
BERKS ALLIANCE



Restoring Passenger Rail Service to Berks County, PA



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Chapter 1

Project Overview

SUMMARY

Chapter 1 of this report sets out the background and purpose of the Berks County Passenger Rail Restoration Study, including outlining the study's goal, the scope, and the methodologies used. In addition, a discussion of the Freight Railroad Principles impacting the project are included at the end of this chapter.

1.1 Introduction

This study will evaluate how passenger rail service connecting Reading, PA with Philadelphia and the Northeast Corridor (NEC) will enhance the economy of the entire Southeastern Pennsylvania region. It will strengthen the economy within the whole corridor by providing better access to markets, jobs, and income, as well as to government and business centers, and social and leisure facilities of the entire NEC, all the way from Boston, Massachusetts to Hampton Roads, Virginia.

This study will provide a pre-feasibility level of understanding of the basics of operating a passenger rail service from Reading to Philadelphia including the ability to provide direct rail connections to New York and Washington D.C. Using basic operating assumptions about route and technology options, this report outlines estimates for the travel market, capital and operating costs, potential financial and economic benefits of expanding passenger rail service along the corridor. It will provide guidance on whether or not there is a case to be made for developing the rail corridor connecting Reading with Philadelphia and will explore several possible technical and institutional approaches for developing the corridor. This includes the choice whether to develop an intercity rail service, a commuter rail service or a combination of both for best serving the needs of the diverse travel markets that exist in the corridor.

Since the early 1980's when the historic passenger service to Reading and Pottsville was discontinued, there have been many changes in the travel environment including:

- The changing demographic and socioeconomic factors that have occurred in the intervening period reflecting greater mobility and a more widely distributed population.
- Changing travel conditions for auto use due to more congestion on the interstate highway system and higher energy (gas) prices that make auto travel more time consuming and expensive.
- Changes due to Air Deregulation that has significantly reduced the amount of air service for trips under 300 miles, and which has tended to concentrate more air travel at a few very large mega-hub airports. Several airports along the Northeast Corridor have benefited from airline deregulation and have become major gateways for both international and domestic travel. The rail system as proposed would link to these airports providing convenient access to Berks, Montgomery and Chester counties.
- The development of more cost effective rail technology due to improved locomotive performance and efficiency, and in particular the rapid advancement of various kinds of dual mode and battery technologies in recent years, has provided more effective ways for dealing

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with operations through the Center City Rail tunnels in Philadelphia than what existed in 1981 when the diesel car services were ended. In addition, the necessary Positive Train Control systems needed to ensure passenger safety have already been installed along all the tracks extending from Reading into Philadelphia.

As a result of these changes, rail travel has become increasingly competitive, and for example Amtrak has seen a significant rise in its ridership since the year 2000 with ridership increasing by 51% nationally between 2000 and 2013. In the same time period, the ridership of the Philadelphia to Harrisburg Keystone route increased by 128%. This signals a strong shift away from auto towards rail, which has been driven both by rising fuel prices and worsening traffic congestion.

Exhibit 1-1: Amtrak Ridership Growth 2000-2013

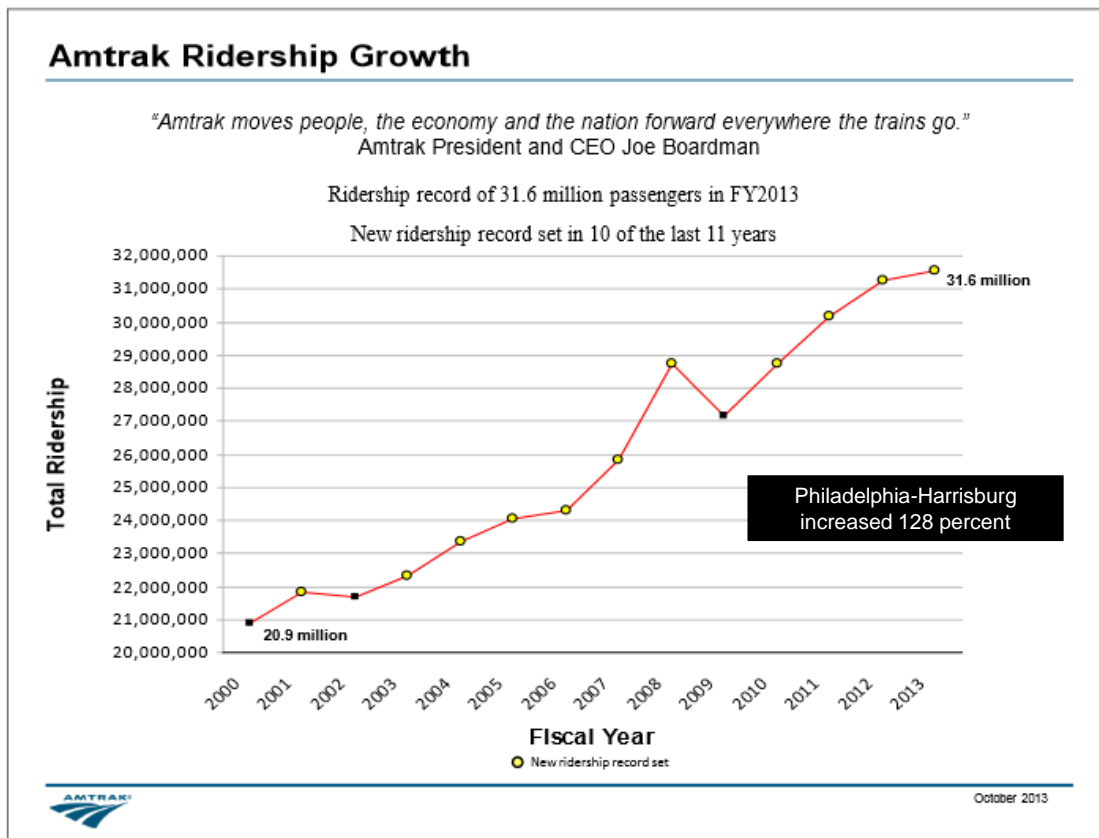
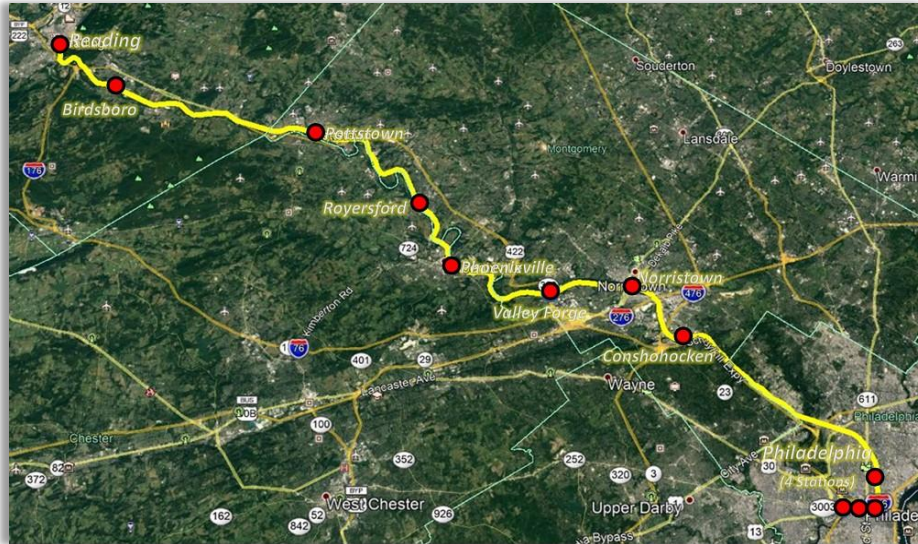


Exhibit 1-2 shows the proposed corridor from Reading to Philadelphia, PA. However, by linking with existing Amtrak service at the William H. Gray III 30th Street Station, direct connections can be provided north and south along the NEC both to New York and Washington, DC. Since the existing Keystone service provides direct service to New York, doing this for the Reading service as well is seen to dramatically increase the ridership and revenue potential of the route. This greatly strengthens the financial and economic case for developing the system.

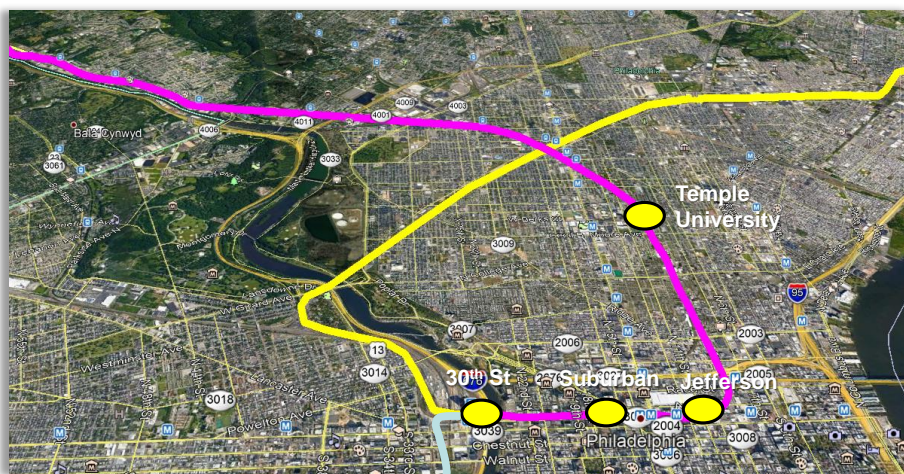
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Exhibit 1-2: Proposed Reading to Philadelphia, PA Rail Corridor



Stations shown in Exhibit 1-2 are based on the historical pattern of station stops based on the 1981 diesel schedule; with the addition of a potential stop in Conshohocken, as well as the four main downtown Philadelphia stations: Temple University, Jefferson, Suburban and the William H. Gray III 30th Street Station that would come with a routing through the Center City Commuter tunnel. While the historical schedule provided a framework for the new service, the route and stations have also been updated to reflect completion of the Philadelphia Center City Commuter Connection which did not open until 1984, nearly three years after Reading's diesel services ended. The historical Reading service never reached Suburban Station or Amtrak at 30th Street; riders had to rely upon the Market-Frankford subway to provide a connection. But today as shown in Exhibit 1-3, a through-routed, single seat ride to New York or Washington, D.C., could be provided. Trains from Reading would arrive at the upper level of 30th Street and could continue directly to New York (the yellow line) or to Washington D.C. (the blue line) without needing to reverse direction. This can be done using only existing rail infrastructure provided the rail equipment is capable of operating through the Center City Commuter tunnel. While other route options for reaching 30th Street station exist, they would all require development of new infrastructure and would require a directional reversal at 30th Street; and as well, those options may not be able to directly serve the four downtown Philadelphia stations, as the existing rail route can do.

Exhibit 1-3: Existing Direct Connections via Philadelphia to New York and Washington, D.C.



1.2 Purpose and Objective

This study will provide the Berk Alliance, Greater Reading Chamber Alliance (GRCA) and other project stakeholders with a basic understanding of:

- The background history supporting the development of the Reading-Philadelphia Corridor.
- Potential route and technology options for the corridor.
- The market for intercity travel in the current travel environment.
- The capital and operating costs of train service.
- The financial and economic benefits that would be derived from implementing the system.

This study will assess the feasibility of developing the rail corridor with regard to: the need for passenger rail development in the corridor; capital costs; operation and maintenance costs; ridership and revenue; operating ratios and benefit-cost analysis; and the economic benefits to the community. It will **not** recommend a “preferred alternative” nor will it exclude any options from future consideration. The assessment assumes an approximate +/-30% level of accuracy, with equal probability of the actual cost moving up or down. Additional work will be needed to develop more precise estimates. This will be done if the project moves into the next stage of the planning process.

1.3 Project Scope

The study approach uses TEMS RightTrack™ Business Planning System to provide a fully documented analysis of the opportunity associated with the development of a Reading-Philadelphia passenger rail corridor. The approach identifies the Business Case for developing the corridor in financial and economic terms, including an assessment of stakeholder and community benefits. Key deliverables include:

- A review of past passenger rail studies that are most relevant to the current proposed development of passenger rail in the corridor.
- A comprehensive intercity travel market analysis for the base and forecast years.
- An assessment of potential routes and stations based on existing and historic analysis of options.
- A review of potential train technology for 79 & 110-mph operations and its potential operating schedules and costs.
- Both a financial and economic analysis of potential options and their ability to meet United States Department of Transportation (USDOT) Federal Railroad Administration (FRA) funding requirements.
- Preparation of a conceptual level pre-feasibility report for use in assessing the project viability and its ability to achieve fundability.

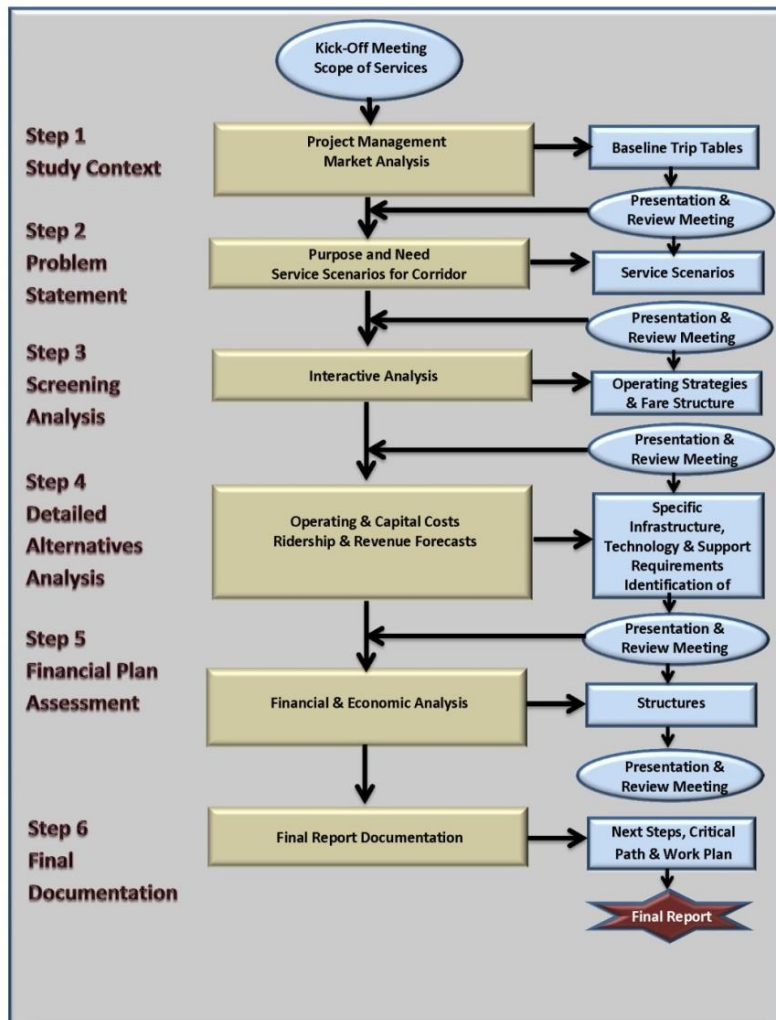
1.4 Project Methodology

To ensure that all of the USDOT FRA criteria and factors are fully evaluated, the study team has used a business planning approach. As specified by the USDOT FRA, the selection of an appropriate rail option is “market driven.” The difference in the selection of one rail option over another is heavily dependent on the potential ridership and revenue. A set of service alternatives has been developed and assessed for potential to improve market access, raise train speed, and reduce costs.

To ensure that market potential is properly measured, the TEMS Business Plan Approach has carried out a preliminary but comprehensive market analysis. The output of this market analysis was then used to determine the right rail technology and engineering infrastructure for the corridor.

In developing the Business Case, the TEMS team used the TEMS RightTrack™ Business Planning Process that was explicitly designed for passenger rail planning and uses the six step Business Planning Process as shown in Exhibit 1-4. Key steps in the process are the definition of the proposed rail service in terms of its ability to serve the market; an interactive analysis to identify the best level of rail service to meet demand, and provide value for money in terms of infrastructure; ridership and revenue estimates for the specific rail service proposed; and the financial and economic assessment of each option.

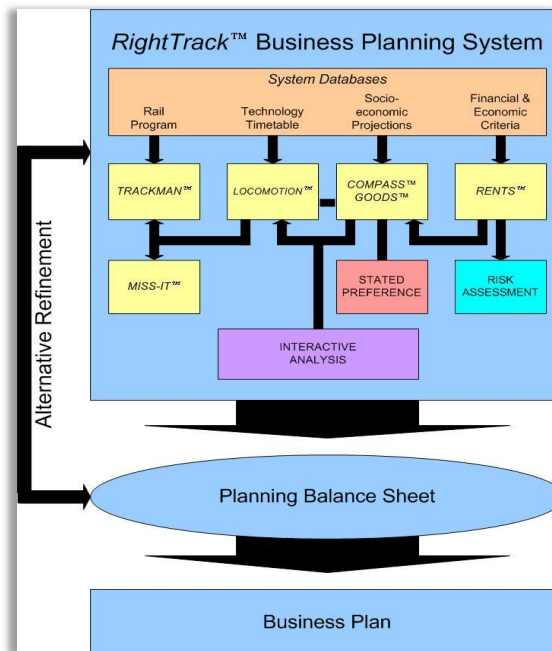
Exhibit 1-4: RightTrack™ Six Step Business Planning Process



1.4.1 Study Process

The Business Planning Process is designed to provide a rapid evaluation of routes, technologies, infrastructure improvements, different operating patterns and plans to show what impact this will have on ridership and revenues, and financial and economic results. To meet this need TEMS has used its RightTrack™ Business Planning System (Exhibit 1-5) to provide a fully documented analysis of the corridor opportunity. RightTrack™ has been successfully used in over one hundred passenger rail corridor studies to provide Market Analysis, Route and Technology Assessment and Financial and Economic Analysis. Using these software tools and databases, TEMS can efficiently complete the work and can provide all the deliverables needed to move the project forward if a good case exists.

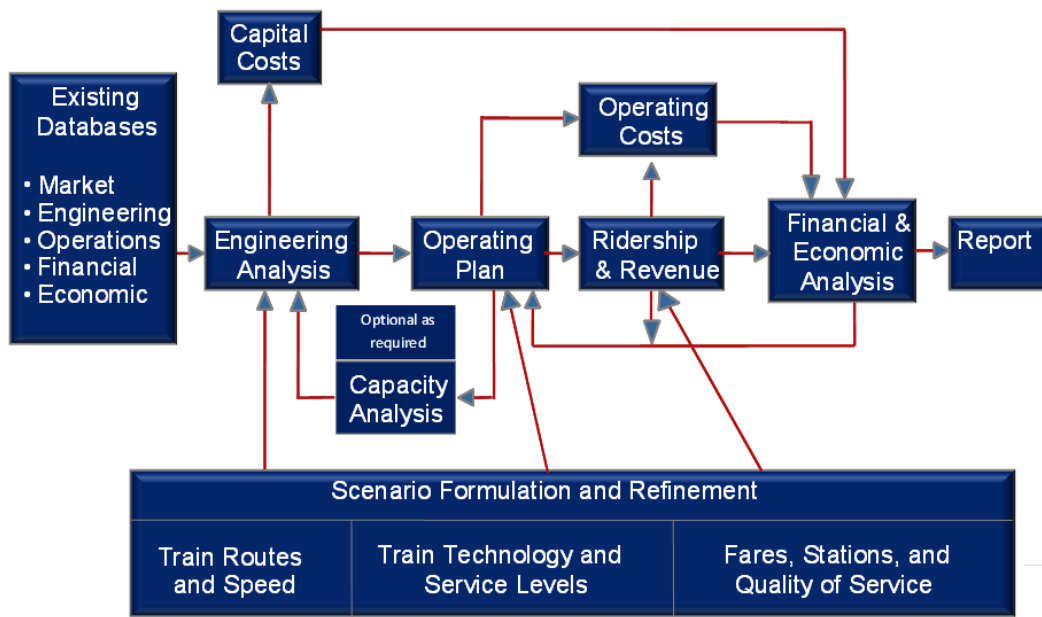
Exhibit 1-5: TEMS RightTrack™ Business Planning System



The current study has entailed an interactive and quantitative evaluation, with regular feedback and adjustments between track/technology assessments and operating plan/demand assessments. It culminated in a financial and economic assessment of alternatives. Exhibit 1-6 illustrates the Interactive Analysis process itself that leads up to the financial and economic results.

The study investigated the interaction between alignments, technologies and service options to identify optimum trade-offs between capital investments in track, signals, other infrastructure improvements, and operating speed. The engineering assessment included GOOGLE® map and/or ground inspections of significant portions of track and potential alignments, station evaluations, and identification of potential locations and required maintenance facility equipment for each option. TRACKMAN™ was used to catalog the base track infrastructure and improvements. LOCOMOTION™ was used to simulate various train technologies on the track at different levels of investment, using operating characteristics (train acceleration, curving and tilt capabilities, etc.) that were developed during the technology assessment. The study identified the infrastructure costs (on an itemized segment basis) necessary to achieve high levels of performance for the train technology options evaluated.

Exhibit 1-6: Interactive Analysis Process



A comprehensive travel demand model was developed using the latest socioeconomic data, traffic volumes (air, bus, auto, and rail) and updated network data (e.g., gas prices) to test likely ridership response to service improvements over time. The ridership and revenue demand estimates, developed using the COMPASS™ demand modeling system, are sensitive to trip purpose, service frequencies, travel times, fares, fuel prices, congestion and other trip attributes.

A detailed operating plan was developed and refined, applying train technologies and infrastructure improvements to evaluate travel times at different levels of infrastructure investment. Train frequencies were tested and refined to support and complement the ridership demand forecasts, match supply and demand, and to estimate operating costs.

Financial and economic results were analyzed for each option using the RENTS™ financial and economic analysis system. The analysis considers cash flows over a 30-year horizon using criteria recommended by USDOT FRA Cost Benefit guidelines, and the U.S. Office of Management and Budget (OMB) Social Discount Rates. The analysis provided a summary of capital costs, revenues, and operating costs for the life of the project, and developed the operating ratio and cost benefit ratio for each option.

1.5 Freight Railroad Principles

It is in the interest of passenger rail feasibility that any shared use of freight rail corridors or tracks along the Reading to Philadelphia rail corridor respect the need for continued safe and economical rail freight operations. At a minimum, it is intended that the freight railroads be able to operate their trains as effectively as they could if passenger service did not exist. Beyond this, it is desirable to actually create benefits for freight rail service if possible while developing the infrastructure needed to support passenger services. Freight railroads must retain their ability not only to handle current traffic, but also to expand their own franchises for future traffic growth.

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As such, both CSX and Norfolk Southern (like the other Class 1 railroads) have established “Letters of Principle” to provide guidance to passenger rail planners¹. The purpose of the principles is to protect the safety of railroad employees and communities, service to freight customers, and the right-of-way and land needed to fulfill the railroads’ freight transportation mission.

With regard to High-Speed Rail (HSR) service and corridors, Norfolk Southern’s principles point out that the following special considerations are necessary:

- Norfolk Southern acknowledges that each passenger proposal is unique, so Norfolk Southern's application of the principles to particular proposals will often be unique as well.
- Norfolk Southern will work with planners to insulate higher-speed rail corridors from interference with and from NS freight corridors.
- On Norfolk Southern, passenger trains operating in excess of 79-mph require their own dedicated tracks. On Norfolk Southern, trains operating in excess of 90-mph require their own private right-of-way.
- Where higher-speed trains share tracks with conventional freight trains, those high-speed trains will not be able to exceed 79-mph. Where shared track is concerned higher speed trains must meet the same safety standards as conventional freight trains.

If it should prove necessary to use any of CSX’s track, their principles require that:

- Access to host railroad track and property must be negotiated between the parties on a voluntary basis.
- Designing for safety is paramount and separate tracks will be needed to segregate freight and conventional passenger rail from higher-speed rail at sustained speeds in excess of 90-mph.
- Service to rail freight customers must be reliable and protected and cannot be compromised; adequate capacity must be maintained and, in some cases, built to address future freight growth.
- New infrastructure design must fully protect the host railroad’s ability to serve its existing customers, both passenger and freight, and locate future new freight customers on its lines. Host railroads must be adequately compensated, especially in regard to the significantly higher maintenance cost associated with enhanced track infrastructure that will be required for high-speed rail.
- Host freight railroads need to be fully protected against any and all liability that would not have resulted but for the added presence of high-speed passenger rail service.

At present the passenger proposals laid out here are still un-negotiated, un-funded and at a pre-feasibility level. This report makes certain assumptions regarding the need for capacity enhancements along rail lines that would be utilized for providing passenger service. The proposal is to separate freight from passenger trains as much as possible on separate tracks, and if possible, on separate rights of way. For example, freight and passenger operations are already separated east of Norristown where SEPTA and

¹ CSX Principles, email from Marco Turra, CSX to Elizabeth Treutel, Michigan Environmental Council, dated June 4, 2015; NS Principles, <https://wideni77.files.wordpress.com/2013/09/norfolk-southern-proposed-passenger-projects-061413.pdf>, retrieved on 08/06/15

Norfolk Southern (NS) operate two separate rail lines on opposite sides of the Schuylkill River. The principle of separation suggests that this existing dedicated SEPTA passenger right of way should be utilized if possible, instead of remaining on the NS freight tracks east of Norristown. Future engineering and operations studies will address the details of integrating the proposed passenger operations with freight operations and will be subject to close negotiations with the railroads. In future detailed studies, additional capacity work will be performed if and as required, within the framework of an overarching strategy to provide dedicated infrastructure for supporting the capacity needs of passenger service.

Although the results of this capacity assessment are consistent with those of the 2005 ***Schuylkill Valley Rail Assessment***, the simulation contains preliminary data which is still subject to review, verification and approval by Norfolk Southern. As of the date of this report, this review process has not taken place. The findings of the capacity analysis are not to be construed as a commitment on the part of Norfolk Southern to operate additional service.

1.6 Organization of the Report

1. **Chapter 1 – Project Overview:** Chapter 1 lays out the overall approach for implementing the proposed Reading to Philadelphia Rail Line (including the development of integrated direct rail service to both New York and Washington D.C.) Chapter 1 outlines the goal for the project, the project scope, and the methodologies used. In addition, a discussion of the Freight Principles impacting the project, particularly regarding the sharing of track with Passenger Rail, are included at the end of this chapter.
2. **Chapter 2 – Background for the Study:** This section provides background on the history and previous studies that have helped focus the current analysis and that have led to identification of potential route and technology options that should be considered for this Study. The aim is to evaluate an affordable set of options that will effectively balance supply with demand, and which can provide good service at a reasonable price.
3. **Chapter 3 – Service and Operating Plan:** This chapter discusses the development of the Service and Operating Plan and includes a discussion of the track infrastructure and train technology options. This chapter also describes the operating plan, station stopping patterns, frequencies, train times and schedules for each route and technology option.
4. **Chapter 4 – Capital Plan:** This chapter discusses the development of the Capital Plan and includes a discussion of the capital cost methodology and a likely range of capital costs for developing the proposed Reading to Philadelphia rail line. These costs will be subject to refinement as a result of further studies and in any case will be subject to negotiation with the railroads.
5. **Chapter 5 – Socioeconomic, Demographic Transportation Databases:** This chapter is divided into subsections of introduction of the chapter, zone system, socioeconomic data, transportation network data, origin-destination data, stated preference survey process, results and analysis. This chapter describes the steps of developing the market data which includes developing a zone system, socioeconomic database of the study area, how the transportation networks were developed, how the origin and destination databases were obtained and validated, and on value of time that were derived from previous stated preference surveys.

6. **Chapter 6 – Travel Demand Forecast:** This chapter also presents the analysis of the Total Travel Demand for passenger rail, including ridership and revenue results. The ridership and revenue forecasts for this study were developed using the COMPASS™ Travel Demand Model. The COMPASS™ Multimodal Demand Forecasting Model is a flexible demand forecasting tool used to compare and evaluate alternative passenger rail network and service scenarios. It is particularly useful for assessing the introduction or expansion of public transportation modes such as passenger rail, air, or new bus service into markets.
7. **Chapter 7 – Operating Costs:** This chapter discusses the development of the Operating Costs and includes a discussion of the operating cost methodology.
8. **Chapter 8 – Financial and Economic Analysis:** This chapter presents a detailed financial analysis for the Reading-Philadelphia rail service, including key financial measures such as Operating Surplus and Operating Ratio. A detailed Economic Analysis was carried out using criteria set out by the 1997 FRA Commercial Feasibility Study² which include the key economic measures such as NPV Surplus and Benefit/Cost Ratio. All of these are provided in this chapter.
9. **Chapter 9 – Supplside Economic Rent Analysis of Community Benefits:** This chapter presents the results of the Supplside Economic Rent Analysis that provides an understanding of the potential impacts on employment, income, property values, and wealth at stations along the Reading-Philadelphia Corridor. It also identifies how the tax base is changed in the corridor, and the increased tax payments that result from building the rail system at a Federal, State, and local level.
10. **Chapter 10 – Conclusions and Next Steps:** This chapter outlines the key findings of the study, and the next steps that should be taken to move forward the development of passenger rail service in the Reading to Philadelphia rail corridor.

² High-Speed Ground Transportation for America: Commercial Feasibility Study Report To Congress:
<https://www.fra.dot.gov/eLib/details/L02519>

Chapter 2

Background for the Study

SUMMARY

The purpose of this chapter is to provide a review of the background history and issues that have helped to focus the current analysis and that have led to the identification of the options that should be considered for the current study. The aim is to evaluate an affordable set of options that would provide good service at a reasonable cost.

2.1 History of Rail Passenger Services in Reading

Reading, Pennsylvania has a long history as a transportation hub, starting with the discovery of large seams of anthracite coal in the mountains north and east of the city. Anthracite is a natural mineral with a high carbon and energy content, making it useful as a clean-burning fuel. Its history in Pennsylvania begins with a documented discovery near Jim Thorpe and the founding of the Lehigh Coal Mine Company in 1792. However, the early use of anthracite coal was restricted due to the difficulties in transporting it.

This transportation problem was resolved at first by development of the Lehigh, Schuylkill, and Delaware & Hudson Canals, as well as smaller waterways such as the Delaware, Morris and Union Canals. Of these, the Union and Schuylkill Canals served Reading directly. The Schuylkill Canal opened in 1825. The early routes of the Union and Schuylkill canals were practically duplicated by the Philadelphia and Reading Railroad, which in 1843 extended a pioneering rail line north from Philadelphia through Reading to the mining town of Pottsville, following the Schuylkill River nearly the whole way. The Black Rock tunnel at Phoenixville was built between 1835 and 1837 as part of the original Philadelphia and Reading construction and is still in use today.

The Reading system expanded west to Harrisburg in 1858 through acquisition of the Lebanon Valley Railroad; and east to Allentown in 1869 by leasing the East Penn Railroad. This created a through route via Reading between Harrisburg and New York City, but also led to rivalries with the much larger Pennsylvania Railroad (PRR) system. After the Reading Railroad developed a Philadelphia to New York route, the PRR retaliated in 1884 by building its own rail line up the Schuylkill River through Reading to Pottsville and it started directly competing with the Reading for a share of the burgeoning anthracite coal business. The PRR was determined to limit the expansion of the Reading Railroad to prevent its becoming part of any major trunk railroad systems and limit its influence to a regional role. With the assistance of the larger railroads and rail moguls of the time, it was largely successful in doing so.

Even so, the Reading offered regional passenger service on both its Harrisburg-Allentown “branch” and Pottsville-Philadelphia “main” lines; a particular challenge being that the Harrisburg-Allentown line passes through Reading north of the main business district. To resolve this problem, Reading built an “Outer Station” in 1874 within a wye-track area north of town where the rail lines converged. The Outer Station mostly served the east-west trains which couldn’t come to downtown Reading without adding a backup move. However, the Outer station was closed on March 16, 1969 following discontinuance of the last east-west train, the *Queen of the Valley* which ran from Harrisburg to Jersey City. After this, only Pottsville-Reading-Philadelphia passenger trains continued to operate, and they used the downtown Franklin Street station.

After the Reading’s having discontinued its east-west passenger trains in 1969, it did not take long before the Penn Central Railroad collapsed in 1970 – it was the largest bankruptcy in American history to that date. It did not help matters that the Reading was forced to continue paying its debts to Penn Central, but Penn Central (because it was in bankruptcy) was not required to pay its debts to the Reading Company. This triggered a domino effect whereby the entire northeastern rail system financially collapsed. As a result, the Reading Company was also forced to file for bankruptcy protection in 1971. Nonetheless, having started to receive some direct government support during bankruptcy, the Reading continued to operate its Pottsville-Reading-Philadelphia passenger trains along with its extensive network of Philadelphia area suburban rail lines.

With the coming of ConRail in April 1976, passenger trains were not considered part of Conrail’s primary mission, and it was expected that funding agencies would take on responsibility for funding any commuter (e.g. non-Amtrak) services that were deemed worthy of continuing. As a result, the Southeastern Pennsylvania Transportation Authority (SEPTA) took over responsibility for the Reading rail service in April 1976 as a part of its larger responsibility for Philadelphia-area rail operations, and it contracted Conrail to continue day-to-day passenger operations for the whole regional rail system.

But by 1981, SEPTA claimed it was losing an average of \$2 million dollars a year operating diesel services out of Reading Terminal. However, SEPTA’s main motivation was development of the new Center City Commuter Tunnel since diesel trains could not run in the new tunnel. Also, since Berks and Schuylkill Counties were not part of the SEPTA compact, SEPTA had no obligation to continue running the service. Local bus companies (all of whom by now are out of business) lobbied to have rail services discontinued. Pennsylvania DOT did not offer to continue supporting the trains, and the counties were unable to pay SEPTA’s full subsidy demand so, on July 1, 1981, SEPTA terminated its contract with ConRail to operate passenger rail service to Reading and Pottsville. Berks and Schuylkill Counties had passenger trains from 1843 to 1981, but there has been no passenger rail service other than excursion trains in these counties since 1981.

2.1.1 History of Freight Tonnage Shifts

For freight, ConRail’s planners favored the Reading’s Harrisburg to Allentown route, mostly because the PRR routes which historically had handled the lion’s share of traffic all tended to funnel freight into the Northeast Corridor (NEC), which had been put under Amtrak’s control. But Reading’s lines from Harrisburg to New York were already free of high-speed passenger trains. As a result, Reading’s former east-west “branch” lines were chosen to become ConRail’s “main” line from Harrisburg to New York, and some of the freight that formerly moved over PRR lines gradually started shifting towards the Reading.

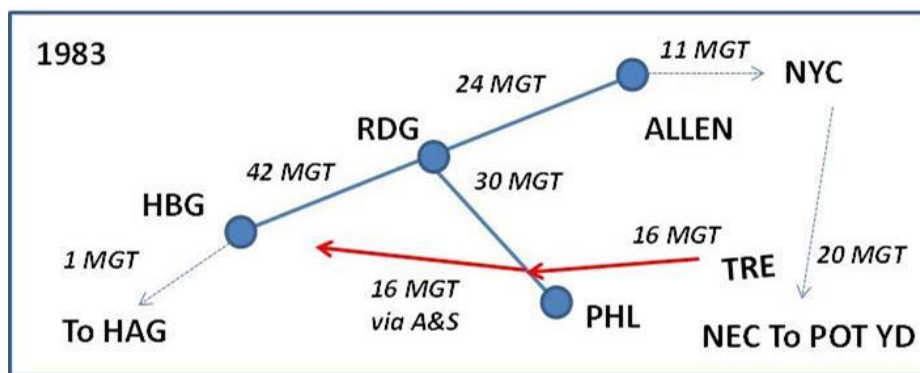
However, when ConRail inherited the former Reading Railroad routes in 1976, it was still using a large fleet of electric freight locomotives that were tied to former PRR lines, including Amtrak’s NEC. This

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slowed the shift of freight towards Reading. ConRail did not discontinue electric freight operations until March 1981, just a few months before Reading's passenger service ended. Even then, ConRail simply substituted diesels for electric locomotives, and continued to maintain its historical routings over the former PRR lines. Exhibit 2-1, which is based on railroad track chart data, shows the traffic patterns on the Philadelphia-Reading line shortly after SEPTA passenger service ended in 1981:

- Freight traffic from Philadelphia to Reading was about 30 million gross tons annually.
- Additionally, 16 million gross tons from Trenton were moving to Harrisburg via Downingtown, using the former Atglen & Susquehanna "Low Grade" freight line (Enola Branch.)
- Another 20 million gross tons of freight were moving from New York and Philadelphia over Amtrak's NEC to Potomac Yard, south of Washington D.C.

Exhibit 2-1: 1983 Freight Tonnage (Millions of Gross Tons by Line Segment)



While Amtrak's high trackage fees and usage restrictions were an ongoing concern to ConRail, the 1987 train collision³ at Chase, Md. was the last straw. This triggered ConRail's decision to remove as much freight from the NEC as possible. As shown in Exhibit 2-2:

- ConRail agreed with Norfolk Southern to shift the interchange from Potomac Yard to Hagerstown, Md. in 1988. 20 million gross tons of freight that had been moving over Northeast Corridor rerouted via Allentown, Reading and Harrisburg to Hagerstown.
- ConRail also abandoned the Atglen & Susquehanna "Low Grade" freight line⁴, adding 14 million gross tons onto the Philadelphia to Reading line⁵ north of Norristown. 30 million tons were already moving, so with some traffic added from Philadelphia as well, the total rose to 45 million tons. West of Reading the line was carrying 100 million Gross Tons each year.

However, even though it put more traffic on the Reading lines, ConRail's 1988 decision to abandon its A&S low-grade freight route can hardly be taken as a vote of confidence that rail freight would grow in the future. Rather, ConRail was clearly in a strong retrenchment as it implemented major reductions in

³ Amtrak train 94 while traveling north from Washington, D.C., to Boston, crashed into a set of Conrail locomotives which had failed to stop at the signals at Gunpowder Interlocking at Chase, Md. about 18 miles north of Baltimore. The ConRail train crew tested positive for marijuana. Train 94's speed at the time of the collision was estimated at about 108 miles per hour. Fourteen passengers on the Amtrak train were killed, as well as the Amtrak engineer and lounge car attendant. Today, Positive Train Control (PTC) would likely have prevented this accident. See: https://en.wikipedia.org/wiki/1987_Maryland_train_collision and <https://www.washingtonpost.com/archive/local/1992/04/14/piece-by-piece-gateway-becomes-a-memory/164a5fad-6637-4629-a23b-39f598a5ee67/>

⁴ Also abandoned in 1988, this former rail line, also called the Enola Branch, have since become the Enola Low-Grade Trail. See: <https://www.trailink.com/trail/enola-low-grade-trail/>

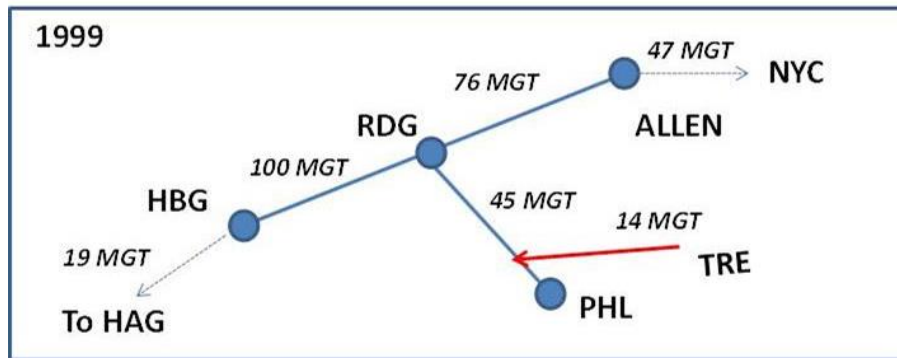
⁵ Upon reaching Norristown, Trenton branch trains instead of continuing east across the Schuylkill River towards Downingtown, were instead diverted to the Earnest Connection and Abrams yard, passing through SEPTA's Norristown station.

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network capacity, and focused all of its traffic on what it considered to be its core routes. After the NEC reroutes, practically all of Philadelphia's and Trenton's freight tonnage moved west to Reading.

Some double stack trains from New York also used the line since they could not fit through the Pattenburg tunnel⁶ on the Lehigh Line; these came through the Woodbourne and Earnest connections to Abrams Yard. Under ConRail, the Philadelphia-Reading line was handling not only nearly all of Philadelphia's freight, but some New York freight as well. Exhibit 2-2 shows ConRail traffic patterns just *prior* to its 1999 split-up between CSX and Norfolk Southern⁷.

Exhibit 2-2: 1999 Freight Tonnage (Millions of Gross Tons by Line Segment)



In 1999, everything changed when Norfolk Southern and CSX agreed to divide ConRail. The two railroads established "ConRail Shared Assets" areas in Philadelphia, New York and Detroit and each took about a 50% share of the freight in each city. CSX took its freight over to its own lines along I-95: the former B&O from Philadelphia to Baltimore, and the former Reading from Philadelphia to New York both saw an increase in traffic. However, Norfolk Southern's tonnages on its Philadelphia-Reading and Lehigh Lines were sharply reduced. Fortunately for Norfolk Southern, Trenton branch tonnage held steady. These results are summarized in Exhibit 2-3, which still reasonably reflects the traffic situation today.

The 28 MGT that is now running from Reading to Philadelphia is very similar to the 30 MGT that was moving in the 1980's when SEPTA passenger trains were still operating. It is, however, worth noting that:

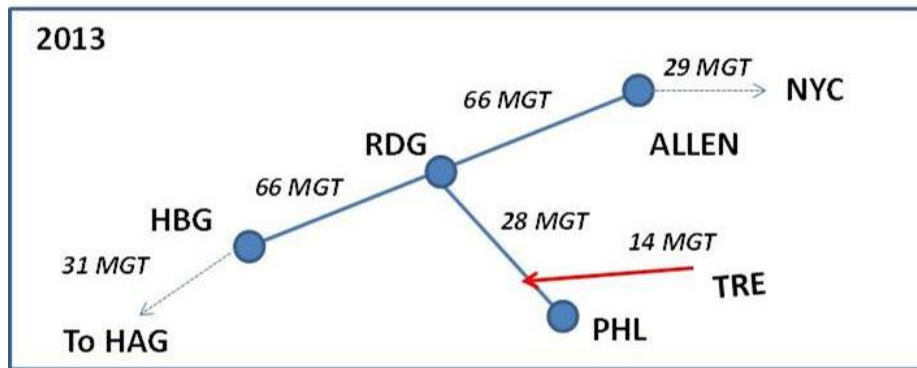
- ConRail handled 47 million annual tons on its single-tracked Lehigh Line in 1999.
- Norfolk Southern handled 31 million tons on its single-tracked Hagerstown line in 2013.

Both single-track benchmarks exceed the 28 million tons now moving from Philadelphia to Reading. There is therefore a risk that Norfolk Southern may decide to single-track the Philadelphia to Reading line, which would be highly detrimental to the prospects for reintroducing passenger service.

⁶ After the ConRail split, Norfolk Southern improved the clearances on the Pattenburg tunnel so these double stacks can use the Lehigh Line. This avoids the need for Norfolk Southern to pay trackage rights fees to CSX for the use of their line between Bound Brook Junction and the Woodbourne connection.

⁷ As an historical footnote, from a freight railroad perspective, there could probably not have been a worse time than January 1999 to launch the Schuylkill Valley Metro study. Although the freight traffic patterns shifted during the course of the study, it was not known prior to the split how freight traffic patterns would stabilize after the CSX/NS division of ConRail. See: *Major Investment Study and Draft Environmental Impact Statement on the Proposed Schuylkill Valley Metro Project Between the City of Philadelphia and the City of Reading and the Borough of Wyomissing, Berks County, PA*: <https://www.transit.dot.gov/regulations-guidance/notices/99-652>

Exhibit 2-3: 2013 Freight Tonnage (Millions of Gross Tons by Line Segment)



Regarding the future, CSX is in the process of expanding its Howard Street Tunnel in Baltimore. Since the rail line from Philadelphia to New York is already cleared, this final improvement will complete a fully-double stack cleared corridor for CSX all the way from Albany New York to Florida. The Howard Street tunnel project is fully funded, set to begin construction in 2021⁸ and be completed by 2024. This will only improve CSX's competitive position and will make it harder for Norfolk Southern to gain share in either Philadelphia or New York.

