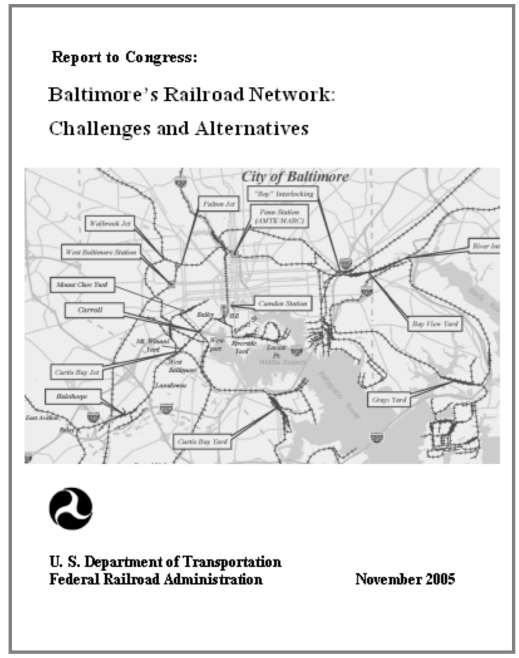
Main Report

Part I:

Challenges



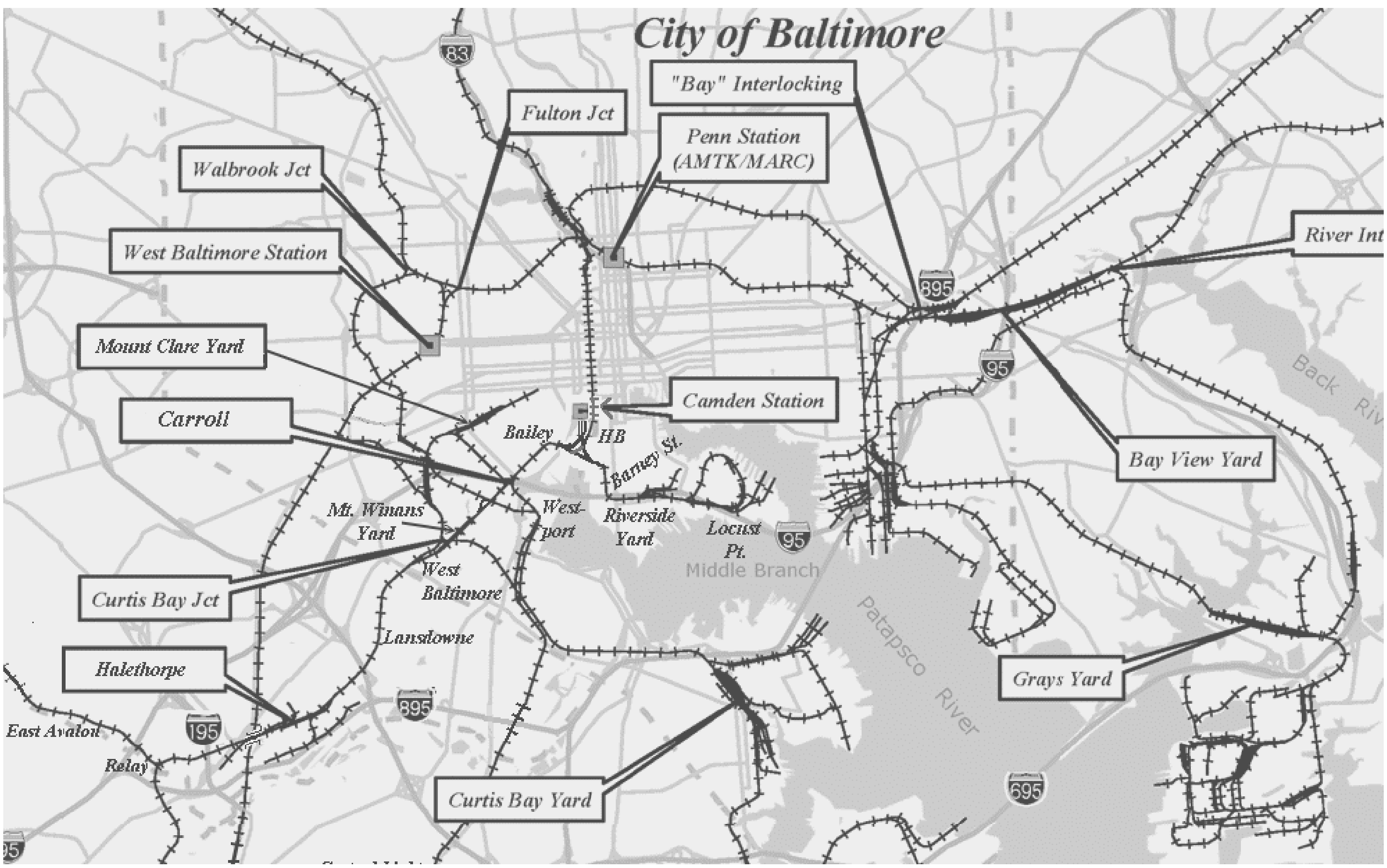
Report to Congress:

Baltimore's Railroad Network:

Challenges and Alternatives

U. S. Department of Transportation
Federal Railroad Administration

November 2005



Chapter One
INTRODUCTION

A. Committee report direction

In November 2001, after the railway infrastructure of Baltimore, Maryland had attracted public attention due a catastrophic fire in CSX Transportation's tunnel under Howard Street, the Congress made the following request:

> *Baltimore, Maryland freight and passenger infrastructure study*.—The conference agreement includes $750,000 to conduct a comprehensive study to assess problems in the freight and passenger rail infrastructure in the vicinity of Baltimore, Maryland. FRA shall carry out this study in cooperation with the state of Maryland, Amtrak, CSX Corporation and Norfolk Southern Corporation, as outlined in the Senate bill (Sec. 351). The Administrator of FRA shall submit a report, including recommendations, on the results of the study to the House and Senate Appropriations Committees not later than 24 months after the date of enactment of this Act.[1]
>
> *[Section 351 of the Senate bill reads as follows:]* SEC. 351. (a) Of the funds appropriated by title I for 16 the Federal Railroad Administration under the heading "Railroad Research and Development," up to $750,000 may be expended to pay 25 percent of the total cost of a comprehensive study to assess existing problems in the freight and passenger rail infrastructure in the vicinity of Baltimore, Maryland, that the Secretary of Transportation shall carry out through the Federal Railroad Administration in cooperation with, and with a total amount of equal funding contributed by, Norfolk Southern Corporation, CSX Corporation, and the State of Maryland.
>
> (b)(1) The study shall include an analysis of the condition, track, and clearance limitations and efficiency of the existing tunnels, bridges, and other railroad facilities owned or operated by CSX Corporation, Amtrak, and Norfolk Southern Corporation in the Baltimore area.
>
> (2) The study shall examine the benefits and costs of various alternatives for reducing congestion and improving safety and efficiency in the operations on the rail infrastructure in the vicinity of Baltimore, including such alternatives for improving operations as shared usage of track, and such alternatives for improving the rail infrastructure as possible improvements to existing tunnels, bridges, and other railroad facilities, or construction of new facilities.

(c) Not later than one year after the date of the enactment of this Act, the Secretary shall submit a report on the results of the study to Congress. The report shall include recommendations on the matters described in subsection (b) (2).

This report represents the response of the Federal Railroad Administration (FRA) to that request, subject to the funding limitations described below.

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[1] U. S. House of Representatives, Report 107-308, Making Appropriations for the Department of Transportation and Related Agencies for the Fiscal Year Ending September 30, 2002, and for Other Purposes, November 30, 2001, p. 100.

B. Funding sources and limitations

The Congressional directive envisioned a $3,000,000 study of an urban railway network that is America's oldest[2] and arguably one of its most important and complex. That amount was appropriate to the task; thus, the FRA, with a $750,000 appropriation in hand, initiated the study on a scale commensurate with the Congressional directive. While the State of Maryland—despite the budgetary constraints afflicting all State governments in Fiscal Year 2002—provided a welcome $250,000 (one third of its Congressionally-foreseen share), the two major freight railroads, CSX Transportation (CSXT) and Norfolk Southern (NS), made no financial contribution.[3] Thus a study that was planned and begun on an assumed $3,000,000 budget ended up $2,000,000 short.[4]

In consultation with the State of Maryland, the FRA revised the study plan during the course of the project to recognize the unforeseen shortfall in funding. Although the reduction in scope precluded completion of the original study design, the study team was able to perform such analyses as would substantially fulfill the Congressional mandate, as evidenced by the present report. The final chapter of this document lays out additional tasks that would build on the work done to date, should interested public and private entities ever elect to pursue and fund comprehensive approaches to the challenges inherent in Baltimore's railways.

C. Contractor

The engineering work underlying this report was performed for FRA and the State of Maryland by the Parsons Transportation Group.

D. Railroad participation

The CSXT, NS, and Amtrak provided certain types of nonproprietary data and met with members of the study team on an as-needed basis. The smaller, local switching railroads (Canton and Patapsco & Back Rivers) were consulted regarding their operational needs. However, at this early stage, the large and small railroads were not asked to review the study concepts; their intensive involvement would, of course, be necessary in future stages of development, if any.

E. Geographic scope of the study

The study focused on the principal elements of Baltimore's network of passenger and freight rail lines, extending from Perryville, northeast of Baltimore on the Susquehanna River—the junction of Amtrak's Northeast Corridor with the NS's principal route from Harrisburg and points west—to Halethorpe, southeast of the city, where the CSXT and Amtrak

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[2] The Baltimore & Ohio Railroad, a predecessor of CSXT, laid its first stone in 1827.
[3] Owing to Amtrak's particularly precarious financial situation at the time of the 2002 appropriation process, the Congress elected not to seek Amtrak's funding participation even though it would be a major beneficiary of certain improvements covered by the study.
[4] I.e., with a total funding of $1,000,000—$750,000 from FRA and $250,000 from Maryland.

lines from Washington cross.[5] A more detailed definition of the study area appears in Chapter Three.

F. Plan of the report

Part I ("Challenges") traces the development, current condition, and utilization levels of Baltimore's rail network. Chapter Two shows how Baltimore's railways evolved over nearly two centuries on the basis of the City's geography and longstanding development patterns. The rail infrastructure, with its geometric failings and operational drawbacks, then undergoes close scrutiny (Chapter Three). Meanwhile, passenger and freight operations have expanded in recent years, and promise to show even more growth by mid-century (Chapter Four). Thus Part I underlines the dissonance between the network as it has developed and the demands placed upon it, a tension that constitutes the fundamental motivation for the study.

Part II ("Alternatives") demonstrates the potential for restructuring actions that would raise passenger and freight railway capabilities in the Baltimore region to a new plateau. Comparing the deficiencies in Baltimore with standard practices in the railroad industry, Chapter Five presents a set of objectives and standards that would appropriately guide the creation and evaluation of alternative Baltimore solutions, and summarizes the methodology adopted in this study. It becomes clear that the goals for passenger and freight service, respectively, cannot be met—given the design limitations established by geography, existing development, and railway operations—with a single mixed-use tunnel facility. Thus, Chapter Six presents the guiding concept for developing restructuring alternatives, while Chapters Seven and Eight explore the passenger and freight options respectively. Chapter Nine provides very preliminary cost estimates for illustrative alternatives, summarizes the study results, and identifies some avenues for further research that might provide decision-makers with deeper insights on the choices, costs, and benefits implicit in the restructuring of Baltimore's railway network.

[5] The crossing is grade separated with no connection ever having existed between the two lines.

ABOUT CHAPTER 1 . . .

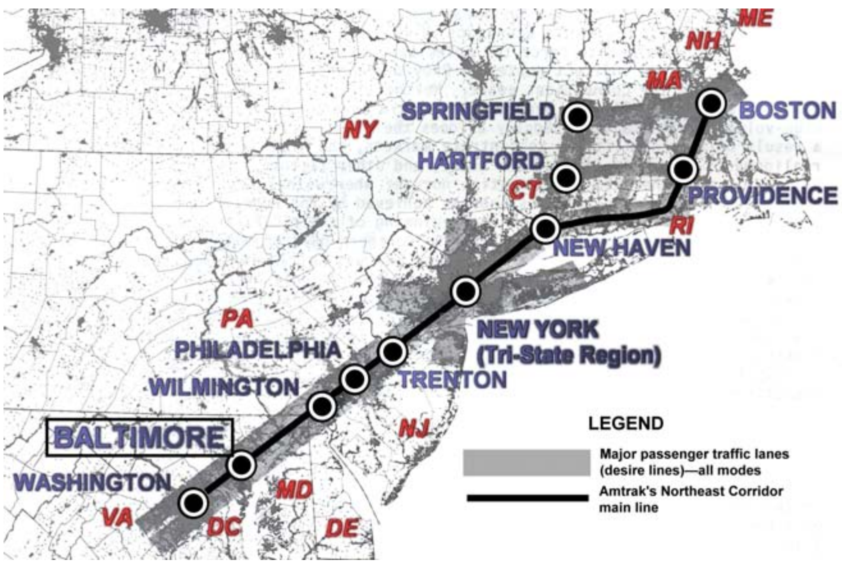
Chapter Two
CONTEXT AND EVOLUTION OF BALTIMORE'S RAILROAD NETWORK

Placing Baltimore's rail network in its national and regional context, this chapter explains the fundamental geographical and historical reasons for the facilities' many deficiencies.

A. Baltimore's importance in passenger and freight railroad transportation[1]

Baltimore City proper, with a population of 628,670,[3] ranks 18th among American cities; the Baltimore-Towson Metropolitan Statistical Area (MSA) ranks 19th among MSAs, with a population of 2.6 million.[4]

Figure 2 - 1: Baltimore's Prime Location in the NEC Region[2]



Transcending its substantial population levels, Baltimore's importance as a source of originating and terminating rail traffic, and as a link in key through routes, dates back to the early 19th Century and remains noteworthy to this day. Baltimore's location on Amtrak's most important route, its Northeast Corridor (NEC) main line between Washington, New York, and Boston (shown in Figure 2 - 1), assures an exceptional frequency and quality of intercity passenger train service. With Amtrak offering faster door-to-door travel times than are available by any other public mode from Baltimore to Washington, Philadelphia, New York, and other popular NEC destinations, Baltimore's Pennsylvania Station generated 424,245 boardings in 2003 and ranked eleventh among Amtrak stations in passenger volumes.[5]

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[1] Details on the facilities and services described in this section appear in subsequent chapters.

[2] Source: Adapted from the cover of U. S. Department of Transportation, *Recommendations for Northeast Corridor Transportation*, September 1971. The travel patterns shown in this figure do not include all those of interest from an intercity passenger rail perspective (e.g., Philadelphia–Harrisburg).

[3] U.S. Census Bureau data, Population Estimates for the 25 Largest U.S. Cities based on July 1, 2003 Population Estimates.

[4] U.S. Census Bureau, *Statistical Abstract of the United States: 2003,* Table No. 26: Large Metropolitan Statistical Areas–Population. 2002 data. In 2003, in a sweeping restructuring of the official list of metropolitan areas, the Office of Management and Budget reconstituted Baltimore as a separate MSA (it had previously been combined with the Washington area as the Washington-Baltimore Consolidated MSA). See Appendix II of the *Statistical Abstract.*

[5] Amtrak data, rankings of its top 20 stations, available at http://www.amtrak.com/about/amtrakfacts.html .

Baltimore has likewise assumed an important role in the growing Maryland Rail Commuter (MARC) service, which links Washington, D.C., with Baltimore's Camden and Pennsylvania stations (with a northeastern extension from the latter to Perryville). From a vestigial service operated (and internally subsidized) by the predecessor railroads in the 1960s, the MARC system has evolved, through State initiative, into a significant transit operation that generates over 175 million passenger-miles annually.

Baltimore has also retained an important role in both through and originating/ terminating freight service. CSXT continues to make use of its main line through Baltimore for important east-west and north-south traffic lanes to and from Philadelphia and other East Coast points. NS preserves, but uses minimally, its through trackage rights over the NEC between Washington, Baltimore, and other NEC points.[6] Originating and terminating rail freight traffic in Baltimore remains significant, largely due to the Port of Baltimore and the region's persistent industrial base. The Port—the closest Atlantic port to major Midwestern markets[7]—ranks 19th in the Nation in terms of tonnage handled (42.1 million short tons),[8] and ranks fourth among Atlantic Coast ports, behind the Port of New York and New Jersey (137.5 million short tons), the ports of Philadelphia and Marcus Hook (combined total of 65.5 million short tons), and the Hampton Roads ports of Newport News and Norfolk Harbor (combined total of 51.2 million short tons).

Thus, from every viewpoint, the Baltimore region represents a very important location on the Nation's railway map. As will become evident in later sections, the region would assume an even greater importance but for the underdeveloped nature of its rail infrastructure.

B. Geographic setting

Since railroads—particularly fledgling and underfunded ones—have historically sought out the path of least resistance to minimize initial expenditure and accelerate revenue production,[9] Baltimore's geography has determined the design of its rail network since 1827 and continues to limit the scope of realistic options for the future. The following sections summarize, and explore the long-term effects of, the city's main natural and man-made features.

1. The Fall Line

In the United States, the fall line—extending in an arc from the Carolinas through Virginia and Maryland to New Jersey—is the boundary between the Piedmont Plateau and the Atlantic Coastal Plain physiographic provinces. The Piedmont Plateau lies between the Coastal Plain and the Appalachian Mountains. Many towns and cities were founded along the fall line because it often marked the limit for navigation on rivers and because the waterfalls provided the

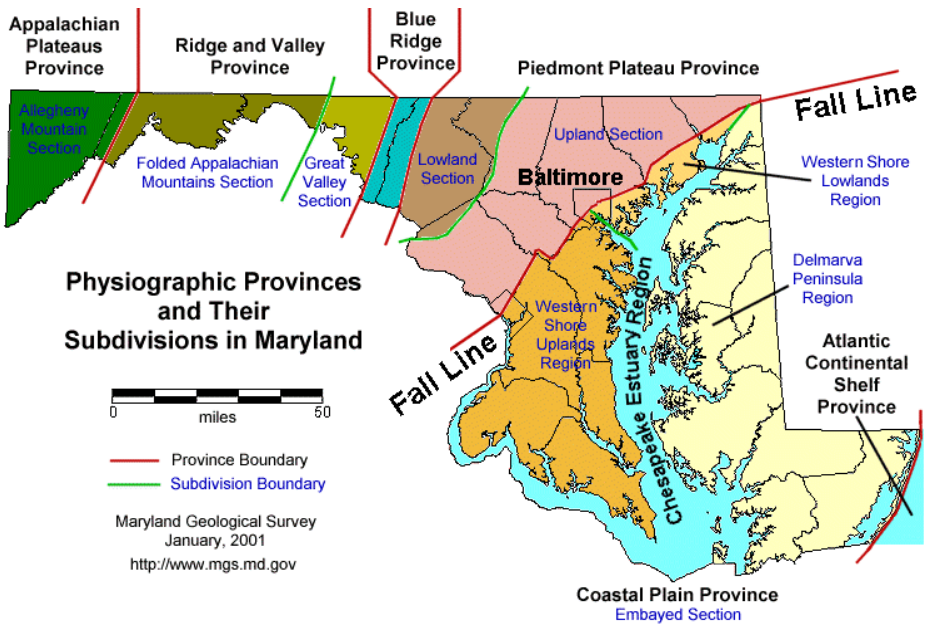
[6] The reasons for this sparing use are described later in this chapter. NS intensively uses its Perryville–Baltimore rights over the NEC; see later in this report.
[7] Maryland Port Administration, http://www.marylandports.com/info/index.htm
[8] Comparative port data are from U.S. Census Bureau, *op. cit.*, Table No. 1074, Selected U.S. Ports by Tons of Traffic, 2001. The tonnage statistics include many huge oil ports on the Gulf Coast—for example, the Port of South Louisiana (213 million short tons) and the Port of Houston (185 million short tons). All the East Coast ports grouped together above are reported individually by the Census Bureau.
[9] Cf. Arthur M. Wellington, *The Economic Theory of Railway Location,* 1877.

opportunity to create flume- and water-wheel-powered industries. Such cities include Baltimore, Philadelphia, and Washington.[10]

The Fall Line, as depicted by the U.S. Geological Survey, appears in Figure 2 - 2. Figure 2 - 3, affording a more detailed view of the Fall Line in Maryland, clearly indicates how the Fall Line bisects Baltimore very close to the harbor itself.

Figure 2 - 2: The Fall Line, Overview

Figure 2 - 3: The Fall Line in Maryland[11]



The geological map of Baltimore (Figure 2 - 4) highlights the complexity of Baltimore's geologic foundations: Piedmont rock formations extend almost to the water's edge.[12]

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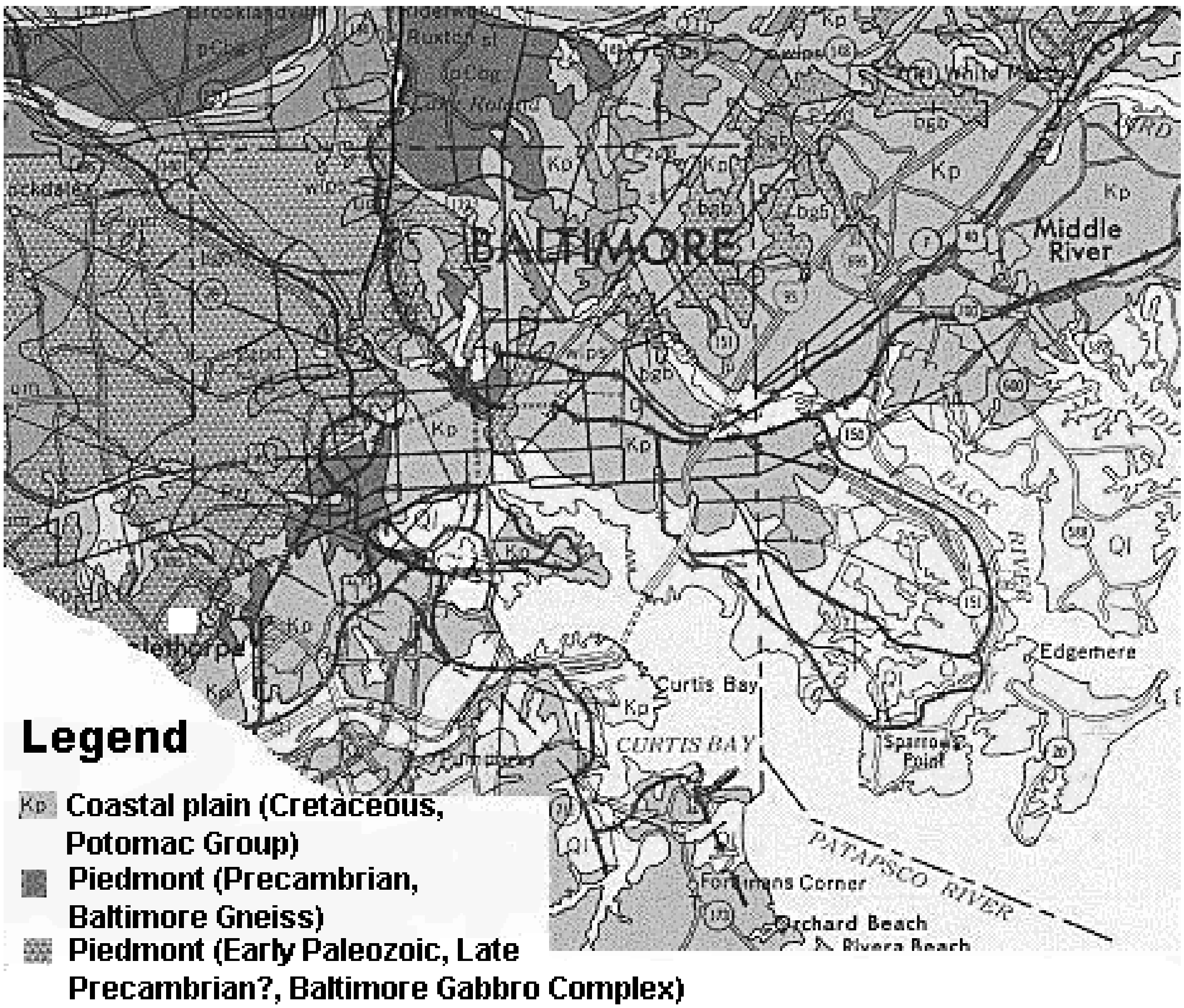
[10] The description and Fall Line overview are from the U.S. Geological Survey, http://tapestry.usgs.gov/features/14fallline.html

[11] From Maryland Geological Survey, http://www.mgs.md.gov/coastal/maps/g1.html

[12] Because tunneling is fundamental to this study, the geology of the region constitutes particularly important background. The Baltimore City area shares two major physiographic and geologic provinces, the Coastal Plain and the Piedmont (see Figure 2 - 4). Southwest of the Fall Line separating the two geologic provinces, the hard rocks of the Piedmont are buried beneath the unconsolidated Cretaceous and Pleistocene deposits of the Coastal Plain, which gradually dip and thicken to the southeast. The Cretaceous deposits are predominantly of the Potomac group, represented by the Patuxent, Arundel, and Patapsco Formations, and consist primarily of buff and light colored fluvial deltaic sands and clays. These sediments contain substantial amount of well to poorly graded silty and clayey sands and are frequently cross-bedded and intermixed with well to poorly graded gravels. Within the river streams, the Potomac group deposits were locally eroded during the sea level lowering and later replaced with estuarine deposits of softer organic clay and silt. The Piedmont province is about 40 miles wide and is characterized by moderate to high relief, rolling topography and by cristalline metavolcanic and metasedimentary rock of Pre-Cambrian and Paleozoic Ages. The Coastal Plain deposits and some adjacent areas of bedrock were capped after the last marine regression by a series of alluvial terrace deposits, represented mainly be inter-bedded gravel, sand, silt and clay of variable composition and sorting. Uppermost deposits may locally include recent marsh deposits. Surficial manmade fills are typical for most of the developed areas of the City.

Figure 2 - 4: Geological Map of Baltimore[13]



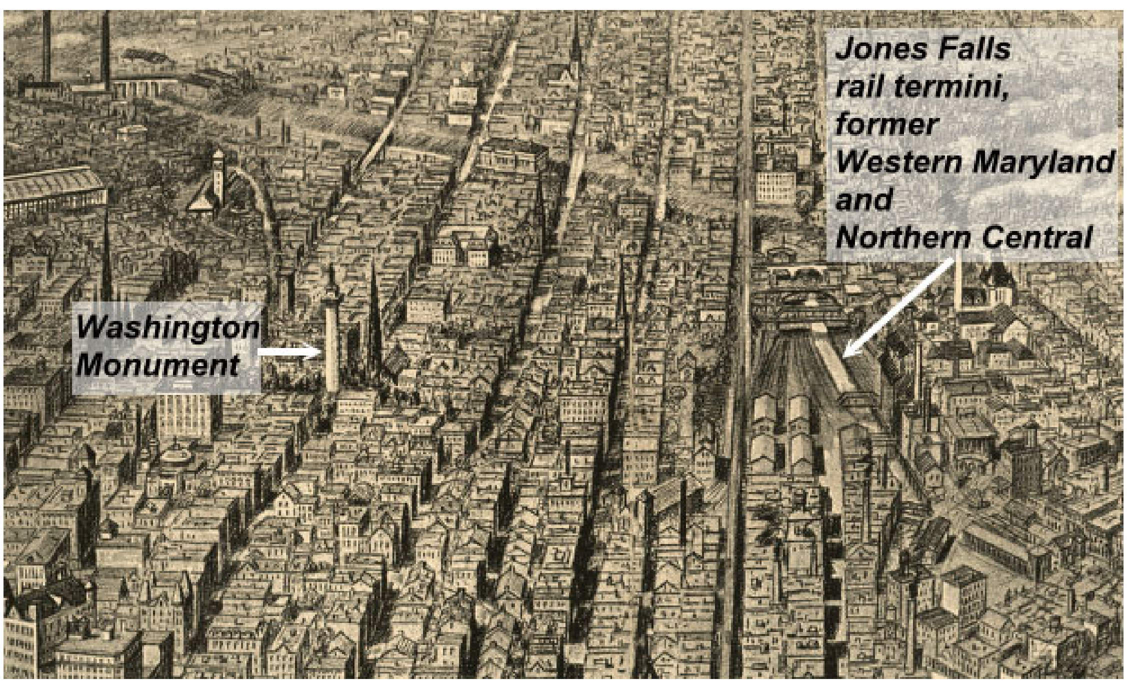
The effects of this topographical and geological complexity at Baltimore's heart become apparent in a 1912 view of Baltimore's core (Figure 2 - 5), which clearly shows the pronounced declivity from west to east, from Charles Street to the Jones Falls; the natural alignment of the easier topography (exploited by two early railways, the Western Maryland (WM) and Northern Central (NC)), along the Jones Falls from south to north; and the higher elevations to the northwest, which reach 425 feet in the far northwest corner of the city.

[13] Source: Maryland Geological Survey, http://www.mgs.md.gov/esic/geo/bal.html

Figure 2 - 5: Bird's Eye View of the Heart of Baltimore, Looking North[14]

These features are even more strikingly revealed in a close-up shot (Figure 2 - 6), taken from the same print. The line of the rooftops from the Washington Monument/ Peabody Conservatory area to the rail termini on the Jones Falls evidences the abruptness of the

Figure 2 - 6: Close-Up of Area between Monument Square and Pennsylvania Station



[14] Edward W. Spofford, "A birds-eye view of the heart of Baltimore," Baltimore, Norman T.A. Munder & Co., c1912, provided by Library of Congress at http://lcweb2.loc.gov.

downgrade. Pennsylvania Station is visible to the north, its original multipurpose nature (as a “Union” station of the NC, WM, and the Pennsylvania’s NEC components) clearly apparent.

