PHILADELPHIA - HARRISBURG RAIL STUDY

Prepared for the

Pennsylvania Department of Transportation

by the

Delaware Valley Regional Planning Commission

in Association with

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Delaware Valley Regional Planning Commission
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Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty and intercity agency which provides continuing, comprehensive and coordinated planning for the orderly growth and development of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties as well as the City of Philadelphia in Pennsylvania and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. The Commission is an advisory agency which divides its planning and service functions among the Office of the Executive Director, the Office of Public Affairs, and four line Divisions: Transportation Planning, Regional Information Services Center, Strategic Planning, and Finance and Administration. DVRPC's mission for the 1990s is to emphasize technical assistance and services and to conduct high priority studies for member state and local governments, while determining and meeting the needs of the private sector.

The DVRPC logo is adapted from the official seal of the Commission and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River flowing through it. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey. The logo combines these elements to depict the areas served by DVRPC.

DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Publication Abstract

TITLE	Date Published: January 1992
Philadelphia - Harrisburg Rail Study	Publication No. 91041

Geographic Area Covered:

Philadelphia-Harrisburg Rail Corridor in Philadelphia, Montgomery, Delaware, Chester, Lancaster, and Dauphin counties

Key Words:

Rail passenger service, track structure, electrification, stations, travel demand, service level, rolling stock, locomotives, coaches, multiple units, financial analysis, capital costs, operating expenses, power choices, management options

ABSTRACT

The study assesses the condition of the 103-mile electrified rail line between Zoo Interlocking in Philadelphia and Harrisburg Terminal, estimates the costs of improvements needed to restore the line to a state of good repair, forecasts 1996 travel demand under three operating scenarios, evaluates equipment needs for electric and diesel propulsion, examines alternative ownership and management configurations, estimates revenue and operating expenses, identifies funding sources, and constructs financial schedules for several funding approaches.

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I. INTRODUCTION

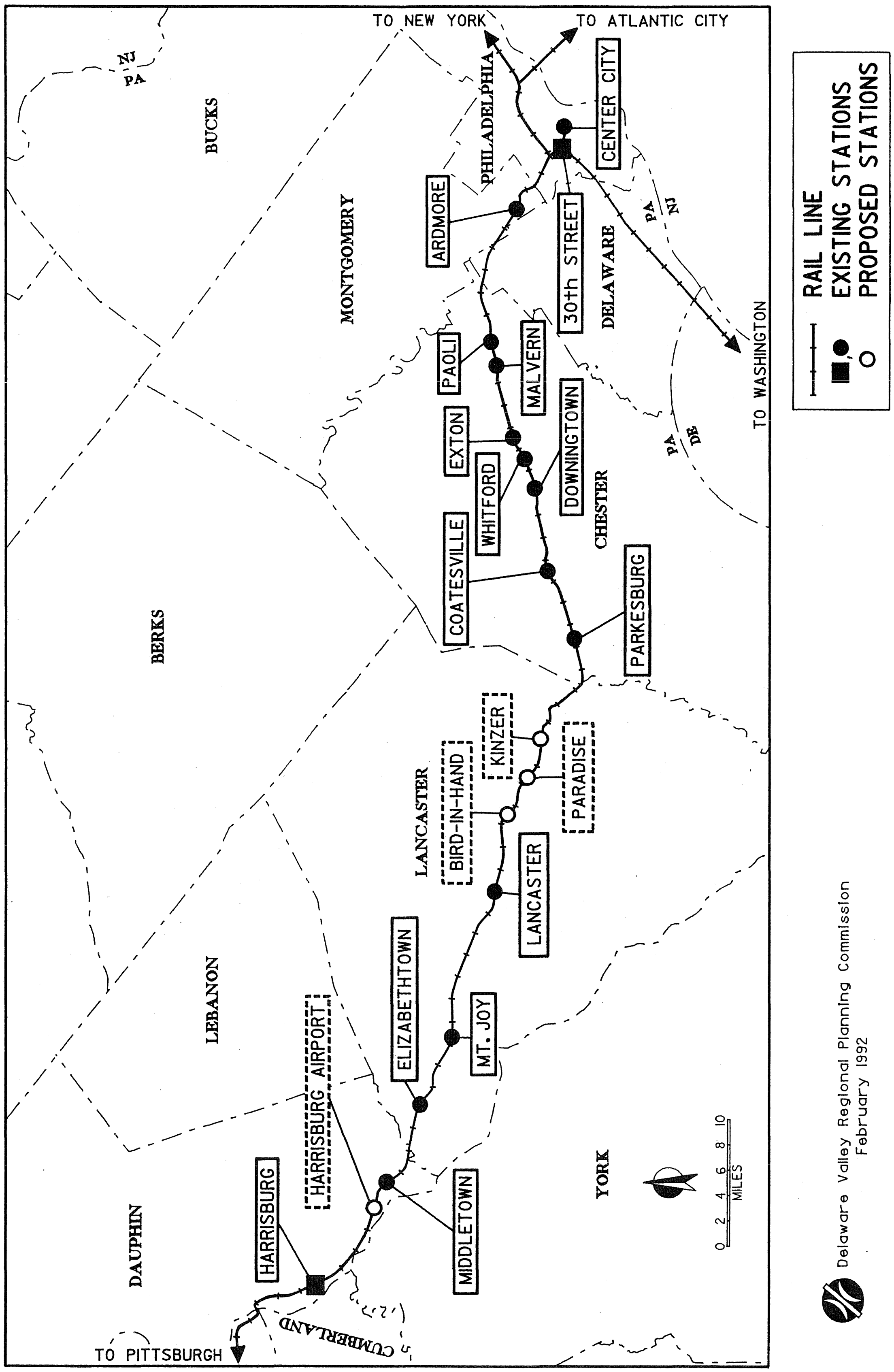
Philadelphia-Harrisburg passenger trains, collectively named the *Keystone Service*, have been operated by the National Railroad Passenger Corporation (Amtrak) since 1971 with financial assistance from the Commonwealth of Pennsylvania. The service had originally been part of an extensive network of passenger trains operated by the Pennsylvania Railroad (PRR), and was continued by the Penn Central Railroad after it was formed from the merger of the PRR with the New York Central in 1968. Prior to the Amtrak takeover, service to Harrisburg consisted of eight weekday local trains, supplemented by two additional long-haul trains, in each direction. Currently, seven weekday trains with Philadelphia-Harrisburg traffic rights [six local trains plus the *Pennsylvanian* (New York-Pittsburgh)] are operated in each direction.

Amtrak's legislative mandate is to provide intercity rail passenger service on a national network. However, under Section 403(b) of the Amtrak Act, states are permitted to contract for service beyond that which would be supplied under purely national considerations. Pennsylvania has taken advantage of this provision and currently supports selected *Keystone* trains (13 one-way trips per week) and the *Pennsylvanian*.

As recently as 1980, over one million trips per year were carried by the *Keystone* trains, but throughout most of the 1980s ridership fell steadily, reaching 317,000 in 1989. Since then, ridership appears to have stabilized. Several reasons for this loss have been advanced, including service cuts, patronage shifts to an expanding local service operated by the Southeastern Pennsylvania Transportation Authority (SEPTA) on the eastern end of the line, and changing markets for rail travel. Also, because of financial constraints and higher priorities elsewhere, Amtrak has not been able to provide the investment needed to reverse this ridership decline. Amtrak has indicated that the line now needs about $32 million worth of capital improvements, but this has been deferred in the face of higher needs elsewhere. Though the line is basically in good condition, the physical plant is aging and some renewal is needed to maintain service into the future. Over the last decade speeds have fallen about ten percent and now average 52.3 mph for the full run between Philadelphia and Harrisburg.

The PRR electrified the Philadelphia-Paoli segment of the line for local commuter service in 1915 and extended the electrification to Harrisburg in 1938 as a spur to its New York-Washington corridor. This permitted operation of the 600-series trains, as the Harrisburg locals are designated, into Suburban Station, as well as through service to New York. Though SEPTA uses electric propulsion for all of its trains, which currently run as far west as Parkesburg in Chester County, Amtrak's use of electric power is declining. Amtrak ceased operating the *Keystone* trains into Suburban Station in 1988, and now all but the New York-Harrisburg trains routinely use F40PH

MAP 1
PHILADELPHIA - HARRISBURG
RAIL LINE



diesels for traction power. The AEM7 electric locomotives are only used as backup power. There is some concern about Amtrak's long-term commitment to maintaining electrification.

In addition to the Harrisburg trains and long-distance trains, the PRR also operated local trains oriented toward Philadelphia on the eastern end of the line. Most of these trains used Paoli as their western terminus, though a few continued as far west as Downingtown. After SEPTA was formed in 1964, the PRR received a public subsidy to support operation of these trains. This arrangement continued under Penn Central and Conrail operation until SEPTA took over direct operation at the beginning of 1983. SEPTA initially operated trains only as far as Paoli, but service to Downingtown was restored in 1985 and extended west to Parkesburg in 1990. Since 1984 the local service has been designated as Route R5. SEPTA's Route R6 to Cynwyd also uses the line for about two miles between the Zoo and 52nd Street interlockings.

The Pennsylvania Department of Transportation (PennDOT) recognizes the *Keystone Service* as an important link in the Commonwealth's regional/intercity public transportation network. With the recent passage of Federal legislation requiring states to develop transportation plans addressing intermodalism, congestion management, and clean air initiatives, the *Keystone* corridor takes on an added significance as a valuable asset in Pennsylvania.

Because of its importance to the State's transportation system, PennDOT asked the Delaware Valley Regional Planning Commission (DVRPC) to assess the condition of the 103-mile line between the Zoo Interlocking in Philadelphia and the Harrisburg Terminal, determine needed improvements, and examine the management and operational options available for improving service. Though the scope of the study did not encompass local service east of Paoli, the analysis of service and ridership trends did consider SEPTA's presence in western Chester County. Further, the analysis of capital requirements recognized the need to accommodate SEPTA's trains.

The study was not designed to produce definitive recommendations on each detailed topic of study, but rather to serve as a basis for decision making on the merits of a stronger presence and possible direct investment by PennDOT in upgrading the service. It represents a preliminary blueprint for considering capital investment options and/or opportunities to improve mobility within this corridor.

A. STUDY OBJECTIVES AND TASKS

The objectives of the Philadelphia-Harrisburg Passenger Rail Study, as delineated by PennDOT, are to:

- Assess the condition of the infrastructure of the Amtrak-owned right-of-way, recommend various levels of needed improvements, and determine the costs associated with each level;
- Determine minimum and desirable levels of service, and forecast ridership;
- Determine the equipment (rolling stock) needs for each service scenario and identify the options available with their associated costs;
- Identify and evaluate ownership and management options, including alternative service providers; and
- Conduct a financial analysis of the various options, including an assessment of their capital and operating requirements.

In response to PennDOT's request and in conformity with the preceding objectives, DVRPC prepared a detailed proposal outlining the tasks required and a study organization. While DVRPC would manage the project and conduct the planning activities, it was felt that the engineering and financing aspects would best be handled by consultants with expertise in these areas. Accordingly, the first task was to prepare a Request for Proposals (RFP) and to select a consulting team that would work with DVRPC.

The tasks comprising the Scope of Services are described below:

Task 1 - Selection of Consultant and Review of Activities
Prepare a Request for Proposals and conduct the Consultant selection process with PennDOT's participation. The Consultant will be responsible for the conduct of Tasks 2 (Infrastructure Assessment), 4 (Equipment Assessment), and 6 (Financial Analysis). After the project is underway, monitor the work product in order to ensure that it meets the contractual obligations and is conducted in a satisfactory manner.

Task 2 - Assessment of Infrastructure
Make an independent assessment of the general condition of the line and estimate the costs required to restore the line for 79 mph operation (Class 4). Compare this estimate with Amtrak's assessment of the capital investment required. Estimate incremental costs for increasing speeds to 90 mph (Class 5). Rank projects by importance and timing. The result should be a general assessment that can be used for capital planning purposes, rather than detailed descriptions of the line and its

associated infrastructure. This assessment should cover right-of-way, including track and bridges; the signal system; the electric power distribution system; and stations. Particular attention should be paid to compliance with relevant FRA standards.

The right-of-way section should cover all components of the track structure, as well as bridges, grade crossings, the drainage system, and other associated components. It should also include a description and an assessment of their general condition and maintenance (or replacement) requirements. Photo documentation can be used to illustrate the condition of the line and observed deficiencies. Signaling includes both wayside and onboard components, centralized traffic control, and train communications. Assess the current system in light of future needs, and if found inadequate, recommended a course of action. The electric distribution system includes the power source, distribution system, and catenary. Examine the susceptibility of the electrical system to outages and identify backup systems.

Base the assessment of stations on their state of repair and their adequacy to meet existing and future passenger needs. Evaluate the potential for joint use of stations, especially in the case of older facilities, which may be larger than what is needed. The parking evaluation should include a short-term component for commuters and day-trippers, and a long-term component to accommodate those who take overnight trips. Identify intermodal connections. Evaluate the adequacy of access to pedestrians, motorists, and from connecting transit lines, and estimate the cost of removing deficiencies. Cost estimates for any additional or relocated facilities needed should include the cost of land acquisition, roadwork, and other related improvements.

Task 3 - Determine Demand and Service Levels

Assess historical levels of service and ridership trends, and compare those with current levels and travel demand within the corridor. The demand consists of local commuter markets at the Philadelphia and Harrisburg ends, through travel, and connections to other intercity services. It is expected that Amtrak will be able to supply ridership data by station. Since SEPTA handles the majority of commuter traffic to Philadelphia and has been expanding its local service to Chester County, include SEPTA service and ridership west of Paoli in this assessment. Use demographic and employment data to estimate overall demand within the corridor.

In addition, make a comparison with similar rail corridors throughout the country, such as the *Empire* Corridor between New York and Albany, the Midwest corridors around Chicago, and the *San Diegans* in southern California. The comparison should look at ridership, level of service, fares, financial performance, passenger amenities, marketing effort, total travel demand and market penetration, and state/local commitment and participation.

Evaluate three levels of service for the line, including the current operation of seven, an intermediate level of ten, and a maximum of 14 round trips per weekday. The analysis should consider all trains carrying passengers between Philadelphia and Harrisburg, including the *Keystone* trains and the *Pennsylvanian*, but the reserved seat *Broadway Ltd* and the *Keystone State Express*, which bypasses 30th Street Station, should be excluded from consideration. Estimate ridership, revenues, and operating costs for a five-year horizon. Include a cost-benefit analysis of incremental increases in service in the evaluation.

If the line is to reach its full ridership potential, it must be properly marketed. Marketing covers all aspects that help sell the service to the public and includes advertising, promotion, pricing, and scheduling. Assess the effectiveness of current efforts, and delineate requirements for each of the identified market segments.

Task 4 - Assessment of Equipment Needs
Compare the merits of the various types of rolling stock, including propulsive power and coaches, based on capital and operating costs, availability, operating characteristics, and reliability. This comparison should be developed from broad considerations using overall knowledge of the state of the rail passenger industry and the market for locomotives and cars. Where appropriate, include an analysis of the tradeoffs between new, used, and rebuilt equipment, but do not develop detailed specifications and cost estimates.

Prepare a discussion on motive power which compares the advantages and disadvantages of self-propelled (multiple-unit) coaches and locomotive-hauled equipment, and indicate the circumstances under which each is preferred. Also assess the cost implications of switching to diesel and dual-power locomotives. The latter would allow access through the tunnel to Suburban Station in Philadelphia.

Evaluate various coach configurations, including options for food service. All coaches must be equipped with lavatories. Consider rebuilding existing coaches or multiple-unit equipment as an option.

Since the choice of equipment depends on train length and the quantity depends on the service levels, estimate the needs for three operating scenarios supplied by DVRPC.

Task 5 - Evaluation of Operational Arrangements
Look at operational arrangements currently used by regional transportation authorities to support rail operations along the Northeast Corridor (NEC) on tracks shared with Amtrak. For example, in Westchester County (NY) Amtrak operates its intercity trains on tracks owned and used by Metro North; whereas in contrast, SEPTA operates its local trains on tracks owned by Amtrak. A third variation is seen in Maryland where

Amtrak operates local trains on its own tracks for the Maryland State Railroad Administration. Each of these variations has implications regarding costs and control of local rail operations. Evaluate possible configurations with respect to their relevance to the Harrisburg Line. Review contractual and financial obligations of the promising options, and summarize their pros and cons.

Task 6 - Review of Options and Analysis of Financing Requirements
Analyze the financial requirements for the various service options and ownership/management/operation configurations identified by DVRPC. Identify and evaluate sources of capital for line renewal and upgrade and for rolling stock, and their annual cost specified. Sources should include, but not be limited to, Federal, State, and local grants; bond issues; and lease arrangements.

Estimate annual operating revenues and expenses, including those resulting from train operation, maintenance of equipment, maintenance of way, and trackage payments, for each of the options. Some items may be shifted from the expense side of the ledger to the revenue side, depending on the option chosen. For instance, shifting line ownership from Amtrak to a local entity would terminate State 403(b) payments to Amtrak and generate revenue from selling trackage rights to Amtrak and freight carriers, in addition to that earned from the sale of tickets. Also, identify impacts on SEPTA operations, such as trackage payments for Route R5.

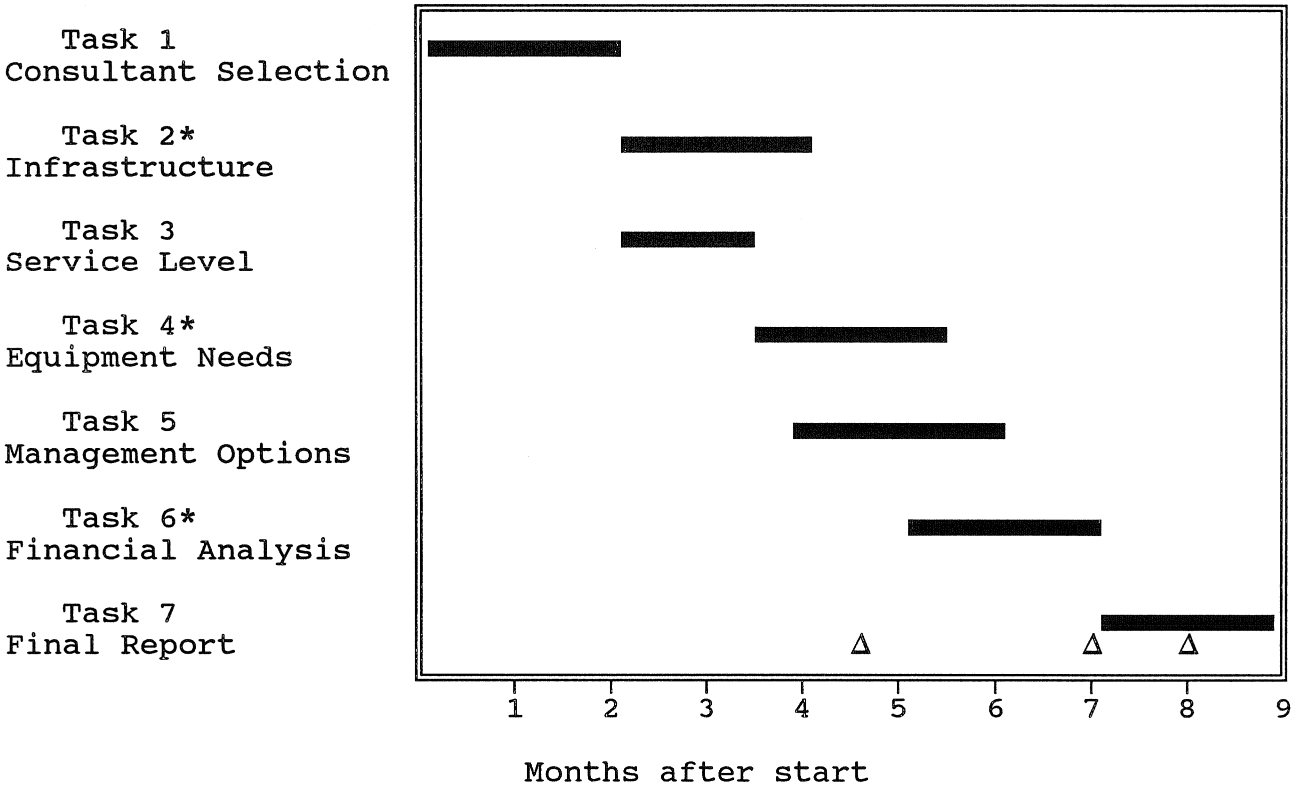
Task 7 - Final Report and Executive Summary
Submit a final report that describes the activities of each of the tasks and summarizes the conclusions and the feasible options for service, management, and finance to PennDOT for review and comments, Descriptions of Tasks 2, 4, and 6 will be prepared by the Consultant. Incorporate any comments received into the Final Report. In addition, produce and submit an Executive Summary as a separate document.

B. STUDY ORGANIZATION AND REPORTS

Overall management of the project resided with PennDOT, who had ultimate responsibility for the direction, scope, and timing of the project. Day-to-day management was provided by DVRPC, who also directly conducted the work activities not assigned to the Consultant.

A Technical Committee, with members representing PennDOT, Amtrak, SEPTA, the City of Philadelphia, DVRPC, Lancaster County, and the Tri-County Planning Commission, reviewed the technical aspects of the work and provided liaison with their respective organizations. The selection process for the Consultant was overseen by a Consultant Selection Committee comprised of three representatives from PennDOT and two from DVRPC.

The work was scheduled to be completed within nine months from the authorization to proceed. Approximately two months were required to select a Consultant and complete contractual arrangements. The following chart specifies the timing for each task. However, work was interrupted by State budgetary constraints imposed at the end of December 1990. Work resumed approximately two months later.



* Task to be completed by Consultant
Δ Technical Committee meeting

The following reports and documentation were submitted to PennDOT during the course of the project:

1. Status Reports - One-page progress reports were submitted monthly covering work accomplished during the preceding period. These included discussion of problems encountered and their resolution. The reports were keyed to the work plan described in this proposal, or as amended and approved by PennDOT.

2. Task Reports - A detailed report describing the findings of each task, with the exception of Task 7, was prepared and five (5) copies, along with supporting documentation, submitted to PennDOT for review and comment. Tasks 2, 4, and 6 were the responsibility of the Consultant. DVRPC prepared the remainder.

3. Early Action Report - It was requested that an Early Action Report summarizing the assessment of infrastructure, equipment needs, service levels, and financial requirements, assuming no change in institutional arrangements, (Tasks 2, 3, 4, and 6) be submitted to PennDOT by 15th December 1990, assuming no delays in signing the contract and that a Consultant is hired and ready to work by the beginning of September, so that the Department can prepare its FY92 budget request in a timely fashion.