2.2 Review of Previous Corridor Studies

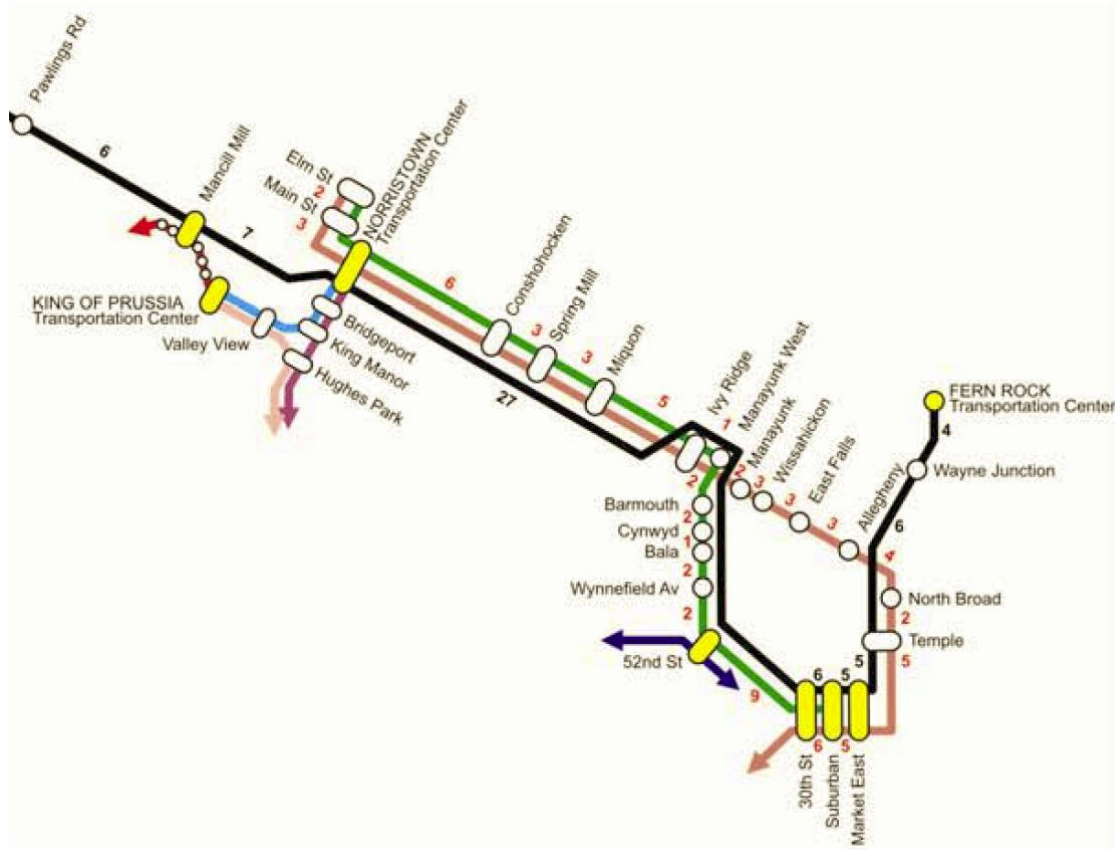
Calls for restoration of rail passenger service to Reading began almost as soon as the original services ended in 1981. However, it took nearly 20 years to launch the 1999 *Schuylkill Valley Metro (SVM)* study, which was by far the largest of the historical studies performed on this rail corridor. However, the SVM did not propose to restore commuter rail service on the existing tracks; rather it proposed to develop a brand-new 62-mile dedicated electrified railway that would have operated like a light rail line, rather than as a commuter rail system. As shown in Exhibit 2-4, the SVM would have followed a looping alignment through downtown Philadelphia utilizing portions of SEPTA's Norristown and Cynwyd Lines. The plan also integrated other rail lines, including Route 100 Norristown High Speed line and some West Philadelphia streetcar operations.

Had the SVM project been funded, its implementation would have been very challenging because of the many complexities on the Philadelphia end of the corridor. The SVM ridership and capital cost estimates were all been prepared in an integrated manner making it challenging to directly identify costs that are specifically related to a stand-alone Reading service.

Also, while the trip tables from within the Delaware Valley Regional Planning Commission (DVRPC) area looked reasonable, there was a discontinuity at the Berks County line, since SVM forecasted very few trips to Reading. As a result, according to SVM projections, trains would have run practically empty north of Pottstown. This error in the SVM ridership contributed to onerous operating subsidy projections and poor returns on capital investment, especially in regard to any possible extension north of Pottstown. This certainly contributed to the reasons why the SVM project was rejected by FTA and terminated in 2006.

⁸ See *Howard Street Tunnel project could be completed by 2024, port official says*, <https://www.bizjournals.com/baltimore/news/2020/02/04/howard-street-tunnel-project-could-be-completed-by.html>

Exhibit 2-4: East end of Schuylkill Valley Metro (SVM) Proposal



After the SVM plan failed, the Montgomery County Planning Commission initiated a follow up **R6 Norristown Line Service Extension Study** (the R6 Study) for a more focused assessment of a commuter rail option for the corridor. This February 2009 study compared diesel, dual-mode and all-electric options for extending SEPTA R6 service beyond Norristown. The R6 Study, however, heavily drew from the databases that had been developed by the earlier SVM study. The R6 Study managed to extract quite a bit of useful Engineering information from the SVM databases, but still retained its flawed ridership forecast. As well, the R6 Study rejected the dual-mode option even though NJ Transit and Montreal's AMT had already placed an order with Bombardier's for the ALP-45DP locomotives. The result of excluding dual-mode technology for the 2009 study was therefore was a stark choice between an underperforming option with serious negative ridership impacts (transfer at Norristown) versus a very expensive one (electrify all the way to Reading.) However, the R6 study's proposal for tolling U.S. Route 422 proved to be its fatal flaw. This funding plan failed to gain any grass root political support and was strongly lambasted by several regional politicians. On October 5, 2011, facing increasing pressure and opposition, DVRPC cancelled the tolling proposal and along with it, plans for the R6 Norristown Extension.⁹

In terms of more recent studies, Phoenixville has been quite active for a number of years in developing options for improving transportation to their borough. In 2008, the community sponsored a "Green Line" study looking to develop a former PRR branch that connected Phoenixville with Devault. This would have developed a Phoenixville branch line diverging from SEPTA's Paoli line at Frazer. As recently as 2018,

⁹ **REPORT: Tolls not the 'best option' for Route 422**, see: https://www.montgomerynews.com/springfieldsun/news/report-tolls-not-the-best-option-for-route/article_9e42b0e9-bf00-52d6-b018-d2ec0c3819be.html

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borough officials were still promoting the idea of the Green Line¹⁰ as a part of their long-term plan.

More recently however, Phoenixville focused on a developing a lower-cost strategy for extending SEPTA's existing R6 commuter rail service from Norristown up to Phoenixville, using the existing NS tracks and dual-mode diesel/electric locomotives. The service plan would consist of 10 round trips on weekdays (4 peak round trips and 3 each mid-day and evening round trips) and 5 round trips on weekend days. This extension would add three stations to the R6 line:

- Valley Forge (King of Prussia)
- Schuylkill Township (Perkiomen Junction)
- Phoenixville

A **Preliminary Study for Regional Rail Service** in 2019 assessed the likely capital and operating costs, ridership and revenues for this service as well as proposing an implementation and development plan for the three proposed stations. The local share of financing for the system would come from Transportation Revitalization Investment Districts at each of the three proposed stations. More recently, a 2020 update of the **Preliminary Study** proposed a four round-trip starter service that would have four morning peak hour SEPTA trains from Phoenixville into Philadelphia, returning to Phoenixville in the evening. On an interim basis, only the Phoenixville station would be served, until the intermediate stops at Schuylkill Township and Valley Forge can also be developed.

Section 7 of the 2019 **Preliminary Study** developed a ridership estimate for the proposed SEPTA service by updating the earlier 2001 SVM forecasts. This resulted in a forecast of 1,982 daily riders, slightly over a million riders annually, from three stations of which 807 daily riders would be from Phoenixville, 475 from Schuylkill Township and 700 riders from Valley Forge. If the Mancill Mill Road station in Valley Forge cannot be developed as envisioned, then the historic Port Kennedy station could probably serve as a close substitute. The ridership of the Schuylkill Township station, currently planned for Perkiomen Junction, could be doubled if the station were moved across the river to Oaks. This would raise the overall forecast for SEPTA commuter ridership from 1.00 to 1.25 million annual trips for a 10-round trip full build option. By comparison, five SEPTA stations beyond Paoli on the Thorndale line have been generating 1.30 million annual SEPTA riders. Once fully developed, the proposed Phoenixville SEPTA extension beyond Norristown could compare very closely to SEPTA's current Thorndale extension beyond Paoli.

The March 2020 update to the **Preliminary Study** however, reduced the ridership forecast slightly; but the most important change was a proposal to launch Phoenixville commuter service without stopping at Schuylkill Township or Valley Forge. The ridership for this four round trip service to Phoenixville was estimated as 692 daily riders. By comparison, SEPTA's daily boardings at Norristown Main and Elm Street stations are 183 and 384 respectively, a total of 567. This is *less* than the number of riders at Phoenixville; yet these two stops beyond the Norristown Transportation Center have been receiving 26 trains each weekday. However, Phoenixville's newest proposal does not divert any existing trains; rather it suggests launching four new trains which would stop only at Norristown, then run express to Temple University.

From the perspective of the Reading service, given the potential magnitude of commuter demand from Schuylkill Township and Valley Forge stations, it would not make sense to run empty trains all the way from Reading just to fill the seats with short-distance riders at Valley Forge. This is why the Valley Forge and Schuylkill Township stops were not included in the current study. The proposed Reading service does not need added stops, and it is very effectively connected to King of Prussia through the stop at

¹⁰ **2018 Review: Rail Project Would Make Phoenixville 'New Main Line'** see: <https://patch.com/pennsylvania/phoenixville/2018-review-rail-project-would-make-phoenixville-new-main-line>

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Norristown that it already has. Instead it would appear that demand would justify running additional local trains for serving the Schuylkill Township and Valley Forge stations. These might well be SEPTA trains.

Routing the proposed SEPTA service via Oaks along the former PRR line into Phoenixville, would reduce capacity pressures along the NS freight rail corridor north of Perkiomen Junction, increase ridership by adding an Oaks station, would likely provide better site options for a Phoenixville station, and may even facilitate future service extensions towards Devault along the Green Line as originally proposed.

The ***Schuylkill Valley Rail Assessment Study*** of March 2005 proposed a “Canal Site” for a Phoenixville train station on the north side of French Creek near where the out-of-service PRR line crosses over the former Reading line. There is a below grade arch at this location (pictured below) which, with drainage improvements, could function effectively as a pedestrian underpass. A station at this location could serve both rail lines. Exhibit 2-5 shows a current photo of the site.

Exhibit 2-5: Current View of SVM-proposed Phoenixville “Canal” Station Site



If SEPTA service were to end in Phoenixville or continue south towards Devault rather than turning west towards Reading, there would be no need to reactivate the abandoned PRR Phoenixville tunnel.

If this integrated development approach for co-developing both commuter and intercity passenger rail services in the Reading to Philadelphia corridor is desirable, it will be important to coordinate study efforts in the next phase of work to develop both a commuter and intercity rail service, particularly in regard to ensuring that sufficient capacity is provided to meet the needs of freight and both express and local passenger services along the corridor.

Chapter 3

Service and Operating Plan

SUMMARY

This chapter discusses the development of the Service and Operating Plan including identifying the technology options that should be considered for the Reading to Philadelphia Corridor. This chapter also describes the station stopping patterns, frequencies and train times for each technology option.

3.1 Introduction

The Reading to Philadelphia rail corridor, shown in Exhibit 3-1, starts at the Reading Franklin Street station and extend to Philadelphia 30th Street station, where connections may be made, or train may run through to Northeast Corridor (NEC) destinations. In the future, the rail corridor may be extended west to Wyomissing and/or north towards Schuylkill County. Segments of the corridor are currently operated by NS and SEPTA:

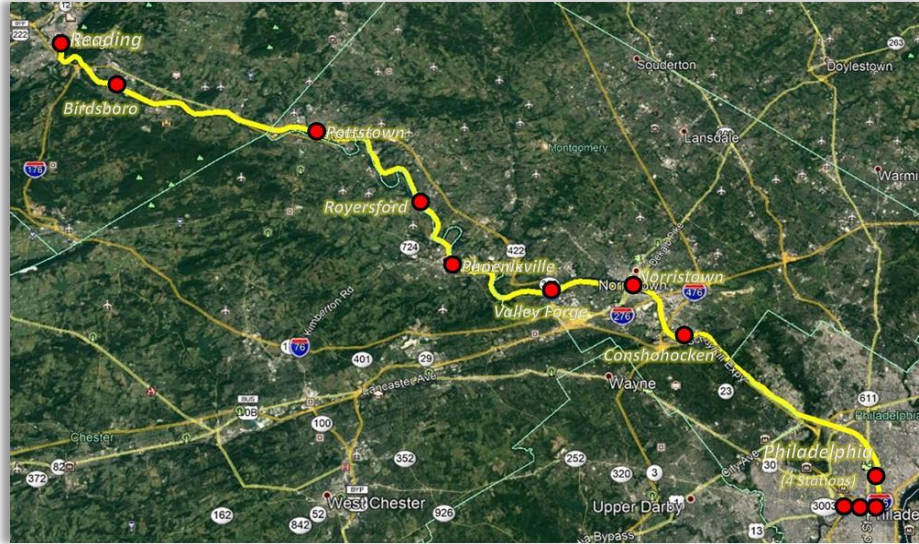
- **Norfolk Southern from Reading Franklin Street to Norristown (41 miles):** the route heads south along the single tracked NS Harrisburg line to Klapperthal Junction (CP Titus) just south of Reading, where the Reading Belt line joins the alignment. New crossover switches have been added two miles east at CP Lorane where the track is straighter. Double track continues from CP Lorane to Cromby just east of Royersford. From CP Cromby to Dreibelbis Road, the former #2 main track still exists, but it has been converted into a siding, and the switch at the former east end of double track has been converted to manual operation. This change added about two miles to the length of the single track bottleneck through Black Rock tunnel. Beyond the tunnel, double track resumes at Phoenixville and continues past the Abrams freight yard to Norris interlocking. From Norris to Kalb, the bridge crossing the Schuylkill River was double tracked, but only a single track remains across the bridge into Norristown, where SEPTA ownership begins and double track resumes. About half of Norfolk Southern's freight trains cross the river from Norris to Kalb for using the Earnest Connection to the Trenton branch. These freight trains share a short stretch of the SEPTA track from Kalb to Ford (through the Norristown Transportation Center) before re-entering their own rails at the Earnest Connection.
- **SEPTA from Norristown to 16th Street Junction in north Philadelphia (14 miles):** Beyond Ford Interlocking, just east of Norristown, the double-track electrified SEPTA R6 commuter line has, a set of crossovers at Miquon, and at 16th Street Junction. At Ivy Ridge, a new track connection called CP Dutch¹¹ could link to the abandoned PRR rail line and Bala Cynwyd. This could provide direct access to 30th Street station without needing to go through the Center City tunnels, and it was an important component of the former Schuylkill Valley Metro project.
- **SEPTA from 16th Street Junction to 30th Street station (4 miles):** the route heads south on the SEPTA Main Line. A quadruple-tracked elevated viaduct extends past Temple University and enters the Center City tunnel at the Fairmont Avenue portal. In the tunnel, the route continues

¹¹ The new track connection between the Norristown and Ivy Ridge Line is designated herein as "DUTCH Interlocking" in memory of Werner "Dutch" Eichorn, a long-time PennDOT District 6-0 employee who died in 2004. In 1979, Dutch led a graduate engineering school project that investigated such a connection.

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as a 4-track electrified line with underground stations at Jefferson (formerly, Market East) and Suburban Station. It emerges from the tunnel at 20th Street, rises to cross the Schuylkill River on a stone arch bridge and enters the upper level platforms of the 30th Street Station. From here, trains could continue north towards New York or south to Washington D.C. on the NEC.

Exhibit 3-1: Proposed Reading to Philadelphia Corridor



This study proposes a basic service stopping only at four stations beyond the existing SEPTA territory which ends at Norristown: these are Reading, Pottstown, Royersford and Phoenixville. After stopping at Norristown, Reading trains would run express to Temple University and then stop at all three main Center City stations: Jefferson, Suburban and 30th Street. Any run through service on the Northeast Corridor beyond 30th Street would conform to current Amtrak service patterns.

Stations were only included as stops in the rail system if it was apparent the level of ridership would justify the cost of development and operation of a station. As well, since each stop adds more time to the schedule, if too many stops are added, this might actually reduce the attractiveness of the rail service. This provides an incentive to reduce the number of stations rather than add too many stops.

The historic rail stations in Reading, Pottstown, Royersford and Phoenixville have all been maintained in adaptive reuse. This means that the station buildings have all been preserved and are currently maintained in non-transportation uses. In many cases, the towns grew up around the stations, so they often tend to be centrally located in regard to the business districts they serve as well as accessible by highway. This study assumes that either the historic stations will be returned to rail use or else that equivalent new facilities will be developed in close proximity to the historic sites. All these stations had low level platforms, although in many instances the platforms have been removed or the active track has been shifted some distance away from the platform. These platforms will need to be replaced as part of any project to restore the stations to passenger use.

By comparison, no usable facilities exist at Birdsboro, Monocacy, Douglasville, Linfield, Schuylkill Township or Valley Forge (Mancill Mill). Some of these proposed stations are sited in remote locations with poor highway access, and others are tied to real estate development projects that have yet to be implemented. Conshohocken station has been consistently identified by regional studies as a major employment center and economic growth node for Montgomery County, but in point of fact the ridership of this SEPTA station has been unremarkable. Perhaps this is due to the lack of an effective circulator bus linking the rail system to the actual employment centers. However, the potential for this station to make a significant contribution to rail ridership still remains. If local communities are willing to take the lead in developing appropriate and attractive stations, once rail service starts, stops could be added at any time.

In regard to Center City stops, while North Broad was historically a stop for Reading trains, this location has become increasingly derelict while Temple University has developed into a major trip attractor. It is apparent that a stop at Temple University would be more beneficial to ridership than one at North Broad, so this substitution has been assumed for this evaluation. Although the historic rail service terminated in Reading Terminal (essentially the same location as today's Jefferson Station) SEPTA's highest volume downtown station has always been Suburban Station. Even since the opening of the Center City Commuter Tunnel, this has continued to be the case. Therefore it is assumed that the most important downtown station will be Suburban Station, while 30th Street will provide connectivity to intercity rail services; since many riders would stay on board if service were extended into the Northeast Corridor (as they do on the Harrisburg-New York Keystone trains.) As a result, the passenger on/off counts at 30th Street actually underrepresent the importance of this station.

For the base case, it is assumed that Reading trains would operate via the Center City Rail Tunnel in a manner conforming to existing SEPTA practice in regards to station stops, acceleration, braking, speed limits, station dwell times and overall schedule or travel times between the 16th Street Junction in north Philadelphia and the upper level platforms of 30th Street station. This is needed to make it easier to find schedule slots through the tunnel for the Reading trains, and to avoid disrupting any of SEPTA's other services through the tunnel.

3.2 Train Technology Options

Train technology was a major stumbling block to the historic 1981 diesel services to Reading, however in the nearly 40 years since those passenger services were ended, rail technology has made major leaps forward and effective solutions are now available to meet the requirements of this corridor service.

- The most immediate requirement for any trains that operate to Reading is that the equipment be acceptable to both Norfolk Southern for sharing the freight rail corridor west of Norristown, and also to SEPTA for sharing the passenger rail corridor east of Norristown. Crash safety will likely be Norfolk Southern's key concern, while compatibility with Center City tunnel requirements will be a key concern of SEPTA's.
- For options that envision run through service on the Northeast Corridor, the trains must also be acceptable to Amtrak. For Northeast Corridor (NEC) compatibility, trains must be capable of sustained top speeds of 125-mph so they can meet NEC schedules and minimize the impact on other NEC high speed operations. Tilt capability is an optional although highly desirable feature of any new trains.
- It is also desirable from an environmental perspective, that trains be able to use the electrification infrastructure where it exists, particularly east of Norristown and on the NEC.

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A number of high-performance train technologies could be capable of running from Reading through Philadelphia's Center City Commuter tunnel and onto the Northeast Corridor. Some examples of these are shown in Exhibit 3-3, and the functional requirements for the trains are summarized in section 3.2.1. For the purpose of this study it is not essential to choose any specific technology at this time; we have assumed a cost level that should be high enough for providing for any of these trains. The specific equipment selection will occur later, based on detailed discussions with equipment vendors and the railroads to determine which option best meets the need for the service.

Exhibit 3-3: A Variety of Rail Equipment Options Are Available for the Reading Passenger Rail Service

Self-Propelled
Electric or Diesel
with Battery
- Or -
Self-Propelled
Hydrogen Fuel
Cell



Diesel with
Battery



Electric Loco
w/Diesel or
Battery Power
Tender



Diesel + Electric
on Each End



3.2.1 Rolling Stock and Operational Assumptions

Consistent with the assumptions customarily made in feasibility-level planning and Tier I EIS studies, the following general assumptions are proposed regarding operating requirements for rolling stock for the Reading to Philadelphia rail corridor for all train technology options are as follows:

- Trains must be able to operate without emissions in the Center City Philadelphia rail tunnel and must be able to operate without catenary from Norristown to Reading. It is assumed that some combination of diesel, electric, battery and/or fuel cell propulsion technologies will be used to satisfy these requirements. Having two locomotives is likely more expensive than having one locomotive that shares certain electric components, but also offers benefits in terms of improved operational flexibility and emergency recovery, for example if the power line were down a diesel train could still operate. This need to be assessed in more detail in future studies.
- Trains will be reversible for easy push-pull operations (able to operate in either direction without turning the equipment at the terminal stations) although this requirement could be relaxed if it is determined that adequate turning facilities are available (e.g. the existing wye track at Reading and the balloon track at Sunnyside Yard in New York.)
- Trains will be accessible for passenger access and egress from low-level station platforms, which is required to ensure compatibility with freight operations; as well as from high-level station platforms which is required to ensure compatibility with the Center City Philadelphia and with NEC rail stations. The requirements of the Americans with Disabilities Act (ADA) can be met by deploying wheelchair lift equipment either at the stations or on board the trains.

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- Trains will have expandable capacity for seasonal fluctuations and will allow for coupling two or more trains together to double or triple capacity as required.
- Train configuration will include galley space, accommodating roll-on/roll-off cart service for on-board food service. Optionally or alternatively, the trains may include a bistro area where food service can be provided during the entire trip.
- On-board space is required for stowage of small quantities of mail and express packages, and also to provide for bicycle transportation, and/or an optional checked baggage service for pre-arranged tour groups.
- Each end of the train will be equipped with a standard North American coupler that will allow for easy recovery of a disabled train by conventional locomotives.
- Trains will not require mid-route servicing, with the exception of food top-off. Refueling, potable water top-off, interior cleaning, required train inspections and other requirements will be conducted at night, at the layover facilities located at or near the terminal stations. Trains would be stored overnight on the station tracks, or they would be moved to a separate train layover facility. Ideally, overnight layover facilities should be located close to the passenger stations and in the outbound direction so a train can continue, without reversing direction, after its final station stop; and
- Trains must meet all applicable regulatory requirements including:
 - FRA safety requirements for crashworthiness,
 - ADA Requirements governing accessibility, seating and rest room facility requirements for disabled persons,
 - Material standards for rail components for high-speed operations, and
 - Environmental regulations for waste disposal and power unit emissions such as EPA Tier IV emission requirements if diesel engines are a part of the solution.

3.2.2 Train Technology Operating Characteristics

Typical performance curves for representative trains are shown in Exhibit 3-4. The curves reflect the acceleration capabilities of a number of commonly deployed rail technologies. With conventional diesel power, one P-42 locomotive on a 300-seat train will accelerate according to the yellow “1 Loco” curve; adding a second P-42 locomotive will improve acceleration slightly as shown by the magenta “2 Loco” curve. This improvement is most noticeable at high speeds, since a single P-42 locomotive (if it is also providing hotel power to the train) has hardly enough power to reach 100-mph; two P-42 locomotives are needed to achieve 110-mph but due to gearing restrictions, they cannot go any faster than that. The new Siemens Charger diesel, however, is capable of reaching 125-mph.

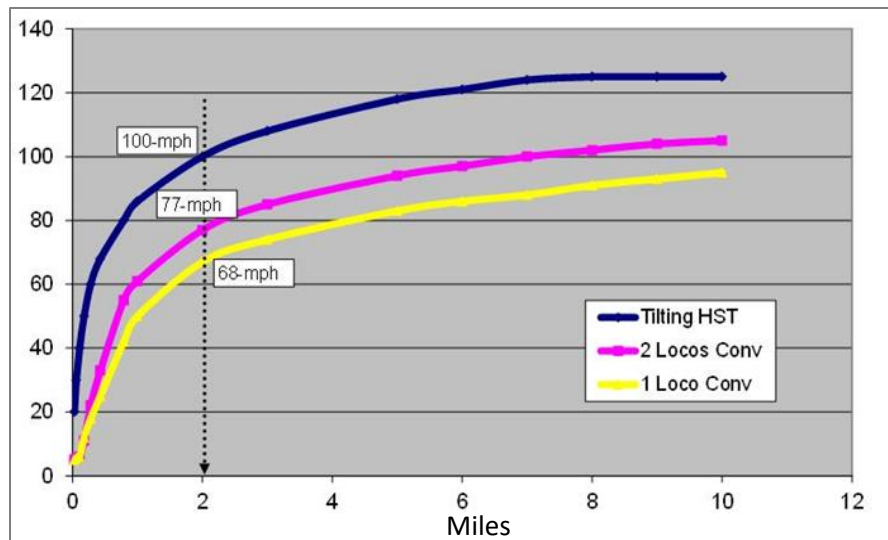
This is the reason why the Chicago to Detroit Wolverine trains was using two P-42 locomotives until the new Siemens Charger locomotives were introduced. The Siemens Charger is considerably more powerful and responsive than was the older P-42 locomotive, so the performance of a single Siemens Charger or even an electric locomotive is represented by the magenta “2 Loco” curve.

As shown in Exhibit 3-4, purpose-built Diesel Trains, such as a single level train pulled by a Siemens Sprinter, can offer considerably improved performance over conventional diesel trains that are based on freight-derived designs. In fact, up to about 80-mph the acceleration capability of a high-speed diesel is very similar to that of an electric locomotive. This explains why the Maryland Commuter (MARC) service

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recently ordered Siemens Charger diesel locomotives to power its trains on the Northeast Corridor¹², which have until now been powered by electric locomotives.

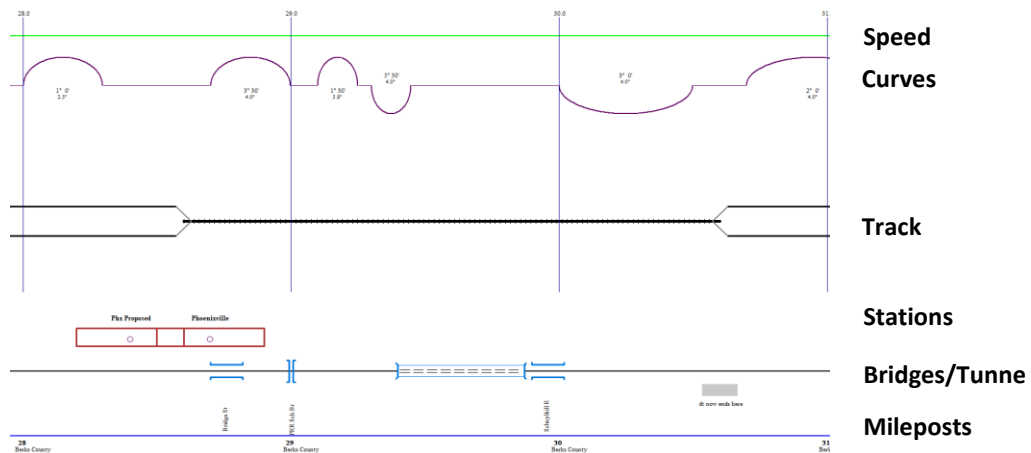
Exhibit 3-4: Comparative Train Acceleration Curves



Based on the acceleration curves shown in Exhibit 3-4, train timetables have been developed based on simulated train running times. These timetables can be used to calculate the number of train sets required to cover any given schedule rotation. Train frequencies and the required train seating capacity are then determined by appropriately matching train capacity to demand to ensure effective utilization of the trains and that the capacity will be neither overloaded nor run empty. This load factor balancing is accomplished via an interactive process using the demand forecast COMPASS™ Model.

Exhibit 3-5 shows how TEMS' TRACKMAN™ software has been used to electronically catalog the track infrastructure and proposed improvements, thus providing a detailed track database. The TRACKMAN™ database captures relevant data on the locations of all stations, grades, curves, speed limits, highway grade crossings, overhead and under grade bridges, side tracks and rail spurs. Based on this detailed infrastructure database, a full range of technology and train service options can be assessed.

Exhibit 3-5: Base Track Infrastructure for the Phoenixville Area as Shown in TRACKMAN™



¹² MARC replacing electric locomotive fleet with high-speed diesels, August 12, 2015, see:

<https://www.railwayage.com/passenger/commuterregional/marc-replacing-electric-locomotive-fleet-with-high-speed-diesels/>

LOCOMOTION™ results are slightly faster than actual times, since they are based on optimized performance of trains under ideal conditions. If dedicated tracks and/or exclusive right of way are used exclusively, then a 5 percent slack time allowance added to the train running time is appropriate. Shared use situations assume that passenger trains will have dispatching priority over freight, but if passenger trains are mixed with large numbers of freight trains then it is not unusual for the passenger trains to get caught behind freight trains and not be able to pass easily. In this case there is need to allow 10-15 percent slack depending on the density of freight traffic and the complexity of the route.

3.3 Passenger Train Timetable Development

Based on the available infrastructure and technology options, operating plans can be developed for the full range of alternatives. TEMS uses an Interactive Analysis (Exhibit 1-5) that estimates train times for each route and technology, then develops train schedules and operating plans that include train stopping patterns, slack time for freight train interaction and can assess train loads between each station. Based on the train loads it has been projected that the Reading to Philadelphia could support 8 train frequencies per day, which is one greater than the 7 daily round trips that had been operated by SEPTA prior to 1981.

The LOCOMOTION™ program reflects different operating characteristics (acceleration, curving and tilt capabilities, etc.) associated with the different types of train technologies as they interact with the rail infrastructure. In the speed profiles, exhibit 3-6 the red line shows the speed limit, and the black line shows the simulated speed actually obtained by the train at that point. The following subsections give the results of the LOCOMOTION™ analysis from Reading to Center City Philadelphia.

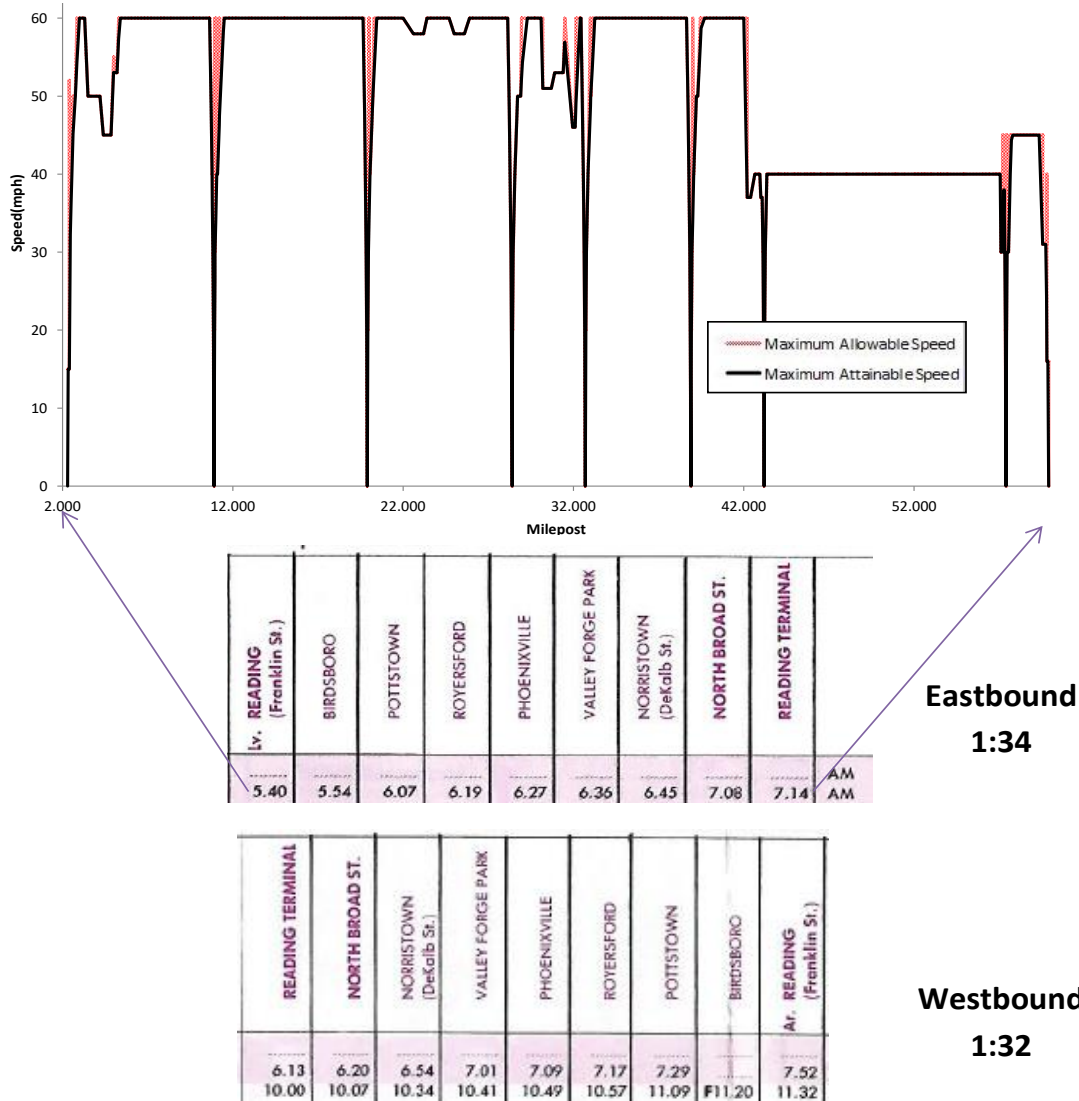
3.3.1 Validation of the Historical Timetable

After entering all the grades, curves and speed restrictions into the TRACKMAN™ database, the first step was to test the integrity of the data by replicating the historic 1981 schedule for Reading passenger service. The simulated train had identical performance, station stops, and speed limits as compared to the 1981 conditions. Exhibit 3-6 shows result of this validation process. For the historic service using Budd Rail Diesel Cars, the speed limit at the time was 60 mph from Reading to Norristown (and freight speeds were 50 mph, as they are today) but speeds were limited to only 40 mph on SEPTA east of Norristown apparently due to some deferred maintenance on the line at the time. The resulting timetable matched the real-world result with 1 hour and 34 minutes with an 8% slack time allowance, which is very reasonable. Starting from this validated base, builds confidence that as we adjust the parameters of the system, for example by raising speeds that the resulting running times will be accurate and the schedules will be achievable.

A detailed comparison of simulated times vs. the historical SEPTA timetable however, shows that:

- From Phoenixville to Norristown eastbound took 18 minutes, whereas westbound only took 15 minutes, with a stop at Port Kennedy. Eastbound trains were 3 minutes slower. With no stop and an improved 79-mph speed limit a 14-minute running time has been estimated.
- From Norristown to North Broad the time was 23 minutes. The new Phoenixville commuter schedule allows 25 minutes from Norristown to Temple University. This is consistent with the historic 1981 timetable and a 40-mph speed limit. With improved 60-mph speeds, express timetables from Norristown to Temple should be 21 minutes, four minutes faster.

Exhibit 3-6: 1:34 Franklin St. to Reading Terminal including 8% slack



For understanding the reason for this 3-minute increase in the eastbound time from Phoenixville to Norristown, exhibit 3-7 shows the historic track layout around Abrams Yard. The four mainline tracks were numbered #4, 2, 1, 3 from south to north (east is on the left) in historic Reading Company and ConRail track charts:

- The inside tracks #2 and #1, had a 35-mph speed and were used by mainline freight tracks for picking up and setting off cars at Abrams rail yard: they were called the “Southbound Slow Speed Track” and “North Bound Slow Running Track” on historic maps.
- The outside tracks #4 and #3 were used by passenger and through freight trains, they had a speed limit of 50-mph for freight, and 60-mph for passenger trains. Track #3 was signaled for running both ways. But track #4 passed directly in front of the yard office, and also between the locomotive servicing area and the main body of the freight yard. Exhibit 3-8 shows a Rail Diesel Car pausing at Abrams Yard office on what would now be Norfolk Southern’s main track #2. (The first track in the foreground is a yard running track which has since been removed.)

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Exhibit 3-7: Mainline track configuration around Abrams Yard in 1981

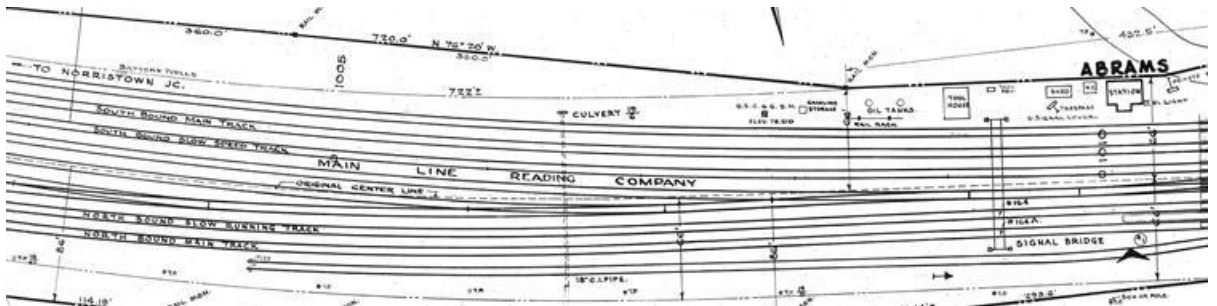
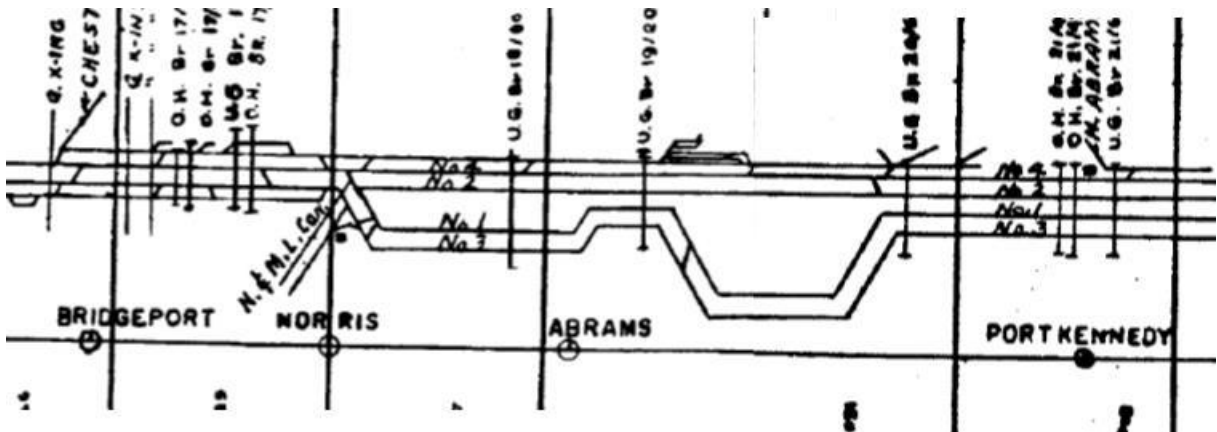


Exhibit 3-8: Rail Diesel Car on #4 Track at Abrams Yard Office in 1974¹³



¹³ Photo credit: Robert Allan. Used with permission.
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Today at Abrams Yard:

- The former #3 track has become Norfolk Southern's track #1. It is signalled in both directions as it always has been and has a freight speed limit of 50-mph, the same as in Reading days.
- The former #1 track still exists as a yard running track along the north side of the yard, but its signals have been removed. Westbound freight trains working in the yard can still pull into it for picking up and setting off cars, while staying clear of main line track #1.
- The former #2 track has been cut into pieces and tied into the Abrams yard switching leads. Those portions that still remain function today as yard tracks.
- The former #4 track has become Norfolk Southern's track #2, and recently received bi-directional signaling. However, since the former "Southbound Slow Speed Track" no longer exists, freight trains working the yard park on track #2 while picking up and setting off cars¹⁴. The speed limit on track #2 is just 30-mph, whereas 50-mph freight trains are allowed on track #1.

Although the main track along the south side of Abrams yard was historically used by passenger trains, because of the loss of the former "Southbound Slow Speed Track", using main line track #2 for passenger trains today would significantly interfere with Abrams yard operations.

If a passenger train were to use track #2 in an emergency, a 3-5-minute delay would likely result. This agrees with the 3-minute eastbound running time differential that was built into the 1981 historical schedules. It is understood that the Phoenixville Commuter train wants to use track #2, but the use of track #2 around Abrams yard should be avoided by passenger trains if possible. This analysis assumes that Phoenixville Commuter trains will use track #2 between Phoenixville and CP Forge, where a new set of universal crossovers will need to be added. Passenger trains would use these crossovers to switch tracks at CP Forge and use track #1 around the yard between CP Forge and CP Norris.

3.3.2 Reading to 30th Street via the Center City Tunnel

Having validated the data and the train performance model, the next step in modeling the corridor was to introduce a set of infrastructure and operational improvements. Opportunities to running times in the rail corridor were considered in three stages, each of which will be described in turn.

The first improvement considered is to raise track speed limits so that trains can run as fast as the existing curve geometry allows. As shown in Exhibit 3-9, the first improvement scenario assessed the impact of raising the speed on Norfolk Southern up to the standard 79-mph speed that is consistent with their passenger principles and practice elsewhere. 79-mph is also the fastest currently allowable speed limit for the I-ETMS Positive Train Control system that NS has deployed on their section of the line. For SEPTA a speed limit of 90-mph could be considered since the R6 Norristown rail line is equipped with a cab-signalling system and uses the ACSES PTC system. This is the same type of PTC and signalling system that Amtrak uses on the Northeast Corridor and it is operating there at 160-mph. However, because of curve geometry on the SEPTA line there is very little potential time savings for raising the speed above 60-mph.

For comparability to Exhibit 3-6 all running time results were based on Jefferson Station, which is in the same approximate location as the historic Reading terminal. This allows a direct "apples to apples" comparison of the performance of different scenarios on a consistent basis. Of course, if service were reinstituted on a rail route via the Center City tunnel, the trains would actually run through to 30th Street. Adding stops at Suburban Station and 30th Street would tack an additional 10 minutes onto the timetable.

¹⁴ A YouTube video shows a freight train arriving on the NS Main #2, and switching cars and locomotives in the Abrams freight yard. See: https://www.youtube.com/watch?v=JuQOq_70C8M

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As shown in Exhibit 3-9, raising the speed and limiting stops to Norristown, Phoenixville, Royersford, Pottstown and Reading would shorten the timetable from 1:34 to 1:18, a savings of 16 minutes or 16% compared to the historic 1981 schedule. This is based on a conventional non-tilting train (4" of cant deficiency, as allowed for a conventional train.) But to achieve this result, the train would skip the former stops at Birdsboro and Valley Forge Park.

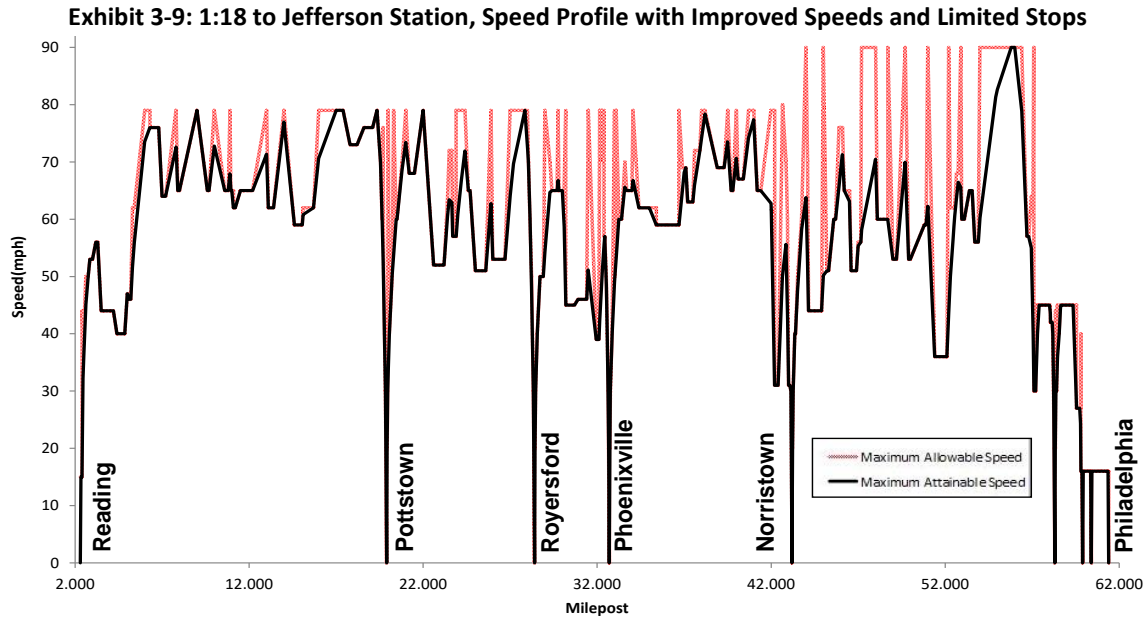


Exhibit 3-10 shows these running times in tabular format, also extending the schedule to 30th Street and to New York based on existing SEPTA timings from Jefferson to 30th Street and using existing Amtrak timings from 30th Street to New York Penn Station.

