service could be re-introduced on the Rockaway Beach Branch, or direct rail service to JFK Airport could be contemplated. In route option 3.2, which constructs a new high-speed line via Long Island, it is possible to offer express commuter service to Penn Station New York from the Nassau Hub, from the outer portions of the Ronkonkoma and Montauk Branches, and potentially on the high-speed line from the Stony Brook and Port Jefferson area. With the appropriate station investments and track connections in Manhattan and Queens, it is possible to create a direct rail link in this alternative between the Hudson Line and Empire Corridor and the LIRR network, offering the potential for direct rail service between these parts of New York State, which are not well-connected by rail today. The type of direct through-service could include a combination of Regional rail, Intercity-Corridor-Other, and Metropolitan service.

In Maryland, Alternative 3 presents the potential opportunity for shifting MARC service on the NEC to the new high-speed line along the CSX corridor north of Baltimore, offering station opportunities at Rosedale, White Marsh, and Joppatowne, which are closer to the population centers of Baltimore and Harford Counties than the existing Amtrak line.

In Massachusetts, new rail capacity is needed to meet a level of Intercity service greater than the expanded Boston South Station can accommodate. This might entail the construction of new rail lines and/or new station and rail terminal facilities. There are multiple possibilities for the locations of and connections between these facilities, and some of these options present opportunities for expanding the coverage and connectivity of the Regional rail network serving the greater Boston region.

Finally in Alternative 3, the re-routing of most of the Intercity-Express service to new rail routes through Baltimore, Philadelphia, and New York City presents an opportunity to utilize the capacity freed up on the existing routes within these metropolitan regions to provide short-headway local rail service—effectively creating new rail transit lines. This concept is analogous to the Overground and Thameslink services in London, the RER service in Paris, and the various S-Bahn networks throughout Germany and Switzerland. The NEC route through Baltimore was identified as a potential future transit line in the 2000 Baltimore Region Rail Plan. In the New York metropolitan area, offering transit-style service on the inner portions of the LIRR network in Queens and in Hudson and Essex Counties in New Jersey could supplement the capacity provided in Alternative 3 and be complementary to both the Regional rail and rail transit networks.

10.2 REPRESENTATIVE ROUTE

The Representative Route of Alternative 3 approximately parallels the existing NEC between Washington, D.C., and New York City. The new high-speed route is closely parallel to the NEC in many locations, but it deviates from the existing corridor in several locations to shorten trip times or service additional travel markets, such as the more direct routes through downtown Baltimore and Philadelphia. North of New York City, the four route options are considered, as described in Section 10.4. In addition, the existing NEC remains as a route for Intercity and Regional rail trains.

10.3 SERVICE PLAN

Alternative 3 offers dramatically more Intercity service on the NEC through the construction of dedicated high-speed rail tracks as well as providing new service to new markets within the NEC Study Area. In the standard peak hour, Intercity-Express service increases to six trains per hour compared to the No Action Alternative and includes limited-stop Intercity-Express trains that run between Washington, D.C., and New York City and between New York City and Boston in under 100 minutes. The new Metropolitan service provides four trains between Washington, D.C., and Philadelphia and eight trains between Philadelphia and New York City in the peak hour. North of New York City, four trains per hour Metropolitan service is offered on two different routes – the existing NEC and the new high-speed spine route. An additional four train slots per hour is provided for Intercity-Corridor-Other and Long Distance trains between Washington, D.C., and New Haven. These slots could be filled by new connecting corridor rail services.

Major NEC cities see an increase in the total number of Intercity trains in the standard peak hour:

- Washington, D.C.: 12–14 tph (6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 4 Metropolitan)
- Philadelphia, PA: 16–18 tph[33] (6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 8 Metropolitan)
- Newark, NJ: 16–18 tph (6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 8 Metropolitan)
- New Haven, CT: 8–18 tph[34] (2–6 Intercity–Express, 2–4 Intercity–Corridor–Other, and 4–8 Metropolitan)

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[33] These services are split between 30th Street Station and a new NEC station on the second-spine route at Market East. The six Intercity-Express and four Metropolitan trains serve Market East. The two Intercity-Corridor-Other trains and the other four Metropolitan trains serve 30th Street Station.

[34] The lower totals for Intercity-Express and Metropolitan correspond to the route options via Central Connecticut, which bypass New Haven. The higher totals correspond to the route options via Long Island, which converge with the existing NEC at New Haven.