4. Draft Final Report - A draft version of the Final Report will be prepared, covering project activities, such as data collection, analytical techniques, supporting documentation, findings, and conclusions, and will include maps and photos. Task descriptions will be based on edited versions of the Task Reports submitted earlier. The report will be submitted to PennDOT for review and comments.

5. Final Report - The received comments will be incorporated into a revised Final Report and submitted to PennDOT in twenty-five (25) copies.

6. Executive Summary - Project activities and findings will be summarized in an Executive Summary using terminology meaningful to management and others familiar with the subject area, and submitted in twenty-five (25) copies.

C. CONSULTANT SELECTION AND STUDY ORGANIZATION

To fulfill the requirements of Task 1, DVRPC prepared a RFP to provide consulting services. This was released on August 16, 1990 with the deadline for responses set at September 14th. The RFP attracted responses from eight teams comprised of consulting firms with national reputations in railroad engineering and finance. The generally high caliber of the responses is a measure of the value of the rail and the interest in preserving operations.

The Consultant Selection Committee met in the offices of PennDOT on September 28th to discuss and rank the received responses. The top two teams were invited to come to Harrisburg on October 4th and meet with the Committee. After the interviews were completed, the team headed by R.L. Banks & Associates, Inc. (RLBA) of Washington, DC was selected, and a contract signed on October 10, 1990. The firm specializes in transportation economics, planning, and engineering. Other members of the consortium were Main Line Management Services, Inc. (MLM) of Mount Laurel, NJ; LTK Engineering Services (LTK) of Blue Bell, PA; and Canby Associates of Baltimore, MD.

The substantive tasks in the study were shared between DVRPC and the members of the consulting team. Task 2, which called for an assessment of the condition of the fixed infrastructure and recommendations for capital investment, was assigned to MLM with assistance from RLBA, who provided expertise in the area of signaling and communications. Task 3, which looked at service levels and demand, was handled by DVRPC. LTK was assigned the responsibility for completing Task 4, which determined rolling stock requirements. DVRPC was responsible for the activities in Task 5, which entailed choosing suitable alternative configurations for managing and operating the service. RLBA, with assistance from Canby Associates, conducted the financial analysis in Task 6. Though each of the parties was asked to produce a report for each of their assigned tasks, DVRPC had the responsibility of assembling these reports into a Final Report for the study.

The Technical Committee met four times during the course of the study. The first was convened on November 15, 1990 for the purpose of describing the terms of the study and meeting the participants. Unfortunately the study did not proceed as smoothly as planned. A State budget crisis forced a suspension of work on December 31st. Supplemental funding was found and work resumed on February 19, 1991. At the second meeting on June 4, 1991, the Committee reviewed the work completed for Tasks 2 (infrastructure) and 3 (service and demand). The remaining work on Tasks 4 (equipment), 5 (management configurations), and 6 (financing) were reviewed at a meeting held on August 27th. The final meeting on January 9, 1992 was held to provide members with an opportunity to review the Final Report and to consider the study in its entirety.

II. INFRASTRUCTURE ASSESSMENT

This chapter provides an assessment of the condition of the fixed infrastructure of the Philadelphia-Harrisburg Line, including track structures and roadbed, bridges, electric distribution system and catenary, signaling, and stations. This assessment will be used to estimate the capital investment required to restore the line to good operating condition, i.e., one that removes slow orders and permits Class 4 (79 mph) operation, and to prioritized the improvement projects so that they can be implemented in a logical order, as funding becomes available. The additional investment needed to raise speeds to 90 mph where terrain permits will also be estimated. The adequacy of the existing stations to serve the market will be addressed with respect to structural condition, passenger amenities, parking, and location.

A. TRACK AND ROADBED

1. Track Assessment

Representatives of Main Line Management Services, Inc. made several site inspections of Amtrak's Philadelphia-Harrisburg line in order to assess track condition. Track was inspected in conjunction with station site inspections on December 5 and December 13, 1990, and a head-end trip over the line was made on December 28. Field samples were taken while walking and driving the line on April 4, 1991, and additional inspections were made at intermittent points along the right-of-way on April 11. Conditions found are tabulated in Appendix A. A track chart of the line, detailing track speeds and the locations of curves, bridges, crossings, etc. is contained in Appendix B. Key locations are listed in Table II-1 for reference.

2. Track Speeds

Although not reflected in the train schedules, much of the line is already rated at Class 5 (90 mph) standards.[1] These segments include both tracks from Paoli [milepost (MP)20.4] to MP50, the westbound track (#4) from MP50 to MP63, the eastbound track (#1) from MP57 to MP66, #1 track from Cork (MP70.2) to MP73, and #1 track from Roy (MP94.8) to State (MP103.2). These 90-mph segments account for over 50 percent of the track miles between Paoli and Harrisburg. The #1 track between MP50 and MP54 was re-laid with welded rail in the mid-1980's and is in the same condition as the other 90-mph sections; however, Amtrak has never increased the speed limit on this segment from 80 mph to 90 mph.

[1]The Federal Railroad Administration (FRA) has established physical standards and maximum operating speeds for six classes of track.

TABLE II-1

KEY LOCATIONS

MAIN LINE—PHILADELPHIA TO HARRISBURG

Interlocking	Interlocking Station	Block Station and Form D Office	STATIONS	Mile Post	Sidings Assigned Direction Car Capacity 50 ft. Cars			Note
					West or North	East or South	Both	
X	X	X-★-◊	ZOO (Connection Septa Main Line)	*1.9	....	....	....	....
....	....	....	52nd STREET	4.0	....	....	....	....
X	....	....	VALLEY (Manayunk Line—Septa) R-Overbrook	4.0	....	....	....	....
X	X	X-★	OVERBROOK	5.4	....	....	....	....
....	....	....	MERION	6.0	....	....	....	....
....	....	....	NARBERTH	6.8	....	....	....	....
....	....	....	WYNNEWOOD	7.5	....	....	....	....
....	....	....	ARDMORE	8.5	....	....	....	....
....	....	....	HAVERFORD	9.1	....	....	....	....
X	P	P-★	BRYN MAWR	10.1	....	....	....	....
....	....	....	ROSEMONT	10.9	....	....	....	....
....	....	....	VILLANOVA	12.0	....	....	....	....
....	....	....	RADNOR	13.0	....	....	....	....
....	....	....	ST. DAVIDS	13.8	....	....	....	....
....	....	....	WAYNE	14.5	....	....	....	....
....	....	....	STRAFFORD	15.4	....	....	....	....
....	....	....	DEVON	16.5	....	....	....	....
....	....	....	BERWYN	17.5	....	....	....	....
....	....	....	DAYLESFORD	18.6	....	....	....	....
X	X	X-★	PAOLI	19.9	....	....	....	....
....	....	....	MALVERN	21.6	....	....	....	....
....	....	....	FRAZER	23.8	....	....	....	....
X	....	....	GLEN .... R-Thorn	25.3	....	....	....	1
...	....	....	EXTON	27.5	....	....	....	....

MAIN LINE—PHILADELPHIA TO HARRISBURG (Continued)

Interlocking	Interlocking Station	Block Station and Form D Office	STATIONS	Mile Post	Sidings Assigned Direction Car Capacity 50 ft. Cars			Note
					West or North	East or South	Both	
....	....	....	WHITFORD	28.3	....	....	....	....
X	....	....	DOWNS .... R-Thorn	32.1	....	....	....	....
....	....	....	DOWNINGTOWN	32.4	....	....	....	....
X	X	X-★	THORN (Trenton Branch)	35.0	....	....	....	....
X	....	....	CALN .... R-Thorn	36.6	....	....	....	2
....	....	....	COATESVILLE	38.4	....	....	....	....
....	....	....	POMEROY	41.9	....	....	....	....
X	....	....	PARK (Enola Branch)	43.9	....	....	....	....
....	....	....	PARKESBURG	44.2	....	....	...	....
....	....	....	ATGLEN	47.0	....	....	....	...
....	....	....	CHRISTIANA	48.4	....	....	....	....
....	....	....	GAP	51.2	....	....	....	....
....	....	....	KINZER	54.1	....	....	....	....
....	....	....	LEAMAN PLACE (Strasburg R.R.)	56.7	....	....	....	....
....	....	....	LEAMAN	57.0	....	....	....	....
....	....	....	GORDONVILLE	58.0	....	....	....	....
....	....	....	BIRD-IN-HAND	61.2	....	....	....	....
....	....	....	LANCASTER	68.0	....	....	....	....
X	X	X-★	CORK (Columbia Sec. Trk. (C.R.C.)	68.1	....	....	....	....
....	....	....	MOUNT JOY	80.1	....	....	....	....
....	....	....	FLORIN	80.7	....	....	....	....
....	....	....	RHEEMS	83.6	....	...	....	....
....	....	....	ELIZABETHTOWN	86.8	....	....	....	....
....	....	....	CONEWAGO	90.2	....	....	....	....
X	....	....	ROY (Royalton Branch C.R.C.) R-State	94.3	....	....	....	....
....	....	....	MIDDLETOWN	94.7	.. .	....	....	....
....	....	....	HIGHSPIRE	98.9	....	....	....	....
....	....	....	STEELTON	99.5	....	....	....	....
X	X	X-★-◊	STATE	104.6	....	....	....	....
....	....	....	HARRISBURG	104.6	....	....	....	....
X	P	P-★-◊	HARRIS	104.8	....	.. .	....	....

*Distance from Penn Center Sta. (Septa)
The direction from Zoo to Harris westward.
The direction at Zoo from 34th St. O.H.
Bridge to connection with No. 2 and No. 4.
Main Line via 36th St. Tunnel is Eastward.
Note 1. Applies on No. 2 and No. 4 tracks only.
Note 2. Applies on No. 1 and No. 2 tracks only.

Interlocking and Block Stations in service part-time as follows:

Station	Hours in Service
Bryn Mawr	6:00 A.M. to 10:00 P.M. Daily except Saturday, Sunday and Holidays.
Harris	11:00 A.M. to 7:00 P.M. Daily.

36TH STREET CONNECTION
(Philadelphia Division)

Interlocking	Interlocking Station	Block Station and Form D Office	STATIONS	Mile Post	West or North	East or South	Both	Note
X	X	X-★-◊	ZOO	*0.0	....	..	....	.
X	X	X-★	PENN (Main Line—Philadelphia to Washington)	0.9	....	....	....	...

The direction from Zoo to Penn is eastward.
*Distance from Zoo.

Source: Amtrak

Most of the remaining segments are comprised of jointed (bolted) rail. Amtrak policy is not to operate over jointed rail at speeds over 80 mph. (Other railroads, such as Santa Fe, have similar policies.) One of the reasons for this policy may be the significant increase in cost ($1,500 to $2,000 per mile per year) of maintaining jointed rail to Class 5 (90 mph) standards, as opposed to Class 4 (80 mph) standards. Most of the jointed rail segments were operated at 80 mph until the mid-to-late 1980s when speeds were reduced to 60 mph.

Since that time, most of the segments have been brought up to 70 mph, with the exception of #1 track from MP84 to Roy. The commuter territory east of Paoli to Valley (MP4.0) is limited to 70 mph and between Valley and Zoo (MP3.3) to 60 mph, partly as a result of the jointed rail, but also due to signal spacing, curves, and train congestion.

Certain curves and interlockings have permanent slow orders in place. Curves with 60-mph restrictions include Overbrook, Narberth, St. Davids, and Whitford, while the curve at Devon is 65 mph. The curves at Malvern, Atglen, Kinzer, Bird-in-Hand, and Middletown are rated at 75 mph; however, the curves at Berwyn and Gap are restricted to 50 mph. Speed restrictions are also in place for the interlockings at Zoo, Overbrook, Paoli, Thorn, Park, Cork, and State, while the approach to the Harrisburg station through State interlocking is limited to 50 mph. Only one temporary slow order, on the freight track through the Thorn interlocking, is currently in effect over the line.

3. Tie Condition

The condition of the crossties was evaluated by assessing samples of 100 ties at various locations along the line and by ascertaining that the sampled sections were representative of and consistent with contiguous track segments. Assessments were made on 42 track sections, which are believed to fairly represent the overall condition of the line. Based on the samples, the entire line appears to have 20-inch tie spacing (which equates to 3,168 ties per mile), typical of a high-speed main line, as opposed to the 21- or 22-inch tie spacing found on most freight main lines and branches.

Tie replacements were programmed in this corridor in 1957, 1963, and 1965. As the average tie life in this region for relatively light density track is approximately 40 years, many of these ties are nearing the end of their useful life. During the late 1960s and early 1970s, under Penn Central, there is little evidence of any program tie replacements, although spot ties and maintenance ties of that era are evident.

Amtrak had limited tie replacement programs in the late 1970s and early 1980's; however, some of this work involved relay ties from the Northeast Corridor as opposed to new ties. With the exception of maintenance ties, little or no tie work was undertaken through the remainder of the 1980s until a small production gang program was conducted in 1989 and 1990. About 25,000 ties were inserted at that time between MP23 and MP44 on track #4 and between MP27 and MP44 on track #1. This was equivalent to about a 20-percent tie replacement on those segments. Another program of 10,000-15,000 ties is scheduled for 1991. A normalized tie maintenance program would require a production gang to be scheduled every four to six years replacing 10-15 percent of the ties on any given segment.

The inspection found some tie condition differences between the jointed rail and welded rail segments; however, on both types of segments it appeared that tie condition often was at a standard less than that called for by the rated track class (see FRA standards included in Appendix C).

The 90-mph segments had an immediate failure rate of about 6 percent and a five-year replacement need of 18 percent. While these percentages are well within the Class 5 standard of 12 good ties per 39-foot section, there was some clustering of bad ties. Since this clustering is on the welded rail sections and not under rail joints, Amtrak has not lowered the speed limits on these segments.

The 70-mph segments had an immediate failure rate of 9 percent and a five-year replacement need of 23 percent. These segments were in jointed rail territory, where the necessity of having good ties under joints to provide support is more critical than in welded rail territory. Without such support, end batter and other forms of wear on the rail structure are greatly increased, while ride quality is greatly decreased. While the number of good ties per 39-foot segment exceeded the Class 4 standard of 12, a large number of bad ties under joints, as well as considerable clustering of bad ties, was observed. (In one sample, 7 consecutive ties were rated as bad.) As a result, several of the sampled segments did not truly meet Class 4 standards for high-speed passenger operations. To eliminate the clustering and bad joint ties, the five-year replacement rate will need to be increased by about 15 percent, resulting in a production program of 25 percent new ties on 70-mph track during that period.

The 60-mph segments had an immediate failure rate of 11 percent and a five-year replacement need of 25 percent. As with the 70-mph track, these segments were in jointed rail territory, where the necessity of having good ties under joints to provide support is more crucial than in welded rail territory. While the number of good ties per 39-foot section exceeded the Class 3 standard of 8, a large number of bad ties under joints, as well as considerable clustering of bad ties, was again observed. Clustering was greater than on the Class 4 track. Again, several of the sampled segments did not truly meet Class 3 standards. To eliminate the clustering and bad joint ties, the five-year replacement rate will need to be increased by about 20 percent, resulting in a production program of 30 percent new ties on 60-mph track during the period.

4. Rail Condition
The Keystone line is comprised of a variety of rail sections, ranging from 131 pounds (per yard) to 155 pounds with 140- and 152-pound sections also common. The rail includes both jointed and welded segments. Rail sections date mostly from the late 1930s to the early 1950s, with some newer rail rolled in the late 1970s and early 1980s. The lighter rail sections use 6-inch tie plates, a modern standard, while the 152- and 155-pound sections require 6 1/2-inch or larger tie plates and other track materials that are no longer being produced. Each track has a different rail make-up, although there is usually some consistency within a given territory, as illustrated in Table II-2.

The average life expectancy of rail is a function of rail weight, curvature, condition of the supporting structure, and the nature and volume of the traffic moving over the line. Rail life expectancy is usually expressed in terms of gross tons moving over a section. For the heavy main line rail on the Harrisburg line, a life of 400-600 million gross tons could be expected before the rail would need to be cascaded (recycled) to secondary tracks, with the lower ranges expected on curves and the higher ranges found on straight welded sections.

Rail will generally need to be replaced if more than two defects per mile are detected. Amtrak has indicated to us that the Sperry Rail Car defect testing, performed at least once per year on welded rail and twice per year on jointed segments, has not shown any significant need of rail change-outs.

Rail is usually changed out as wear approaches 5/8 inch. The measurements made on the sampled track sections indicated typical wear of 2/16-3/16 inches, with a range from 0/16 to 6/16 inches. No rail segments in need of replacement due to wear were observed.

Based on the tonnages moving over the line, rail wear was not expected to be a problem. Most through freight trains do not use the line between Roy and Park and instead use the "freight" center track(s) between Park and Thorn or Park and Glen. Heavy trains, such as ore and coal trains moving to or from Philadelphia, cause more track damage and have not used the Roy-Park line since Conrail was created in 1976.

Annual gross tonnages per track moving over the line today are probably 1-1.5 million tons west of Paoli and no more than 2 million tons east of Paoli. This would be considered relatively light density track. Although much of the rail along the line was re-laid from other locations (such as the Northeast Corridor) where the traffic density was higher, field observations indicate that the rail still has more than 50 percent of its wear-related life left.

TABLE II-2

RAIL SECTION DESIGNATION AND YEAR ROLLED OR LAID USED

Track Number	Line Segment	Rail Section	Welded (W)/ Jointed (J)/ Mixed (M)	Year(s) Rolled	Year(s) Laid Used
1	Zoo-Bryn Mawr	140RE[a]	W	1969	
	Bryn Mawr-Paoli	131PS[b]	J	1942	
	Paoli-Park	140RE	W		1982
	Park-Kinzer	131PS	W		1983
	Kinzer-Lancaster:				
	MP54-MP57	131PS	J	1945	
	MP57-MP66	140RE	W		1983
	MP66-MP70	Mixed 130RE, 140RE, 152PS	J		1930s
	West End of Cork-MP73	Mixed 152PS, 155PS	W		1983
	MP73-Roy	152PS	J	1940s	
	Roy-MP98.5	140RE	W		1982
	MP98.5-Harrisburg	131PS	W		1982
2	Zoo-Overbrook	131PS	J	1965	
	Overbrook-Bryn Mawr	155PS	J	1951	
	Bryn Mawr-Paoli	140RE	J	1962	
	Lancaster-Mount Joy	152PS	J	Late 1930s	
	Mount Joy-Harrisburg	131PS,	J	Early 1940s	
		Some 140RE	J	1951	
3	Overbrook-Paoli	140RE	W		1982
4	Zoo-Overbrook	131PS, 140RE, 155PS	M	Varied	
	Overbrook-Downingtown	140RE	W	1969 or	1982
			Few J	1953	
	Downingtown-Caln	131PS	W		1981
	Caln-Park	152PS	W		1981
	Park-Leaman Place	140RE	W		1982
	Leaman Place-MP63	131PS, 140RE	W		1983
	MP63-MP66.4	140RE	J	1947	

NOTE: SEPTA is the primary user of Track 1 between Overbrook and Paoli and Track 4 between Zoo and Paoli. Amtrak is the primary user of Track 2 and Track 3 between Overbrook and Paoli.

Source: MLMS

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[a]RE is a standard section designated by the American Railway Engineering Association (AREA).

[b]PS is the designation of a rail section designed by and produced for the former Pennsylvania Railroad.

Two other factors that may require rail change-outs are excessive curve wear and end batter of jointed rail. There are relatively few curves on the line, with only 23 curves greater than two degrees, of which only five are greater than three degrees. Curve wear appears to be a problem only on the four-degree curves at Berwyn, Gap, and Eby (east of Kinzer). Curve wear from 3/8 to 5/8 inches was measured at these locations, which will normally be upgraded by routine rail replacements or by transposing the rail sections. A major program to replace curve-worn rail is not required.

End batter occurs on jointed rail where the supporting track structure under the joints is weak. As previously mentioned, the tie condition under many of the joints needs improvement. This has resulted in some end batter of the rail in the jointed sections; however, the extent of this end batter is relatively minor. Once the tie condition is improved, a scheduled rail slotting program should correct any deficiencies without the need for any significant rail replacements. [Rail slotting is a procedure in which the rail ends are ground to a proper configuration.] Other problems created by the tie condition, such as the inability of the track to hold line and surface, will also be corrected through a tie replacement program. Problems with the jointed rail structure, such as loose or broken bolts, are handled as part of routine track maintenance.

5. Line and Surface Condition
A key factor in the overall ride quality of the Keystone line and the speeds at which passenger trains can reasonably operate is the maintenance of the line and surface of the track structure. Amtrak has an active program to maintain the line and surface in this corridor. In the past two years, more than 176 track-miles on the Harrisburg Line (nearly 75 percent) have been lined and surfaced.

Although the overall tie condition is deteriorating, thereby weakening the track structure, with the exception of a few small isolated spots, no significant line and surface problem areas were observed. The welded rail segments hold their line and surface reasonably well and require no more than routine attention to maintain their upkeep.

However, on the jointed rail sections, particularly west of Lancaster where tie condition is the worst, constant attention is required to maintain the line and surface. While the positive impact of Amtrak's program work over the past few years is evident, some deterioration on the jointed rail segments is already apparent. Once tie condition on the jointed rail has been addressed, however, a routine line and surface program should be sufficient to maintain the route for high-speed operations.

6. Drainage Condition
Good drainage is extremely important in maintaining a solid track structure, as well as in extending the life of the various track components. One of the key elements of good drainage is the ballast section, which also provides support to the overall track

structure. Other elements include the ditching and culverts that carry water away from the roadbed.

The ballast section under the railroad appeared to be in excellent condition. There was little or no evidence of fouled ballast, nor were there segments where the ballast section was either ground down or washed away. Similarly, the ditching and culvert systems were generally clear and properly functioning. Some routine ditching west of Lancaster in the next year would improve the overall condition.

There appear to be minor drainage problems between Overbrook and Paoli, but these are most likely a function of overbuilding in the area rather than a function of the track structure. Similarly, there is a problem of mud running off onto the right-of-way from a new housing development in Downingtown.

7. Grade Crossing Condition

As shown in Table II-3, the Keystone line has relatively few public grade crossings, each of which is protected by gates and flashing lights. All are in Lancaster County. Only one, Irishtown Road (MP59.2), is located east of Lancaster. The other public crossings are at Eby Cheques Road (MP77.7) and Newcomer Road (MP79.6).