Exhibit 3-10: 1:18 to Jefferson Station, Tabular Schedule with Improved Speeds and Limited Stops

	Miles	Time	
Reading Franklin St	0	0:00	Dp
Pottstown	18	0:18	Ar
Royersford	26	0:30	Ar
Phoenixville	30	0:38	Ar
Norristown Trans Ctr	41	0:52	Ar
Temple Univ	56	1:13	Ar
Market East/Jefferson	58	1:18	Ar
Suburban	58	1:23	Ar
30th Street	59	1:29	Ar
Trenton, NJ	92	2:00	Ar
Newark, NJ	140	2:33	Ar
New York, NY	150	2:53	Ar

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For capacity assessment of proposed Phoenixville express commuter service, the schedule timings for non-tilting trains as shown in Exhibits 3-9 and 3-10 were used. The resulting 40-minute schedule from Phoenixville to Market East is 3 minutes faster than the *Preliminary Study for Regional Rail Service* assumed. This reflects the improved 60-mph speed limit that now exists on the SEPTA Norristown line as compared to the 40-mph limit that was in effect in 1981.

Exhibits 3-11 and 3-12 show the effect of using a tilting train (with 7" of cant deficiency). By tilting, the train can go around curves faster. This reduces the timetable from 1:34 to 1:11, a time savings of 23 minutes or 24% as compared to the historic 1981 schedule or seven minutes compared to the non-tilting option. This suggests that while tilt is not an absolute requirement, it could provide a valuable enhancement to the quality of the service.

Exhibit 3-11: 1:11 to Jefferson Station, Speed Profile using a tilting train

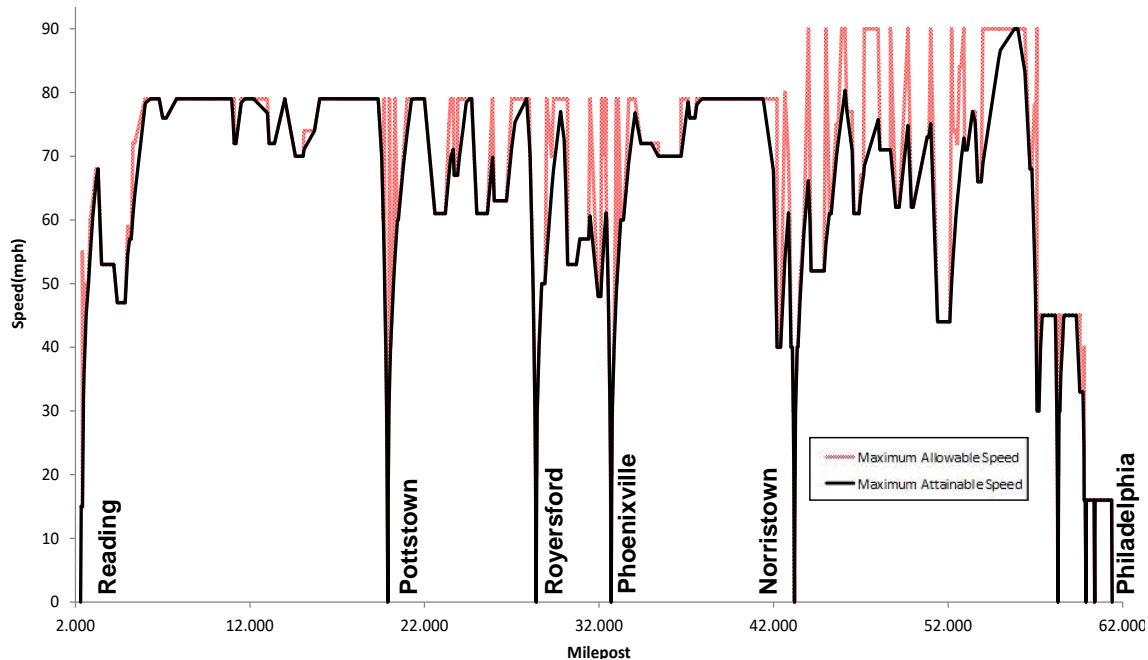


Exhibit 3-12: 1:11 to Jefferson Station, Tabular Schedule using a tilting train

	Miles	Time	
Reading Franklin St	0	0:00	Dp
Pottstown	18	0:18	Ar
Royersford	26	0:27	Ar
Phoenixville	30	0:38	Ar
Norristown Trans Ctr	41	0:48	Ar
Temple Univ	56	1:06	Ar
Market East/Jefferson	58	1:11	Ar
Suburban	58	1:16	Ar
30th Street	59	1:22	Ar
Trenton, NJ	92	1:53	Ar
Newark, NJ	140	2:26	Ar
New York, NY	150	2:46	Ar

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Exhibit 3-13 shows the effect of using a tilting train (7" of cant deficiency) along with an aggressive package of improvement to both the Norfolk Southern and SEPTA corridor segments. On SEPTA there are two areas where sharp curves severely limit speeds, but where those restrictions could be alleviated by utilizing the superior geometry of the parallel (abandoned) PRR right of way. These two areas are:

- **Mogeess, where the alignment makes a series of reverse curves as it wriggles underneath the Pennsylvania Turnpike.** About half of the ex-PRR right of way at Mogeess already has track on it since it forms a part of the NS Earnest connection.
- **Glen Willow curves in Ivy Ridge.** At Ivy Ridge, the proposed improvement would not only ease the curves but could also provide a direct track connection to former PRR alignment towards Bala Cynwyd. Since the PRR right of way has better geometry than does the Reading line in this area, the improvement would bypass the Glen Willow curves. While eliminating the curves, the location of the proposed "Dutch" interlocking connection (between the PRR and Reading lines) would also be shifted farther west towards Shawmont. This proposed reconfiguration of the "Dutch" connection would not only eliminate the sharp vertical curves and steep gradients associated with the original design for connection track but would bypass the Glen Willow curves as well.

As shown in Exhibit 3-13, a third opportunity exists for easing a short, sharp curve on the existing right of way that occurs near the UMP Railroad overpass. This improvement would be undertaken as a conventional curve easement.

Exhibit 3-13: Possible SEPTA Curve Geometry Improvements

Mogeess / Norristown East



UMP Bridge



Ivy Ridge / Glen Willow Curves



The effect of raising the speed limit to 90-mph on the Norfolk Southern portion of the corridor was tested. The three SEPTA improvements would together save about 90 seconds, and the NS improvements an additional 90 seconds for an overall possible time savings of about 2-3 minutes. The speed profile is shown in Exhibit 3-14, and the tabular timetable in Exhibit 3-15.

Since raising the speed limit to 90-mph west of Norristown would no longer be in compliance with Norfolk Southern's passenger principles and would only save 90 seconds, it is not worth doing. Easing curves on SEPTA would entail considerable capital expense, and the primary beneficiary would actually be SEPTA riders, since SEPTA runs far more trains than are planned to run to Reading. The 90 seconds time savings are not essential for re-launching the Reading passenger service, but could be considered in a future assessment in conjunction with SEPTA.

Exhibit 3-14: 1:09 to Jefferson Station, Speed Profile using the Aggressive Improvement Scenario

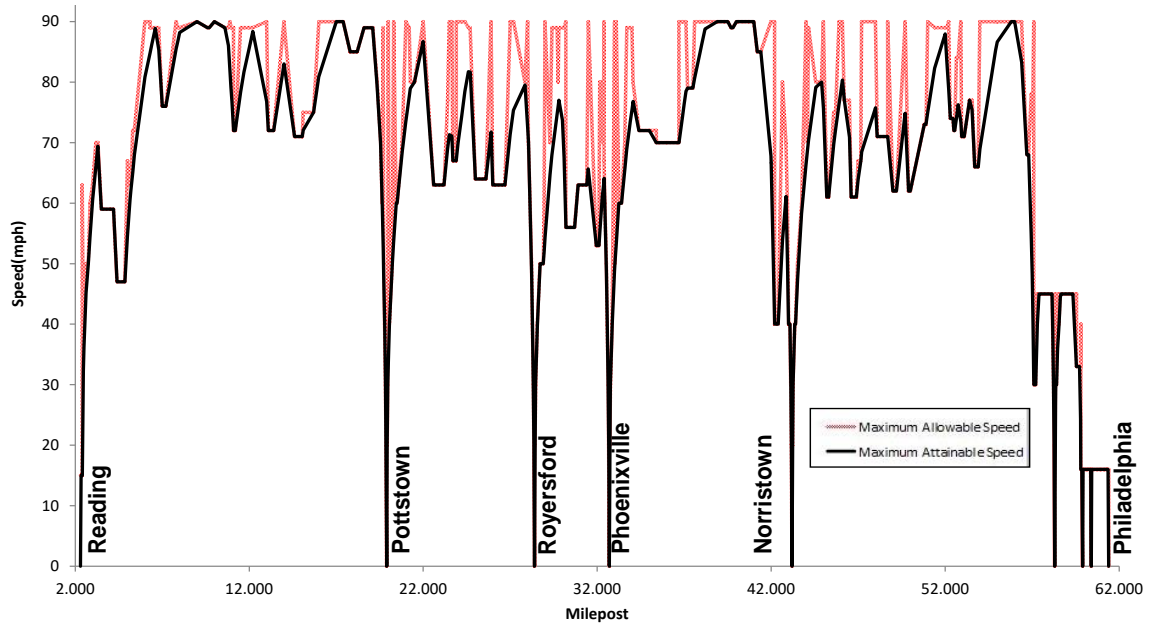


Exhibit 3-15: 1:09 to Jefferson Station, Tabular Timetable, Aggressive Improvement Scenario

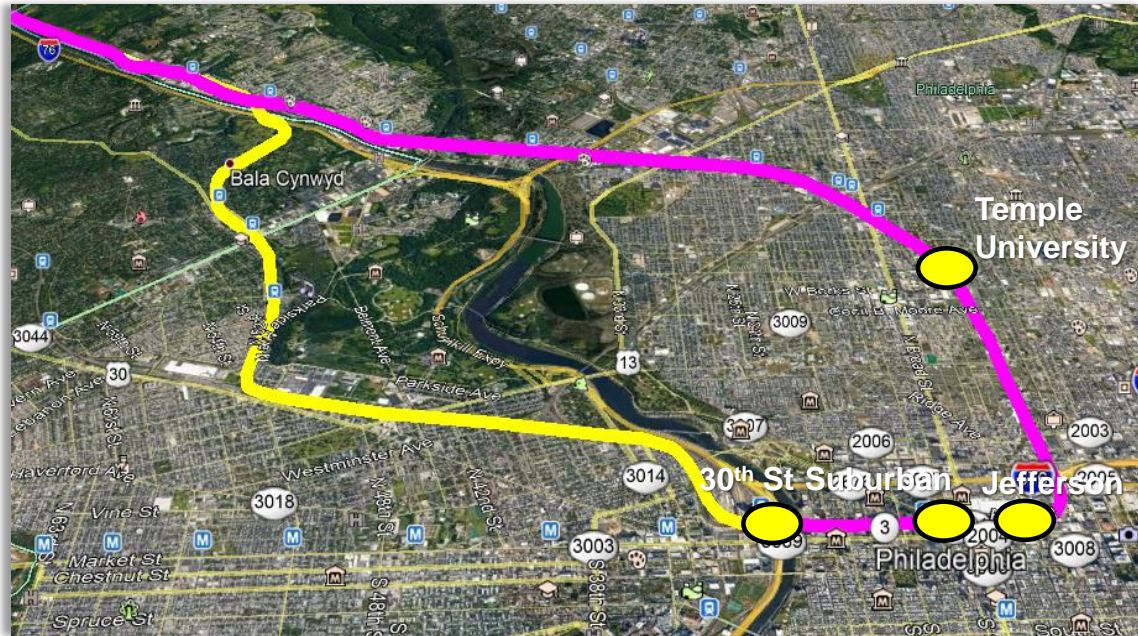
	Miles	Time	
Reading Franklin St	0	0:00	Dp
Pottstown	18	0:16	Ar
Royersford	26	0:26	Ar
Phoenixville	30	0:34	Ar
Norristown Trans Ctr	41	0:46	Ar
Temple Univ	56	1:03	Ar
Market East/Jefferson	58	1:09	Ar
Suburban	58	1:13	Ar
30th Street	59	1:20	Ar
Trenton, NJ	92	1:50	Ar
Newark, NJ	140	2:23	Ar
New York, NY	150	2:43	Ar

For now, the 1:18 or 1:11 options as described in Exhibits 3-9 through 3-12 are recommended to be carried forward. Either of these scenarios would use the existing infrastructure to its limit, but still remain consistent with Norfolk Southern's passenger principles and would not require any curve relocations. The practical choice between these options will largely depend on whether suitable tilting equipment can be obtained in the market place for a reasonable price, since it is clear that tilting equipment would have the ability to run the route faster and provide a more comfortable ride than non-tilting equipment could.

3.3.3 Reading to 30th Street via Bala Cynwyd

The Schuylkill Valley Metro study developed an option for developing the “Dutch” track connection at Ivy Ridge (just described and shown in Exhibit 3-13) that would connect the R6 Norristown line to the former PRR alignment just west of Manayunk. From there trains could follow the former PRR Schuylkill alignment across the large concrete arch bridge at Manayunk, through Bala Cynwyd and join the former PRR main line at Overbrook. This would develop an alternative access route directly to 30th Street station which could provide access to either the upper or lower level platforms at 30th Street. This alternative alignment is shown in Exhibit 3-16.

Exhibit 3-16: Alternative Route to 30th Street Station via Bala Cynwyd



This option could provide a direct approach to 30th Street station that does not require a train to travel through the Center City Commuter tunnels. Alternatively, it could enable a faster looping return of trains directly towards Reading, or it could allow a run-through service with any corridor on the Reading side of the network (e.g. to Quakertown/ Bethlehem). The main concerns with this approach are that:

- It would not allow a direct run-through to New York City within reversing the direction of travel.
- In addition, there has never been a track connection at Ivy Ridge between the two lines, and the track across the Manayunk arch bridge has been removed.

As a result, developing the Bala Cynwyd loop would require significantly more capital expense to develop than the option of running through the Center City tunnels, it might not directly serve the Philadelphia downtown stations, and it would make a run through operation to New York more difficult than it would otherwise need to be.

As shown in Exhibits 3-17 and 3-18, the Bala-Cynwyd option could reach 30th Street via Bala-Cynwyd in about the same time as the normal approach would reach Jefferson Station. Times to Suburban Station would be very similar. Going directly to 30th street via Bala-Cynwyd is slightly shorter than going via the Center City tunnel, but the Bala-Cynwyd route has worse geometry and more severe speed restrictions as

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compared to the normal approach along the Reading main line. As a result of these speed restrictions, the two routes are practically equivalent in time even though the Bala-Cynwyd route is shorter.

There are two other possible routes for going directly to 30th Street station, the first alternative using an existing track connection to the NEC at North Philadelphia; the other using CSX's Belmont Connection. The Belmont approach is particularly disadvantageous since it would bring in CSX as a party to the negotiation. Although the route could bypass SEPTA, it would also bypass an important station stop at the Norristown Transportation Center, and would require extended running of passenger train on the NS and CSX freight tracks.

An alternative route to 30th Street via Bala-Cynwyd, the Belmont Connection or North Philadelphia is only going to be effective if the goal is **only** to reach 30th Street station and not downtown Philadelphia stations; and **only** if trains are not going to run through to New York. These routes have been considered in previous studies that consider using only diesel locomotive power. Otherwise if dual-mode power can be used, entering the Center City Tunnel from the north is clearly going to be the most effective for facilitating an efficient run through to New York and the NEC without reversing direction.

Exhibit 3-17: 1:09 to 30th Street Station, Speed Profile via Bala Cynwyd

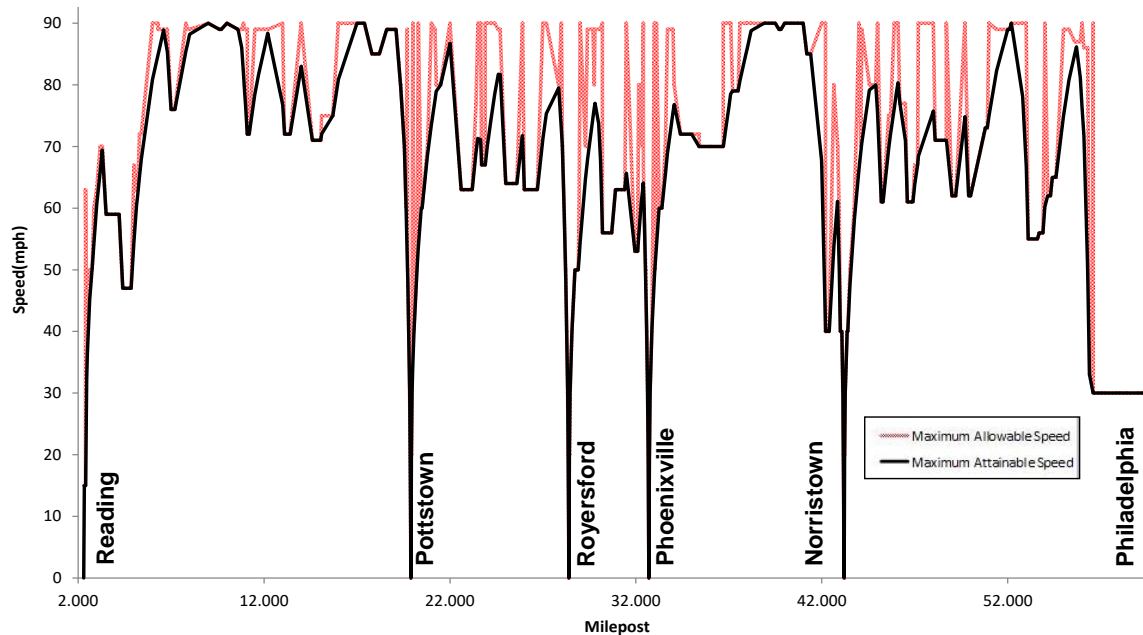


Exhibit 3-18: 1:09 to 30th Street Station, Tabular Timetable via Bala Cynwyd

	Miles	Time	
Reading Franklin St	0	0:00	Dp
Pottstown	18	0:16	Ar
Royersford	26	0:26	Ar
Phoenixville	30	0:34	Ar
Norristown Trans Ctr	41	0:46	Ar
30th Street	56	1:09	Ar
Suburban	58	1:14	Ar
Market East/Jefferson	58	1:19	Ar
Temple Univ	59	1:25	Ar

3.4 Rail Capacity Needs

SEPTA owns the R6 rail corridor from Philadelphia to Norristown and has upgraded the signals to allow for bi-directional running on either track, and equipped the line with the ACSES PTC system. Beyond Norristown to Reading, the line is owned by Norfolk Southern. In the 1980's the corridor featured significant segments of triple and even some quadruple track, but the old signal system only allowed one-way or "current of traffic" running. By now, most of these multiple track areas have been reduced to double track, but the signals have been upgraded to allow for bi-directional running, and Norfolk Southern has equipped the line with the I-ETMS PTC system.

The most recent detailed line capacity analysis, the **Schuylkill Valley Rail Assessment** was completed in conjunction with Norfolk Southern in 2005. The current assessment, however, develops an updated capacity study for supporting both the current and future requirements of rail service in the corridor. However, this update contains preliminary data which is still subject to review by Norfolk Southern. There are three sections of single track that pose a particular concern. These are:

- **Single track from Norristown around Abrams Freight Yard.** Norfolk Southern freights use the Schuylkill River bridge for reaching the Earnest Connection to the Morrisville line, however the connection at CP Norris on the Abrams side of the bridge only accesses the #1 track and Abrams freight yard. In 2005, double track across the Schuylkill River was still in place, although only one track remained in use. By 2020 the second track across the river bridge was completely removed, although the bridge substructure is still in place.

Making matters worse, there are no crossovers at CP Forge, or any other place between CP Norris and Phoenixville that would connect the bridge to any part of the #2 track. Since only the #1 track is accessible at CP Norris, this creates a 16-mile long single track bottleneck from CP King on the Morrisville line to CP Cromby near Royersford. While freight trains can also use the #2 track, the only way to access the Schuylkill River Bridge is through Abrams Yard, since the direct connection from #2 track to the bridge at CP Norris is missing.

- **Single track just north of Phoenixville through the Black Rock tunnel.** The tunnel was single tracked in 1956. When it was two tracks, clearances were so tight that no other train was allowed to enter the tunnel when a passenger train was going through. Although the tunnel is tall enough to permit double stacks through the middle, it would need both to be widened and have the ceiling raised in order to support the restoration of two tracks.

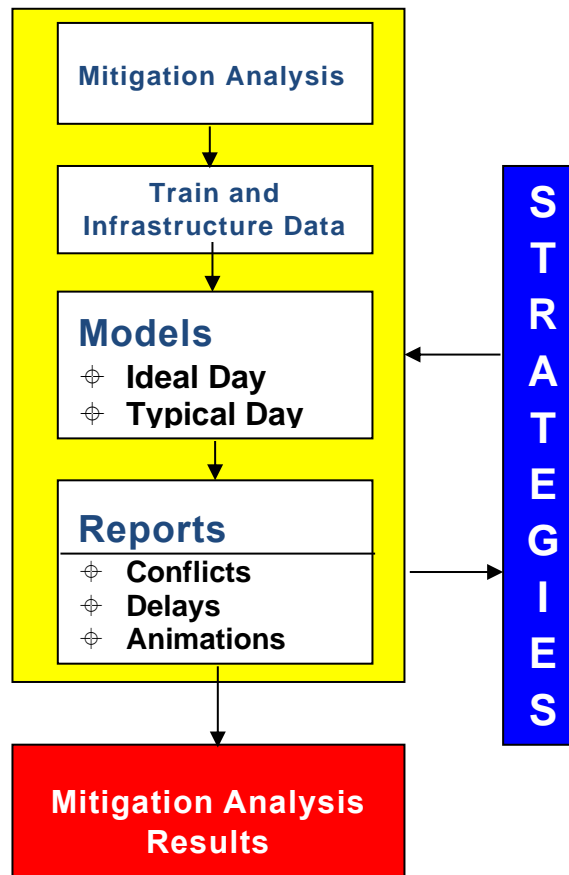
Recent Norfolk Southern signaling changes have moved the control points away from the tunnel portals at both ends. Originally less than a mile long, re-signaling has extended the length of single track so the bottleneck now exceeds 3 miles.

- **Single track through Downtown Reading.** The entire Pottsville to Philadelphia main line was at one time double tracked; but after discontinuance of passenger service, the stretch through downtown Reading was single tracked from CP Walnut past the Franklin Street station to Klapperthal Junction (CP Titus). But as a result of re-signaling of the line, the point of connection to the Belt Line was moved two miles east to CP Lorane, lengthening this single track bottleneck. Since about half of the Philadelphia-Reading trains use the Belt line around Reading, ConRail did not consider it necessary to maintain double track on the line through the city. It has been single tracked at least since 1997 for improving clearances under some of the overhead bridges in downtown Reading.

3.4.1 Capacity Planning Methodology

For assessing the capacity impacts of each investment scenario, TEMS used its Shared-Use™ simulation software that was originally developed for the Midwest Regional Rail Initiative study. The Shared-Use™ “Red Ball/Green Ball” Conflict Identification methodology has since been incorporated into a “Shared Use” tool by TRB under project NCFRP-30 and has been reviewed by the Federal Railroad Administration (FRA), Association of American Railroads (AAR), and freight railroads (BNSF and NS.) The methodology has been shown to be an effective tool for assessing the capacity impacts of adding more passenger trains to a freight rail line. The Shared-Use™ model has been compared by TRB and FRA to the results of earlier models (like RTC and RAILS-2000) and found to perform just as effectively as those models in assessing freight train performance.¹⁵ In addition, the Shared-Use™ model provides much better analysis of passenger train performance especially for replicating the acceleration and braking profiles of modern High Speed trains (including tilt trains) which are capable of operating above 79-mph. A web-based version of the software has been made publicly available by the FRA. Exhibit 3-19 shows a flowchart of the process.

Exhibit 3-19: Shared-Use™ Modeling Process



¹⁵ NCHRP Report 773: *Capacity Modeling Guidebook for Shared-Use Passenger and Freight Rail Operations* performed an independent assessment which found on page 66 that: “The North Sound RTC simulation, grid time analysis and SU Tool analysis provide results that are in some ways quite similar. The RTC simulation showed that, with the new passenger trains (Cascades and North Sound regional rail trains), passenger train performance would deteriorate somewhat, but freight train performance would be enhanced. This is the same finding generated by the SU Tool application. While the results like average speed per passenger and freight trains are different, **the findings overall are consistent.**” See: <http://www.trb.org/Publications/Blurbs/171662.aspx>

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As shown in Exhibit 3-19, the objective of a Shared-Use™ capacity analysis is to develop a “Mitigation Analysis,” which is intended to shield freight and existing passenger services from degradation associated with the addition of new passenger trains to the corridor. This means that existing freight and passenger services must continue to operate as effectively with additional passenger trains as they do today without them. Both Ideal Day (feasibility level) and Typical Day (investment grade level) are available for the evaluation process. Shared-Use™ is used for identifying how host freight railroads can be held “harmless” by determining what level of infrastructure is needed to maintain not just passenger rail schedules, but freight schedules as well.

Capacity can be measured in several ways. Two main approaches have been identified in the literature:

- One measure of capacity is freight operations delay expressed as a target freight train delay level. This base level can be estimated by simulating freight operations over existing infrastructure in a future forecast year. Mitigation is achieved by adding sufficient infrastructure to maintain freight train delays at the same level as the future forecast year, with new passenger service added.
- A second approach to capacity measurement was proposed by a 2007 study sponsored by the Association of American Railroads. This study suggested a Level of Service (LOS) based definition similar to the Highway Capacity Manual. This approach suggests that satisfactory arrangements between freight railroads and the public sector can be reached by maintaining a specific LOS (e.g., C or D or better) through the forecasted time horizon. This approach develops a throughput metric rather than a delay metric.

Both delay and throughput-based metrics can be produced by the Shared-Use™ tool, providing insight into the nature of interactions between freight and passenger trains.

Train traffic flow can easily be confirmed by viewing an animation of train operations, which is produced by the Shared-Use™ tool. If the operation is distressed, delays are obvious in the animations. If freight trains are not moving well in a Shared-Use™ simulation, it is not likely that passenger trains will be able to be satisfactorily handled, either – since passenger trains are generally understood to have higher service requirements than freight trains do. If additional trains are added, impacts can be assessed in terms of both additional conflicts and the likely delays.

For conceptual or feasibility level planning, an Ideal Day Capacity Analysis is performed. This type of analysis considers the meets and conflicts on the system and provides recommendations for additional infrastructure requirements based on train-meets, as well as providing estimates of the level of delay to freight operations that must be mitigated in order to ensure the continued effective operation of freight trains on the route.

This Ideal Day Analysis uses information about train departure and arrival times and replicates travel times by using each train’s acceleration and deceleration rates and stopping patterns, along with detailed information about the track infrastructure and speed limits. The Ideal Day Analysis is a “static” process in that it assumes that the conditions under which the trains operate are identical from day to day, producing identical travel times each day. Because there is no variation in travel times, trains are assumed to operate under “ideal” conditions. The Ideal Day Analysis is particularly effective for inexpensively developing preliminary estimates of the cost of implementation before more detailed cost estimates can be developed.

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In the Preliminary Engineering phase, which is typically undertaken as part of an Environmental study, a Typical Day Analysis produces a more detailed evaluation of train operations than the Ideal Day Analysis. It considers all forms of variation in train performance, particularly actual departure times. Instead of an “ideal” picture of train travel times, the Typical Day Analysis simulates a variation in departure times for trains in order to more realistically replicate day-to-day departure and arrival patterns.

In the implementation phase, final operating plans are produced to show how the construction phasing and implementation process will affect operating plans and how capacity requirements change as more trains are added to the corridor.

Each of these levels of capacity planning can be completed using TEMS’ software systems. The decision concerning which level of analysis is required depends on the quality of estimate required, budget available and the level of traffic on any given route or corridor. As such, it may be appropriate to carry out a Typical Day Analysis for a feasibility study, if the track is heavily used. Such an analysis has already been performed in 2005 by the **Schuylkill Valley Rail Assessment** study. However, the results of this analysis based on updated data are very consistent with the earlier study results.

The evaluation structure for any capacity analysis study is critical as it provides the framework for assessing mitigation measures and determining investment needs. The Shared-Use™ evaluation framework first establishes a base case and sets a standard against which to measure the impact of additional trains and the effectiveness of proposed infrastructure improvements. Then a series of evaluations are developed, to test various capacity analysis options and to ensure that existing railroad performance standards are maintained following the introduction or expansion of passenger service. A Shared-Use™ capacity analysis consists of a series of cases:

- **Case I – Base Case:** This case simulates the corridor’s existing freight and passenger traffic so that delay for freight trains can be estimated. These estimates are part of the basic calibration of the capacity analysis system and are used to judge and adjust the performance of the model.
- **Case II – Do Nothing:** This case measures the delay for freight traffic in selected forecast years (e.g., 2040) without the addition of passenger trains. It is this level of freight and passenger traffic delay that sets the standard for train delay, which must be maintained for the freight railroad to be mitigated in the future forecast year.
- **Case III – Do Minimum:** Passenger trains are introduced, and the increased train delay associated with freight and passenger trains is measured. Only the improvements that are absolutely needed for passenger operations, such as stations, are added. In heavily congested corridors, the introduction of passenger trains has a significant impact on freight train operations, so this scenario may not even be operable. In less heavily used corridors, less mitigation is needed for maintaining an acceptable level of service for freight trains.
- **Cases IV – Mitigation:** In these cases, various mitigation strategies (infrastructure, signaling, and operations) are tested for their ability to alleviate the increase in freight and passenger train delay measured in Case III, and to reduce it to the level previously identified in Case II. The number of mitigation cases developed depends on the number of infrastructure and operating strategies that can be devised to reduce freight and passenger delays. If a large number of infrastructure strategies exist, multiple cases must be assessed.

In carrying out a Shared-Use™ capacity analysis, the average travel times, standard error, and associated train delay will be calculated for each train.

3.4.2 Capacity Analysis Data Requirements

The Shared-Use™ capacity analysis planning process focuses on the development of two databases that are initial inputs of the evaluation of capacity for a rail corridor. These two databases are the track infrastructure for which the capacity is being measured, and the train schedules that reflect the train operations in the corridor.

Track Infrastructure - TEMS develops the corridor track infrastructure database using its TRACKMAN™ program. This program is designed to build an infrastructure inventory database and to provide graphic review capabilities for a given railroad route. Using railroad track charts, engineering information, field inspection and GOOGLE EARTH aerial photography, TEMS builds a mile-by-mile inventory database within TRACKMAN™ that contains the physical infrastructure of the route including gradients, sidings, crossovers, curves, bridges, tunnels, yards, and signaling systems. This data is displayed along with the maximum permissible train speed to provide a clear definition of the track conditions and capability.

The TRACKMAN™ database shows which track sections will limit train performance, and the program's upgrade facilities make it possible to develop a list of track improvements that will raise maximum permissible speeds and train capacity on a given route. Using either specific engineering cost data or default unit costs, the proposed list of improvements can be costed and prioritized. In this way, TRACKMAN™ provides a mechanism for identifying the base track condition as well as possible strategies for alternative capacity and speed improvements. These strategies can be tested in the Shared-Use™ capacity analysis evaluation.

Train Schedules - The second key tool is the LOCOMOTION™ program, which develops both point to point running times and train schedules for both passenger and freight trains using train performance, engineering track geometry, and train control input data. LOCOMOTION™ provides both tabular and graphic output showing mile-by-mile train performance, based on the characteristics of both the train and the track and to build detailed train schedules with prospective arrival and departure times at each point along the line.

The outputs of the TRACKMAN™ and LOCOMOTION™ software programs are combined in the Shared-Use™ program to perform capacity analysis and to assess train delays. A Mitigation Analysis is performed to identify and resolve train conflicts, measure delays, and to develop the appropriate levels of track, signaling and operating improvements that are needed to make the proposed schedules work while mitigating freight train delays to acceptable levels.

The Mitigation Analysis framework is designed to identify the infrastructure that is needed to make a freight railroad “whole” for the cost of added freight train delays. Practically, since capacity comes in increments or step functions, it is seldom possible to satisfy the mitigation criteria exactly. To reduce freight train delays below their target level, it is usually necessary to “overshoot” the mark, so the resulting investment strategy usually does produce a net operating benefit to the freight railroad.

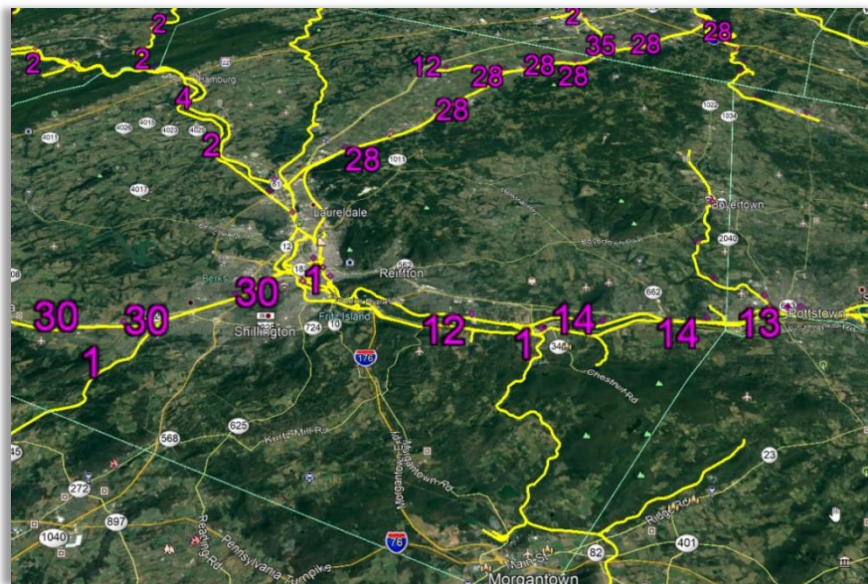
The current study will develop a preliminary analysis of corridor capacity needs based on publicly available data. The next step will be to review the findings with Norfolk Southern and SEPTA to obtain their input and, if possible, concurrence with the results based on the current level of planning. As the project moves towards implementation, the analysis will need to be refined by using detailed railroad-provided rather than public data. This typically requires the execution of confidentiality agreements with the railroads and will need to be progressed in the next phase of work.

3.4.3 Freight Train Volumes and Schedules

To establish a base case, it is necessary to establish the freight train volumes and associated schedules. However, the volume of freight trains moving on the Philadelphia to Reading rail line has changed over the years. There have been fundamental shifts in demand, rail freight routings, and the 1999 division of ConRail between CSX and Norfolk Southern had a significant effect on traffic flows. Train volumes moving on the Philadelphia to Reading line have been confirmed and cross checked using four independent methodologies: the FRA Grade crossing database, Gross Tonnage data from track charts, by direct observation and by using the STB Public Carload Waybill sample. Each of these methodologies is described below.

The **FRA Rail/Highway Grade Crossing Database** directly gives train counts. Using the grade crossing data, TEMS was able to create a map in Exhibit 3-20 which shows daily train counts as 13-14 between Philadelphia and Reading, or 7 trains each way per day. Train counts from Harrisburg to Reading and towards Allentown are more than double those going towards Philadelphia.

Exhibit 3-20: FRA Grade Crossing Database Train Counts



Track charts provide a valuable source of data on infrastructure changes that have occurred over time. ConRail included Gross Tonnage¹⁶ data on its track charts, and Norfolk Southern has continued the practice. According to these charts (summarized in Exhibits 2-1 though 2-3) the Reading to Philadelphia line carried 28 Million Gross Tons in 2013.

While tonnages do not provide a direct measure of train counts, they can be converted into train counts by dividing by the average tonnage per train. This was done to provide an independent corroboration of the grade crossing data. Norfolk Southern's average train weight¹⁷ was 5,380 tons in 2013, so this

¹⁶ Gross Tonnage gives the total weight of locomotives, railcars and lading moving over any given track segment. This data was included on the engineering track charts because it is relevant to track maintenance needs.

¹⁷ According to Norfolk Southern's 2013 R-1 filing with the Surface Transportation Board the railroad had: 193,551,759 thousand revenue ton miles (RTM); 400,884,202 thousand gross ton miles (GTM); and 74,795,669 train miles (TM). As a result, the average train weighed 5,380 tons and carried a net lading weight of 2,588 tons. Source:

<http://www.nscorp.com/content/dam/nscorp/get-to-know-ns/investor-relations/other-reports/2013R-1.pdf>

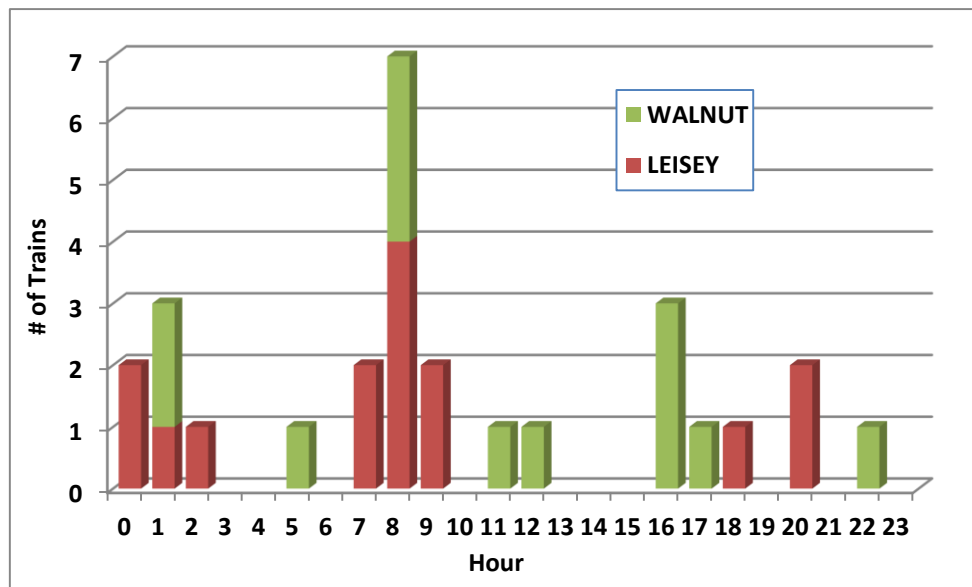
suggests 5,204 annual trains or an average daily count of 14 trains, ***which precisely matches the grade crossing database.***

Direct Observations can be used to count trains, as well as to ascertain the direction and time of operations. Reading area rail operations were directly observed from Tuesday December 3rd through Thursday December 5th, 2019. During this 3-day period, 28 eastbound departures and 26 westbound arrivals were counted; an average of 8-9 daily trains in each direction; but this includes a local train serving the Pottstown Thoroughbred Bulk Terminal (TBT), and a second local train that serves the Dyer Quarry on the Turkey Path at Birdsboro. Accounting for the two local trains, this again ***precisely matches the grade crossing database by*** suggesting that 7-8 daily through trains operate each way¹⁸.

Exhibit 3-21 shows that the eastbound departure time distribution shows a strong peak in the morning; with additional departure times scattered throughout the evening. Exhibit 3-22 shows the eastbound arrival time distribution, and it shows a cluster of train arrivals in the late evening around midnight. Taken together, these results suggest that there is very little freight activity overnight.

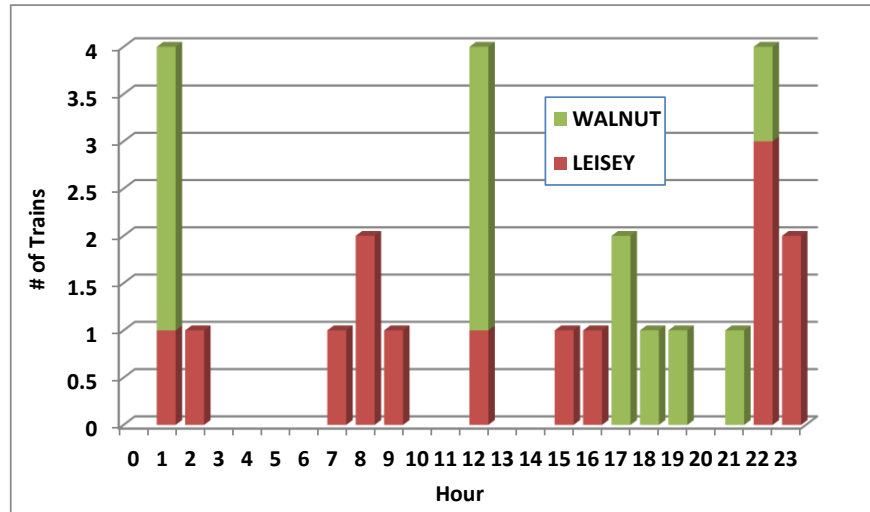
These arrival and departure time distributions were used for generating the train departure times in the Shared-Use™ simulation model runs, so most freight trains are going to be operating during daylight hours when passenger trains also are running. There is very little freight activity overnight. About half the trains use the Belt Line to CP Leisey, and the other half use the downtown Reading route to CP Walnut.

Exhibit 3-21: Departure Time Distribution for Eastbound Trains at Reading



¹⁸This count also agrees with an informal internet source that reports a total of 15 daily trains (both directions) at CP Titus. By itself, such a source would not be considered reliable, but in conjunction with other data it adds credibility to the reliability of the estimate: <http://www.railfanreading.com/Titus.htm>

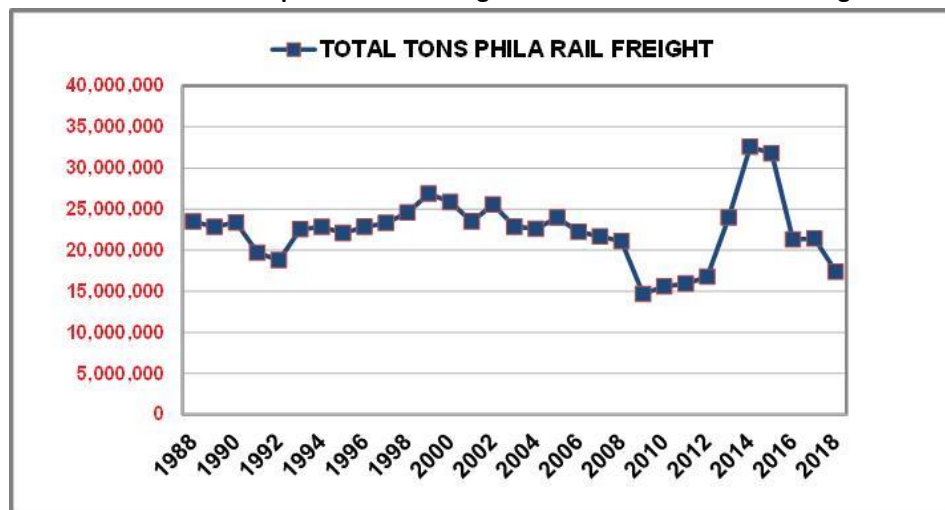
Exhibit 3-22: Arrival Time Distribution for Westbound Trains at Reading



The **STB Public Carload Waybill Sample** reports the total rail carloads and tons originated and terminated each year. The Surface Transportation Board uses BEA Zones¹⁹ for the creation of its annual Public Waybill file. BEA Zone 12 is defined to include “Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD” and this includes the parts of southeastern Pennsylvania and southern New Jersey that the Philadelphia-Reading rail line serves.

The rail waybill tonnage history for BEA Zone 12 is very stable back to 1988, which is the earliest year for which the Public Use Waybill data is still available. Depressed tonnages in 2009-2012 correspond to the period of the Great Recession, followed by several years of very high tonnages, peaking at over 30 million tons, that were driven by oil train movements to East Coast refineries. By 2016 however, oil train movements had practically ceased, and rail tonnages returned to normalized levels in the range of 20 million tons for 2016 and 2017; in the last year 2018 for which waybill data is available, rail traffic fell below 20 million tons. The overall pattern of Philadelphia rail freight could be characterized as one of fairly long-term market stability with little discernable traffic growth, except for the short-lived oil boom.

Exhibit 3-23: BEA Philadelphia Zone 12 –Originated and Terminated Rail Freight Tonnage



¹⁹ The Bureau of Economic Analysis (BEA) of the United States Department of Commerce is a U.S. government agency that provides official macroeconomic and industry statistics.

Under the right economic conditions, some of the oil traffic could return, but it would not likely rise to the historic 30-million-ton level. As a result of an explosion and fire²⁰, the Philadelphia Energy Solutions refinery, the largest oil refinery on the East Coast has permanently closed. With a 335,000 bbl/d capacity, this refinery had provided 28% of the gasoline that was consumed in the northeastern United States. Although Delta Air Lines' subsidiary Monroe Energy's 185,000-bbl/d refinery in Trainer, PA still remains in operation (for now) this facility is also reportedly up for sale²¹. With nearly $\frac{2}{3}$ of the Philadelphia's refinery capacity gone, any recurrence of the oil boom of 2014/15 seems unlikely. Rather, the refinery's closure is more likely to depress the market for rail service since in addition to receiving unit trains, the facility also shipped and received a considerable volume of regular carload freight.