- Boston, MA: 12–13 tph (6 Intercity–Express, up to 1 Intercity–Corridor–Other,[35] and 6 Metropolitan)

Regional rail service is increased to fill the capacity made available in this alternative. This includes increasing the quantity of zone express service on NEC Regional rail lines, increasing service to existing branch lines, introducing service on new Regional rail branch lines or existing lines that currently only offer transfer connections to the NEC. In addition, this alternative includes introduction of express Regional rail services that operate from the outer Regional rail service zones and share portions of the new high-speed tracks with intercity trains, offering significantly reduced trip times for long-distance regional commuters.

10.4 INFRASTRUCTURE ELEMENTS

Alternative 3 provides major new rail capacity throughout the entire NEC with two new high-speed tracks between Washington, D.C., and Boston, as well as upgrades to the existing NEC similar to Alternative 1, which brings the existing NEC to a state of good repair and provides capacity and chokepoint relief along the corridor. Alternative 3 provides a new route through New York City with six tunnel tracks beneath the Hudson and East Rivers, along with station facilities for all service types, addressing the most critical capacity issues within the Study Area. Additional infrastructure improvements in Alternative 3 include downtown routing in Baltimore and Philadelphia and terminal capacity expansion in Washington, D.C., New York City, and Boston. New Stations could be built in locations such as downtown Baltimore, Philadelphia International Airport, and Danbury, Connecticut.

Six-track sections, locations where there is a new segment adjacent to the four-track NEC, increase considerably on the south end. Six-track sections extend from Washington, D.C., to Baltimore, and Philadelphia to New York City. Six-track sections are also located in coastal Fairfield County.

10.4.1 CHOKEPOINT RELIEF PROJECTS

Alternative 3 includes capital projects at specific locations to relieve chokepoints on the existing NEC. Most of the chokepoint projects in Alternative 3 are the same as those identified for Alternatives 1 and 2, addressing chokepoints near stations, at railroad junctions, and at yard locations where trains lay over and change direction. The inclusion of new segments or new tracks at certain locations obviates the need for a separate chokepoint project. Chokepoint relief projects identified in Alternative 3 include:

- New Carrollton Station, 4 platform tracks, to permit express and local trains to operate on separate tracks
- Odenton Station island platforms, to enable Metropolitan trains to stop at this station on the express tracks
- Newark, DE, station relocation and track reconfiguration, to provide for smoother intercity, regional rail and freight train movements
- Wilmington, DE, express bypass tracks, to enable non-stopping trains to pass or overtake stopping trains, and to reduce trip times for non-stopping trains

[35] The Intercity-Corridor-Other train at Boston operates on the Inland Route (via Hartford, Springfield and Worcester) at less than hourly service frequencies.

- Philadelphia flyover, to facilitate regional rail local train movements
- Trenton Station and yard access, to facilitate regional rail terminal operations
- Mid-Line Loop, to facilitate turning of regional rail zone express trains
- Metropark Station platforms on express tracks, to enable Intercity-Express and Intercity-Corridor trains, including Metropolitan trains, to stop at this station on the express tracks
- Hunter Flyover and Westbound Waterfront Connection, improving access to the NEC from the Raritan Valley Line and from Hoboken Terminal
- New Rochelle (Shell Junction) grade separation, to provide smoother train flows between the Hell Gate Line and New Haven Line.

10.4.2 NEW TRACK

Alternative 3 includes the construction of fewer new-track projects on the existing NEC, because the need for additional tracks is reduced with the construction of new high-speed tracks along the entire corridor. The locations of the most prominent new-track projects are the following:

- Odenton, MD, to West Baltimore, MD (4th track)
- Bayview, MD, to Perryville, MD (4-track railroad)
- Hell Gate Line, Bronx, NY (4 tracks)
- Providence, RI, to Hyde Park, MA (4 tracks)

10.4.3 NEW SEGMENT

Alternative 3 includes multiple new segments parallel to and outside of the existing NEC right-of-way, providing a second-spine route between Washington, D.C. and Boston, MA. This alternative also increases the capacity of the existing NEC with the Baltimore Tunnel and new segments of two track line parallel to the New Haven Line between New Rochelle and Stamford.

11. Phased Implementation

To ensure that incremental capital investment in the NEC will result in benefits for the entire corridor, the FRA anticipates that the Action Alternatives will be implemented in phases consisting of integrated, complementary projects. Such phased implementation of the expanded service envisioned in the Action Alternatives is inevitable due to many factors, including funding, environmental approvals, market growth, and practical constraints relating to construction on a very busy rail corridor. Even as NEC FUTURE uses the year 2040 as a horizon year for planning purposes, the time frame for implementing corridor improvements is likely to extend beyond 2040.