Each of these locations have had rubberized crossing panels installed in recent years. The panels at Irishtown Road and Newcomer Road appear to be in excellent condition; however, the panels at Eby Cheques Road show considerable wear from truck traffic. However, wear is uniform and replacement is several years away. This wear is likely due to a cross-elevation change at the crossing, which is on a curve in excess of one degree with super-elevation of 3.5-3.75 inches.

In addition to the three public crossings, there are two private crossings protected by signs, one crossing for access to a sub-station (also with signs), and one pedestrian crossing, which is protected by a warning bell. These crossings appeared to be in acceptable condition.

8. Track Rehabilitation Program

A track rehabilitation program is required to bring parts of the line up to Class 4 (80 mph) standards, while additional improvements will be required to operate the line at 90 mph (Class 5 standards). Routine maintenance functions, such as spot tie and rail replacements, ditching, bolt tightening, rail grinding, weed spraying, etc., are not considered part of the rehabilitation requirements.

The proposed program identifies short-term, medium-term and long-term elements. The short-term elements are necessary to bring the entire line back up to 80-mph operation and should be completed in the first or second year of the program. The medium-term elements, which should be completed in the third and fourth years of the program, are necessary to maintain the various segments at either 80 or 90 mph on a continuing basis, or to raise speeds in the congested commuter territory to 80 mph. The long-term elements are those improvements that could be completed within five years to upgrade the entire line to 90 mph, improve the ongoing maintenance standards of the line, and thereby decrease transit time.

Table II-4 illustrates potential running time improvements by upgrading various track segments to either 80 mph or 90 mph. These running time improvements exclude slow orders due to curves and interlockings, or to time lost in making station stops. However, they provide an order-of-magnitude estimate of the potential impact of various improvements.

The short-term program involves relatively low-cost items and is focused on bringing the line to a minimum 80-mph condition, which will provide the greatest running time improvements. For example, upgrading Track 1 from today's speeds to a minimum of 80 mph potentially will save 5.9 minutes, while upgrading to 90 mph west of Paoli may save another 2.5 minutes. Similar improvements for Track 2 result in savings of 6.0 minutes at 80 mph and an additional 4.3 minutes at 90 mph.

Rail end batter and proper line and surface of the line are problems in the 60- and 70-mph segments; however, these problems are minor and should be corrected with improved tie conditions. Thus, the short-term program primarily involves tie replacements.

The Year 1 tie replacement program should be concentrated on one track in the territory from Lancaster west. On track #2, a 25-percent tie replacement (almost 33,000 ties) is needed to bring the entire track from 70 mph up to 80 mph standards from MP63 to Harrisburg. This tie program should concentrate on replacing all bad joint ties, as well as on eliminating clusters of failed ties. Once completed, it should be followed by a line and surface program for this segment. At that point, the speed limit on this track should be elevated to 80 mph.

The Year 2 tie replacement program should concentrate on bringing track #1 up to standard. Between MP66 and MP70.2 (westward limits of Cork) and between MP73 and MP84, track #1 is presently 70 mph and a 25-percent tie replacement on these segments is recommended. Between MP84 and MP94.8 (westward limits of Roy), where track #1 is 60 mph, a 30-percent tie replacement is recommended. A tie replacement on track #1 through State interlocking from MP103.2 to MP104.6 is also warranted. Altogether, almost 24,000 ties are needed on track #1 from Lancaster west. Once the tie program is completed, a line and surface program on this track will allow speeds to be increased to 80 mph.

TABLE II-3

GRADE CROSSING LOCATIONS

Milepost	Township	Crossing
59.2	Leacock	Irishtown Road
73.4	East Hempfield	Substation Access
75.9	East Hempfield	Oak Lane
77.7	West Hempfield	Eby Cheques Road
78.6	Rapho	Benders Road
79.6	Mt. Joy Boro	Newcomer Road
81.3	Mt. Joy Boro	Market Street Pedestrian

TABLE II-4

IMPACT OF TRACK IMPROVEMENTS ON RUNNING TIME
(minutes)

Track	MP Segment	Today	80 mph	90 mph
All	3.3 - 4.0	0.7	0.5	0.5
#4	4.0 - 5.0	0.9	0.8	0.7
#2	4.0 - 5.0	1.2	0.8	0.7
#1	4.0 - 5.0	0.9	0.8	0.7
All	5.6 - 19.1	11.6	10.1	9.0
#1	50.0 - 54.0	3.0	3.0	2.7
#1	54.0 - 57.0	2.6	2.3	2.0
#4/2	63.0 - 66.4	2.9	2.6	2.3
#1	66.0 - 66.4	0.3	0.3	0.3
#2	70.2 - 103.2	28.5	24.9	22.1
#1	73.0 - 84.0	9.4	8.3	7.3
#1	84.0 - 94.8	10.8	8.1	7.2

The tie condition on track #1 between Christiana and Kinzer (MP49 to MP54) and between Kinzer and Leaman (MP54 to MP57) should also be addressed in Year 2. The former section is welded rail, but the poor tie condition is one reason the track has not been brought up to 90 mph. The latter section is 70-mph jointed rail. A 25-percent tie replacement program of over 6,000 ties, followed by a line and surface program, should bring the track speeds on these segments to 90 and 80 mph, respectively. Replacement of the curve-worn rail in this territory should be accomplished as part of the routine maintenance program.

By the end of the second year of the program, a determination should be made whether the 80-mph segments will be brought up to 90 mph by replacing the jointed rail with welded rail. The cost of maintaining welded rail on 90-mph segments is significantly less than for jointed rail (perhaps by as much as $2,500-$3,000 per mile annually). However, considering that the jointed rail would not otherwise need to be replaced, going to welded rail to achieve 90-mph speeds is a relatively high-cost improvement for relatively small running time savings (potentially 2-3 minutes).

We recommend, as an optional improvement, that the jointed rail segments on track #1 between MP54 and MP57 and on track #4 between MP63 and MP66 be replaced with welded rail as the improvement program continues, so that both tracks from Paoli to Cork can be operated at 90 mph. This would be done concurrently with needed tie replacement. Although the potential time savings is about 20 seconds, such a program will standardize the track condition east of Lancaster and eliminate isolated maintenance intensive locations, thereby allowing day-to-day maintenance crews to be concentrated on the jointed rail territory west of Lancaster. Some annual maintenance savings will also result from the replacement of jointed rail with welded rail. (We also recommend that some of the jointed rail being replaced should be used to replace the few remaining segments of 130PS rail along the line, such as in the vicinity of Lancaster station.) If welded rail is installed on these segments, the line and surfacing and slotting programs identified for these lines can be deleted from the overall project.

If it is determined that the jointed rail west of Lancaster should be retained, then a rail slotting program should be undertaken at the end of Year 2 to eliminate end batter and other rail related problems on the jointed rail sections of both tracks. The field observations indicated a relatively minor problem with end batter; therefore, it is estimated that a rail slotting program will be required on less than 20 percent of the jointed rail sections. However, to improve ride quality, the slotting program should be undertaken over all of the jointed rail segments.

The Year 3 program should concentrate on the deteriorating tie condition on the 90-mph track west of Paoli. A 20-percent tie replacement, totaling over 50,000 ties, normally would be required on track #4 from the west end of Paoli (MP20.4) to

MP63, as well as on track #1 from Paoli to MP49 and from MP57 to MP66. However, the recommended program takes Amtrak's recent and current track projects into account. Since Amtrak tie programs over the past few years will have replaced about 40,000 ties in this territory, only about 10,000 additional ties are necessary, primarily east of Frazer and west of Park. Furthermore, 90-mph sections of track #1 between Cork and MP73 and between Roy and State should also have a 20-percent tie replacement, or about 7,000 ties.

The Year 4 program should concentrate on the commuter territory east of Paoli. Track speeds of 90 mph are not possible without changes in the signal spacing in this section, however, other improvements should allow the top speed to be increased from 70 to 80 mph, particularly on track #2 and track #3, the express tracks.

Tie condition in the commuter territory is deteriorating, yet this is the segment with the highest density of traffic. The only significant improvements to this track in recent years has been the tie and rail replacement at the new Blue Route bridge. The rail on track #1 and track #2 is jointed, while rail on track #3 and track #4 is largely welded. To maintain ride quality over this track, a minimum of 20 percent of the ties should be replaced on the welded sections and 30 percent on the jointed sections, which would require about 53,000 ties. Although the Harrisburg trains primarily use only half the tracks in the commuter territory (track #2 and track #3 between Overbrook and Paoli and track #1 and track #2 between Zoo and Overbrook) and would require only about half the ties in the absence of SEPTA service, the complete tie program on this segment is recommended. A line and surface program should be completed after the tie replacement on the jointed rail sections.

At the end of four years, all of the welded rail sections west of Paoli will be in a solid Class 5 (90 mph) condition, while the commuter territory east of Paoli and the jointed rail segments will be able to sustain 80-mph operations. If resources and funding are available, it is recommended that the third and fourth year programs be consolidated and completed in Year 3. At this point, major capital investments will be required to further reduce transit times over the line.

9. Optional Upgrading Improvements

After the four-year rehabilitation program, the line will be at either 80 or 90 mph. To further upgrade the line, the most obvious investment would be in welded rail for the remaining jointed rail sections of the line. Amtrak's policy prohibits 90-mph operations over jointed rail, even if all of the components of the track structure meet Class 5 standards. Thus, the jointed rail west of Lancaster will have to be replaced to operate at 90 mph. This would include track #2 from Cork to State, as well as track #1 from MP73 to Roy. If the joints and tie condition are properly maintained, ride quality on jointed rail at 80 mph should be almost equal to ride quality on welded rail at 90 mph. Thus, the welded rail program will not significantly improve the overall quality of the ride. Similarly, such a program would reduce running times by only 1-2 minutes, depending on the location of station stops.

The jointed rail segments east of Paoli will need to be replaced only if other actions are taken to enable trains to operate at 90 mph in this territory. The most significant of those actions would be to increase the spacing of the signals to permit 90-mph operations. Even if the entire line were put into condition for 90-mph service, there are still some problem areas that will result in slower operations. These include interlocking plants, curves, and gradients.

The interlockings, or block stations, are points at which trains can be switched between two or more tracks. Such locations include Zoo, Valley, Overbrook, Bryn Mawr, Paoli, Glen, Downs, Thorn, Caln, Park, Leaman, Cork, Roy, State, and Harris. Field inspections of the switches at Paoli, Park, Cork, and Roy revealed no apparent maintenance problems with those facilities.

There are permanent speed restrictions in place through some of interlocking plants, including Zoo, Overbrook, Bryn Mawr, Paoli, Park, Cork, and State. The tracks were recently reconfigured at Valley, thereby eliminating the slow order at that location. Furthermore, Park has been closed and will be reconfigured, which should eliminate any speed restrictions through that point.

Of the remaining locations with speed restrictions, Paoli, Cork, and State are immediately adjacent to passenger station locations, where accelerating or decelerating trains will be running at less than full speed. Therefore, any steps to increase the speed limits through those facilities resulting in any substantial costs are not warranted.

Speed limits are 30 mph (except for a small portion at 50 mph) through Zoo, where Amtrak's Northeast Corridor and Harrisburg trains and SEPTA's Paoli, Trenton, and Chestnut Hill trains all merge. From Zoo to the lower level of 30th Street Station, the speed limit is also 30 mph. The distance from 30th Street to the western limit of Zoo is about 2.3 miles. Even if trains could operate at 60 mph through this highly congested territory, less than two minutes would be saved on the schedule. Although Zoo interlocking is not included in the study area, it should be noted that Amtrak has plans to make extensive changes in its configuration. Absent those changes, no major improvements are justified there in order to reduce transit times.

At Overbrook, speeds are limited to 30-70 mph, depending on which track the train is operating. At Bryn Mawr, a 50-mph limit is imposed on track #2 and track #3. Both of these locations are in the congested commuter territory, with train operations particularly complex at Bryn Mawr, where SEPTA trains turn back to Philadelphia. High-speed turnouts and other design changes might be warranted at both locations, but only if 90-mph operations are achieved through the commuter territory. Otherwise, the transit time savings from such improvements could not possibly justify the cost of such projects.

As shown in the track chart in Appendix B, curves are numbered consecutively from Philadelphia, beginning with number 601. Speed restrictions are also imposed on 20 of the 110 curves along the route (see Table II-5), although the curve restrictions at Valley and Overbrook should not impact any Harrisburg trains. The curve at Narberth exceeds two degrees and runs for about one mile. It has a 60-mph speed restriction, as does the curve at St. Davids, which is greater than three degrees but is less than 0.2 miles in length. The curve at Devon exceeds two degrees for 0.3 miles and has a 65-mph restriction, while the Berwyn curve is greater than four degrees for 0.3 miles with a 50-mph speed limit. These curves are in four-track commuter territory and to some extent in cuts or on fill. At the present 70-mph track speed through the area, the loss of time as a result of the curves is about 0.5 minutes. Since there is little that can be done to flatten the curves in this section short of finding a new alignment for the railroad, no significant actions are warranted.

Three curves just west of Malvern are restricted to 75 mph. They are each two degree curves and their total length is about 1.6 miles. Express trains lose about 20 seconds slowing for these curves, while trains that stop at Malvern are barely impacted. Therefore, a major expenditure to reduce this delay is not warranted. However, these curves are in former four-track territory, where the two middle tracks have been removed. Using the existing right-of-way, it may be possible to flatten these three curves and raise the speed at minimal cost. A further engineering study of this will be needed to make such a determination.

Two curves west of Whitford are restricted to 60 mph for a distance of over 1.5 miles. Express trains slowing for these curves lose about 25 seconds, with the impact slightly less for trains stopping at Whitford. As long as freight track #2 is retained between Glen and Downs, little can be done about improving these curves. However, if that track is ever removed, the opportunity to flatten the curves, similar to at Malvern, should be investigated.

The two degree curve west of Atglen has a 75-mph restriction for a length of 0.7 miles. Trains approaching this speed restriction lose less than 10 seconds; however, there may be some room in the right-of-way to flatten the curves to a small extent. For such a small savings, anything greater than a minor expenditure is not warranted.

The series of curves at Gap warrant closer examination, both from the standpoint of degree of curvature and from the standpoint of gradient. The ruling eastbound grade runs through the two curves (both greater than four degrees) that have permanent slow orders in the eastbound direction, effectively making the grade even steeper,

TABLE II-5

LOCATION OF CURVES WITH SPEED RESTRICTIONS

Curve #	Milepost	Location	Speed Limit (mph)	Degrees/ Minutes Curve
610	4.2	Valley	30	4° 30′
611	5.1	Overbrook	60	3° 15′
612	6.6	Narberth	60	2° 30′
620	13.6	St. Davids	60	3° 00′
623	16.8	Devon	65	2° 20′
624	17.3	Berwyn	50	4° 00′
628	21.8	Malvern	75	2° 12′
629	22.1	Malvern	75	2° 10′
630	22.5	Malvern	75	2° 07′
638	29.7	Whitford	60	3° 00′
639	30.3	Whitford	60	2° 30′
657	47.4	Atglen	75	2° 02′
661	50.2	Gap	80	2° 00′
662	50.8	Gap	50	4° 20′
663	52.0	Gap	50	4° 10′
664	52.8	Gap	75	2° 10′
670	59.5	Ronks	80	1° 12′
671	60.2	Bird-in-Hand	75	2° 02′
672	61.0	Bird-in-Hand	75	2° 02′
701	94.6	Middletown	70	2° 12′

Source: MLMS

while westbound trains are just leaving the ruling westbound grade and are moving sharply downhill through the four westbound curves that have slow orders. The total length of this curved territory is about 2.6 miles and long trains pulled by one engine usually cannot make track speed up the grade. Trains lose more than one minute of running time through this segment. Unfortunately, the only feasible way to significantly improve the curves or gradient would be to relocate the line. For such a relatively small time savings, such a major undertaking would not appear to be warranted.

Two curves at Bird-in-Hand, both greater than two degrees, are restricted to 75 mph, while a third curve at Ronks, just east of Bird-in-Hand, is 80 mph in the eastbound direction only. There might be some limited opportunity to flatten the curves slightly within the existing right-of-way; however, the potential time savings of 20-25 seconds does not warrant a major expenditure. Furthermore, unless the Bird-in-Hand curves can be raised above 80 mph, there is no time lost as a result of the Ronks curve having an 80-mph slow order on it. However, some additional super-elevation on this curve might eliminate the existing speed restriction. One additional consideration is that a station may potentially be located at Bird-in-Hand. Any trains slowing for such a station stop would not be adversely impacted by the existing slow orders.

The final curve on the line with a speed restriction in effect (75 mph) is just west of the Middletown station and Roy interlocking. Trains stopping at Middletown are not impacted by the speed restriction, nor would there be an adverse impact if the station were relocated near the Harrisburg airport. Express trains lose only about 8-10 seconds through this curve. Due to its location, adjacent to Conrail's Royalton Branch freight track, very little can be done to improve the speed restriction through this curve.

10. Estimated Unit Costs

Various unit costs have been developed for the different work elements identified in the track rehabilitation program. These unit prices have been derived from an understanding of what a typical Class I railroad would experience in undertaking the work. Where possible, the unit prices have been broken out into categories of labor, materials, and equipment and are expressed in 1991 dollars. Telephone calls have been made to a number of suppliers to verify the price of materials.

The price per installed tie assumes a mechanized tie program. Labor is estimated at \$22.40 per tie, including fringes and overheads. The cost of a main line tie is estimated at \$22.60, including handling. Machinery, etc., for the program is estimated at \$3.60 per tie, for a total cost of \$48.40 per tie installed. It is assumed that none of the ties being removed can be marketed for landscape purposes. (Note that Amtrak has indicated they used a planning estimate of \$100 per tie on the

Northeast Corridor. However, the NEC has many more miles of interior track and maintenance must be conducted under heavier traffic conditions. Both factors tend to increase the cost of tie replacement. Amtrak estimates their costs on the Harrisburg Line would fall in the $60-$70 range.)

Welded rail is assumed to be fit 140RE sections. The price per track-foot is based upon fit rail and other track material, except for new bolts, nut locks, spikes, ties, and ballast. Labor per track foot of welded rail is estimated to be $31.50, including fringes and overheads, while materials are estimated at $31.20 per track-foot. Work train and other equipment costs are estimated at $6.30 per track-foot, resulting in a total cost of $69.00 per track-foot. (Amtrak estimates welded rail replacement at $66.30 per track-foot if new and $47.35 per track-foot with second-hand rail.)

However, the estimates for installing welded rail include a certain percentage of new ties incorporated as part of the installation. Some sections slated for welded rail will have recently had a tie replacement program. Therefore, $4.30 per track-foot should be allowed to reflect the fact that no new ties will have to be installed as part of the welded rail project. Furthermore, it is assumed that the rail being replaced can be salvaged for re-use on secondary main lines. The value of the salvaged rail and other track materials is estimated at $13.00 per track-foot, less the cost to salvage of $8.30 per track-foot. Therefore, a credit of $4.70 per track-foot should be made to reflect the net salvage value of the track materials to be replaced. The total net cost for welded rail on sections previously tied is $60.00 per track-foot.

The other element of the rehabilitation program is lining and surfacing track, which has been estimated at $1.10 per track foot for labor (including fringes). A rail slotting program, which might normally be considered a part of normal maintenance (as might lining and surfacing), has been estimated at $0.20 per track-foot.

The components of the unit prices developed have been compared with those of certain Class I and shortline railroads for reasonableness. For example, the cost of an installed tie was estimated at $48.60 per tie. By comparison, Conrail's "1991 Additions & Improvements Budget Instructions" lists the cost of a new 8'6" crosstie as $22.53, with the labor for installation at $15.19 including fringe benefits. Equipment costs are shown as $3.40, resulting in a total per tie of $41.12. Soo Line's Engineering Department uses estimates of $23.12 for ties and $21.34 for labor and other to determine total installation costs of $44.46, while CSXT's Engineering Department recommended using $24 per tie and $26 for installation costs, or a total of $50 per tie installed. A recent tie renewal program on the Octoraro Railway, sponsored by PennDOT, was undertaken by a contractor at $42.57 per tie installed.

11. Track Rehabilitation Summary

The estimated costs of the proposed four-year track rehabilitation program on the Philadelphia-Harrisburg line are set forth in Table II-6 and total $8.75 million. This total can be reduced to $6.9 million if it is decided not to install welded rail on two three-mile segments east of Lancaster. Of this total, just over $1.2 million is required for the tracks used primarily by SEPTA between Zoo and Paoli. If possible, this project should be completed over a three-year period. At completion, track speeds will be 90 mph on welded rail and 80 mph throughout all the jointed rail sections. When compared to the current nominal track speeds, these improvements should result in a running time savings of 5-6 minutes.

An additional $20.9 million optional project to replace the jointed rail with welded rail has also been developed, as also shown in Table II-6. However, the track speed increases resulting from this program would only reduce travel times by an additional 2-3 minutes, with even less savings when the impact of station stops is included. The potential benefits from such a project do not appear to justify the relatively large expense. Such an investment might be better applied to equipment that can quickly accelerate and decelerate, thereby reducing transit times as well as potentially attracting new riders.

Regardless of the investment, however, major improvements in running times over the line will not occur without some rationalization of Amtrak scheduling practices. Train times are significantly slower today than they were a decade ago. Some of this can be attributed to deteriorating track conditions, which should be addressed by the outlined rehabilitation program. Some additional schedule time might be a result of conflicts and meets with SEPTA service on the line, which has been greatly expanded west of Paoli. However, even based on current track speeds, Amtrak's schedules are slow and appear to have an excessive amount of pad. Of course, such a practice significantly increases the on-time performance and reliability of those trains.

The proposed substantial track rehabilitation program will upgrade track speeds and result in a potential 5-6 minute running time improvement. However, Amtrak's existing schedules contain at least 5-6 minutes of excessive time (generally closer to 10-12 minutes). While it is unlikely that Amtrak will tighten up the schedules without a significant track rehabilitation program, any agency funding of such a program should ensure that Amtrak will tighten up its schedules if a track project is undertaken.

Furthermore, any program should take into account the adverse effect on travel times of excessive station stops, as well as the potentially adverse impact of operating the wrong type of equipment on the line. Running times for equipment suited for rapid acceleration should be significantly better than for equipment that takes miles to get up to track speed.