In 1999, the STB data shows that the region originated or terminated 26.9 million tons of rail freight. In 2013 this reduced slightly to 24.0 million net tons. However, this is the net weight of only the goods. As a result, the commodity net tonnage of 26.9 million tons needs to be **doubled** to account for the added weight of railcars and locomotives²². Therefore, the gross tonnage generated by the Philadelphia region rail traffic was 54 million tons in 1999, or 48 million gross tons in 2013.

- The 1999 result of 54 million tons squares nicely with the 45 million tons that ConRail hauled on the Reading-Philadelphia rail line in 1999 (Exhibit 2-2), while still leaving a few million tons for CSX to move.
- The 2013 result of 48 million tons again squares with the 28 million tons that Norfolk Southern hauled (Exhibit 2-3) suggesting that it would have held a 58% share of Philadelphia rail tonnage that year, with CSX handling the balance. This is a reasonable share of the total market and further supports the conclusion that Norfolk Southern train volume is likely in the range of 7-8 trains per day in each direction, or a total of 14-16 daily through trains between CP Norris and Reading.

3.4.4 Freight Growth and Forecast Scenarios

The proposed capacity mitigation must not just handle today's freight volumes, but must also guarantee Norfolk Southern that the proposed passenger service won't interfere with its future freight traffic growth opportunities. As such, it is necessary to forecast future freight volumes, and to develop a future year scenario in the simulation model.

As a source for such a forecast, the Freight Analysis Framework version 4 (FAF4) database was used²³. This database was produced through a partnership between Bureau of Transportation Statistics (BTS) and Federal Highway Administration (FHWA). It integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation. Starting with data from the 2012 Commodity Flow Survey (CFS) and international trade data from the Census Bureau, FAF4 incorporates data from agriculture, extraction, utility, construction, service, and other sectors and it includes forecasts for 2020 through 2045. FRA Guidance²⁴ requires that corridor plans be developed 20 years into the future, so the 2040 FAF4 forecast is of the most interest.

²⁰ After Explosion, Philadelphia Refinery To Be Permanently Shut Down, February 17, 2020.

<mailto:https://www.forbes.com/sites/andystone/2020/02/17/with-ample-drama-largest-east-coast-refinery-meets-its-end/#7e01be017ef7>

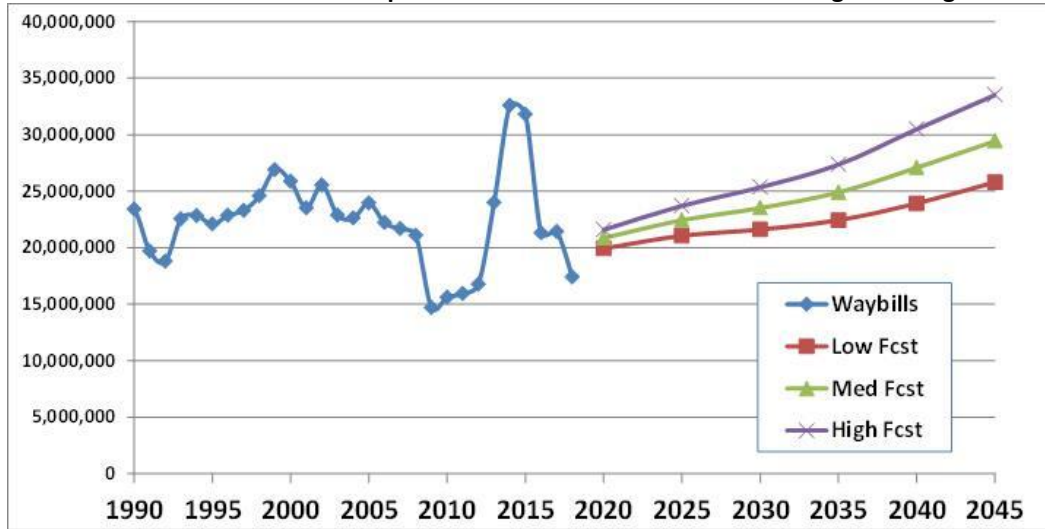
²¹ See <https://rbnenergy.com/shop-around-part-2-the-refineries-on-the-block-in-the-western-us>

²² Referring once again to Norfolk Southern's 2013 R-1 filing: the railroad generated 400,884,202 thousand gross ton miles (GTM) to produce 193,551,759 thousand revenue ton miles (RTM) – slightly more than a 2:1 ratio. This provides for the extra weight of the railcars and locomotives, as well as for empty returning railcars and the locomotives needed to haul them.

²³ See: https://ops.fhwa.dot.gov/freight/freight_analysis/faf/

²⁴ *Railroad Corridor Transportation Plans: A Guidance Manual*, FRA, 2005: <https://railroads.dot.gov/elibrary/railroad-corridor-transportation-plans-guidance-manual>

Exhibit 3-24: BEA Philadelphia Zone 12 – FAF4 Forecasted Rail Freight Tonnage



As shown in Exhibit 3-24, FAF-4 forecasts that rail tonnage of the Philadelphia BEA will grow at an annual rate between 1.0% to 1.8% throughout the forecast period.

- The Low-case projection is that rail tonnage will grow at an annual rate of 1.0%, or 23.0% overall from 19.9 million tons in 2020 to 23.9 million tons by 2040.
- The Mid-case projection is that rail tonnage will grow at an annual rate of 1.4%, or 31.8% overall from 20.8 million tons in 2020 to 27.0 million tons by 2040.
- The High-case projection is that rail tonnage will grow at an annual rate of 1.8%, or 42.3% overall from 21.6 million tons in 2020 to 30.5 million tons by 2040.

By comparison, the *Schuylkill Valley Rail Assessment*, a detailed capacity assessment conducted with Norfolk Southern in 2005 had forecasted a growth rate of 2.8%.

- This would have resulted in a **75% increase** in traffic from 2005 to 2025, so this growth rate is much more aggressive even than the FAF4 High-case projection.
- 2005 actual tonnage was 23.9 million tons, if traffic had in fact grown at a 2.8% rate from 2005, it **should have increased by 43%** to a level of 34.3 million tons by 2018.
- What actually happened, is traffic **actually declined by 27%** to a level of 17.4 million tons in 2018. As a result, actual 2018 freight traffic turned out to be just half what the *Schuylkill Valley Rail Assessment* had forecasted for that year.

In retrospect, it is clear that the aggressive 2.8% growth rate that the *Schuylkill Valley Rail Assessment* assumed can only be characterised as a “major forecasting miss” – wishful thinking at best.

The reality is that the waybill data shows that Philadelphia-area rail tonnage has been flat since 1988, and that rail freight has actually been on the decline since 2005, as the northeastern industrial base has continued to atrophy. The only exception was a short two-year period when oil trains were moving to east coast refineries -- but even then, that traffic was considered likely unsustainable, since oil would continue to use rail only until pipeline capacity could be built. But given the recent closure of the Philadelphia Energy Solutions refinery and CSX’s upcoming enhancement of its double-stack capability along I-95 – neither of these outcomes are going to help Norfolk Southern grow its Philadelphia freight franchise.

Nonetheless, public policy does recognize the valuable contribution that rail freight makes not only to the economy, but also to the environment. According to AAR, *“Railroads are the most environmentally sound way to move freight over land. On average, trains are three to four times more fuel efficient than trucks. They also reduce highway gridlock and greenhouse gas emissions. Through the use of greener technologies and more efficient operating practices, our nation’s freight railroads are committed to even greater environmental excellence in the years ahead.”*²⁵

Given these caveats and concerns regarding future rail traffic growth assumptions, there is still a need to develop a future-case planning scenario for this study. Future scenarios are designed to ensure Norfolk Southern will have enough capacity to be able to effectively respond to whatever freight market opportunities it can find. These scenarios will include the development of additional mitigation measures that are designed not only to increase capacity, but which could help Norfolk Southern to start growing its freight markets as well.

Freight Scenarios for the Simulation Cases – For planning purposes, the following will be assumed in development of the capacity analysis simulation cases:

- For reflecting current (2020) train volumes, the base freight scenario assumes 8 daily trains in each direction, or 16 freight trains per day total. This is conservative since the grade crossing, track chart and direct train counts have all suggested that only 7 road train round trips have actually been running, plus a few local trains. As well, Norfolk Southern adopted Precision Scheduled Railroading (PSR) operating principles in 2019. One of the main tenets of PSR is to “run fewer” (but heavier) trains²⁶ thus it is likely that PSR has reduced, not increased the number of trains that are being operated over the line today. Therefore, the base case will include one additional train beyond what the data says are actually running.

Freight trains are scheduled according to the arrival/departure time distributions as shown in Exhibits 3-21 and 3-22. As a result, most freight operates during the day when passenger trains are also running. This increases the level of conflict with passenger trains and therefore the required mitigations.

Finally, even though the freight train speed limit is 50-mph, freight train speeds have been artificially capped at 30-mph. As a result, freight trains need at least 90 minutes to go from Reading to Abrams Yard, a distance of 40 miles. Using slower, more conservative speed profiles for freight trains ensures that catch-up conflicts between freights and faster passenger trains are appropriately modeled.

- For reflecting future (2040) train volumes, the forecast freight scenario assumes four additional daily freight trains in each direction, an increase of 50% in train volume over the 20-year period.

As a result, the forecast freight scenario assumes 12 daily trains in each direction, or 24 freight trains per day. Over the 20-year forecast period, the assumed annual growth rate is 2.0%. This exceeds the 1.8% growth rate of the FAF4 “High Growth” projection, although it is not as high as the failed 2.8% forecast that the **Schuylkill Valley Rail Assessment** used. Nonetheless, the growth rate used is higher even than the most aggressive FAF4 (US government sanctioned) forecast. This 50% increase in assumed freight train volumes used in the 2040 forecast year, should provide more than adequate capacity to absorb any growth in freight volumes.

²⁵ See: <https://www.aar.org/wp-content/uploads/2018/07/AAR-Environmental-Benefits-Moving-Freight-by-Rail.pdf>

²⁶ See: https://www.progressiverailroading.com/norfolk_southern/news/NS-readies-operating-plan-for-precision-scheduled-railroading--57731

3.4.5 Passenger Timetables

A basic requirement for passenger scheduling is to ensure the operational feasibility of the schedule. For example, passenger trains can only meet one another in sidings or where double track sections. Any schedule that does not reflect such constraints is impossible to operate. As a result, in schedule development, trains have to be timed so train meets on single track do not occur. Overtakes between express and local passenger trains have to be similarly timed. Some overtakes can be prevented by coordinating schedules to ensure that express trains depart ahead of locals. However, if an overtake cannot be avoided, it needs to be carefully orchestrated to ensure that no opposing traffic is using the second track at the same time.

The R6 Manayunk/Norristown line operated by SEPTA, is the only passenger rail service that is operating today in the corridor. SEPTA's R6 timetable that was used for this analysis is detailed in Exhibit 3-25.

Restoring Passenger Rail Service to Berks County, PA

Exhibit 3-25: SEPTA R6 Manayunk/Norristown Line Schedule, December 15, 2019

MONDAYS through FRIDAYS (except MAJOR HOLIDAYS)																																			
TO CENTER CITY	Fare Zone	Services	Stations	Train Number	207	2311	2301	2715	209	6203	6205	2407	6221	6217	6223	6225	227	229	6231	235	237	2357	2555	2367	2751	2371	6267	6271	273	275	277	279	6281	6283	
					AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
	3	✓	Elm Street		5:45	6:13	6:49	6:57	—	7:34	—	—	8:11	—	8:45	9:19	10:01	11:01	11:55	12:45	1:49	3:10	3:56	4:36	5:09	5:40	6:20	7:17	7:54	8:45	9:48	10:52	12:39	1:36	
	3	✓	Main Street		5:48	6:16	6:51	6:59	—	7:36	—	—	8:13	—	8:47	9:21	10:03	11:03	11:57	12:47	1:51	3:12	3:58	4:38	5:11	5:42	6:22	7:19	7:56	8:47	9:50	10:54	12:41	1:38	
	3	✓	Norristown T.C.		5:52	6:19	6:55	7:03	—	7:40	8:05	—	8:17	—	8:51	9:25	10:07	11:07	12:01	12:51	1:55	3:16	4:03	4:42	5:15	5:47	6:26	7:23	7:59	8:51	9:54	10:58	12:45	1:42	
	3	✓	Conshohocken		5:57	6:24	7:01	7:09	—	7:45	8:11	—	8:23	—	8:56	9:30	10:12	11:12	12:06	12:56	2:00	3:23	4:08	4:46	5:20	5:53	6:31	7:28	8:05	8:56	9:59	11:03	12:50	1:47	
	3	✓	Spring Mill		6:00	6:27	7:04	7:12	—	7:48	8:13	—	8:26	—	8:59	9:33	10:15	11:15	12:09	12:59	2:03	3:27	4:11	4:49	5:23	5:57	6:34	7:31	8:08	8:59	10:02	11:06	12:53	1:50	
	2	✓	Miquon		6:04	6:30	7:08	7:18	7:26	7:53	8:17	8:22	8:30	8:44	9:02	9:36	10:18	11:18	12:12	1:02	2:06	3:29	4:14	4:52	5:26	6:00	6:37	7:34	8:11	9:02	10:05	11:09	12:56	1:53	
	2	✓	Ivy Ridge		6:08	6:35	7:13	7:23	7:33	7:58	—	8:27	8:35	8:48	9:07	9:40	10:22	11:22	12:16	1:06	2:10	3:33	4:19	4:57	5:30	6:05	6:41	7:38	8:15	9:06	10:09	11:13	1:00	1:57	
	2	✓	Manayunk		6:10	6:37	—	7:25	7:36	8:00	—	8:30	8:37	8:52	9:09	9:42	10:24	11:24	12:18	1:08	2:12	3:35	4:22	4:59	5:32	6:07	6:43	7:41	8:17	9:08	10:11	11:15	1:02	1:59	
2	✓	Wissahickon T.C.		6:13	6:40	—	7:27	7:40	8:03	—	8:33	8:40	8:56	9:12	9:45	10:27	11:27	12:21	1:11	2:15	3:38	4:25	5:02	5:35	6:11	6:46	7:44	8:20	9:11	10:14	11:18	1:05	2:02		
1	✓	East Falls		6:15	6:43	—	7:31	7:44	8:06	8:32	8:36	8:43	9:00	9:15	9:48	10:30	11:30	12:24	1:14	2:18	3:41	4:28	5:05	5:38	6:14	6:49	7:47	8:23	9:14	10:17	11:21	1:07	2:04		
1	✓	Allegheny		6:18	6:45	—	7:33	7:48	—	8:35	8:39	—	9:04	—	9:51	10:33	11:33	12:27	1:17	2:21	3:44	4:31	5:08	5:41	6:17	6:52	7:50	8:26	9:17	10:20	11:24	1:10	—		
1	✓	North Broad		6:22	6:49	—	7:37	7:52	—	8:39	8:42	—	9:08	9:22	9:54	10:36	11:36	12:30	1:20	2:24	3:47	4:33	5:13	5:45	6:21	6:57	7:53	8:29	9:21	10:25	11:28	1:13	—		
C	✓	Temple University		6:24	6:51	7:24	7:39	7:54	8:14	8:41	8:44	8:51	9:10	9:24	9:56	10:38	11:38	12:32	1:22	2:26	3:49	4:35	5:16	5:48	6:23	6:59	7:55	8:31	9:23	10:27	11:30	12:15	—	12:12	
C	✓	Jefferson Station		6:29	6:57	7:30	7:45	8:00	8:20	8:47	8:50	8:57	9:16	9:30	10:02	10:44	11:44	12:38	1:28	2:32	3:55	4:42	5:24	5:54	6:30	7:06	8:01	8:37	9:28	10:33	11:36	12:16	—	12:18	
C	✓	Suburban Station		6:34	7:02	7:35	7:50	8:05	8:25	8:52	8:55	9:02	9:21	9:35	10:07	10:49	11:49	12:43	1:33	2:37	4:00	4:47	5:28	5:59	6:35	7:11	8:06	8:42	9:34	10:38	11:41	12:16	—	12:24	
C	✓	30th Street Station		6:38	7:06	7:40	7:54	8:09	8:29	8:56	8:59	9:06	9:25	9:39	10:11	10:53	11:53	12:47	1:37	2:41	4:04	4:51	5:32	6:03	6:39	7:15	8:10	8:46	9:38	10:42	11:45	1:38	—	2:28	
C	✓	University City		6:41	7:10	7:43	—	8:12	—	—	9:01	—	—	—	10:57	11:57	—	1:39	2:45	4:08	—	5:35	—	6:43	—	—	—	8:49	9:40	10:44	11:47	—	—	—	
			Train continues to (see Destination Codes)	NWK	AM	AM	AM	TTC	WIL	—	—	AIR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
				AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM
TO MANAYUNK / NORRISTOWN	Fare Zone	Services	Stations	Train Number	6212	216	220	3224	5224	5226	8230	222	3234	236	6238	3240	6242	6244	8246	6248	6250	7250	252	5256	264	8266	8270	272	274	276	6278				
					AM	AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	AM			
	C	✓	University City		—	6:17	6:50	7:30	—	—	—	10:35	11:23	12:21	—	2:24	—	—	—	—	—	—	5:32	—	6:34	—	—	9:34	10:42	11:30	—	—			
	C	✓	30th Street Station		5:37	6:20	6:55	7:33	8:05	8:39	9:38	10:38	11:26	12:24	1:27	2:27	3:09	3:54	4:24	4:40	4:59	5:12	5:37	6:05	6:37	7:32	8:36	9:37	10:45	11:33	—	12:33			
	C	✓	Suburban Station		5:42	6:25	7:00	7:38	8:10	8:44	9:43	10:43	11:31	12:29	1:32	2:32	3:14	3:59	4:29	4:45	5:04	5:17	5:42	6:10	6:42	7:37	8:41	9:42	10:50	11:38	—	12:38			
	C	✓	Jefferson Station		5:47	6:30	7:05	7:43	8:15	8:49	9:48	10:48	11:36	12:34	1:37	2:37	3:19	4:04	4:34	4:50	5:09	5:22	5:47	6:15	6:47	7:42	8:46	9:47	10:55	11:43	—	12:43			
	C	✓	Temple University		5:52	6:34	7:09	7:47	8:19	8:53	9:52	10:54	11:40	12:40	1:41	2:41	3:23	4:08	4:38	4:54	5:14	5:26	5:51	6:19	6:51	7:46	8:50	9:51	10:59	11:47	—	12:47			
	1	✓	North Broad		5:54	6:36	7:11	—	8:21	8:55	9:54	10:56	11:42	12:42	1:43	2:43	3:25	4:10	4:40	—	—	—	5:53	—	6:53	7:48	8:52	9:53	11:01	11:49	—	—			
	1	✓	Allegheny		5:57	6:38	7:16	7:53	8:26	9:00	9:58	10:59	11:46	12:45	1:46	2:47	3:30	4:14	4:44	—	—	—	5:56	—	6:56	7:52	8:55	9:56	11:04	11:52	—	—			
	1	✓	East Falls		6:00	6:41	7:19	7:56	8:29	9:03	10:01	11:02	11:49	12:48	1:51	2:50	3:33	4:17	4:47	5:02	5:22	5:34	6:00	6:26	6:59	7:55	8:58	9:59	11:07	11:55	—	12:53			
2	✓	Wissahickon T.C.		6:02	6:43	7:21	7:58	8:31	9:06	10:03	11:04	11:51	12:50	1:53	2:52	3:35	4:19	4:49	5:04	5:24	5:36	6:03	6:29	7:02	7:58	9:00	10:01	11:09	11:57	—	12:55				
2	✓	Manayunk		6:05	6:46	7:24	8:01	8:34	9:09	10:06	11:07	11:54	12:53	1:56	2:55	3:38	4:22	4:52	5:07	5:27	5:39	6:06	6:32	7:05	8:01	9:03	10:04	11:12	12:00	—	12:58				
2	✓	Ivy Ridge		6:07	6:48	7:26	8:03	8:36	9:11	10:08	11:09	11:56	12:55	1:58	2:57	3:40	4:24	4:55	5:10	5:30	5:42	6:09	6:35	7:07	8:03	9:05	10:06	11:14	12:02	—	1:00				
2	✓	Miquon		6:12	6:52	7:30	8:08	8:41	9:16	10:12	11:13	12:01	12:59	2:03	3:02	3:45	4:29	5:00	5:15	5:35	5:47	6:14	6:40	7:13	8:08	9:09	10:10	11:18	12:06	—	1:04				
3	✓	Spring Mill		6:15	6:56	7:33	8:12	8:44	9:20	10:17	11:16	12:04	1:02	2:06	3:05	3:48	4:32	5:03	5:18	5:38	5:50	6:17	6:43	7:16	8:11	9:12	10:13	11:21	12:09	—	1:07				
3	✓	Conshohocken		6:18	6:59	7:36	8:15	8:47	9:24	10:20	11:19	12:07	1:05	2:09	3:08	3:51	4:35	5:06	5:21	5:41	5:53	6:20	6:46	7:19	8:14	9:15	10:16	11:24	12:12	—	1:10				
3	✓	Norristown T.C.		6:26	7:08	7:45	8:21	8:53	9:30	10:26	11:26	12:14	1:12	2:21	3:15	4:03	4:45	5:16	5:31	5:51	6:03	6:30	6:55	7:26	8:22	9:24	10:26	11:34	12:22	—	1:18				
3	✓	Main Street		6:29	7:11	7:48	8:24	8:57	9:34	10:29	11:29	12:17	1:15	2:24	3:18	4:06	4:48	5:19	5:34	5:54	—	6:35	6:59	7:29	8:25	9:27	10:29	11:37	12:25	—	1:21				
3	✓	Elm Street		6:32	7:15	7:51	8:28	9:00	9:37	10:33	11:35	12:21	1:21	2:28	3:23	4:10	4:52	5:23	—	5:58	—	6:40	7:02	7:34	8:29	9:31	10:33	11:41	12:29	—	1:25				
				AM	AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM	PM			

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As shown in Exhibit 3-25, SEPTA's R6 service has the following characteristics:

- On a typical weekday, SEPTA operates 26 inbound and 26 outbound trains between 30th Street and Norristown Elm Street. The running time is 50-60 minutes each way. In the morning peak, three additional trains operate from Miquon to 30th Street. These trains serve inner stations, so some semi-express Norristown trains can skip the inner stops. This could evolve into a zonal pattern of operations in the future.
- In the three morning peak hours, 11 trains operate including three Miquon trains. These trains tend to be spread across the whole three hours since commuters want schedule flexibility to arrive at different times.
- The evening peak hour is very intense since many establishments close at 5 PM, so the workers all want to return home at the same time. Five trains operate in the "peak of the peak" between 4:30 and 5:30 PM. SEPTA operations in the Center City Tunnel are very intense at this time.
- Aside from the "peak of the peak", the rest of the evening is more spread out than the morning peak. 8 trains operate in the evening three peak hours; no express trains or Miquon locals operate in the evening.
- An irregular train stopping pattern can be confusing to passengers. However, on the Paoli/Thorndale line a regular and predictable pattern of zonal operations has been put into effect; Bryn Mawr and Paoli stations serve as clearly identifiable zone boundaries for both the morning and evening peaks. However, a zonal operation requires enough ridership in the outer zone stations to fill a train. The R6 Norristown/Manayunk line does not yet appear to have enough ridership to be able to support the type of zonal operation that the Paoli/Thorndale line has; so it mostly remains an all-stopping service.

Two new passenger services have been proposed: An extension of R6 commuter rail to Phoenixville, and a new intercity service to Reading with a possible run-through operation to New York.

- The first challenge in scheduling these new services is to find "slots" where there is enough time between existing SEPTA R6 trains to permit the insertion of an additional train into the schedule.
- Between Norristown and Reading, as already pointed out, there exist three sections of single track where meets between passenger trains have to be avoided.
- Passenger trains also have to be scheduled at convenient times for riders and in such a manner as to promote efficient equipment utilization.
- No attempt has been made in the current study to develop detailed schedules for extending Reading trains over the NEC to New York; this level of scheduling cannot be developed without directly engaging Amtrak, so it will have to be addressed in the next phase of work.

Phoenixville Commuter Schedules – For simulation of an R6 service extension to Phoenixville, the starting point for the capacity evaluation was the proposed four-round trip schedule from the March 2020 update to the *Preliminary Study for Regional Rail Service*. Here, a peak hour only service was proposed consisting of four morning express trains into Center City with four express trains returning in the evening. Schedules for these proposed trains are shown in Exhibit 3-26.

Exhibit 3-26: R6 Phoenixville Express Commuter Schedule (As Originally Proposed)**A.M. PEAK PERIOD**

	PHX 1	PHX 3	PHX 5	PHX 7
Phoenixville	6:28	6:56	7:13	7:46
Norristown T.C.	6:41	7:09	7:26	7:59
Temple University	7:06	7:34	7:51	8:24
Jefferson Station	7:12	7:39	7:56	8:29
Suburban Station	7:17	7:44	8:01	8:34
30 th Street Station	7:21	7:48	8:05	8:38

P.M. PEAK PERIOD

	PHX 2	PHX 4	PHX 6	PHX 8
30 th Street Station	4:37	5:20	5:31	6:28
Suburban Station	4:42	5:25	5:36	6:33
Jefferson Station	4:47	5:30	5:41	6:38
Temple University	4:52	5:34	5:46	6:42
Norristown T.C.	5:17	5:59	6:11	7:07
Phoenixville	5:30	6:12	6:24	7:20

As proposed, the commuter train would have a 53-minute schedule from Phoenixville to 30th Street station; broken down as follows: Phoenixville-Norristown in 13 minutes, Norristown-Temple in 25 minutes, and Temple-30th Street in 15 minutes.

The first step in setting up these schedules for a capacity evaluation was to confirm the running times using the LOCOMOTION™ train performance calculator; as a result, a few minor changes were needed as already detailed in Section 3.3.1. The running times were adjusted as follows: Phoenixville-Norristown in 14 minutes, Norristown-Temple in 21 minutes, for a net reduction of 3 minutes. Temple-30th Street running time remained unchanged at 15 minutes based on SEPTA benchmark times. The overall schedule for Phoenixville express commuter service would be 50-minutes assuming a 45-second station dwell time.

After this, the proposed departure times from Phoenixville and 30th Street were tested for potential conflicts with existing R6 SEPTA schedules and needed to be adjusted as follows:

- The schedule for the four morning Phoenixville trains was found feasible with proposed departure times at 6:28, 6:56, 7:13 and 7:46; but this required some minor SEPTA schedule adjustments so the new Phoenixville express trains would precede the existing R6 locals:
 - The schedule for SEPTA #2715 departing Norristown T.C. was set back by 7 minutes to 7:10 AM so PHX 3 could go ahead of it.
 - Also, the schedule for SEPTA #209 departing Miquon was set back by 9 minutes to 7:35 AM so PHX 5 could go ahead of it.
- Validating schedules for the four evening Phoenixville trains was more challenging, since slots for at least three of the proposed departures from 30th Street, at 4:37 PM, 5:20 PM, and 5:31 PM were problematical and had to be adjusted:
 - The proposed 4:37 PM express departure of PHX 2 would be sandwiched between SEPTA #8246 at 4:24 and SEPTA #6248 at 4:40; this provides only a 16-minute window between existing SEPTA trains, so PHX 2 will overtake #8246 around Conshohocken and be delayed. The departure time of PHX 2 was advanced to 4:20 PM ahead of #8246 which provides a 30-minute schedule gap, and this eliminated the conflict.
 - The 5:20 PM departure of PHX 4 is following SEPTA #7250 too closely and will overtake that train at Manayunk. The solution was to delay this departure time until 5:35 PM, just ahead of SEPTA #252 and this eliminated the conflict.

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- There is no available slot for PHX 6 at 5:31 PM since this is a peak SEPTA operating hour and the correction to the schedule of PHX 4 already consumed the one available slot. This train was shifted back to the 6:28 PM time slot, and PHX 8 was shifted back from 6:28 PM to 7:28 PM.
- These adjustments to the Phoenixville schedule resolved all the conflicts between westbound Phoenixville trains and existing R6 SEPTA trains without having to adjust the schedules of any of the existing SEPTA trains. It would have been undesirable to have adjusted the evening peak hour SEPTA schedules since these trains are all coming from other lines, so any adjustment would have had a cascading effect.

Exhibit 3-27 gives the finalized adjusted schedules for the Phoenixville service which resolved the conflicts with existing R6 SEPTA trains and was able to be run in the capacity assessment.

Exhibit 3-27: R6 Phoenixville Express Commuter Schedule (For Capacity Analysis)

A.M. PEAK PERIOD				
	PHX 1	PHX 3	PHX 5	PHX 7
Phoenixville	6:28	6:56	7:13	7:46
Norristown T.C.	6:42	7:10	7:27	8:00
Temple University	7:03	7:31	7:48	8:21
Jefferson Station	7:08	7:36	7:53	8:26
Suburban Station	7:13	7:41	7:58	8:31
30 th Street Station	7:18	7:46	8:03	8:36
P.M. PEAK PERIOD				
	PHX 2	PHX 4	PHX 6	PHX 8
30 th Street Station	16:20	17:35	18:28	19:28
Suburban Station	16:25	17:40	18:33	19:33
Jefferson Station	16:30	17:45	18:38	19:38
Temple University	16:35	17:50	18:43	19:43
Norristown T.C.	16:56	18:11	19:04	20:04
Phoenixville	17:10	18:25	19:18	20:18

Reading Intercity Service Schedules – Exhibits 3-10 and 3-12 provide running times for the Reading trains but do not develop a detailed operating timetable for the service, which is needed for the capacity analysis. Once again, the starting point in development of this schedule is to find slots for getting trains from Norristown into Center City Philadelphia, while avoiding conflicts with existing SEPTA and proposed Phoenixville services, and avoiding train meets in single track sections.

The resulting pro-forma schedule for Reading service is shown in Exhibit 3-28. This timetable interleaves the proposed Intercity schedules with the new Phoenixville trains (based on Exhibit 3-27) and also includes possible service extensions both to Wyomissing and to New York City. The schedule requires four trainsets plus two spares. The service can be extended to New York without requiring any additional trainsets. Train pairs E2/W3, E3/W4, and E4/W5 have enough layover time so they could run to Washington D.C. instead of to New York, if desired. Equipment rotations for the Reading-New York service are shown in Exhibit 3-29. The conceptual schedule is feasible for the capacity analysis but was developed for conceptual purposes. It is preliminary and requires further discussion with the railroads. It will undoubtedly be subject to many further adjustments and refinements as this project moves towards implementation.

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Exhibit 3-28: Proposed Reading Service Schedules, interleaved with the new Phoenixville Trains

EASTBOUND TIMETABLE												
Equipment Set	1	-	2	-	-	3	-	4	1	2	3	4
	RDG E1	PHX 1	RDG E2	PHX 3	PHX 5	RDG E3	PHX 7	RDG E4	RDG E5	RDG E6	RDG E7	RDG E8
Wyomissing	5:14	-	5:45	-	-	6:37	-	-	-	14:54	18:14	21:20
Reading (Franklin St)	5:24	-	5:55	-	-	6:47	-	7:40	11:56	15:04	18:24	21:30
Pottstown	5:42	-	6:13	-	-	7:05	-	7:58	12:14	15:22	18:42	21:48
Royersford	5:54	-	6:25	-	-	7:17	-	8:10	12:26	15:34	18:54	22:00
Phoenixville	6:02	6:28	6:33	6:56	7:13	7:25	7:46	8:18	12:34	15:42	19:02	22:08
Norristown T.C.	6:16	6:42	6:47	7:10	7:27	7:39	8:00	8:32	12:48	15:56	19:16	22:22
Temple University	6:37	7:03	7:08	7:31	7:48	8:00	8:21	8:53	13:09	16:17	19:37	22:43
Jefferson Station	6:42	7:08	7:13	7:36	7:53	8:05	8:26	8:58	13:14	16:22	19:42	22:48
Suburban Station	6:47	7:13	7:18	7:41	7:58	8:10	8:31	9:03	13:19	16:27	19:47	22:53
30 th Street Station	6:53	7:18	7:24	7:46	8:03	8:16	8:36	9:09	13:25	16:33	19:53	22:59
New York (Penn Sta)	8:17	-	8:48	-	-	9:40	-	10:33	14:49	17:57	-	0:23
SEPTA Interweaving	Ahead of #2311	Ahead of #2301	Ahead of #2301	#2715 back to 7:10 NOR	#209 back to 7:35 MIQ	Ahead of #6203	Ahead of #2407	#6217 back to 8:52 MIQ	Ahead of #235	Ahead of #2555	Ahead of #6271	Between #277+279
WESTBOUND TIMETABLE												
Equipment Set	4	1	2	-	3	4	-	1	-	2	-	3
	RDG W1	RDG W2	RDG W3	PHX 2	RDG W4	RDG W5	PHX 4	RDG W6	PHX 6	RDG W7	PHX 8	RDG W8
New York (Penn Sta)	4:29	8:36	11:36	-	14:57	15:47	-	16:36	-	18:21	-	-
30 th Street Station	5:53	10:00	13:00	16:20	16:21	17:11	17:35	18:00	18:28	19:45	19:28	21:30
Suburban Station	5:59	10:06	13:06	16:25	16:27	17:17	17:40	18:06	18:33	19:51	19:33	21:36
Jefferson Station	6:04	10:11	13:11	16:30	16:32	17:22	17:45	18:11	18:38	19:56	19:38	21:41
Temple University	6:09	10:16	13:16	16:35	16:37	17:27	17:50	18:16	18:43	20:01	19:43	21:46
Norristown T.C.	6:30	10:37	13:37	16:56	16:58	17:48	18:11	18:37	19:04	20:22	20:04	22:07
Phoenixville	6:44	10:51	13:51	17:10	17:12	18:02	18:25	18:51	19:18	20:36	20:18	22:21
Royersford	6:52	10:59	13:59	-	17:20	18:10	-	18:59	-	20:44	-	22:29
Pottstown	7:04	11:11	14:11	-	17:32	18:22	-	19:11	-	20:56	-	22:41
Reading (Franklin St.)	7:22	11:29	14:29	-	17:50	18:40	-	19:29	-	21:14	-	22:59
Wyomissing	-	-	14:39	-	18:00	18:50	-	19:39	-	21:24	-	23:09
SEPTA Interweaving	Between #6212+216	Between #8230+222	Between #236+6238	Ahead of #8246	Ahead of #8246	Ahead of #7250	Ahead of #252	Ahead of #5256	Ahead of #264	Ahead of #8270	Ahead of #8266	Ahead of #272
						Use #1 trk to pass #6250						

Exhibit 3-29: Equipment Rotations for the Proposed Reading Service Schedules

EQUIPMENT TURNS					
Trainset 1:	Depart		Arrive		Layover
RDG E1	WYOM	5:14	NYP	8:17	
RDG W2	NYP	8:36	RDG	11:29	0:19
RDG E5	RDG	11:56	NYP	14:49	0:27
RDG W6	NYP	16:36	WYOM	19:39	1:47
Trainset 2:	Depart		Arrive		
RDG E2	WYOM	5:45	NYP	8:48	
RDG W3	NYP	11:36	WYOM	14:39	2:48
RDG E6	WYOM	14:54	NYP	17:57	0:15
RDG W7	NYP	18:21	WYOM	21:24	0:24
Trainset 3:	Depart		Arrive		
RDG E3	WYOM	6:37	NYP	9:40	
RDG W4	NYP	14:57	WYOM	18:00	5:17
RDG E7	WYOM	18:14	PHL	19:53	0:14
RDG W8	PHL	21:30	WYOM	23:09	1:37
Trainset 4:	Depart		Arrive		
RDG W1	NYP	4:29	RDG	7:22	
RDG E4	RDG	7:40	NYP	10:33	0:18
RDG W5	NYP	15:47	WYOM	18:50	5:14
RDG E8	WYOM	21:20	NYP	0:23	2:30

It is assumed that all trains are serviced overnight and that they can run all day without needing further mechanical attention. Some cleaning can be done by service personnel while trains are enroute, if such servicing is needed.

In development of the schedule there were several instances where “short turns” as well as “quick turns” were scheduled. There are two instances where a train is turned in Reading Franklin Street station, because there is not enough time between connections to allow the train to go all the way to Wyomissing. In two other instances, there is enough time to go to Wyomissing if a “quick” 15-minute turn can be made. There is one instance where there is not enough time for a train to go to New York and it has to turn at Philadelphia 30th Street. In two instances, trains need to make a quick turn at New York Penn station, immediately turning back west rather than continuing east to Sunnyside yard. The feasibility of doing this needs to be discussed with Amtrak but one reason for proposing such a turn would be to conserve on platform capacity at Penn Station.

As this schedule is designed, three trains lay overnight in Reading and start their daily assignments either at Wyomissing or at Franklin Street. The fourth train would lay overnight at Sunnyside Yard in New York, and it both starts and ends its day at Penn Station. No trains need to lay overnight or be serviced in Philadelphia; but one train would turn in Philadelphia and with a fairly short 1:37 layover time.

3.4.6 Basic Infrastructure Needed for Passenger Service

This section will describe the basic infrastructure that is needed just for supporting the operational requirements of the proposed passenger services. This basic package does include some infrastructure improvements that are obviously needed for supporting shared use of the corridor by both passenger and freight trains, so it does include some capacity mitigation. As well, it also includes investments that are needed just for implementing the basic passenger services along the line.

Norfolk Southern has relocated many of the historical interlockings (switching and signal locations) along the line as a result of their project to re-signalize the line and install PTC. Similarly, SEPTA recently made a number of improvements to their part of the line. In development of plans for “going forward” it is important to try to build on what now exists, and resist the temptation to try to return the line back to its 1970’s configuration. While there may have been good reasons why Reading Company installed infrastructure as they did, Norfolk Southern and SEPTA also had good reasons for updating the infrastructure.

SEPTA Segment - no changes are assumed on the SEPTA line for adding more passenger trains. The rail line from Norristown into Center City has very recently been rebuilt and upgraded with a modern, bi-directional signal system and PTC, so it needs very little improvement. It is assumed that Reading and Phoenixville commuter trains will be able to use the SEPTA infrastructure as-is, while fully conforming to SEPTA’s requirements regarding use of the line.

The only real concern with the SEPTA portion of the line is the 60-mph speed limit; but this has really been optimized for SEPTA’s operation. Because of sharp curves and frequent stops, non-tilting trains have very little to gain by raising the speed. Even an express train would gain very little due to the curves.

The only upgrades that non-tilting trains could really benefit from would be curve easements to eliminate the most restrictive speed limits, as proposed in Exhibit 3-13. Only with introduction of tilting trains would raising SEPTA’s speed become a worthwhile discussion. Right now, it would be premature since it is not clear, due to manufacturing economics, whether tilting trains that meet the requirements of this corridor can be obtained for a reasonable cost. This issue requires further investigation. If affordable tilting equipment can be found or Reading can tack onto a larger equipment order, it would be worthwhile to loop back and have this discussion with SEPTA. For now, the capacity analysis assumes only that the existing SEPTA infrastructure with no improvements will be used.

Norfolk Southern Segment – Norfolk Southern has been maintaining FRA Class IV infrastructure, which could be good for 60-mph freight trains and 79-mph passenger trains, but has only been operating it at a 50-mph speed. The first need for passenger service is to raise the speed on the Norfolk Southern infrastructure to permit 60-mph freight trains and 79-mph passenger trains, as the track class allows. Norfolk Southern has, in fact, been raising speeds on its own in higher density territory. For example, in 2018, it raised train speeds on its Reading to Allentown line²⁷ affecting 36 highway grade crossings in Berks and Lehigh Counties. The same thing needs to be done on the Reading to Norristown line to facilitate both freight and passenger operations. This cost is likely to be minor, \$3-5 million for retiming grade crossing circuits and for adjusting some signal circuits and PTC systems as necessary, to permit the higher speeds that the FRA track class already allows.

²⁷ See: https://www.wfmz.com/news/area/berks/norfolk-southern-to-increase-speed-of-trains-on-reading-line/article_c9f39698-5ff3-5871-a1c2-fee3a18297f2.html

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Second, stations need to be developed. At a minimum, only simple platforms and basic shelters need to be provided, for example like the simple station facility at Middletown, PA, shown in Exhibit 3-30. The cost for this minimal configuration is likely to be about \$2 million per station, or \$8 million for four stations.

Exhibit 3-30: Minimal Requirement for a Starter Station Facility (Middletown, PA)



Each community along the line, except for Wyomissing, has an historic station building which has been preserved in adaptive reuse, and which might be repurposed back to its original rail use. In each case a boarding platform linking the station building to the trackside would need to be reinstalled. Ideally, a better station facility than the minimum shown above could be provided, but it is up to each community to decide how it wants to develop its station, and a simple facility would be sufficient to get started.

A key question will be whether to develop station platforms only on one side of the track, or on both sides. If passenger trains operate only on one track (as for example, Phoenixville’s *Preliminary Study for Regional Rail Service* proposes) then only a single platform is needed. This is adequate for a directional, peak-hour service such as Phoenixville’s proposed starter service, but it is not effective for an all-day bi-directional service where both tracks need to be used. The Virginia Rail Express (VRE) commuter system started out this way, but as VRE wants to develop an all-day rather than just peak-hour oriented system, they found that the one-platform approach is not “scalable” to a service that runs all day both ways. Specifically, VRE’s “*Penta-Platforms Project*”²⁸ will add capacity to the CSXT RF&P Subdivision by generally extending platforms and/or adding second platforms at five VRE Fredericksburg Line stations.”

In the past, for facilitating access to multiple tracks, stations along the Reading-Philadelphia line used wooden boarding platform extenders like the one pictured at Middletown (in Exhibit 3-31, shown partially dismantled due to COVID-19 temporary service discontinuance.) SEPTA still use platform extenders on its Paoli/Thorndale line and as shown at Middletown, Amtrak also still uses them. It is standard operating procedure to halt trains running on the inside track if a passenger train is boarding, so no trains may pass between a station and a boarding passenger train. Exhibit 3-32 shows the historic platform configuration at Pottstown. The boarding platform extension is visible immediately in front of the Rail Diesel Car, which will be boarding its passengers from the middle track.

Nonetheless, Norfolk Southern may not agree to “grandfather” the historic platform arrangement by agreeing to the use of platform extenders. Freight railroads are very notorious for wanting to prevent pedestrian access to any active rail track, and it has been Norfolk Southern’s policy not to permit the

²⁸ See: <https://www.vre.org/development/station-improvements/penta-platforms-station-improvements/>

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installation of any new level pedestrian crossings crossing tracks that it owns. Norfolk Southern wants to fully grade separated pedestrian access across its right of way, which typically requires the development of either an overhead bridge or a tunnel. If required, these can cost \$10-20 million each.

Exhibit 3-31: Wooden Boarding Platform Providing Access to Inner Track



Exhibit 3-32: Historic Station Platform Configuration at Pottstown, PA



For the capacity analysis it is assumed that station platforms will be constructed on both sides of the alignment so passenger and freight trains could freely use any track. Restricting passenger trains to only a single track is not going to be practical for the Reading service, since the goal is to develop an all-day service. In the next phase of project development, this will require consultation with the communities, Norfolk Southern, SEPTA and possibly Amtrak to develop station plans that can work for everyone. This is a critical path item for development of the passenger rail service. Phoenixville's peak-hour starter service can operate using a single platform as proposed; of course, today there is only one track at the Phoenixville train station. But the proposed Reading service would operate all-day in both directions, so station development plans should provide for platforms on both tracks.

Requirements for Phoenixville starter service - The capacity analysis assumes that a Phoenixville starter service will be implemented first, but that this will be quickly followed up by implementation of intercity rail service to Reading. For the assessment, exhibit 3-33 shows the basic package of infrastructure improvements at CP Norris, CP Forge and CP Phoenix that have been assumed for supporting the Phoenixville commuter service:

1. Currently there is no crossover at CP Norris allowing a direct movement from the Schuylkill River bridge to the #2 track. As shown in Exhibit 2-3, about half the freight trains moving in the corridor come from the Morrisville line, so the inability to cross Morrisville trains over to the #2 track is a major handicap. It forces all Morrisville trains either into Abrams Yard or onto the #1 track. As previously explained (in Section 3.3.1) the #2 track has a 30-mph speed limit and is frequently used by freight trains picking up and setting off cars in the yard. As such, it is not good for passenger trains to use #2 track around Abrams yard, but the track is still good for freight trains. A new crossover at CP Norris is needed to allow freight trains to utilize the #2 track when the #1 track is being used by passenger trains. Adding this crossover at CP Norris will likely cost around \$2-3 million.
2. According to the **Preliminary Study**, Phoenixville plans to use the #2 track for commuter trains. The 2005 **Schuylkill Valley Rail Assessment** had recommended using the #1 track. Since the use of #2 track through Abrams Yard is undesirable for passenger trains, the capacity analysis will assume that Phoenixville trains use #1 track to CP Forge, then use a set of new universal crossovers (to be installed) at CP Forge to reach the #2 track. Adding these universal crossovers to the existing interlocking at CP Forge will likely cost around \$3 million.
3. According to the updated **Preliminary Study**, the proposed Phoenixville station will be in the same vicinity as the historic station. A universal crossover should be added at CP Phoenix so passenger trains can approach the station on either track, and a tail track should be added so passenger trains can clear the mainline while waiting in station platform. While the tail track may be used for facilitating daytime station operations, it should not be used for overnight train storage. Instead, a secure train storage yard should be developed off the Norfolk Southern right-of-way to provide a safe place to service and clean the trains, and to store them overnight. The Phoenixville Industrial Complex, just a short distance east of the proposed station, might provide a location for such a yard. A good prototype for the type of facility that is needed for servicing trains would be the Frederick, Md. train storage yard, shown in Exhibit 3-34. Adding universal crossovers and a tail track at CP Phoenix will likely cost around \$3 million. The train storage yard and servicing facility will likely cost \$10-25 million depending on the intended role and level of maintenance capability of the facility. We assume it will cost \$15 million.
4. The **Preliminary Study** has proposed to add a crossover at CP Kalb²⁹, but this is not needed since the existing crossover at CP Ford can easily be used for directing Phoenixville commuter trains towards the Schuylkill River bridge. Station signage and announcements can be used to direct passengers to use the #1 track platform at Norristown Transportation Center.