2. Rivers

The Patapsco River is one of the shorter rivers emptying into the western edge of the Chesapeake Bay, extending only 52 miles from its headwaters to its mouth. Along the way, it drains about 540 square miles of land. The river starts inauspiciously, seeping from a small pond on a farm at Parr's Spring. Not until it reaches Elkridge does the Patapsco widen and deepen, maturing into a full-fledged river.

The Tidewater area of the Patapsco includes the Northwest and Middle Branches. Like the Chesapeake, this section of the Patapsco River is considered an estuary—the zone where fresh water meets salt water. Several secondary tributaries flow into the Patapsco River Estuary: Jones Falls (much of which is channelized, as depicted at the lower right corner of Figure 2 - 5) joins the estuary on the north side of the Baltimore Inner Harbor, while Gwynns Falls discharges into the Middle Branch. To the south, smaller tributaries empty into the Patapsco.

Other major rivers in the study area from Halethorpe to Perryville include the Back, Middle, Gunpowder, and Bush Rivers, as well as the mighty Susquehanna—the source of the Chesapeake Bay. These rivers do not differentially impact the present study.

3. Drainage and Groundwater Levels

Baltimore City is located in the Chesapeake Bay drainage system, which reaches the Bay through the broad estuaries of the rivers named above. Groundwater levels coincide or are slightly above the water levels at streams or bays. Locally, the groundwater levels may be influenced by adjacent construction activities and by leakage from utility lines.

4. Tidal Levels

Using the NOAA database for the Fort McHenry Station and a tidal epoch of 1960 to 1978, the following are estimates of Patapsco River levels referred to the Baltimore City Datum:

- Highest observed water level (8/23/1933) .. 8.47
- Mean Higher High Water (MHHW) 2.23
- Mean High Water (MHW) 1.92
- Mean Low Water (MLW) 0.81
- Mean Lower Low Water (MLLW) 0.57

Baltimore City Datum is 0.57 feet below the 1929 National Geodetic Vertical Datum (NGVD).

5. Baltimore Harbor[15]

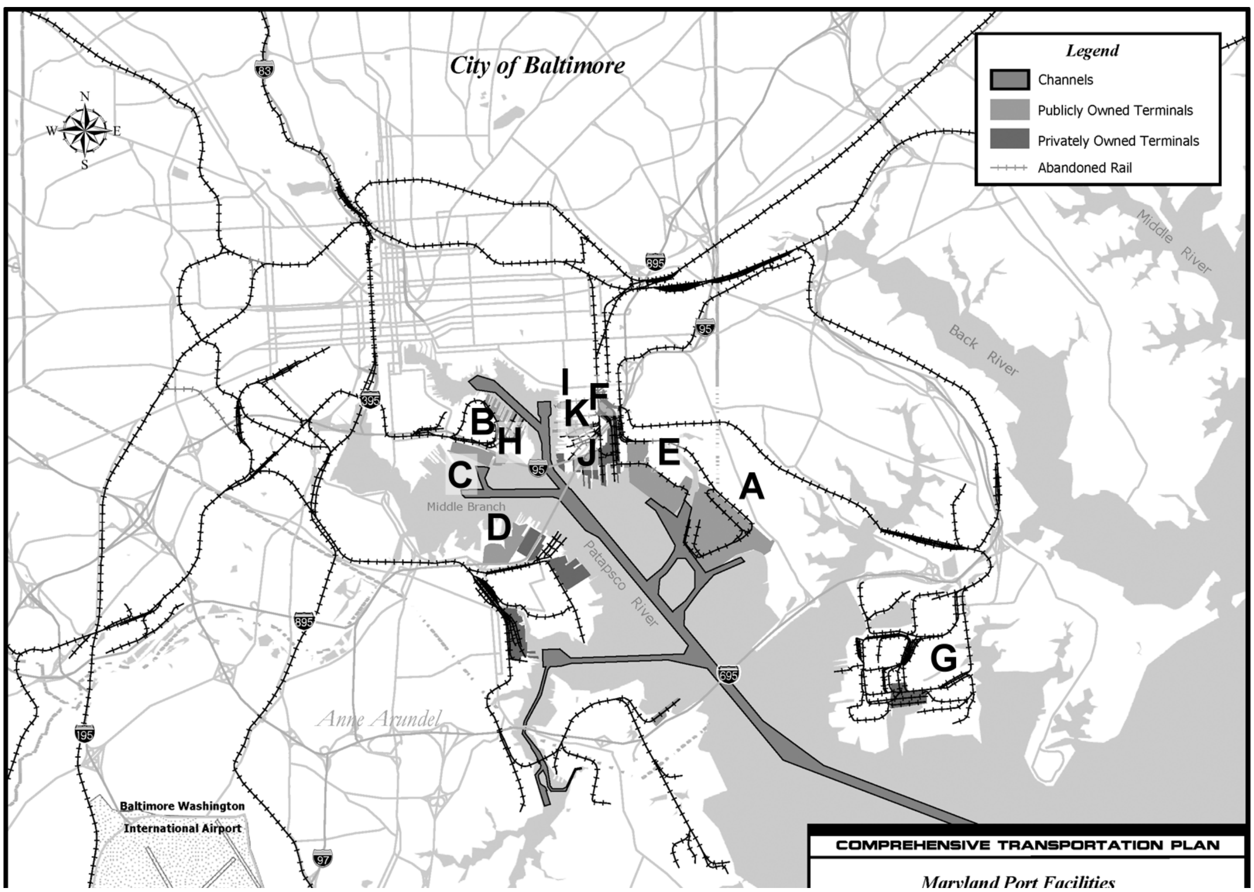
Established in 1706, the Port of Baltimore, located on the banks of the Patapsco River, initially transported farmers' crops along the Eastern Seaboard, as well as cargoes to and from

[15] Information for this section comes principally from the Maryland Port Administration, http://www.marylandports.com/info/index.htm

international destinations. As demand for Baltimore's port services grew, the naturally shallow depth of the harbor and river began to restrict the size of a ship that could navigate to the City. Dredging of the river began as early as 1798 and continues to this day[16]; the required channel depth has obvious practical implications for any tunneling under the harbor.

Traditionally one of the busiest maritime facilities on the East Coast (see at page 2-2), the Port of Baltimore generates $1.4 billion in revenues annually, employing nearly 126,700 Marylanders in maritime-related jobs. It has easy access to six interstate highways, which are linked by the Baltimore Beltway. Both CSXT and NS serve the port, providing on-dock or near-dock service. Thus the port has land connections to all points, although the highway facilities are more modern than the rail capabilities, with their circuity and often limited clearances.

Figure 2 - 7: Major Facilities of the Port of Baltimore
(Letters Indicate Approximate Locations of Selected Sites Mentioned in Table 2 - 1)



The port contains public terminals, owned and managed by the Maryland Port Administration, and private terminals. The various facilities are depicted in Figure 2 - 7 and listed in Table 2 - 1.

[16] Years of industrial and shipping activity in the area have caused toxic compounds to accumulate within the bottom sediments of the port, so the spoil is now dumped behind a 29,000-foot dike positioned just outside the mouth of the Patapsco.

Table 2 - 1: Selected Terminals of the Port of Baltimore[17]

("Location" refers to letters in Figure 2 - 7 showing approximate sites of the facilities.)

Name	Location	Public	Private	Description
Dundalk Marine Terminal	A	•		The facility is a multi-use general cargo facility that handles container, automobile, ro-ro (roll-on-roll-off), and general cargo traffic. NS presently has direct access to the terminal; CSXT has switching rights to access the facility.
North Locust Point	B	•		This port facility, located in South Baltimore, is a general cargo terminal, primarily handling steel and paper products. CSXT provides direct access to the facility.
South Locust Point	C	•		The terminal is a multi-use general cargo facility. CSXT provides direct rail access.
Fairfield Auto Terminals	D	•		A specialized auto terminal with easy access to the highway network. CSXT provides direct rail access.
Intermodal Container Transfer Facility	E	•		The terminal enables the efficient transfer of containers between the Seagirt Marine Terminal and intermodal trains. CSXT operates the Intermodal terminal, which is accessible to NS via the Canton Railroad.
Rukert Marine Terminal	F		•	The Rukert facility specializes in metals, ores, fertilizers, and alloys.
Sparrows Point Terminal	G		•	The terminal is a bulk and breakbulk loading and unloading facility.
Baltimore Metal and Commodities Terminal	H		•	The Terminal specializes in metals, soft commodities, and project cargo.
Highland Marine Terminal	I		•	The terminal was developed as an EPA Brownfields project; CSXT and NS serve the terminal's storage facilities.
Canton Marine Terminal	J		•	The terminal handles bulk, breakbulk, project, and Ro-Ro cargo.
Terminal Corporation	K[18]		•	The firm specializes in the handling of unitized, breakbulk, and project cargoes.

6. Tunnels

The following major tunnels in Baltimore are germane to this study. They appear in the maps on subsequent pages and in many detailed illustrations later in this report.

[17] For a fuller list and more information, readers are referred to the Maryland Port Authority's web site, http://www.mpa.state.md.us/facil/index.htm#PageTop

[18] Figure 2 - 7 shows one of multiple locations for the Terminal Corporation.

- **Railroad Tunnels:**
  - — **B&P (Baltimore & Potomac) Tunnel,** Amtrak, to the west of Pennsylvania Station;
  - — **Union Tunnels,** Amtrak, to the east of Pennsylvania Station;
  - — **Howard Street Tunnel,** CSXT, between Camden and (the disused) Mount Royal Stations;
- **Transit Tunnel:**
  - — **MTA Heavy Rail,** from Charles Center to the northwest, with an easterly extension to Johns Hopkins Hospital;
- **Highway Tunnels**
  - — The Fort McHenry Tunnel, Interstate 95;
  - — The original Baltimore Harbor Tunnel, Interstate 895.

All these tunnels, not just the railroad facilities, are important to this study because of clearance, construction staging, and similar considerations as they relate to the geometry of possible alternative rail routings.

7. Other urban features

Baltimore's other salient features (some of which include the tunnels) are listed below and summarized in a series of maps.

a. Subway and light rail systems

The light rail and subway lines constructed and proposed thus far appear in Figure 2 - 8.

b. Highway network

Baltimore's highly-developed system of interstate highways provides three major crossings of Baltimore Harbor, as shown on Figure 2 - 9:

- The two Harbor Tunnels mentioned above, and
- The Francis Scott Key Bridge, Interstate 695.

All are toll facilities, and all provide truckers and motorists with cross-Baltimore facilities that are far superior to those provided today by the rail network.

c. Baltimore City and typical neighborhoods

Figure 2 - 10 focuses on typical neighborhoods of Baltimore City and the rail lines that pass through them.

d. Baltimore Central Business District (CBD)

Showing streets, transit lines, and railroads, Figure 2 - 11 zooms in on Baltimore's CBD.

Figure 2 - 8: Principal Transit Lines

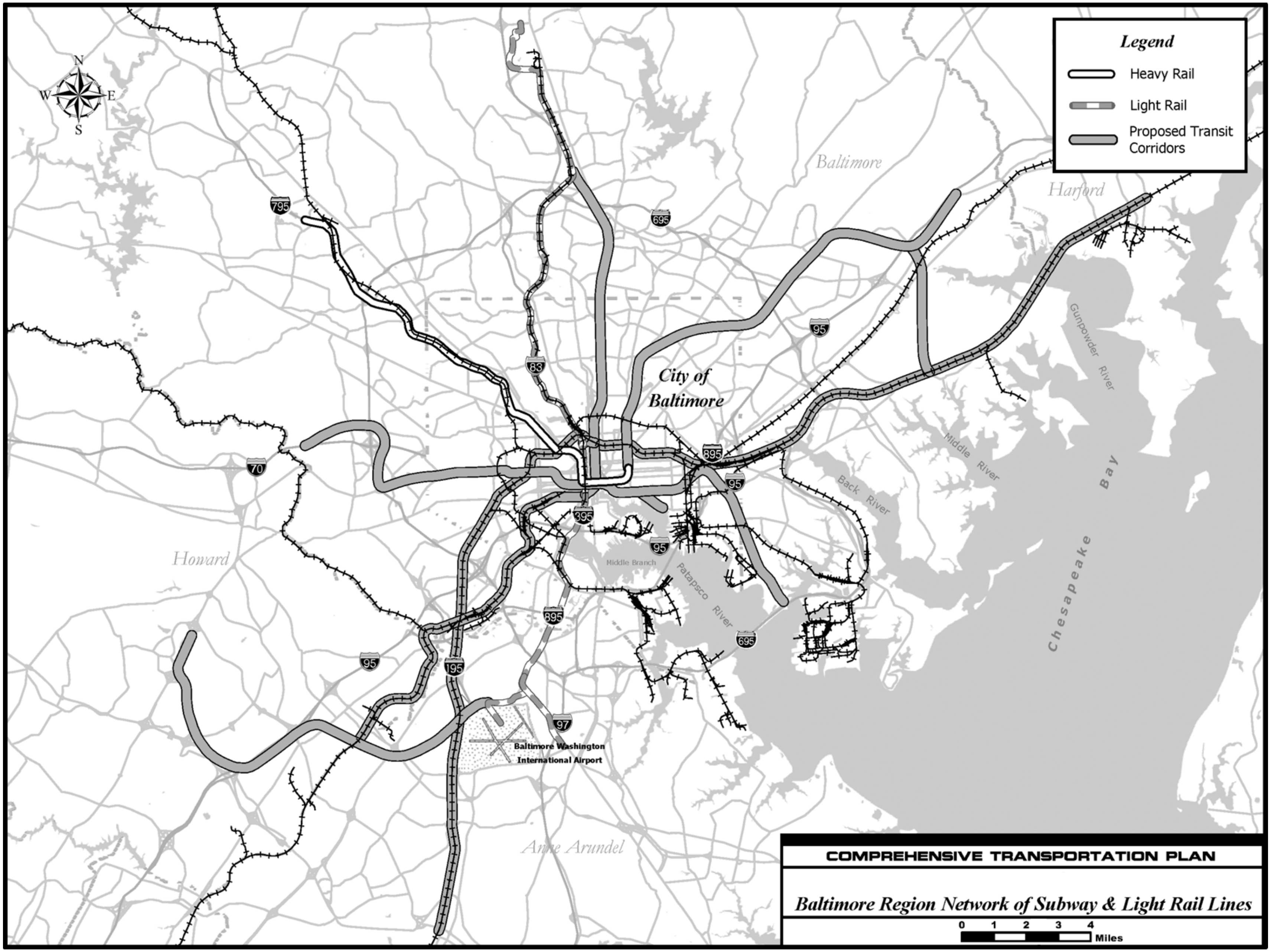


Figure 2 - 9: Principal Highways

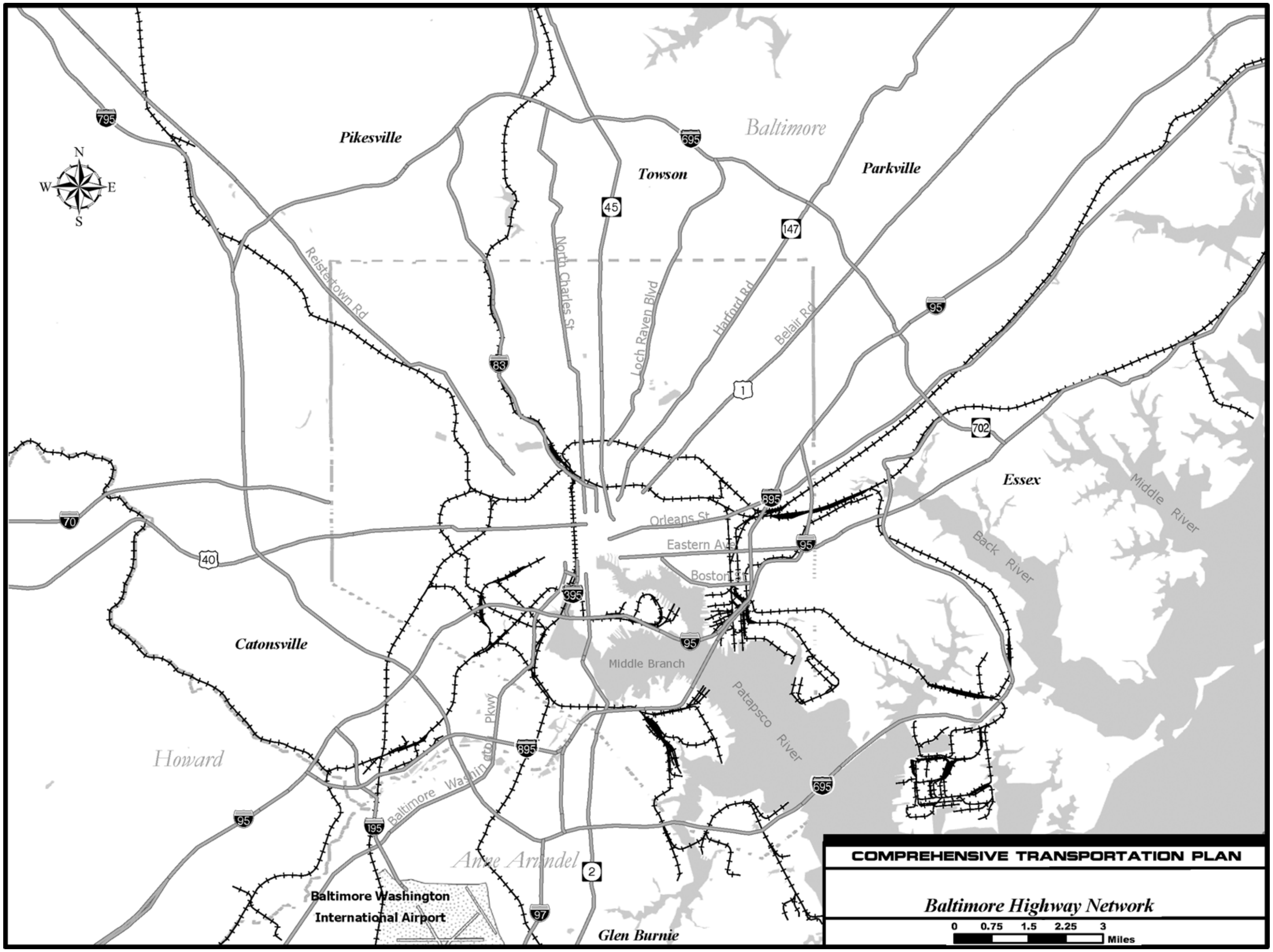


Figure 2 - 10: Typical Neighborhoods with Rail Lines (NOTE: Not all neighborhoods are labeled.)

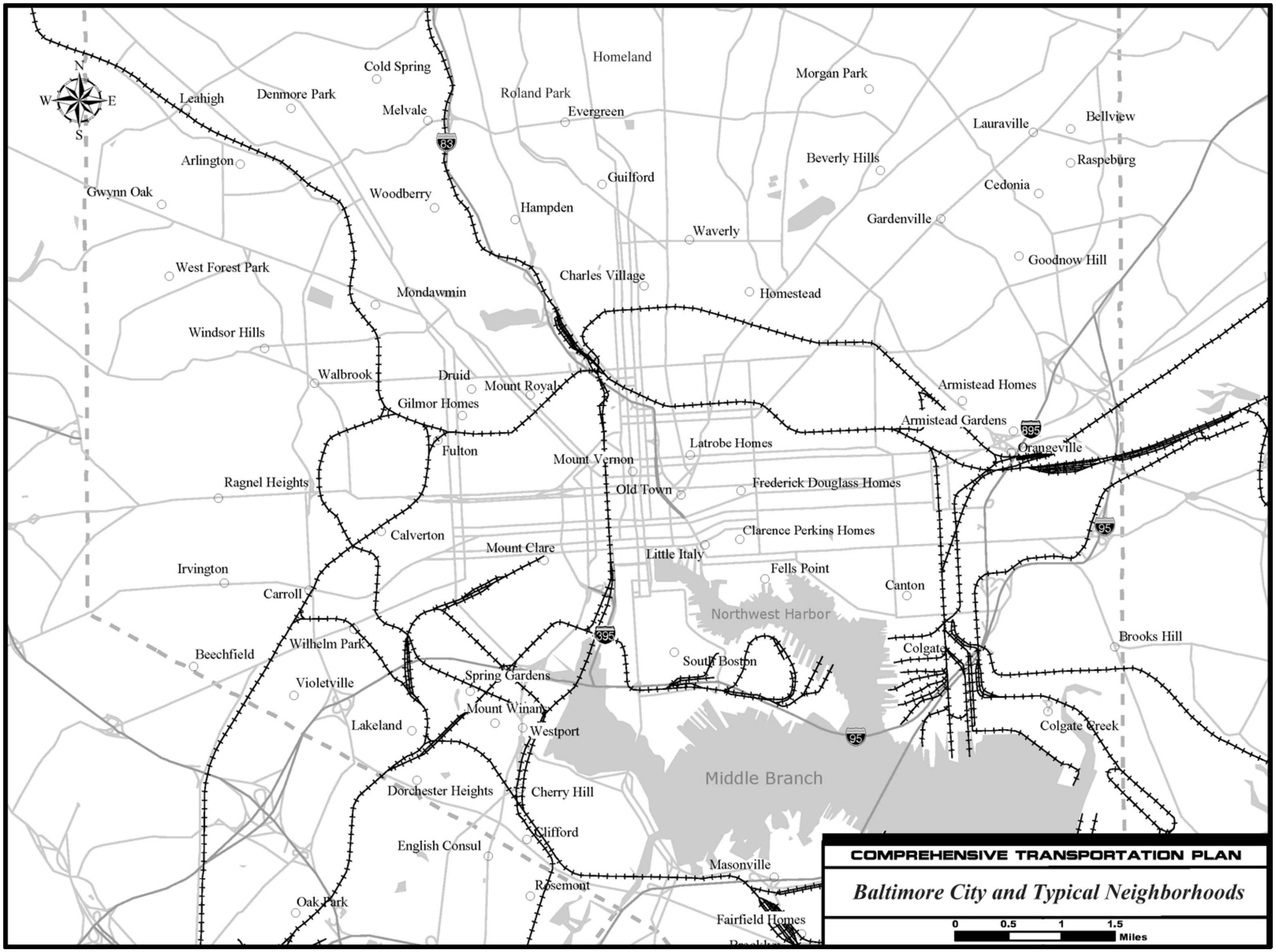
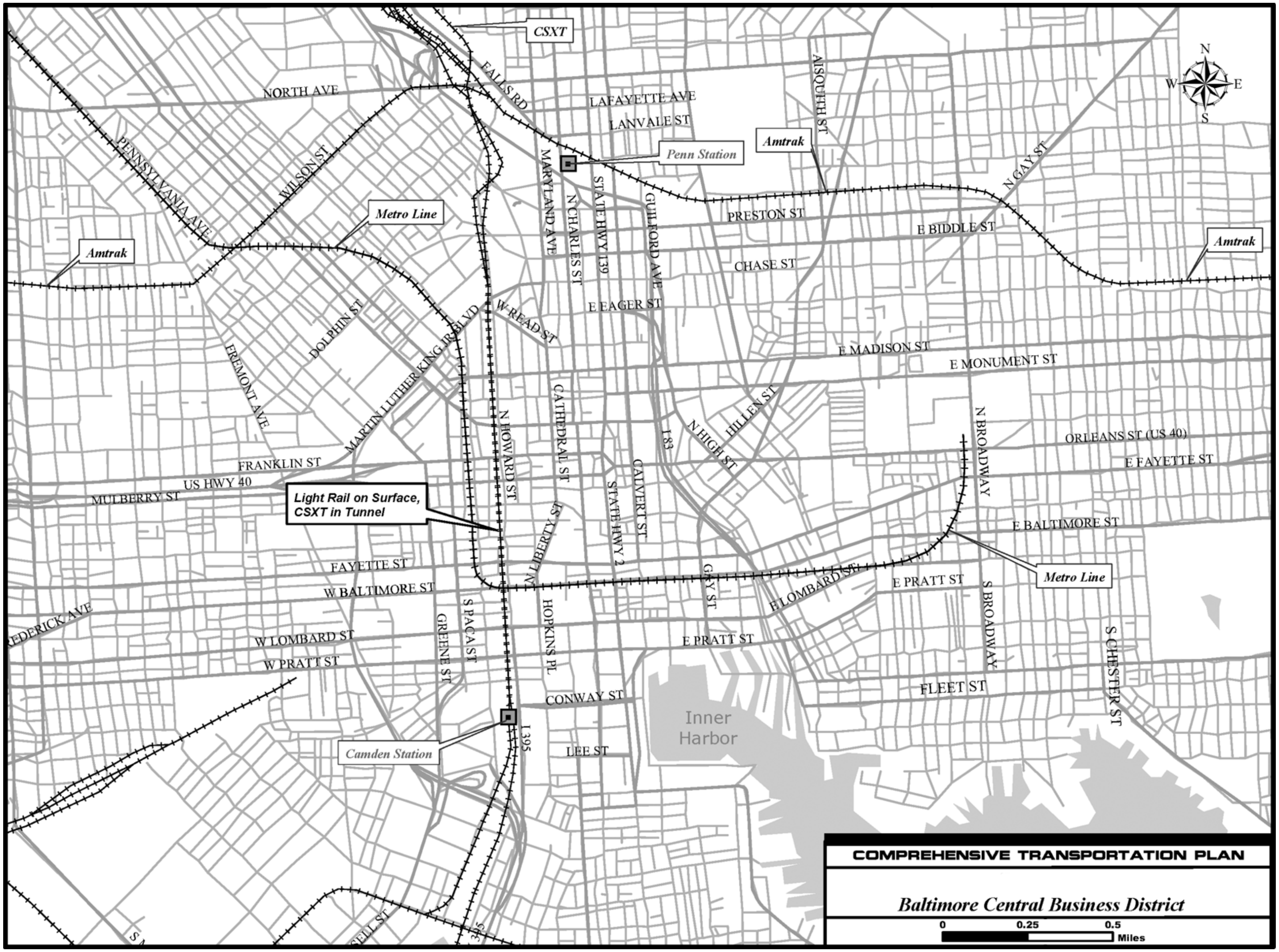


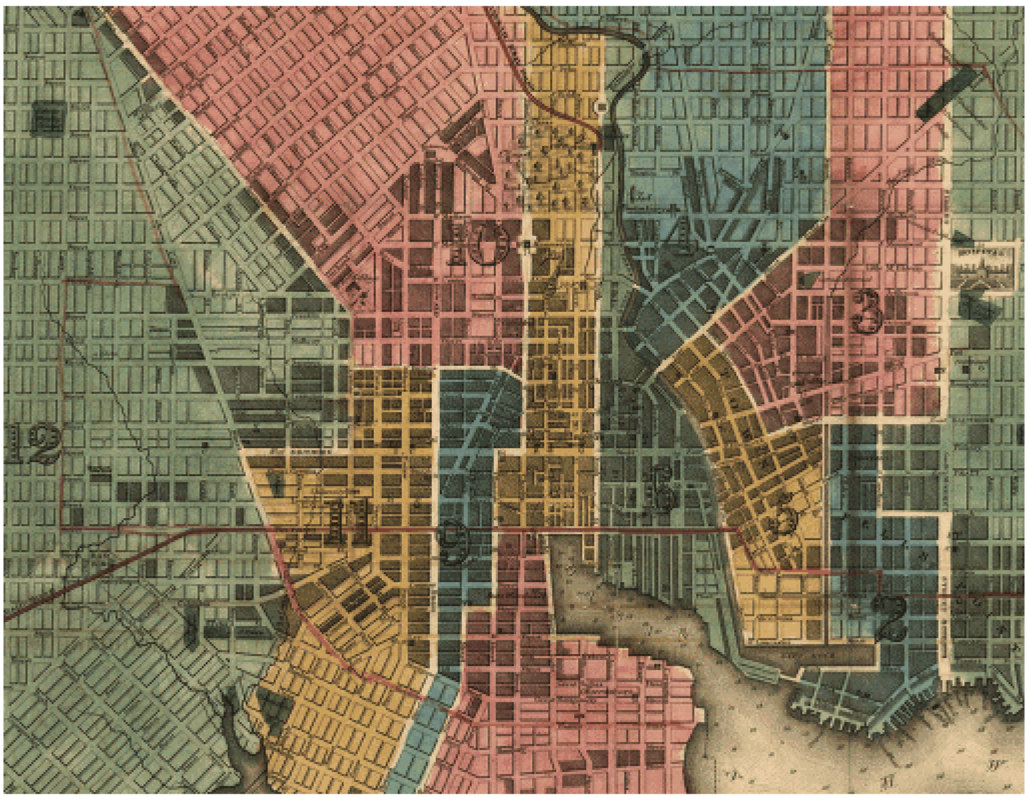
Figure 2 - 11: Central Business District



8. Implications of Baltimore's early importance

The age and early development of the CBD are noteworthy and germane to this report. In 1820, contemporary documents record a population of 62,738 for Baltimore; by 1836, it had grown by one-half to 91,000.[19] Thus by the dawn of the railway era, the area north of the Inner Harbor was already heavily built-up and populated, and growing more so, as a map dating to 1822-1836 (Figure 2 - 12) clearly demonstrates.

Figure 2 - 12: Early 19th-Century Development of Baltimore's CBD
(Map Surveyed 1822, Published 1836)



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Therefore, even had the fledgling antebellum railroads found a satisfactory east-west through route across Baltimore, its cost would have been prohibitive. By the time the railroad companies matured in the later 19th Century, the development of the CBD had become even more intense, as a view looking south from the Washington Monument in 1880 indicates (Figure 2 - 13).