TABLE II-6
ESTIMATED TRACK REHABILITATION COSTS

Year	Item	MP Segment	Location	Track	Quantity	Unit Cost	Estimated Cost	Effect
1	Ties	63.0-104.6	Witmer - Harrisburg	4/2	33,000 ties	$48.40	$1,597,200	upgrade to 80 mph
1	L&S	63.0-104.6	Witmer - Harrisburg	4/2	219,648 tf	$1.10	241,613	upgrade to 80 mph
						Year 1 Total	$1,838,813	
2	Ties	66.0-70.2	Cork - Longs Park	1				
2	Ties	73.0-94.8	Landisville-Roy	1				
2	Ties	103.2-104.6	Harrisburg	1	24,000 ties	$48.40	$1,161,600	upgrade to 80 mph
2	L&S	66.0-70.2	Cork - Longs Park	1				
2	L&S	73.0-94.8	Landisville-Roy	1				
2	L&S	103.2-104.6	Harrisburg	1	144,672 tf	$1.10	159,139	improve ride quality
2	Ties	49.0-57.0	Christiana - Leaman	1	6,000 ties	$48.40	290,400	upgrade to 80 mph
2	L&S	49.0-57.0	Christiana - Leaman	1	42,240 tf	$1.10	46,464	improve ride quality
2	Slot	63.0-104.6	Witmer - Harrisburg	4/2	219,648 tf	$0.20	43,930	improve ride quality
2	Slot	54.0-57.0	Kinzer - Leaman	1				
2	Slot	66.0-70.2	Cork - Longs Park	1				
2	Slot	73.0-94.8	Landisville - Roy	1				
2	Slot	103.2-104.6	Harrisburg	1	160,512 tf	$0.20	32,102	improve ride quality
						Year 2 Total	$1,733,635	
3	Ties	20.4-63.0	Paoli - Witmer	4				
3	Ties	20.4-49.0	Paoli - Christiana	1				
3	Ties	57.0-66.0	Leaman - Cork	1	10,000 ties	$48.40	$484,000	maintain at 90 mph
3	Ties	70.2-73.0	Longs Park-Landisville	1				
3	Ties	94.8-103.2	Roy - Harrisburg	1	7,000 ties	$48.40	338,800	maintain at 90 mph
						Year 3 Total	$822,800	
4/3	Ties	3.3-20.4	Zoo - Paoli	1				
4/3	Ties	3.3-20.4	Zoo - Paoli	2				
4/3	Ties	5.4-20.4	Overbrook - Paoli	3				
4/3	Ties	3.3-20.4	Zoo - Paoli	4	53,000 ties	$48.40	$2,265,200	upgrade to 80 mph
4/3	L&S	10.0-20.4	Bryn Mawr - Paoli	1				
4/3	L&S	3.3-20.4	Zoo - Paoli	2				
4/3	L&S	3.3-14.7	Zoo - Wayne	4	177,936 tf	$ 1.10	195,730	improve ride quality

TABLE II-6 (cont.)

Year	Item	MP Segment	Location	Track	Quantity	Unit Cost	Estimated Cost	Effect
4/3	Slot	10.0-20.4	Bryn Mawr - Paoli	1				
4/3	Slot	3.3-20.4	Zoo - Paoli	2				
4/3	Slot	3.3-14.7	Zoo - Wayne	4	177,936 tf	$0.20	35,587	improve ride quality
						Year 4/3 Total	$2,496,517	
						GRAND TOTAL	$6,891,765	
						(PORTION ON TRACKS PRIMARILY FOR SEPTA)	$1,213,871	
Optional								
2	CWR	54.0-57.0	Kinzer - Leaman	1	15,840 tf	$60.00	$950,400	upgrade to 90 mph
2	CWR	63.0-66.0	Witmer - Cork	4	15,840 tf	$60.00	950,400	upgrade to 90 mph
*	credit	L&S/Slot			31,680 tf	$1.30	41,184	
						Total Optional	$1,859,616	
						TOTAL RECOMMENDED PROJECT	$8,751,381	
Additional Optional								
5	CWR	66.0-104.6	Cork - Harrisburg	4/2				
5	CWR	66.0-70.2	Cork - Longs Park	1				
5	CWR	73.0-94.8	Landisville - Roy	1				
5	CWR	103.2-104.6	Harrisburg	1	348,480 tf	$60.00	$20,908,800	upgrade to 90 mph

Source: MLMS

B. STATIONS

Fourteen existing stations along the Keystone line were inspected. In addition, sites for potential future stations at eleven locations were assessed. Table II-7 provides details of these stations and sites.

1. Existing Locations

Amtrak currently provides service at 14 stations along the Keystone line, which were inspected in December, 1990 and again in April, 1991 and are described below.

- **Philadelphia-30th Street** - (MP 1.0). Amtrak is in the process of completing a major renovation to 30th Street Station. This facility handles both the Harrisburg and Northeast Corridor trains, serving 3,655,696 riders in 1990. It provides the full range of passenger services, as well as offering many ancillary services. Harrisburg trains now use the lower level of the station, which is accessible to the handicapped. Ample paid parking is available at municipal and private lots for about $8 per day.

- **Ardmore** - (MP 8.5). Ardmore station is adjacent to US 30 and has good highway access. This station serves selected Amtrak trains, as well as most SEPTA Paoli line trains. In 1990, Amtrak handled 15,990 passengers at this location. The station building on the eastbound side is open in the morning and early afternoon. SEPTA tickets are sold here, but it appears that Amtrak tickets are not handled. Newspapers and snacks are sold and telephones are available on the eastbound side, which also has restroom facilities. When the station is closed, there is a covered waiting area. On the westbound side, a "building" is available for use as a fully-enclosed shelter.

  The lighting and platforms are in reasonably good condition. A tunnel connecting the eastbound and westbound sides is also in acceptable condition, as are the stairways. Handicapped access, however, is limited. Platforms are low-level, making wheelchair access to trains difficult. The eastbound side can be reached conveniently by a wheelchair user; however, a ramp is necessary for a wheelchair user to reach the westbound side, which can now be reached only through the paid parking lot (controlled by a gate) at the east end of the platform.

  There is paid parking available on both sides of the station, but the lots are generally full. The eastbound lot is operated by SEPTA, which charges $10 per month for a permit, while the westbound lot is privately operated and offers long-term parking at a charge of $1 per day. Additional parking

TABLE II-7

STATION LOCATIONS BY MILEPOST

Milepost	Station	User[a]	Transit	Parking Spaces	Fees[b]
30TH STREET CONNECTION					
0.9	Penn (30th Street Station)	A	SEPTA	1000+	$8 D
0.0	Zoo				
MAIN LINE					
1.0	30th Street Upper Level	S	SEPTA		
1.9	Zoo				
8.5	Ardmore	A/S	SEPTA	110	$10 M
19.9	Paoli	A/S	SEPTA	458	$0.50 D/$10 M
21.6	Malvern	Ax/S	SEPTA	145	$0.50 D
23.8	Frazer	S*	none		
25.3	Glen (Glen Loch)	S*	none		
27.5	Exton	A/S	SEPTA	202	$0.50 D
28.3	Whitford	Ax/S	none	151	free
32.4	Downingtown	A/S	Reader	206	$0.50 D
35.0	Thorn (Thorndale)	S*	none		
38.4	Coatesville	A/S	none	40+	free
44.2	Parkesburg	Ax/S	none	60	free
47.0	Atglen	A*/S*	none		
54.1	Kinzer	A*	RRTA		
56.7	Leaman Place		RRTA		
57.1	Pequea Lane		RRTA		
58.0	Gordonville		none		
61.2	Bird-in-Hand	A*	RRTA		
68.0	Lancaster	A	RRTA	140+	$3 D
77.7	Eby Cheques Road	A*	RRTA		
80.1	Mount Joy	Ax	RRTA	50+	free
86.8	Elizabethtown	A	RRTA	70+	free
94.7	Middletown	Ax	CAT	60+	free
95.2	Harrisburg Airport	A*	none		
104.6	Harrisburg	A	CAT	150+	$8-12 D

Source: MLMS

[a]User Codes: A = Amtrak; S = SEPTA; * = proposed station; x = discontinuance recommended

[b]Fee Codes: D = Daily; M = Monthly

FIGURE II-1

Eastbound Platform at Paoli. *This is a major suburban stop for Amtrak and the western terminus of dense SEPTA commuter service.*

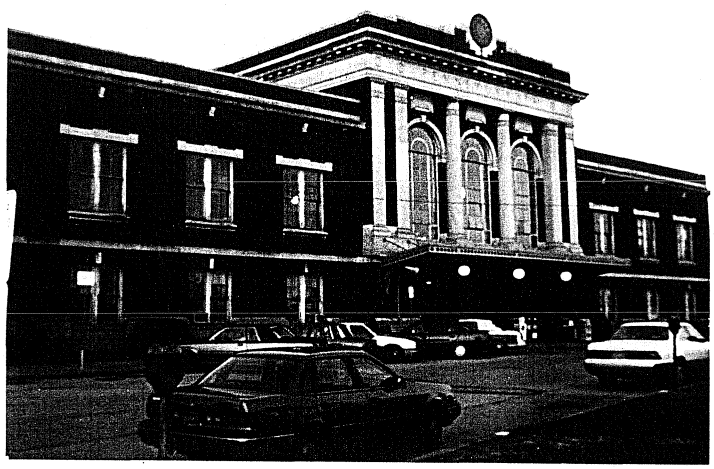


FIGURE II-2

Lancaster Station. *With the exception of 30th Street Station, Lancaster is the busiest Amtrak station on the line.*

FIGURE II-3

Harrisburg Train Shed. *Work trains with high wire cars also use the station.*

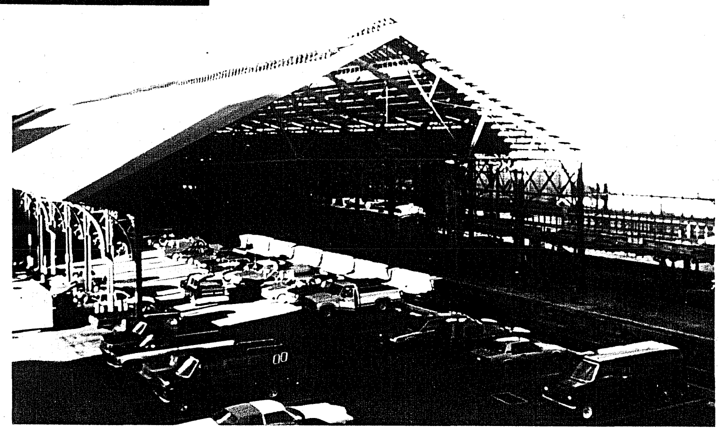


FIGURE II-4

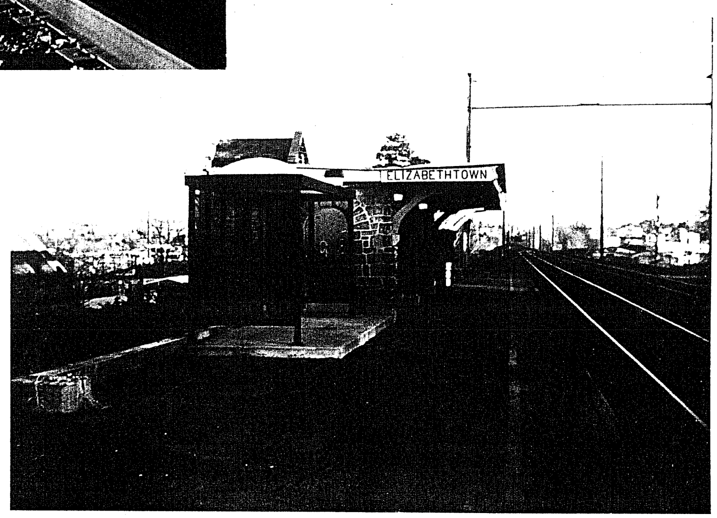
Parkesburg Station. *The building is closed and presents a poor appearance. At a minimum, platform repairs and new passenger shelters are needed.*

FIGURE II-5

Leaman Place. *Here the line joins the Strasburg Railroad, coming in from the left, and passes under US 30. A joint station has been proposed at Paradise, 0.5 mile further west.*

FIGURE II-6

Westbound Platform at Elizabethtown. *A passenger waiting room should be provided in the now closed, but attractive stone building, located to the left and below track level.*



spaces are needed at this location, which is surrounded by commercial development. SEPTA bus routes stop in reasonable proximity to the station.

- **Paoli** - (MP 19.9). Paoli is adjacent to US 30 and has good highway access. This station serves all Amtrak trains, as well as the SEPTA Paoli line trains. Amtrak handled 50,086 riders here in 1990. The station building on the eastbound side is open in the morning and afternoon. SEPTA and Amtrak tickets are sold here, but from separate windows. Newspapers and snacks are sold and telephones are available on the eastbound side, which also has restroom facilities. When the station is closed, there is a covered waiting area. On the westbound side, a "building" is available for use as a fully enclosed shelter.

  The lighting and platforms are in reasonably good condition. The eastbound and westbound sides are connected by means of a stairway from the eastbound side to a highway overpass, then from the westbound parking lot down a stairway to the platform. The stairways are in acceptable condition. Handicapped access, however, is limited with low level platforms making wheelchair access to trains difficult. The eastbound side can be reached without problem by a wheelchair user; however, for a wheelchair user to reach the westbound side it would be necessary to cross the four active tracks, which are separated by a mid-track fence to prevent access. Furthermore, the small "temporary" platforms between these tracks are not lined up to allow effective wheelchair access.

  There is paid parking available on both sides of the station at a rate of $0.50 per day or $10 per month, but the lots are generally full. Additional parking spaces are needed at this location. SEPTA bus routes serve the station directly as feeder lines from local business parks or stop in reasonable proximity to the station.

- **Malvern** - (MP 21.6). Malvern station is located off King Street and has good highway access to the eastbound side; however, the westbound side is reached either through a narrow highway tunnel or by a winding residential street. This station serves about half of the Amtrak trains, as well as the SEPTA Downingtown trains. Amtrak's ridership at the station was 8,662 during 1990. The station building on the eastbound side is open for a few hours in the morning. Amtrak tickets are sold here, but not SEPTA tickets. Newspapers are sold, but not snacks, and telephones are available on the eastbound side, which also has a restroom. When the station is closed, there is no protected waiting area. Similarly, on the westbound side there is no shelter of any type.

The lighting and platforms are in reasonably good condition. The eastbound and westbound sides are connected by means of a ramp from the westbound side to a highway underpass, then to a stairway through the eastbound parking lot to the platform. The ramp and stairway are in acceptable condition. Handicapped access, however, is limited with low level platforms making wheelchair access to trains difficult. The eastbound side can be reached without problem by a wheelchair user; however, for a wheelchair user to reach the westbound side it would be necessary to go up the steeply inclined ramp or cross the tracks, which is unsafe and difficult due to the different elevations of the platforms.

There is paid parking ($0.50 per day) available on the eastbound side of the station and a free municipally-owned lot on the westbound side, but the lots are generally full. Additional parking spaces are needed at this location. SEPTA bus routes stop in reasonable proximity to the station.

- **Exton** - (MP 27.5). Exton station is off PA 100 and has good highway access and can be reached through residential streets. This station serves more than half of the Amtrak trains, as well as the SEPTA Downingtown trains. The station was constructed by SEPTA in the late 1970s and served 6,195 Amtrak riders in 1990. There are no buildings on either side, although shelters are provided on both sides. No tickets are sold here and newspapers and snacks are not available, but telephones are provided.

  The lighting and platforms are in good condition. The eastbound and westbound sides are connected by means of a stairway from the westbound side to a highway underpass, then to a stairway through the eastbound parking lot to the platform. The stairways are in acceptable condition. Handicapped access to trains is via a high-level ramp at one end of each platform. These ramps appear to be unused. Each platform can be reached without problem by a wheelchair user.

  There is paid parking available on both sides of the station for $0.50 per day. While the lots are generally full, some spaces are available because of the large number of cars parking along the roadway or in neighboring fields. Therefore, additional parking spaces are needed at this location. It is understood that property for an additional 200 parking spaces has been acquired. SEPTA and Reeder's bus routes stop in reasonable proximity to the station. Reeder's Inc. provides hourly weekday service between Coatesville and West Chester, with Downingtown and Exton served en route.

- **Whitford** - (MP 28.3). Whitford station is off Whitford Road and has acceptable highway access, although it is reached through winding residential streets. This station serves only a few of the Amtrak trains, as well as the SEPTA Downingtown trains. Amtrak ridership at this location in 1990 was 5,198. The station is sandwiched in under a bridge supporting a Conrail freight line, but over the Whitford Road bridge. There is a small building that is open for use as a shelter on the eastbound side; however, no tickets are sold here. There is no shelter on the westbound side. Newspapers and snacks are not available, but telephones are provided.

  The lighting and short platforms are in adequate condition. The eastbound and westbound sides are connected by means of a stairway from the westbound side to a highway underpass (which has no sidewalk), then to a stairway through the eastbound side to the platform. The stairways are in acceptable condition. The platforms are low-level, making wheelchair access to trains difficult. The eastbound platform can be reached without problem by a wheelchair user, but the westbound platform cannot be accessed without using the stairs or crossing the tracks.

  There is a limited amount of free parking available on both sides of the station, although the platform on the westbound side is reachable from the park lot only via the stairs. The lots are generally full, with a large number of cars parking in neighboring fields, indicating a need for additional parking spaces. However, the gravel lot currently owned by SEPTA on the westbound side will eventually be taken by PennDOT as part of the Exton by-pass project. No SEPTA bus routes stop near the station.

- **Downingtown** - (MP 32.4). Downingtown station is adjacent to business US 30 and has reasonably good highway access. This station serves all of the Amtrak trains, as well as the SEPTA Downingtown trains. Amtrak ridership in 1990 was 27,542 at Downingtown. There is a station building in fair condition on the eastbound side, which is open but sells only Amtrak tickets during the morning and early afternoon, and a shelter on the westbound side. Newspapers and snacks are not available, but telephones and rest room facilities are provided.

  The lighting and platforms are in adequate condition. The eastbound and westbound sides are connected by a passenger tunnel, which is in acceptable condition but cannot be used by handicapped individuals. The platforms are low-level, making wheelchair access to trains difficult. The westbound platform can be reached without problem by a wheelchair user, but the eastbound platform is difficult for handicapped users to reach from some parking lot locations.

There is a parking lot on the eastbound side and a limited amount of parking is available on the westbound side. The daily parking fee is $0.50 and the parking lots fill to capacity. Municipal parking is also available at a higher daily rate. Additional parking spaces are needed at this location. Reeder's buses stop near the station.

- **Coatesville** - (MP 38.4). Coatesville station is one block north of business US 30 and has reasonably good highway access. This station serves about 75 percent of the Amtrak trains, and SEPTA has recently added three Parkesburg trains that stop here. Coatesville was used by 19,127 Amtrak riders in 1990. There is a station building on the eastbound side that is open, but sells only Amtrak tickets during the morning. The building is currently boarded up and has a rather poor appearance, and the shelter on the westbound side is in disrepair. Newspapers and snacks are not available, but telephones are provided.

  The lighting is in adequate condition, but the platforms are in need of attention. The eastbound and westbound sides are connected by means of a driveway tunnel, which is in fair condition but cannot be used easily by handicapped individuals. The platforms are low-level, making wheelchair access to trains difficult. The westbound platform can be reached only through the tunnel or across the tracks and is not readily accessible to a wheelchair user. The eastbound platform, which is at a different elevation than the entrance to the station, is difficult for handicapped users to reach.

  There is a fair amount of parking available on the westbound side and a limited amount on the eastbound side. The parking is free, but the parking lots were empty. The station agent indicated that riders are generally afraid to leave their cars at this location. Reeder's bus service is available along Main Street (US 30 Business) a short distance away.

  A city rehabilitation program for the station building is about to get underway. Though this will not directly address the need for passenger improvements, it should correct structural and maintenance deficiencies, bring in tenants, improve the general appearance of the area, and provide additional security.

- **Parkesburg** - (MP 44.2). Parkesburg station is one block north of PA 372 near the intersection with PA 10 and has reasonably good highway access. This station serves about half of the Amtrak trains, while SEPTA has recently added three Parkesburg trains that stop here. Amtrak ridership in 1990 was 7,853. There is a station building on the eastbound side that is boarded up and has a rather poor appearance. The building is closed and provides only limited shelter. The shelter on the westbound side is adequate but presents a poor appearance. No signs or train schedules are posted and the telephones do not work.

The lighting is in fair condition, while the platforms are in need of attention. The platforms are low-level, making wheelchair access to trains difficult. Each side of the station can be reached by road.

There is some unpaved parking available on the eastbound side and a limited amount of parking available on the westbound side. The parking is free and the parking lots were full. No SEPTA bus routes stop near the station.

- **Lancaster** - (MP 68.0). Lancaster station is located on McGovern Avenue, one block from US 222. It has reasonably good highway access, although directional signage is poor and one-way streets result in indirect access from the west. This station serves all of the Amtrak trains, including the Broadway Limited, and ridership in 1990 was 206,413. This total exceeds the boardings at Harrisburg and is about twice the level that Amtrak handles on its trains through Pittsburgh. There is a station building that serves both directions, which was renovated in the late 1970's and provides most of the amenities expected by passengers. Food service, however, is limited and the ticket office is open for about 16 hours per day.

  The platforms are reached via stairs leading down from an enclosed pedestrian walkway which, along with lighting and canopies over the platforms, are in good condition. Hi-level platforms allow wheelchair access to trains. However, wheelchair users cannot get to the platforms (or ticket window) through the main waiting room, which is located upstairs. Instead, handicapped riders must use the baggage elevators outside the station, which is not a particularly pleasant means of access and requires the assistance of the baggage man.

  There is parking available at $0.25 per hour or $3.00 overnight. The parking lots were filled to about two-thirds capacity. RRTA and intercity buses stop at the station.

- **Mount Joy** - (MP 80.1). Mount Joy station is on Marietta Avenue (PA 772) just off PA 230 and has reasonably good local highway access, but is in a poor location for regional users. This station serves about half of the Amtrak trains, and ridership in 1990 was only 1,744. The station is in a cut and is only reachable by stairs from the street. Small bus type shelters are at platform level. No signs or train schedules are posted and no other amenities are provided.

There was no apparent lighting except at the street level. The platforms are in good condition, but at low-level making wheelchair access to trains difficult. However, wheelchair users could not even reach the platforms, since stairways, although in good condition, provide the only access to street level.

There is some limited free parking available on the westbound side in a public lot, but the parking lots were largely empty. RRTA bus routes stop near the station.

- **Elizabethtown** - (MP 86.8). Elizabethtown station is on High Street, a few blocks south of PA 230 and has reasonably good local highway access; however, it is in a poor location for regional users. This station serves all of the Amtrak trains, except the Pennsylvanian, and ridership was 13,043 in 1990. The beautiful stone station building is closed, along with the elevator to the overhead platforms. Shelters are provided at platform level, and telephones are the only other amenities provided.