²⁹ Norfolk Southern only recently (in 1995) reconfigured CP Kalb to remove the switch from Track #2, so NS is unlikely to support the idea of reinstalling the switch for the same reasons that they removed it in the first place. Ultimately, it may prove necessary to reinstall the switch for fully restoring double track across the Schuylkill River, so it does not make sense to modify the same interlocking twice. Rather it probably makes more sense to just wait until funding is available to restore the double track across the river and reinstall the switch at that time. For further description, see: <http://www.trainweb.org/phillynrhs/RPOTW150215.html>, <http://www.trainweb.org/phillynrhs/RPOTW150301.html>, <http://www.trainweb.org/phillynrhs/RPOTW150308.html>, <http://www.trainweb.org/phillynrhs/RPOTW150315.html>, <http://www.trainweb.org/phillynrhs/RPOTW150531.html>

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This infrastructure is assumed to be the cost responsibility of the Phoenixville commuter service, since it will be needed to launch the commuter operations.

Exhibit 3-33: Basic Infrastructure Package for Phoenixville Commuter Service

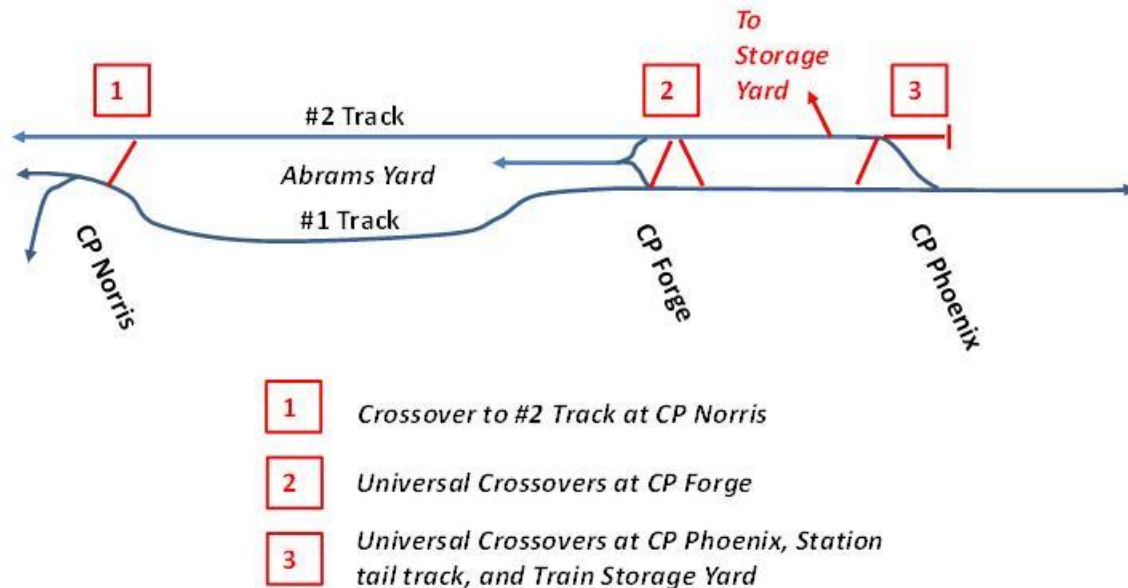


Exhibit 3-34: Prototype Train Storage and Maintenance Yard in Frederick, Md.



Additional Requirements for Reading Intercity service – In addition to 79-mph speed upgrades, station facilities along the line and interlocking improvements at CP Norris, CP Forge and CP Phoenix, a station siding is needed at the Reading Franklin Street station (at a minimum) so passenger trains can clear the freight main track while they are sitting in the station. A minimum length siding would require the installation of at least ½ mile of track with switches and control points at each end of a controlled siding. A siding would cost \$4-5 million, but once the switches and signals at the ends of the siding have been paid for, the length of the double track could be extended for a much lower cost per mile. Complete double tracking between CP Walnut and Klapperthal Junction (3 miles) would offer much more value. A single switch would be installed at Klapperthal Junction, and universal crossovers would be added at CP Bird and Pottstown. The existing control point at CP Walnut would be converted into a set of universal crossovers. This has been estimated to cost \$9 million, but there is one engineering issue that needs to be examined in the next phase of work for confirming this cost.

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As shown in Exhibit 3-35, the Reading cut has been excavated underneath the Walnut Street bridge to improve the overhead clearance. In the process of deepening the cut, ConRail may have uncovered the foundations of the retaining walls. It appears that they may have solved this problem by pouring large concrete footers, shown in Exhibit 3-35 to stabilize the walls. It appears that this is the real reason why the track needed to be centered through the cut; but these large concrete blocks would have to be removed to make space for restoring double track. If this proves to be the case, then one possible solution may be not to fully restore the double track through the cut; or another method, such as by installing reinforcing beams underneath the track, may need to be used for stabilizing the retaining wall foundations. This structural engineering problem needs detailed examination in the next phase of work.

Exhibit 3-35: Concrete Footers on Both Sides of the Reading Cut



Finally, the Reading service will also need a secure train storage and servicing yard, which will most likely need to be located in the old Reading Railroad shop complex. The cost for the storage yard has been estimated as \$18 million.

Summary of Basic Package Investments and Costs – Exhibit 3-36 summarizes the likely costs for the basic infrastructure upgrade needed for starting Phoenixville and Reading passenger services:

Exhibit 3-36: Phoenixville and Reading Passenger Rail Projects and Costs

	Phoenixville Service	Reading Service	TOTAL
<i>Station Platforms and Shelters</i>	\$2.00	\$6.00	\$8.00
<i>79-mph Speed Upgrade</i>	\$1.25	\$3.75	\$5.00
<i>CP Norris</i>	\$3.00		\$3.00
<i>CP Forge</i>	\$3.00		\$3.00
<i>CP Phoenix</i>	\$3.00		\$3.00
<i>Reading Station Double Track</i>		\$9.00	\$9.00
<i>Phoenixville Train Storage Yard</i>	\$15.00		\$15.00
<i>Reading Train Storage Yard</i>		\$18.00	\$18.00
TOTAL	\$27.25	\$36.75	\$64.00

As shown above, the infrastructure cost for starting the Reading service will be \$36.75 million, and the cost for the Phoenixville service will be \$27.25 million. This assumes some cost-sharing in the areas of shared stations and the 79-mph speed upgrade. If the Phoenixville commuter project doesn't happen, then the Reading project will have to absorb an additional \$9.25 million in shared costs, bringing the Reading project's infrastructure total to \$46 million.

3.4.7 Additional Capacity Mitigation

Since the basic investment package would eliminate the single track bottleneck through Reading, only two areas of single track will still remain. These are the Schuylkill River bridge at Norristown, and the Black Rock tunnel.

Schuylkill River Bridge double track - A fundamental issue that limits the benefit of restoring double track across the Schuylkill River bridge is the fact that both freight and passenger trains would both still have to deal with other areas of single track immediately adjacent to the bridge:

- Freight trains still need to use the Earnest Connection, which remains single track.
- Passenger trains would still only use the #1 track around the north side of Abrams Yard between CP Norris and CP Forge. They would only use the #2 track through the yard in emergencies.

As a result, a simple restoration of double track across the river bridge would be of limited value. There are two possible variations, therefore, of the Schuylkill River bridge project:

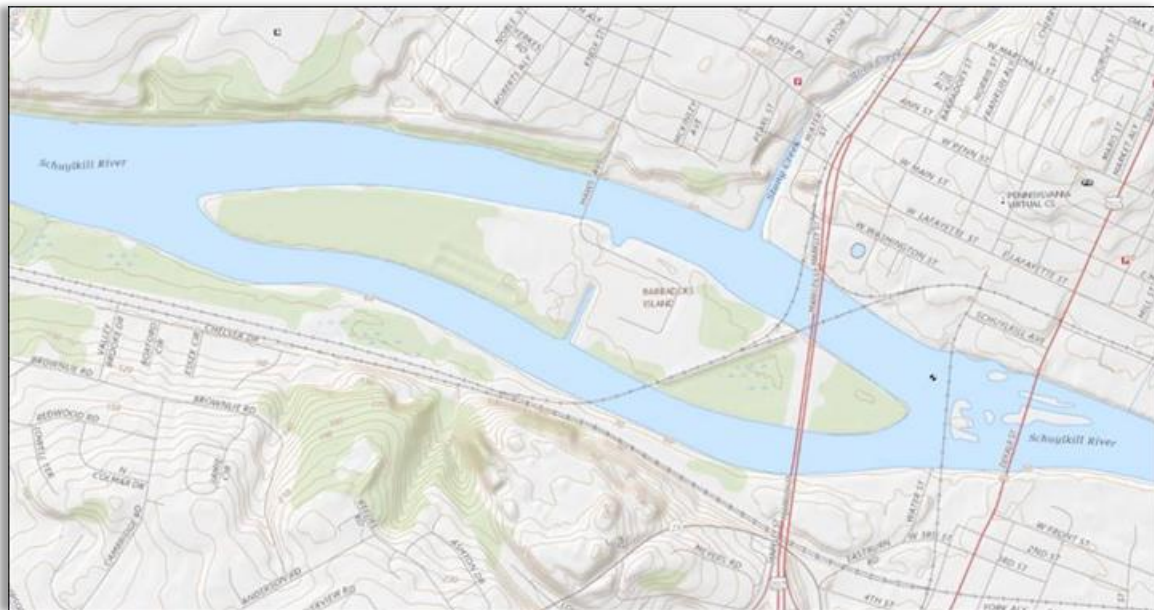
- The simplest approach would be simply to restore double track between CP Kalb and CP Norris. As shown in Exhibit 3-37, the rail line actually crosses two separate but rather narrow river channels; the fill structure across Barbadoes Island (on land) between two bridges actually comprises most of the length of the crossing. Thus, for most of the way, the cost would only be for relaying the track on standard ballasted right-of-way; less than half of the distance is actually on bridge structure. The cost for this would probably be around \$10-15 million.

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- A far more effective approach would be to combine the bridge restoration with the development of a second main line track around the north side of Abrams Yard. This would likely entail the rehabilitation and signalization of the former Reading #1 track, which still exists as a yard running track, so it can be put it back into use as a mainline track between CP Norris and CP Forge. This would completely solve the single track problem for passenger trains between Norristown and Phoenixville -- doing these two projects together would be far more effective than doing either one alone. The cost for restoring the double track around the north side of Abrams yard will probably be another \$10-15 million bringing the cost for the two projects together likely into the \$20-30 million range.

Exhibit 3-37 shows how Barbadoes Island divides the Schuylkill River crossing into two relatively short bridge segments.

Exhibit 3-37: Barbadoes Island River Crossing³⁰



Black Rock Tunnel - Fortunately, the Black Rock tunnel is a self-supporting unlined rock tunnel, and this type of tunnels is usually fairly economical to enlarge. Norfolk Southern has extensive experience as a result of its **Heartland Corridor Clearance Improvement** project³¹, where it expanded 29 tunnels (30,000+ feet) for a cost of \$151 million, or \$5,033 per foot³². The Black Rock Tunnel, however, would need both to be widened and also have the ceiling raised in order to support the restoration of double track. Once the tunnel has been cleared, in preparation for track work, the current hand-thrown switch at the former east end of double track at Dreibelis Road would simply be removed, and the interlocking at CP Cromby would be converted into a standard double track configuration with universal crossovers. Then by extending the existing double track eastward through the tunnel, it would be connected to the tail track at Phoenixville station as shown in Exhibit 3-33. Since CP Phoenixville would already have universal crossovers, it would be fully prepared for making this connection as part of the tunnel double tracking project.

³⁰ Map source: <https://storymaps.arcgis.com/stories/e1c74084350b4d0fa4e6454ce8bcce14>

³¹ Heartland Corridor Clearance Improvement Project, https://www.arena.org/files/library/2010_Conference_Proceedings/Heartland_Corridor_Clearance_Improvement_Project.pdf

³² The Heartland Corridor, presentation to Virginia Commonwealth Transportation Board, December 14, 2006: http://www.virginiadot.org/ctb/resources/agenda_item6_heartland_ctb_update_dec2006_short.pdf

In today's dollars the cost for expanding the 1,932 feet long Black Rock tunnel to double track would likely fall in the \$15-30 million range. A detailed Engineering assessment is recommended to be undertaken in the next phase of work, for developing a more accurate cost.

3.4.8 Mitigation Analysis Results

The Shared-Use™ simulation model was been used to develop a mitigation analysis and to test the effectiveness both of the basic investment package, and of adding the Schuylkill River bridge and Black Rock tunnel as additional improvements. The results are shown in Exhibits 3-38 and 3-39 which show the effective of various investment strategies on mitigating Norfolk Southern freight train delays. Exhibit 3-38 shows total daily freight train delay in hours and minutes (HH:MM) while Exhibit 3-39 normalizes the results to a delay per train basis.

Exhibit 3-38: Projected Total Daily Delay to Freight Trains, in HH:MM format

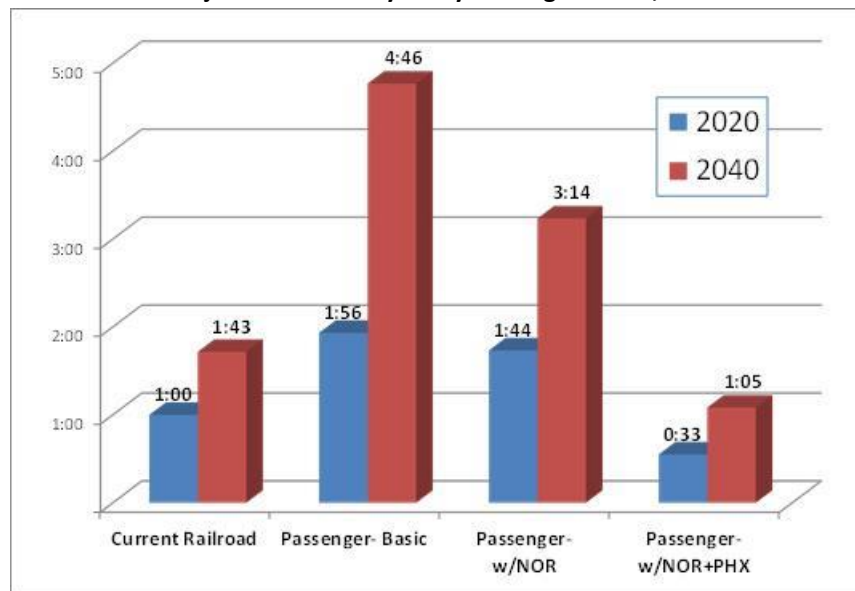
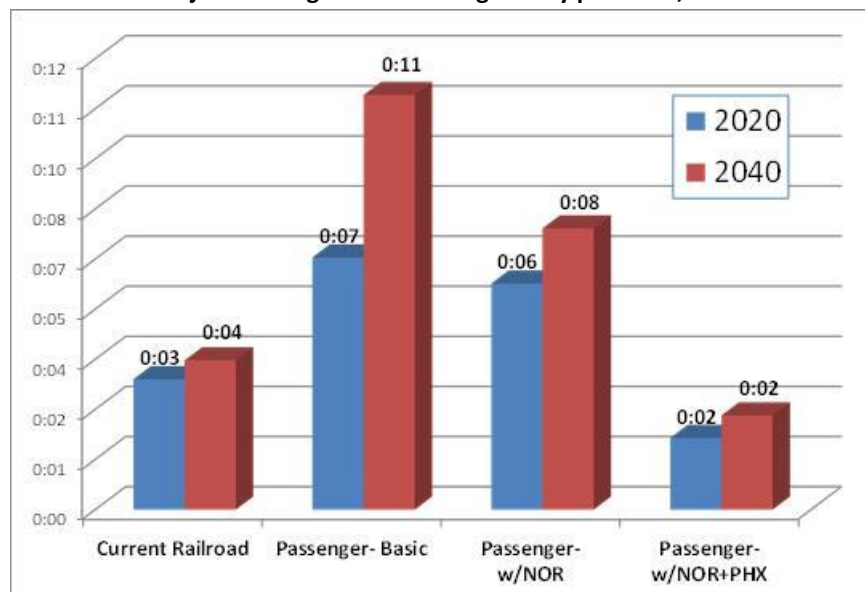


Exhibit 3-39: Projected Freight Train Average Delay per Train, in HH:MM format



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In Exhibits 3-38 and 3-39:

- The Current Railroad columns show freight train delays at their current level and also at projected 2040 levels. These results measure the delays due to line-of-road interactions between trains and do not include yard-related delays.
- The Passenger-Basic column adds the four Phoenixville commuter trains along with eight Reading passenger trains. Between Norristown and Phoenixville, it includes the package of improvements shown in Exhibit 3-33. In Reading it includes the restoration of double track from CP Walnut to Klappertal Junction so that freight trains could get around a passenger train while it is parked in Franklin Street station.
- The Passenger-W/NOR column adds to the previous option, double track across the Schuylkill River bridge but it does not add triple track around the north side of Abrams yard because the operational simulation had not yet indicated the need for that improvement.
- The Passenger-W/NOR + PHX column adds to the previous option, restoration of double track through the Black Rock tunnel.

The “Current Railroad” simulation results suggest that freight train delay in the base case (current railroad) is at very low levels (1:00 of total delay per day, rising to 1:43 in 2040) and that in fact a single track configuration could easily handle the volume of freight trains that are operating in the territory. From this, it would appear that there is plenty of capacity to add passenger trains with a minimal level of investment. However, the amount of delay to freight trains in the base case is extremely low, and this produces a very aggressive mitigation benchmark.

The “Passenger-Basic” results suggest that with addition of passenger trains, freight delays would increase slightly (to 1:56 and 4:46 per day) but would remain within acceptable norms (7 minutes delay per train increasing to 11 minutes in 2040. As a result the “Passenger-Basic” investment package does not satisfy the technical “mitigation” requirement (reduce freight delays back to current levels) -- but nonetheless, operation of the rail line is seen to remain in free flow conditions with multiple (3 or more trains) interactions only rarely occurring. The line is able to accommodate all freight train movements at a high level of service and still has plenty of capacity to accommodate future freight growth.

With the implementation of the two major capacity enhancement projects at Norristown bridge and Black Rock tunnel, freight train delays would fall to 0:33 and 1:05 at 2040 traffic levels. This satisfies the technical mitigation requirements, but the problem is that the capital cost for making these improvements is out of line with the value of the train delay benefit, as follows:

- To satisfy the technical mitigation requirement would require a capital expenditure of \$60 million dollars which would reduce daily freight train delays by 1:56 – 0:33 = 1:23 (or 1.38 hours) in 2020. The savings would rise to 4:46 – 1:05 = 3:41 (or 3.68 hours) by 2040, if freight growth actually materializes as according to the FAF-4 forecast.
- The average cost per hour of freight train delay was estimated as \$213 per hour in 2006; this is detailed in Table 6.4 on page 97 of Shaefer³³. Accounting for 22% inflation from 2006 to 2020, the current cost of train delay would be \$260 per hour. So, Norfolk Southern’s delay cost would be worth \$260 x 1.38 = \$359 per day (\$131,000 per year) in 2020, rising to \$260 x 3.68 = \$957 per day in 2040 (\$349,000 per year, in constant dollars.)

³³ Schafer, D. H. *Effect of Train Length on Railroad Accidents and a Quantitative Analysis of Factors Affecting Broken Rails*. MS thesis. University of Illinois at Urbana–Champaign, 2006. See: <http://railtec.illinois.edu/wp/wp-content/uploads/pdf-archive/DarwinSchaferThesis.pdf>

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- Discounting this stream of cash flows, the Present Value of the delay savings benefits over 25 years is:
 - \$4,056,375 at 3%
 - \$2,611,974 at 7%
 - \$1,371,094 at 15%

As can be seen, the Present Value of train delay savings falls far short of the need for \$60 million in investments that would be needed for fully reducing freight delays to their base level. It is clear from this that if Norfolk Southern were simply offered a cash payment, they may well choose to pocket the cash. They would not likely choose to invest the money in the rail corridor for such marginal returns.

It is true that the two investments do provide some passenger benefits, and so they might be justified on that basis. While the planning for these two projects should be further developed in the next phase of work, it is clear that the passenger rail corridor could operate without them, at least for a time. However, since it will be necessary to modify CP Norris for adding a connection to Track #2 as a part of the basic investment program, the interlocking should be prepared to receive the added switches and signalling that will be needed for accommodating this future double tracking as well. Making all the necessary changes at CP Norris at once, would avoid the need for having to reconfigure the same interlocking twice.

3.5 Summary

The overall objective of the operational analysis has been to develop an affordable option that maintains compliance with Norfolk Southern's passenger principles and develops a run-through service from Reading to Philadelphia to New York City. By approaching the Center City tunnels from the north rather than from the west, trains would arrive at the upper level platforms of 30th Street station in an ideal position to continue directly to New York or Washington D.C. without having to reverse direction. As such the planning for the proposed service will need to satisfy Amtrak's requirements, as well as those of Norfolk Southern and SEPTA.

Because of the numerous curves along the corridor, the deployment of tilting trains would result in an opportunity for time savings, so it is recommended that this option remain on the table. A thorough review of equipment options and availability of equipment that is suitable for the proposed service – including the ability to run under the wire at 125-mph into New York City – as well as to operate from Norristown to Reading without electrification -- is needed.

- To optimize tilt train operation, an option for upgrading the NS speed to 79-mph, and the SEPTA speed to 90-mph (where existing geometry allows) should remain on the table.
- For a non-tilting train NS speeds should still be upgraded to 79-mph, but SEPTA speeds can remain where they are at 60-mph. Or for reducing the cost of initial implementation of the system, SEPTA speeds can stay at 60-mph, because this improvement can always be done later.

The capacity assessment has identified a Basic Package of infrastructure improvements that will effectively support both the freight and passenger requirements for operations on the Norristown to Reading line. The capacity assessment has included both eight proposed Reading round trips and four peak-hour Phoenixville round trips. SEPTA's R6 Norristown line has also been simulated, and this suggests that the Norristown line can accommodate the additional trains. SEPTA would, of course be compensated for this, either by acting directly as the train operator or by being paid on a train-mile basis for access to its track and electrical power systems.

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Although the updated capacity analysis is based on publicly available data, it has ***exactly the same result*** as the 2005 ***Schuylkill Valley Rail Assessment*** that was conducted in conjunction with Norfolk Southern. However, at this stage the findings of the capacity analysis are not to be construed as a commitment on the part of Norfolk Southern to operate additional service.

Norfolk Southern train delays in the base case are so low that the study has suggested it would be uneconomic and unnecessary to try to mitigate train delays all the way back to base line levels. The low existing level of train delay is in fact suggestive that Norfolk Southern is maintaining uneconomically high levels of excess capacity. Even after passenger operations are added, that freight operations will remain free-flow, delays will remain at minimal levels, and Philadelphia to Reading Corridor still has substantial capacity available for traffic growth.

As a result, implementing just the basic package of investments, along with offering cash or other form of compensation to Norfolk Southern for the small increase in freight train delays, would be the most effective approach to development of the rail corridor at this time.

As well, a set of additional corridor enhancement options has been identified. These should remain on the table and be considered as part of a longer-term plan for the development of the corridor, which can be pursued as resources permit. Some of these longer term opportunities include:

- Double tracking the Schuylkill River bridge and providing an addition main track along the north side of Abrams Yard from CP Norris to CP Forge.
- Expanding and restoring double track through the Black Rock Tunnel.
- Extending service to Wyomissing and possibly restoring rail service to Schuylkill County
- Curve easements on the SEPTA line east of Norristown, at the UMP Bridge and at the Glen Willow curves.
- Development of the alternative 30th Street access route via Bala Cynwyd and a consideration of its potential benefits, both from an intercity and commuter service perspective.
- Development of detailed Station Development plans for each community to optimize the joint development and economic impacts of the rail service.

The current level of study has done enough analysis that it can suggest that it will be feasible not only to restore passenger service to Berks County, but also that the proposed peak hour Phoenixville commuter service can be added at a manageable level of cost. At this point a detailed investment plan and implementation strategy have been developed, but this is on the basis of an initial concept study that has been based only on publicly available data.

The next step would be to start engaging with Norfolk Southern, SEPTA, Amtrak and community stakeholders to develop even more data, and in particular to further refine the simulations based on confidential data from the railroads. This will ensure that the capacity work satisfies the railroads' requirements and meets their needs.

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However, railroad negotiations also have to be conducted for:

1. Establishing the financial terms for rail corridor access
2. Establishing station and other operating requirements so that communities will be able to develop effective facilities at a reasonable cost.

Up until now the analysis has been primarily conceptual based on publicly available data. It has served to establish the basic feasibility of rail service restoration – from an operational, ridership, financial and economic point of view. But from now on it is going to become much more necessary to “roll up our sleeves” and “get into the weeds” by working with the railroads and communities to carefully review all the available data and resolve implementation issues.

Chapter 4

Capital Plan

SUMMARY

This chapter develops preliminary Capital Costs for the proposed Philadelphia to Reading service. These costs could provide an initial starting point for negotiations with the railroads. Actual costs will depend on the outcome of the negotiations and may end up lower or higher. These costs are consistent with the train speeds and running times that were used as the input to the evaluation process.

4.1 Infrastructure Needs

Although the required signal and PTC systems already exist along the line, at a minimum some signal, grade crossing and PTC system modifications would be needed to raise passenger train speeds to 79-mph on Norfolk Southern.

The capacity requirements are as yet uncertain and will require the completion of a capacity analysis to confirm the need. However, for now it is assumed that the improvements NS has already made will suffice. This focus would then shift to a consideration of how NS might be compensated for the investments it has already made, rather to the need for new capacity investment in the corridor. This issue will be addressed in Section 4.3.

This leads to a cost of \$46 million for infrastructure capital. This includes a train maintenance base and servicing facility in Reading, station platforms, grade crossing improvements and minor track capacity upgrades including a passing siding at Franklin Street station, so other trains could pass while passenger trains are pulled into the clear of the mainline and are waiting in the station. If the Phoenixville project can share some of the cost, Reading's cost would be reduced to \$36.75 million as shown in Exhibit 3-36.

4.2 Equipment Scheduling and Capital Cost

Each train would be able to make two round trips per day from Reading to Philadelphia, so four trainsets would be needed for covering eight round trips. Two spares would also be required; a total of six trainsets would be needed for the service. At a cost of \$35 million each for tilting, dual-mode trains the cost would be \$210 million total. Second-hand equipment could probably be procured at a lower cost.

If the service were scheduled and operated as a commuter service, due to the peak hour directional imbalance, many of the trains would have to lay over in Philadelphia during the mid-day waiting for their evening return to Reading. However, extending the route to New York or Washington would eliminate these mid-day layovers in Philadelphia since the trains would run through. Doing this would greatly improve equipment utilization.

Perhaps just one or two additional trainsets would be needed for supporting an NEC run through service. However, if any additional trains beyond the six were required for the service extension, they would not be the cost responsibility of Reading service. This leads to a capital cost of \$210 Million for the trains.

4.3 Norfolk Southern Compensation

Norfolk Southern will expect compensation for passenger use of its rail line. In part, this reflects the significant value of investments NS has already made in improving the corridor, including the costs for upgraded signals and PTC, which have already been installed on the rail line:

The final result for purchasing track and right of way access will be the result of a negotiation, but based on other agreements would expect it to fall within a \$22 to \$100 million range. In lieu of paying access fees, the higher \$100 million up-front capital cost number has been assumed as a placeholder in the cost benefit ratio.

4.4 Equipment and Total Capital Cost

Overall capital cost results are summarized in Exhibit 4-1. In this approach, costs for station improvements beyond the platforms remains the responsibility of local communities, but this can be largely funded by joint development at or near the stations.

Exhibit 4-1: Capital Cost Summary, in 2020 Dollars

Right of Way	Infrastructure	Equipment	TOTAL	\$/Mile* Overall
\$100	\$46	\$210	\$356	\$6.0

Chapter 5

Demographics, Socioeconomic and Transportation Databases

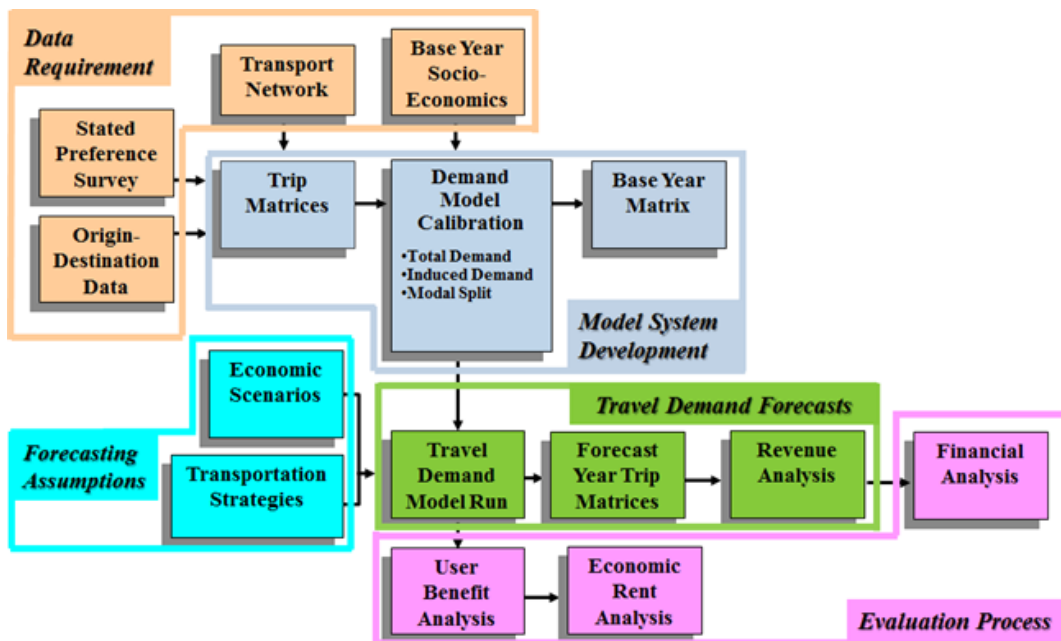
SUMMARY

This chapter describes the market analysis databases, including the zone system, socioeconomic data, transportation networks, origin-destination data, and stated preference survey data upon which the forecast will be based.

5.1 Introduction

To better represent the travel market that covers the Reading to Philadelphia Corridor, the study area is divided into zones to reflect the characteristics of travelers and trips of different origin-destinations pairs which are the basic building blocks of the COMPASS™ Model (See Exhibit 5-1). In order to forecast the future Total Travel Demand in the corridor, base year and future socioeconomic data for each zone are developed and inputted into the model. All databases: socioeconomic characteristics, transportation networks, and trips, are also built at the zonal level. In particular, the main drivers of the travel market, namely, population, employment and income, are developed at the zonal level. The COMPASS™ Model then processes the data and outputs the Travel Demand Forecast including passenger rail ridership and revenue results, at the zonal level.

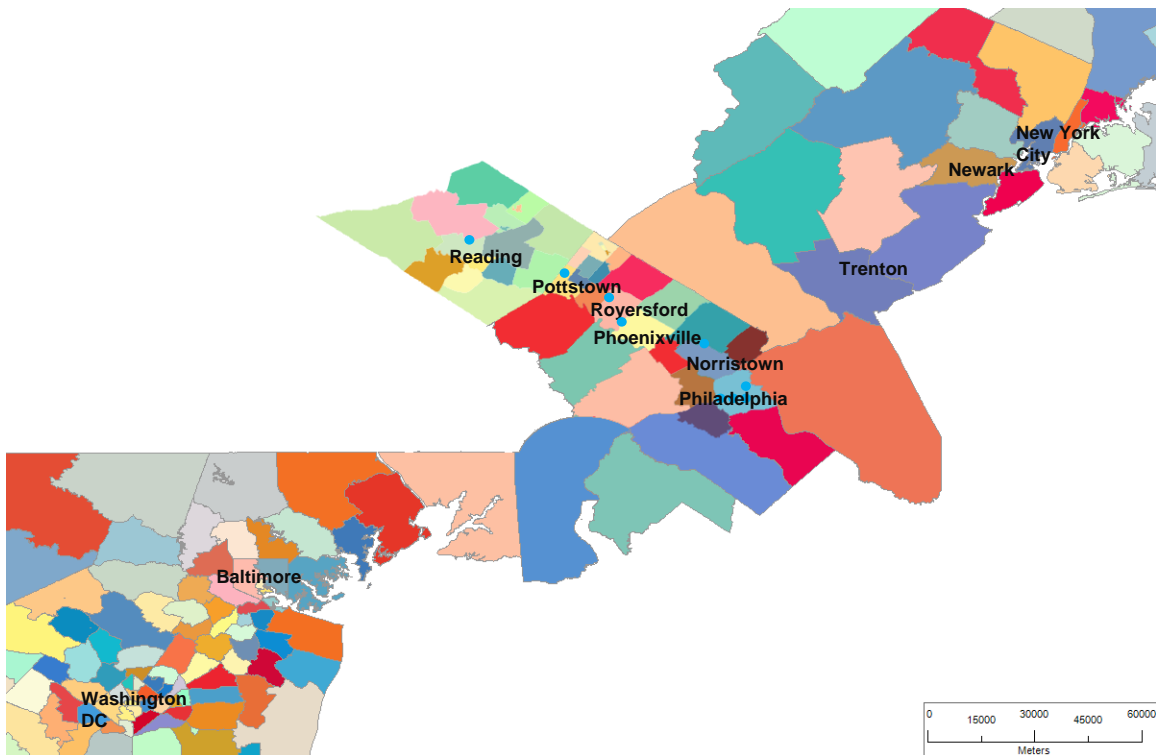
Exhibit 5-1: COMPASS™ Model Diagram



5.2 Zone System

To understand the potential level of intercity and interurban travel in the Reading to Philadelphia Corridor, the zone system was extended to include the Northeast Corridor. A zone system was defined that allows the number of trips between one location (zone) and another (zone) to be measured. As such, the system provides a representation of the travel occurring from zone origins to zone destinations for any given market in the corridor (e.g., business, commuter, social travel). For passenger rail planning, most rural zones are represented by larger areas. However, where it was important to precisely identify trip origins and destinations in urban areas, finer zones were used. The Travel Demand Model forecasts the total number of trip origins and destinations by mode and by zone pair. Exhibit 5-2 shows the zone system for study area which includes not only the Reading to Philadelphia Corridor (32 zones), but which extends along the Northeast Corridor all the way from Washington D.C. to New York including a total of 162 zones. As a result, the model will be able to predict not only the number of trips Reading to Philadelphia Corridor, but it can also model those trips which interconnect with the Northeast Corridor as well.

Exhibit 5-2: Study Area Zone System



5.3 Socioeconomic Database Development

In order to estimate the base and future travel market total demand, the travel demand forecasting model requires base year estimates and future growth forecasts of three socioeconomic variables of population, employment and per capita income for each of the zones in the study area. A socioeconomic database was established for the base year (2020) and for each of the forecast years (2020-2050).

The data was developed at five-year intervals using the most recent data collected from the following sources:

- U.S. Census Bureau
- American Community Survey 5-Year Estimates
- U.S. Bureau of Economic Analysis
- Woods & Poole Economics
- Local Planning Agencies (DVRPC, RATS)

Exhibit 5-3 shows the base year and TEMS socioeconomic projections for the Reading to Philadelphia Corridor. Two different tables are given: firstly, the by itself, on a stand-alone basis as if only local trips were being modeled. Secondly, the corridor if interconnected to the Northeast Corridor, reflecting the socioeconomics of the whole Zone system shown in Exhibit 5-2. It is obvious that the size of the fully connected NEC market is much larger. This will result in a corresponding increase in the intercity trip making potential if the travel needs within the entire zone system are taken into consideration.

Exhibit 5-3: Corridor Base and Projected Socioeconomic Data

Reading-Philadelphia Corridor Only

	2020	2025	2030	2035	2040	2045	2050	Average Annual Growth Rate
Population	4,756,374	4,847,707	4,933,883	5,002,115	5,049,471	5,080,603	5,101,331	0.23%
Employment	3,001,997	3,155,873	3,305,147	3,442,802	3,568,336	3,687,670	3,804,989	0.79%
Per Capita Income (\$)	45,334	48,626	51,712	54,335	56,848	59,524	62,744	1.09%

Reading-Philadelphia and Northeast Corridor Combined

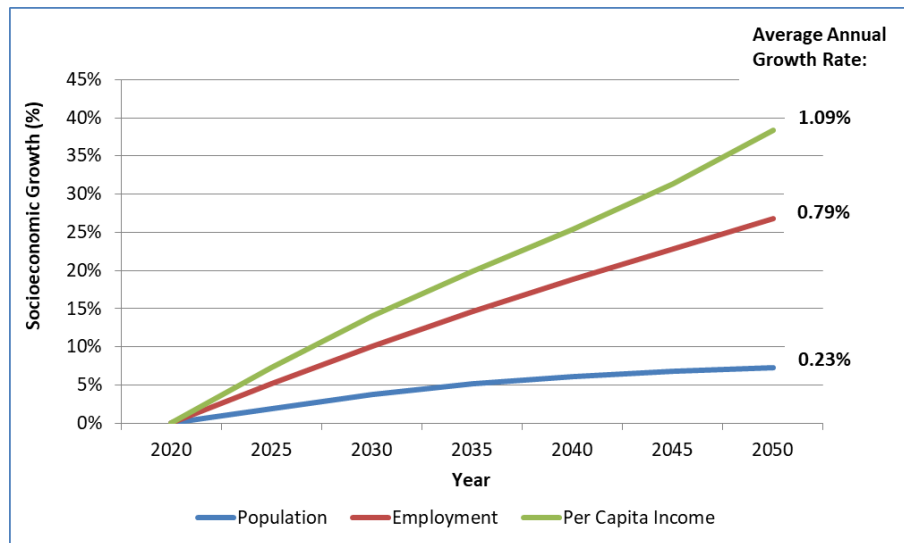
	2020	2025	2030	2035	2040	2045	2050	Average Annual Growth Rate
Population	31,514,046	32,415,262	33,228,464	33,938,404	34,605,874	35,251,764	35,777,734	0.42%
Employment	20,971,456	22,136,483	23,247,140	24,253,221	25,241,677	26,298,679	27,259,850	0.88%
Per Capita Income (\$)	52,413	55,652	58,729	61,467	63,996	66,695	69,622	0.95%

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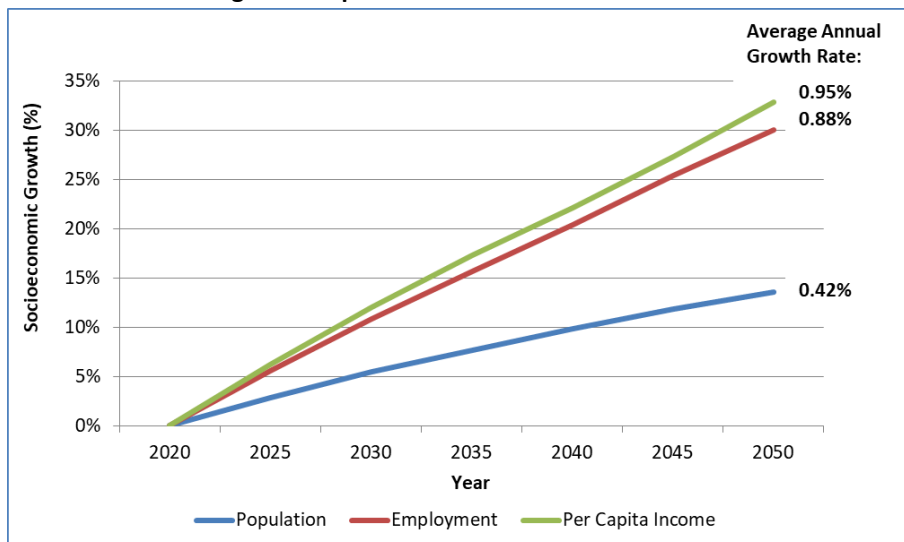
Exhibit 5-4 shows the socioeconomic growth projections for the study area again, for the local corridor zones and for the entire market area including the NEC. Both charts show that per-capita income and employment levels are growing faster than population; although Reading-Philadelphia Corridor population is growing slower (0.23% per year) than the whole NEC region; this reflects the very large influx of population into New York and Washington. Even though population of the Reading-Philadelphia Corridor is only growing slowly, changes in employment and income are outpacing population growth, and these drivers, which are growing faster than population, also stimulate more demand. As a result, travel is likely to continue to rise faster than the population growth rates, both within the Reading-Philadelphia Corridor as well as the demand for interconnecting trips to and from NEC destinations.

Exhibit 5-4: Study Area Socioeconomic Data Growth Rate

Reading-Philadelphia Corridor Only



Reading-Philadelphia and Northeast Corridor Combined



The exhibits in this section show the aggregate socioeconomic projection for the whole study area. It should be noted that in applying socioeconomic projections to the model, separate projections were made for each individual zone using the data from the listed sources. Therefore, the socioeconomic projections for different zones are likely to be different and thus may lead to different future travel sub-market projections.

5.4 Base Year Transportation Database Development

To understand the existing travel market of the corridor, the base year existing travel networks and travel demand by mode and travel purpose in the corridor are developed. The travel modes include auto, bus, and air. The travel purposes are business, commuters, and other (social, tourist and etc.) trips. This separation of business and non-business trips is important since business trips are paid for by firms who have a willingness to use more expensive options and have a high value of time (VOT), while non-business trips are paid for by individuals who look for less expensive travel choices and who typically have a much lower value of time (VOT). In addition to calculating values of time (VOTs) for different travel purposes and travel modes, generalized costs for values of frequency (VOFs) and values of access time (VOAs) are also developed for the corridor.

5.4.1 Base Year (2020) Transportation Networks

In transportation analysis, travel desirability/utility is measured in terms of travel cost and travel time. These variables are incorporated into the basic transportation network elements that provide by mode the connections from any origin zone to any destination zone. Correct representation of the existing and proposed travel services is vital for accurate travel forecasting. Basic network elements are called nodes and links. Each travel mode consists of a database comprised of zones and stations that are represented by nodes, and existing connections or links between them in the study area. Each node and link are assigned a set of travel attributes (time and cost). The network data assembled for the study included the following attributes for all the zone pairs.

For public travel modes (air, rail, bus):

- Access/egress times and costs (e.g., travel time to a station, time/cost of parking, time walking from a station, etc.)
- Waiting at terminal and delay times
- In-vehicle travel times
- Number of interchanges and connection times
- Fares
- Frequency of service

For private mode (auto):

- Travel time, including rest time
- Travel cost (vehicle operating cost)
- Tolls
- Parking Cost
- Vehicle occupancy

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The highway network was developed to reflect the major highway segments within the study area. The sources for building the highway network in the study area are as follows:

- State and Local Departments of Transportation highway databases
- The Bureau of Transportation Statistics HPMS (Highway Performance Monitoring System) database

Two networks were developed for highway and for each public transportation mode: one for business travel, one for non-business travel (commuter, social, tourist and etc.) because the business vs. non-business travelers perceive these link costs differently.

5.4.2 Origin-Destination Trip Database

The multi-modal intercity travel analyses model requires the collection of base origin-destination (O-D) trip data describing annual personal trips between zone pairs. For each O-D zone pair, the annual personal trips are identified by mode (rail, auto, air, and bus) and by trip purpose. Because the goal of the study is to evaluate intercity travel, the O-D data collected for the model reflects travel between zones (i.e., between counties, neighboring states and major urban areas) rather than within zones.

TEMS extracted, aggregated and validated data from a number of sources in order to estimate base travel between origin-destination pairs. The data sources for the origin-destination trips in the study are:

- U.S. Census Bureau
- Woods & Poole Economics
- Bureau of Economic Analysis
- Local Planning Agencies (DVRPC, RATS)

The travel demand forecast model requires the base trip information for all modes between each zone pair. In some cases, this can be achieved directly from the data sources, while in other cases the data providers only have origin-destination trip information at an aggregated level (e.g., AADT data, station-to-station trip and station volume data). Where that is the case, a data enhancement process of trip simulation and access/egress simulation needed to be conducted to estimate the zone-to-zone trip volume. The data enhancement process is shown in Exhibit 5-5.