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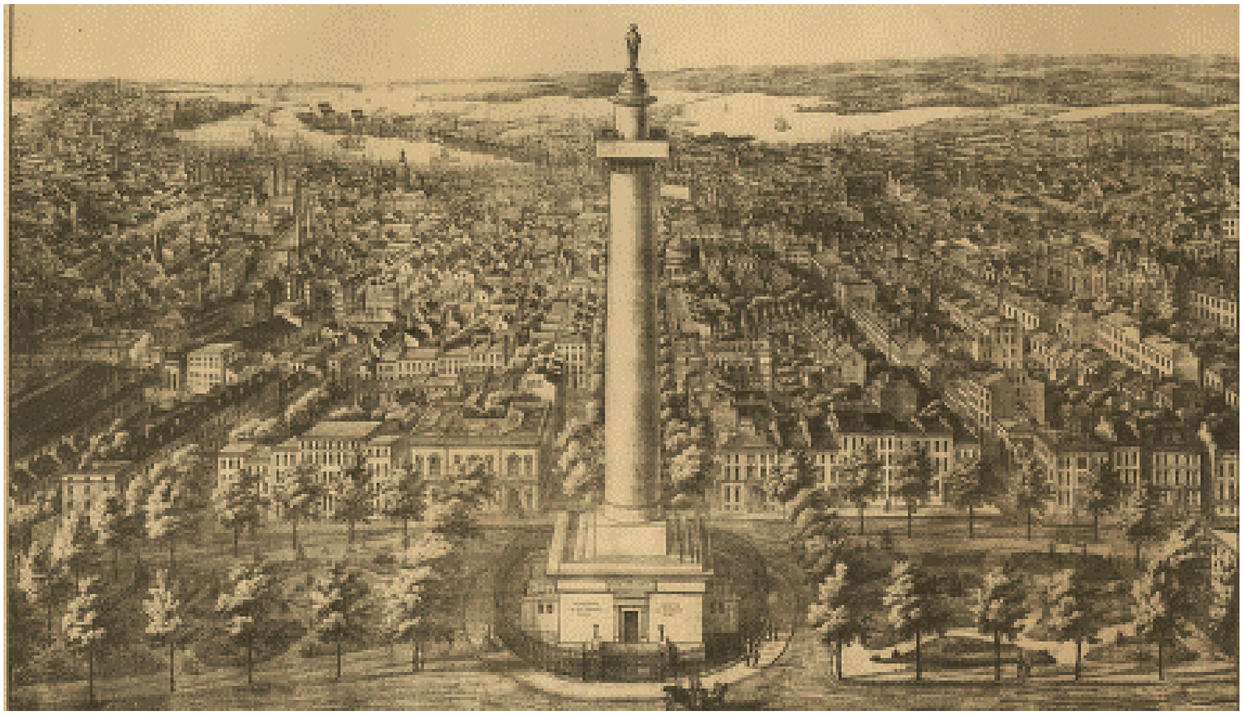
[19]The population figures and map are drawn from "Plan of the city of Baltimore compiled from actual survey by Fielding Lucas, Jr., 1822," call number G3844.B2 1836 .L8 TIL, Library of Congress Geography and Map Division Washington, D.C. 20540-4650, digital ID
(Copy one) g3844b wd000016 http://hdl.loc.gov/loc.gmd/g3844b.wd000016.

Figure 2 - 13:
View Looking South from the Washington Monument, 1880, Showing Heavy Development of CBD[20]



C. Development of the Baltimore Network

The complex historical development of the Baltimore rail network reflected geography, economics, and business relationships. The following summary presents the main stages of this development, with emphasis on the legacy facilities that still form the network's basis. For further details, readers are referred to excellent historical books covering the period and the roads involved.[21]

1. Stage 1: The early period and the line of least resistance (1827-1872)

During these formative years, neither the B&O nor the competing PRR possessed a "Northeast Corridor" through route across Baltimore. Passenger and freight movements across the City made use of various water-level expedients, such as horse-drawn cars along Pratt Street and car ferries across the harbor.

2. Stage 2: The Pennsylvania Railroad (PRR) consolidates through routes across Baltimore, in all directions (1873-1880)

[20] Sachse (A.) & Company--The city of Baltimore City, Md. in 1880, reproduction number LC-USZ62-91157 DLC (b&w film copy neg.), repository: Library of Congress Prints and Photographs Division Washington, D.C. 20540, digital id (b&w film copy neg.) cph 3b37503 http://hdl.loc.gov/loc.pnp/cph.3b37503 ; (raster image) g3844b pm002541 http://hdl.loc.gov/loc.gmd/g3844b.pm002541

21 See especially *Royal Blue Line*, Herbert H. Harwood, Jr., Greenberg Publishing Company, Inc., 1990. The book is a source of abundant data relative to the expansion of the B&O to New York City and the subsequent variations of rail service between the two cities. The historical discussion in this section draws heavily on this source.

In this stage, the PRR carried out a master plan to establish direct through service between New York, Philadelphia, and Washington via Baltimore, as well as to create a through route from Washington and Baltimore to points west via Harrisburg, by:

- Building the present NEC route through the B&P and Union tunnels[22]; and
- At the route's junction with prestigious Charles Street, building a new Union Station[23] affording a connection with the Northern Central and Western Maryland railways to points north and west (and to downtown stations along the Jones Falls).

Although substandard geometrically even by the standards of the times (see Box 2 - 1), the PRR tunnels gave that carrier a through "Northeast Corridor" route.

Box 2 - 1: The PRR's Baltimore Tunnels Through the Years

The PRR's route through Baltimore was the result of the construction of a series of four under-street tunnels totaling 11,074 feet in length across north-Baltimore. The routing, alignment, and the grades were not ideal. The Union Tunnel north of the PRR passenger station has a 1.2 percent northward grade. However, the three tunnels south of the station, collectively referred to as the B&P Tunnel, are more restrictive. The tunnel consists of a single 7,669-foot bore separated by two short open cuts. A sharp curve at the south portal of the tunnel prevents southbound trains departing Baltimore Pennsylvania Station from accelerating beyond 30 mph. An uphill, mile-long, 1.34 percent grade further constrains train performance.

The PRR lowered the floor of the tunnel approximately 2-1/2 feet in 1916-17 to accommodate larger trains. The work included: underpinning of the side walls, installation of a concrete invert slab, and reconstruction of the track structure. The bases of the tunnel walls were chipped away to improve horizontal clearance.

Prior to the electrification of the New York – Washington main line in 1935, the poorly ventilated tunnels easily filled with smoke from the steam locomotives. The smoke also was a nuisance to the residential neighborhoods above the tunnels.

The tunnel was gunited to waterproof the arch and prevent icicles from shorting out the catenary wires prior to the initiation of electrified operation. However, financial considerations prevented the PRR from constructing a new passenger tunnel on the Presstman Street alignment, for which it previously had acquired rights. The PRR's plan envisioned using the new B&P and the original Union Tunnel for passenger operations, while the old B&P and a new, parallel Union Tunnel (completed in the 1930s) would have been used for freight operations.

In the late 1950s, the B&P tunnel, with its low and narrow clearances, became a hindrance to the growth of PRR's piggyback business. The curve at Pennsylvania Avenue was the biggest constraint. The PRR modified the tunnel walls and ceiling for a distance of 2,200 feet to improve clearance and enable high cars and piggyback trailers to traverse the tunnel without damaging their roofs. Second, a 928-foot long gantlet track was installed on southbound track 3 to route trains 17 inches closer to the middle of the tunnel. However, trains could not operate on track 2 while track 3 and the gantlet were being used. The use of the gantlet created a single-track tunnel; if a freight train broke down while using the gantlet, the tunnel was closed to all traffic until the train was moved.

Even with the gantlet, cars in excess of Plate C or in excess of 16 feet 3 inches in height were prevented from using the tunnel.

The tunnel underwent rehabilitation as part of the NECIP in the early 1980s. The repairs included replacing the existing invert, repairing the tunnel lining, upgrading the track structure, installing a new gantlet track,[24] and rehabilitating the tunnel drainage system. No fundamental change, however, was made in the tunnel's difficult geometry.

[22] This was completed in 1873. Herbert Harwood, op. cit., p.24.
[23] Subsequently renamed "Pennsylvania Station."
[24] The gantlet track was subsequently removed due to changes in freight traffic patterns.

3. Stage 3: The B&O struggles to attain its own direct route through Baltimore (1880-1900)

Competitive pressures forced the B&O to provide its own northeast-southwest route through Baltimore. While readily constructing its own "Royal Blue" line from East Baltimore to Philadelphia, the B&O faced a much greater difficulty—due to the geographic and developmental factors stressed earlier in this chapter—in forging a link across its home town. "To build eastward toward Philadelphia [from Camden Station, the B&O] was *blocked on one side by the densely-developed city* and *on the other by the harbor, which was too wide to bridge or tunnel at any reasonable cost*."[25] [Emphasis added.[26]]

The B&O's solution, with which its successor roads have lived to this day, was to build a tunnel north from Camden Station in the soft and watered soils under Howard Street. The "Belt Line" would emerge from the tunnel at Mount Royal Station (designed as an "uptown" stop very near the PRR's Pennsylvania Station), proceed north to cross over the PRR, and then make an almost 90-degree right turn to meet the Royal Blue Line at Bay View. The tunnel route, due to its length, adverse grades, and curves—all of which were evident from the beginning—would require electrification, which persisted until Dieselization in the 1950s.

With the exception of the PRR's second Union Tunnel in the 1930s, Baltimore's main line rail configuration was essentially fixed on completion of the B&O's Belt Line.

4. Summation: Geography and history unite to create challenges in Baltimore.

With the Piedmont Plateau virtually reaching the sea, with precocious urban development blocking water-level routes along the harbor shore, with no single railroad controlling an integral route through the city until well into the 19th Century, and with strong competition among carriers precluding concerted action, no easy, exploitable railway alignment through Baltimore has ever existed. Once the substandard B&P and Howard Street routes were in place, the two companies could never jointly develop a solution that would rectify the operating problems and undue expenses of the two problematic alignments. Meanwhile, the evolution of railway technology has made the two routes even less serviceable than before, and more needful of remediation.

The following chapter examines in more detail the physical plant as it stands today.

[25] Herbert Harwood, *op. cit.*, p. 31.
[26] Note the figures above that emphasize the early and complete development of Baltimore City north of the Inner Harbor

Box 2 - 2: The B&O's Howard Street Tunnel Through the Years

The B&O originally proposed to connect its Camden Station on the southwest side of downtown Baltimore to Philadelphia via an elevated line near the downtown shoreline. This was expensive and controversial; as an alternative, the B&O built the 7.3-mile Baltimore Belt Railroad north from Camden Station under Howard Street, across the Jones Falls Valley to Huntingdon Avenue, and then eastward across Baltimore's north side to the B&O's Philadelphia line at Bay View.[27]

The Belt Line included the 1.4-mile-long Howard Street Tunnel and eight short tunnels. The Howard Street Tunnel proved difficult to construct and then to operate. The tunnel had a grade of 0.8 percent to its north portal; from there to Huntingdon Avenue, the grade steepened until it reached a maximum of 1.55 percent. The 7,340-foot-long tunnel became the country's longest soft-earth tunnel. The Belt Line crossed over the top of the B&P tunnel near its east portal.

Train operations began in 1895 with electric traction, which was eliminated in the early 1950s with the B&O's Dieselization. Following the elimination of passenger service in 1958, the B&O and its successors single-tracked the tunnel and made other minor changes to obtain better clearances. Capacity was reduced, however, and the basic geometry of the tunnel remained unchanged from its 1896 state.

On Wednesday, July 18, 2001, a major fire occurred in the Howard Street Tunnel when part of a 60-car CSXT freight train derailed. A separation was found between the 45th and 46th cars, and Cars 45 through 54 were derailed, some of them carrying hazardous materials. The derailment occurred below the intersection of Howard and Lombard Streets. The major source of the fire was the 52nd car, a tank car loaded with tripropylene. The fire ignited adjacent cars loaded with paper, pulpwood, and plywood. A break in a 40-inch water main almost directly above the derailment hampered emergency response efforts. On July 21, emergency personnel removed three cars from the tunnel, with their contents still burning, and finally extinguished the fire. A subsequent inspection found no significant structural damage to the tunnel, allowing train traffic to resume. The first freight train passed through the tunnel at 8:48 a.m. on July 24.

The tunnel closing caused major disruption to CSXT freight traffic, Maryland Rail Commuter (MARC) commuter trains, and to Central Light Rail Line trains and bus lines that traversed Howard Street. To avoid the Howard Street Tunnel, CSXT had to send freight trains west to Cleveland, north to Albany, New York, and then south to Baltimore, incurring a three- to four-day delay. Some CSXT trains were rerouted via the busy NS line through Manassas, Virginia, Hagerstown, Maryland, and Harrisburg, Pennsylvania. At one point during the fire, eight CSXT trains that would have used the tunnel were detouring through Cumberland, Maryland, and Youngstown Ohio; five through Hagerstown and Harrisburg; five through Cleveland and Albany, New York; and 12 trains were stopping in various yards.

Beyond the adverse effects on railroad traffic, there was a massive effect on life and activities in downtown Baltimore. The incident forced the closing of streets and business over much of downtown for several days. Officials cancelled three Baltimore Orioles game, resulting in a $5 million loss to the team. They also closed Howard Street, along with 14 other cross streets, for five days. A two-block stretch of Howard Street remained closed for six more weeks. MTA rerouted 23 bus lines, and MARC service to Camden Station was suspended. The fire also disrupted or shut down many other activities for the duration. The fire and burst water main damaged power cables and left 1,200 Baltimore buildings without electricity. Severed fiber-optic lines backed up traffic regionally and nationally because the fiber-optic cable through the tunnel is a major line for the extremely busy Northeast corridor.

The aftermath of the fire affected some activities for longer periods. MTA shut down light rail service through the city for over seven weeks, with shuttle buses running between the North Avenue and Patapsco stations, and later between North Avenue and Camden. The City did not open the intersection of Howard and Lombard, one of the busiest in the city, until September 5. After a three-year investigation, the National Transportation Safety Board on December 16, 2004 issued an accident investigation report[28] *stating that it could not determine the cause of the accident. Therefore, this disaster can provide no lessons learned for the present study. However, it is reasonable to presume that a new facility, with easier grades and curves, modern construction, and state-of-the-art fire and life safety provisions, might preclude a great number of possible contributing factors to such disasters as that which occurred in the Howard Street Tunnel.*

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[27] Herbert Harwood, op. cit., pp. 85 ff.
[28] National Transportation Board, http://www.ntsb.gov/publictn/2004/RAB0408.htm, December 16, 2004.

Chapter Three
TODAY'S INFRASTRUCTURE

The prior chapter explained how Baltimore's challenging railway plant came to be; the present chapter examines today's infrastructure in some detail. Although emphasis falls on the CSXT and NEC main lines, any further development of restructuring options would require intensive scrutiny of the storage and classification yards, branch lines, and trackage serving industries and the Port of Baltimore.

The geometrically substandard railroads of the Baltimore region can neither assure reliable operations, nor expeditiously move their critical burden of passenger and freight traffic, nor accommodate many state-of-the-art, high-capacity freight cars. These manifest failings provide the background for an analysis of potential improvements.

A. Limits of the study area

This report primarily treats the railroads in the region between the Gunpowder River,[1] to the northeast of Baltimore City, and Halethorpe (in the vicinity of Amtrak's BWI Airport Rail Station), where the CSXT tracks cross over Amtrak's Northeast Corridor. (Figure 3 - 1.)

The major railroads in the study area are Amtrak, CSXT, and NS.[2] Two short line railroads, the Canton Railroad and the Patapsco & Back Rivers Railroad (P&BR), serve selected portions of the industrial area on the eastern side of the region. Although the layout of trackage must be complex to reach the Port and industries, the main lines essentially consist of two parallel routes, those of Amtrak and CSXT, both serving the same Northeast Corridor (NEC) metropolitan areas. The principal yards, stations, and junctions in the study area are shown in Figure 3 - 2**.**

Baltimore—important as it is—cannot undergo scrutiny entirely in isolation. For instance, improvements in Baltimore to attain more generous freight car clearances along the NEC traffic lanes would be of limited value if the clearance limitations in Washington's Virginia Avenue Tunnel and at other locations are left unaddressed. For reasons such as this, the study team not only considered an extended region from the Susquehanna River through the District of Columbia **(**Figure 3 - 3**)**, but was also mindful of the larger-scale traffic flows across the Nation that depend on a smoothly functioning network in Baltimore.[3]

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[1] CSXT and NS freight yards are located at Bay View, about 10 miles southwest of the Gunpowder River.
[2] Although NS owns no main lines in the immediate area, it accesses Baltimore on trackage rights and owns important yard and industrial facilities.
[3] See, for example, the preceding discussion of the nationwide impacts of the Howard Street Tunnel disruptions due to a fire in 2001 (Chapter Two, Box 2-2, "The B&O's Howard Street Tunnel Through the Years").

Figure 3 - 1: The Study Area

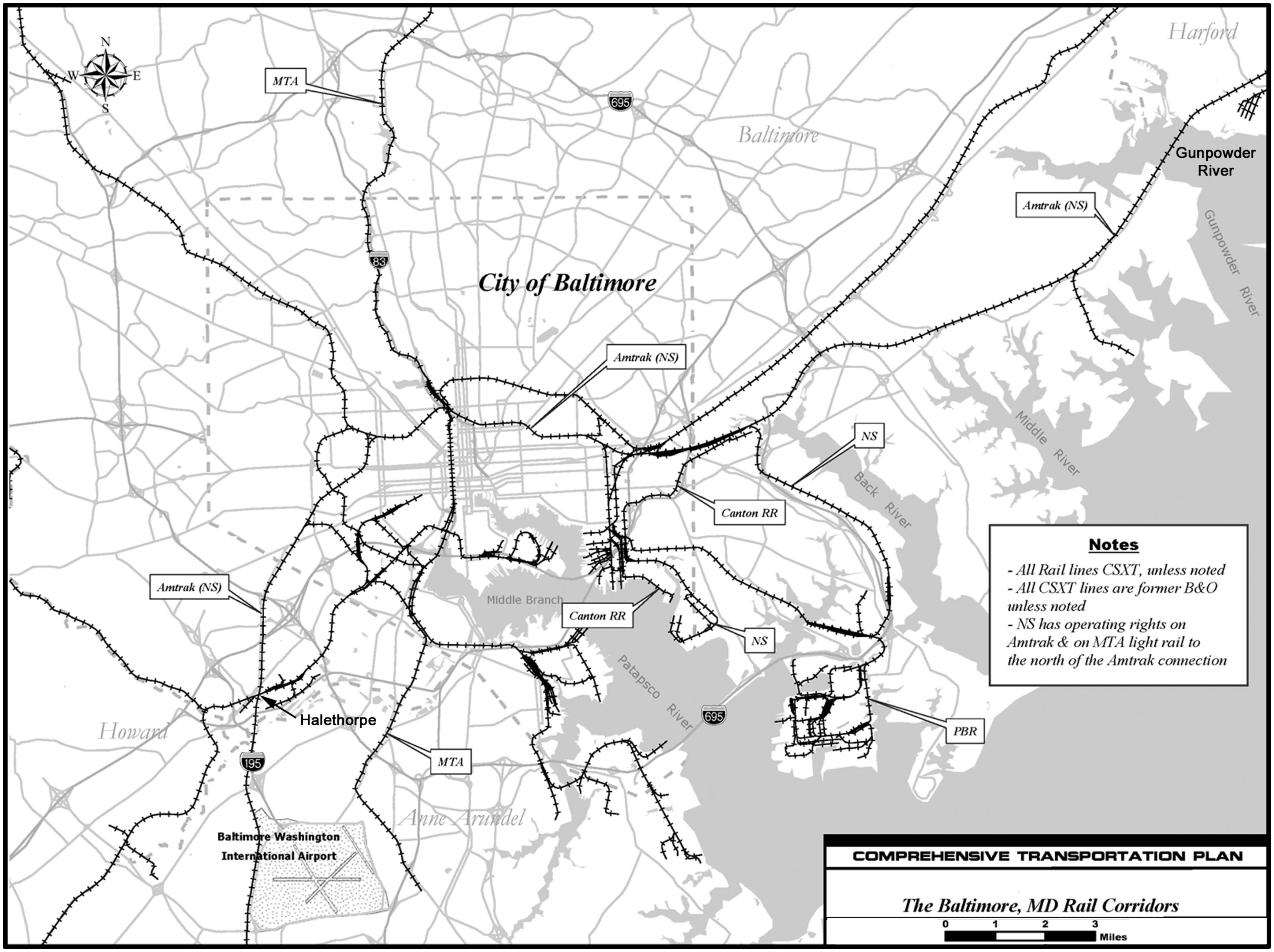


Figure 3 - 2: Principal Yards, Stations, and Junctions

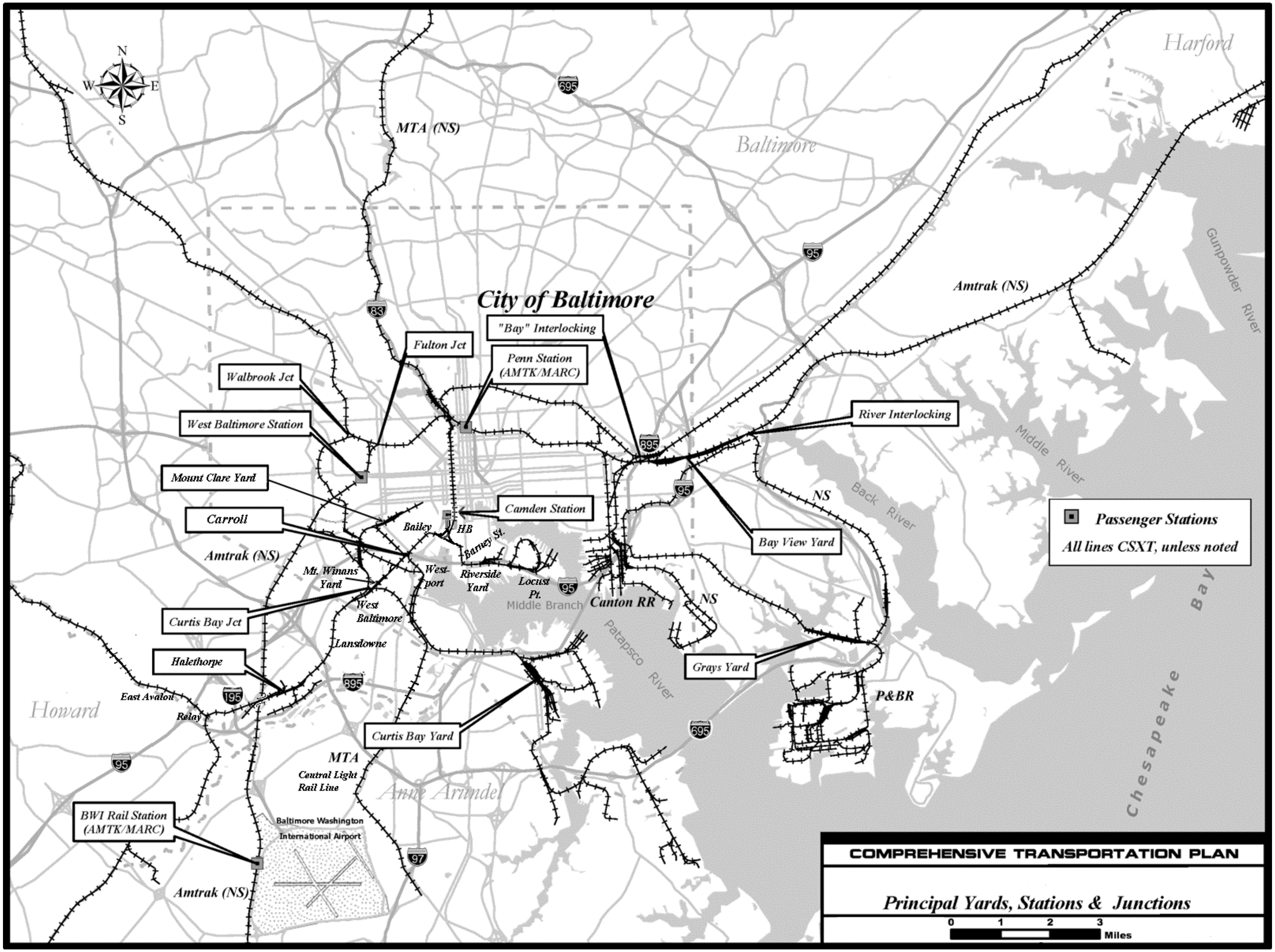
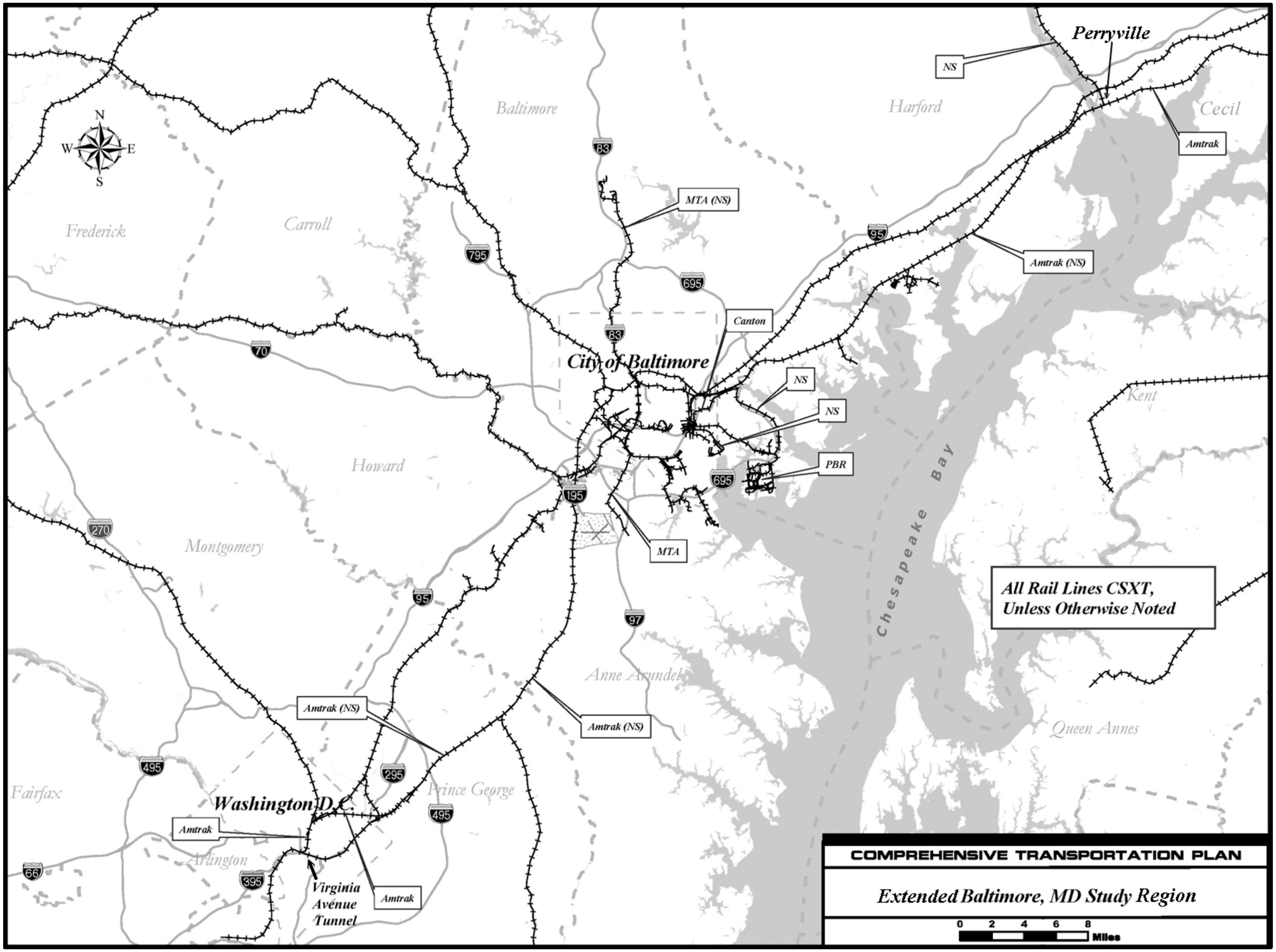


Figure 3 - 3: Extended Study Region



B. Ownership and control

As noted earlier, the owners of the railroad main lines in the study area are Amtrak and CSXT. NS owns only freight support facilities—yards, branch lines, industrial tracks, and appurtenances.