  The lighting and platforms are in very good condition, as are the tunnel from the station under the tracks and the stairs to the platforms. The platforms are low-level, making wheelchair access to trains difficult. However, wheelchair users cannot reach the platforms since the elevator is out-of-service leaving stairways as the only access from street level.

  There is ample free parking adjacent to the station, and the parking lots were about 25 percent occupied. RRTA bus routes stop on PA 230, several blocks from the station.

- **Middletown** - (MP 94.7). Middletown station is on Mill Street south of PA 230 and has reasonably good local highway access, but it is in a poor location for regional users. This station serves about half of the Amtrak trains, but ridership in 1990 was only 3,757. The station is on a curve and has a platform on the westbound side only. A small bus type shelter is adjacent to the platform, up a small ramped sidewalk from the parking lot. No other amenities are provided.

  The platform is in good condition, but is low-level, making wheelchair access to trains difficult. As the station is on a curve, the step up to the coaches is quite steep.

  There is an ample paved parking lot available on the westbound side. Although parking is free, the lot was largely empty. CAT bus routes apparently operate near the station.

- **Harrisburg** - (MP 104.6). Harrisburg station is located on Chestnut Street within walking distance from the Capitol complex. It has reasonably good highway access, although directional signage is poor. This station serves all of the AMTRAK trains, including the Broadway Limited, and ridership in 1990 was 197,321. The station building was renovated in the early 1980's and provides for most of the amenities expected by passengers, although food service is limited. The ticket office is open for about 16 hours per day.

  The platforms are reached via stairs down from an enclosed pedestrian walkway which, along with the lighting and train shed over the platforms, is in good condition. The platforms are hi-level, allowing for wheelchair access to trains. However, to reach the platforms, wheelchair users must use the baggage elevators, which usually requires the assistance of a redcap.

  There is short-term parking available in front of the station at $0.25 per half hour or long-term permit parking underneath the station. The parking lots were about half full. In addition, several municipal lots are within one or two blocks of the station; however, the rates at these public lots run as high as $12 per day. Some reasonably priced all-day parking spaces need to be provided to encourage travel by occasional users. CAT and intercity bus routes stop at the station.

2. Potential Station Sites

Sites of potential new station stops in the joint Amtrak-SEPTA territory between Paoli and Parkesburg, as well as in the segments between Parkesburg and Lancaster and between Lancaster and Harrisburg, were identified from field inspections and are described below.

- **Frazer** - (MP 23.8). Frazer is located on PA 352 near US 30. Highway access to the station site is severely restricted due to a narrow underpass that would make turns rather dangerous. The site is at the location of the former Frazer station and is just east of the new SEPTA maintenance facility. The passenger tunnel from this station is still in place, although it is now used as a conduit for electrical wires. However, it may be possible to relocate the utilities now in the passenger tunnel. No other facilities are in place and the potential for parking is limited at the site. However, a potential site for a parking lot is available across PA 352. SEPTA has plans available for the layout of this station site.

- **Glen Loch** - (MP 25.3). Glen Loch is located on Phoenixville Pike near US 30. Highway access to the station site is good. The site is near the former

Glen Loch station. Plans for a development proposed at this location would result in a station being built for SEPTA.

- **Thorndale** - (MP 35.0). Thorndale is located on business US 30 and the station site is at the west end of Thorn Tower where Conrail's Trenton Line joins the Amtrak line. A highway underpass at South Bailey Road can be used as a passenger tunnel. SEPTA has acquired 6.5 acres for parking at this site. No other facilities are in place at this location, although SEPTA has plans to place a station at this site.

- **Atglen** - (MP 47.0). Atglen is located on PA 41, just north of PA 372, in the right-of-way of Conrail's former low grade line immediately adjacent to the Amtrak line. Highway access is excellent from both Chester and Lancaster Counties. SEPTA has acquired land sufficient for 250 parking spaces at this site. No other facilities are in place at this location, although SEPTA has plans to place a station at this site.

- **Kinzer** - (MP 54.1). Kinzer is located on US 30 and the site, adjacent to an RRTA bus turnaround, has room for a moderate sized parking lot. Highway access is excellent. The tunnel is in place at Kinzer Road. No other facilities are in place at this location. Handicapped access to the platforms might be difficult, since track level is about 15 feet above the roadway level at this point.

- **Leaman Place** - (MP 56.7). Leaman Place is located on US 30 and the site is on a curve and adjacent to the Strasburg Railroad. This site, served by an RRTA bus route, has room for a moderate sized parking lot on the eastbound side, but access on and off US 30 is quite hazardous. The US 30 bridge over the railroad does not have a sidewalk and could not be used for patrons going from one platform to the other. A lumber yard on the westbound side prevents the development of any facilities along US 30. No other facilities are in place at this location.

- **Pequea Lane** - (MP 57.1). The Pequea Lane site is located just north of US 30 and west of the existing terminus of the Strasburg Railroad. This site was recently proposed by the Strasburg Railroad and has not been inspected. The Pequea Road underpass could be used as a pedestrian crossing point and the site could be served by a slightly detoured RRTA bus route. The site has adequate room for parking and access from US 30 is acceptable. No other facilities are in place at this location and the Strasburg Railroad would need to be extended almost one-half mile to effect an interchange with Amtrak passengers at this location.

- **Gordonville** - (MP 58.0). Gordonville is located on Leacock Road, between US 30 and PA 340 at the former station location, which is now occupied by a feed mill. The site has room for a moderate sized parking lot on the eastbound side, but access on and off Leacock Road is difficult to the westbound side, which is residential in nature and has little room for parking. The stairway from Leacock Road to the former westbound station is still in place; however, the bridge over the railroad does not have access to the eastbound side and could not be used for patrons going from one platform to the other. No other facilities are in place at this location.

- **Bird-in-Hand** - (MP 61.2). Bird-in-Hand is located on PA 340 and an RRTA bus route serves the site, which is the former station location now occupied by a potato mill and storage company. The location has room for a moderate sized parking lot on the eastbound side. The stairways from PA 340 to the former eastbound and westbound platforms are still in place; moreover, the tunnel under the railroad can be used for patrons going from one platform to the other. No other facilities are in place at this location.

- **Mount Joy (Eby Cheques Road)** - (MP 77.6). A site on Eby Cheques Road is located just east of Mount Joy at the grade crossing off PA 230 near the PA 283 exit. The location, served by an RRTA bus route, is in a light industrial area and has room for a moderate sized parking lot. Access off the major area roads is excellent and the grade crossing can be used for patrons going from one platform to the other. No other facilities are in place at this location. Handicapped access between the eastbound and westbound platforms can be accomplished without the need for any ramps, overpasses, or tunnels.

- **Harrisburg Airport** - (MP 95.2). A Harrisburg Airport/Penn State campus site is just west of Middletown along PA 230 near the PA 441 exit. The location has room for a moderate sized parking lot with excellent access off the major area roads. No other facilities are in place at this location. Handicapped access between the eastbound and westbound platforms may be difficult, as the site is raised above the adjacent roadway. Furthermore, station design would have to blend with the airport facility and should also provide access to the Penn State campus without requiring pedestrians to cross PA 230 at grade.

3. Station Recommendations

Amtrak's Harrisburg line trains currently serve as many as 14 stations. In some locations, station spacing is as little as 1-2 miles, though elsewhere the spacing exceeds 24 miles. While track programs to increase speeds to 80 mph are intended both to reduce travel times and improve ride quality, programs to go to 90 mph are primarily to reduce travel times. The purpose of any such programs will be largely defeated if trains make too many stops; however, it is equally important that trains stop at sufficient points to attract passengers to the system.

We recommend that station spacing in the joint Amtrak-SEPTA territory be increased for the Amtrak trains by consolidating certain stops, and that two new station locations be developed for local commuter traffic. The station at Malvern is less than two miles from Paoli, while the station at Whitford is less than one mile from Exton. While both stations generate considerable ridership, that traffic is primarily commuter in nature (as opposed to intercity) and would best be handled by expanded SEPTA service on the Downingtown Line. Thus, Amtrak trains should drop those locations. As a result, Amtrak trains would have six mile station spacing between Paoli and Parkesburg. The new stops at Frazer and Thorndale are recommended, but only to serve the commuter market. Should the developer construct a station at Glen Loch, this also should be for SEPTA passengers only.

The area between Parkesburg and Lancaster, the fast growing region of Lancaster County, does not have any local stations. SEPTA has proposed extending their service to the Chester County-Lancaster County boundary by building a station at Atglen. This site has excellent highway access from western Chester County and from eastern Lancaster County. When compared to the Parkesburg station location, Atglen provides much better access for potential Amtrak patrons in the region. Therefore, we recommend that Amtrak service at Parkesburg be relocated to the Atglen station once it is developed.

Of the four sites evaluated in eastern Lancaster County, we believe Bird-in-Hand is in the best location (along busy PA 340) and offers the best station site. It is in the middle of a highly travelled tourist and Amish corridor and offers direct access to local RRTA transit services. However, it is also only seven miles from Lancaster and is not in the middle of this section. We believe the next best alternative is Kinzer, with good access off US 30 at an RRTA bus turnaround. The two stations closest to the mid-point of the segment are the poorest site alternatives. Gordonville is not along a major road or transit route and presents potential problems with highway and handicapped access. Leaman Place, while attractive because of the Strasburg Railroad, is even worse as a site. Access from US 30 is quite dangerous, the proximity of the lumber yard presents station development problems, the curve is a dangerous location to be boarding trains, and access for both handicapped and non-handicapped riders between the eastbound and westbound tracks will be difficult.

We recommend that both Bird-in Hand and Kinzer be developed as station sites. To minimize the number of Amtrak stops in this area, however, we suggest that trains alternate stopping between the two sites. However, since our initial recommendation, the Strasburg Railroad has proposed another site as a possible station location. Pequea Lane would provide a safe connection with the Strasburg Railroad, which handles over 425,000 passengers annually. The site is centrally located almost half-way between the Bird-in-Hand and Kinzer sites and could be served by RRTA. Should only one station be developed in eastern Lancaster County, this would be in the middle of the region and would be equally spaced between the proposed Atglen station and the Lancaster station. A major drawback, however, is the need to extend the Strasburg Railroad (about 0.5 miles) along the Amtrak right-of-way. Such an extension, plus the cost of the station, might easily exceed $1 million. We recommend that this option be explored further, but suggest that unless the extension can be developed in the short-term, plans continue forward with adding an eastern Lancaster County station at one of the recommended locations as soon as possible.

West of Lancaster, we recommend that two stations be relocated. The Mount Joy station is the most poorly patronized station on the line, with an average of less than three boarding and four alighting passengers per weekday, which equates to less than one person per train. The station is poorly located (in a cut in the center of a small community) and cannot effectively serve the surrounding region. We suggest that it be relocated to Eby Cheques Road, which provides excellent access from the western Lancaster suburbs. The Middletown station, situated on a sharp curve so that it can only be served from one track, is also poorly located, Middletown has the second lowest ridership on the line (six on/eight off per weekday), averaging only one or two riders per train. We recommend moving the station to the Airport/Penn State site, which is adjacent to major highways in the region. By relocating the two stations, spacing between Lancaster and Harrisburg is adjusted to 9-10 miles.

4. Improvements

The five recommended Amtrak station sites (Atglen, Kinzer, Bird-in-Hand, Eby Cheques Road, and Harrisburg Airport), if supported by ridership projections, will all have to be developed to provide full accessibility to the handicapped. Similar facilities will also have to be included at the new SEPTA only sites (Frazer, Glen Loch, and Thorndale). Such stations generally cost $250,000-$350,000 for the basic platform, shelter and lighting. Costs for any passenger bridges or tunnels, as well as land acquisition and parking facilities, are not included in this estimate.

Existing stations do not have to meet full accessibility standards until 2010; therefore, we have not identified the improvements needed to bring them to full accessibility. Nevertheless, they do require improvements. As a minimum, we recommend that every station have a heated waiting area with lights and a telephone. At Coatesville and Parkesburg, we recommend installation of pre-fabricated plexiglass shelters, with time-lock entrance, electric heat element, lights and a telephone, at a costs of about $100,000 each, including site preparation. Further, we recommend that a portion of the station building at Elizabethtown be partitioned off for use as a heated, sheltered waiting room. Platform repairs are also required at Coatesville and Parkesburg, which should be accomplished when the new shelters are being installed and should be relatively minor in cost. The total estimated improvement cost at existing stations is about $300,000, as shown in Table II-8.

The biggest problem that needs to be addressed, however, is the availability of parking. While SEPTA has plans for two large parking lots west of Downingtown, every station from Downingtown east is near or at its parking capacity. Plans are being evaluated for a multi-level parking garage at Ardmore, but additional parking is needed throughout the SEPTA territory. This is primarily a SEPTA problem, existing at both Amtrak and non-Amtrak stations along the line; however, the lack of parking will also limit the number of intercity riders. Also, since Amtrak owns the stations, it must approve any plans for station development and parking expansion.

C. ELECTRIC TRACTION SYSTEM

The objective in this portion is to assess the condition of the traction electrification system and verify its suitability for electrical service between Philadelphia and Harrisburg. The electric traction system was constructed by the Pennsylvania Railroad in the 1930's. Electric power comes from the Safe Harbor generating facility. Our understanding is that the two 28-MW water wheels and one 25-MW frequency converter are owned by the Pennsylvania Power and Power Company (PP&L), while the voltage step-up facility is owned by Amtrak, which also has certain maintenance responsibilities at the facility. Power from Safe Harbor is fed to the Harrisburg line at Royalton and at Parkesburg, as well as directly to the Northeast Corridor at Perryville. Amtrak stated that the existing power system has been sufficient to support the varying levels of service over the past 60 years, and that no recent assessment has been made to evaluate the level of traffic it has the potential to support.

For our purposes, a field trip was undertaken on April 11, 1991, during which a number of stops were made along the route to inspect the general condition of the traction power substations and the overhead catenary system supplying electrical power to the trains. It should be noted that due to the time and budget limitations, only cursory inspection was possible. Therefore, the cost estimates and conclusions should be considered only as preliminary.

1. Field Trip Observations

A total of 15 stops were made along the system between Philadelphia and Harrisburg. The electrification system was observed using binoculars and no detailed inspections, such as contact wire wear measurement, were performed. The major items observed are noted as follows:

- **Stop 1. MP 12.6, Radnor, Blue Route.** Construction of new overhead catenary system and replacement of the wire was observed in this 4-track area. The overhead system installed is the inclined catenary type.

- **Stop 2. MP 13.8, St. Davids Station.** The overhead catenary is in good overall condition. There were no broken strands on any of the messenger wires. Several new insulators were noticed on the catenary and feeder conductors. Some supporting poles will require painting in the near future.

- **Stop 3. MP 19.5, PA 252 and Paoli.** The overhead system is in satisfactory condition. There were no broken strands noticed and several new insulators were installed.

  The supporting poles will need new paint in the future. A pole foundation was crumbling somewhat. Although not considered as critical, it is recommended that the foundation condition be regularly monitored.

  The contact wire wear was significant, approximately 30 percent of the original cross-section area. For continuing electric service, replacement of the contact wire is recommended.

- **Stop 4. MP 25.3, Glen Loch.** The overhead system condition was considered to be generally good. The contact wire wear was estimated at approximately 30 percent. For continuing electric service, replacement of the wire is recommended.

- **Stop 5. MP 38.8, Coatesville.** The overhead system was in acceptable condition with no major shortcomings observed with the possible exception of the contact wire wear.

- **Stop 6. MP 44.0, Parkesburg.** Substation No. 66 was inspected, including the following traction power equipment, signal power supply equipment and station auxiliaries:

  Traction power equipment. Substation No. 66 is supplied from 138-kV subtransmission system and contains three step-down transformers with the following parameters:

Power rating: 4,500 kV-A
Voltage: 132,000/12,000 V
Impedance: 4.3%
Frequency: 25 Hz
Temperature rise: 45 degrees C
Coolant: 4,980 gallons of oil

The transformer is connected to the high voltage system via disconnect switches. The transformer secondaries feed the overhead catenary via an arrangement of circuit breakers and disconnect switches.

Signal power supply equipment and station auxiliaries. This substation also contains a building housing metering, control and signal power supply equipment. The signal power supply equipment consisted of two motor/generator sets. Each set included the following equipment:

20 hp, 220 V	Repulsion-start, single-phase, induction motor
100 hp, 2300 V	Induction motor
70 kV-A, 440 V	AC generator

The condition of the traction power supply equipment was judged good considering the age of the equipment. The substation is obviously well maintained.

The metering equipment was in very good condition and the control equipment appeared in reasonable condition. However, one of the signal power supply motor/generators was inoperative.

- **Stop 7. MP 47.0, Atglen.** The overhead system was in generally good condition at this location. The contact wire wear appeared to be approximately 30 percent worn.

- **Stop 8. MP 49.8, Undergrade Bridge.** The overhead system in this location was in generally good condition, similar to previous locations.

- **Stop 9. MP 51.0, Gap.** The overhead catenary system is of the "triangular" type with two messenger wires and one contact wire. General condition is acceptable.

- **Stop 10. MP 54.0, Kinzer.** Kinzer substation No. 67 was inspected without actually entering the substation site. The condition of the facility appeared generally good.

  The overhead system was also in generally good condition at this location. The contact wire wear appeared to be approximately 30 percent worn.

- **Stop 11. MP 55.94, Belmont Road.** The overhead system in this location was in generally good condition, similar to previous locations.

- **Stop 12. MP 57.39, Pequea Creek.** The overhead system in this location was in generally good condition, similar to previous locations.

- **Stop 13. MP 61.9, Mill Creek.** The overhead system in this location was in generally good condition, similar to previous locations.

- **Stop 14. MP 63.0, Witmer.** The overhead system in this location was in generally good condition, similar to previous locations.

- **Stop 15. MP 66.4, Cork.** The overhead system in this location was in generally good condition, similar to previous locations. However, the contact wire wear appeared to be less than the approximate 30 percent observed elsewhere.

2. Upgrade Recommendations
In order to operate the Philadelphia-Harrisburg Keystone service at either 80 mph or 90 mph and to enable regular scheduled operation of Amtrak trains, it is recommended that the following work be performed on the electric traction system:

a. An analysis of the transformer coolant to determine oil condition. The following tests should be performed:

   - Dielectric breakdown voltage test
   - Acidity test
   - Gas-in-oil analysis
   - Interfacial tension test
   - Power factor test

   The deteriorated oil should be filtered or replaced as appropriate.

b. A detailed survey of the contact wire condition to determine sections where contact wire replacement is necessary.

c. Replacement of the 12-kV oil circuit breakers with modern 12-kV switchgear equipped with multi-zone distance protection and overload relays.

3. Upgrade Cost Assessments
The cost assessment of the upgrade is presented in two parts: substation upgrade and overhead catenary system upgrade.

a. Substation Upgrade. The cost of substation upgrade will depend on the results of the oil analyses and the actual number of transformers treated. Further, the cost will include the price of the 12-kV circuit breakers and their installation cost. Table II-9 shows the number of transformers and circuit breakers in each substation.

Substation #9, at Zoo, is not considered as part of the Harrisburg line. A transmission system runs from Sub #9 Zoo up the former Schuylkill Valley Branch to Earnest, then along the Trenton Branch to Sub #64 Frazer. Another transmission line runs from Sub #55 Safe Harbor west to Sub #71 Royalton and east to Sub #66 Parkesburg. This route runs along Conrail's Columbia Branch and former Enola Branch. Voltages utilized for the transmission system are 138,000 volts stepped down to 12,000 volts, 25 Hz.

The substation upgrade effort is estimated as follows:

Transformer oil analysis @ $300/transformer [$300 x 24 transformers tested]	$7,200
Oil replacement @ $12,000/transformer [$12,000 x 6 transformers (estimated)]	$72,000
Circuit breaker replacement @ $35,000/breaker [$35,000 x 35 breakers]	$1,225,000
Total substation upgrade estimate	$1,304,200

The number of transformers and circuit breakers subject to this upgrading program may actually be less than identified here. Since Conrail has eliminated the electrification on the Trenton Cut-off Line, the power demand on the Parkesburg, Thorndale, and Frazer substations is lower. However, in order to determine how many transformers and circuit breakers could be retired, a more detailed power demand study would be required. Such a study might reduce the upgrading requirement by

TABLE II-8

COST OF STATION IMPROVEMENTS

Location	Improvement	Cost
Coatesville	New Shelter	$100,000
Coatesville	Platform	20,000
Parkesburg	New Shelter	100,000
Parkesburg	Platform	20,000
Elizabethtown	Waiting Room	60,000
	Total	$300,000

Source: MLMS

TABLE II-9

SUBSTATION EQUIPMENT

Name	Substation Number	Milepost	Number of Transformers	12-kV Oil CBs
Bryn Mawr	#3	10.1	0	1
Paoli	#4	20.1	2	3
Frazer	#64	24.8	3	4
Thorndale	#65	33.8	4	5
Parkesburg	#66	44.0	3	4
Kinzer	#67	54.1	2	3
Witmer	#68	62.0	2	3
Landisville	#69	73.3	2	3
Rheems	#70	83.9	2	3
Royalton	#71	94.0	2	3
Harrisburg	#72	104.1	2	3
Total			24	35

Source: LTK Engineering Services

as much as $150,000 (four transformer tests, one oil replacement, and four fewer breakers). We recommend that such a study be undertaken before proceeding with the substation upgrading program. However, in the absence of such a study, since the transformers and circuit breakers also improve the system feeding and sectioning flexibility, we do not recommend the reduction of any equipment.

b. Overhead Catenary System Upgrade: The cost of the overhead catenary system upgrade will depend on the actual length of contact wire replaced. The total length of main line electrified trackage is estimated at 253 miles. Assuming that 80 percent of the wire needs to be replaced and allowing 10 percent for yard, crossovers and stations, the length of wire to be replaced is: 1.1 x 253 x 0.8 = 223 miles.

Cost of contact wire @ $15,000/mile [$15,000 x 223 miles]	$3,345,000
Cost of installation @ $20,000/mile [$20,000 x 223 miles]	$4,460,000
Total overhead catenary system upgrade	$7,805,000

We have estimated the cost of "trolley" wire replacement at $35,000 per mile. Amtrak, however, uses a conceptual planning number of $52,000 per mile in estimating replacement costs.