For the auto mode, the quality of the origin-destination trip data was validated by comparing it to AADTs and traffic counts on major highways and adjustments have been made when necessary. For public travel modes, the origin- destination trip data was validated by examining station volumes and segment loadings.

Exhibit 5-5: Zone-to-Zone Origin-Destination Trip Matrix Generation and Validation

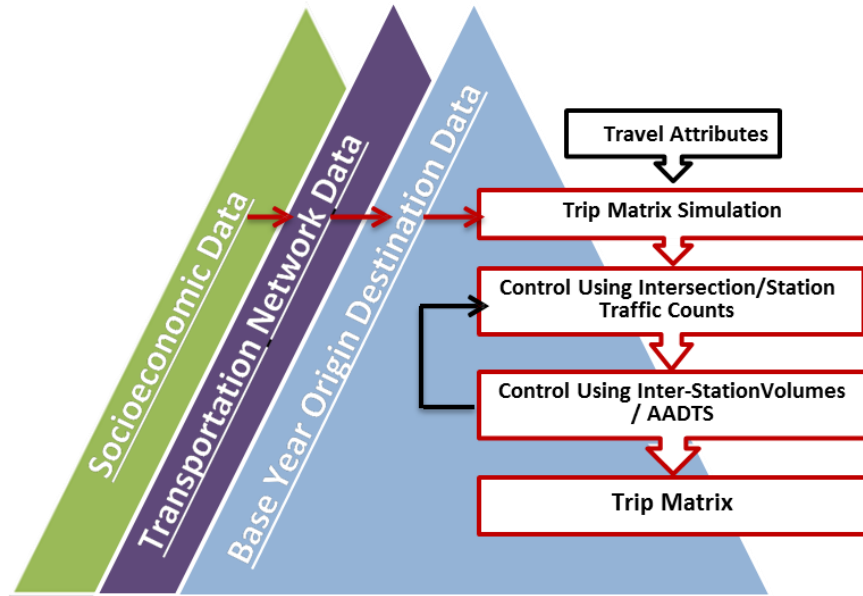
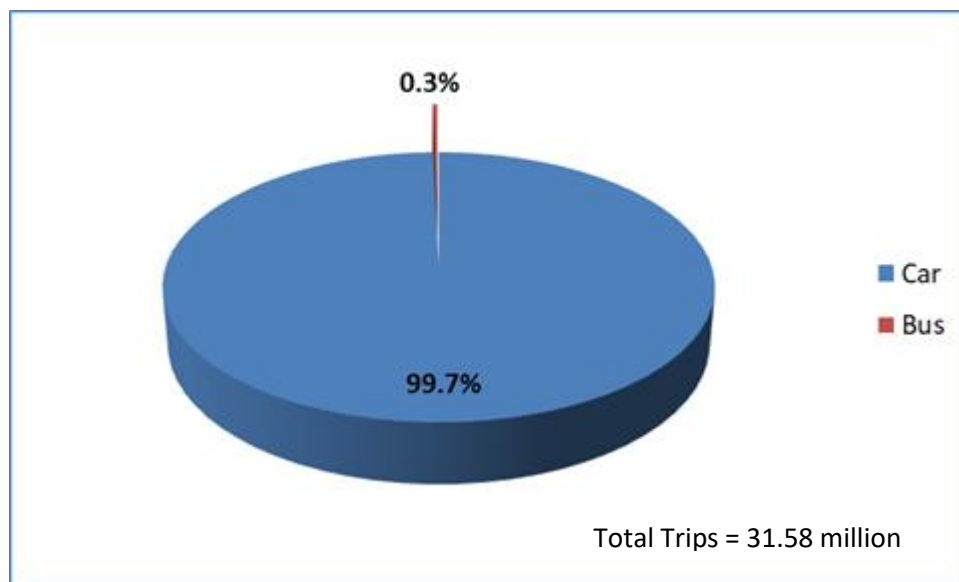


Exhibit 5-6 shows the base 2020 study area travel market share of air, bus, and auto modes. The total intercity and interurban travel demand in the corridor is 31.58 million in 2020 and this includes travel to NEC connecting zones such as New York and Washington DC. It can be seen that auto mode holds 99.7% percent of market share, so the region is almost completely auto dependent. This reflects the withdraw of Greyhound from Reading as well as the bankruptcy and sudden shutdown of Bieber Tourways³⁴ which has left the area almost completely bereft of any public transportation options.

Exhibit 5-6: Base Year Travel Market (2018)



³⁴ Bieber abruptly cancels bus service, closes for good, *The Morning Call*, February 8, 2019. See: <https://www.mcall.com/news/breaking/mc-nws-bieber-cancels-bus-service-20190208-story.html>

5.4.3 Values of Time, Values of Frequency, and Values of Access Time

Generalized cost of travel between two zones estimates the impact of improvements in the transportation system on the overall level of trip making. Generalized Cost includes all the factors that are key to an individual's travel decision (such as travel time, fare, frequency) that are all included in the Generalized Cost equation for the COMPASS™ Model. Generalized Cost is typically defined in travel time (i.e., minutes) rather than cost (i.e., dollars). Costs are converted to time by applying appropriate conversion factors such as Value of Time, derived from Stated Preference Survey. The generalized cost (GC) of travel between zones i and j for mode m and trip purpose p is defined as follows:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH}{VOT_{mp} * F_{ijm}}$$

Where,

TT_{ijm} = Travel Time between zones i and j for mode m (in-vehicle time + station wait time + connection time + access/egress time), with waiting, connect and access/egress time multiplied by a factor (waiting and connect time factors is 1.8, access/egress factors were determined by ratios from the Michigan Detroit-Chicago SP survey) to account for the additional disutility felt by travelers for these activities.

TC_{ijmp} = Travel Cost between zones i and j for mode m and trip purpose p (fare + access/egress cost for public modes, operating costs for auto)

VOT_{mp} = Value of Time for mode m and trip purpose p

VOF_{mp} = Value of Frequency for mode m and trip purpose p

F_{ijm} = Frequency in departures per week between zones i and j for mode m

OH = Operating hours per week (sum of daily operating hours between the first and last service of the day)

Value of Time (VOT) is the amount of money (\$/hour) an individual is willing to pay to save a specified amount of travel time, the Value of Frequency (VOF) is the amount of money (\$/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation. Access/Egress time is weighted higher than in-vehicle time in generalized costs calculation, and its weight is derived from value of access stated preference surveys. Station wait time is the time spent at the station before departure and after arrival. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found in previous stated preference surveys.

Exhibits 5-7 and 5-8 shows the values of time and values of frequency from the Michigan DOT Chicago-Detroit/Pontiac Stated Preference Survey. These values have been updated from 2012 to 2020 dollars but are likely to be conservative, due to the generally lower values of income in the Midwest as compared to the Northeast Corridor. (TEMS has in the past collected Stated Preference data in the Northeast Corridor yielding higher values than these.)

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However, to justify raising the values of time for this study would require undertaking a new Stated Preference survey within the Philadelphia-Reading Corridor. Doing this would likely justify using higher VOTs than those that are currently being assumed. If higher VOTs were used then the volume of trips made at any given fare level would increase, making the current forecast conservative.

Exhibit 5-7: VOT values by Mode and Purpose of Travel (\$2020/hour)

Value of Time (VOT)	Business	Non-business
Auto	\$30.06	\$27.11
Bus	\$22.35	\$16.46
Rail	\$42.87	\$30.68
Air	\$54.06	\$42.97

Exhibit 5-8: VOF values by Mode and Purpose of Travel (\$2020/hour)

Value of Frequency (VOF)	Business	Non-business
Bus	\$5.82	\$5.78
Rail	\$11.42	\$9.66
Air	\$27.99	\$20.14

Chapter 6

Travel Demand Forecast

SUMMARY

This chapter develops the market analysis of the potential for passenger rail, presenting the Travel Demand Forecast for the Reading to Philadelphia Corridor including ridership, revenue and market share results.

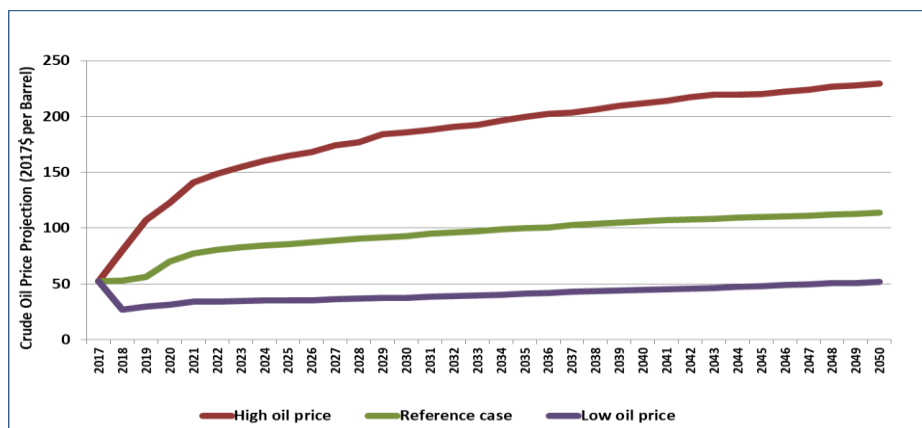
6.1 Future Travel Market Strategies

In order to forecast the future potential for rail ridership, consideration has to be given to how future travel markets will be impacted by changing transportation conditions. The critical factors that will change future travel conditions include fuel price, vehicle fuel efficiency, as well as highway traffic congestion. In addition, the forecasts need to assess the different levels of rail service that might be developed, and how it will compete with auto, air, and bus markets.

6.1.1 Fuel Price Forecasts

One of the important factors in the future attractiveness of passenger rail is fuel price. Exhibit 6-1 shows the Energy Information Agency (EIA)³⁵ projection of crude oil prices for three oil price cases: namely a high world oil price case that is for an aggressive oil price forecast; a reference world oil price case that is moderate and is also known as the central case forecast; and a conservative low world oil price case. In this study, the reference case oil price projection is used to estimate transportation cost in future travel market. The EIA reference case forecast suggests that crude oil prices are expected to be \$70 per barrel in 2020³⁶ and will increase to \$114 per barrel in 2050.

Exhibit 6-1: 2018 Crude Oil Price Forecast by EIA



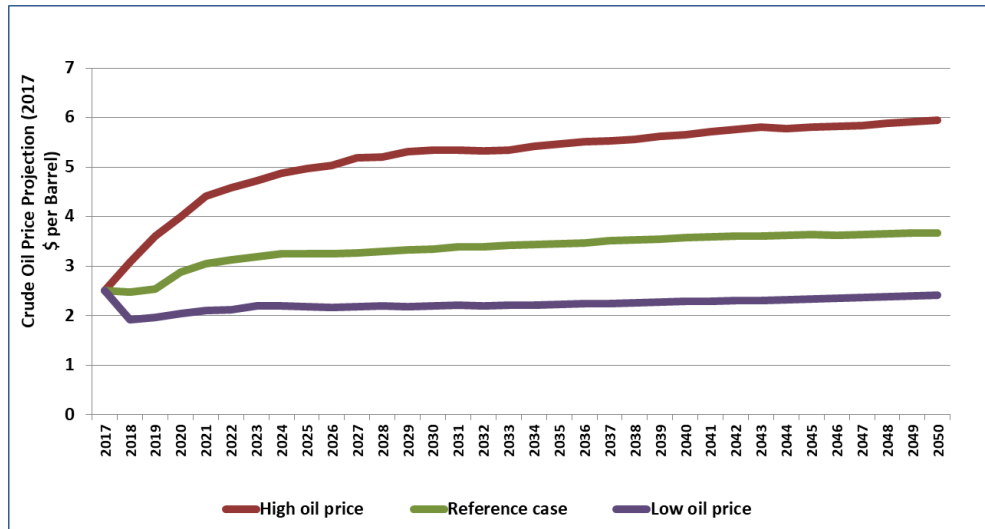
³⁵ EIA periodically updates historical and projected oil prices at www.eia.gov/forecasts/aeo/tables_ref.cfm

³⁶ Prior to recent coronavirus oil price impact

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EIA has also developed a future retail gasoline price forecast, which is shown in Exhibit 6-2. The implication of this is a reference case gasoline price of \$2.88 per gallon in 2020, with a high case price of \$4 per gallon, and a low case price of \$2.03 per gallon. The reference case gasoline price will increase to \$3.67 per gallon in 2050. The impact of rising energy prices will clearly impact the competition between the modes of travel in the corridor. Typically, rising energy and therefore gas prices will most severely impact auto travel followed by air mode, bus mode and finally rail. Rail is very fuel efficient and its market share typically increases with rising energy and gas prices. Increasing energy prices has been largely responsible for the recent dramatic increases in Amtrak traffic.

Exhibit 6-2: U.S. Retail Gasoline Prices Forecast by EIA



6.1.2 Vehicle Fuel Efficiency Forecasts

Future improvement in automobile technology is likely to reduce the impact of high gas prices on automobile fuel cost with better fuel efficiency. The Oak Ridge National Laboratory (ORNL) Center for Transportation Analysis (CTA) provides historical automobile highway energy usage in BTU (British thermal unit) per vehicle-mile data for automobiles since 1970 (Exhibit 6-3).

Exhibit 6-3: ORNL Historical Highway Automobile Energy Intensities Data

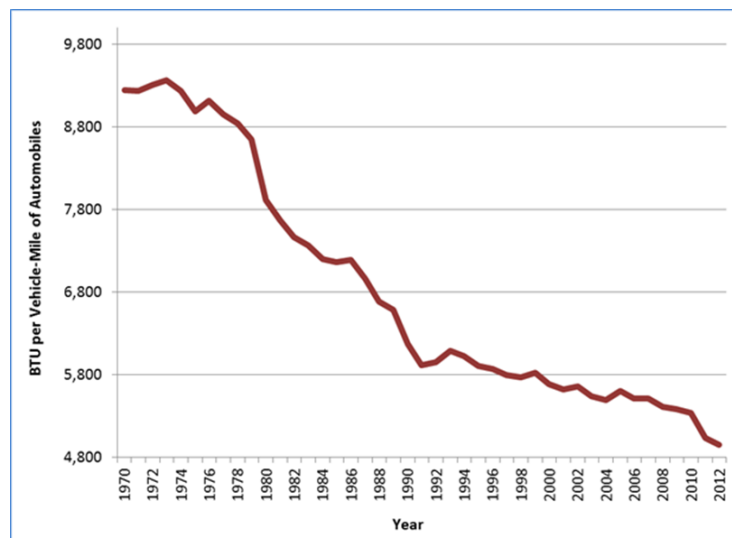
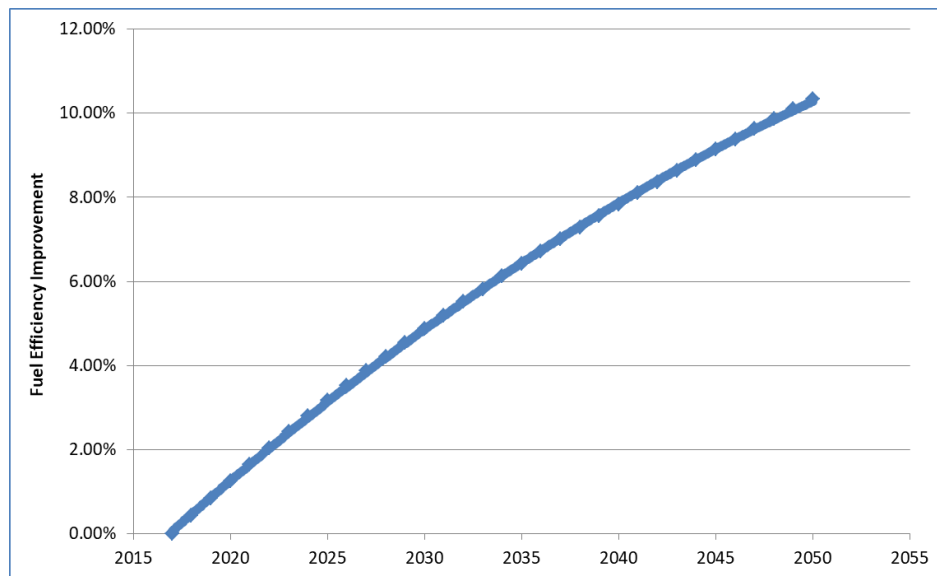


Exhibit 6-3 shows the historical highway automobile energy intensities from 1970 to 2012. It can be seen that automobile fuel efficiency has been improving gradually during the past few decades, but the improvement perhaps surprisingly has slowed down in recent years. Future automobile fuel efficiency improvement was projected by TEMS as shown in Exhibit 6-4. The TEMS forecast reflects the actual performance of the vehicle fleet, which is much lower and slower to be implemented than the regulated Corporate Average Fuel Economy (CAFE) standards for new cars. The auto fleet simply changes at a much slower pace than the standards for new cars. It was based on the historical automobile fuel efficiency data. The TEMS forecast shows a slow but consistent increase in car fuel efficiency to 2050, and beyond. It shows that the automobile fleet fuel efficiency is expected to improve by more than 10 percent by 2050 as compared to fuel efficiency of today.

Exhibit 6-4: Auto Fuel Efficiency Improvement Projections



6.1.3 Highway Traffic Congestion

The average annual auto travel time growth in the corridor was estimated with the projected highway traffic volume data and the Bureau of Public Roads (BPR) function that can be used to calculate travel time growth with increased traffic volumes:

$$T_f = T_b * [1 + \alpha * \left(\frac{V}{C}\right)^\beta]$$

where

T_f is future travel time,

T_b is highway Average travel time,

V is traffic volume,

C is highway Average capacity,

α is a calibrated coefficient (0.56), it describes the volume of traffic required for the capacity of the road to become limited by traffic (i.e., when it will begin to slow traffic speed)

β is a calibrated coefficient (3.6), it describes the slope or sensitivity of the highway to congestion once capacity becomes limited (i.e., how quickly traffic speed falls as traffic increases).

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The projected travel times were calculated by computing travel time on each segment of the highway route between two cities. The key assumptions are as follows:

- $\alpha = 0.56$
- $\beta = 3.6$

The above two coefficients are from the Highway Capacity Manual, they determine how traffic volume will affect travel speed. The resulting projections are shown in Exhibit 6-5.

Exhibit 6-5: Highway Congestion Travel Time Forecasts

City Pairs	Distance (miles)	Current Travel Time (hh:mm)	Projected 2050 Travel Time (hh:mm)	Avg Annual Increase
Reading, PA - Pottstown, PA	19	0:32	0:35	0.36%
Reading, PA - Phoenixville, PA	30	0:49	0:57	0.55%
Reading, PA - Norristown, PA	45	1:05	1:18	0.61%
Reading, PA - Philadelphia, PA	60	1:30	1:51	0.73%

6.2 Travel Demand Forecast Results

Applying the COMPASS™ Total Demand Model with the data inputs discussed in Chapter 5 (demographics, socioeconomics and transportation databases), generated the Total Demand Forecast presented in the follow sections of this chapter, including the rail Ridership and Revenue results.

6.2.1 Rail Scenarios

For the purpose of the rail ridership and revenue analysis, a 79-mph top speed and tilting train as described in Exhibits 3-9 and 3-10 were used. For convenience, exhibit 6-6 shows again the tabular schedule that matches Exhibit 3-10. A one hour and 11-minute running time from Reading to Jefferson Station is 23 minutes or 24% faster than was the historic 1981 schedule.

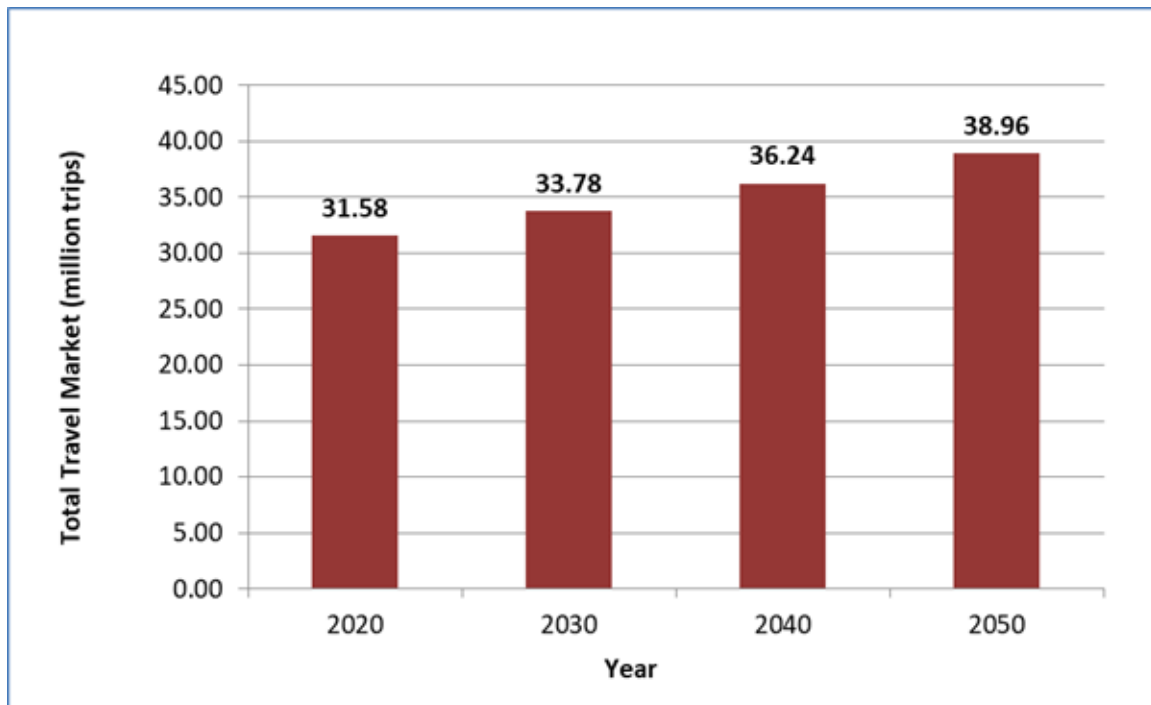
Exhibit 6-6: 1:11 to Jefferson Station, Tabular Schedule using a tilting train

	Miles	Time	
Reading Franklin St	0	0:00	Dp
Pottstown	18	0:18	Ar
Royersford	26	0:27	Ar
Phoenixville	30	0:38	Ar
Norristown Trans Ctr	41	0:48	Ar
Temple Univ	56	1:06	Ar
Market East/Jefferson	58	1:11	Ar
Suburban	58	1:16	Ar
30th Street	59	1:22	Ar
Trenton, NJ	92	1:53	Ar
Newark, NJ	140	2:26	Ar
New York, NY	150	2:46	Ar

6.2.2 Total Demand

Exhibit 6-7 shows the total intercity Travel Demand Forecasts for 2020, 2030, 2040 and 2050 for the entire corridor, based on trips that either originate or terminate within the Reading-Philadelphia Corridor; having at least one trip end within the local corridor zone system, but also including the interconnecting trips to or the Northeast Corridor zones. Travel demand on this basis will increase from 31.58 million in 2018, to 33.78 million in 2030, and increases to 38.96 million in 2050. The average annual corridor travel market growth rate is 0.79 percent per year, which is in line with the socioeconomic growth within the travel market for the corridor.

Exhibit 6-7: Reading-Philadelphia Corridor Total Travel Demand Forecast (millions)

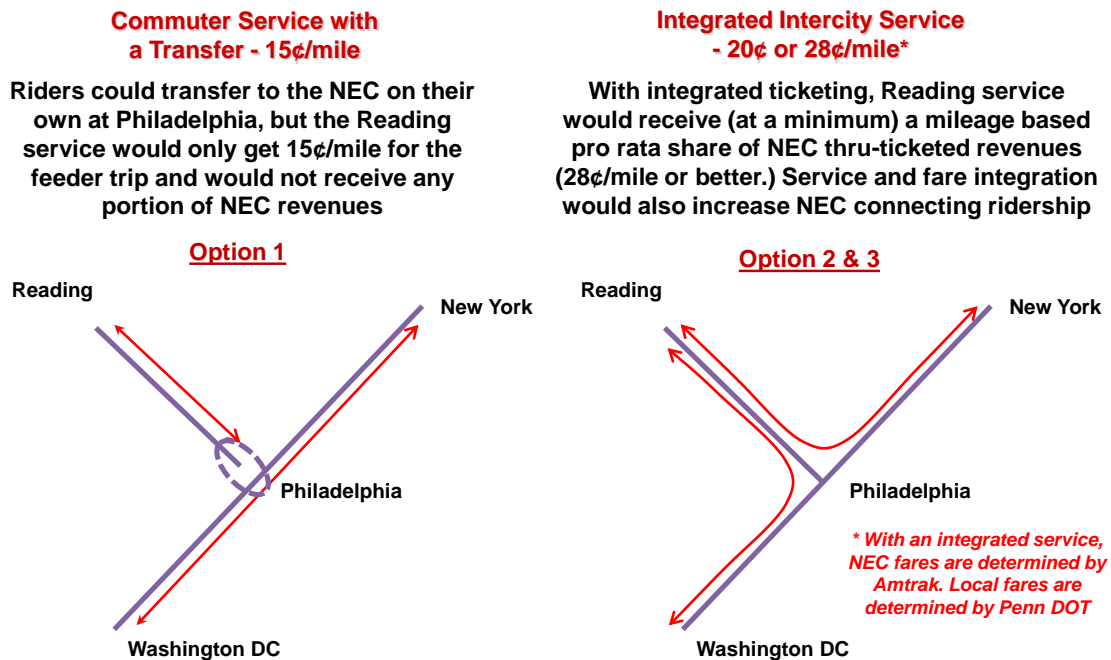


6.2.3 Ridership Forecasts

Three different scenarios have been assessed based on different combinations of fares and connectivity assumptions. They are all based on the same 1:11 train service option, but in Option 1 the trains do not run through Philadelphia and passengers are required to transfer. Options 2 and 3 assume higher fares but also an integrated ticket and some run through train service. Loosely described these alternatives could be considered as variations of either SEPTA or AMTRAK service options, although the actual analysis is a generic one and is not specific to any particular operator. As shown in Exhibit 6-8, the three scenarios may be described as follows:

1. **Commuter Rail Option** – With an average revenue yield of 15¢/mile comparable to SEPTA, trains would operate only to Philadelphia. Passengers could transfer to the NEC but would purchase separate tickets.
2. **Intercity Rail Option at Amtrak Fares** – With an average revenue yield of 28¢/mile (slightly less than Keystone's 30¢/mile yields) this would provide integrated ticketing and direct train service to NEC destinations as the existing Keystone service does, including run through trains.
3. **Intercity Rail Option at Reduced Fares** – This alternative is similar to Option 2 but lowers the revenue yield on local Reading to Philadelphia trips to just 20¢/mile. This would reflect a heavy discount on Keystone's pricing to result in local fares that would be more comparable to a commuter rail option.

Exhibit 6-8: Three Options Assessed for the Study

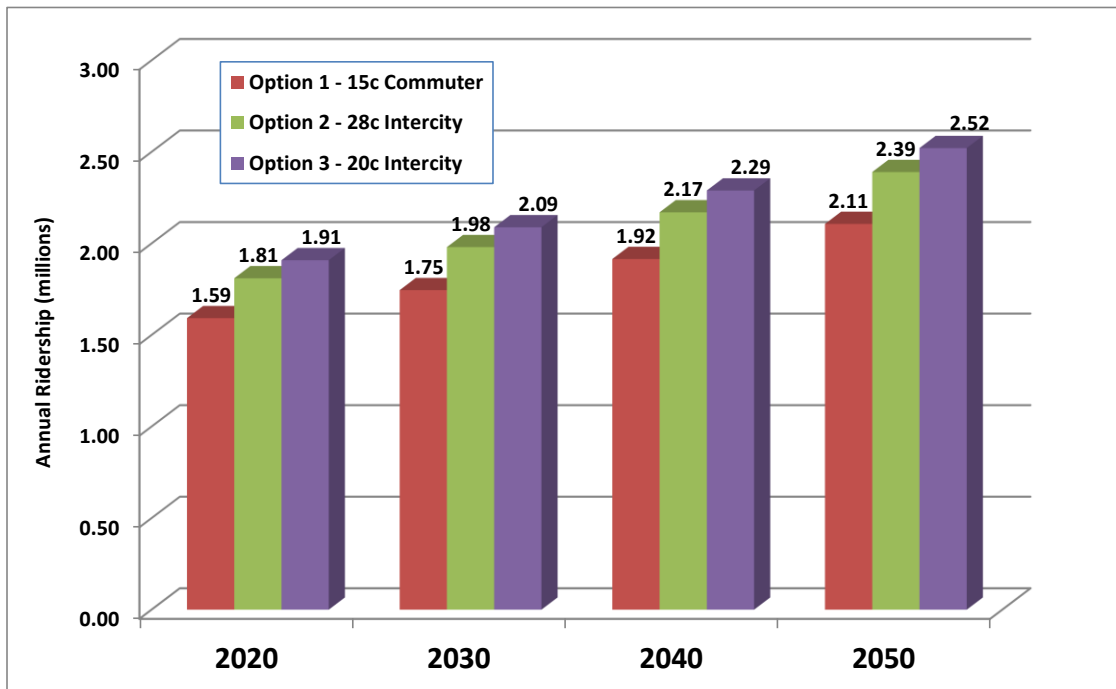


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Based on this, exhibit 6-9 summarizes the forecast results:

- Option 1, a Commuter service is estimated to have 1.75 million trips in 2030, 1.92 million trips in 2040, and 2.31 million trips in 2050.
- Option 2, an Intercity service with Keystone comparable local fares is estimated to have 1.98 million trips in 2030, 2.17 million trips in 2040, and 2.39 million trips in 2050.
- Option 3, an Intercity service with reduced local fares is estimated to have 2.09 million trips in 2030, 2.29 million trips in 2040, and 2.52 million trips in 2050. Option 3 produces the highest ridership because of the NEC connecting ridership and a lower fare for local trips.

Exhibit 6-9: Reading-Philadelphia Passenger Rail Ridership Forecast (annual millions of trips)

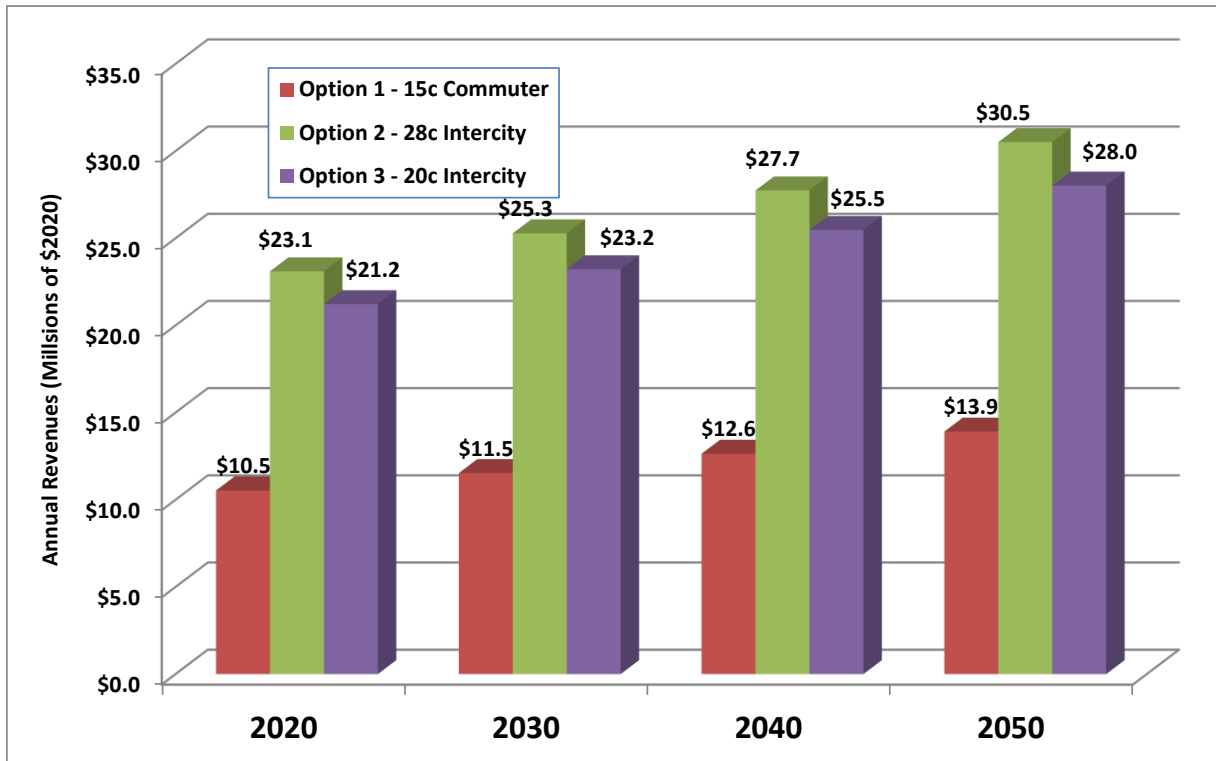


6.2.4 Revenue Forecasts

The passenger rail revenue forecast is shown in Exhibits 6-10.

- Option 1, a Commuter service is estimated to have \$11.5 million revenue in 2030, \$12.6 million revenue in 2040, and \$13.9 million revenue in 2050.
- Option 2, an Intercity service with Keystone comparable local fares is estimated to have \$25.3 million revenue in 2030, \$27.7 million revenue in 2040, and \$30.5 million revenue in 2050. Option 2 produces the highest revenue, but Option 3 revenues are only about \$2 million less each year.
- Option 3, an Intercity service with reduced local fares is estimated to have \$23.2 million revenue in 2030, \$25.5 million revenue in 2040, and \$28.0 million revenue in 2050.

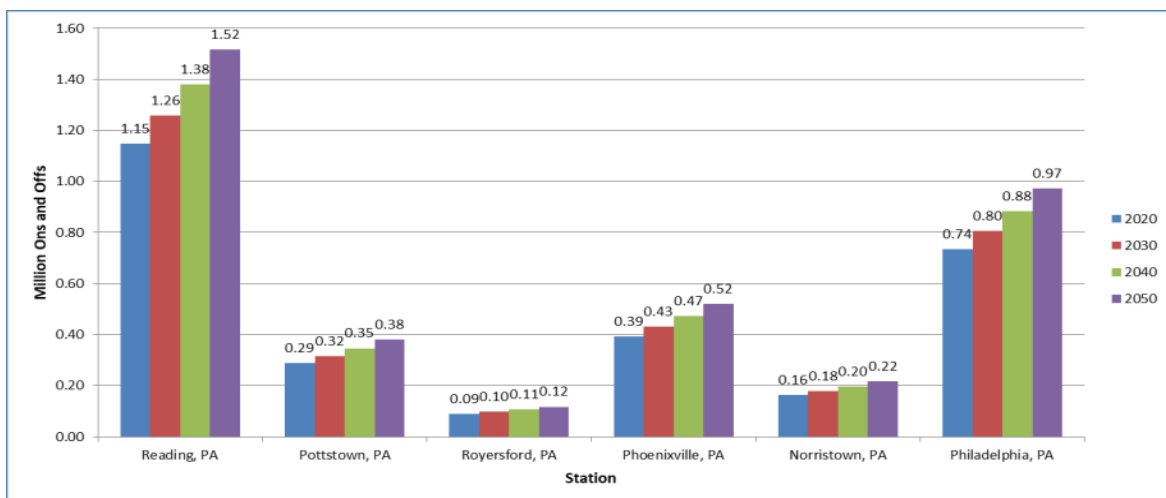
Exhibit 6-10: Reading-Philadelphia Passenger Rail Revenue Forecast (annual millions \$)



6.2.5 Station Volumes and Segment Loadings

Exhibit 6-11 shows the station volumes for Option 2, which is the option that integrates with intercity service and produces the most revenue. Reading is projected to be the strongest station having over one million passengers each year. It is assumed that through riders to New York and Washington would remain on board the train, so these riders do not count towards the Philadelphia station totals. If the transfer riders were included, Philadelphia stations would be the largest. This exhibit also suggests that some time might be saved by skipping some of the lower volume stops, for example if an Express train skipped Royersford, Norristown and Temple University it could get to Philadelphia in just one hour.

Exhibit 6-11: Station Volumes by Year for Option 2 (millions of passengers)

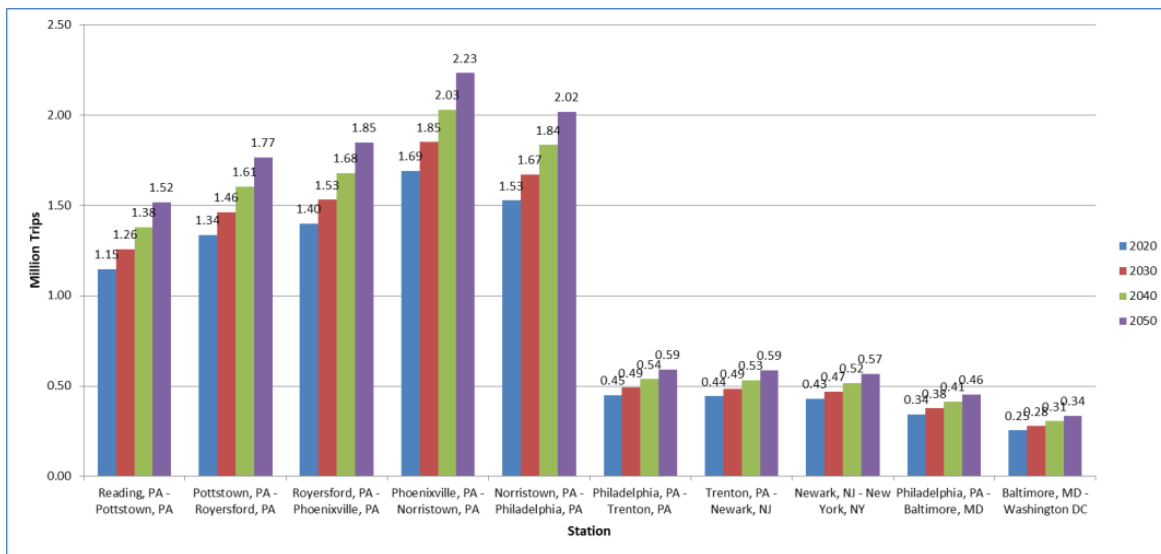


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Exhibit 6-12 shows the segment loadings for Option 2. This chart is related to the Station volume chart, the key difference being that it shows the cumulative number of passengers aboard the train for each segment of its route. Ridership grows as far as Norristown, but then it declines slightly because more people are forecasted to get off the train in Norristown than will board it. (The Rockville, Md. Station stop on the MARC Brunswick line exhibits similar behavior since riders can transfer to the Red Line subway there. So, this is not an unusual pattern for a suburban stop that provides a connection to a rail transit system.)

Exhibit 6-12 also shows the number of riders from the Reading to Philadelphia corridor who are traveling beyond Philadelphia to NEC destinations. Nearly a million annual riders are going to NEC destinations beyond Philadelphia. The forecast is that north vs. southbound connecting ridership would be almost evenly split in Philadelphia with the number of riders heading north only slightly greater than the number of southbound riders.

Exhibit 6-12: Segment Loadings by Year for Option 2 (millions of passengers)

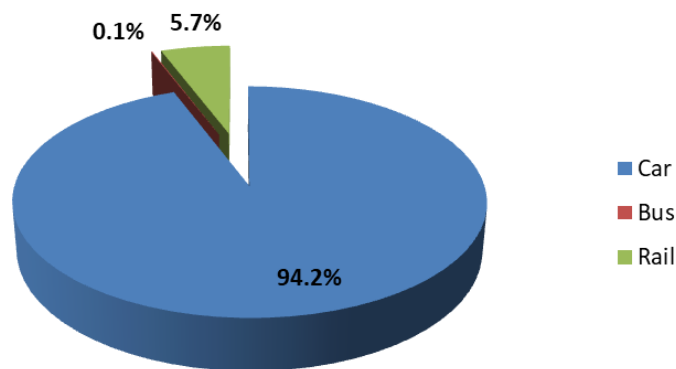


6.3 Market Shares

6.3.1 Travel Market Modal Split

Exhibit 6-13 shows forecasted overall market shares for the Philadelphia-Reading Corridor in 2040. The rail travel market share is 5.7%. Auto trips still dominate the travel market although auto's market share drops from 99% to 94% due to introduction of the new rail service.

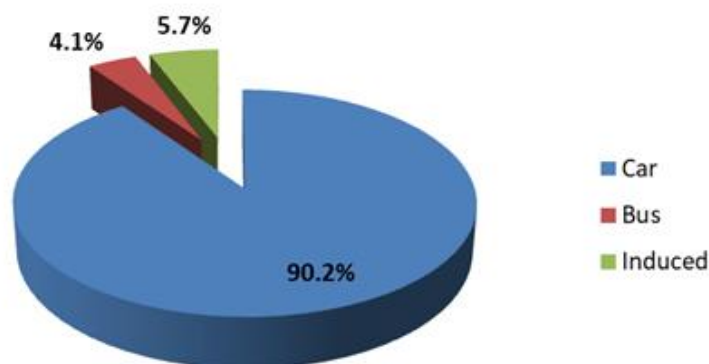
Exhibit 6-13: 2040 Rail Market Share



6.3.2 Source of Trips

Exhibits 6-14 illustrate the sources of the rail trips for the corridor in 2040. 90% of rail trips would be diverted from auto while only 4% would be diverted from bus. Induced demand or newly generated trips due to the access improvement provided by the rail passenger system, would amount to 5.7% of rail forecasted trips. It should be noted however that driving still dominates the future travel market because it is the most popular travel choice in the corridor.

Exhibit 6-14: 2040 Rail Trip Sources Forecast



6.4 Benchmarks

The forecasted ridership of the Reading service has been compared to the actual performance of the Harrisburg/Lancaster Keystone service. This is because there are many parallels between the existing Keystone service and how a new service to Reading would likely be structured. The parallels extend to both the intercity and commuter components of the proposed operation:

- As a base line, the Keystone Corridor (Harrisburg-Philadelphia) has been generating 1.5 Million Amtrak riders per year.
 - Of these, about 0.5 Million riders (about $\frac{1}{3}$) stay on the train beyond Philadelphia, the vast majority of these going to New York.
 - An unknown number of Keystone riders transfer to other Amtrak services in Philadelphia, including to the NEC north of New York (for which the Amtrak reservation system transfers riders at Philadelphia) as well as Keystone riders who may switch trains in Philadelphia for Baltimore, Washington D.C. or points south. We would estimate that probably 0.1-0.2 million Keystone riders make connections in Philadelphia to other Amtrak services.
- SEPTA is also bringing in 1.3 million commuter riders per year from five stations in its “extended commuter territory” west of Paoli as far as Thorndale. (This station is a SEPTA-only stop halfway between Amtrak’s Downingtown and Coatesville stations, as shown in Exhibit 6-15.)

Exhibit 6-15: Keystone Corridor Ridership Comparison



Five SEPTA stations are in the “extended commuter zone” beyond Paoli

By comparison, the 2020 Option 2 forecast for Reading service is for 1.81 million riders. Of these, 0.45 million are heading north on the NEC, 0.34 million are heading south on the NEC, and nearly all the remaining balance of 1.02 million riders are heading to local Philadelphia destinations.

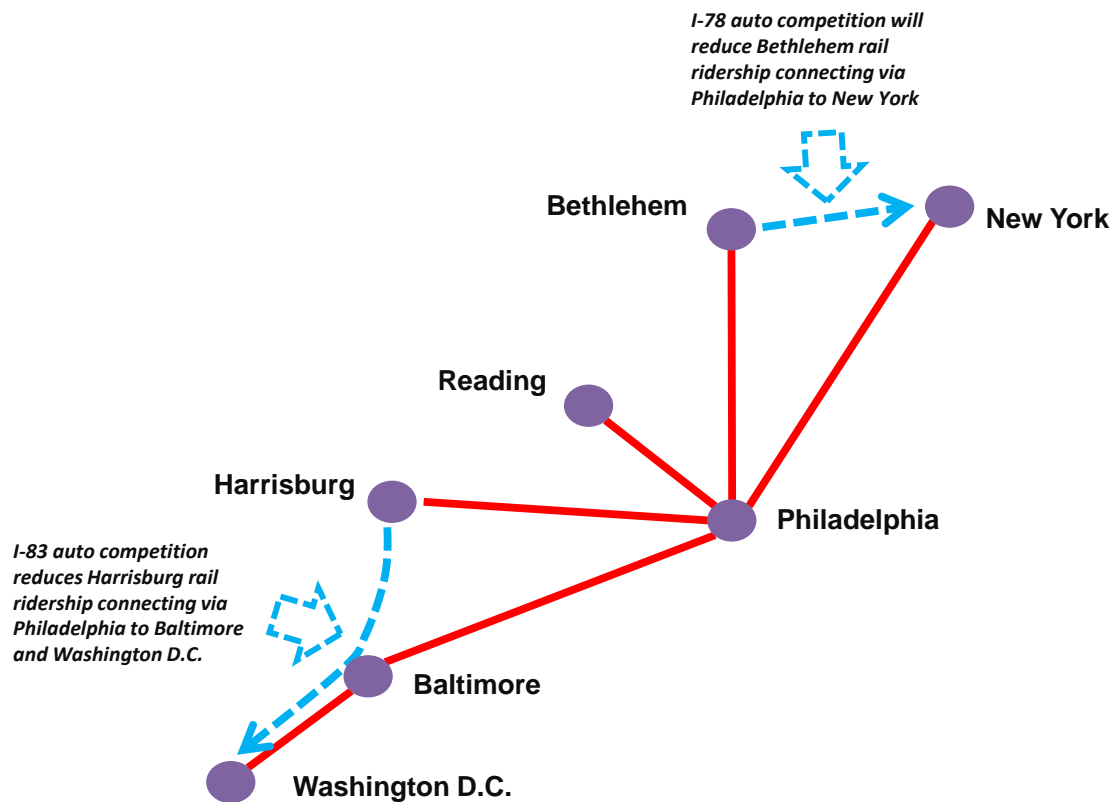
It can be seen that the forecast distribution of ridership on the Reading service is very similar to the existing Keystone service.