A summary of current track ownership and operating control appears in Table 3 - 1**.**

Table 3 - 1: Track Ownership and Operating Control of Main, Branch, and Short Lines in the Study Area

	Locations	Milepost[4]		Owner	Subdivision	Route-Miles	Dispatched From
		Between-	**And-**				
CSXT Main Lines	East Aikin (Perryville) – Bay View	BAK 54.5	BAK 89.6	CSXT	Philadelphia	35.1	Jacksonville, FL
CSXT Main Lines	Bay View – HB Tower	BAK 89.6	BAK 96.0	CSXT	Baltimore Terminal	3.4	Jacksonville, FL
CSXT Main Lines	HB Tower – Halethorpe	BAA 0.4	BAA 5.8	CSXT	Baltimore Terminal	5.4	Jacksonville, FL
CSXT Main Lines	Halethorpe – JD	BAA 5.8	BAA 33.6	CSXT	Capital	27.8	Jacksonville, FL
CSXT Main Lines	***Old Main Line:*** Halethorpe–East Avalon	BAC 5.9	BAC 7.9	CSXT	Old Main Line	2	Jacksonville, FL
CSXT Branches	***Sparrows Point Branch:*** Bay View Yard to Grays Yard	0	6	CSXT	Baltimore Terminal	6	Trainmaster Penn Mary
CSXT Branches	***Passenger Terminal Lead Track:*** Camden Station – HB or Carroll	BAA 0.0	BAA 0.7	CSXT	Baltimore Terminal	0.7	Jacksonville, FL
CSXT Branches	***Locust Point Branch:*** Barney St. – Bailey	BAM 0.0	BAA 0.7	CSXT	Baltimore Terminal	0.8	Jacksonville, FL
CSXT Branches	***Mt. Clare Branch:*** Carroll – Curtis Bay Junction	BAN 0.0	BAN 2.2	CSXT	Baltimore Terminal	2.2	Jacksonville, FL
CSXT Branches	***Curtis Bay Branch:*** Brooklyn – Curtis Bay Junction	BAO 0.0	BAO 3.3	CSXT	Baltimore Terminal	3.3	Jacksonville, FL
CSXT Branches	***Marley Neck Industrial Track:*** South End Curtis Bay Yard to Curtis Creek	BBR 0.0	BBR 6.2	CSXT	Baltimore Terminal	6.2	n/a
CSXT Branches	***Former Western Maryland Main Line:*** Westport – Walbrook Jct	BRN 0.5	BAS 3.8	CSXT	Baltimore Terminal and Hanover	4.3	Jacksonville, FL
Amtrak NEC Main Line	***The Northeast Corridor:*** Perryville – BWI Airport Station	59.4	106.3	Amtrak	Main Line-Philadelphia to Washington (PW)	56.9	Philadelphia
NS Branches	***Sparrows Point Industrial Track:*** Bay View Yard to North Point Boulevard			NS		5.6	Yardmaster Bay View
NS Branches	***Bear Creek Running Track:*** Canton Jct. to Dundalk			NS		5.4	Yardmaster Bay View
Short Lines	***Canton Railroad:*** East Baltimore, MD					6	(Short line in local service)
Short Lines	***Patapsco & Back Rivers Railroad:*** Sparrows Point, MD						(Short line in local service)

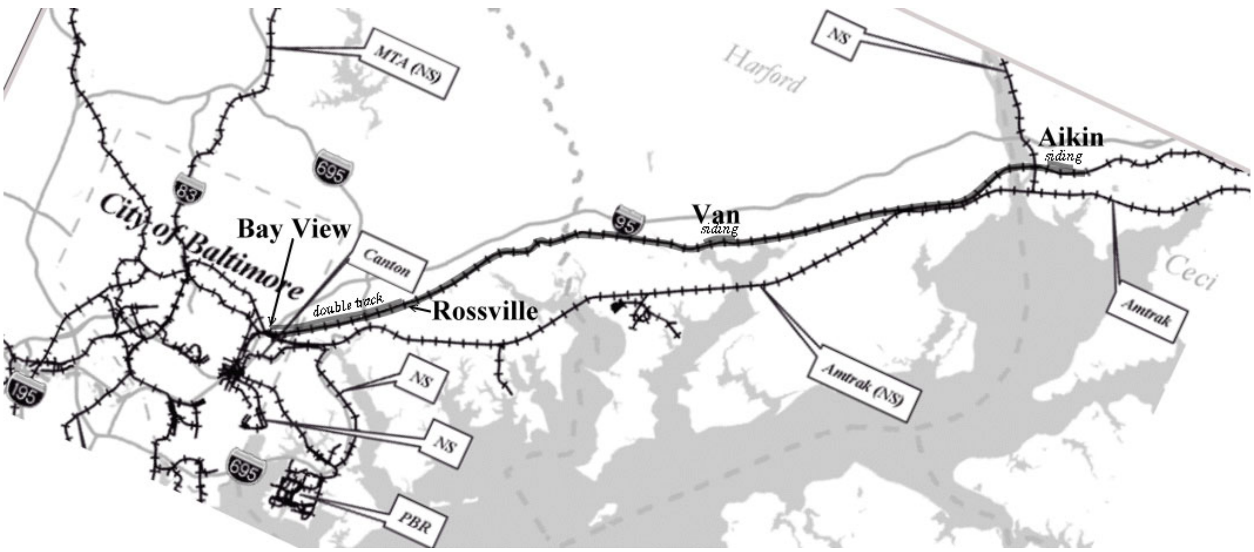
[4] Several numbering systems are in use in the study area; these reflect the subdivision organization of CSXT and the ownership of the rail segments in question by CSXT, Amtrak, and two short line railroads.

C. Trackage and track conditions by segment

This report assumes, on the basis of limited observations in the course of the study, that all segments of trackage have been maintained to a level of repair that meets or exceeds the FRA safety standards for the reported speed classifications.[5]

1. CSXT Main Line

Figure 3 - 4: East Aikin–Bay View (CSXT Main Line)



a. East Aikin–Bay View

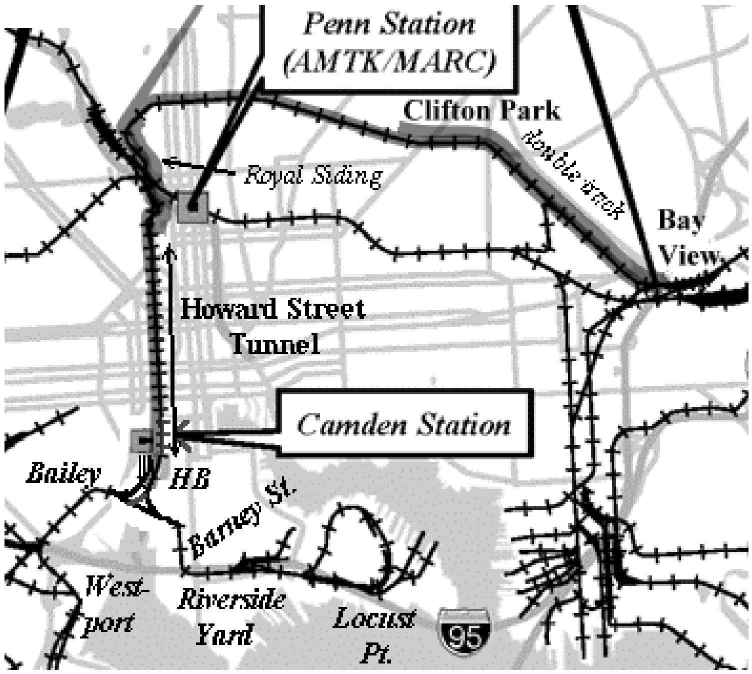
This segment (Figure 3 - 4), a portion of the Philadelphia Subdivision of the CSXT mainline, is primarily single-tracked with sidings. The sidings include the 10,000-foot Aikin siding (east of the Susquehanna River Bridge) and the 10,450-foot Van siding. The Subdivision is double-tracked between Rossville (BAK 84.4) and Bay View (BAK 89.6).[6] The maximum freight train speed is 50 mph east of Bay View.

b. Bay View–HB Tower

This segment, a portion of the Baltimore Terminal Subdivision of the CSXT Main Line, is primarily single-tracked with one siding— the 4,600-foot Royal siding, which is located at the north end of the Howard Street Tunnel. The Subdivision is double-tracked between Bay View (BAK 89.6) and Clifton Park (BAK 91.5). The segment of the line between Clifton Park and HB Tower includes eight short tunnels and the Howard Street Tunnel. The rail line is single-tracked

[5] No conclusions regarding the safety of the infrastructure should be drawn from this assumption, which is for planning purposes only.
[6] The entire B&O line between Baltimore and Philadelphia was, however, double-tracked at its inception. Herbert Harwood, op. cit., p. 43.

Figure 3 - 5: CSXT, Bay View to HB



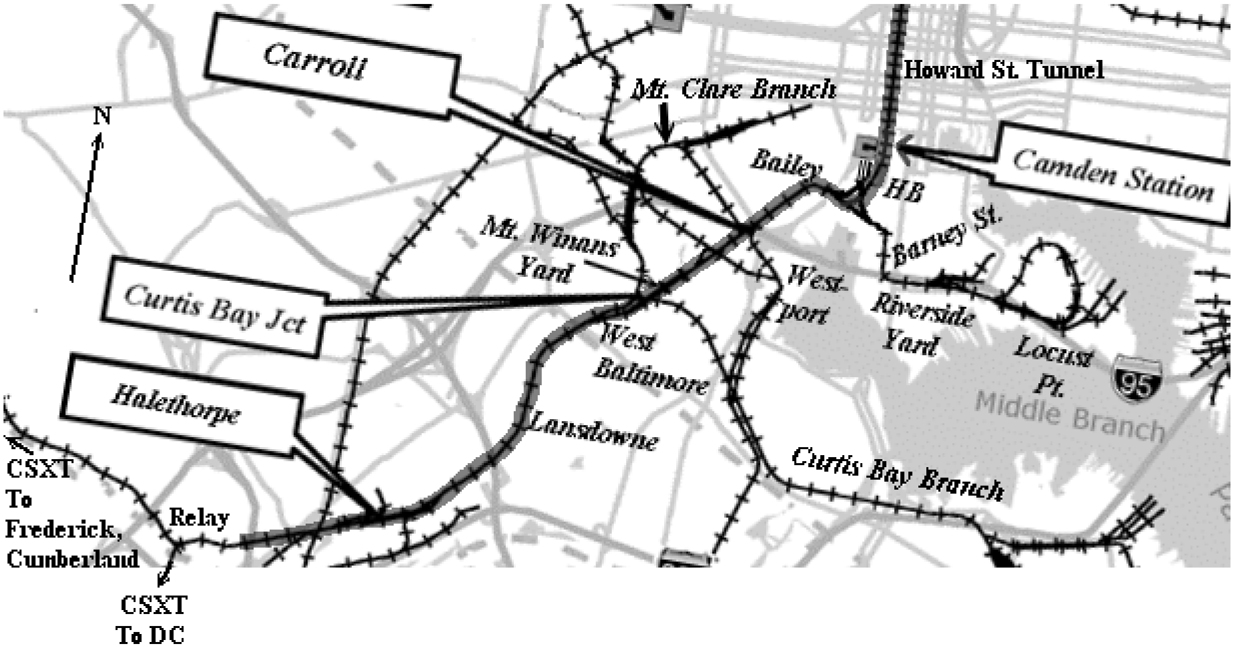
through the tunnels for clearance purposes. Passenger trains no longer operate over the line. The maximum freight train speed is 35 mph between Bay View and HB Tower.

c. HB Tower–Halethorpe

This line is a segment of the CSXT main line between Baltimore and Washington. MARC commuter trains originate on the passenger lead tracks at Camden Station and operate to Washington Union Station. The track configuration allows commuter train operations to merge with the main line either at HB (BAA 0.4) or Carroll (BAA 1.5). The Baltimore Terminal Subdivision is presently:

- Double-tracked for freight service between Bailey (BAA 0.7) and Carroll (BAA 1.5); a third track is configured exclusively for passenger train access to and from Camden Station;
- Double-tracked to West Baltimore (BAA 3.2), where the tracks to Curtis Bay Junction, the Curtis Bay Branch, and the Mt. Clare Branch become parallel to the main line tracks;
- Triple-tracked to Lansdowne (BAA 3.8); and
- Quadruple-tracked to Halethorpe (BAA 5.8).

Figure 3 - 6: HB to Halethorpe



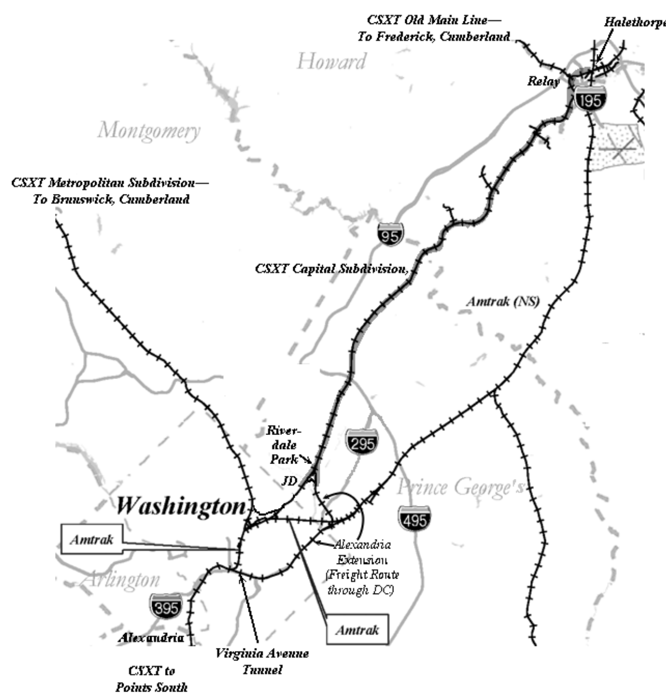
West of Halethorpe (BAA 5.8), the CSXT mainline becomes the Capital Subdivision. The Old Main Line Subdivision to Cumberland and points west diverges from the Capital Subdivision at Relay (BAA 9.0).

The maximum passenger train speed is 50 mph; the maximum freight train speed is 40 mph.

d. Halethorpe – JD

This segment of the Capital Subdivision is primarily double-tracked[7]. The maximum passenger train speed is 70 mph; the maximum freight train speed is 55 mph. There also are a few short yard leads and storage tracks to access yards, serve local industries, and store cars.

Figure 3 - 7: Overview Halethorpe—JD

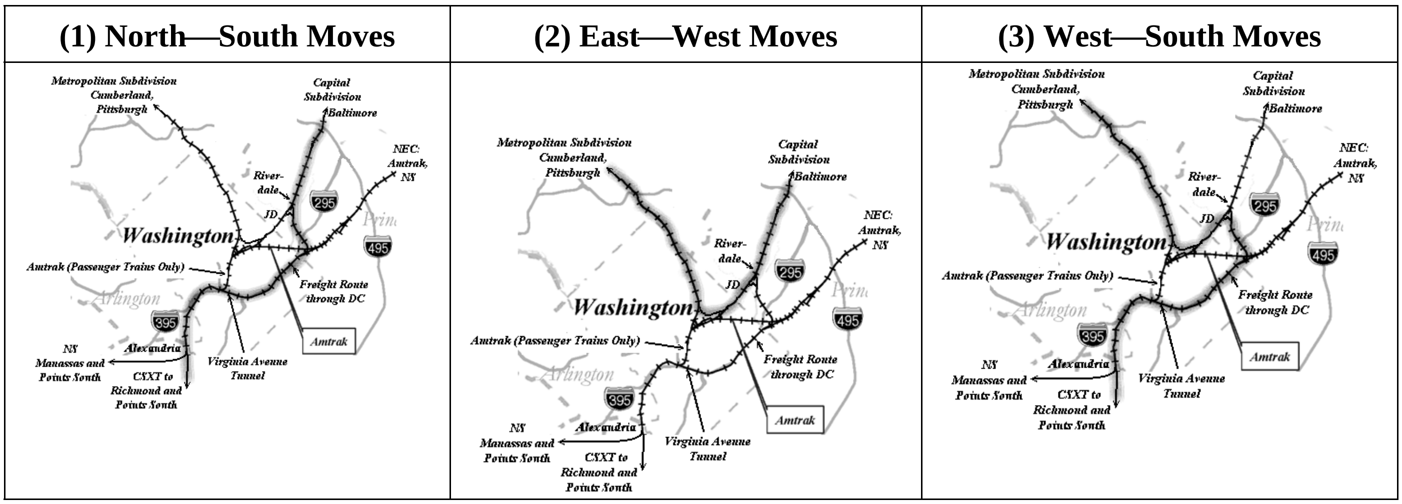


The wye connection to the Alexandria Extension is located in Hyattsville between Riverdale Park (BAA 32.7) and JD (BAA 33.6). This connection facilitates the following three movements, each in both directions (see Figure 3 - 8):

[7] Commuter trains use short sidings at Greenbelt.

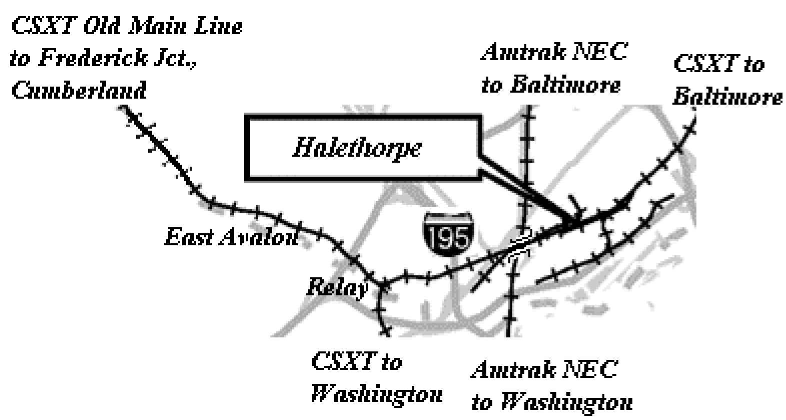
1. Between Baltimore and points north, and Alexandria, Virginia and points south, via Anacostia and the Virginia Avenue Tunnel in D.C.;
2. Between Baltimore and points north, and Cumberland and points west,[8] via the CSXT wye just north of Union Station and the Metropolitan Subdivision; and
3. Between Cumberland and points west, and Alexandria and points south, also via the CSXT wye just north of Union Station and the Metropolitan Subdivision.

Figure 3 - 8: CSXT Movements Through Washington



Of the three CSXT traffic flows described above, one—the major East Coast north/south movement—is constrained by both the Virginia Avenue Tunnel in Washington and the Howard Street Tunnel in Baltimore, and their approaches. (Any analogous NS freight moves via the NEC are similarly constrained, by the Virginia Avenue, B&P, and Union Tunnels and approaches.) Thus, to be fully effective, any comprehensive approach to the Baltimore challenge would need to address clearance and other limitations in and near Washington as well; hence the importance of Washington's rail freight traffic flows, and the inclusion of the Nation's Capital as part of the extended study area.

Figure 3 - 9: Halethorpe – East Avalon



[8] Historically, CSXT and its predecessors have used two routes for freight trains between Baltimore and points west: one via the Old Main Line and Frederick Junction, the other via the Capital and Metropolitan Subdivisions.

e. Halethorpe – East Avalon (Figure 3 - 9)

At Halethorpe, the CSXT main line crosses over Amtrak's NEC. At Relay there is a junction between the Old Main Line (to and from Cumberland via Frederick Junction) and the Capital Subdivision (to and from Washington and points west and south). The Old Main Line Subdivision is generally single-tracked west of Relay. The MAS westward initially is 25 mph; it increases to 30 mph at MP BAC 7.4.

2. Selected CSXT Branches

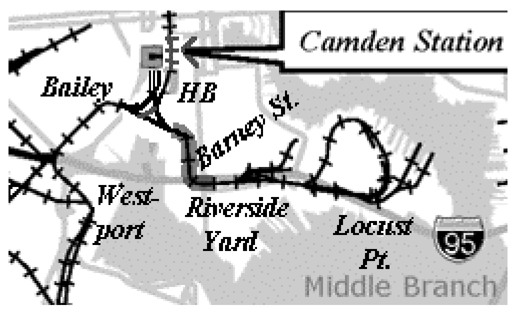
a. Sparrows Point Industrial Track

This CSXT branch extends for approximately six miles from a wye at the west end of Bay View Yard, southward through the Canton area of Baltimore, thence eastward to Grays Yard in Sparrows Point. The branch, providing for freight car interchange between CSXT and the Canton and P&BR railroads, is controlled by the yardmaster at Penn-Mary Yard in Canton.[9]

b. Passenger Terminal Lead Track

Allowing CSXT/MARC commuter trains to access the Camden Station terminal tracks, this 0.7 mile track operates in conjunction with the HB Tower–Halethorpe segment described above (page 7; note the configuration leading to Camden Station in Figure 3 - 10).

Figure 3 - 10: Locust Point Branch

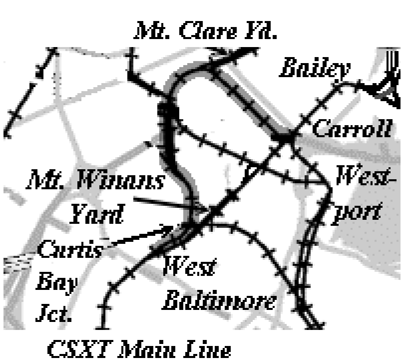


c. Barney St. – Bailey (Locust Point Branch)

The wye connection to the Locust Point Branch is located between HB (BAA 0.4) and Bailey (BAA 0.7). The west wye is the extension eastward of Baltimore Terminal Subdivision Track 2 to Locust Point Yard. The east wye provides a connection to and from the main line and the Howard Street Tunnel. The branch is double-tracked to Locust Point Yard.

d. Carroll – Curtis Bay Junction (Mt. Clare Branch)

Figure 3 - 11: Mt. Clare Branch



Initially constructed in 1829 as the main line[10] of the B&O west and south of Baltimore, the Mt. Clare Branch provides access to Mt. Clare Yard and an alternate route between West Baltimore and the Baltimore Terminal Subdivision at Carroll. The branch is non-signaled, except for the approach to Carroll. The branch is single-tracked over the historic Carrollton Viaduct and to Carroll. Currently, the maximum authorized speed (MAS) for trains is 10 mph.

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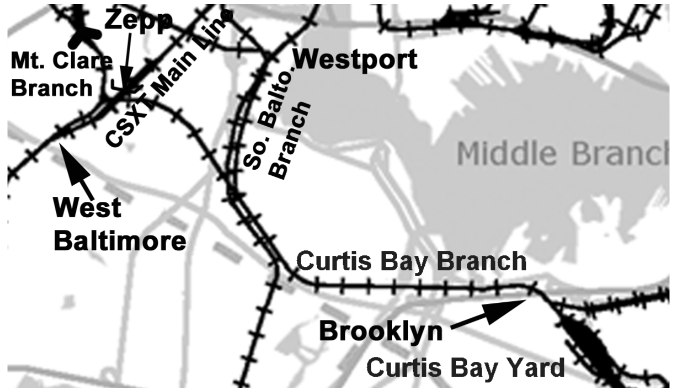
[9] CSX Transportation, Baltimore Division Timetable No. 4, April 2002, p. 6.
[10] Now known as the Old Main Line west of Relay.

e. Curtis Bay Junction - Brooklyn (Curtis Bay Branch)

Curtis Bay Junction (BAO 3.3) provides a wye connection to the Curtis Bay Branch from the Baltimore Terminal Subdivision and the Mt. Clare Branch. The branch is single-tracked on the bridge over the Baltimore Terminal Subdivision, and double-tracked from Zepp (BAO 3.1) to Brooklyn (BAO 0.0). Curtis Bay Yard extends eastward from Brooklyn. Currently, the maximum authorized speed (MAS) for freight trains is 15 mph.

Figure 3 - 12: Curtis Bay Branch



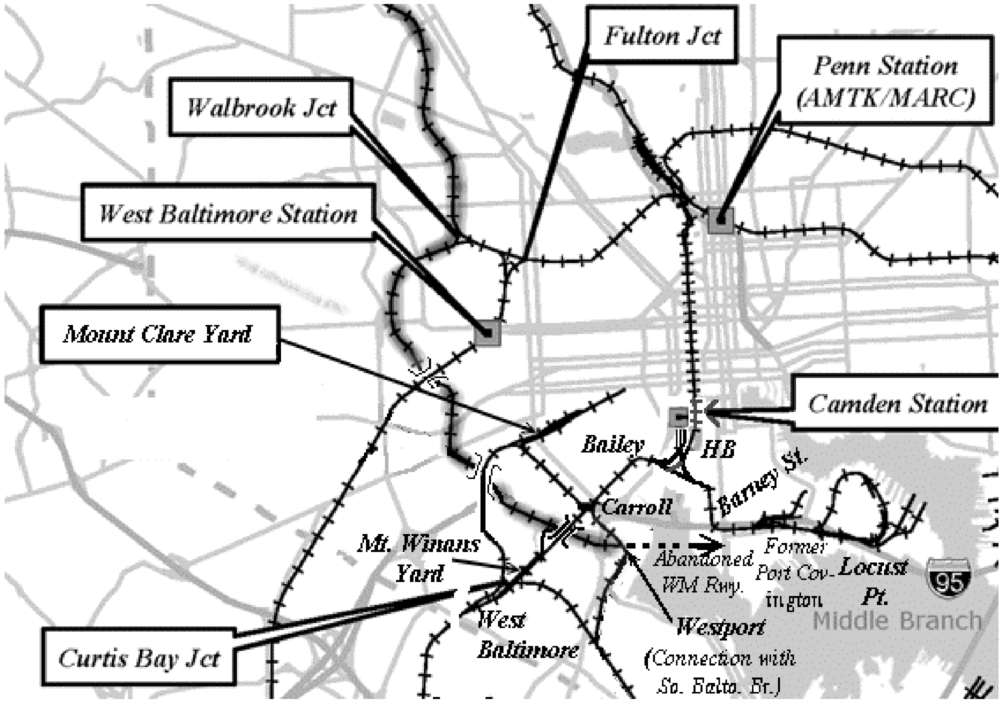
f. Former Western Maryland Railway: Westport–Walbrook Junction

Historically, the Western Maryland Railway (WM) linked its freight terminus at Port Covington (south of the Locust Point facility) with southern Pennsylvania, western Maryland, and West Virginia.[11] The WM's traffic flows reached west of Pittsburgh via connecting lines. With the WM's absorption into CSXT and the decline of the coal industry in its service area, traffic patterns changed: Port Covington and its connecting bridge across the Middle Branch were abandoned, through freight service to and from Baltimore ceased, much trackage was transferred to short lines or placed out of service, and a portion of the former WM main line became a CSXT local freight service route between Baltimore and Hanover, Pennsylvania.

Today, CSXT's operations over the former WM begin at Westport (see Figure 3 - 13), where the Westport Branch connects with the South Baltimore Industrial Track to Curtis Bay. Proceeding west, the Westport Branch passes under CSXT's Main Line at Mount Winans Yard and becomes the Hanover Subdivision. A loop track[12] connects the Hanover Subdivision with Mount Winans Yard. Following the Gwynns Falls valley for part of its route, the Hanover Subdivision continues northwest, passing under the Mount Clare Branch and Amtrak's NEC main line. At Walbrook Junction, today's Hanover Subdivision joins the former WM main line from Hillen Street and Pennsylvania Station, and proceeds northwest to Baltimore County and Hanover, Pennsylvania.

[11] The WM also provided service to the east side of Baltimore, including passenger trains to and from Hillen Station near the Jones Falls in downtown Baltimore, via trackage rights on the PRR.
[12] At the time this study was completed, the loop track was not in service.

Figure 3 - 13: Hanover Subdivision and Westport Branch



The Hanover Subdivision—mainly single-tracked, with an MAS of 25 mph—will enter into some of the alternatives discussed later in this study.

3. Perryville – BWI Airport Station (NEC Main Line)

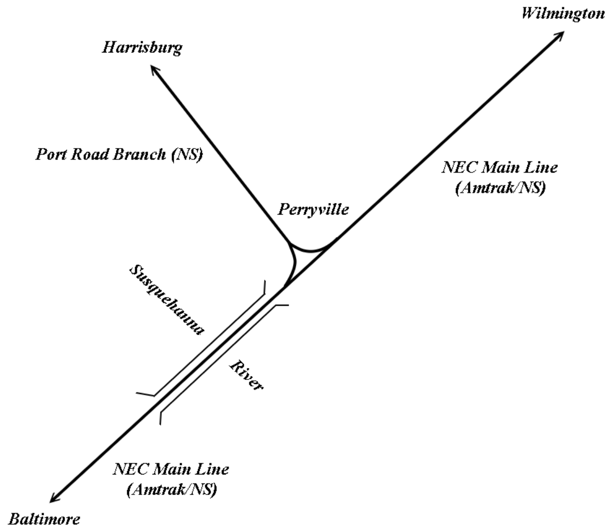
Consisting of three- and four-track segments punctuated by several double-track bottlenecks, Amtrak's NEC south of Perryville essentially parallels the CSXT main line, but is closer to the western shore of the Chesapeake Bay. Between the Jones Falls/Pennsylvania Station area and Halethorpe, however, the positions are reversed (see Figure 3 - 1): the Amtrak line is farther from, and the CSXT more proximate to, the Harbor and the Bay. Double-track segments on the NEC include the Susquehanna River Bridge immediately south of Perryville; the Bush River Bridge; the Gunpowder River Bridge; and the B&P Tunnel.

Many and varied rail operations make use of the NEC main line in the Baltimore region. MARC Penn Line commuter service links Perryville, Baltimore (Pennsylvania Station), and Washington.[13] Amtrak intercity trains connect Boston, New York, and intermediate points with Baltimore (Pennsylvania Station), Washington, and points south and west. NS freight trains to and from points north and west, and even points south,[14] serve Baltimore and Wilmington via the Port Road Branch along the Susquehanna River. At Perryville, there is a three way-junction

[13] All services mentioned have additional intermediate stops. Union Station is the main Washington, D.C. station for all passenger trains serving that city.

[14] Owing to restrictions on freight train access to the NEC, and to clearance limitations in Baltimore and Washington as discussed below, NS traffic between the South and Baltimore ordinarily flows via the Shenandoah Valley, Hagerstown (Maryland), Harrisburg, the Port Road, and Perryville, rather than via the more direct routing through Washington.

Figure 3 - 14: Schematic of Perryville for NS Freight



(Figure 3 - 14) between the Port Road Branch and the NEC in the directions of Wilmington and Baltimore.