Our recommendation is that contact wire with excessive wear, over 20 percent of the original cross-section area, should be replaced. Catenary system design calculations, such as wire tensions for various temperatures and span lengths, are based on a certain wire wear condition. In the absence of actual design parameters, a typical value of 30% wear was assumed. In the event that the wear exceeds the design condition, the tension increases beyond the permissible value and the wire can break. Therefore, any time wear is observed that exceeds 20%, a survey should be carried out to identify the actual wear and identify catenary system hard spots that are subject to breakage. For the purposes of this study, we have assumed that 80% of the catenary wire will need to be replaced within five years. A detailed inspection of the wire condition, however, may identify considerably less wire to be replaced; therefore, we recommend such a detailed study be undertaken before the upgrading program is initiated. The results of such a detailed study may reduce the upgrading requirement by as much as $2,000,000.

Field observation indicates that the traction power substations and the overhead catenary system along the Philadelphia-Harrisburg line are in reasonable condition, considering the age of the equipment. However, in order to use the line for the service intended, it is recommended that the electrification equipment along the line be upgraded to withstand the increased level of operation. In particular, it is recommended to:

- Identify and replace deteriorated oil in the substation equipment,
- Replace the 12-kV oil circuit breakers feeding the overhead catenary system, and
- Replace worn contact wire.
- Conduct more detailed studies of power demand and contact wire wear.

The total cost to upgrade the traction electrification system for the Keystone service along the Philadelphia-Harrisburg line is estimated at $9,109,200, although this may be reduced to about $7 million based on the findings of more detailed power demand and contact wire wear studies. Following the equipment upgrade, the electrification system should be capable of supplying adequate traction power for the Keystone service.

D. SIGNAL SYSTEM

This portion of the study provides estimates of the nature and capital cost of improvements and rehabilitation to the signal system required for operation of passenger trains at (a) 79 miles per hour and (b) 90 miles per hour.

A member of the R. L. Banks consultant team observed the signal system and its operation from the cab of one Amtrak train from Philadelphia to Harrisburg and another from Harrisburg to Philadelphia. Amtrak furnished abstracts from the current working timetable, detailed signal location charts of the line from Malvern, MP 21.6, the first station west of Paoli, to Harrisburg, less detailed signal charts for the territory from Harrisburg to, but not including, Zoo Interlocking, Philadelphia, and a chart showing grades and curvature for the entire line. These less detailed signal charts and the chart of grade and curvature do not show the stationing, precise locations in feet. Amtrak also furnished its braking curves, the data from which it calculates signal spacing for various speeds and grades. Furthermore, the consultant made use of Pennsylvania Railroad braking data shown on the detailed charts, Malvern to Harrisburg. Amtrak policy prohibited it from providing records of signal failures and maintenance expenditures. The work plan did not provide for inspection of the apparatus at interlockings or at signal locations.

Three questions regarding the signal system, including highway crossing protection, are implied in the scope of work for this study or should be considered if added passenger train operation is to be sponsored. They are:

- Is the system so old or obsolete that rehabilitation is necessary to achieve economical operation and maintenance?

- Is the system maintained or can it be maintained in a condition to operate reliably?

- How, if at all, must the system be modified to permit operation at (a) 79 miles per hour or (b) 90 miles per hour where operation at such speeds is otherwise feasible, and what is the cost of any such modifications?

These questions are addressed in turn below.

- Is the system uneconomically obsolete?

  Since no data as to maintenance expense or signal failures were furnished, no firm answer can be given to this question. However, the apparatus is old. An Amtrak representative (Mr. Horace G. Ramp, Director Transportation Planning, Philadelphia) stated that the interlockings have mechanical locking between the levers. This is an obsolete system subject to wear.

- Is the system reliable?

  The enforcement of the Signal Inspection Act and of the Federal Railroad Administration's <u>Rules and Regulations Governing Railroad Signal and Train Control Systems</u> assures that a railroad signal system is reliable in the sense that it is safe. The question is, are there safe failures, failures which delay trains? While the lack of failure data is unfortunate, on the inspection trips only one burned out light was observed (a matter of little importance since position light signals display aspects of three lights in a row) and only one cab signal "flip" occurred (a momentary change of cab signal aspect, a harmless and not uncommon occurrence). It seems most likely that the system is reliable.

- What is necessary to operate at (a) 79 miles per hour; (b) 90 miles per hour?

  The study requirements provided for the two maximum speeds because the Federal Railroad Administration signal specifications differ for the two speeds. Where passenger trains are operated at 79 miles per hour, an automatic block signal system is required. Where passenger trains are operated in excess of 79 miles per hour a cab signal system or an automatic train stop system is required. It has been suggested that, with frequent trains operating at 90 miles per hour, a cab signal system should be supplemented with automatic speed control as is the case on the Northeast Corridor between Boston and Washington. As it happens, an automatic block signal system and a cab signal system are in service on the entire line between Philadelphia and Harrisburg. The electric locomotives which pull some of the Amtrak trains are also used on the Northeast Corridor and are equipped with automatic speed control. The diesel locomotives in which the inspection trips were made were said to be equipped with automatic speed control although, because the engineer complied promptly and properly with all restrictive cab signal changes, there was no opportunity to see the speed control in operation. In short, the required systems are already in use for either 79 miles per hour or 90 miles per hour maximum speeds.

In fact, west of Paoli a large part of the mileage is now operated at 90 miles per hour, chiefly on welded rail. The speed limit has been reduced to 80, 70, or 60 miles per hour on some stretches not because of the signal system, which is the same throughout, but because of jointed rail in less than first class condition. Through Paoli Interlocking the speed limit is 65 miles per hour on one through track and 60 on the other and through Cork Interlocking at Lancaster the speed limit is 70, perhaps because maintaining track line and surface at switches is more expensive than in open track. The speed limit on the Lancaster station tracks (which parallel the main tracks) is 30 miles per hour. This has no effect on train speed because the station tracks are used only by trains which stop (at present all trains stop except sometimes the Broadway Limited). The speed limit through Park Interlocking at Parkesburg is 70 miles per hour but Amtrak furnished a sketch of planned rearrangement simplifying the layout and providing for 90 miles per hour running.

Between Paoli and Harrisburg there are three road crossings protected with flashers or flashers and gates, one where the speed limit is 90 miles and two where it has been reduced to 70 miles. If, which is doubtful, the warning circuits have been shortened for 70 miles per hour running, it would be a minor expense to restore them, several thousand dollars each at most.

In short, between Paoli and Harrisburg the signal system is already adequate for 90 miles per hour and, of course, 79 miles per hour operation with the possible exception of a need to restore warning circuits at two crossings to their former length, a minor expenditure.

East of Paoli, train speeds are 70 mph or lower. Through the extensive Zoo Interlocking the timetable speed limits are 30 mph and 50 mph (less than 1/2 mile segment). Since trains must run through crossovers to reach the Harrisburg line from 30th Street Station lower level, actual speeds are less. It is understood that Amtrak is planning a complete revision of Zoo Interlocking; whether this revision will include the complicated layout at 52nd Street, Valley Interlocking, with its 30 miles per hour limit on Track 4, is not known. Such revision could increase speeds, but curvature probably would not permit speeds of 79 or 90 miles per hour.

Between Valley (MP 4.0) and Paoli (MP 20.4), the speed limit is generally 70 miles per hour. The line has numerous curves, four restricted to 60 (or 65) and one to 50 miles per hour. The grade ranges from .52 percent descending to 1.00 percent ascending (there is a 1.50 percent ascending grade approaching Valley from Zoo Interlocking); by far the larger portion of the mileage is on ascending grades.

A vital requirement of any automatic block signal system, whether or not it is supplemented with cab signals or cab signals and speed control, is sufficient spacing between successive signals so that a train observing the indication, "prepare to stop at next signal," can do so. That is, the spacing between successive signals must equal or exceed braking distance for a train traveling at maximum speed, taking into consideration that it takes a greater distance to stop a train going down grade than on level track or on an ascending grade. In some cases the system is arranged to give an indication equivalent to "prepare to stop at second signal," allowing for, on the average, one-half braking distance between successive signals.

The spacing between successive signals on the four-track line east of Paoli is less than on the line west of Paoli. The signals were probably spaced more closely in recognition of the fact that the amount of curvature on the route made high speed running impractical. Closer signal spacing also makes it possible for trains to follow one another at shorter intervals, in other words for more trains to be run.

If the study of track and alignment shows that speeds above 70 miles per hour are feasible, the present signal spacing will permit some increase. A complicating factor is that a few signals are shown as capable of displaying a fourth aspect which may or may not provide added braking distance.[2]

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[2]Aspect is the appearance of the signal as seen from an approaching train; indication is the information conveyed by the aspect; most automatic block signals can display three aspects conveying three indications. Aspects of position-light signals consist of a row or rows of three lights: vertical -

Although the information supplied by Amtrak is not sufficient to make an exact determination of the limitations on maximum speed imposed by the signal spacing between Paoli and Valley, an approximate estimate is possible.

The detailed signal plans for the line west of Paoli show the actual distance between signals and the equivalent distance on level track. They also show the maximum speed which the spacing will permit. In most cases the speed is simply shown to be more than 100 miles per hour. However, in one case a speed of 96 miles per hour is the maximum; in another, 93. From this information the braking or deceleration rate was computed. A comparison of the equivalent and actual spacings in a few cases confirmed the results. The computations showed a braking rate of 1.27 ft/sec^2. From the known deceleration rate and approximate locations of signals and grade change points the speeds permitted by the present signal spacing between Paoli and Valley were estimated. From Valley to Paoli and through Paoli, primarily an ascending grade, present signal spacing would permit 90 miles per hour maximum speed. Through Paoli to the first signal east of Paoli, Signal 178 just west of Berwyn, signal spacing would permit 90 miles per hour running. From Signal 178 to Signal 162 near Devon 80 (or 79) miles per hour would be allowed. From Signal 162 to Bryn Mawr the limit would again be 90 and from Bryn Mawr to Signal 68 at Narberth the limit would be 80 (or 79). East of Narberth, MP 6.8, there would be no increase in the present speed limits. It must be emphasized that these estimates are based on approximations; it is apparent that, as far as the signal system is concerned, speeds could be increased but exactly where and to what extent can be determined only through a more extensive examination beyond the scope of this study and using data not currently available.

East of Paoli, respacing signals and providing a fourth aspect where necessary without reducing track capacity and flexibility in this heavily used commuter territory would practically require completely replacing the old signal system at an estimated cost of $13 million.

While the existing system can probably be kept functioning indefinitely with patching here and there, it would be more economical to replace it than to make extensive modifications. Because curvature restricts speeds at many

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proceed at normal speed; diagonal - prepare to stop at next signal; horizontal - stop. A fourth aspect and indication, diagonal over vertical - approach next signal at 30 mph, is used when the next signal governs a move from one track to another which must be made at that speed; however, it is also used in some cases when the second signal ahead indicates stop, thus providing the sum of the two signal spacings as stopping distance.

points close enough together to prevent accelerating to high speeds between successive curves, replacing the signal system to increase speeds east of Paoli could not be justified, particularly when it is realized that increasing the speed from 70 to 79 miles per hour between Valley and Paoli would save about one minute and from 70 to 90 miles per hour about two minutes. More time than this will probably be saved by the anticipated revisions at Zoo and Park Interlockings referred to above. However, if and when it is decided that the signal system's economic life has expired, plans for any replacement should take into consideration the possibility of increased speeds where, if anywhere, curvature is not too great.

Three conclusions should be noted here:

- The signal system is old; however, the limited data provided does not allow a determination as to whether maintenance and operating expenses are so high as to justify the capital cost of replacement.

- Federal standards presumably assure that the system is safe; it appears to be reliable and does not appear to be a routine cause of train delays.

- The system already permits 90, and therefore also 79 miles per hour operation west of Paoli. East of Paoli factors other than the signal system limit speed; even disregarding these factors, the possible saving of one or two minutes would not appear to justify a capital expenditure estimated at roughly $13 million.

E. BRIDGES

This portion of the study was intended to validate Amtrak's assessment of its bridges between Philadelphia and Harrisburg. Amtrak did not supply an assessment, and a set of bridge inspection reports was not received until four weeks <u>after</u> the inspection trip. Finally, Amtrak was unable to provide a hi-rail inspection, so all bridges were not viewed. Instead, an audit was conducted of 19 bridges reachable by road (with extensive driving near the right-of-way), constituting approximately one-quarter of on-line bridges between Radnor and Lancaster, including all major structures. The uniformity of condition of those bridges which were viewed would suggest generally that other bridges not viewed shared the same fair to good condition. Amtrak's inspection reports denote most exceptions as "not hazardous-note any change next inspection."

From the supplied bridge reports, one percent (6,192 feet) of the Overbrook (Philadelphia) and Harrisburg Amtrak route is comprised of bridge structures. Only structures of at least six feet in length are listed. A distribution of the structures by four primary types is presented below, with a detailed list of bridges in Table II-10.

PERCENT OF BRIDGES BY NUMBER AND BY LENGTH

Bridge Type	By Number	By Length
Masonry Arch	60 %	64 %
Concrete Beam	22	14
Steel Girder	15	21
Pipe (assorted)	3	1
Total	100 %	100 %

Source: Amtrak.

This line was formerly Pennsylvania Railroad's main line, and most of its bridges were built during a period in which that company constructed facilities for long life. All major and many minor structures are masonry (brick or stone), mostly turn-of-the-century stone structures, built at a time when steel construction was available at far less cost than masonry construction and immediately before concrete became widely accepted. Because of this monument building era, most bridges are sound, low-maintenance structures. Many of Amtrak's inspection notes on masonry structures relate to wingwalls, handrails and ballast retainers (to contain track ballast), which do not relate to load bearing capacity.

Nearly every large stone arch bridge had steel beams bolted above and through the arch. Material beneath the track tends to exert outward pressure and push the stone sides out. This wall-restraining steelwork appears to have been universally applied as a preventive (and possibly overly conservative) measure. Patching to seal rock/headwalls should be performed, but in general no conditions require more than normal maintenance.

Other bridges are typically road crossing separations: steel girders or concrete beam construction. Many of the steel structures had been painted within the last decade. Several could use some touch-up, but none were overdue for paint. Only one had a timber deck (which typically requires special tie fabrication and replacement every 15 years). Some steel bridges have corrosion (generally in unimportant bracing). Additional decay should be minimal.

The worst bridge was at St. Davids (MP 13.8), where, despite evidence of recent work (painting and replacement of many bridge seats), external water damage indicated significant internal corrosion. However, the worst steelwork was under the

TABLE II-10

AMTRAK BRIDGES BETWEEN OVERBROOK AND HARRISBURG

	Mile	Type	Spans[a]	Total Length (feet)	Tracks	Date Built	Over
1	4.24	B+SA	1	16	8	1902	SEPTA
2	4.26	B+SA	1	20	1	1902	SEPTA
3	4.52	B+SA	1	69	11	1887	56th Street
4	5.26	B+SA	1	57.5	5	1893	Woodbine Avenue
5	5.59	B+SA	1	6	4	1934	Passenger Tunnel
6	5.62	B+SA	1	15	4	1884	Mill Creek
7	6.06	B+SA	1	6	4	1884	Passenger Tunnel
8	8.55	TG	2	38	4	1917	Anderson Avenue
9	9.17	BA	1	6	4	1883	Passenger Tunnel
10	9.18	TG	1	40	4	1929	Haverford Station Road
11	9.40	CS	1	36	4	1914	Booth Lane
12	10.13	TG	1	35	4	1926	Morris Avenue
13	10.17	BA	1	6	4		Passenger Tunnel
14	11.61	CS	1	26	4	1915	County Line Road
15	11.74	Pipe	1	7.5	4	1950	Passenger Tunnel
16	12.00	BA	1	6	4		Passenger Tunnel
17	12.51	BA	1	8	4		Stream
18	12.70	CS	1	40	4	1911	P&W RR
19	13.00	BA	1	6	4		Passenger Tunnel
20	13.06	Pipe	1	24	4	1967	King of Prussia Road
21	13.80	TG	1	29	4	1915	Chamounix Road
22	14.19	CS	1	25	4	1915	Aberdeen Avenue
23	14.63	BA	1	6	4	1915	Passenger Tunnel
24	14.54	CS	1	34	4	1983	Wayne Avenue
25	15.46	DG	1	28	4	1914	Old Eagle School Road
26	15.79	SA	1	32	5	1889	Conestoga Road
27	16.06	CS	1	28	4	1917	Old Lancaster Road
28	16.49	BA	1	6	4	1889	Passenger Tunnel
29	16.54	B+SA	1	29	4	1887	Waterloo Road
30	16.54	BA	1	6	4		Stream

[a]Bridge Type Legend: (A) Arch; (BA) Brick Arch; (B+SA) Brick and Stone Arch; (CA) Concrete Arch; (CB) Concrete Block; (CS) Concrete Slab; (DG) Deck Steel Girder; (IB) I-Beam; (Pipe) Corrugated Pipe or Tunnel Liner; (SA) Stone Arch; (TG) Through Steel Girder.

TABLE II-10 (cont.)

	Mile	Type	Spans	Total Length (feet)	Tracks	Date Built	Over
31	16.94	BA	1	6	4		Stream
32	17.21	BA	1	6	4		Stream
33	17.23	CS	1	30	4	1914	Old Lancaster Road
34	18.62	CS	1	44	4	1914	Glen Road
35	19.44	IB+CS	2	43	4	1915/50	PA 252
36	20.48	B+SA	1	20	1	1905	Duck Under
37	20.52	DG	2	159	3	1937	US 30
38	21.57	BA	1	20	3		Warren Avenue
39	22.10	BA	1	7	3		Stream
40	22.61	SA	1	7	3		Streams
41	22.85	B+SA	1	10	3		Old Milan Road
42	23.87	CS	1	26	3		Sprouls Road (PA 352)
43	24.34	B+SA	1	6.5	3		Stream
44	24.70	CS	1	38	1		CR Fly-over
45	25.00	BA	1	26	3		Ravine Road
46	25.04	B+SA	1	6	4		Stream
47	25.36	CS	1	22	3		Phoenixville Pike
48	26.53	BA	1	10	3		Stream
49	26.70	BA	1	24	3		Ship Road
50	27.47	CS	1	27	3		Crest Avenue
51	27.52	DG	1	72	3		PA 100
52	27.56	BA	1	10	3		Stream
53	28.35	BA	1	22	3		Whitford Road
54	28.85	BA	1	8	3		Stream
55	29.17	BA+SA	1	12	3		Stream
56	29.81	BA	1	20	3		Boot Road
57	30.00	B+CA	3	111	3		Valley Road
58	32.00	SA+CS	1	28	4		Brandywine Av. (US 322)
59	32.10	SA	4	258	4		E. Br., Brandywine Creek
60	32.30	SA	1	20	4		Viaduct Avenue
61	32.46	BA	1	6	4		Passenger Tunnel
62	33.09	BA	1	6	4		Stream
63	33.19	IB+CS	1	29	4		Lloyd Avenue
64	35.27	DG	1	35	3		South Bailey Road
65	35.27	DG	1	35	2		South Bailey Road

TABLE II-10 (cont.)

	Mile	Type	Spans	Total Length (feet)	Tracks	Date Built	Over
66	35.82	BA	1	35	10		Conveyor Tunnel
67	36.63	IB+CS	1	35	2		Caln Road
68	36.63	TG	1	35	2		Caln Road
69	37.54	CS	1	29	4		11th Avenue
70	37.88	TG	3	45	4		North Chester Street
71	38.28	SA	1	24	4		4th Avenue
72	38.44	CS	3	45	4		3rd Avenue
73	38.79	SA	10	780	4		W. Br., Brandywine Creek
74	39.07	BA	1	6	5		Pedestrian Tunnel
75	39.49	BA+SA	1	10	4		Stream
76	39.99	SA	1	6	4		Stream
77	41.18	S+B+CA	1	7	5		Stream
78	42.40	S+CA	1	24	4		Spruce Street
79	44.70	TG	2	164	1		Conrail
80	45.88	SA	1	6	2		Stream
81	46.75	SA	1	24	2		Octorara Creek
82	46.87	BA	1	24	2		Green Street
83	47.02	TG	1	40	2		Main Street
84	48.22	BA	1	15	2		Octorara Creek
85	50.06	S+BA	1	6	2		Stream
86	52.26	BA	1	12	2		Private Road
87	53.65	TG+CS	1	38	2		Kinzer Road
88	54.01	Pipe	1	6	2		Drain
89	54.64	TG+CS	1	30	2		Vintage Road
90	55.94	CS	1	33	2		Belmont Road
91	56.32	BA	1	8	2		Stream
92	56.37	S+BA	1	30	2		Private Road
93	57.33	S+BA	1	118	3		Peqea Creek
94	57.48	S+BA	1	12	2		Stream
95	58.62	SA	1	6	2		Stream
96	60.00	TG+CS	1	38	2		North Ronks Road
97	61.10	IB+CS	1	40	2		PA 340
98	61.54	S+BA	1	6	2		Stream
99	61.90	SA	4	240	2		Mill Creek
100	65.01	CS	1	8	2		Greenfield Road

TABLE II-10 (cont.)

	Mile	Type	Spans	Total Length (feet)	Tracks	Date Built	Over
101	66.35	SA	5	329	2		Conestoga Creek
102	66.43	SA	1	7	2		Water Main
103	66.89	SA	1	15	1		Old Main Line
104	66.98	TG+CS	1	72	4		PA 23
105	67.15	BA	1	8	4		Drain
106	67.33	TG+CS	3	58	4		Marshall Street
107	67.53	BA	1	6	4		Drain
108	67.54	TG+ST	1	50	4		Plumb Street
109	67.76	IB+CS	1	15	5		Cattle Pass
110	68.01	CB	1	10	6		Baggage Tunnel
111	70.01	SA	1	6	3		Stream
112	71.01	CP	1	12	3		Fords Run
113	71.55	SA	1	30	2		Little Conestoga Creek
114	72.31	CS	1	10	2		Stream
115	73.22	CS	1	16	2		Stream
116	77.18	TG+CS	1	91	2		Old Harrisburg Pike
117	77.41	S+BA	2	140	2		Big Chickies Creek
118	79.43	S+BA	2	108	2		Little Chickies Creek
119	79.52	CS	1	19	2		Longnecker Road
120	82.15	SA	1	30	2		Old Harrisburg Pike
121	82.20	SA	1	12	2		Stream
122	84.42	SA	1	40	2		Old Harrisburg Pike
123	85.40	SA	1	8	2		Stream
124	86.32	SA	1	24	3		Conoy Creek
125	86.48	SA	1	36	3		Bainbridge Street (PA 241)
126	86.74	CB	1	8	3		Passenger Tunnel
127	86.82	TG+CS	1	34	2		High Street
128	90.22	SA	3	265	3		Conewago Creek
129	90.61	SA	1	6	1		Stream
130	91.61	SA	1	9	2		Shiremans Creek
131	91.76	SA	1	24	2		Hillsdale Drive
132	92.04	S+BA	1	10	2		Stream
133	92.62	CS	1	22	2		Geyer Church Road
134	92.89	CS	1	16	2		Stover Road
135	93.99	CS	1	28	2		Stream/Young Road

TABLE II-10 (cont.)