- While 33% of arriving Keystone riders continue north towards New York, the comparable percentage for Reading is 25%.
- While about 10% of Keystone riders likely continue south towards Washington D.C. the comparable percentage for Reading will be 19%.

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Exhibit 6-16 shows the transportation geography of Southeastern Pennsylvania and how this will affect the forecasted distribution of riders connecting to the Northeast Corridor.

Exhibit 6-16: Transportation Geography of Southeastern Pennsylvania



As a result, the forecast distribution of NEC connecting ridership on the Reading service makes good sense, considering the geography of the corridor:

- Since the drive from Harrisburg to Washington D.C. is short using I-83 and the rail trip is very circuitous via Philadelphia, the Harrisburg service should have a very low percentage of NEC connecting trips heading south, and it does. If a direct Harrisburg-York-Baltimore-Washington D.C. rail service were ever restored, Harrisburg riders would likely use that train, but they are not going to use an extremely circuitous rail routing to Washington D.C. via Philadelphia if they have an option to drive.
- Since the drive from Harrisburg to New York is long and the rail trip is very direct, Harrisburg rail service should be very competitive to New York. It should have a high percentage of NEC connecting trips heading north, and it does.

Now considering options from Reading, we see that Reading is more distant from Washington D.C. but closer to New York than is Lancaster:

- Since the drive from Reading to Washington D.C. is longer and the rail trip is more direct, the Reading service should have a higher percentage of NEC connecting trips heading south, and it does.
- Since the drive from Reading to New York is shorter and the rail trip is less direct, the Reading service should have a lower percentage of NEC connecting trips heading north, and it does.

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By contrast, consider the hypothetical case of a rail service restoration from Bethlehem, PA to Philadelphia. We see that Bethlehem is more distant from Washington D.C., but even closer to New York than is Reading:

- Since the drive from Bethlehem to Washington is long but the rail trip is very direct, Bethlehem rail service should be very competitive to Washington D.C. It should have a very high percentage of NEC connecting trips heading south, and it would.
- Since the drive from Bethlehem to New York is short using I-78 and the rail trip is very circuitous via Philadelphia, the Bethlehem service should have a very low percentage of NEC connecting trips heading north, and it would. If a direct Bethlehem-New York rail service were ever restored, Bethlehem riders would likely use that train, but they are not going to use an extremely circuitous rail routing to New York via Philadelphia if they have an option to drive.

This shows that the change in proportion of connecting riders heading north vs. south on the NEC will depend upon where the riders are coming from. It shows that the Washington D.C. connecting market is essentially lost to the Keystone service and that the New York market would be lost to a Bethlehem service. However, the Reading service is geographically positioned such that it can attract NEC connecting riders headed **both** north and south. This clearly enhances the ridership potential of the route.

In terms of comparing the Keystone vs. Reading routes in terms of potential for SEPTA commuter service, as already noted, the ridership of the Schuylkill Township station, currently planned to be located at Perkiomen Junction, could be doubled if another station were developed across the river at Oaks. This would raise the overall forecast for SEPTA commuter ridership to Phoenixville from 1.00 to 1.25 million annual trips. TEMS Option 2 2020 forecast for the Phoenixville station is 0.39 million trips. If SEPTA would pick up 0.25 million of the trips corresponding to the local Phoenixville-Philadelphia riders, then:

- SEPTA's ridership from the four commuter stations added west of Norristown would be increased to 1.5 million riders on the Phoenixville extension, which is very similar to the 1.3 million riders that SEPTA is hauling from the five stations west of Paoli.
- If SEPTA picks up the 0.25 million trips, then ridership of the Reading service would be reduced from 1.81 million riders down to 1.56 million trips. This again is very similar to the 1.5 million riders that Amtrak has on the Keystone service reflecting the fact that Amtrak does not haul the full load from the two shared SEPTA outer stations, which are Exton and Downingtown.
- If SEPTA service does not develop to Phoenixville, then the Reading train would need to handle the full 0.39 million riders from Phoenixville. Either way, the financial impact on Reading service will not be very large, since Phoenixville only generates short haul riders (except for those connecting to the NEC); so either way it is not going to have a major impact on the economic viability of the Reading service.

The conclusion is that there are many similarities between the proposed Reading service and the existing Keystone service, so the Keystone service can provide an effective model for the development of a new passenger rail service to Reading. The main difference is that Reading will generate more riders heading south on the NEC towards Baltimore and Washington than does the current Keystone service. Since Amtrak needs riders south of Philadelphia to help fill its trains, this is a very good thing from an Amtrak perspective. It will be important however to ensure effective and convenient rail connections at 30th Street both north and south, including the possible development of run-through services in both directions.

Chapter 7

Operating Costs

SUMMARY

Operating costs were calculated for each year the system is planned to be operational using operating cost drivers such as passenger volumes, train miles, and operating hours. As in the case of the Midwest Regional Rail Initiative (MWRI) and Ohio Hub studies, the aim is to develop an affordable set of options that provide good service at a reasonable cost.

7.1 Operating Cost Methodology

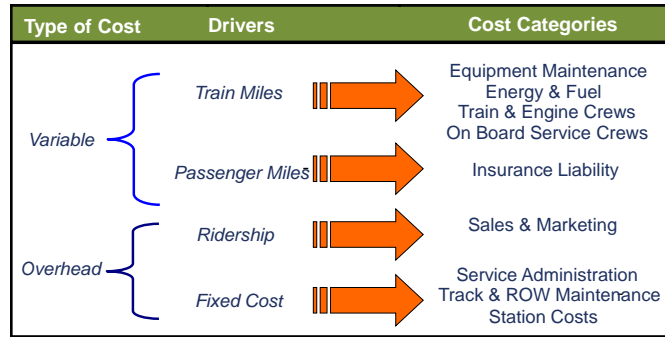
This section describes the build-up of the unit operating costs that have been used in conjunction with the operating plans, to project the total operating cost of each corridor option. A costing framework originally developed for the Midwest Regional Rail System (MWRRS) and subsequently applied to the Northeast Corridor (enhancing it with additional elements such as electric locomotive and catenary maintenance costs) was adapted for use in this study. This analysis has also been validated against current Amtrak Passenger Rail Investment and Improvement Act of 2008 Costs (PRIIA) costs as used by Amtrak and States for costing the provision of intercity rail services. PRIIA costs differ from standard MWRRS costs since PRIIA costs tend to include a larger share of allocated fixed (or overhead) costs than what the MWRRS methodology called for. However, in all other respects the PRIIA and MWRRS costing framework have been demonstrated to produce comparable results.

Following the MWRRS methodology³⁷, nine specific cost areas have been identified. As shown in Exhibit 7-1, variable train-mile driven costs include equipment maintenance, energy and fuel, and train and onboard service (OBS) crews. Passenger miles drive insurance liability, while ridership influences marketing, and sales. Fixed costs include administrative costs, station costs, and track and right-of-way maintenance costs. Signals, communications and power supply are included in track and right-of-way costs.

This detailed costing framework enables the direct development of costs based on directly controllable and route-specific factors, and allows sensitivity analyses to be performed on the impact of specific cost drivers. It also enables direct and explicit treatment of overhead cost allocations, to ensure that costs which do not belong to a corridor are not inappropriately allocated to the corridor, as would be inherent in a simple average cost-per-train mile approach. It also allows benchmarking and direct comparability of Reading-Philadelphia Corridor costs with those developed by other rail studies across the nation, including those with which the proposed corridor route would connect.

³⁷ Follow the links under “Midwest Regional Rail Initiative (MWRI)” at <http://www.dot.state.mn.us/planning/railplan/studies.html>

**Exhibit 7-1:
Operating Cost Categories and
Primary Cost Drivers**



Operating costs can be categorized as variable or fixed. As described below, fixed costs include both Route and System overhead costs. Route costs can be clearly identified to specific train services but do not change much if fewer or additional trains were operated.

- Variable costs change with the volume of activity and are directly dependent on ridership, passenger miles or train miles. For each variable cost, a principal cost driver is identified and used to determine the total cost of that operating variable. An increase or decrease in any of these will directly drive operating costs higher or lower.
- Fixed costs are generally predetermined, but may be influenced by external factors, such as the volume of freight tonnage, or may include a relatively small component of activity-driven costs. As a rule, costs identified as fixed should remain stable across a broad range of service intensities. Within fixed costs are two sub-categories:
 - Route costs such as track maintenance, train control and station expense that, although fixed, can still be clearly identified at the route level.
 - Overhead or System costs such as headquarters management, call center, accounting, legal, and other corporate fixed costs that are shared across routes or even nationally. A portion of overhead cost (such as direct line supervision) may be directly identifiable but most of the cost is fixed. Accordingly, assignment of such costs becomes an allocation issue that raises equity concerns. These kinds of fixed costs are handled separately.

Operating costs have been developed based on the following premises:

- Based on results of recent studies, a variety of sources including suppliers, current operators' histories, testing programs and prior internal analysis from other passenger corridors were used to develop the cost data. However, as the rail service is implemented, actual costs will be subject to negotiation between the passenger rail authority and the contract rail operator(s).
- Freight railroads will maintain track and right-of-way that they own, but ultimately, the actual cost of track maintenance will be resolved through negotiations with the railroads. For this study, a track maintenance cost model will be used that reflects actual freight and passenger railroad cost data.
- Maintenance of train equipment will be contracted out to the equipment supplier.
- Train operating practices follow existing work rules for crew staffing and hours of service. Average operating expenses per train-mile for train operations, crews, management and supervision were estimated through a bottoms-up staffing approach based on typical passenger rail organizational needs.

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The MWRRS costing framework was originally developed in conjunction with nine states that comprised the MWRRS steering committee and with Amtrak. In addition, freight railroads, equipment manufacturers and others provided input to the development of the costs. However, the costing framework has been validated with recent operating experience based on publicly available data from other sources, particularly the Midwest 403B Service trains, Northern New England Passenger Rail Authority's (NNEPRA) Downeaster and Northeast Corridor High Speed Rail costs, and data on Illinois passenger rail operations that was provided by Amtrak. It has been updated and brought to a 2020 costing basis.

The original concept for the MWRRS was for development of a new service based on operating methods directly modeled after state-of-the-art European rail operating practice. Along with anticipated economies of scale, modern train technology could reduce operating costs when compared to existing Amtrak practice. In the original 2000 MWRRS Plan, European equipment costs were measured at 40 percent of Amtrak's costs. However, in the final MWRRS plan that was released in 2010, train-operating costs were significantly increased to a level that is more consistent with Amtrak's current cost structure. However, adopting an Amtrak cost structure for financial planning does not suggest that Amtrak would actually be selected for the corridor operation. Rather, this selection increases the flexibility for choosing an operator without excluding Amtrak, because multiple operators and vendors will be able to meet the broader performance parameters provided by this conservative approach.

7.1.1 Variable Costs

Variable costs include those that directly depend on the number of train-miles operated or passenger-miles carried. They include train equipment maintenance, train crew cost, fuel and energy, onboard service, and insurance costs.

7.1.1.1 Train Equipment Maintenance

Equipment maintenance costs include all costs for spare parts, labor and materials needed to keep equipment safe and reliable. The costs include periodical overhauls in addition to running maintenance. It also assumes that facilities for servicing and maintaining equipment are designed specifically to accommodate the selected train technology. This arrangement supports more efficient and cost-effective maintenance practices. The MWRRS study developed a cost of \$9.87 per train mile for a 300-seat train in 2002. This cost was increased to \$17.30 per train mile for a dual mode diesel/electric train in 2020.

7.1.1.2 Train and Engine Crew Costs

The train operating crew incurs crew costs. Following Amtrak staffing policies, the operating crew would consist of an engineer, a conductor and an assistant conductor and is subject to federal hours of service regulations. Costs for the crew include salary, fringe benefits, training, overtime and additional pay for split shifts and high mileage runs. An overtime allowance is included as well as scheduled time-off, unscheduled absences and time required for operating, safety and passenger handling training. Fringe benefits include health and welfare, Federal Insurance Contributions Act (FICA) and pensions. The cost of employee injury claims under Federal Employers Liability Act (FELA) is also treated as a fringe benefit for this analysis. The overall fringe benefit rate was calculated as 55 percent. In addition, an allowance was built in for spare/reserve crews on the extra board.

Crew costs depend upon the level of train crew utilization, which is largely influenced by the structure of crew bases and any prior agreements on staffing locations. Train frequency strongly influences the amount of held-away-from-home-terminal time, which occurs if train crews have to stay overnight in a hotel away from their home base. Since a broad range of service frequencies and speeds have been evaluated here, a parametric approach was needed to develop a system average per train mile rate for

crew costs. Such an average rate necessarily involves some approximation, but to avoid having to reconfigure a detailed crew-staffing plan whenever the train schedules change, an average rate is appropriate for a Feasibility study. A more specific and detailed level of assessment would be appropriate for an investment-grade study. For this study, a value of \$8.13 per train mile was assumed. This is a moderate level of crew cost that still includes the need for some away from home layover.

7.1.1.3 Fuel and Energy

An average consumption rate of 2.42 gallons/mile was estimated for a 110-mph 300-seat train, based upon nominal usage rates of all three technologies considered in Phase 3 of the MWRRS Study. A fuel cost of \$9.12 per train mile is being assumed for the diesel portion of the route and for the electrified territory east of Norristown, costs of half that amount or \$4.56 per train mile for electric supply to the dual mode train.

7.1.1.4 Onboard Services (OBS)

Onboard service (OBS) costs were not included in the current analysis because Amtrak does not provide the services on its Harrisburg Keystone trains. However, the discussion of the costs will be retained here to explain how the assessment might be done if it should be required in the future.

OBS are those expenses for providing food service onboard the trains. OBS adds costs in three different areas: equipment, labor and cost of goods sold. Equipment capital and operating cost is built into the cost of the trains and is not attributed to food catering specifically. The goal of OBS franchising should be to ensure a reasonable profit for the provider of on-board services, while maintaining a reasonable and affordable price structure for passengers. In previous studies, it has been found that the key to attaining OBS profitability is selling enough products to recover the train mile related labor costs. For example, if small 200-seat trains were used, given the assumed OBS cost structure, even with a trolley cart service the OBS operator will be challenged to attain profitability. However, the expanded customer base on larger 300-seat trains can provide a slight positive operating margin for OBS service.

Because the trolley cart has been shown to double OBS revenues, it can result in profitable OBS operations in situations where a bistro-only service would be hard-pressed to sell enough food to recover its costs. While only a limited menu can be offered from a cart, the ready availability of food and beverages at the customer's seat is a proven strategy for increasing sales. Many customers appreciate the convenience of a trolley cart service and are willing to purchase food items that are brought directly to them. While some customers prefer stretching their legs and walking to a bistro car, other customers will not bother to make the trip.

The cost of goods sold is estimated as 50 percent of OBS revenue, based on Amtrak's route profitability reports. For labor costs, including costs for commissary support and OBS supervision, an intermediate value of \$4.23 per train mile has been estimated. This is a moderate level of crew cost that includes the need for some away from home layover.

These costs are generally consistent with Amtrak's level of wages and staffing approach for conventional bistro car services. However, this study recommends that an experienced food service vendor provide food services and use a trolley cart approach. A key technical requirement for providing trolley service is to ensure the doors and vestibules between cars are designed to allow a cart to easily pass through. Since trolley service is a standard feature on most European railways, most European rolling stock is designed to accommodate the carts. Although convenient passageways often have not been provided on U.S. equipment, the ability to support trolley carts is an important equipment design requirement for the planned service.

7.1.1.5 Insurance Costs

Liability costs were estimated 1.516¢ per passenger-mile, the same rate that was assumed in the earlier MWRRS study brought to 2020. Federal Employees Liability Act (FELA) costs are not included in this category but are applied as an overhead to labor costs.

The Amtrak Reform and Accountability Act of 1997 (\$161) originally provided for a limit of \$200 Million on passenger liability claims. In 2015, that limit was raised to \$295 Million³⁸. Amtrak carries that level of excess liability insurance, which allows Amtrak to fully indemnify the freight railroads in the event of a rail accident. However, a General Accounting Office (GAO) review³⁹ concluded that this liability cap applies to commuter railroads as well as to Amtrak. If the GAO's interpretation is correct, the liability cap may also apply to other passenger rail operators as well. It is recommended that qualified legal advice be sought on this matter to determine whether SEPTA or any other prospective operator would be similarly protected under this law.

7.1.2 Fixed Route Costs

This cost category includes those costs that, while largely independent of the number of train-miles operated, can still be directly associated to the operation of specific routes. It includes such costs as track maintenance, which varies by train technology, and station operations.

7.1.2.1 Track and Right-of-Way Costs

Currently, it is industry practice for passenger train operators providing service on freight-owned rights-of-way to pay for track access, dispatching and track maintenance. Rates for all these activities are ultimately based upon a determination of the appropriate costs that result from negotiations between the parties. The purpose here is to provide estimates based on the best available information; however, as the project moves forward, additional study and discussions with the railroads will be needed to further refine these costs.

The costing basis assumed in this report is that of incremental or avoidable costs⁴⁰ for shared tracks. The passenger operator, however, must take full cost responsibility for maintaining any tracks that it must add to the corridor either for its own use, or for mitigating delays to freight trains. For the purpose of this assessment it is assumed that the passenger rail system would take full cost responsibility for maintaining one of the Norfolk Southern tracks between Norristown and Reading, and it has been assumed that it will pay SEPTA an access fee on a train-mile basis equivalent to what SEPTA is required to pay Amtrak when it runs on Northeast Corridor trackage.

The following cost components are included within the Track and Right-of-Way category:

- **Track Maintenance Costs.** Costs for track maintenance were estimated based on Zeta-Tech's January 2004 draft technical monograph Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors⁴¹. Zeta-Tech costs have been adjusted for inflation to 2020. However, Zeta-Tech's costs are conceptual and subject to negotiation with the freight railroads. For this study it is assumed that the passenger service would pay the full cost for maintaining one

³⁸ See: <https://www.nbcnews.com/news/us-news/amtrak-derailment-liabilities-capped-200-million-due-1997-law-n831071>

³⁹ See: <http://www.gao.gov/highlights/d04240high.pdf>

⁴⁰ Avoidable costs are those that are eliminated or saved if an activity is discontinued. The term incremental is used to reference the change in costs that results from a management action that increases volume, whereas avoidable defines the change in costs that results from a management action that reduces volume.

⁴¹ Zeta-Tech, a subsidiary of Harsco (a supplier of track maintenance machinery) is a rail consulting firm who specializes in development of track maintenance strategies, costs and related engineering economics. See a summary of this report at <http://onlinepubs.trb.org/onlinepubs/trnews/trnews255rpo.pdf>. The full report is available upon request from the FRA.

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of the two Norfolk Southern tracks. This has been estimated as \$23,670 per year as the operating and \$33,159 per mile as the capital component of cost. The capital component is subject to a ramp-up period of several years after a major project has been completed.

- **Dispatching Costs and Out-of-Pocket Reimbursement.** Passenger service must also reimburse a freight railroad's added costs for dispatching its line, providing employee efficiency tests and for performing other services on behalf of the passenger operator. If the passenger operator does not contract a freight railroad to provide these services, it must provide them itself. As a result, costs for train dispatching and control are incurred on dedicated as well as shared tracks and are now shown under a separate "Operations and Dispatch" cost category. This is \$0.56 per train mile.
- **Costs for Access to Track and Right-of-Way.** Access fees, particularly train mile fees incurred as an operating expense, are specifically excluded from this calculation because it is assumed that the passenger rail system will "buy into" to right to use the tracks by making a Capital Contribution to the Norfolk Southern to reduce the ongoing operating costs..
- **SEPTA Track Charges.** For using SEPTA infrastructure from Norristown into Philadelphia, access charges were estimated at the same rate at which SEPTA has to pay Amtrak when it runs over Amtrak. This was assessed at \$24.41 per train mile for a 300-seat train.

7.1.2.2 Station Operations

A simplified fare structure, heavy reliance upon electronic ticketing and avoidance of a reservation system will minimize station personnel requirements. Station costs include personnel, ticket machines and station operating expenses. The cost for unstaffed stations covers the cost of utilities, ticket machines, cleaning and basic facility maintenance, costing \$88,873 per year. Volunteer personnel such as Traveler's Aid, if desired could staff these stations. Consistent with modern approaches it is assumed that the local communities would staff the station using Traveler's Aid or local tourism volunteers. Any additional station services would be provided by the local communities.

7.1.2.3 System Overhead Costs

The category of System Overhead largely consists of Service Administration or management overheads, covering such needs as the corporate procurement, human resources, accounting, finance and information technology functions as well as call center administration. A stand-alone administrative organization appropriate for the operation of a corridor system was developed for the MWRRS and later refined for the Ohio Hub studies. This organizational structure, which was developed with Amtrak's input and had a fixed cost of \$8.9 Million plus \$1.43 per train-mile (in 2002) for added staff requirements as the system grew. Inflated to 2020, this became \$12.8 Million plus \$1.92 per train mile. However, the Sales and Marketing category also has a substantial fixed cost component for advertising and call center expense, adding another \$3.3 Million per year fixed cost, plus variable call center expenses of 78.7¢ per rider, all in 2020 dollars⁴². Finally, credit card (1.8 percent of revenue) and travel agency commissions (1 percent) are all variable. In addition, the system operator was allowed a 10 percent markup on certain direct costs as an allowance for operator profit.

⁴² In the MWRRS cost model, call center costs were built up directly from ridership, assuming 40 percent of all riders call for information, and that the average information call will take 5 minutes for each round trip. Call center costs, therefore, are variable by rider and not by train-mile. Assuming some flexibility for assigning personnel to accommodate peaks in volume and a 20 percent staffing contingency, variable costs came to 57¢ per rider. These were inflated to 66¢ per rider in 2008 and now 78.1¢ per rider in 2020.

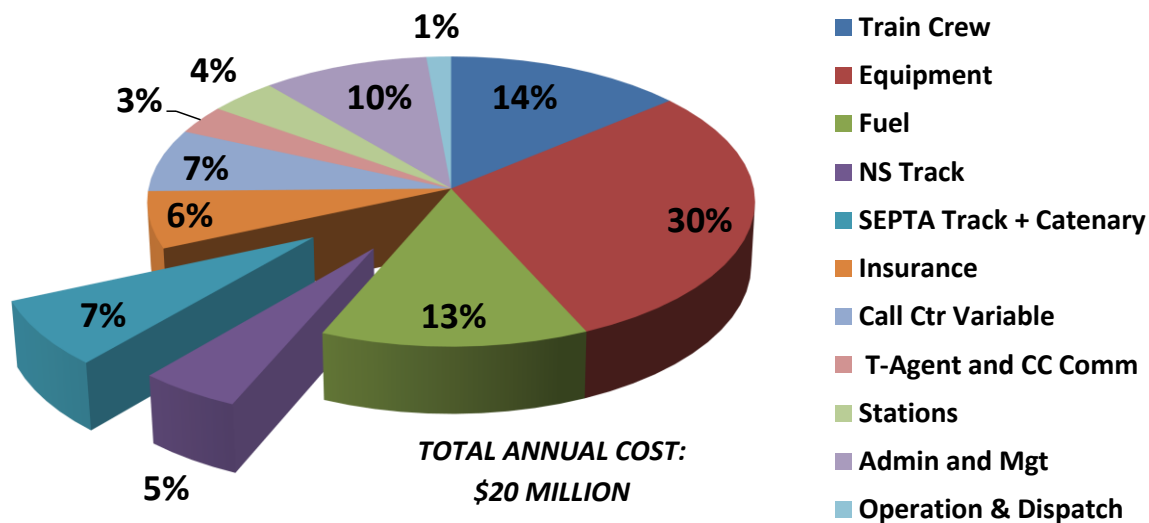
Therefore, the overall financial model for a stand-alone organization has \$16.1 Million (\$12.8 + \$3.3 Million) annually in fixed cost for administrative, sales and marketing expenses. Since this service is costed on an incremental basis the \$16.1 Million in fixed administrative, sales and marketing expenses is replaced by a benchmarked PRIIA overhead allocation of \$4.72 per train mile. This provides for an equivalent contribution to the train operator's overhead cost.

The \$1.92 per train mile cost for incremental management staff is still included however bringing the administrative cost per train mile up to \$6.65. The variable call center (78.1¢ per rider), credit card and travel agency commissions (combined, 2.8 percent of revenue) variable costs are directly applied based on the ridership and revenue cost drivers.

7.1.3 Operating Cost Breakdown

Exhibit 7-2 gives a breakdown of projected 2020 operating costs for an option that run 8 daily round trips to Reading at 79-mph. Assuming that the system pays the full maintenance cost for one track from Reading to Norristown and pays SEPTA the same rate that Amtrak charges per train-mile, total operating costs fall in the range of \$20 million per year. For the 79-mph option this comes to \$68.59 per Train-Mile for a 325-seat train. 12% of this cost would be for infrastructure and SEPTA track access fees.

Exhibit 7-2: 2020 Operating Cost Breakdown for 8 Round Trips



Chapter 8

Financial and Economic Analysis

SUMMARY

This chapter presents a detailed financial and economic analysis for the Reading to Philadelphia Corridor, including key financial measures such as Operating Surplus and Operating Ratio. A detailed Economic Analysis was carried out using criteria set out by the 1997 FRA Commercial Feasibility Study including key economic measures such as NPV Surplus and Benefit/Cost Ratio at a 3 percent discount rate which are also presented in this chapter.

8.1 Introduction

Two measures, Operating Ratio and Benefit Cost ratio will be assessed here to evaluate the economic returns of the Reading-Philadelphia rail system. The financial performance of the system, reflected by the Operating Ratio, is a key driver of the economic evaluation since it strongly influences the ability to franchise the operation of the system to the private sector. **System Revenues** include the fare box revenues and revenues from onboard sales. **Operating Costs** are the operating and maintenance costs associated with running the train. The Operating Ratio is defined as Revenues/Costs.

- Operating Ratios as calculated here include direct operating costs only. Operating ratio calculations do not include capital costs, depreciation or interest.
- It should be noted that freight railroads and intercity bus companies typically define it as the reciprocal Costs/Revenues.

By this analysis, a positive operating ratio does not imply that a passenger service can fully cover its capital costs, but having a positive cash flow does at least allow the operation to be franchised and run by the private sector. This requirement of the FRA *Commercial Feasibility Study* puts passenger rail on the same basis as other modes of transportation, such as intercity bus and air, where the private sector operates the system but does not build or own the infrastructure it uses. Other modes do pay access fees for using the infrastructure, which supports some cost recovery which varies by mode. For a passenger rail system, track access costs would fall into this category. All calculations are performed using the standard financial formula, as follows:

Financial Measure:

$$\text{Operating Ratio} = \frac{\text{Financial Revenues (by year or PV)}}{\text{Operating Costs (by year or PV)}}$$

Economic Measures:

$$\text{Net Present Value} = \text{Present Value of Benefit} - \text{Present Values of Costs}$$

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$$\text{Benefit Cost Ratio} = \frac{\text{Present Value of Benefits}}{\text{Present Value of Costs}}$$

Present Value is defined as:

$$PV = \sum_t \frac{C_t}{(1+r)^t}$$

Where:

PV = Present value of all future cash flows

C_t = Cash flow for period t

r = Discount rate reflecting the opportunity cost of money

t = Time

Benefit Cost ratio requires development of a project's year-by-year financial and economic returns, which are then discounted to the base year to estimate present values (PV) over the lifetime of the project⁴³. In terms of Economic Benefits, a positive NPV and Benefit Cost Ratio imply that the project makes a positive contribution to the economy. Consistent with standard practice, Benefit Cost ratios are calculated from the perspective of the overall society without regard to who owns particular assets receives specific benefits or incurs particular costs.

By comparison, the Operating Ratio can be presented either on a specific year-to-year basis, or it can be summarized based on the discounted values of operating revenue and operating cost, and presented as a single number for the entire life of the project.

- **If the operating surplus is positive**, the system will not require any operating subsidy, and it will even be able to make a contribution towards its own Capital cost. Because the system is generating a positive cash flow, a Private-Public Partnership or other innovative financing methods can be used to construct and operate the system. This absolves the local governmental entity of any need for providing an operating subsidy but more than this, it is not uncommon for the operating cash flow to be sufficient to cover the local capital match requirement as well.
- **If the operating surplus is negative**, the system will not only require a grant of capital to build the system, but in addition it will also require an ongoing operating subsidy. An operating subsidy not only prevents the project from being a Public Private Partnership, but casts doubt on the efficiency of the system and the reason for the project. In addition, a subsidy will reduce the economic performance of the system as it will actually offset part of the economic benefits of the system (e.g. Consumer Surplus, Environmental Benefits). This will depress the Benefit Cost ratio as well. If the subsidy is not too great and the capital cost is not too high, in some cases it may still be possible to maintain a positive Benefit Cost ratio. But the larger the subsidy and the higher the capital cost, the harder it is to show a positive Benefit Cost ratio. It is not uncommon for slow passenger rail systems to fail both FRA's Operating Ratio and Benefit Cost criteria.

⁴³ For this analysis, a 25-year project life from 2025 to 2050 was assumed, with a five year implementation period from 2020-2024. Revenues and cost cash flows were discounted to the 2020 base year using 3 and 7 percent discount rates. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets (5 percent).

8.2 Economic Assessment Methodology

A demandside economic evaluation has been completed for all three of Options for which a ridership and revenue forecast were assessed. This followed typical financial/economic cash flow analysis, and USDOT-Tiger Grant guidelines, as well as OMB discount procedures for the economic analysis. The analysis was completed using data derived from the Ridership and Revenue Analysis, the Infrastructure Analysis, and the Operating Analysis. This provided:

- System Revenues: Fare box, onboard and freight railroad revenue
- Operating Costs: Operating and maintenance costs
- Capital costs: Infrastructure costs

In addition, the Economic Analysis calculated other factors that are required for the analysis.

- Consumer Surplus - benefit to system users
- Highway Congestion Savings - benefits to road users of less congestion
- Airport Delay Savings - benefits to air travelers
- Safety Benefits - benefit of less accidents
- Reduced Emissions - benefit of lower emissions levels

8.2.1 Key Assumptions

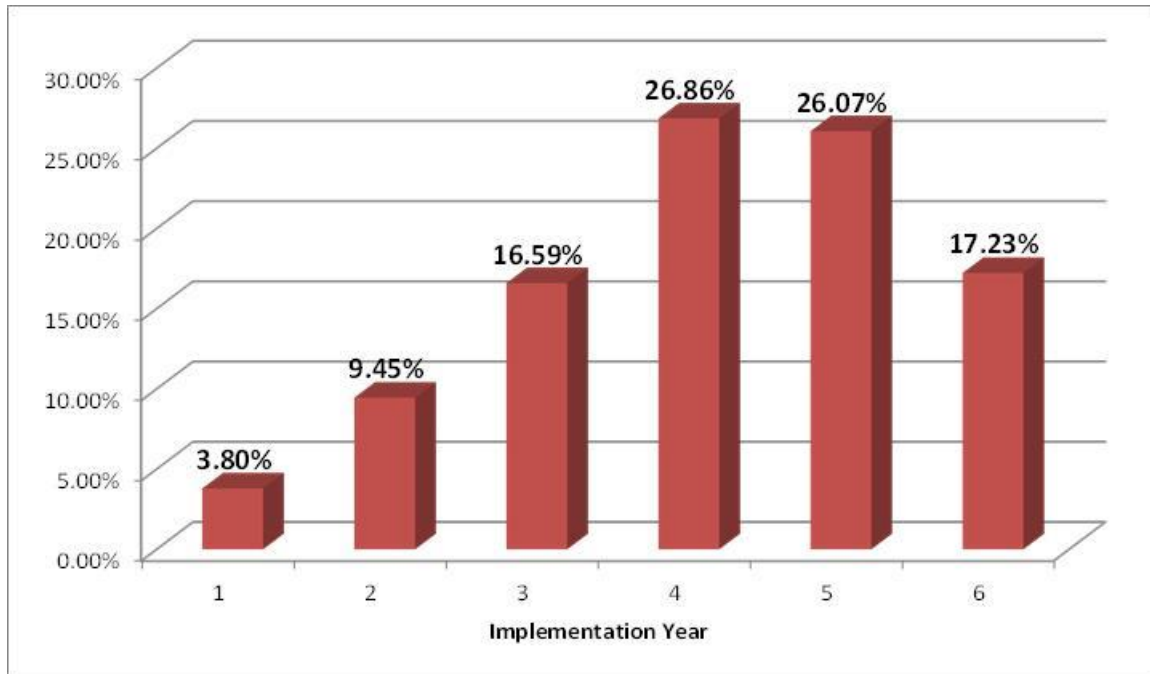
The analysis projects travel demand, operating revenues and operating and maintenance costs for all years from 2025 through 2050. The financial analysis has been conducted in real terms using constant 2020 dollars. Accordingly, no inflation factor has been included, and real discounting rate of 3 and 7 percent have been used. Revenues and operating costs have also been projected in constant dollars over the time frame of the financial analysis. A summary of the key efficiency measure inputs are presented below.

8.2.1.1 Ridership and Revenue Forecasts

Ridership and revenue forecasts were originally prepared for 2020, 2030, 2040 and 2050. Revenues in intervening years were projected based on interpolations, reflecting projected annual growth in ridership. Revenues included not only passenger fares, but also onboard service revenues.

8.2.1.2 Capital Costs

Capital costs of \$356 million range (being used as a Placeholder pending the completion of a capacity analysis) include rolling stock, track, freight railroad right-of-way purchase, commuter easement fees, bridges, fencing, signaling, grade crossings, maintenance facilities and station improvements. A year-by-year implementation plan was developed which detailed the Capital cash flows and funding requirements. These were the same for all options. Using these data, the Benefit Cost calculations were able to be assessed. For the purpose of this study it is assumed that the Capital Costs will be spent over a six year period with the distribution shown in Exhibit 8-1 but for the purpose of this analysis it has been compressed into a five year time frame, with the first two years combined. Over 80 percent of funds are spent in the last four years of the implementation period as construction occurs.

Exhibit 8-1: Assumed Capital Spend Distribution

8.2.1.3 Operating Expenses

Major operating and maintenance expenses include equipment maintenance, track and right-of-way maintenance, administration, fuel and energy, train crew and other relevant expenses. Operating expenses were estimated in 2020 constant dollars so that they would remain comparable to revenues. However, these costs do reflect the year-by-year increase in expense that is needed to handle the forecasted ridership growth, in terms of not only directly variable expenses such as credit card commissions, but also the need to add train capacity and operate either larger trains, or more train-miles every year in order to accommodate anticipated ridership growth.

8.2.1.4 User Benefits

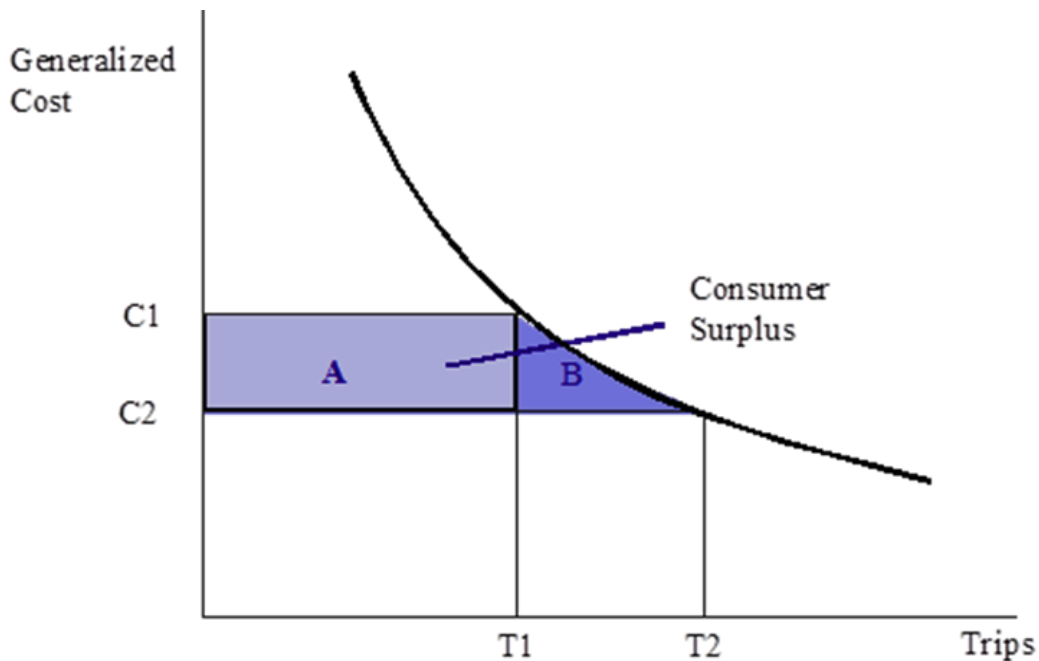
The analysis of user benefits for this study is based on the measurement of Generalized Cost of Travel, which includes both time and money. Time is converted into money by the use of Values of Time. The Values of Time (VOT) used in this study were derived from stated preference surveys conducted in the Chicago-Detroit/Pontiac EIS and used in the COMPASS™ Multimodal Demand Model for the ridership and revenue forecasts. These VOTs are consistent with previous academic and empirical research and other transportation studies conducted by TEMS.

Consumer Surplus: Benefits to users of the rail system are measured by the riders' consumer surplus. Consumer surplus is used to measure the demand side impact of a transportation improvement on users of the service. It is defined as the additional benefit consumers (users of the service) receive from the purchase of a commodity or service (travel). Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone. The benefits apply both to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted from a different mode to the passenger rail system.

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The RENTS™ financial and economic analysis estimates passenger travel benefits (consumer surplus) by calculating the increase in regional mobility, traffic diverted to rail, and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term generalized cost refers to the combination of time and fares paid by users to make a trip. A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus. Exhibit 8-2 presents a typical demand curve in which Area A represents the increase in consumer surplus resulting from cost savings for existing rail users and Area B represents the consumer surplus resulting from induced traffic and trips diverted to rail.

Exhibit 8-2: Consumer Surplus Concept



The formula for consumer surplus is as follows –

$$\text{Consumer Surplus} = (C_1 - C_2) * T_1 + ((C_1 - C_2) * (T_2 - T_1)) / 2$$

Where:

- C₁** = Generalized Cost users incur before the implementation of the system
- C₂** = Generalized Cost users incur after the implementation of the system
- T₁** = Number of trips before operation of the system
- T₂** = Number of trips during operation of the system

The passenger rail fares used in this analysis are the average fares set for each option.

8.2.1.5 Non-User Benefits

In addition to rail-user benefits, travelers using auto or air will also benefit from the rail investment, since the system will contribute to highway congestion relief and reduce travel times for users of these other modes. For purposes of this analysis, these benefits were measured by identifying the estimated number of auto passenger trips diverted to rail and multiplying each by the updated monetary values derived from previous stated preference studies updated to 2020.

Highway Congestion: The highway congestion delay savings is the time savings to the remaining highway users that results from diversion of auto users to the rail mode. To estimate travel time increase within the corridor, historical highway traffic volumes were obtained from the State DOTs and local planning agencies. The average annual travel time growth in the corridor was estimated with the historical highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes.

Airport Congestion Delay Savings: Airport Congestion Delay Savings would include the airport operation delay saving and air passenger delay saving, but since the share of air travel diverted to rail is practically nonexistent in this corridor, this benefit was not assessed.

Auto Operating Cost (Non-Business): Vehicle operating cost savings for non-business travelers have been included in the current analysis as an additional resource benefit. This reflects the fact that social/leisure travelers do not accurately value the full cost of driving when making trips. As a result, the consumer surplus calculation for commuters, social, leisure and tourist travelers has not fully reflected the real cost of operations of an automobile, but only the cost of gas. The difference between the cost of gas and the full cost of driving reflects a real savings that should be included in a Benefit Cost analysis.

Emissions: The diversion of travelers to rail from the auto mode generates emissions savings. The calculated emissions savings are based on changes in energy use with and without the proposed rail service. This methodology takes into account the region of the country, air quality regulation compliance of the counties served by the proposed rail service, the projection year, and the modes of travel used for access/egress as well as the line-haul portion of the trip. Highway Reduced Emissions were estimated from the vehicle miles traveled (VMT) and flight reductions derived from the ridership model, however there were no forecasted reductions in airline flights. The assumption is that a reduction in VMT or flights is directly proportional to the reduction in emissions. The pollutant values were taken from the TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide⁴⁴.

Public Safety Benefits: Public Safety is calculated from the diverted Vehicle-Miles times the NHTSA⁴⁵ fatality and injury rate per Vehicle mile and then times the values of fatality and injury from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide.

8.3 Financial and Economic Results

Both the Financial and Economic results are shown in Exhibits 8-3 through 8-7. Three options have been assessed. The results show that there is a very different result for each option, even though the only difference between the second and third option is the level of fare charged to local riders on the Reading to Philadelphia rail service.

⁴⁴ http://www.dot.gov/sites/dot.dev/files/docs/TIGER_BCA_RESOURCE_GUIDE.pdf

⁴⁵ <http://www.nhtsa.gov/>

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- **For the Commuter Rail Option #1:** The system would need about \$7.3 Million annual operating subsidy due to loss of revenue sharing with Amtrak and smaller numbers of interconnecting riders traveling than if the services were better integrated. For the economic analysis, the Benefits exceed Costs over 25-Years at 3% Real Interest Rate, but the economics are marginal and may fail at the 7% rationing hurdle rate. This option requires a financial subsidy each year and at the assumed level of capital costs, cannot quite reach the Cost Benefit hurdle at the 7% discount rate.

Exhibit 8-3: Financial Results for Option 1 – Commuter Rail

Discount Rate		3.0%	7.0%
Revenues			
	System Passenger Revenues	\$153.03	\$62.90
	On Board Service Revenues	\$0.00	\$0.00
Total Revenues		\$153.03	\$62.90
Costs			
	O&M Costs	\$247.64	\$102.29
Total Costs		\$247.64	\$102.29
Net Cash Flow from Operations		(\$94.61)	(\$39.39)
Operating Ratio		0.62	0.61

Exhibit 8-4: Economic Results for Option 1 – Commuter Rail

Discount Rate		3.0%	7.0%
Benefits to Users			
	Users Consumer Surplus	\$420.85	\$172.00
Benefits to Public at Large			
	Highway Congestion Delay Savings (million 2020\$)	\$168.95	\$68.95
	Highway Reduced Emissions (million 2020\$)	\$92.79	\$37.87
	Highway Safety Savings (million 2020\$)	\$7.77	\$3.17
	Total Public at Large Benefits	\$269.50	\$109.98
Total Benefits		\$690.35	\$281.98
Costs			
	Capital Cost	\$264.04	\$180.07
	O&M Costs	\$247.64	\$102.29
	Cyclic Mtn	\$7.83	\$2.63
Total Costs		\$519.52	\$285.00
Benefits Less Costs		\$170.84	(\$3.01)
Benefit/Cost Ratio		1.33	0.99

Restoring Passenger Rail Service to Berks County, PA

- **For the Integrated Intercity Rail Option #2:** Financially, the system generates positive cash flow from operations, will not need a subsidy and it can even contribute to covering some of its own capital costs. For the economic analysis, the Benefits exceed Costs over 25-Years at both the 3% and 7% Real Interest Rate with healthy B/C ratios of 1.73 and 1.31, respectively. This option performs much more favorably producing both an Operating Surplus as well as a positive Benefit Cost ratio at both 3% and 7% discount rates.