Where geometric and other factors allow, the maximum intercity passenger train speed on the Perryville–Halethorpe segment of the NEC is 125 mph; 50 mph is the maximum freight train speed. However, freight trains are restricted to 30 mph between 6 a.m. and 10 p.m., when most intercity and commuter trains operate. This segment benefited from an important public investment under the NEC Improvement Program (NECIP) in the 1970s and 1980s,[15] and continues to receive ongoing maintenance and some betterments from Amtrak; for example, concrete ties have been installed in most tracks throughout the corridor. Previous studies have identified the Susquehanna River, Bush River, and Gunpowder River Bridges, as well as the B&P Tunnel, as needing replacement within the next two decades, although the funding and institutional arrangements for such massive capital projects have not crystallized.

4. NS Branch Lines

While accessing Baltimore by means of trackage rights, NS owns and operates some freight trackage in the region. Its principal yard facility is Bay View Yard,[16] located in East Baltimore on the south side of Amtrak's NEC Main Line.

a. Bay View Yard to North Point Blvd (Sparrows Point Industrial Track)

Diverging from the NEC Main Line east of Bay View [NS] Yard, this NS industrial track provides access to the Patapsco & Back Rivers Railroad that serves the Bethlehem Steel Sparrows Point complex. The track is within yard limits and is controlled by the NS yardmaster at Bay View.

b. Canton Jct. to Dundalk (Bear Creek Running Track)

Located in NS's Baltimore Terminal Area, the 10-mph running track winds through the port and industrial facilities of eastern Baltimore. The running track crosses the Canton Railroad at grade.

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[15] For details on the NECIP, see the 1986 FRA report, *Northeast Corridor: Achievement and Potential,* at www.fra.dot.gov/us/content/1596 .

[16] There are two separate yards at Bay View: that of CSXT to the north, and that of NS to the south. There is an interchange switching connection—but no connection for through service—between the two facilities, originally built by two railroads that were historically completely separate, highly competitive with one another, and reliant (between 1935 and approximately 1980) on divergent sources of line-haul motive power.

5. Short Line Railroad Companies

a. Canton Railroad

Connecting with the NS and CSXT, the Canton Railroad is a short line in the eastern part of Baltimore City and adjacent Baltimore County. It serves warehouse, distribution, port, and industrial facilities and is involved in numerous industrial development activities.[17]

b. Patapsco & Back Rivers Railroad (P&BR)

The Patapsco & Back Rivers Railroad Company is one of a number of subsidiary railroad companies owned by ISG/Bethlehem Steel. A common carrier short line operating in the Sparrows Point vicinity of Baltimore County, Maryland, where ISG has a steel mill,[18] the P&BR connects with CSXT and NS in Grays Yard.

D. Signaling

The CSXT main line, the Locust Point Branch, and the Curtis Bay Branch are signaled, and CSXT Traffic Control System Rules 265-272 govern train operations. The CSXT Sparrows Point Branch is not signaled; its train operations are under the direction of the yardmaster at Penn Mary Yard in Canton. The Hanover Subdivision is not signaled; CSXT Direct Traffic Control Block System Rules 120-132 govern train operations.

On the high-speed NEC between Perryville and BWI Airport Station, the NECIP replaced a more than 40-year-old signal system, so that the average age of the signaling between these two points is now less than 25 years. All main tracks have cab signaling installed. The Centralized Electrification & Traffic Control center (CETC) in Philadelphia controls train operations.

E. Highway-Railroad Grade Crossings

In the study area, the CSXT and NS trackage has a large number of public and private highway-rail grade crossings, while the Amtrak NEC main line is totally grade-separated. In total, there are 72 public and private crossings in the study area on the main lines and key branches of Class I railroads, as summarized in Table 3 - 2.

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[17] Further Canton Railroad information, including a list of shippers, is available on the Canton Railroad's web site at www.cantonrr.com.

[18] More information on Sparrows Point appears in Chapter Eight, "Freight Alternatives," under Harbor Sector crossings. Further information on the P&BR is also available through the parent company's web site, http://www.bethsteel.com/customers/fac_rail.shtml

Table 3 - 2: Grade Crossing Summary

Segment	Line	Route-Miles	Number of Public Crossings	Public Crossings per Mile	Number of Private Crossings	Private Crossings per Mile	Total Crossings	Total Crossings per Mile
CSXT Main Line and Selected Branches:								
Philadelphia Subdivision*	BAK	35.1	20	0.57	1	0.03	21	0.60
Baltimore Terminal Subdivision	BAK/ BAA	11.8	24	2.03	6	0.51	30	2.54
Capital Subdivision**	BAA	27.8	6	0.22	0	0.0	6	0.22
Locust Point Branch	BAM	0.5	2	4.00	0	0.0	2	4.00
Curtis Bay Branch	BAO	3.3	1	0.30	0	0.0	1	0.30
Hanover Subdivision	BAS	3.3	1	0.30	1	0.30	2	0.60
Total CSXT		81.8	54	0.66	8	0.10	62	0.76
Amtrak NEC:	NEC	49.7	0	0.0	0	0.0	0	0.0
NS Selected Branches:								
Sparrows Point Industrial Track	n/a	5.6	2	0.36	1	0.18	3	0.54
Bear Creek Running Track	n/a	5.4	6	1.11	1	0.19	7	1.30
Total NS		11.0	8	0.73	2	0.18	10	0.91

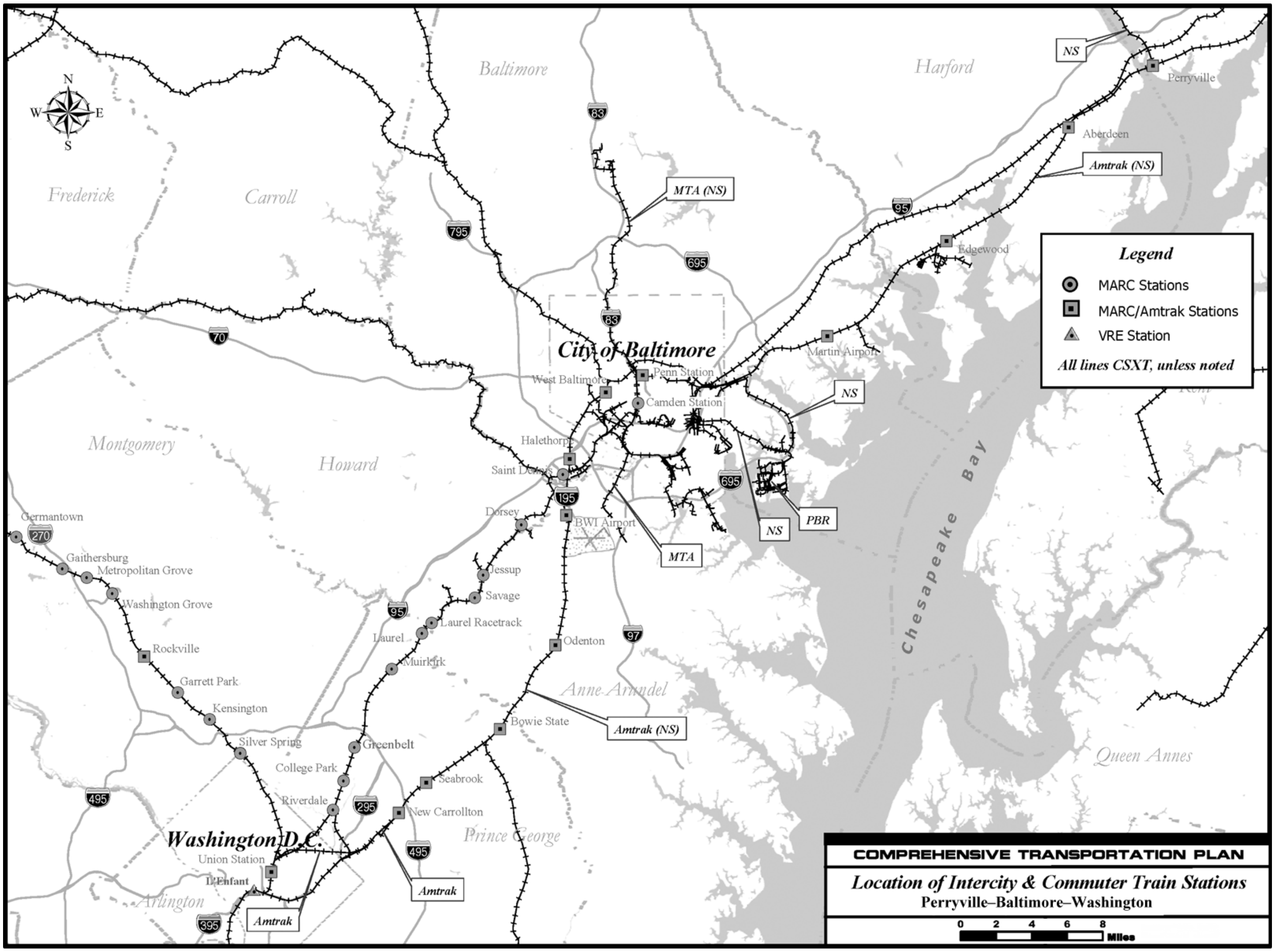
* E. Aikin, BAK 54.5, to Bay View, BAK 89.6.
** Halethorpe, BAA 5.8, to JD, BAA 33.6.

At a minimum, all the public crossings are protected by crossbucks. Various combinations of flashing lights, gates, and ringing bells are installed at most crossings.

F. Passenger Stations

Figure 3 - 15 shows the locations of intercity and commuter stations in the extended Perryville–Baltimore–Washington study area. An inventory of station ownership appears in Table 3 - 3. The location, ownership, and users of the stations are listed.

Figure 3 - 15: Passenger Stations in the Extended Study Area



Two issues concerning the rail passenger stations in the Baltimore region bear mention at this point: the location of the main NEC station (Pennsylvania Station) and the lack of an easterly "beltway"-type intercity station.

1. Pennsylvania Station

Amtrak's Pennsylvania Station has a location on the northern edge of Baltimore's central business district (CBD). As described above, its site was dictated by the PRR's search for a through route through Baltimore that would also service the Northern Central Railway, thus providing simultaneously for through operations between Washington, Philadelphia, and New York on the one hand, and (albeit more awkwardly) between Washington, Baltimore, Harrisburg, and the Midwest and upstate New York on the other.

Table 3 - 3: Inventory of Stations, Perryville–Relay

Note: Status as of February 2003.

SHA = State Highway Administration (Maryland), MTA = Mass Transit Administration (Maryland)

Milepost	Location	Users	Owner		
			Land	Station	Parking (Number of Spaces)
Amtrak NEC Main Line/MARC Penn Line					
NEC 59.4	Perryville	MARC	Amtrak	Amtrak	Amtrak (125)
NEC 65.5	Aberdeen	Amtrak-MARC	Amtrak	Amtrak	Amtrak (113)
NEC 75.1	Edgewood	MARC	Amtrak	MTA (Trailer)	Amtrak, MTA, US Govt., Edgewood (196)
NEC 84.0	Martin Airport	MARC	SHA	MTA (Trailer)	SHA (16519)
NEC 95.7	Baltimore	Amtrak-MARC	Amtrak	Amtrak	City (550)
NEC 98.5	West Baltimore	MARC	City	N/A[20]	City (256[21])
NEC 103.0	Halethorpe	MARC	MTA	N/A[22]	MTA (730 + 300 on street)
NEC 106.3	BWI	Amtrak-MARC	Amtrak	Amtrak	MTA[23] (3,114)
CSXT Baltimore and Capital Subdivisions/MARC Camden Line					
BAA 0.0	Camden	MARC	MSA[24]	MTA	n/a
BAA 6.8	St. Denis	MARC	CSXT	N/A	CSXT (41 + street)

Chapter Five analyzes Pennsylvania Station's location as it relates to future rail restructuring opportunities in the Baltimore region.

2. Beltway-Type Stations

The FRA planning guidelines state:

> One or more suburban stations need to be provided in the larger metropolitan areas with easy access to the local primary road system in order to accommodate potential riders living outside the city centers. Classic successful examples of suburban or beltway stations are Route 128 outside of Boston, MA and New Carrollton, MD outside of Washington, D.C. These "beltway"-type stations cater to automobile-oriented riders and thus need to have many hundreds,

[19] To be expanded with the construction of MD 43.
20 Shelters (reclaimable by MTA) and platforms only
[21] To be expanded to 300+.
22 MTA to add trailer.
[23] Land owned by State Highway Administration
[24] Maryland Stadium Authority

if not several thousand, parking spaces to fulfill their role in corridor transportation.[25]

Baltimore currently has a "beltway"-type station at BWI Airport that has so successfully attracted passenger traffic from the south and west sides of the region as to become Amtrak's sixteenth-busiest station nationwide. However, intercity travelers who originate east of the CBD for northeasterly destinations must currently either double back into the city to use Pennsylvania Station, or drive to Aberdeen—30 miles distant and infrequently served. Therefore, future studies of railway passenger traffic in Baltimore would usefully consider alternatives for a Beltway-type station east of the City, the existence of which may affect operating patterns and facility design in the study region as a whole. This topic, too, is outside the scope of this report, but worthy of attention nonetheless.

G. Tunnel clearances

1. The importance of clearances in modern rail freight transport

As the railroad industry matured in its almost two centuries of operation, it consistently sought to increase the ratio of payload to gross tonnage by carrying freight in higher, wider, and longer cars. Since 1929 alone, the average capacity of a freight car has doubled—from 46.3 to 93.1 tons.[26] Over the ten-year period 1994-2003, the average capacity of multi-level or trailer/container flat cars—of which some types require especially generous clearances—increased by over 28 percent. By 2001, some two-fifths of U.S. carloads were carried in multi-level or trailer/container flat cars.[27]

Thus, the utility of a railway facility increasingly depends on its ability to accommodate modern, high-capacity freight cars. To the extent such accommodation is lacking, the Nation's railroads must direct the affected traffic via circuitous routings, thereby incurring additional costs and consuming excess energy.

2. Clearance Plate Diagrams

The AAR's publication, *Railway Line Clearances*, specifies the allowable dimensions and weight of rail cars over various segments of individual railroads. Maximum load dimensions are defined in terms of "plates," diagrams that specify cross-sectional areas within which a certain series of railroad cars can be built. Five plates are presently defined as: "B," "C," "E," "F," and "H."

Based on two fundamental axes (Top of Rail Line and Track Centerline), the plate diagrams are oriented in an upright plane perpendicular to the centerline of a specified track. **The diagrams specify the extreme width of a car at a given height above the top of rail** (see Table 3 - 4); by this criterion, the limiting factor in tunnels is the height of the eaves at the two

[25] Federal Railroad Administration, *Rail Corridor Transportation Plans: A Guidance Manual,* available at: http://www.fra.dot.gov/us/content/1415
[26] Association of American Railroads (AAR), *Yearbook of Railroad Facts,* 2002, p. 53.
[27] AAR Economics and Finance Department, *Railroad Equipment Report*, pp. 51, 53, and 65.

upper corners of the car, rather than the maximum height at the center of the tunnel's cross-sectional arch.

Table 3 - 4: Typical Clearance Plates—
Critical Dimensions and Examples of Associated Car Types

Plate	Maximum Height above top of rail	Width at Maximum Height above top of rail	Typical Car Types Satisfying Plate
C	15'6"	7'0"	Conventional box cars, flats (depending on load), gondolas, coal hopper cars
F	17'0"	8'10"	Modern box cars, single level trailers
H	20'2"	8'6-3/8"	Double stack containers, tri-level container stacks, tri-level auto carriers.

3. Other Clearance Considerations

For a variety of reasons, railway engineers do not design and build tunnels and other structures to the dimensions listed for a specific plate. Instead, whether for an upgraded or newly-constructed tunnel, the design requirements incorporate various adjustments to the plate dimensions. These adjustments define the "clearance envelope"—the available space for cars or lading to pass through, or the space that is to be checked for a potential obstruction[28] to the passage of a specific car. The adjustments—

- Allow for the movement dynamics of a car (sway and bounce) as it travels along the track;
- Accommodate the presence of overhead catenary;
- Provide for the effect of curvature on the centerline of the envelope; and
- Provide for the minor horizontal and vertical shifts in the location of the track, and catenary, if present, resulting from normal maintenance.

a. Curved Track

The minimum lateral clearance on each side of a track centerline is increased 1.5 inches per degree of curvature to account for the end of the car swinging outward from the centerline, and the center of the car swinging inward from the centerline. The allowance decreases to zero inches when the obstruction adjacent to the track is at least 80 feet beyond, or before, the curve and on tangent track.[29]

[28] The envelope is defined within a plane, which is perpendicular or radial to the track centerline.
[29] Individual states, railroads, and Canada may require greater clearances than the minimums recommended by the American Railway Engineering and Maintenance-of-Way Association (AREMA).

b. Catenary

The electrification of the NEC, presently alternating current at a voltage of 12.5 kV, 25-cycles,[30] requires vertical and horizontal adjustments beyond those used in non-electrified railroads. The construction clearance must allow for a number of factors[31]:

- The electrical clearance between the structure and live parts of the overhead catenary system[32];
- The loading gage (i.e., the maximal static cross section of the vehicles to be operated);
- The electrical clearance between the contact wire and loading gage;
- The horizontal and vertical dynamic movement of the rolling stock, which creates a kinematic envelope that normally exceeds the loading gage by 1.5 to 2.5 inches);
- The uplift of the catenary system when the contact wire is swept by the pantograph (normally 1 to 2 inches, except 3 inches in tunnels);
- The construction and maintenance engineering tolerances; and
- The depth of the catenary, including wire and hardware.[33]

4. Clearances in the Baltimore tunnels

All the factors described above result in the following clearances through the Baltimore tunnels and nearby limiting facilities:

Table 3 - 5: Existing Tunnel Clearance Plates

Tunnel	Plate
NEC (Amtrak, NS)	
Union Tunnel Tracks 1 and 2	C+
Old Union Tunnel Track 3	C+
Pennsylvania Station, Baltimore: tracks beneath concourse	C
Pennsylvania Station, Baltimore: Track F (does not pass beneath concourse)	F
B&P Tunnel Tracks 2 and 3	C
CSX main line	
Howard Street Tunnel	F+
In Washington, D.C.—Affects traffic flows on both NEC and CSX	
Virginia Avenue Tunnel	F

These clearance limitations have the following effects on traffic flows in the study area:

[30] The conversion to a 25kV 60-cycle system has been evaluated.
[31] AREMA Manual, Chapter 33, Part 2.
[32] The catenary is the system of overhead wires that delivers the power to the train, by means of a power-collecting unit (pantograph) attached to the locomotive. The NEC and its Harrisburg extension are America's only long-distance, electrified passenger railroads; freight service on the NEC, formerly electrified as well, now uses Diesel power exclusively.
[33] Since the NEC elevation is lower than 3,000 feet above sea level, an altitude compensation factor is not used.

Table 3 - 6: Effects of Clearance Limitations on Rail Traffic Flows

Traffic Lane	Limiting Plate	Location(s) of Limitation	Alternate Route
NEC			
NS north-south flows, Virginia and Philadelphia/New Jersey/New York	C	B&P Tunnel	Via NS Shenandoah Valley route and former PRR main line
NS east-west moves, Midwest/ Pennsylvania and all NEC points south of Bay View Yard	C	B&P Tunnel	None nearby
NS east-west moves, Midwest/ Pennsylvania and Port of Baltimore points east of Union Tunnels	No limitation in the study area		
CSX main line (refer to Figure 3 - 8, page 9)			
CSX north-south flows, Virginia and Philadelphia/New Jersey/New York	F	Virginia Avenue Tunnel, D.C.	None nearby
CSX east-west flows via former B&O to Baltimore Harbor **south** of Howard Street Tunnel	No limitation in the study area		
CSX east-west flows via former B&O to all points north and east of Howard Street Tunnel	F+	Howard Street Tunnel	None
CSX west-south flows via former B&O and former RF&P, Midwest/Pennsylvania and Virginia/points south	F	Virginia Avenue Tunnel, D.C.	None nearby

Table 3 - 6 clearly shows that none of the north/south traffic lanes through Baltimore can accommodate the most modern, efficient freight cars (Plate H—double- and triple-stack container and auto carriers). NS must divert any such traffic to its hilly Shenandoah Valley route some 60 miles to the West[34]; CSXT owns no alternate route east of the Appalachian Mountains. Furthermore, for east-west traffic, NS cannot service any local shippers south of Baltimore with the most modern cars, nor can CSXT do so east or north of the Howard Street Tunnel. Moreover, NS faces such tight clearances in the B&P and Union Tunnels as to make the NEC unavailable to it for any cars exceeding Plate C. The only traffic lanes that benefit from comparatively unrestricted clearances are those of CSXT between points west and the southwestern part of the Port of Baltimore, and those of NS and the northeastern sectors of the Port.

In order to obtain even the limited available clearances, all CSXT tunnels in the study area have been single-tracked, thus severely constraining capacity (as will be discussed below).

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[34] In the 1980s, Conrail had already diverted as much as possible of its former NEC traffic to its east-west main line via Harrisburg and Bethlehem, Pennsylvania, to Northern New Jersey and New York State. At that time, Conrail connected with the NS's Shenandoah Valley route at Hagerstown, Maryland, and with the CSX's east-west traffic at Lurgan, Pennsylvania.

Similar measures took place in the B&P Tunnel, as described in Chapter Two, Box 2-1. Today, the conditions in the B&P tunnel—as well as its criticality to the protection of a reliable passenger service—preclude its expanded use for most freight and constrain the flow of commerce to and through the Baltimore region.

H. Grades and curves

A railroad's efficiency as a transportation machine inherently depends on its vertical and horizontal profiles—its grades and curves. The same small zone of contact between steel wheel and steel rail,—which reduces rolling resistance and allows a single train with a minimal crew to move huge volumes of freight,[35]—also demands, for maximal utility, as straight and flat a roadbed as possible. This section examines the relationship of grades and curves to railroad operating performance in general and to the capabilities of Baltimore's rail lines in particular. As a general rule, freight service—with its heavier trains, relatively modest speeds, lower power-to-weight ratio, and need to be able to stop and restart at any point on the line without stalling or slipping—demands easy grades, and can tolerate most curves except as they exacerbate effective grades. Passenger service, on the other hand, can tolerate most grades—the ruling grade on the NEC for passenger service is two percent, in the Pennsylvania Station tunnels of New York City—but suffers from excessive curves due to the speed restrictions they impose for reasons of ride quality and safety. Thus the two services have different geometric tolerances and requirements.

1. How grades and curves influence railway operations[36]

Grade, particularly in combination with curvature, has a major impact on the tractive effort[37] and horsepower required to move a train of a given tonnage over a line. Collaterally, grades affect the speed, schedule, and on-time performance of a freight train, and to a lesser degree, a passenger train.

The total resistance a locomotive has to overcome is determined by adding grade resistance to the train and other resistances. The resistance is higher for a train starting up than for a moving train. Simply stated, on a tangent track, a given number of locomotives would haul fewer and fewer cars up increasingly steeper grades.

The presence of curvature increases resistance as the result of increased friction between wheels and the rail.[38] Curve resistance is measured in terms of the grade which would offer the

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[35] In 2001, the average freight train—including locals as well as through freights—had 68.5 cars (versus 47.6 cars in 1929) and carried 3,005 tons of freight (versus 804 in 1929). Also in 2001, the railroad industry generated 3,516 revenue ton-miles per employee-hour (versus 108 in 1929). (AAR, *Yearbook of Railroad Facts,* 2002 edition, pp.35, 37, and 41.) These efficiencies are largely inherent in the mode's configuration of steel wheel on steel rail.

[36] This discussion is based on William W. Hay, *Railroad Engineering*, 2nd Edition, John Wiley & Sons. 1982.

[37] "Tractive effort is the pulling force exerted, normally by a locomotive. When a bare figure for tractive effort is quoted without a speed qualification, this is normally for starting tractive effort, i.e. at a dead start with the wheels not turning." —Source: http://encyclopedia.thefreedictionary.com/Tractive%20effort

[38] The friction is the result of the inside and outside wheels traveling different distances and the rubbing of wheel flanges on the head of the outside rail on the curve.

same resistance as that imposed by the curve. Research in the 20th century concluded that the curve resistance of a one-degree curve equates to the resistance of a 0.04 percent grade.[39]

Thus, for example, a six-degree curve located on a 0.80 percent grade would result in an effective gradient of:

$$(0.80) + (6 \times 0.04), \text{ or } 1.04 \text{ percent}$$

Continuing the example, assume that a 12,000-ton train could operate up a 0.80 percent grade without stalling, but if a six-degree curve were superimposed on the grade, the train would stall.

To reduce the effective grade to 0.80 percent, the designer would seek ways to reduce the actual grade by—

$$(6 \times 0.04) \text{ or } 0.24 \text{ percent}$$

—to 0.56 percent to prevent the 12,000-ton train from stalling.[40]

Such a reduction may not be practical, particularly on an existing route that is crisscrossed by numerous highways, streams, valleys, and other features. The presence of overhead and undergrade bridges and adjacent development may prevent altering the grade. Consequently, the rail operator has limited options:

- Reduce the tonnage hauled by a train, thus requiring more trains to haul the potential traffic over the line;
- Add a locomotive(s) to the train to prevent stalling, which can be done in several ways:
  - Have the locomotive(s) on the train from originating terminal to destination terminal, which means that the train is overpowered for the majority of its route, or
  - Have the locomotive(s) added locally as a “helper” in railroad terminology, which delays the train and requires the helper locomotive(s) to return to the location where they were added, effectively reducing the capacity of that segment of the route, increasing the labor force necessary to conduct the operation, and potentially necessitating facility expansion.

All the above options would increase the railroad’s operating ratio (expenses divided by revenues), thus harming the company’s self-sustainability and status as a going concern.

Curves, in themselves, can severely limit train speeds because of the forces they create as trains pass over them, and the safety, ride quality, maintenance, and cost issues that these forces raise—issues that are worsened in mixed traffic conditions. For example, allowable superelevations (banking) on curves may differ for passenger and freight service. Where both

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[39] Amtrak’s *MW 1000, Specifications for Inspection, Construction and Maintenance of Track*, states that the value for each degree of curvature should be 0.05 percent at locations where trains frequently stop.

[40] Depending on site-specific circumstances, reducing the actual gradient may have the additional negative effect of lengthening the grade, the distance needed to attain the desired elevation.

services regularly share the same trackage, compromises must be made that may allow neither service to operate optimally.

2. Curves and their effects in the study region

An inventory follows of the curves in the CSXT and NEC main lines through the study area.

a. CSXT alignments

Figure 3 - 16 shows the distribution of curvature in three segments of the CSXT main line.

(1) From the Susquehanna River to the south end of Bay View Yard (32.8 route-miles total)

Of this 32.8-mile segment, approximately 77 percent of the alignment is tangent. Twenty-five curves (most of them less than one degree) comprise the remaining 7.6 miles. Three of the curves exceed of three degrees, and are located in segments of the rail line restricted to 40 mph.

(2) From the south end of Bay View Yard to the south end of the Howard Street Tunnel at HB Tower (6.9 route-miles total)

Approximately 58 percent (4.0 miles) of the alignment between the south end of Bay View Yard and the south end of the Howard Street Tunnel (HB Tower) is tangent. However, of the 2.9 miles of curves, 65 percent of the distance (1.9 miles) has curvature greater than three degrees. Thus, as Figure 3 - 16 shows, the curves between Bay View and HB are much sharper than those north of Bay View.

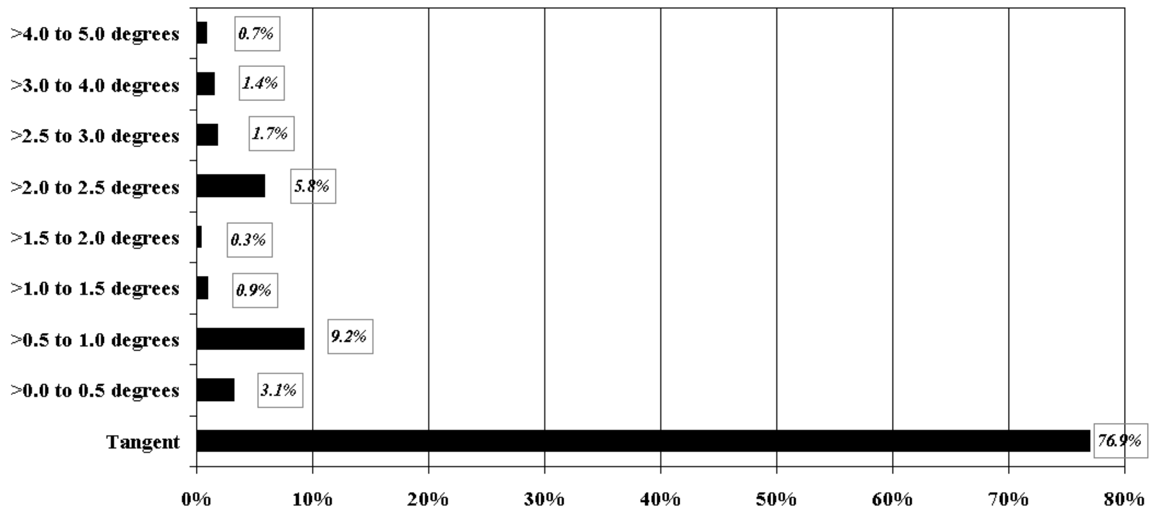
(3) From the south end of the Howard Street Tunnel to Riverdale Park/JD Tower, near D.C. (33.1 route-miles, total)

The Riverdale Park/JD Tower area of the CSXT main line houses the junction of CSXT's passenger line to Union Station, Washington, with the freight line to the South via Anacostia. Approximately 49 percent (16.1 miles) of the alignment between the south end of the Howard Street Tunnel and the Riverdale Park/JD area is tangent. Thirty-seven curves comprise the remaining 17 miles. Of these 17 miles, 6.2 miles (36 percent) of the curved alignment has a curvature between one degree and one degree thirty minutes. The curves immediately south of the Howard Street Tunnel are sharper than those south of MP BAA 10.1. Twelve of the curves are in excess of three degrees.