	Mile	Type	Spans	Total Length (feet)	Tracks	Date Built	Over
136	94.67	BA	4	305	3		Swatara Creek
137	94.74	TG	3	82	3		S. Union Street (PA 441)
138	94.87	CB	1	6	4		Pedestrian Tunnel
139	95.38	BA	1	9	4		Stream
140	95.91	CS	1	15	5		Pedestrian Tunnel
141	97.84	BA	1	6	3		Burds Run
142	97.98	TG	3	66	3		Street
143	98.06	SA	1	30	3		Railroad Street
144	98.21	SA	1	24	3		Commerce Street
145	98.31	SA	1	13	2		Stream
146	98.58	SA	1	12	3		Motor Road
147	101.69	Pipe	1	8	4		Stream
148	102.74	SA	1	40	4		Paxton Creek
149	104.61	CB	1	6	3		Passenger Tunnel
150	104.69	CS	4	90	9		Market Street
		Total	191	6,192			

Source: Amtrak.

passenger platform which has minimal loads. At a minimum, one girder should be opened up and the internal deterioration measured. Replacement may be necessary.

Concrete construction has not survived as well as stone construction. Many concrete beams and headwalls are spalling (surface crumbling exposing interior concrete), which in a few cases has uncovered steel reinforcing. No spalling was significant enough to affect bridge ratings, but all spalling allows moisture to enter and increase the deterioration rate, so corrective action (cleaning and sealing) should be undertaken.

Amtrak's reports on pedestrian tunnels of stone or concrete block construction indicate the structures are sound, but many require cosmetic work (lighting, painting and paving). Pipe construction was generally used for newer, small structures, which do not require work.

Amtrak advised that all highway bridges over its tracks were not its responsibility. Responsibility for these "orphan bridges" may need to be explored further by the appropriate agencies. However, Amtrak's inspectors do file inspection reports on these bridges (an industry practice). Several have severe problems, but short of collapse, should not affect the railroad.

Amtrak has assigned at least a dozen structures workers each at Harrisburg, Lancaster and Philadelphia, although the forces must also repair all buildings and stations on the line.

In general, the bridges inspected were in good condition and should require only average maintenance. Bridge inspection reports indicate that nearly all bridges are in fair condition, with about nine bridges in poor, but repairable condition. Other than the St. Davids bridge, normal maintenance, as opposed to major rehabilitation, should suffice. Should replacement be more economical than repair at St. Davids, as expected, an approximate cost would be $1,000,000. Analysis to determine if higher operating speeds are feasible (though much of the line is already capable of 90 mph operation) would require a bridge by bridge analysis. With the heavy construction and preponderance of masonry structures, it is unlikely that any bridge would be restrictive.

F. SUMMARY

Amtrak's Keystone line provides service to Amtrak intercity passengers between Philadelphia and Harrisburg, as well as SEPTA commuters between Philadelphia and Parkesburg. Conrail local freight service is also handled over the line. The Pennsylvania Department of Transportation (PADOT), through the Delaware Valley Regional

Planning Commission (DVRPC) commissioned this study to assess the condition of the line and determine the requirements to bring the line up to 80 mph and 90 mph standards.

The evaluation of the track indicated that a significant tie replacement program would be needed to bring the line to 80 mph standards or to maintain those segments currently meeting 90 mph standards at that level. Rail condition was deemed to be good to excellent; however, to elevate the entire line to 90 mph operations, jointed or bolted rail would need to be replaced by welded rail sections. A $6.9 million tie replacement program was developed over a three-year period. This program includes about $1.2 million for lines that primarily serve SEPTA commuter trains. Travel times can be reduced by 5-6 minutes as a result of this program. In addition, it is recommended that two three-mile segments east of Lancaster be re-laid with welded rail to bring the track speeds up to 90 mph. This optional improvement is estimated at $1.9 million. Due to the limited improvements in running time and ride quality, a $20.9 million welded rail program west of Lancaster is not believed to be justified.

The condition of the existing stations is generally good or acceptable. However, about $300,000 in improvements are required to the stations at Coatesville, Parkesburg, and Elizabethtown. The study recommends reducing the number of Amtrak stations in Chester County by having SEPTA provide all of the service at Malvern and Whitford. New SEPTA stations are also recommended at Frazer, Glen Loch, and Thorndale. The lack of adequate parking is viewed as a serious detriment to attracting additional riders at stations east of Downingtown.

A new SEPTA station is also recommended at Atglen with suggested relocation of Amtrak service at Parkesburg to this new facility. In eastern Lancaster County, new stations are recommended at Kinzer and Bird-in-Hand; however, a recent proposal by the Strasburg Railroad for a transfer station at Paradise warrants further consideration. West of Lancaster, it is recommended that the Mount Joy station be relocated eastward to Eby Cheques Road and the Middletown station be relocated westward to Harrisburg Airport/Penn State. It is estimated that four new stations can be provided for $1.1 million, excluding land acquisition and access improvements.

The Keystone line is presently electrified, and improvements to substations and to the contact wire are required to ensure continued availability of the system. These have been estimated at $9.1 million; however, a more detailed study of power demand and contact wire wear may reduce this amount by as much as $2 million. The signal system along the line is adequate to meet 80 mph operations in the commuter territory east of Paoli and 90 mph operations elsewhere. In order to raise the speeds to 90 mph east of Paoli, a $13 million program of signal relocations is necessary. Based on the limited running time improvements that would result from this program, these signal changes are not recommended. Bridge conditions along the line are deemed to be good, with the exception of one bridge at St. Davids. About $1 million cost is estimated for necessary bridge repairs.

Altogether, the study developed a three year $20.3 million improvement program for the line, which will bring speeds up to 80 mph generally, maintain existing segments at 90 mph, and reduce transit times by 5-6 minutes. This program, which is summarized in Table II-11, includes $1.2 million on lines used primarily by SEPTA and $1.9 million for some optional rail replacements.

The additional $33.9 million needed ($20.9 million to replace jointed rail with welded rail, mostly west of Lancaster, and $13 million for new signaling east of Paoli) to bring the entire line up to 90 mph standards is not recommended. Due to the relatively small savings in travel time and the minimal impact on ride quality, we do not believe such an expenditure can be justified.

TABLE II-11

COST OF IMPROVEMENT PROGRAM
(millions)

Element	Upgrade to 80 mph	Upgrade to or Maintain at 90 mph
Track	$8.8	$29.7
Stations[a]	1.4	1.4
Electric Traction	9.1	9.1
Signals	0.0	13.0[b]
Bridges	1.0	1.0
Total	$20.3	$54.5

[a]Excludes costs of any passenger bridges or tunnels, land acquisition or expanded parking facilities required at new and existing stations.

[b]Entire amount needed east of Paoli.

III - TRAVEL DEMAND AND SERVICE LEVELS

Assuming that the capital investment recommended in Chapter II has been made and the line has been returned to good operating condition free of slow orders, the next step is to estimate rail travel demand in the corridor for a five-year horizon (1996). In this chapter, three levels of service are considered, ranging from seven (existing) to fourteen weekday round trips. Weekend service ranged from five to ten daily round trips. Since other factors, including fares, parking, and promotion affect demand, two sets of elasticities were used to gauge the impact of additional trains. The higher level assumes new equipment with enhanced on-board amenities, station improvements, and an effective marketing effort. The lower level assumes that little will be done to improve the attractiveness of train travel other than to add service.

Rail service in this corridor serves a number of separate travel markets. There are two separate commuter markets, one oriented eastward toward Philadelphia and the other westward toward Harrisburg. Since the line connects the state's largest city with the capital, a significant number of business trips are generated. Many members of the Amish community, centered in Lancaster County, rely on the train to meet their travel needs. Students travel to and from schools located along the line, several with campuses located within walking distance of stations. The discretionary markets includes visitors to Philadelphia, Lancaster, and Harrisburg, as well as local residents needing access to the national Amtrak and airline networks.

Before estimating future demand, current and past ridership and service trends since 1980 in the *Keystone* and other rail corridors around the country are examined. This helps to ascertain long-term travel patterns and to determine the impact that service trends have on ridership.

A. PAST AND CURRENT TRAVEL DEMAND

As late as 1980 the Harrisburg Line, *Keystone Service* carried as many as 1,000,000 trips per year, but by 1990 annual patronage had fallen to 335,000. Several reasons for this have been advanced, including service cuts, patronage shifts to an expanding local service operated by SEPTA or to other Amtrak trains, and changing markets for rail travel. In addition to the *Keystone* trains running between Philadelphia and Harrisburg, Amtrak operates daily round-trips between New York and Harrisburg, New York and Pittsburgh, and New York and Chicago; and SEPTA operates local service between Philadelphia and Parkesburg. Since the Broadway Limited (New York-Chicago) is an all-reserved train with no traffic rights in the range of interest, it will not be considered further in this analysis, but other Amtrak trains do supplement the

Keystone Service and will be included. The analysis must also include SEPTA trains operating west of Paoli, but SEPTA service east of Paoli will be disregarded. Dense local service with significantly different market and service characteristics has been operated continuously in the Paoli-Philadelphia range from the days of the Pennsylvania Railroad and should have little impact on *Keystone* ridership.

1. Ridership Trends

Amtrak has published monthly reports of ridership by route since 1978. Ridership, service, and fare trends since 1980 for the line are shown in Table III-1. The years given are fiscal years ending in September of the indicated year. Generally the trend has been one of falling patronage, though ridership does appear to have bottomed in 1989. Ridership rose by 5.5 percent in 1990. Though the first half of the decade showed an average annual loss of 6.2 percent, in the second half the loss rate increased to 18.4 percent per year, notwithstanding the bounce back at the end.[3] Line ridership is shown graphically in Figure III-1.

It is widely believed that the most important parameters affecting travel decisions are frequency of service, travel time, and cost, though other factors, such as service reliability and passenger comfort are also clearly important. The values shown in Table III-1 for daily round-trips, average speed, and fares are those in effect on October 31st (winter timetable) of the fiscal year indicated. The value given for daily round-trips represents a weighted average over a week and was obtained by counting the number of one-way trips (in both directions) made between Philadelphia and Harrisburg and dividing by 14. Changes in service levels since 1980 are shown in Figure III-2. Longer distance trains with traffic rights in this range were included, as they help attract riders to this market. The largest single service change occurred in January 1986, when Amtrak reduced the number of daily round-trips from 9.5 to 6.6 (from 11 to 7 round-trips, Mon-Thu). Note that this service reduction of 30.5 percent coincided with the steepest decline in ridership observed during the decade, 45.3 percent from 1985 to 1987. At the same time SEPTA reinstated commuter service to Downingtown and siphoned off some of the local ridership in Chester County.

- **Average speeds.** These were calculated from the scheduled time required to traverse the entire length of the line and are shown in Figure III-3. Speeds declined over the decade, but were not as dramatic as the service reductions. Though a reduction of 5 mph only adds about ten minutes to the schedule and probably has an insignificant impact on ridership, average speed is also a measure of the condition of the track structure and the quality of the ride.

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[3] These are statistical averages reflecting the slope of the best fit straight line drawn through the points and do not depend solely on the end points chosen.

Table III-1

AMTRAK RIDERSHIP TRENDS AND SERVICE CHARACTERISTICS

Fiscal Year	Ridership	Daily RTs	Avg. Speed	Fare One Way	Fare Excursion
1980	1,024,700	9.7	57.6	$8.25	
1981	895,3001	11.1	57.7	$10.00	
1982	815,600	11.1	56.7	$12.10	$20.30
1983	807,800	11.1	57.2	$13.75	$21.00
1984	741,747	9.4	57.9	$14.75	$22.50
1985	756,616	9.5	56.4	$14.75	$22.50
1986	578,595	9.5	55.3	$15.25	$23.00
1987	413,711	6.7	56.0	$16.00	$24.00
1988	349,806	6.6	55.8	$16.00	$24.00
1989	317,443	6.6	52.1	$16.50	$25.00
1990	334,963	6.6	52.0	$17.00	$25.50
1991	330,619	6.6	52.3	$17.00	$26.00
Average Annual Change					
1980-85	-6.15%	-1.69%	-0.24%	10.41%	
1985-90	-18.42%	-8.78%	-1.66%	2.69%	2.50%

Route Length: Philadelphia (30th St.)-Harrisburg - 102 miles
1991 Fare per Mile: 16.7¢ (OW); 12.7¢ (RT)

Sources: Amtrak Ridership by Route
The Official Railway Guide

FIGURE III - 1
AMTRAK RIDERSHIP

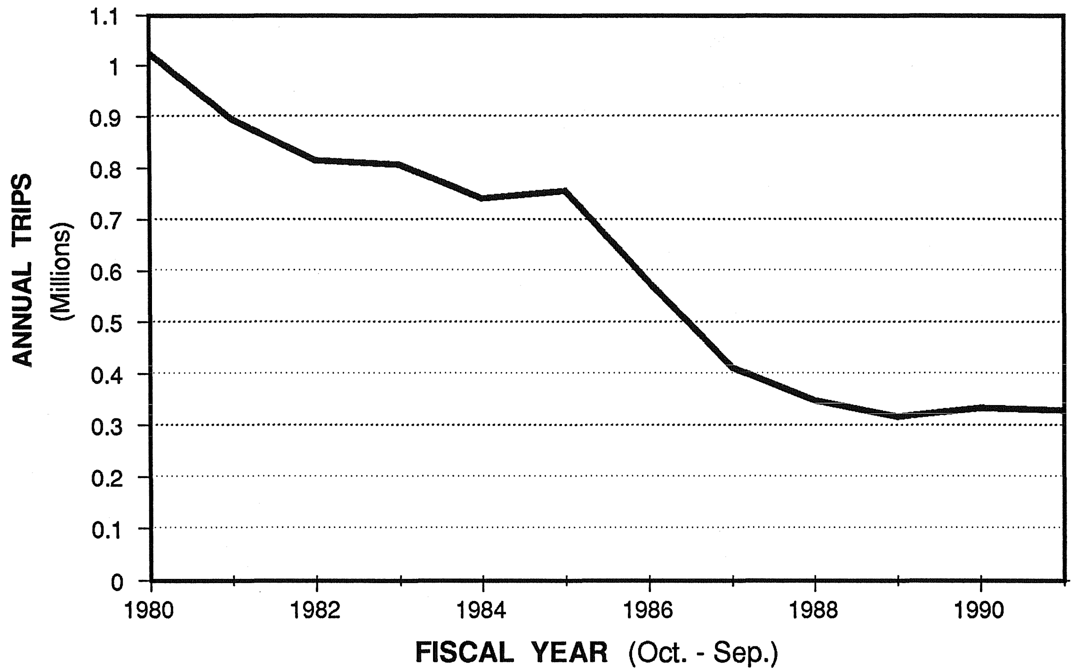
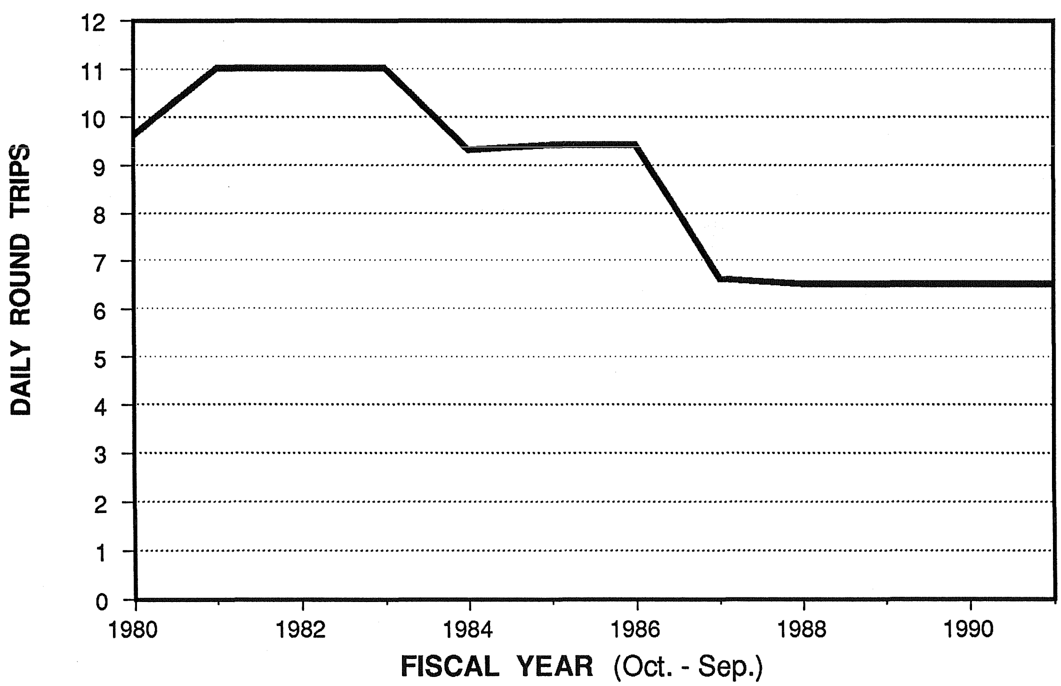


FIGURE III - 2
SERVICE LEVEL



- **Fares.** These increased steadily over the decade, but the rate of increase slowed after 1984. Both one-way and round-trip adult fares for travel between Philadelphia and Harrisburg are shown in Figure III-4. Generally, excursion fares have been set at approximately 1.5 times the one-way fare. Between 1980 and 1984 Amtrak raised one-way fares at an average rate of 15 percent per year, though the impact on ridership was moderated somewhat by the introduction of excursion fares in 1982. Even so, ridership fell by 27.6 percent in the first four years of the decade. Since then the rate of increase has fallen below the inflation rate, and now probably has only slight impact on ridership.

- **Schedule reliability.** This is defined as the percentage of trains arriving at their destination within 15 minutes of the scheduled time, is shown in Figure III-5. The graph is based on monthly averages of on-time performance for *Keystone* trains for the fiscal years 1985 through 1991. Though significant fluctuations from month to month are evident, the general trend shows declining performance in the early years, reaching a nadir in November 1987. Then performance improved markedly and has remained on a relatively high plateau since. Consistency has also improved with smaller fluctuations observed over the last two years. Currently, these trains rank among Amtrak's most reliable, achieving 95 percent on-time performance in most months.

In 1980 Conrail operated a single round-trip under contract to SEPTA on weekdays for commuters from Parkesburg to Philadelphia. This service was discontinued when SEPTA took over direct operation of the commuter trains in January 1983, and for the next two years Amtrak was the only carrier providing passenger service west of Paoli. In March 1985 SEPTA reinstated service as far as Downingtown with two weekday round-trips. Service was subsequently expanded in stages, with midday and Saturday service added in 1988, and a route extension to Parkesburg introduced in April 1990. On weekdays SEPTA currently operates 13.5 round-trips beyond Paoli. Though most use Downingtown as their terminus, three travel to/from Parkesburg.

SEPTA's annual survey of Regional Rail riders provides data on station activity, which can be used to estimate ridership on specified line segments. Table III-2 compares Amtrak and SEPTA ridership and service. The estimates of SEPTA ridership were obtained by totaling the passengers boarding or alighting at stations west of Paoli, and using a factor of 254 to convert from average weekday to annual ridership. Riders have responded positively to increases in service, and in 1990 SEPTA carried approximately 580,000 trips. This brings total line ridership to over 900,000, the highest level since 1981. It would appear that some of Amtrak's losses can be accounted by passengers switching to a cheaper SEPTA service.