Exhibit 8-5: Financial Results for Option 2 – Integrated Intercity Rail

Discount Rate		3.0%	7.0%
Revenues			
	System Passenger Revenues	\$335.72	\$138.00
	On Board Service Revenues	\$0.00	\$0.00
Total Revenues		\$335.72	\$138.00
Costs			
	O&M Costs	\$283.33	\$116.96
Total Costs		\$283.33	\$116.96
Net Cash Flow from Operations		\$52.39	\$21.04
Operating Ratio		1.18	1.18

Exhibit 8-6: Economic Results for Option 2 – Integrated Intercity Rail

Discount Rate		3.0%	7.0%
Benefits to Users			
	Users Consumer Surplus	\$559.11	\$228.94
Benefits to Public at Large			
	Highway Congestion Delay Savings (million 2020\$)	\$250.75	\$102.29
	Highway Reduced Emissions (million 2020\$)	\$137.71	\$56.18
	Highway Safety Savings (million 2020\$)	\$11.53	\$4.70
	Total Public at Large Benefits	\$399.99	\$163.17
Total Benefits		\$959.10	\$392.11
Costs			
	Capital Cost	\$264.04	\$180.07
	O&M Costs	\$283.33	\$116.96
	Cyclic Mtn	\$7.83	\$2.63
Total Costs		\$555.20	\$299.66
Benefits Less Costs		\$403.89	\$92.45
Benefit/Cost Ratio		1.73	1.31

Restoring Passenger Rail Service to Berks County, PA

- **For the Integrated Intercity Rail Option #3 with Discounted Local Fares:** In this option, local fares have been reduced from an average yield of 28¢ to 20¢ per mile. As a result of the lower fares, ridership and many of the (non-cash) economic benefits of the system increase, but revenue decreases. At a fare level of 20¢ per mile (as applied to local tickets only) the corridor financially breaks even. For the economic analysis, the Benefits exceed Costs over 25-Years at both the 3% and 7% Real Interest Rate and the B/C ratios rise slightly to 1.76 and 1.34, respectively. However, this improvement in the B/C ratio is accomplished at the expense of the Operating Ratio and would put the system on the very edge of needing an operating subsidy. This is similar to Option 2 meeting all the US DOT economic requirements, but due to a lower fare Option 3 has a weaker Operating Ratio, but a stronger Benefit Cost ratio than does Option 2.

Exhibit 8-7: Financial Results for Option 3 – Integrated Intercity Rail with Discounted Local Fares

Discount Rate		3.0%	7.0%
Revenues			
	System Passenger Revenues	\$308.32	\$126.74
	On Board Service Revenues	\$0.00	\$0.00
Total Revenues		\$308.32	\$126.74
Costs			
	O&M Costs	\$293.33	\$121.05
Total Costs		\$293.33	\$121.05
Net Cash Flow from Operations		\$14.99	\$5.68
Operating Ratio		1.05	1.05

Exhibit 8-8: Economic Results for Option 3 – Integrated Intercity Rail with Discounted Local Fares

Discount Rate		3.0%	7.0%
Benefits to Users			
	Users Consumer Surplus	\$585.12	\$239.28
Benefits to Public at Large			
	Highway Congestion Delay Savings (million 2020\$)	\$256.97	\$104.84
	Highway Reduced Emissions (million 2020\$)	\$141.12	\$57.58
	Highway Safety Savings (million 2020\$)	\$11.81	\$4.82
	Total Public at Large Benefits	\$409.90	\$167.23
Total Benefits		\$995.02	\$406.51
Costs			
	Capital Cost	\$264.04	\$180.07
	O&M Costs	\$293.33	\$121.05
	Cyclic Mtn	\$7.83	\$2.63
Total Costs		\$565.20	\$303.75
Benefits Less Costs		\$429.82	\$102.76
Benefit/Cost Ratio		1.76	1.34

Chapter 9

Supplyside Economic Rent

Analysis of Community Benefits

SUMMARY

This chapter presents the results of the Supplyside Economic Rent Analysis that provides an understanding of the potential impacts on employment, income, property values, and wealth at stations along the Reading-Philadelphia Corridor. It also identifies how the tax base is changed in the corridor, and the increased tax payments that result from building the rail system at a Federal, State and local level.

9.1 Introduction

In order to estimate the economic impact of the Reading-Philadelphia Corridor project, it is important to understand the character of the different economic benefits that can be quantified.

Benefits will arise from the development and the presence of the passenger rail system. The impact of these benefits will be significant both at a firm and household level (see Exhibit 9-1). However, it is important to understand that the sets of benefits quantified in this report, assume equilibrium in the economy. In order for the economy to be in equilibrium, the Supplyside Benefits must equal Demandside Benefits. Supplyside and Demandside benefits should not be added together in the assessment of the full benefits of the project, as they are merely two different measurements of the same benefits.⁴⁶

9.2 The Character of the Overall Economy

The model of the economy⁴⁷ shows that an economy is circular in character, with two equal sides (Exhibit 9-1).

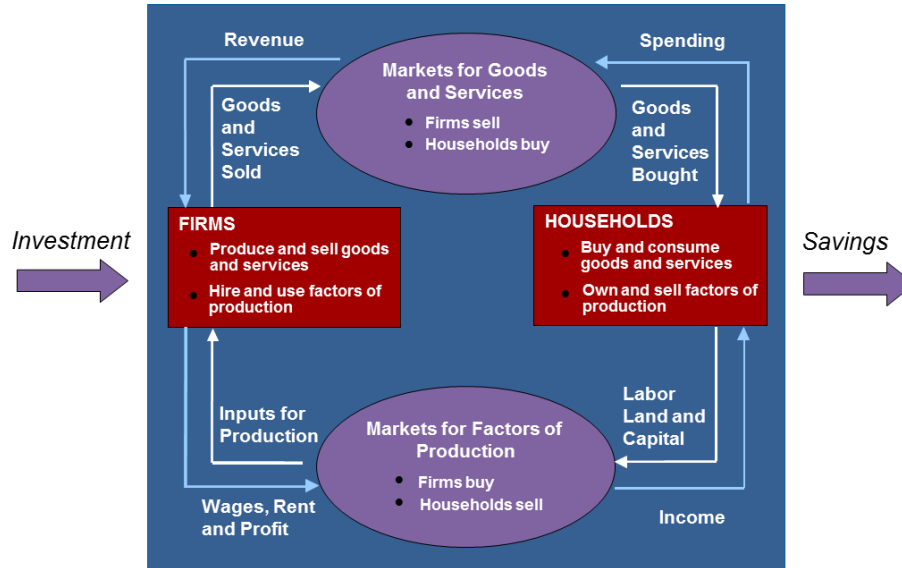
On one side of the economy is the consumer side – the market for goods and services – in which consumers buy goods and services by spending the income earned by working for a commercial enterprise. If a transportation investment improves travel times and costs for individuals, it increases consumer surplus. An analysis of the impact of a transportation investment on the market for goods and services quantifies the level of Consumer Surplus generated by a project, by showing how much time, money and resources individuals save. This was measured in the Demandside Cost Benefit Analysis.

The notion that a transportation project will be worthwhile if travel is made more cost effective is based on the idea that not only the cost, but also the travel time of a trip has value. Academic and empirical research has also shown that this concept holds true for commuters and recreational travelers. Considerable research has been carried out to both identify the theoretical justification for value of travel time and to quantify its value.

⁴⁶ See: Mishan, E. 'Cost Benefit Analysis,' New York, NY: Praeger Publishers, 1976.

⁴⁷ See Samuelson, P. & Nordhaus, W. Economics. 14th Edition. New York: McGraw-Hill, 1992.

Exhibit 9-1: Simple Model of the Economy



On the other side of the economy is the market for factors of production. Most importantly, it is the market for land, labor and capital, which individuals provide to firms in exchange for wages, rent and profit. From the perspective of policy makers and the local community, this side of the economy is very interesting as it shows how investment in a new transportation infrastructure changes the productivity of the economy by creating new business opportunities; and therefore, increases jobs, income, property values and wealth.

One of the most important aspects of the circular economy model is that it shows that any project has two impacts, one in the consumer market – the benefits to travelers; the second, in the factor markets or Supplside of the economy⁴⁸ – which identifies benefit to the community in terms of improved welfare due to increases in jobs, income and wealth. The supplside benefits can be quantified as the increase in Economic Rent. This is shown in Exhibit 9-2.

For the economy to reach equilibrium, both sets of benefits must be realized. As such, the benefits of a project are realized twice, once on the Demandside and once on the Supplside. As a result, there are two ways to measure the productivity benefits of a transportation project; and theoretically, both measurements must equal each other. This is a very useful property since in any specific analysis one measure can be used to check the other, at least at the aggregate level. This is very helpful and provides a check on the reasonableness of the estimates of project benefits.

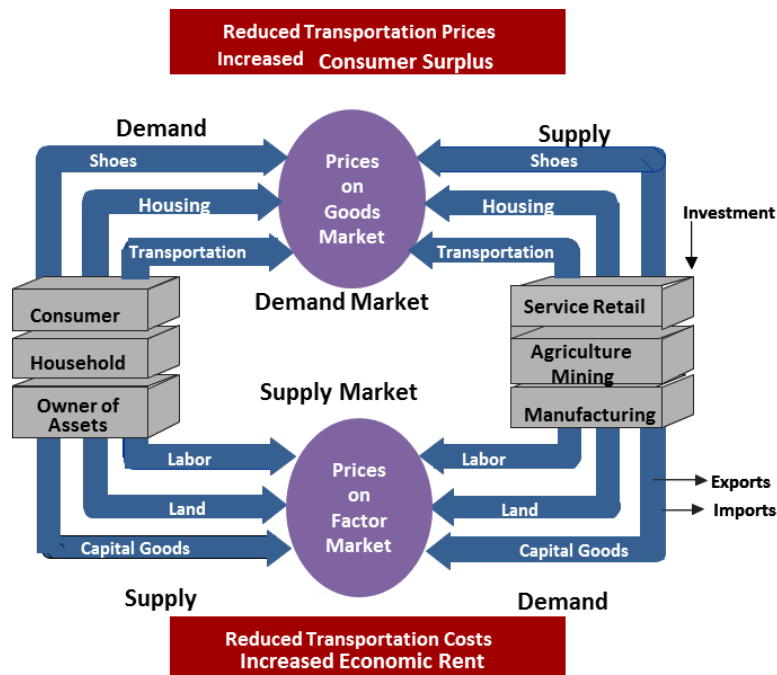
However, in assessing the benefits of a transportation project, it is important not to double-count the benefits by adding Supplside and Demandside benefits together. It must be recognized that these two sets of benefits are simply two different ways of viewing the same benefit. The two markets are both reflections of each other and measure the same thing. For example, if both sets of benefits equal \$50 million, then the total benefit is only \$50 million as expressed in two different ways: travelers get \$50 million of travel benefits and the community gets \$50 million in jobs, income, and increased profits. As a ripple effect (or transfer payment), the economy also gets an expanded tax base and temporary construction jobs.

⁴⁸ See: Mishan, E. 'Cost Benefit Analysis,' New York, NY: Praeger Publishers, 1976.

Therefore, if a given transportation project is implemented, equivalent productivity benefits will be seen in both the consumer market for goods and services (as the economy benefits from lower travel times and costs); as well as in the Supplyside factor markets. In the Supplyside side market, improved travel efficiency is reflected in more jobs, income and profit. Therefore, for a given transportation investment, the same benefit occurs on both sides of the economy. In the consumer markets, users enjoy lower travel costs and faster travel times. On the Supplyside of the economy, the factor markets take advantage of the greater efficiency in transportation. As a result, both sides of the economy move to a new level of productivity in which both sides of the economy are balanced in equilibrium.

Improved efficiency will generate Supplyside spending and productivity benefits that have a very real impact on the performance of the local economy. The method that develops estimates of productivity jobs and wealth creation is an Economic Analysis. It measures how the performance of a new transportation investment raises the efficiency of the economy. This efficiency improvement creates jobs and income, and raises local property values to reflect the improved desirability of living or working in the area.

Exhibit 9-2: Relation between Consumer Surplus and Economic Rent in the Economy



9.3 Assessing Supplyside Benefits

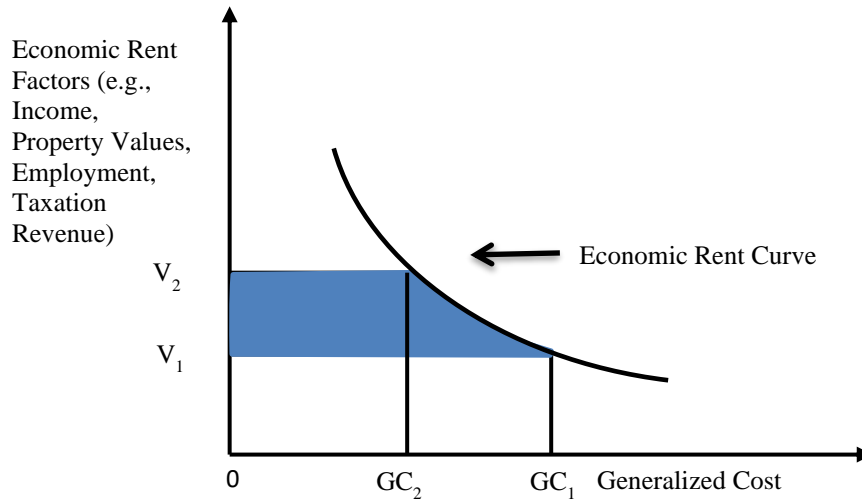
The Economic Rent theory builds from the findings of Urban Economics and The Economics of Location that support Central Place Theory⁴⁹. Central Place Theory argues that in normal circumstances, places that are closer to the “center” have a higher value or economic rent. This can be expressed in economic terms; particularly jobs, income, and property value. There is a relationship between economic rent factors (as represented by employment, income, and property value) and impedance to travel to market centers (as

⁴⁹ Metcalf, A.E. ‘Economic Rent: A New Dimension in the Economic Evaluation Process’, Transportation Research Board, 71st Annual Meeting, January 12-16, Washington, DC, 1992.

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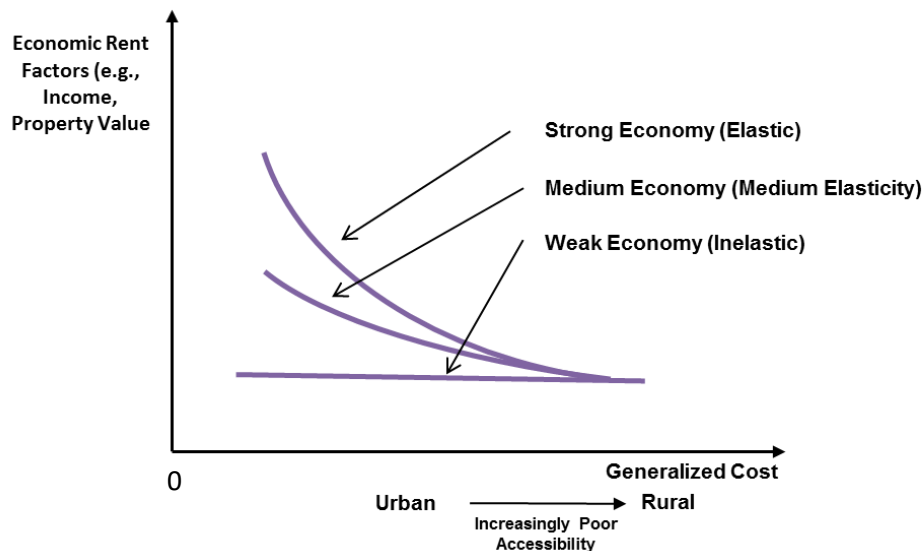
measured by generalized cost). As a result, lower generalized costs associated with a transport system investment lead to greater transportation efficiencies and increased accessibility. This, in turn, results in lower business costs/higher productivity and, consequently, in an increase in economic rent. This is represented by moving from point V1 to point V2 in Exhibit 9-3, as a result of the improved accessibility as measured by moving from GC1 to GC2.

Exhibit 9-3: Economic Rent Illustration



It should be noted that the shape of the economic rent curve reflects the responsiveness (elasticity) of the economy to an improvement in accessibility. Large cities typically have very large economic rent activity (represented by a steep Economic Rent Curve), which indicates that a project improving transportation accessibility will have a significant economic impact; smaller communities have less economic rent activity (less steep curves), and rural areas have very flat curves that indicate lower economic responsiveness. Similarly, depressed areas will experience flatter curves than better off areas. This is due to factors not directly related to transportation, such as level of education, population structure and industrial structure. A significantly improved transportation provision may bring a useful contribution to alleviating the problems faced by disadvantaged areas, but will not by itself solve the economic issues and problems that these areas face. See Exhibit 9-4.

Exhibit 9-4: Representation of Different Economic Rent Curves by Strength of Economy



Finally, the strength of the relationship between generalized cost and economic factors is established by calculating the relationship between economic rent factors and generalized cost weighted by the amount of trips completed for the particular region of study. This ensures that when calculating the Supplyside effect of a transportation improvement, real gains in accessibility that benefit a large number of users, produce greater Supplyside benefits than projects that provide real accessibility gains for a small number of individuals.

The mathematical expression of the Economic Rent Curve is therefore:

$$SE_i = \beta_0 GC_i$$

Where:

SE_i - Economic rent factors – i.e., socioeconomic measures, such as: employment, income, property value of zone i ;

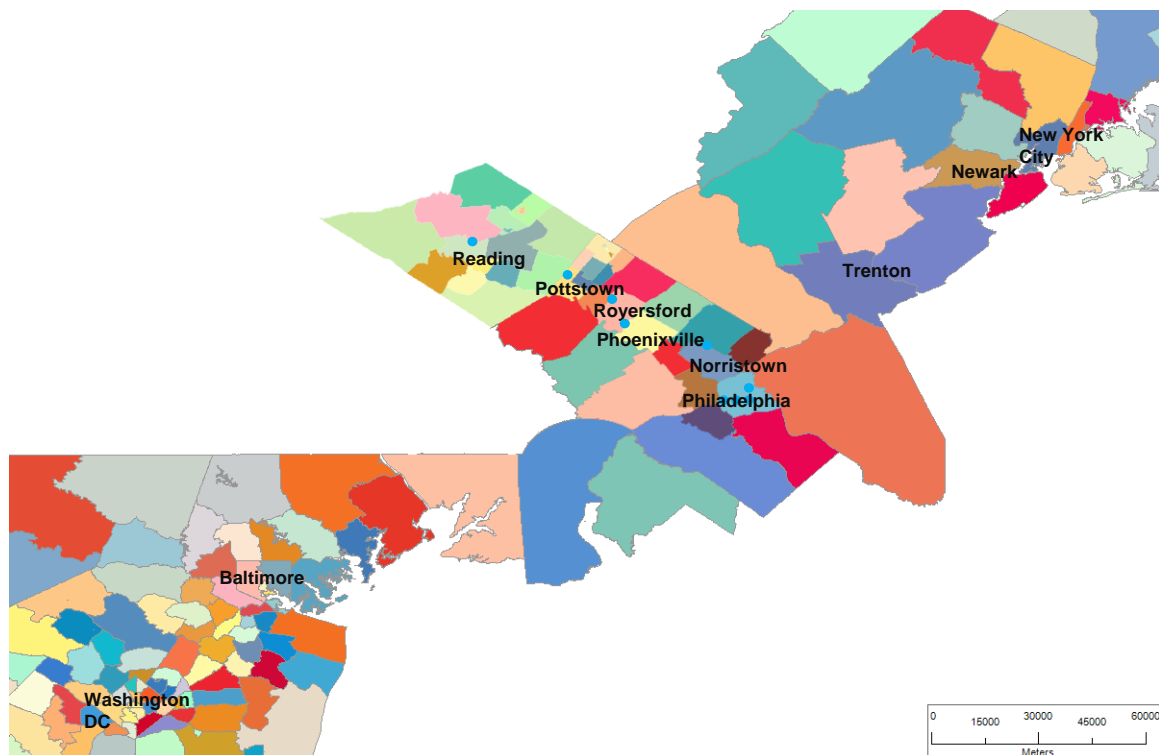
GC_i - Weighted generalized cost of auto travel for all purposes from (to) zone i to (from) other zones in the study area;

β_0 - Calibration parameters.

9.4 Data Sources and Study Database

For the economic impact study, zones developed in the Reading-Philadelphia Corridor were adopted as shown in Exhibit 9-5.

Exhibit 9-5: Zonal System used for the Purpose of the Study

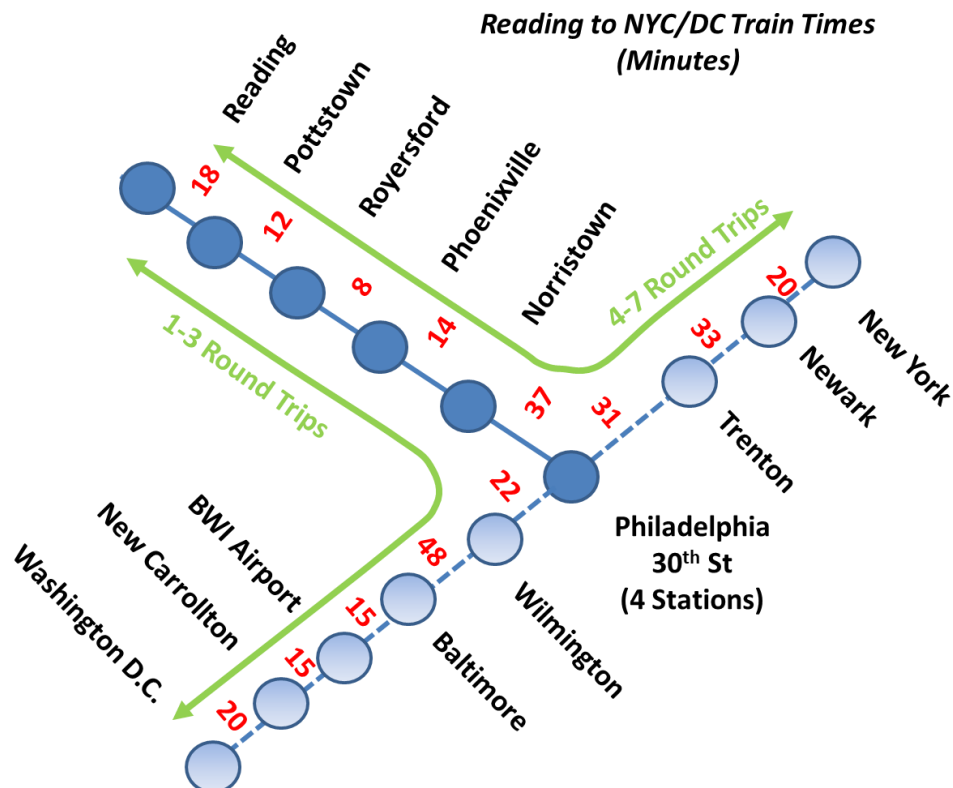


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In order to estimate the economic impact, base year 2020 socioeconomic database established in the ridership and revenue study were used for the supplyside model calibration, and socioeconomic forecasts were used in calculating supplyside benefits in the 30 year period from 2020 to 2050.

This information enabled TEMS to use the rail network of up to 79-mph service from Reading to Philadelphia, and up to 125-mph in the Northeast Corridor as shown in Exhibit 9-6 to establish transportation service improvements for the zones in the corridor, and to calculate both the current and future generalized costs. Economic Rents benefits were only calculated for the Pennsylvania stations, which are the darker shaded stations in Exhibit 9-6.

Exhibit 9-6: 110 MPH Passenger Rail Network



9.5 Supplyside Analysis Results: Deriving Economic Rent Elasticities

Economic Rent theory proposes that for a transportation project to have value there will be a strong relationship between socioeconomic variables and accessibility. As such, the relationship between accessibility and income, employment, and property density in the Reading to Philadelphia rail corridor was calculated through regression analysis. This analysis established the level of sensitivity of the region's economy to transportation improvements. Exhibits 9-7, 9-8, and 9-9 show the relationship established between accessibility and employment, income, and real property value, along with the statistical measures indicating the strength of the relationship found.

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As can be seen in the relationship exhibits, the relationship between accessibility and socioeconomic characteristics is a linear relationship of the following form:

$$\ln(SE_i) = \beta_0 + \beta_1 \ln(GC_i) \quad \text{Equation 1}$$

Where:

SE_i - Economic rent factor (socioeconomic variable) of zone i ;

GC_i - Weighted generalized cost of travel for all purposes from (to) zone i to (from) other zones in the zone system;

β_0 and β_1 - Regression coefficients.

Exhibit 9-7: Relation between Accessibility and Employment in Reading-Philadelphia Corridor

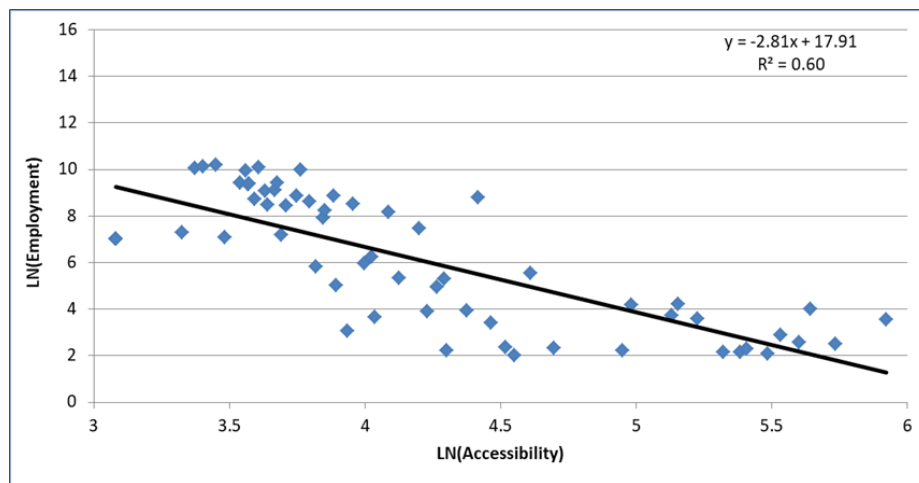
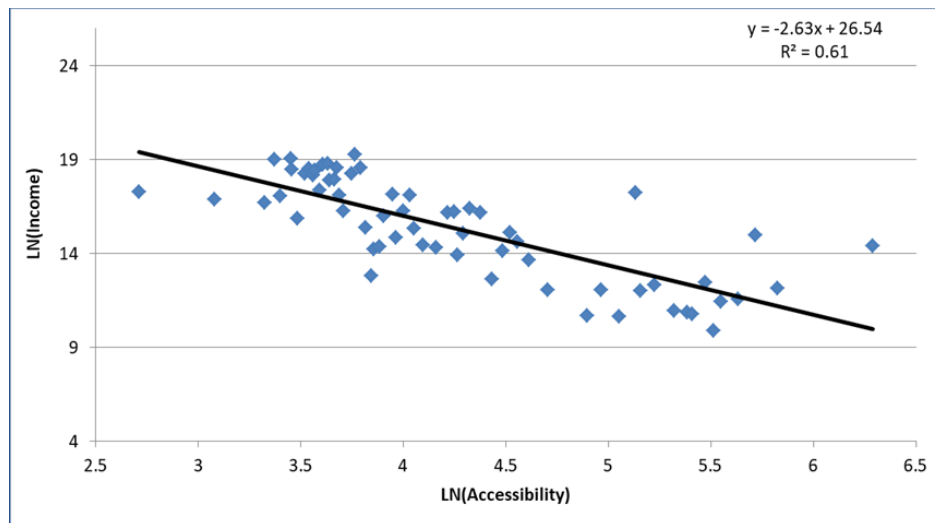
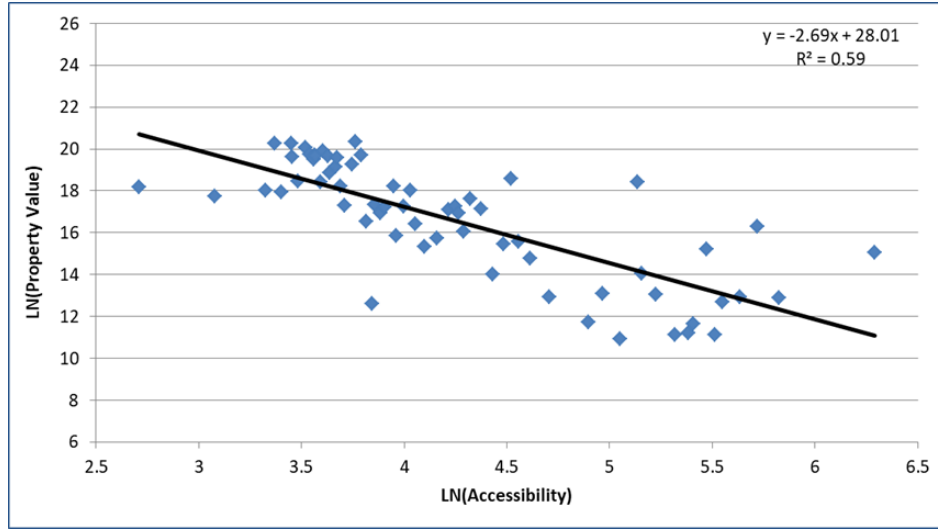


Exhibit 9-8: Relation between Accessibility and Income in the Reading-Philadelphia Corridor



**Exhibit 9-9: Relation between Accessibility and Real Property Values
in the Reading-Philadelphia Corridor**



The value of the coefficients of determination (R^2) shows how much the dependent variable (e.g. employment) is influenced by the predictor variable (accessibility). In other words, the coefficient of determination measures how well the model explains the variability in the dependent variable. R^2 therefore illustrates the strength of the relationship between the dependent and predictor variables.

Student's t statistics were calculated for the two regression coefficients - β_0 (the intercept) and β_1 (the slope) indicate the significance of the regression coefficients. A t-statistics above the value of two in absolute terms is generally accepted as statistically significant.

It can be seen that for the current study, the calibration was successful and regression coefficients in each equation were shown to be significant. (See Exhibits 9-10, 9-11, and 9-12). This shows that the economic rent profiles are well developed for the Reading-Philadelphia rail corridor. Each equation has highly significant 't' values and coefficients of determination (R^2). This reflects the strength of the relationship and, given the fact that there is a strong basis for the relationship, shows firstly, that the socioeconomic variables selected provide a reasonable representation of economic rent; and, secondly, that generalized cost is an effective measure of market accessibility.

Exhibit 9-10 shows the detailed calibration results for employment, income, and property values.

Exhibit 9-10: Detailed Calibration Results

Economic Rent Factor	Intercept (β_0)	T-statistics for β_0	Slope (β_1)	T-statistics for β_1	Coefficient of Determination – 'R square' (R^2)
Employment	17.91	14.11	-2.81	-9.43	0.60
Income	26.54	22.82	-2.63	-9.76	0.61
Real Property Value	28.01	22.61	-2.69	-9.37	0.59

The impact on the socioeconomic indicators gathered for the current study, with regard to the improvement in accessibility provided by the new Passenger Rail system, is calculated according to the elasticities (i.e. the sensitivity of the socioeconomic parameters to accessibility) established through the differentiation of the economic rent function in equation (1) with respect to generalized cost. The result of such differentiation is present in Equation 2. It is easy to see that slope $\beta_1 E$ in the regression equation represent economic rent elasticities.

$$\Delta SE_I = \frac{\partial SE_I}{SE_I} = \beta_1^E \frac{\partial GC_I}{GC_I} \quad \text{Equation 2}$$

The resulting elasticities were then applied to each zone pair according to the specific generalized cost improvement calculated for each zone for each phase of the project. This allows for the effect of Passenger Rail to be calculated from a Supplyside perspective.

The resulting effect on the socioeconomic parameters are presented below. The results are estimated for each zone, and for the purpose of reporting, socioeconomic benefits for each station hinterland will be shown in the following session.

9.6 Socioeconomic Benefits Results

Direct socioeconomic benefits include employment benefits, income benefits, and real property value benefits. Employment benefits are derived from the Reading-Philadelphia rail corridor transportation service improvement. These are productivity jobs and not temporary construction jobs associated with building the project. Income benefits are derived from the increased economic performance of the region due to the accessibility improvement. Income benefits result from both the increase in the number of households in the corridor and the increase in the average household income per household. Real property value benefits result from the increase of the number of properties in the region as well as increase in the average value of commercial and residential buildings.

9.6.1 Direct Employment

The operation and management of the Reading to Philadelphia passenger rail service will create 425 jobs, which over the 30-year life of the project will generate 12,750-man years of work. The annual income from this employment will be \$20.7 million per year and over the life of the project will equal \$621 million.

9.6.2 Indirect Employment, Income, and Property Values,

9.6.2.1 Employment Growth Estimates

Exhibit 9-11 shows that the total employment growth in man year from 2025 to 2054 in the Reading-Philadelphia Corridor of nearly 16,000-man years of work. The urban areas of Reading, Pottstown, Royersford, Phoenixville will see an increase of 6,500-man years of work over the life of the project. Norristown and Philadelphia will see an increase of over 9,300-man years of employment.

Exhibit 9-11: Employment Improvement by Station Coverage Area

Station Name	Employment Improvement (man years) 2025~2054
Reading, PA	3,434
Pottstown, PA	1,289
Royersford, PA	495
Phoenixville, PA	1,297
Norristown, PA	1,403
Philadelphia, PA	7,904
Total	15,823

9.6.2.2 Personal Income Growth Estimates

The personal income growth is shown in Exhibit 9-12. It can be seen that the total income growth in the Reading-Philadelphia rail corridor will be \$760 million from 2025 to 2054. Reading, Pottstown, Royersford, Phoenixville and Norristown will receive nearly 50 percent of the income growth due to the project. Reading, Pottstown, and Royersford will combined have nearly \$300 million of income growth during the period.

Exhibit 9-12: Personal Income Improvement by Station Coverage Area

Station Name	Income Improvement 2025~2054 (million \$)
Reading, PA	180.1
Pottstown, PA	69.5
Royersford, PA	23.8
Phoenixville, PA	69.9
Norristown, PA	78.8
Philadelphia, PA	337.8
Total	760.0

9.6.2.3 Real Property Value Growth Estimates

Exhibit 9-13 shows the real property value growth in the Reading-Philadelphia rail corridor from 2025 to 2054. The real property value in the corridor will also increase as result of the proposed passenger rail service. The total amount of real property value increase from 2025 to 2054 will be \$1,076.3 million. The five northern stations will get more than 50 percent of the property value increase. The Reading area's real property value increase is \$265.9 million, with Pottstown, Royersford and Phoenixville and Norristown \$353.5 million.

Exhibit 9-13: Property Value Improvement by Station Coverage Area

Station Name	Property Value Improvement 2025~2054 (million \$)
Reading, PA	265.9
Pottstown, PA	103.8
Royersford, PA	33.7
Phoenixville, PA	99.0
Norristown, PA	117.0
Philadelphia, PA	456.9
Total	1,076.3

9.7 Transfer Payments (Tax Benefits)

Transfer payments play an exceptional role in the overall project evaluation. The tax benefits include real property tax increase as result of real property value appreciation, the federal and local income taxes will also benefit as result of personal income increase in the corridor. The rates used reflect current 2018 tax rates.

9.7.1 Real Property Tax Growth Estimates*

Exhibit 9-14 shows the real property tax increase in the Reading-Philadelphia Corridor from 2025 to 2054. The real property tax in the corridor will increase as result of the increased real property value in the corridor. The total amount of real property tax increase from 2025 to 2054 will be \$676 million. Reading, Pottstown, Royersford, Phoenixville, and Norristown will receive \$479 million in real property tax over the project life. Reading's tax benefit will be \$240 million.

Exhibit 9-14: Property Tax Improvement by Station Coverage Area

Station Name	Property Tax Improvement 2025~2054 (million \$)
Reading, PA	5.8
Pottstown, PA	2.3
Royersford, PA	0.7
Phoenixville, PA	2.2
Norristown, PA	2.6
Philadelphia, PA	10.2
Total	23.7

*based on county tax rates

9.7.2 Federal Income Tax Growth Estimates

The federal income tax growth as result of income growth in the Reading-Philadelphia rail corridor is shown in Exhibit 9-15. It can be seen that the total federal income growth in the corridor will be over \$248.4 million from 2025 to 2054. The Reading Federal tax base expansion will be by \$65.4 million. The Philadelphia impact will be an increase of \$122.8 million.

Exhibit 9-15: Federal Tax Improvement by Station Coverage Area

Station Name	Federal Tax Improvement 2025~2054 (million \$)
Reading, PA	65.4
Pottstown, PA	25.3
Royersford, PA	8.7
Phoenixville, PA	26.2
Norristown, PA	28.7
Philadelphia, PA	122.8
Total	248.4

9.7.2.1 Local Tax Growth Estimates

The local income tax growth as result of income growth in the Reading-Philadelphia rail corridor is shown in Exhibit 9-16. It can be seen that the total local income growth in the corridor will be over \$60 million from 2025 to 2054. Reading will receive over \$14.1 million local tax growth. The five northern cities will receive over \$33 million expansion of their tax base.

Exhibit 9-16: Local Tax Improvement by Station Coverage Area

Station Name	Local Tax Improvement 2025~2054 (million \$)
Reading, PA	14.1
Pottstown, PA	5.6
Royersford, PA	2.0
Phoenixville, PA	5.4
Norristown, PA	6.3
Philadelphia, PA	26.9
Total	60.3

The projected expansion of the tax base is considerable and over the lifetime of the project the increase in Federal and Local income tax of over \$300 million is nearly sufficient to cover nearly 90 percent of the project's cost of \$356 million.

9.8 Conclusions

Below is a summary of each set of benefits calculated for the project. As seen in the analysis, the proposed passenger rail project will not only generate financial and demandside economic benefits but will provide a strong stimulus the economy of the Reading-Philadelphia Corridor. Supplyside benefits are the estimated benefits to business and the economy due to the increase in accessibility provided by improvements in transport infrastructure. It is based on the relationship (the elasticity) that the economy exhibits today to transportation accessibility (i.e., sensitivity to improved accessibility). Given the circular nature of the economy, Supplyside benefits under economic theory are equal to the Demandside benefits due to the integrated nature of the economy. The project will create long-term well-paid service and manufacturing employment due to improved productivity. Furthermore, it will benefit the general population through higher incomes and higher real property values. Federal and local government will be able to recoup nearly 90 percent of the cost of the investment in the project through an expanded tax base. Exhibit 9-17 shows the overall socioeconomic and transfer payment benefits of the Reading-Philadelphia for the 30-year period from 2025 to 2054.

Exhibit 9-17: Socioeconomic and Transfer Payments Improvements Summary

Economic Supply Side Items	Economic Supply Side Improvements
Direct Socioeconomic Benefits	
Employment (2025~2054 man years)	28,573
Income (2025~2054, million \$)	1,381.0
Property Value (2025~2054, million \$)	1,076.3
Transfer Payments (Tax Benefits)	
Federal Income Tax (2025~2054, million \$)	248.0
Local Income Tax (2025~2054, million \$)	60.3
Property Tax (2025~2054, million \$)	23.7

Estimates over the 30-year life of the project are:

- Long-term productivity employment will rise by 28,573 person years. The jobs will be created in the business services, logistics, maintenance, health care and retail sectors.
- \$1,381.0 million increase in personal income over 30 years throughout the corridor. This is twice the cost of the project.
- Property Values are estimated to rise by \$1.076 Billion, with an opportunity for significant Transit Oriented development in the city centers of Reading, Pottstown, Royersford, Phoenixville, and Norristown.

The economic impacts of the project in terms of transfer payments are:

- \$248.0 Million new federal tax over 25 years will be generated.
- \$60.3 Million new local tax over 25 years will be generated.
- \$23.7 Million in property tax will be collected at the local level.

Chapter 10

Conclusions and Next Steps

SUMMARY

This chapter outlines the key findings of the study, and the next steps that should be taken to move the Reading to Philadelphia Passenger Rail Line project forward.

10.1 Summary of Findings

The results of this study have identified a strong case for restoration of Reading to Philadelphia passenger rail service. This restoration would produce substantial economic benefits for all the communities along the line including jobs, income and property development opportunities. Additionally, the project would generate benefits for travelers and could be effectively integrated with Northeast Corridor (NEC) rail services to both New York and Washington D.C.

The project also has significant benefits to government with a tax base expansion that more than covers the cost of the project.

Most intercity rail systems focus on trips in the 100-400-mile range, which are too long to comfortably drive but too short for air travel. Although the 59-mile long Reading to Philadelphia Corridor is shorter than this, the ability to link the service to the Northeast Corridor provides many opportunities for trip lengths exceeding 100 miles. However as currently envisioned, the proposed Reading to Philadelphia service would also handle a significant share of daily commuter trips, as the Chicago-Milwaukee Corridor does. As a result, the service as proposed would closely resemble Amtrak's Hiawatha (Chicago-Milwaukee) service or other services such as Boston-Portland or Richmond to Washington DC.

However, it is not only commuters would use the train, but also Business and Social travel would also contribute strongly to the success of the rail service. The rail system would also effectively connect Reading with convenient rail access to Philadelphia, Newark Liberty and Baltimore/Washington International Airports enhancing its value as an intermodal connector.

Because it will serve a full range of trip purposes this study uses the Federal Railroad Administration (FRA) Commercial Feasibility Study criteria. On this basis of these criteria, it has been found that development of the proposed rail system shows very strong potential, and a real case for developing the service exists. It has been found that the system will satisfy the FRA's Cost Benefit requirements. If interconnected with the Northeast Corridor, the higher revenue yields and additional ridership associated with NEC trips would boost system revenues enough so that it could cover its own operating costs and run without a subsidy.

It is important to understand that the financial results of the rail service can be strongly influenced by the way a project is financed and who operates it. It is typical that rail corridor services need an operating subsidy. This is largely due to the fact that 79-mph operation is not directly competitive with the automobile. However, the Northeast Corridor is clearly generating a positive cash flow thus it does not need an operating subsidy. The Reading system has an opportunity to join with the Northeast Corridor

and feed additional trips into it. As a result, the Reading service has an opportunity to share in the NEC's financial success.

10.2 Next Steps

To move the project forward as a public or public/private project TEMS would advise the completion of a much more detailed Feasibility study. If the need for infrastructure improvements can be held to a minimum it is possible that the need for a full EIS can be avoided. A more detailed feasibility study would advance development of the project by further refining the marketing, train equipment, infrastructure, institutional, operating and funding strategies for the corridor.

- The next study should define the optimal approach to development of the rail corridor, while developing all documentation needed for Pennsylvania to be able to apply for all available Federal funding. It must include enough scope to permit consultation with the freight railroads and the completion of enough capacity analysis to verify the adequacy of the infrastructure plan and obtain freight railroad support.
- Develop both a Service Development Plan (SDP) and a Service NEPA (Environmental Scan). A key determination of the Feasibility study will be the level of Environmental study that is needed to advance the project, since the vast majority of proposed rail improvements would be developed within the existing rail right of way.

A Detailed Feasibility study will need to address the following issues:

- **A Market Assessment** – Confirm and further refine the demand forecast with a view to gaining a more complete understanding of specific trip attractors within the corridor and to assess –
 - Seasonality and trip chaining
 - The detailed characteristics of particular target markets such as daily commuters, air connect riders, business travelers, students and corporate groups, and how they travel, and specific target NEC markets and the best way to reach them.
 - Carry out a Stated Preference Survey.
- **A Network Assessment** – Consider additional possible service options such as –
 - Develop detailed pro-forma operating schedules and plans detailing infrastructure requirements more precisely.
 - Analyze the relationship of the proposed service with existing and developing services, including the ability to coordinate operating schedules with the NEC and SEPTA services including the proposed service extension to Phoenixville.
 - Consider possibilities to promote the development of rail freight along with passenger service and any possible synergies or opportunities that co-production might allow.
- **An Institutional Assessment and Implementation Plan** –
 - Consider the potential for a PPP/franchise in order to attract private capital to the project. Consider also how Amtrak might be able to contribute to the project.

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- Develop a detailed Implementation Plan, outlining the short- and long-term actions that need to be taken to initiate service at a minimum speed of 79-mph and over time, for further upgrading the system. This includes identifying the development steps of the corridor and aligning those with a funding plan, to allow the project to be phased in the most effective manner.
- **Joint Development and Local Economic Assessment –**
 - Complete a station location study with a particular view to optimizing the real estate development and value capture opportunities associated with the implementation of the rail service.
 - Identify existing connecting transit services and consider the development, as necessary of additional feeder bus connections as appropriate and the ability to integrate these with regional transit and airports. This may provide a way to tie some of the smaller communities along the line, e.g. Douglasville, into the rail service so that they can more directly share in the benefits without having to slow the trains down by adding too many stops to the rail service.
- **An Engineering and Operational Assessment –** Optimize the infrastructure investment strategy for the whole line, balancing the needs of freight and passenger service, and conduct a capacity analysis to confirm the adequacy of the plan for handling forecasts freight and passenger traffic.
- **An Equipment Strategy –** Develop a detailed plan for meeting the immediate equipment needs of the start-up service and meet with prospective new equipment vendors to develop plans for procuring new trains in the long run.
- **A Financial/Economic and Funding Plan –**
 - Enhance the benefits assessment to reflect the fact that infrastructure investments will be mutually supportive to all users of the rail line. While some costs may clearly be the responsibility of one service or the other, other costs are shared.
 - A collaborative approach would help facilitate a better understanding of the synergies between the needs of different corridor users.
 - Developing a single integrated Cost Benefit calculation would avoid the need for developing allocations of shared costs, which often tend to be arbitrary.
 - This offers the best prospect for accelerating the time frames for badly needed infrastructure improvements and would help to ensure that Penn DOT optimizes its return on investment for improving the Reading to Philadelphia rail corridor.
- **Implement a Public Outreach Effort** with a structured approach for communicating the study findings while engaging both the project stakeholders and the public at large