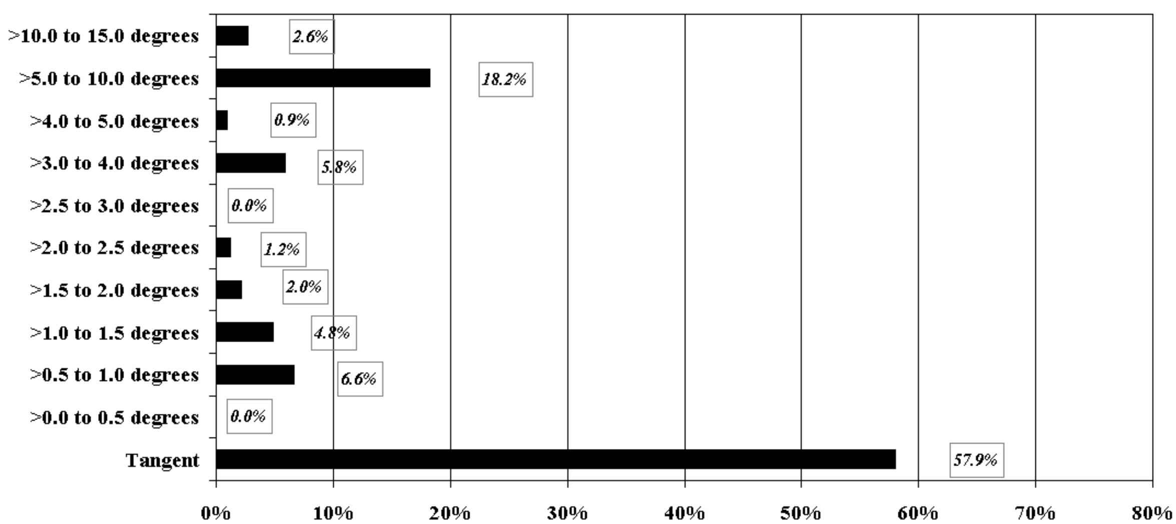
The freight speeds between the Howard Street Tunnel and MP 10.1 range between 25 and 45 mph. Freight train speeds are 55 mph between MP BAA 10.1 and JD.

Figure 3 - 16: CSXT—Percentage of Route Segments by Degree of Curvature

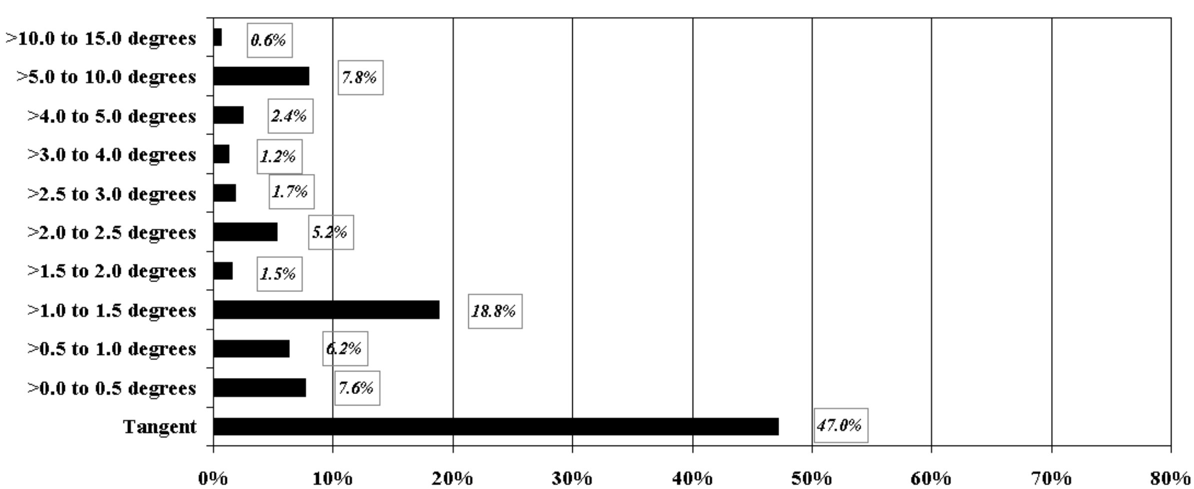
CSXT Curvature: Susquehanna River -
South End Bay View Yard [32.8 Total Miles]



CSXT Curvature: South End Bay View Yard
—South End Howard Street Tunnel [6.9 Total Miles]



CSXT Curvature: South End Howard Street Tunnel
—Riverdale Park (near D.C.) [33.0 Total Miles]



(4) Summary: CSXT curvature

Figure 3 - 16 clearly indicates that the CSXT's curvature problems most seriously affect the segments south of Bay View Yard. Relative age undoubtedly influences the comparative quality of these alignments: the territory north of Bay View Yard represents a relatively "recent" alignment (the Royal Blue Line completed in 1886), whereas CSXT's route from Baltimore to Washington (the "Washington Branch") dates back to 1835, eight years after the B&O's founding.[41] The Howard Street tunnel with its approaches, completed last of all in 1895, constitutes a special case due to Baltimore's exceptionally difficult railway topography as described earlier in this report.

b. NEC alignments

Figure 3 - 17 presents the curvature pattern for three segments of the NEC that are roughly analogous to the three CSXT main line segments just described. With the exception of the very difficult tunnel alignments on both roads, the NEC enjoys a more favorable alignment than the CSXT. Between Baltimore (north of the tunnels) and the Susquehanna River, for example, the NEC has only 0.8 miles of route curvature that exceeds two degrees; the CSXT has 3.2 miles. South of the Baltimore tunnels, the CSXT has a higher percentage of route-miles in sharper curves than does the NEC. These divergences stem both from geography (to the north, Amtrak's route hugging the Chesapeake Bay is gentler than the CSXT's inland, hillier route) and history (the NEC south of the tunnels is of more recent design and construction[42] than the CSXT's legacy alignment).

c. Speed effects of curvature

Railway engineers develop detailed formulas for calculating maximum authorized speeds (MASs) for various traffic types on specific sections of trackage. Among the many factors that enter into these calculations are:

- The degree of curvature;
- The adequacy of the spirals transitioning from tangent track to the maximum degree of curvature;
- The allowable superelevation (banking) to accommodate the needs of all traffic types making use of the segment;
- Other equipment- and site-specific conditions.

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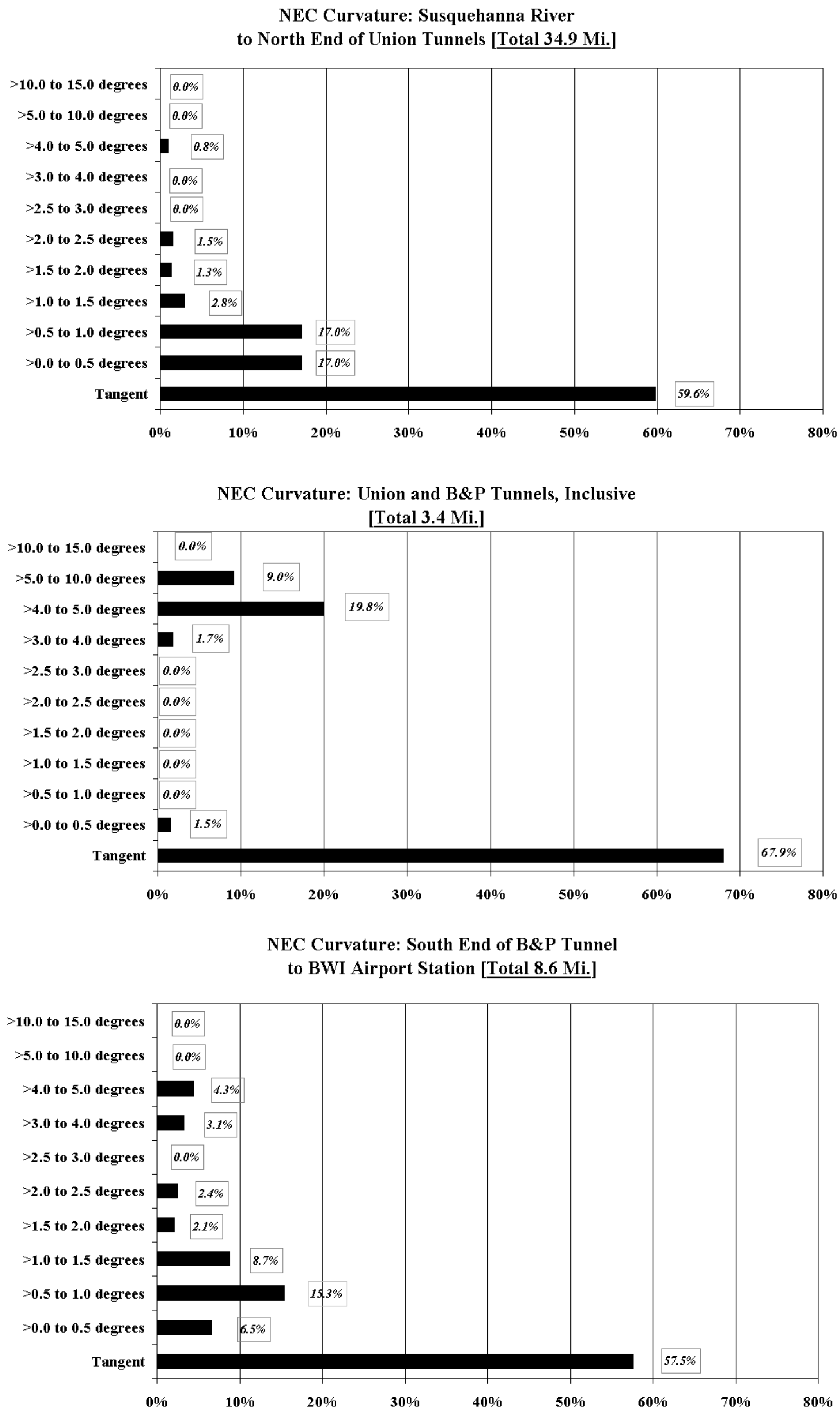
[41] Timothy Jacobs, ed., *History of the Baltimore & Ohio Railroad*, New York: Smithmark Publishers, Inc., 1995, pp. 64, 28, and 68.
[42] 1873, versus the 1835 completion of the B&O's Washington Branch quoted above.

Figure 3 - 17: NEC—Percentage of Route Segments by Degree of Curvature



For the main lines at issue in this report, the results of these many calculations appear in Table 3 - 7.

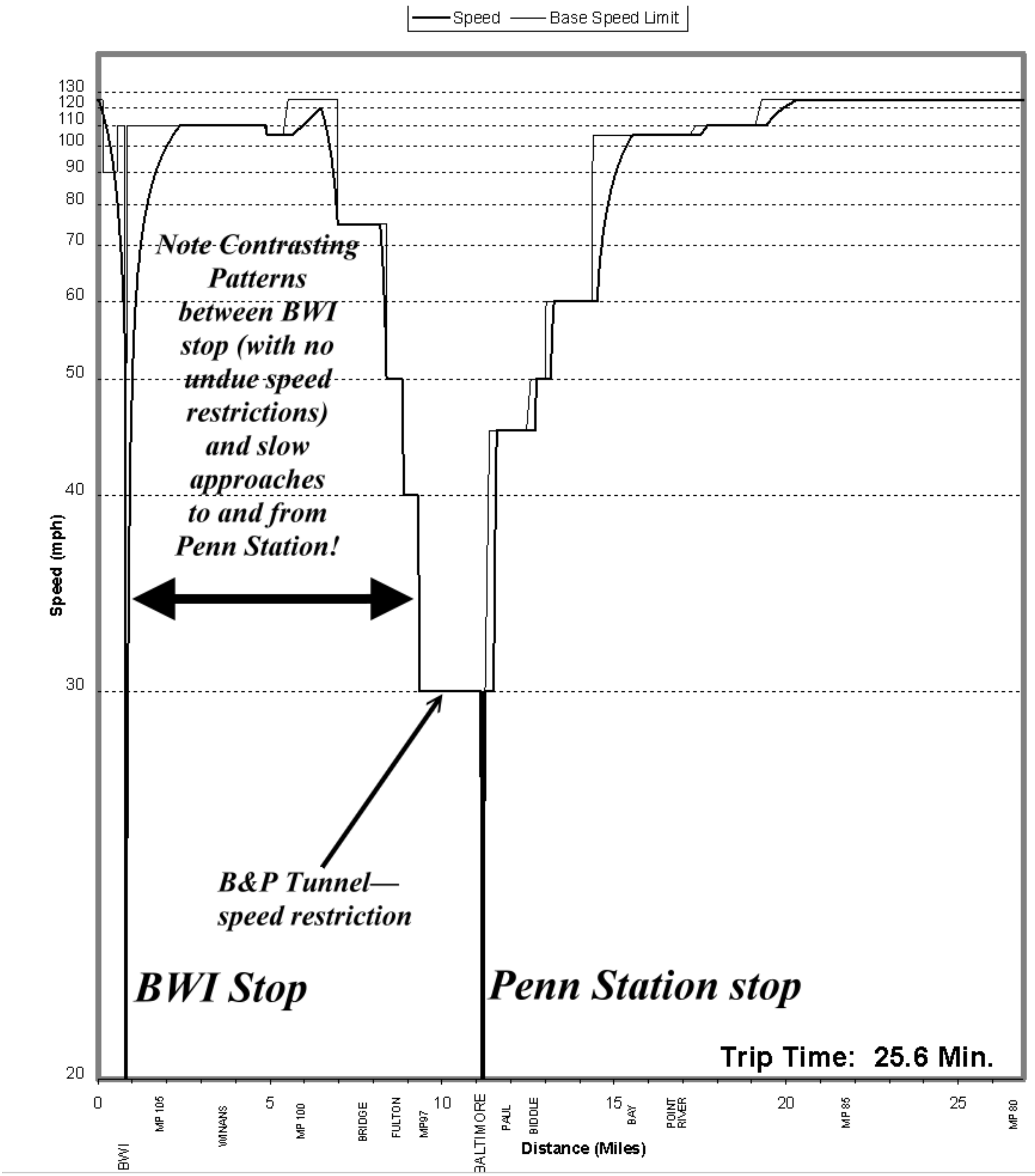
Table 3 - 7: Maximum Allowable Speeds[43]
on CSXT and Amtrak Main Lines through Baltimore

Route Segment	Maximum Allowable Speeds	
	For Passenger Service	**For Freight Service**
CSXT Main Line		
North of Baltimore	no service	50 mph
—Except: On curves greater than 3º 15'	no service	*45 mph or less*
South of Bay View (MP BAK 90.6) to St. Paul/Calvert Street tunnel (MP BAK 03.4)	no service	35 mph
St. Paul/Calvert Street tunnel (MP BAK 93.4) through Howard Street Tunnel to Carroll (MP BAK BAA 1.5)(total of 4 miles approximately[44])	On passenger tracks: 15 to 45 mph	On freight thru tracks: 25 mph
South of Baltimore	70 mph	55 mph
—Except: On curves greater than 2º 15' but under 3º 0'	*65 mph or less*	55 mph
—Except: On curves greater than 3º 0'		*50 mph or less*
Amtrak NEC		
—Perryville (MP 59.4) and MP 85 (10.7 mi. north of Penna. Sta.)	125 mph	50 mph or less
—MP 85 to MP 91.9 (3.8 mi. north of Penna. Sta.)	110 mph	50 mph or less
—In Union Tunnels, north of Penna. Sta. *(Speeds gradually lessen on approach to station, where all trains stop)*	45 mph	30 mph
—In B&P Tunnel, south of Penna. Sta.	30 mph	20 mph
—From south of B&P Tunnel (MP 97.7) to BWI Airport Station (MP 106.3)	110 mph	50 mph or less

Figure 3 - 18 exemplifies the effects of Baltimore's difficult railway configuration on train performance. Especially noteworthy are the restrictions imposed by the B&P Tunnel (30 mph over some two miles, MP 95.9 to 97.7), and—especially—the contrast in linear shape between the stop at BWI, in which the train maintains and resumes top speeds very close to the station, and that at Pennsylvania Station, which takes many miles and minutes to accomplish.

[43] These are general guidelines, always subject to site- and time-specific considerations.
[44] Based on CSXT Baltimore Division Timetable No. 4, April 2002, and *Official Guide of the Railways,* June 1916, p. 526.

Figure 3 - 18: Optimal Speeds Achieved by an Acela Trainset Operating Unimpeded Between Perryville and BWI (Over Today's NEC Track Configuration)

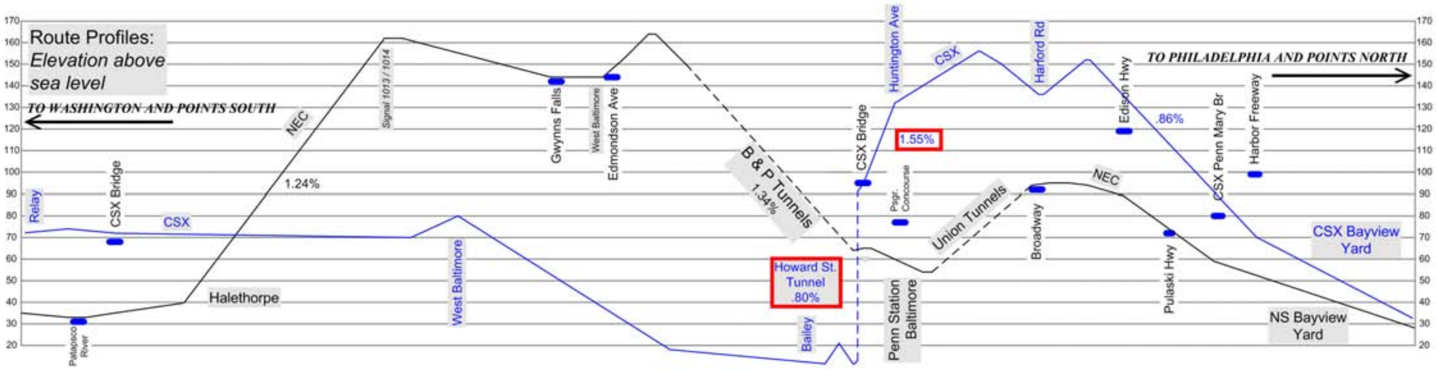


As the BWI stop demonstrates, it is not the equipment that consumes all the excess time in stopping at Pennsylvania Station—it is the alignment. Moreover, it is not just the high-speed intercity passenger service that loses time in central Baltimore City—it is the MARC commuter service as well, not to mention Amtrak's more conventional trains.

3. Grades and their effect on the study region

As described earlier in this chapter, the railroads in the 19th century made compromises to fulfill their conflicting goals of maintaining their separate multipurpose rights-of-way, providing passenger service as close to the central business district as possible, and avoiding construction that would wipe out critical areas of the city (i.e., the Inner Harbor), all within a challenging topographical environment. In no domain were these compromises more debilitating than in the maintenance of easy grades, a requisite for efficient freight service[45] and a help to all operations.

Figure 3 - 19: Grades through Baltimore on CSXT and NEC Routes[46]



These compromises show themselves starkly in Figure 3 - 19, which displays the grades of the CSXT and NEC main lines, each of which is described in the following sections.

a. Profile of the CSXT

(1) CSXT - Susquehanna River (BAK 56.58) to South End of Bay View Yard (BAK 89.5)

The CSXT rail line south of Philadelphia can be characterized as having a "saw tooth profile," in that the line consists of numerous adjacent crests and sags,[47] which can adversely affect train performance. (By contrast, the NEC has a flatter profile because it is closer to the Chesapeake Bay and constructed in less rolling terrain.[48]) The grades north of CSXT Bay View Yard generally are less steep than those in, and north of, the Howard Street tunnel. The steepest grade, 0.04-mile of downhill 1.17 percent (between MP BAK 87.68 and MP BAK 87.72), is near Bay View Yard. Charts showing the prevalence of various grades on the CSXT appear in Figure 3 - 20.

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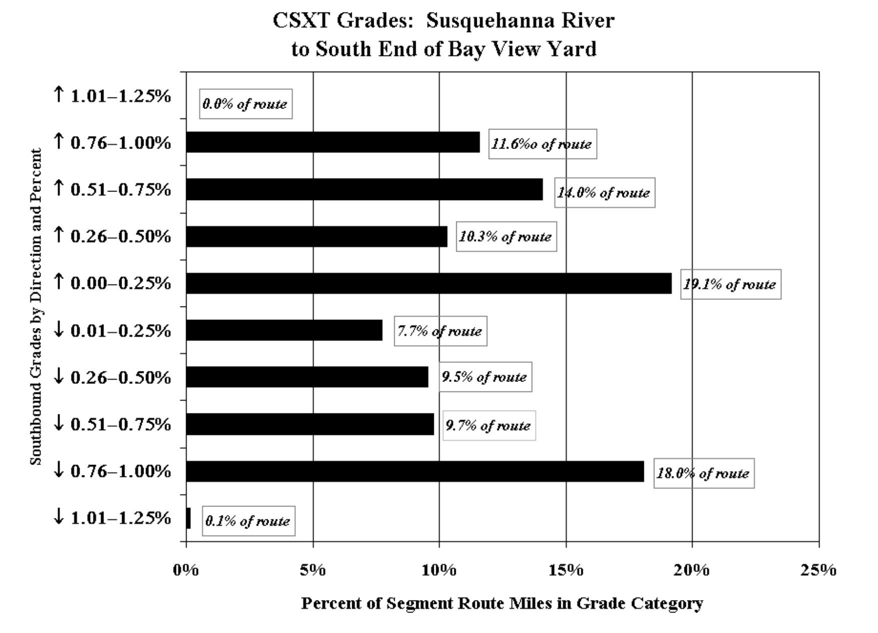
45 For example, according to Robert S. McGonigal, "a given locomotive … can haul only half the tonnage up a 0.25-percent grade that it can on the level." (http://www.trains.com/Content/Dynamic/Articles/000/000/003/015kegsf.asp)

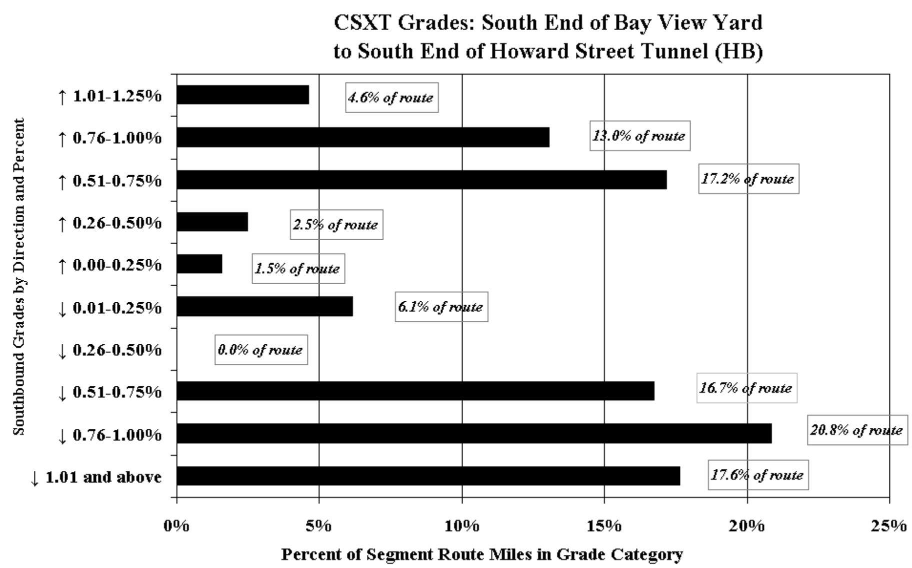
46 Figure courtesy of Amtrak's Planning Department.

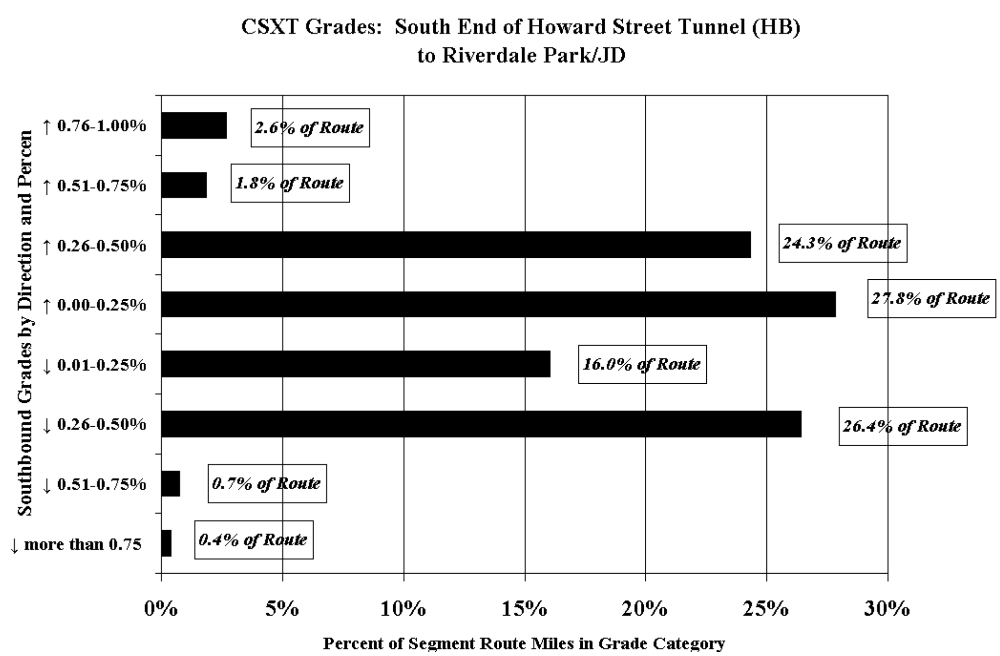
47 The sags generally located where the rail line crosses the various rivers, streams, and creeks flowing into Chesapeake Bay.

48 However, the NEC has the disadvantage of requiring major bridges on the Bush and Gunpowder estuaries.

Figure 3 - 20: Prevalence of Grades of Varying Severity on CSXT







(2) CSXT: South end of Bay View Yard to south portal of Howard Street Tunnel at HB Tower (between MP BAK 89.5 to MP BAA 0.5)

The grade from the vicinity of Camden Station to the north is uphill 0.8 percent through the 7,341-foot, single-track Howard Street Tunnel. The grade continues to climb[49] for approximately 4.5 miles. Between the Howard Street tunnel portal and Huntingdon Avenue, the northbound uphill grade reaches 1.55 percent—the type of freight railroad incline that is more appropriate to mountain passes than tidewater cities. The elevation at the south end of the tunnel is 11 feet above sea level; to the north, the highest elevation on the grade is 157.1 feet, near the Greenmount Avenue short tunnel.[50] The presence of three curves of between 3 degrees 15 minutes and 4 degrees 30 minutes in the Howard Street Tunnel, and of five curves of between 5 degrees 45 minutes and 10 degrees 10 minutes between the north end of the Howard Street Tunnel and Greenmount Avenue, further restricts the maximum authorized speeds. As described on page II-22, these curves effectively increase the grades in this segment by from 0.13 to 0.41 percent. The grades and the curvature thus combine to aggravate the constraints that make the Howard Street Tunnel a choke point in CSXT operations between Richmond and Philadelphia.

(3) CSXT: South portal of Howard Street Tunnel at HB Tower to Riverdale Park/JD (between MP BAA 0.5 and MP BAA 32.71)

The grades south of the Howard Street Tunnel generally are less steep than those in, and north of the tunnel. The steepest grade, 0.8 mile of southward uphill 0.83 percent (MP BAA 1.9 to MP 2.7), is located north of, and extends through, Mt. Winans Yard. The rail line south of Mt. Winans to Riverdale Park, in Hyattsville, the connection to Benning Yard, the District of Columbia, and Virginia, is largely gently rolling and presents a far easier gradient than the segments of CSXT main line north of HB Tower,

b. Profile of the NEC

(1) Susquehanna River to north portal of Union Tunnel

The grades north of Amtrak's Union Tunnel generally are moderate. The steepest grade, uphill 0.65 percent (MP 62.01 to MP 60.96), is located south of Grace as the NEC climbs out of the Susquehanna River valley. A comparison of Figure 3 - 21 with Figure 3 - 20 underlines the contrast in profiles between the NEC and the CSXT main lines northeast of Baltimore.

(2) North portal of Union Tunnel to south portal of B&P Tunnel

The Union Tunnels comprise:

- The original double-track tunnel—subsequently single-tracked in the 1930s—constructed in 1873 (at the same time as the B & P Tunnel); and
- A double-track tunnel, located south of the old tunnel, constructed in 1934.

Southbound, the grade through the Union Tunnels is downhill 1.17 percent.