As such, the FRA believes it is important to identify an initial phase of the long-term NEC FUTURE vision that addresses the NEC's most critical near-term needs, provides tangible transportation benefits, and provides a "down-payment" on achieving the long-term vision articulated by each of the alternatives. A Universal First Phase would address the most pressing capacity, chokepoint, and state of good repair needs of the NEC by implementing a set of projects that address these common needs across all the Action Alternatives. In some cases, the specific scope and design of a project in this Universal First Phase may vary across the Action Alternatives to allow for subsequent implementation of the unique characteristics of a specific alternative.

Implementation of this first phase would create a level starting point for further advancing any of the three Action Alternatives. Importantly, implementation of this first phase would enable NEC stakeholders to more quickly realize the benefits of investment in the NEC—increased service, improved reliability and advancing state-of-good-repair priorities—as well as build the stakeholder partnerships required to successfully implement a highly complex, integrated and complementary program of service and infrastructure improvements. Subsequent incremental phases can be developed that build upon the initial investment and ultimately achieve the full long-term vision.

Many factors will ultimately influence the scope of an initial phase of service for each alternative. These include the following:

- Political and governance support for investment to offer enhanced services
- Growth in passenger rail ridership demand
- Availability of public and private funding for capital investment and operating expenses
- Environmental and other regulatory clearances, approvals, and permits
- Workforce and construction industry capacity to undertake and sustain the scope of work
- Impacts on, and constraints imposed, to protect ongoing NEC rail service

The Universal First Phase will be fully described in the Tier 1 Draft EIS. A full phasing plan, including a set of prioritized service objectives and necessary improvements that achieve important regional benefits, for the Selected Alternative will be detailed in the SDP.

12. Next Steps

The Tier 1 Draft EIS will analyze and compare the Action Alternatives outlined in this document to the No Action Alternative. The framework for this evaluation ties directly to the NEC FUTURE Purpose and Need; as such, the FRA identified evaluation metrics to measure, both quantitatively and qualitatively, how well the No Action and Action Alternatives address Study Area needs. The evaluation factors developed for the early screening of Initial and Preliminary Alternatives form the basis for this more detailed evaluation of alternatives. The evaluation framework also considers other factors such as ridership, cost, and constructability.

The FRA established specific metrics to evaluate how the No Action and Action Alternatives address these factors and to compare alternatives. Table 19 presents the evaluation factors and the specific metrics to evaluate them. The transition from an earlier set of less detailed metrics used to screen Initial and Preliminary Alternatives is also presented to show how the metrics have evolved toward increasingly detailed and quantitative analysis.

Table 19: Evaluation Factors and Metrics

Factors	Early Metrics for Screening	Metrics for Evaluation of Alternatives
NEC FUTURE NEEDS		
Aging Infrastructure	■ NEC in a state of good repair	■ NEC in a state of good repair ■ Passenger trips shifted to safer mode of travel
Capacity	■ Peak-hour trains ■ Peak-hour seats/ passengers at major screenlines annual trips ■ Annual passenger miles	■ Peak trains per hour ■ Capacity utilization/available capacity (residual capacity) – train slots/passenger seats ■ Annual trips
Connectivity	■ Stations served by Intercity trains ■ Station-pairs served by Intercity trains ■ Airport stations	■ Service frequency – train volume for key city pairs and key stations ■ Service frequency – train volume for connecting corridors ■ Ridership changes at airport stations (new, existing) ■ Ridership within 10-mile buffer of Representative Route ■ Qualitative assessment of transfers/connections/access at key stations
Performance	■ Express trip time savings ■ Maximum trains per hour ■ Peak-hour trains operating on NEC	■ Travel-time savings (key city-pairs) ■ Average speed (key city-pairs) ■ Top speed by segment ■ Qualitative assessment of on-time-performance/reliability
Resiliency	■ N/A	■ Redundancy for key network links ■ Route miles/passenger miles within or outside areas vulnerable to weather-related events
Environment	■ Areas of environmental sensitivity	■ Rating of magnitude of effects on water resources, ecologically sensitive habitats, air quality/GHG emissions, EJ populations, Section 4(f)/cultural resources and conversion of land cover by type, noise/vibration effects and indirect and cumulative effects
Economic Growth	■ N/A	■ Jobs resulting from construction and/or operations ■ Value of travel-time or cost savings, change in emissions ■ Land premium or agglomeration potential
BENEFITS, COSTS, AND OTHER FACTORS		
Ridership – Interregional and Regional	■ Annual Passengers	■ Annual Passengers ■ Annual Passenger Miles ■ Peak-hour Passengers
Capital/O&M Costs	■ N/A	■ Total capital cost ■ Total O&M cost
Constructability/ Phasing	■ N/A	■ Ridership and service benefits of Initial Phase