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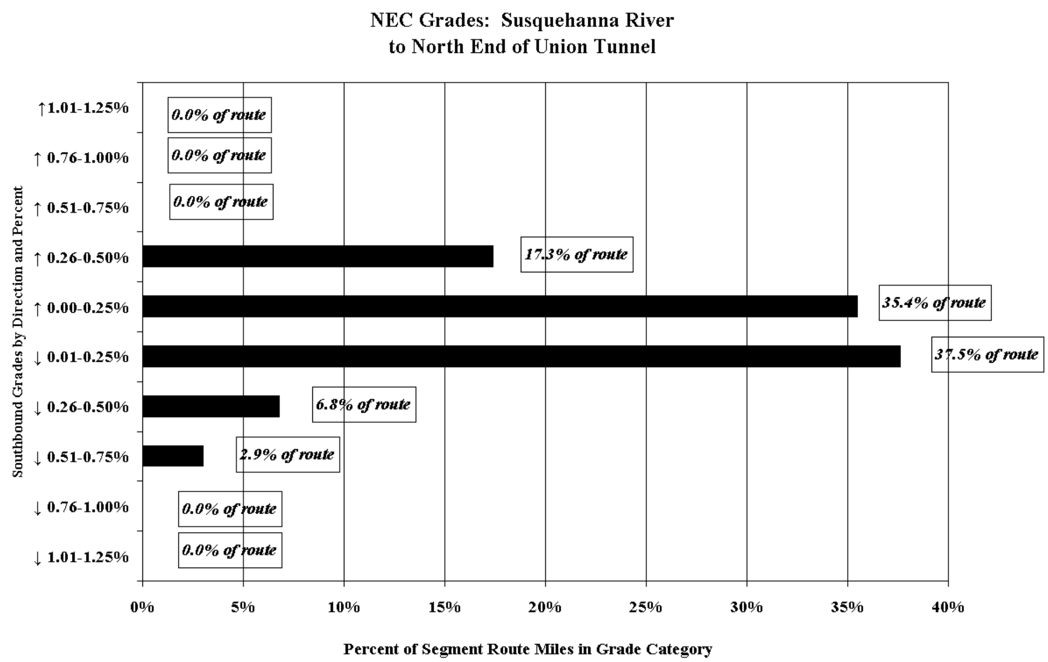
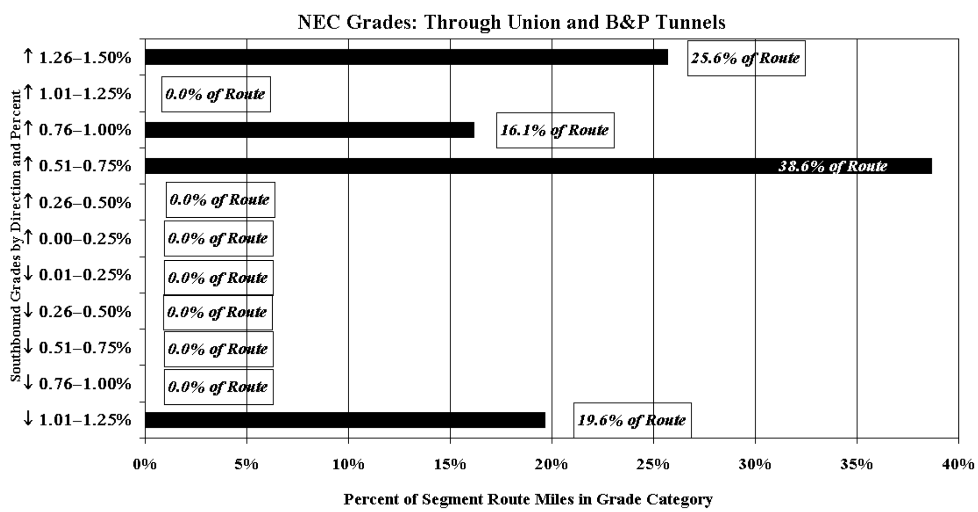
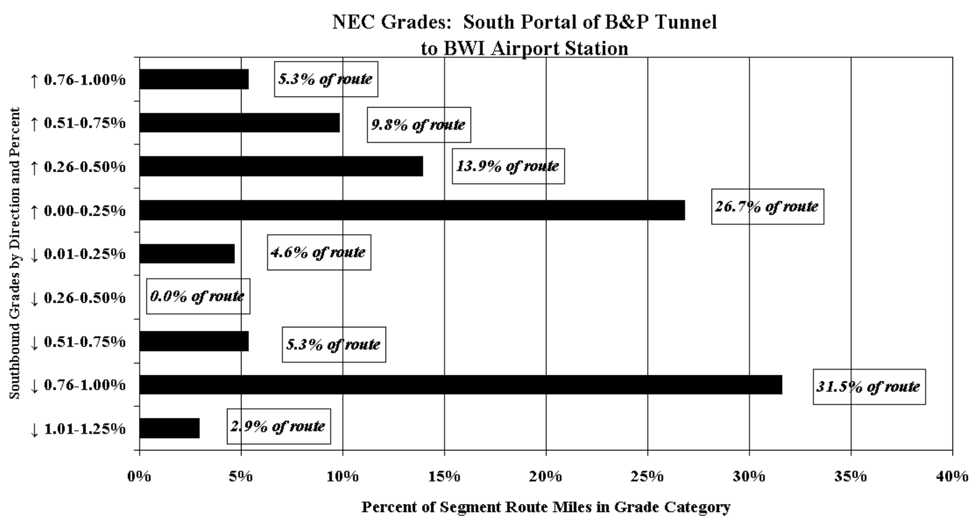
[49] A short downhill segment of less than ¾-mile is located approximately three miles into the segment.
[50] These elevations are derived from a 1949 B&O track chart.

Figure 3 - 21: Prevalence of Grades of Varying Severity on the NEC







The most restrictive grade between Philadelphia and Washington on the NEC is located in the B&P Tunnel, a series of three tunnels spanning 7,669 feet, separated by two short open cuts. Southbound trains entering the tunnels slow for a sharp curve, then ascend a mile-long 1.34 percent grade.

(3) NEC: South of B&P Tunnel (MP 97.7) to BWI (MP 106.3)

The grades south of the B&P Tunnel are steeper than the grades located north of the Union Tunnels.[51] The steepest grade, downhill 1.24 percent (MP 100 to 100.3), is located south of Wilkins Avenue.

I. Recap: Net effect of fixed plant on operations and their costs

As the main line for most freight and all passenger traffic by rail along the East Coast, the twin CSXT and NEC routes through Baltimore perform the same function as Interstate 95 does in the highway grid—with a critical difference: whereas I-95 has many nearby parallel routing options, there is no other rail option for through passenger service and, some sixty miles to the west, only a limited and circuitous parallel route for NS freight traffic. Indeed, CSXT has no other north-south option along the East Coast for its freight. Yet despite the criticality of the rail infrastructure through Baltimore, its design—last updated a century-and-a-quarter ago, with substandard engineering even for the 19th century—falls short of 21st century needs in the following ways:

- **Speed.** Freight trains must crawl through several miles of trackage at a maximum speed of 25 to 30 mph, where grades permit even that much; passenger trains lose valuable minutes in excruciatingly slow negotiation of the approaches to and from Pennsylvania Station. (By contrast, the Fort McHenry Tunnel of I-95 offers a 55 mph speed limit.)
- **Throughput capacity.** The main (CSXT) freight line through Baltimore is single-tracked, and the use of helper locomotives further reduces its capacity. The through (NEC) passenger route has only two tracks through the B&P Tunnel, to accommodate a growing mixture of commuter, high-speed, and conventional passenger trains that, with freight service, makes active use of three and four tracks elsewhere on the NEC. (By contrast, there are eight lanes in the Fort McHenry tunnel, four lanes in the Baltimore Harbor Tunnel, four lanes on the outer harbor crossing, and approximately six lanes on the Baltimore Beltway around the city to the north, for a total of 22 highway lanes through and around Baltimore.)
- **Loading flexibility.** Neither freight route accommodates the most modern, high-value freight cars (Plate H) with double-stacked containers or triple auto racks. In addition, the NEC cannot accommodate any cars exceeding Plate C, such as larger box cars or single-level trailers.

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[51] The rail line south of Baltimore is located in the Western Shore Uplands Region, while the line north of Baltimore is located in the Western Shore Lowlands Region and borders tidewater over much of its length.

- **Interoperability.** The CSXT and NEC routes through Baltimore City are essentially independent of each other. There is no expeditious way to operate CSXT freight traffic over the NEC, NEC freight traffic over CSXT, or any passenger traffic over the parallel route.[52] This situation reflects clearance differences, track layouts, and the status of operating rights. The lack of interoperability came to the fore in the Howard Street Tunnel fire, when CSXT had to route trains via Cleveland, Ohio (see Chapter Two, Box 2-2).
- **Interconnectivity within, and competitiveness of, Port of Baltimore.** Due to capacity, speed, and loading constraints, all-rail freight movements between the northeast and southwest parts of the Port of Baltimore are difficult and costly to accomplish. Furthermore, due to clearance inhibitions, the northeast part of the Port cannot route many types of shipments west via the CSXT, and the southwest part has similar limitations to use of the NS. This lack of connectivity and routing flexibility detracts from the Port's efficiency and attractiveness.
- **Externalities.** Inefficiency has its costs, and the antiquated rail link through Baltimore has implications for the general public as well as for the carriers and shippers involved. While measurement of these external costs was beyond the resources of this study, they merit at least a listing:

Costs to the general public:

— Highway congestion and its time, energy, and emissions costs due to the substitution of trucking for inefficient or impracticable rail freight moves across, to, and from Baltimore; as well as on highway corridors outside the study region, the truck traffic of which is influenced by the constraints inherent in the Baltimore rail system;

— Highway congestion and its costs due to rail's inability to further reduce its passenger trip times, enhance its reliability, and divert more automobile traffic;

— Reduced economic activity at the Port and in the Baltimore Region due to the constraints on its rail access;

— Constraints on access to BWI Airport due to limited rail capacity.

Costs to rail users:

— Added shipping and inventory costs for shippers due to the limitations and inefficiencies in rail freight transit across, and service to, Baltimore. Because this is the main East Coast rail link, these costs are also borne by shippers distant from Baltimore itself;

— Time-penalties for intercity rail passengers and commuters due to the slow running through Baltimore.

[52] Connections do exist for limited freight interchange, but these are not designed for through traffic purposes.

Costs to carriers:

— Added costs to freight railroads due to inefficiencies in their Baltimore operation;

— Opportunity costs of freight traffic lost due to capacity, speed, and loading constraints;

— Added costs to freight railroads due to circuitous routings around Baltimore;

— Added operating and maintenance costs to Amtrak and MARC due to the slow, difficult, and antiquated transit of Baltimore; and

— Opportunity costs of passenger traffic lost by Amtrak and MARC to other modes, due to extended rail travel times through Baltimore (see Figure 3 - 18).

Chapter Four
TRAFFIC LEVELS

Using the infrastructure, with its limitations, as portrayed in Chapter Three, the railroad companies manufacture their product—passenger and freight transportation—and thus generate their revenue by serving their customers. Of concern in this study are not only the present levels of rail traffic, but also those of the foreseeable future, since any contemplated restructuring must be assumed to remain in service for at least as long as the nineteenth-century B&P and Howard Street tunnels have thus far endured. Furthermore, insofar as engineering economy will allow, restructuring alternatives should provide for future expansion *beyond* foreseeable service levels, so as to reduce the investment that future generations may be forced to make the preserve the fluidity of their railway network.

After characterizing the region's rail traffic as a whole, the following sections examine each of the major traffic types in turn, both in their present and future aspects. The forecasts make use of various planning horizons ending with the "planning year," 2050. (In the context of this particular study, forty-five years into the future is not a very long time: it is only one-third the age of the present B&P Tunnel.) The chapter ends with a recapitulation of the levels of *total* traffic, passenger and freight, which the network bears currently and must be expected to handle in the future.

A. Overview of the existing operation

This section introduces the discussion of traffic levels by summarizing the types and quality of the transportation currently performed.

1. The traffic mix

Illustrating the diversity and complexity of the rail traffic mix to, from, within, and through the Baltimore region is the following partial list of today's train movements:

- Through and local freight train operations of CSXT between the Camden Station vicinity and Bay View Yard, via the Howard Street Tunnel;
- CSXT through-freight operations between Bay View Yard and West Aikin, an interlocking station east of the Susquehanna River;
- Amtrak passenger and NS through-freight operations between Perryville and the NS Bay View Yard in East Baltimore;
- CSXT freight operations and MARC commuter operations between the Camden Station area and Washington, D.C.;
- Intercity passenger and commuter rail operations through the B&P Tunnel and southward to Washington Union Station;

- CSXT and NS local freight yards and related movements in the Baltimore Terminal area; and
- Moves to and from the Canton and P&BR railroads and Maryland Port Administration and private port facilities, in places not readily accessible from the CSXT and NEC main lines.

2. Service quality

a. On the NEC

Even prior to marked traffic increases foreseen by 2050, the on-time performance of intercity passenger services on the NEC falls short of world-class standards. Of the corridor trains serving Baltimore, only one-third arrive at their final destination (usually Washington, New York, or Boston) punctually to schedule.[1] The two-thirds of trains that are late, are on average some 20 minutes late at their final terminals. Many and varied are the reasons for this performance: congestion elsewhere than in the Baltimore region, mechanical difficulties, failures in various system components such as downed electric traction wires, and heavy usage of portions of the NEC not controlled by Amtrak—all play their role. But the cramped, old, and convoluted facilities in Baltimore do not alleviate the present, and can do nothing to relieve the prospective, performance challenges faced by Amtrak in its most important corridor. On the other hand, NS freight operations between Perryville and Baltimore are regarded as relatively reliable.

b. On CSXT

MARC commuter passenger services between Baltimore and Washington on CSXT, as well as CSXT freight operations between Philadelphia and Washington, incur delays on a regular basis. The lack of capacity to operate existing levels of service is at issue. Over the years, analyses repeatedly have identified choke points, such as the Howard Street Tunnel and the lack of track capacity between Baltimore and Washington.

The freight-only CSXT mainline between Perryville and Baltimore exemplifies the day-to-day difficulties of many railway operations in the study area. Single-tracked except for several short segments of double-track, the route is equipped with automatic block signals. Freight trains use one or more of the main tracks at Bay View Yard (East Baltimore) and locations in West Baltimore to set off and pick up cars. These operations consume track capacity and result in conflicts with other trains. Southbound freights that are unable to access Track 2 adjacent to Bay View Yard to set off and pick up, are held on the signaled siding at Van Bibber, further consuming capacity. Under these circumstances, with so little margin of operating error over a fixed plant that presents challenges even when traffic is flowing smoothly, delays on the CSXT freight line north of Baltimore can snowball, thus affecting freight and passenger flows on CSXT's larger network.

Capacity and service issues like these reinforce the need for a careful scrutiny of the traffic patterns in the study region as a whole.

[1] That is, exactly on time or before time. These figures include no allowance for lateness.

B. Passenger services

Passenger services in the study region include Amtrak's intercity trains (corridor and long-distance) as well as MARC's commuter operations. These are described below.

1. Intercity passenger trains

As the owner as well as the operator of the NEC, Amtrak currently operates all intercity passenger trains in the Perryville–Baltimore–Washington corridor. Heavy frequencies and high speeds (up to 125 mph) characterize Amtrak service south of New York City.

Amtrak provides two types of intercity passenger service in the NEC: corridor-type services linking Boston, New York City, Philadelphia, Washington, Richmond, and intermediate points, and longer-distance services to and from points south of Washington and Richmond. In general, the corridor trains have fewer, and the longer-distance trains have greater, passenger amenities, in keeping with the contrasting journey lengths of the respective clienteles. This basic operational pattern of intercity passenger service is assumed, for analytical purposes, to continue indefinitely into the future, irrespective of any institutional changes that may occur.

a. Existing traffic levels—Intercity Passenger

(1) Corridor Services

Amtrak presently operates three categories of corridor service on the NEC[2]:

- **High-Speed.** *Acela* is Amtrak's premium high-speed service, making a limited number of intermediate stops between Boston, New York City, and Washington. *Acela* offers reserved First Class and Business Class seating. Scheduled trip times between New York and Washington range between 2 hours 42 minutes and 2 hours 52 minutes.[3] *Metroliner* service is similar to *Acela*, but uses conventional Amfleet equipment. *Metroliners* have a limited number of intermediate stops between New York and Washington, D.C. Current scheduled trip times range between 2 hours 55 minutes and 3 hours 5 minutes.
- ***Regional*** – Amtrak's frequent *Regional* service provides numerous intermediate stops between Boston, New York City, and Washington, with selected trains continuing on to Richmond and Newport News, Virginia. *Regional* offers Business Class and coach seating. Current scheduled trip times between New York and Washington exceed three hours and vary according to the number of scheduled stops and the time of day. A single train[4] in both directions has traditionally operated overnight between Boston and Washington, with either connecting or through train arrangements for traffic to and from Richmond and Newport News. Amtrak groups all these conventional train services together under the category *"Regional."*

[2] The following discussion refers to, and assumes, Amtrak's normative schedules, with *Acela* equipment in full, active service. As this report goes to press (mid-2005), an extraordinary and, it is assumed, temporary hiatus in *Acela* service prevails, due to equipment difficulties.
[3] All times are as of 2003, when the analyses for this report were completed.
[4] This train, formerly named *The Federal*, has no sleeping car as this report goes to press.

(2) Extended Corridor Services

"Extended corridor" services operate in daylight over distances of some 600-650 miles or more, with modest amenities and no first-class accommodations. At present Amtrak operates three extended corridor trains over the NEC:

- The ***Palmetto***, between New York and Savannah, Georgia;
- The ***Carolinian***, linking the NEC with destinations in Virginia and North Carolina; and
- The ***Vermonter***, between Washington and northern Vermont.

(3) Overnight services

Typically offering sleeping, dining, and lounge car facilities, Amtrak's overnight trains mainly accommodate long-distance travel, although some shorter-distance markets are served where schedules permit:

- ***Silver Service*** **–** Amtrak's Silver Service operates two overnight round-trip trains (*Silver Meteor*, *Silver Star*) linking the NEC with destinations in Florida, Georgia, South Carolina, North Carolina, and Virginia.
- ***Crescent*** **–** Amtrak's Crescent links the NEC with destinations in Virginia, North Carolina, South Carolina, Alabama, Mississippi, and Louisiana.

Amtrak's existing service offering in the Northeast Corridor via Baltimore is summarized in Table 4 - 1. That the importance of this service to Amtrak cannot be overemphasized becomes clear in Box 4 - 1.

Table 4 - 1: Existing Intercity Passenger Train Service Through Baltimore

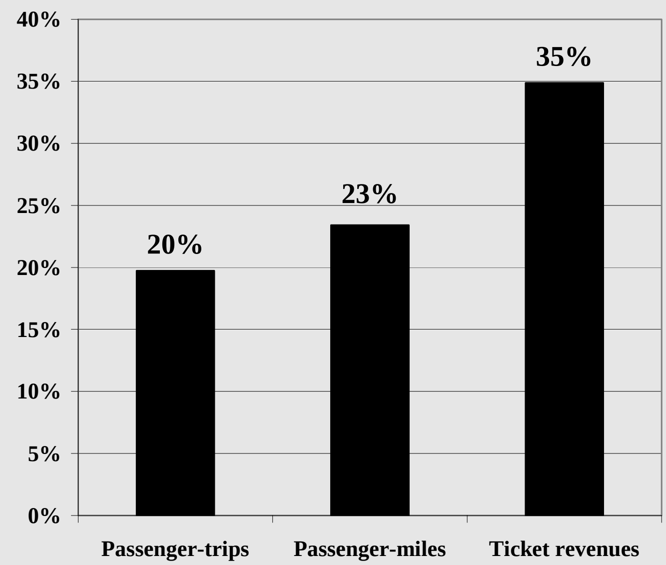
Market Served	Train	Line of Business	Northern Terminus	Southern Terminus
Northeast Corridor/ Virginia	*Acela*	Corridor	Boston	Washington
	Metroliner	Corridor	New York	Washington
	Regional	Corridor	Boston	Washington/Richmond/ Newport News
Northeast Corridor–Georgia–Florida	*Palmetto*	Extended Corridor	New York	Savannah
	Silver Star	Overnight	New York	Florida
	Silver Meteor	Overnight	New York	Florida
Northeast Corridor–North Carolina	*Carolinian*	Extended Corridor	New York	Charlotte
Northeast Corridor–New Orleans	*Crescent*	Overnight	New York	Atlanta/New Orleans
Northeast Corridor–Vermont	*Vermonter*	Extended Corridor	St. Albans, VT	Washington

Box 4-1: **Importance of the Baltimore Tunnels to Amtrak**

Amtrak's route through Baltimore is crucial to the viability of all intercity rail passenger service in the United States. As demonstrated in the chart below, fully one-fifth of Amtrak's passenger-trips, one-quarter of its total passenger-miles, and *over one-third of its total ticket revenues* stem from trips making use of at least one of the NEC's Baltimore tunnels. Most of these trips depend on *both* the B&P and Union tunnels.

Figure 4 - 1:

Percentage of Amtrak's Total Traffic Dependent on One or Both of the NEC's Baltimore Tunnels
(Percentages are for 2004.)



b. Projections—Intercity Passenger

Amtrak has developed a 2015 planning timetable that contains corridor-type (high-speed[5] and *Regional*), extended corridor, and overnight services—the same types that exist today. Amtrak expects its train volumes (total movements in both directions) to increase from 2003 to 2015 at a 0.43 percent annual compound rate—from 96 daily trains to 101 daily trains by 2015. From 2015 to 2050, Amtrak train volumes are assumed to grow at a lower annual rate of 0.24 percent, which yields 110 trains per day by 2050—the assumed upper limit of the NEC's intercity passenger capacity. Significant investment, both in equipment and in bottleneck amelioration, would be required to support that growth rate. Operating longer intercity trains would accommodate some of the market's growth; for example, the *Acela* trainsets were designed to include up to 10 cars, thereby increasing available seating by approximately 85 percent over the present 6-car trainset. Throughput capacity in Pennsylvania Station, New York, constrains NEC operations during peak hours and would require attention and equitable resolution by all participating carriers, in order to assure reliable intercity service under the increased frequency assumptions of this report.

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[5] I.e., Acela and Metroliner-type services

This report assumes that all intercity passenger trains in the study region will continue to operate (a) through Baltimore and (b) on the NEC. No intercity passenger trains would originate or terminate in Baltimore, nor would there be any restoration of intercity service on the CSXT in the area under examination.

Table 4 - 2 summarizes the intercity passenger train volumes projected for 2050 and considered in this study. No increase in the number of overnight trains is foreseen. However, this study assumes that—

- Corridor train movements would increase to 90 per day;
- Extended corridor services in the New York–Charlotte traffic lane would grow to eight movements per day;
- A new daylight round trip (two movements) would be instituted in the extended corridor between New York and Atlanta; and
- All other extended corridor services would retain their existing frequencies.

Table 4 - 2: Projected Intercity Passenger Train Service Through Baltimore, 2050

Market Served	**Train**	**Line of Business**	**Northern Terminus**	**SouthernTerminus**	**Train Volume (Weekday)**	
					Round Trips	**Train Operations**
Northeast Corridor/Virginia	*Acela-type*	Corridor	Boston	Washington	23	46
	Regional (includes Virginia service)	Corridor	Boston	Washington/ Richmond/ Newport News	22	44
Northeast Corridor-Georgia-Florida	*Palmetto*	Extended Corridor	New York	Savannah	1	2
	Silver Star	Overnight	New York	Florida	1	2
	Silver Meteor	Overnight	New York	Florida	1	2
Northeast Corridor-North Carolina	*Carolinian*	Extended Corridor	New York	Charlotte	4	8
Northeast Corridor-Atlanta-New Orleans	*Crescent*	Overnight	New York	Atlanta/New Orleans	1	2
	Daylight train	Extended Corridor	New York	Atlanta	1	2
Northeast Corridor-Vermont	*Vermonter*	Extended Corridor	St. Albans, VT	Washington	1	2
Total projected intercity passenger train volumes, 2050					**55**	**110**

2. Commuter service

As shown in Figure 4 - 2, the Maryland Department of Transportation, Mass Transit Administration, operates an extensive commuter rail network through the study region: two lines between Baltimore and Washington ("Camden Line" via CSXT, "Penn Line" via NEC), and an extension of the Penn Line between Perryville (on the Susquehanna River) and Baltimore (with service to and from Washington). Additional services, not directly affecting Baltimore, operate northwest from Washington over CSXT's Metropolitan Subdivision to Montgomery County, Brunswick, and Frederick (Maryland) and to Martinsburg (West Virginia). Table 4 - 3 presents some of MARC's vital statistics.

Figure 4 - 2: MARC System of Commuter Lines

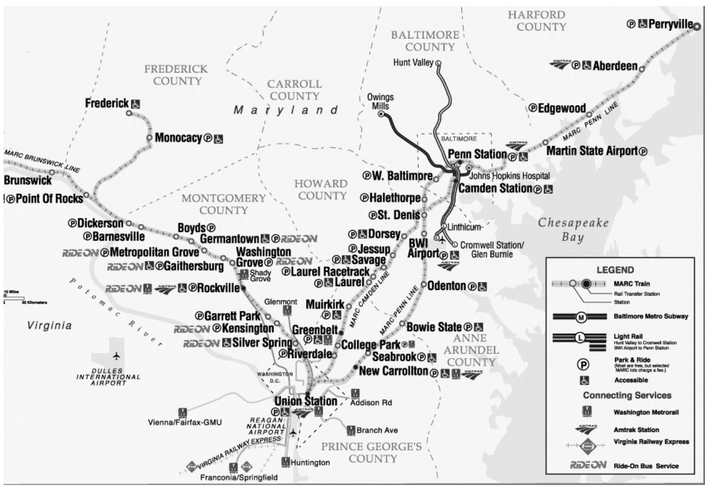

Table 4 - 3: Statistical Snapshot of MARC, 2001[6]

Operating Expense	$49,158,496
Capital Funding	$41,544,868
Annual Passenger Miles	175,191,930
Annual Vehicle Revenue Miles	4,438,031
Annual Unlinked Trips	5,816,975
Average Weekday Unlinked Trips	22,901
Annual Vehicle Revenue Hours	110,750
Fixed Guideway Directional Route-Miles	373
Vehicles Available for Maximum Service	140
Average Fleet Age in Years	12.2
Vehicles Operated in Maximum Service	110
Peak to Base Ratio	2.2
Percent Spares	27%
Incidents	61
Patron Fatalities	0

a. Existing traffic levels—Commuter

Most of today's commuter operations are not recent additions, as the former B&O and PRR offered local services in this region; however, today's rush hour frequencies are greater than those of the mid-1950s.[7] Thus, today's commuter services impose a relatively new pressure on the available capacity of the rail infrastructure, which has not changed in most respects in the intervening decades. The pressure is all the more intense because of the concentration of both intercity and commuter traffic in the rush hours, particularly in the afternoon.

[6] Source: Federal Transit Administration, National Transit Database, 2001, Maryland MTA section, "Commuter Rail."

[7] For example, in 1956, the PRR offered only two afternoon rush-hour (between 4 and 6 p.m.) local departures from Washington to Baltimore; today's Penn Line offers five such departures. The B&O offered two local departures in the same hours from Washington to Baltimore; MARC's Camden line today offers four such departures. Thus today's rush hour frequencies are at least double those of 1956. *Official Guide of the Railways*, July 1956, pp. 339 (PRR) and 428 (B&O); today's MARC schedules from the Maryland MTA web page, http://www.mtamaryland.com/services/marc.

b. Projections—Commuter

Over the entire planning period, commuter operations are expected to grow at an annual compounded growth rate of about one percent for the long-established Camden and Penn (Baltimore–Washington) lines, and at a rate just short of two percent for the newer Penn line extension between Perryville and Baltimore. However, the Baltimore–Washington commuter operations are expected to remain much more frequent than the service north of Baltimore. (See Table 4 - 4.) The expected frequency increases reflect MARC's 2020 planning timetable, extrapolated to 2050 at sharply reduced growth rates for the Camden and Perryville routes, and at a slightly increased rate for the Penn (Baltimore–Washington) segment. That these growth rates are relatively modest results from the assumed use of longer, higher-capacity trains to satisfy surging demand.

All told, the study team expects commuter train volumes on existing services to double, approximately, between 2003 and 2050. Thus, in any further elaboration of the present study, the Camden and Penn Line commuter projections will have to be compared in detail with likely CSXT, NS, and Amtrak traffic levels to determine the level of capacity improvements that would be necessary to protect the reliability and frequency of all services. Furthermore, since the Baltimore region has numerous rail lines, a widely distributed population, and severe motor vehicle congestion, new commuter services also are possible by 2050. The feasibility and cost of any such new services would relate closely to comprehensive planning for rail operations and facilities in the study area.

Table 4 - 4: Projected Growth in MARC Commuter Traffic

Route	Round trips per weekday			Train operations per weekday			Average annual compounded growth rates		
	2003	2020	2050	2003	2020	2050	Period 2003-2020	Period 2020-2050	Average, 2003-2050
MARC Camden Line (via CSXT)—Baltimore and Washington[8]	11	16.5	18.5	22	33	37	2.41%	0.40%	1.1%
MARC Penn Line (via NEC)—Perryville and Baltimore[9]	8	12.0	19	16	24	38	2.42%	1.54%	1.9%
MARC Penn Line (via NEC)—Baltimore and Washington	22.5	26.5	39	45	53	78	0.95%	1.31%	1.2%

[8] Does not include any deadhead moves (nonrevenue round trips) between Riverside Yard and Camden Station.
[9] Includes 6 deadhead trains (the equivalent of 3 nonrevenue round trips) between Baltimore and Perryville in the base year. The proportion of deadhead to total movements in future years will depend on MARC's operational planning and the availability of storage facilities at appropriate locations.

C. Freight services

The following discussion treats the existing and projected freight services in the Baltimore region.

1. Existing traffic levels

The predominant rail freight operations in and through the region are those of its two primary Class I carriers, CSXT and NS.[10] However, smaller railroads provide important localized services as well, the protection and furtherance of which will require close attention in any further planning.

a. CSXT

CSXT operates through and local freight services over the length of the study corridor. The route traverses the Baltimore Terminal, which consists of the Howard Street Tunnel, its approaches, and a series of yards and branches that serve local customers and the Port of Baltimore. (CSXT also provides rail service to the Morgantown and Chalk Point Power Plants located on the Popes Creek Branch, which intersects the NEC at Bowie; the unit coal trains operate through Benning Yard, Landover, and Bowie.)

b. NS via NEC

NS currently provides through and local freight service between Harrisburg and Baltimore on the NEC. From Harrisburg, through freight and unit coal trains operate via the "Port Road" along the Susquehanna River to Perryville, and thence via the NEC to the NS Bay View Yard. NS operates local freight trains from Bay View Yard to locations south of the B&P Tunnel. NS has overhead rights to operate between Baltimore and Alexandria, Virginia, thence to Manassas and the southeastern United States on its Piedmont Division. Presently, NS does not operate through freight trains between Bay View and Alexandria.[11]

Most of the comparatively slow freight service on the corridor operates at night to avoid conflicts with the much faster intercity and slightly faster commuter trains. In fact, Amtrak restricts all freight trains to a maximum speed of 30 mph between 6:00 AM and 10:00 PM. Amtrak permits solid intermodal trains and solid empty hopper trains to operate at various speeds up to 50 mph between 10:00 PM and 6:00 AM.

c. Local movements

The Patapsco & Back Rivers (P&BR) and Canton railroads provide important local movements to and from port and industrial sites on the east side of Baltimore Harbor. Access between these smaller carriers, the CSXT and NS, and local industrial and port facilities is provided by means of various interchange and switching arrangements worked out among the

[10] In addition, the Delaware and Hudson Railway (D&H), part of the CP Rail System, has overhead trackage rights over the NEC from Perryville to Alexandria, Virginia, to permit it to interchange with railroads serving the southeastern United States. The D&H currently operates over the NEC south of Perryville on an irregular basis and is not presently a major factor in the Baltimore region.

[11] CSXT operates unit coal trains over its lines to Benning Yard in D.C., whence CSXT makes use of the NEC to access the Popes Creek Branch at Bowie, Maryland. This movement does not involve trackage in Baltimore.

carriers and industries. In addition, CSXT and NS need to interchange freight among themselves, and move cars between the two sides of the port. All these additional movements are over and above those shown in the summary table of daily train operations (Table 4 - 1), further below.

2. Projections—Freight

Forecasts of future freight traffic through Baltimore are uncommonly hazardous because—

- Provision of a modernized facility with improved clearances, grades, and curves will constitute a marked “paradigm shift” that will open the door to new traffic flows—originating, terminating, through, and local. Standard forecasting methods are of uncertain value in such a situation.
- Developments in the rail industry—for instance, mergers or improvements in other parts of the grid—could alter some freight traffic flows; and
- The future of heavy industry in Baltimore and its neighboring regions is unclear, as the closing of General Motors’ Baltimore assembly plant in May 2005 exemplifies.

In making the following projections, the study team assumed no major structural change in America’s freight railroad industry and no significant shift in the economic base of the Baltimore region or, indeed, of the Northeast Corridor megalopolis. Any such fundamental modifications would, of course, affect the projections and might alter the conclusions of any follow-on studies.

a. Underlying growth in freight volumes

Freight train-miles (FTMs) by service type constitute the appropriate unit of measure for this study because the number and performance of trains is the primary, but not the only, determinant of capacity. Such other measures as train weight and length also have a role in the design of betterments—for example, in the determination of siding length.

The four basic service types are:

- “Premium”—intermodal, i.e. trailers or containers;
- “Unit”—single-commodity, e.g. coal;
- “Merchandise”—all other through freight; and
- “Local”—operating within the study area.

Table 4 - 5 summarizes the annual compound growth rates that were applied to both CSXT and NS traffic levels, before some carrier- and site-specific adjustments came into play.

Table 4 - 5: Projected Annual Growth Rates in Freight Train-Miles

	Service Type							
	Premium		Unit		Merchandise		Local	
Time Period	Low	High	Low	High	Low	High	Low	High
2001 – 2007	1.23%		1.16%		1.19%		1.19%	
2007 – 2012	0.85%	1.36%	0.58%	0.93%	0.67%	1.07%	0.67%	1.07%
2012 – 2020	0.85%	1.36%	0.58%	0.93%	0.67%	1.07%	0.67%	1.07%
2020 – 2030	1.00%	1.61%	0.53%	0.86%	0.78%	1.25%	0.67%	1.07%
2030 – 2050	0.89%	1.43%	0.53%	0.86%	0.67%	1.07%	0.67%	1.07%

The projections in Table 4 - 5 reflect those provided by CSXT[12] by train type for the period 2001-2007. The post-2007 projections use, as their upper limit for the "high" case, the historical growth in tonnage for the Eastern Class I railroads (1.6 percent compounded annually between 1985 and 2001); this maximum growth rate is adjusted downward to acknowledge long-term increases in tonnage per train. The "low" case assumes growth rates on the order of two-thirds of the "high."

Train-miles in premium service are expected to grow relatively quickly after 2020 on the assumption that capacity and clearance improvements both within and adjoining the study region will allow a fuller range of auto rack and double-stack container cars to pass through Baltimore, thus allowing rail better to compete with truckers in the I-95 and I-81 corridors. By contrast, growth in unit-train volumes would lag behind that of other service types; while traffic may increase in such cargos as municipal solid waste, reductions in coal use for electric power generation are ultimately possible for environmental reasons.

b. Site- and carrier-specific projections

Beyond the general projections of freight traffic increases, the study team assumed that NS would, by 2020, divert from its Shenandoah Valley–Manassas–Hagerstown routing a pair of merchandise trains and a pair of premium intermodal trains between Alexandria, Virginia and Perryville, Maryland via the NEC through Baltimore.[13] Also assumed was the diversion of a

[12] NS provided no projections but, warning of the volatility of any such forecasts, took no exception to those adopted in this report. Letter from Steve Eisenach, NS's Director of Strategic Planning, to Richard U. Cogswell of FRA, August 25, 2003.

[13] These trains would make use of NS's trackage rights over the freight route through Washington, D.C., as well as NS's freight line between Anacostia and Landover. CSXT currently owns the entire railroad from Alexandria (where the junction with the NS lies south of the passenger station), across the Potomac River on the Long Bridge, through Southwest D.C., and via the Virginia Avenue Tunnel and the bridge over the Anacostia River to the junction with the NS freight route to Landover and the NEC. Historically, however, most of the route belonged to the PRR,

second pair of merchandise trains and a second pair of premium intermodal trains by 2030. This rerouting anticipates both the physical improvements mentioned above and a resolution—mutually beneficial to both the NEC's owner and NS—of the cost of, and appropriate time slots for, running freight on the high-speed passenger corridor north of Washington.

c. Distribution of freight train volume by segment and traffic lane

In the study area, CSXT originates and terminates numerous trains to and from the west and south, and fewer trains to and from the east and north. Numerous CSXT trains operate through Baltimore. It is projected that these patterns will continue.

NS presently originates local trains in Baltimore that operate between Baltimore and Washington and return. While NS has the rights to operate trains between Baltimore and Alexandria (Virginia) using CSXT tracks south of Landover, Maryland, it presently does not do so. Thus, all NS through-freight trains presently operate between Baltimore, Perryville, and Harrisburg (Pennsylvania). As mentioned above, it is anticipated that the implementation of capacity and clearance improvements through Washington and Baltimore would result in an increase in the number of NS trains routed to Baltimore, via Alexandria and Washington.

d. Detailed projections of freight volumes

Table 4 - 6 provides a breakdown of expected freight train volumes by segment, railroad, and type of freight service.

The study team regards these freight projections as balanced between optimism and pessimism—as taking into account both the historical trend lines in tonnage and train payloads, and recent evidence of transition from manufacturing to service in certain sectors of the economy of the Middle Atlantic States. However, in such a case as that of Baltimore, there is a danger in equating "balanced," even "low" traffic projections with "conservatism." To under-design a multi-billion dollar facility that will, if the past is any guide, likely serve the Nation for well over a hundred years, could lead to a recurrence of today's impasse and hobble commerce for many decades—until a future generation restudies the situation and invests in a "fix." Moreover, the incremental cost of added capacity in a project of this magnitude is far less than that of a future expansion, at least in current-dollar terms—particularly if the initial design makes cost-effective provision for possible future expansions. For these reasons, it will be important in any future studies to test a range of traffic assumptions and determine the related costs and benefits of various levels of capacity and utility.

Penn Central, and Conrail, and passed into CSXT's ownership (with the NS trackage rights) at the time of the Conrail breakup.

Table 4 - 6: Detailed Projections of Freight Traffic by Railroad, Segment, and Year

[NOTE: Low and high projections were only done for 2012 and later years. Totals may not add precisely due to rounding.]

CSXT: Aikin to Baltimore	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	7	8	8	8	9	9	10	11	12	15
Unit	4	5	5	5	5	5	5	6	6	7
Merchandise	9	9	9	10	10	10	11	12	12	15
Locals	0	0	0	0	0	0	0	0	0	1
Freight Total	21	22	22	23	24	25	26	29	31	37

NEC: Perryville to Baltimore (all NS trains)	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	3	4	4	4	4	4	7	7	11	13
Premium - *rerouted*					2	2	2	2		
Unit	2	2	2	2	2	2	2	3	3	3
Merchandise	2	2	2	2	2	2	5	5	8	9
Merchandise - *rerouted*					2	2	2	2		
Locals	1	1	2	2	2	2	2	2	2	2
Freight Total	9	9	10	10	14	15	20	21	23	27

CSXT: Washington to Baltimore	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	14	15	15	16	16	18	18	21	22	28
Unit	6	6	6	7	7	7	7	8	8	9
Merchandise	10	11	11	11	12	12	13	14	15	18
Locals	1	1	1	1	1	1	1	1	1	1
Freight Total	31	33	33	35	36	38	39	44	46	56

NEC: Washington to Baltimore (NS trains except as indicated)	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	0	0	0	0	0	0	2	2	5	5
Premium - *rerouted*					2	2	2	2		
Unit[14]	0	0	0	0	0	0	0	0	0	0
Merchandise	0	0	0	0	0	0	2	2	5	5
Merchandise - *rerouted*					2	2	2	2		
Locals	2	2	2	2	2	2	2	2	2	3
Freight Total	2	2	2	2	6	6	10	10	12	13

[14] CSXT unit coal trains that originate west of Brunswick, Maryland and use the NEC between Washington, Bowie (Maryland), and the Popes Creek Branch, are excluded from this table as they do not pass through the Baltimore region.

D. Total train movements, all traffic types

Both the CSXT and NEC main lines are largely multipurpose facilities and will most likely remain so.[15] Thus, the interaction among train types, and the total traffic burden to be borne by each facility, are important considerations in planning. The following sections, therefore, consolidate the traffic statistics and projections for the main facilities under analysis.

1. Existing traffic levels

Table 4 - 7 portrays the average weekday traffic, in terms of total train operations in both directions, over the main line railroads in the study area.

Passenger operations are almost always scheduled in advance and relatively easy to characterize accurately. Freight operations, however, are less predictable than passenger services, in terms of arrival and departure times, train size, and frequency in a given period. Freight trains' performance capabilities vary significantly; so does their compatibility with passenger trains. For example, unit trains (carrying coal and grain) generally have a lower horsepower-to-tonnage ratio than more time-sensitive trains; the former are usually restricted to lower speeds than the latter. Thus, a general merchandise or intermodal train ordinarily takes less time to clear a given route segment than a unit coal train. An intermodal train (with an average speed of approximately 45 mph) takes less time to clear a give route than a commuter train, which makes frequent stops. Readers should bear these factors in mind when reviewing Table 4 - 7 and similar traffic summaries. A railway route segment's capacity depends, not just on its physical layout and condition, —not just on the sheer number of trains it carries, —but on the complex interactions between a variety of train types of widely varying performance characteristics. This is especially true in the Baltimore region, with its diverse traffic mix.

2. Projections

Table 4 - 8 summarizes the mix of services as foreseen for the year 2050. The same projection appears in graphical form, with intermediate years' traffic levels, in Figure 4 - 3. Both displays make use of the "high" projections, which pertain to freight traffic only. An overview of the growth of total train movements for all rail services in the two major traffic lanes—north and south of Baltimore—appears in Figure 4 - 4**.**

The simple number of daily trains envisioned in Table 4 - 8 and Figure 4 - 3 for a typical 24-hour period does not adequately depict the potential congestion in the main lines of the study region. Intercity passenger trains are concentrated into an 18- rather than a 24-hour day, since operations between 11:00 p.m. and 5:00 a.m. are minimal. Furthermore, a business-oriented corridor such as the NEC, in which most trips are under 225 miles and take less than three hours, will tend toward a schedule with additional train departures at the start and end of the business day. Commuter trains have even more pronounced two- to three-hour morning

[15] However, as will be seen, specific restructuring alternatives may particular line segments to specialized roles.

Table 4 - 7: Existing Main Line Railroad Services in the Study Region[16]

(Number of Weekday Train Operations by Segment.[17] Total Both Directions—Round Trip Counts as Two Operations)

Type of Service	Via CSXT Main Line		Via NEC Main Line	
	Aikin – Baltimore	Baltimore–Washington	Perryville – Baltimore	Baltimore -Washington
Passenger				
Intercity				
Corridor-type services				
Acela Express			24	24
Metroliner			13	13
Regional (includes Virginia and "overnight" NEC services)			40	40
Total – Corridor Services			**77**	**77**
Extended corridor services				
NEC–North Carolina (*Carolinian*)			2	2
NEC–Georgia (*Palmetto*[18])			2	2
NEC–Vermont (*Vermonter*)			2	2
Total – Extended Corridor Services			**6**	**6**
Overnight services				
NEC–New Orleans (*Crescent*)			2	2
NEC–Florida (*Silver Service*)			4	4
Total – Overnight Services			**6**	**6**
Total Intercity Passenger			**89**	**89**
Commuter				
MARC Camden Line		22[19]		
MARC Penn Line (includes Perryville)			16[20]	45
Total commuter		**22**	**16**	**45**
Total Passenger Services		**22**	**105**	**134**
Freight [21]				
Operated by CSXT[22]	21	31	0	0
Operated by NS	0	0	9	2
Total Freight Services	**21**	**31**	**9**	**2**
Study Area Total	**21**	**53**	**114**	**136**

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16 Total trains on a typical weekday (round trips count as 2 trains). Because of the variability and directional imbalance of traffic flows, the numbers shown are estimates, and vary by day of week and season of year.

17 Data for freight and passenger operations apply generally to the period 2001-2003, during which significant long-term changes in service did not intervene.

18 Classification of the *Palmetto* as an "extended corridor" service actually began in 2004. In 2003, it was an overnight service that served Florida as well—but without sleeping car accommodations.

19 Does not include 10 "deadhead" i.e., nonrevenue train movements from Riverside Yard, Baltimore, to Camden Station.

20 Includes 6 deadhead trains between Baltimore and Perryville.

21 Includes through freights, locals, and coal trains.

22 CSXT unit coal trains that originate west of Brunswick, Maryland and use the NEC between Washington, Bowie (Maryland), and the Popes Creek Branch, are excluded from this table as they do not pass through the Baltimore region.

Table 4 - 8: Projected Main Line Railroad Services in the Study Region— 2050

(Number of Daily Train Operations by Segment, Total Both Directions. Round Trip = Two Operations.
NOTE: "High" and "Low" Ranges Apply Only to Freight.)

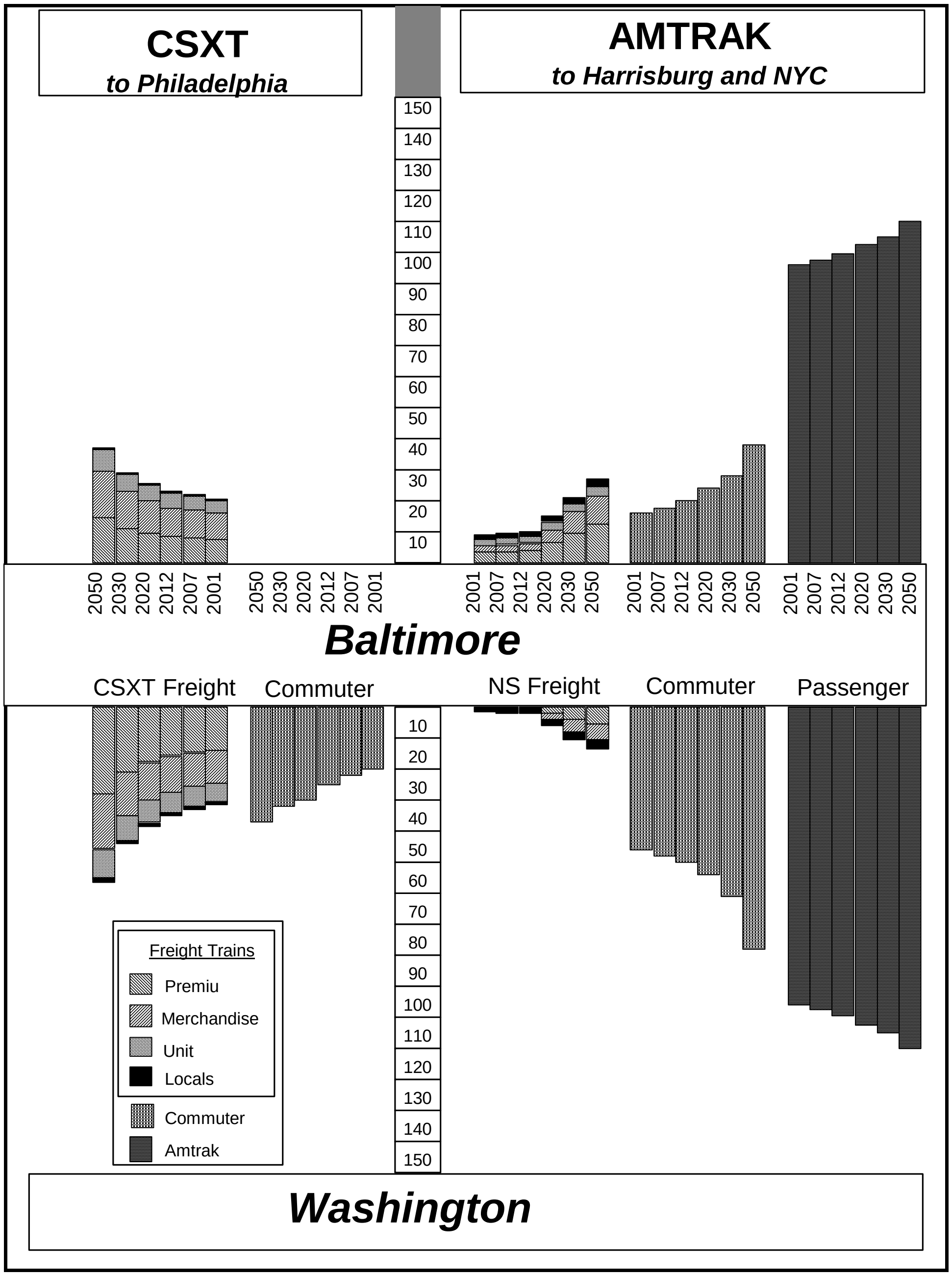
Type of Service	Via CSXT Main Line		Via NEC Main Line	
	Aikin-Baltimore	**Baltimore-Washington**	**Perryville-Baltimore**	**Baltimore-Washington**
Passenger Services				
Intercity				
Corridor	0	0	90	90
Extended corridor	0	0	14	14
Overnight	0	0	6	6
Total intercity	0	0	110	110
Commuter Services	0	37	38	78
Total passenger services	**0**	**37**	**148**	**188**
Freight services—*High Volume*[23]				
Operated by NS[24]			27	13
Operated by CSXT[25]	37	56[26]		
Total freight service—High Volume	**37**	**56**	**27**	**13**
Grand total, projected train operations with freight service at high volume	**37**	**93**	**175**	**201**
Freight services—*Low Volume*[23]				
Operated by NS[24]			23	12
Operated by CSXT[25]	31	46[26]		
Total freight service—Low Volume	**31**	**46**	**23**	**12**
Grand total, projected train operations with freight service at low volume	**31**	**83**	**171**	**200**

and evening peaks. Freight operations—typically unscheduled on American railroads—are not only random to a degree, but also subject to circumstances that may occur hundreds of miles away from the study area.[27] Thus, an assessment of the potential for congestion requires the analysis of the complex interactions of through freight, local freight, and passenger trains in congested portions of the study region over a typical week.[28] Such an in-depth analysis would

[23] With respect to freight traffic, which will show daily directional imbalances and volume fluctuations, the numbers shown must be regarded as projected daily averages over time.
[24] Includes through freights, locals, and coal trains.
[25] CSXT unit coal trains that originate west of Brunswick, Maryland and use the NEC between Washington, Bowie (Maryland), and the Popes Creek Branch, are excluded from this table as they do not pass through the Baltimore region.
[26] Includes trains south to Alexandria/Richmond and west to Cumberland.
[27] The same unpredictability currently affects Amtrak's overnight and extended corridor operations over the freight railroads, which then impact on NEC reliability.
[28] Multi-day simulations are necessary because of the variability of freight traffic. In any event, detailed capacity analyses of freight and passenger operations and interactions, in a terminal zone of Baltimore's complexity, would make use of computerized train performance and simulation models and were beyond the scope of the present study.

inevitably be part of follow-on studies, if a decision is made to pursue comprehensive rail alternatives for the Baltimore region. Any analysis of this type would also need to examine carefully local freight operations in the Baltimore Terminal Area, including the setting off and picking up of cars.

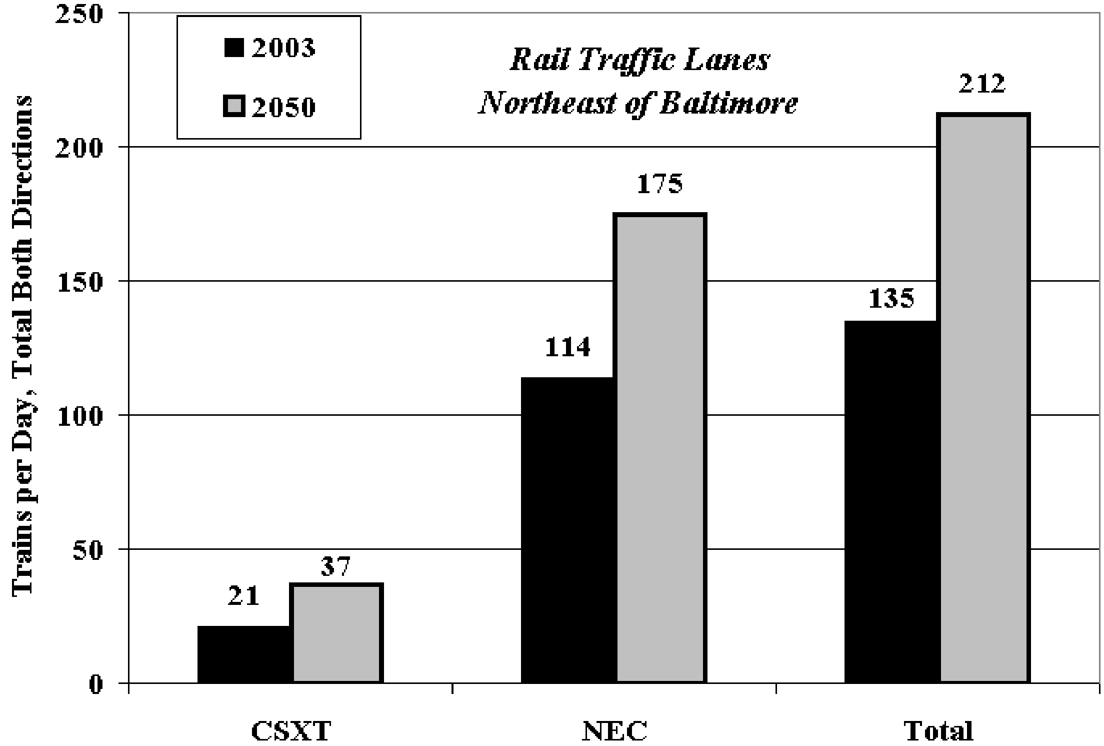
Figure 4 - 3: Expected Trends in Train Volumes in the Study Region by Year and Service Type, "High" Range[29]

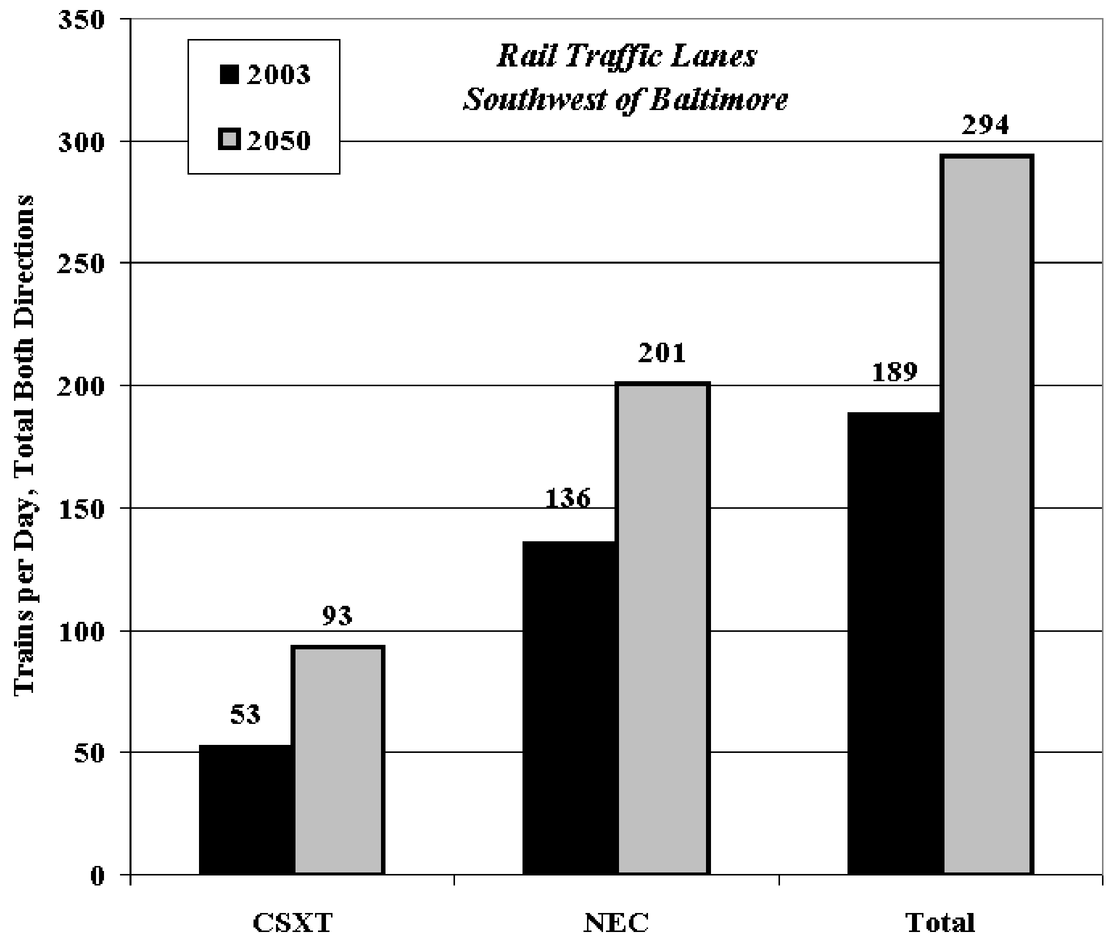


For recent examples of modeling techniques of this type, readers are referred to recent transportation planning reports by Amtrak and FRA on the Washington–Richmond, Philadelphia–Harrisburg, and Richmond–Charlotte corridors at http://www.fra.dot.gov/us/content/1240 .

[29] The "high" and "low" ranges pertain only to freight. See Table 4 - 8.

Figure 4 - 4: Overview of Expected Rail Volume Growth, All Service Types in the Baltimore–Northeast and Baltimore–Southwest Traffic Lanes
(With "High" Freight Traffic Levels)





E. Recapitulation: The challenges in brief

As Figure 4 - 4 demonstrates, the demand for total train movements of all types is expected to increase by over 50 percent by 2050 from its 2003 levels. In 2050, such a heightened pressure for transport would place a huge incremental load on a rail network that would, if left unchanged[30]—

- Date back between 100 and 150 years, in some cases even further back;
- Hamper train movements with a geometry more fitting for mountainous terrain than for the tidewater East Coast of the United States;
- Present capacity constraints that already (in 2005) discourage rail transport and favor other modes that themselves are chronically congested;
- Consume crew time and fuel well beyond what an efficient railway would require, thus ballooning railway operating expenses for all carriers concerned;
- Add to freight transit times and unreliability, thus imposing costs on shippers up and down the East Coast—not just in the study area;
- Inflate intercity passengers' and commuters' travel time due to slow schedules and erratic performance through Baltimore, thus making auto travel relatively more attractive; and
- Impose social costs due to all the inefficiencies inherent in the system.

It is the purpose of the balance of this report to describe alternatives that would reverse these inherent difficulties by improving train routings, expanding freight clearances, and enhancing freight and passenger operations and capacities in the Baltimore region.

[30] This statement assumes that the physical facilities can survive for another half-century—an assumption for which no conclusive engineering backup presently exists. As explained later in this report, the design life for new tunnels is 120 years.