FIGURE III - 3
AVERAGE SPEED

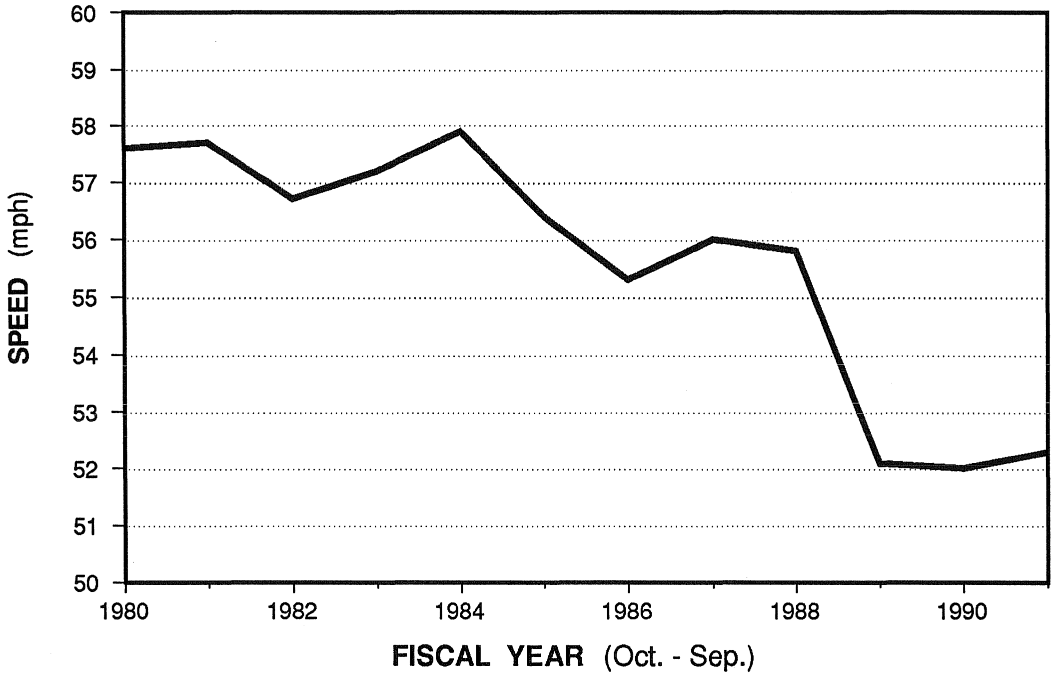


FIGURE III - 4
AMTRAK FARES

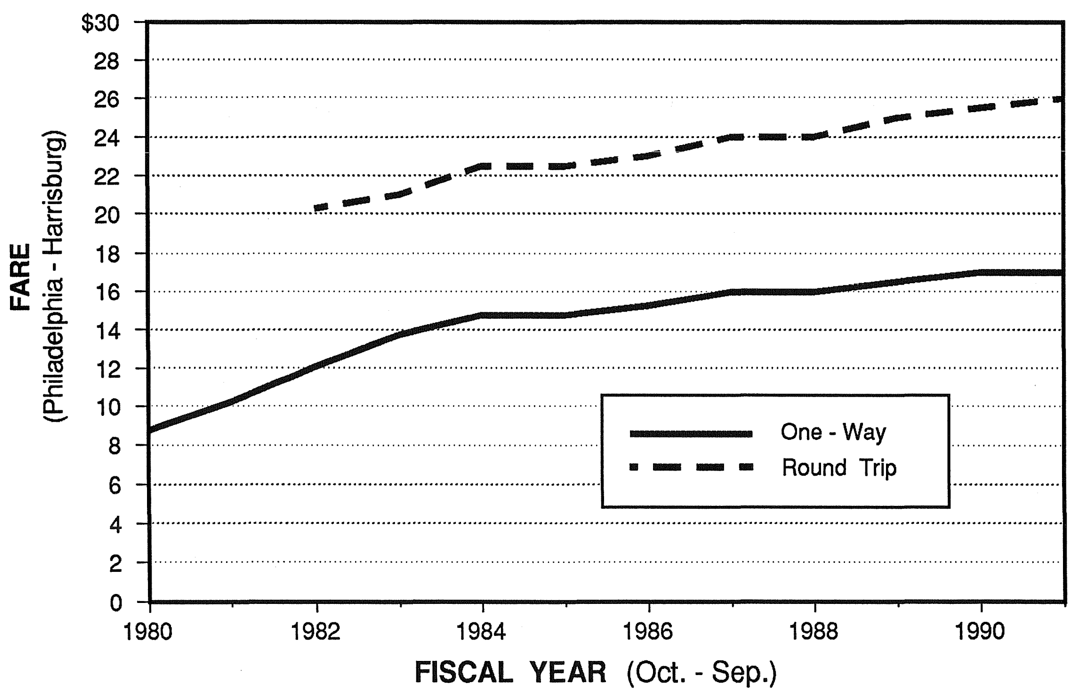


FIGURE III-5

SCHEDULE RELIABILITY

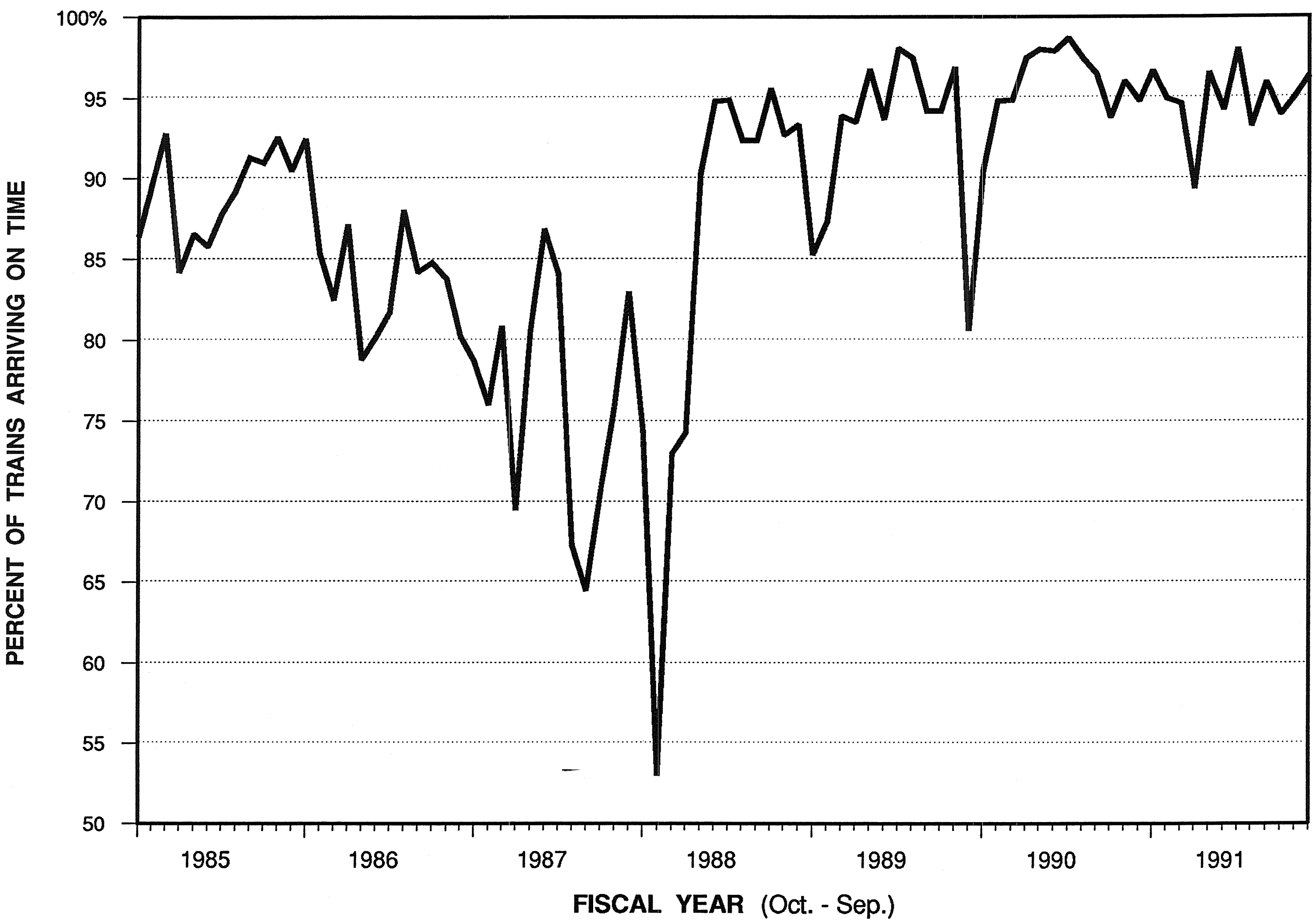


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Table III-2

COMBINED AMTRAK AND SEPTA LINE RIDERSHIP

ANNUAL RIDERSHIP (FY)	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
SEPTA (west of Paoli)	103,124	115,316	80,010	50,546	no service		80,772	358,648	497,840	588,264	584,708
Amtrak	1,024,700	895,300	815,600	807,800	741,747	756,616	578,595	413,711	349,806	317,443	334,963
Total	1,127,824	1,010,616	895,610	858,346	741,747	756,616	659,367	772,359	847,646	905,707	919,671
SEPTA + Amtrak (east of Parkesburg)				409,431	223,266	243,630	257,822	448,423	562,554	660,006	638,302
Amtrak (remainder)				448,915	518,481	512,986	401,545	323,936	285,092	245,701	281,369
AVERAGE DAILY ROUNDTRIPS (in effect on Fall/Winter schedules)											
SEPTA[a]	0.7	0.7	0.7	0.7	0.0	0.0	1.4	2.9	9.9	10.6	11.1
Amtrak	9.7	11.1	11.1	11.1	9.4	9.5	9.5	6.7	6.6	6.6	6.6

Sources: Amtrak Ridership by Route
SEPTA Inbound Boardings by Station

[a] No service west of Paoli (1/1/83 - 2/28/85)

To test this hypothesis, Amtrak's ridership was divided into ranges using origin/destination data available from the Amtrak Passenger Accounting System. Results are shown in Table III-3. Retrieving this data involved constructing a composite trip table from the microfiche records of three routes: Philadelphia-Harrisburg (*Keystone*), New York-Harrisburg, and New York-Philadelphia-Pittsburgh. Thus, the data do include riders on long-distance trains, provided their trip is confined to the Philadelphia-Harrisburg segment, as well as those on the *Keystone* trains. To avoid the effort required to search twelve sets of monthly records for each year, September was used to represent travel behavior for the year.

Riders whose entire trip lay east of Parkesburg constituted almost 48 percent of all Amtrak passengers on the line in 1983, but by 1990 their share had declined to 16 percent. In 1983, less than 48 percent of the line's business was for trips that crossed the Chester/Lancaster county line, i.e., between stations on the eastern half of the line and stations on the western half, but in 1990 these trips constituted 78 percent of the market. Local trips at the Harrisburg end, i.e., west of Lancaster, rose slightly, from five to six percent. It does appear that Amtrak's market has indeed changed from one that handled significant number of local riders at the Philadelphia end to one that focuses on attracting through passengers traveling longer distances.

2. Daily and Monthly Ridership Variation

Currently, Amtrak provides seven round-trips on weekdays and five on weekends, with an extra westbound trip on Friday evenings and a return on Sundays. In January 1991 a new twist was added to the schedule when one of the *Keystone* trains was replaced by an *Atlantic City Express* extended to provide through service to Harrisburg. Ridership varies by day of week with Friday the busiest, when an average of 1600 trips is carried. Excluding Fridays, weekday ridership averages about 1100 trips. On weekends, an average of 600 trips are carried on Saturdays and 800 on Sundays. These figures are based on data for September 1990.

Corridor ridership displays a decided seven-day cyclic variation, as can be seen from the data for September 1990, which is shown in Figure III-6. Ridership rises from a minimum on Saturday (585 trips) to 1200 daily trips in the early part of the week, dips slightly in mid-week, and then rises to a sharp maximum of 1600 trips on Fridays. The effect of a holiday is seen on the first weekend in which the minimum is pushed back to Sunday (9/2) and some holiday return traffic spills over into the following Tuesday. A pronounced, but unexplained, eastbound bias occurs on Sunday through Tuesday which does not appear to be balanced by heavier westbound travel later in the week. The monthly totals show about 1000 more eastbound trips.

3. Market Segments

A detailed analysis of ridership by train and by day does give some basis on which to segment the market, at least into broad categories such as commutation, weekday

Table III-3

TRIP TRENDS BY LINE SEGMENT

	Segment Share				
	I	II	III	IV	Total
Sep 1983	4.6%	43.2%	4.7%	47.6%	100.0%
Sep 1984	2.4%	27.7%	6.9%	63.0%	100.0%
Sep 1985	2.6%	29.6%	6.8%	61.0%	100.0%
Sep 1986	2.3%	28.4%	6.6%	62.8%	100.0%
Sep 1987	2.2%	19.4%	6.3%	72.0%	100.0%
Sep 1988	2.0%	16.4%	6.4%	75.1%	100.0%
Sep 1989	2.2%	14.3%	6.1%	77.4%	100.0%
Sep 1990	2.5%	13.5%	6.0%	78.0%	100.0%

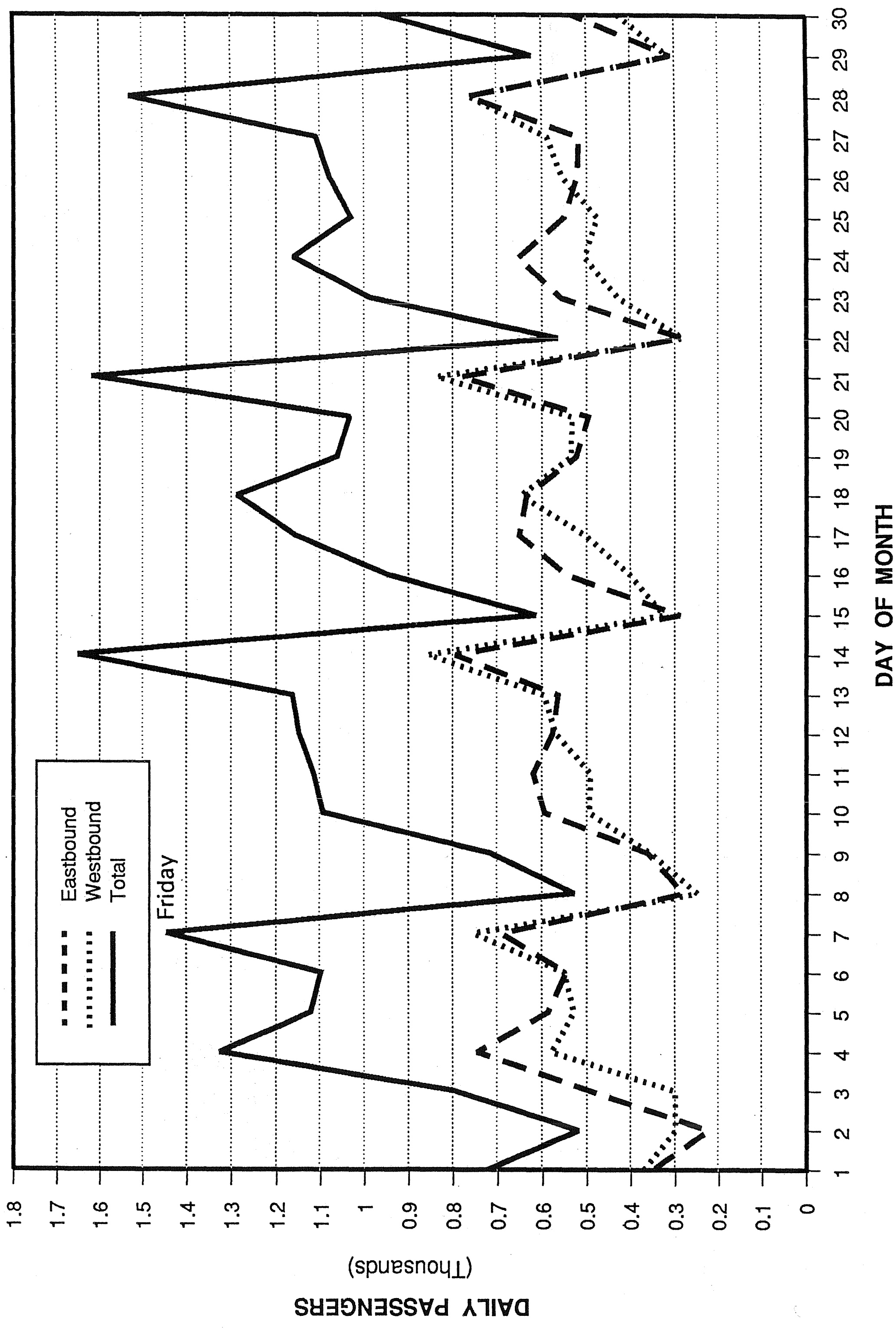
	Annual Ridership (000)				Total
1983	37.2	349.0	38.0	384.5	807.8
1984	17.8	205.5	51.2	467.3	741.7
1985	19.7	224.0	51.4	461.5	756.6
1986	13.3	164.3	38.2	363.4	578.6
1987	9.1	80.3	26.1	297.9	413.7
1988	7.0	57.4	22.4	262.7	349.8
1989	7.0	45.4	19.4	245.7	317.4
1990	8.4	45.2	20.1	261.3	335.0

Range I - Philadelphia to Paoli
Range II - Philadelphia to Parkesburg exclusive of Segment I
Range III - Lancaster to Harrisburg
Range IV - Trips between Segments II and III

Source: Amtrak Passenger Accounting System

FIGURE III-6

DAILY RIDERSHIP - SEPTEMBER 1990



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discretionary, and weekend trips, and by direction, i.e., whether oriented toward Philadelphia or Harrisburg. Amtrak's passenger accounting system provides detailed trip information for each train, but unfortunately the origin-destination data is based on tickets lifted, and hence does not include data for passengers traveling on commutation tickets or employee passes. These riders are, however, included in the summary for each train. Ridership data for the months of September 1983 and September 1990 are shown in Appendix D. The counts include all passengers for Philadelphia-Harrisburg trains (#600 through 629), but omits those using multi-ride tickets or passes to travel on other Amtrak trains. This omission is probably most serious for New York - Harrisburg trains running during weekday rush hours (#640/641 in 1990, #42/43 in 1983).

On weekdays the first train of the day (#600) is essentially a commuter train, with 36 percent of the passengers traveling on commuter tickets and another 20 percent on employee passes. In addition to Amtrak employees, the latter category includes some Conrail employees who have retained pass riding privileges from earlier times. Both railroads maintain significant employment in Philadelphia. The second train (#602), which arrives at 30th Street Station at 8:36 am, has about 20 percent of its riders traveling in these categories. Trains #615 and #617 handle the return trips in the afternoon. The average daily combined ridership on these trains was 253 in the morning and 261 in the afternoon, with the ridership never falling below 187 during the month. The minimum number was used to estimate the size of the existing commuter market (round-trips) to Philadelphia, and anything above the minimum was assigned to the weekday discretionary market.

The commutation market to Harrisburg is served by trains #601 and #603 in the morning and by #616 in the afternoon, which carry average passenger loads of 114 and 116, respectively). Following similar logic, the Harrisburg market was estimated at 81.

The discretionary market consists of the remaining riders during the rush hours plus those at midday and in the evening, properly sorted by direction. Trips destined to Philadelphia were assumed to be eastbound in the morning and westbound in late afternoon and evening, with the midday trips apportioned to provide balance. Trips in the reverse direction were assigned to Harrisburg and Lancaster. Lancaster is a significant travel destination as well, as an important origin, and now generates more Amtrak passenger activity than does Harrisburg. Average weekday discretionary round-trips were estimated at 152 toward Philadelphia and 138 toward Harrisburg.

For travel purposes the weekend starts at midday Friday and continues through Sunday evening. Since Friday is the heaviest travel day of the week, the excess above the weekday average was considered as part of the outbound segment for weekend trips. Trips taken on Sunday were assumed to be return legs, and Saturday trips were apportioned for balance. This methodology assigned 916 weekend round-trips to the market oriented toward Philadelphia and 1064 toward Lancaster and Harrisburg.

Though the preceding analysis ignored one-way trips and trips with external origins or destinations, as well as round-trips that were not completed within one day or on a weekend, it did provide a reasonable basis for a broad market segmentation and is supportable from the existing data base. It is also possible to analyze data from earlier periods to obtain information on market trends. Table III-4 compares the 1990 markets with those found seven years earlier in 1983. Three trends are immediately noticeable. First, the total market oriented toward Philadelphia has declined from 73.3 percent of the total to 56.9 percent. Second, the market for commutation has declined from 42.2 to 35.4 percent, and third, weekend riders now comprise 26.2 percent of the total, up from 14.6 percent seven years earlier. These are all consistent with the conjecture that the expansion of local SEPTA service to Parkesburg has captured most of the short-haul market at the eastern end of the route.

B. COMPARABLE RAIL CORRIDORS

Amtrak operates intercity service on several medium-distance corridors in other parts of the country, and it is useful to compare their characteristics and performance with that of the *Keystone Corridor*. Accordingly, the following nine corridors (one with two sub-corridors) were selected for comparison:

Corridor	Length (miles)	Daily RTs	State Operating Support?	FY90 Ridership
Philadelphia-Harrisburg	102	6.6	yes	334,963
New York-Albany	142	10.3	no	1,063,821 (combined)
New York-Buffalo	431	3.5	no	
Chicago-Detroit	279	3.0	no	360,961
Chicago-Indianapolis	195	1.4	no	64,522
Chicago-St. Louis	282	3.0	yes	281,590
Chicago-Milwaukee	86	6.3	yes	297,621
Los Angeles-San Diego	128	8.0	yes	1,780,464
Oakland-Bakersfield	312	3.0	yes	450,317
Seattle-Portland	186	3.0	no	84,745

Other than that they serve city pairs at distances that are competitive (or potentially competitive) with air, these corridors vary greatly in their attributes and their effectiveness in serving their markets. They vary in length from under 100 miles to more than 400, and in service from less than two round-trips per day to more than

Table III-4

MARKET SEGMENTATION

		1983			1990		
Market Segment	Orientation	Weekday RTs	Weekly OWs	Market Share	Weekday RTs	Weekly OWs	Market Share
Commuter	Philadelphia	523	5,230	32.5%	187	1,870	24.7%
	Harrisburg	157	1,570	9.7%	81	810	10.7%
Discretionary	Philadelphia	546	5,460	33.9%	152	1,520	20.1%
	Harrisburg	150	1,500	9.3%	138	1,380	18.3%
Weekend	Philadelphia		1,124	7.0%		916	12.1%
	Harrisburg		1,228	7.6%		1,064	14.1%
	Weekly Ridership		16,112	100.0%		7,560	100.0%

Source: Amtrak Passenger Accounting System ten. (Fractional round-trips result from averaging the number of trips over a week.) They are distinguishable from commuter corridors by being longer, having major cities at each end, and generally carrying passengers on single or round-trip tickets (though some do offer multiride tickets for regular riders). Some have received state capital assistance for upgrading track and other structures, and some receive operating assistance under Section 403(b) of the Amtrak Act.

- **New York City-Albany-Buffalo.** The *Empire Corridor*, which connects New York City with Albany and Buffalo, has experienced annual ridership increases of about three percent for the past decade. Average speeds have increased as a result of state capital investment, though no state operating subsidy has been provided. Service was increased over the 142-mile segment between New York and Albany in 1984 and again in 1989. Of all the corridors considered, the New York-Albany portion is probably the most comparable to the *Keystone Corridor*. Both connect the state's largest city with its capital and historically have had similar levels of ridership and service.

- **Chicago-Detroit.** Chicago has long been a rail hub, and today eleven Amtrak routes radiate from the city, four of which were analyzed for this study. Chicago-Detroit is a long corridor receiving relatively sparse service. Ridership fell 13 percent after service was cut 20 percent in 1986, but bounced back by 22 percent when promotional fares were introduced in 1989. Service was restored to three round-trips per day in 1990.

- **Chicago-Indianapolis.** This is an example of a corridor that lost all rail passenger service and then had a limited service restored. With only a single round-trip annual ridership hovered around 60,000 for most of the 1980s. In the last year ridership has blossomed, apparently as a result of a fare cut in 1990. A 37 percent reduction in the one-way fare stimulated a 37 percent increase in ridership.

- **Chicago-St. Louis.** The restructuring of rail freight service has resulted in the downgrading of the former Illinois Central Gulf mainline now used by Amtrak for its Chicago-St. Louis service. Consequently, speeds and ride quality have suffered as the line was no longer maintained at the level needed for passenger service. The use of state money for line improvements and the introduction of promotional fares have given a boost to ridership, but higher speeds and improved reliability are still needed if the line is to reach its full potential.

- **Chicago-Milwaukee.** Ridership in the *Hiawatha Corridor* connecting Chicago with Milwaukee jumped by 31 percent when service was increased from three to four daily round-trips in 1984. A major upgrade in 1989, which saw service increased to six round-trips and the consists reequipped with new push-pull coaches, resulted in an additional ridership gain of 51 percent. Service was increased to eight daily round-trips in October 1991.

- **Los Angeles-San Diego.** In contrast to the Midwest corridors, which have enjoyed good rail service for many decades, the California corridors are relatively new creations. The Los Angeles-San Diego corridor, with eight daily round-trips, is now Amtrak's second busiest corridor, exceeded only by the *Northeast Corridor*, but when Amtrak assumed service in 1971, the line carried only 380,000 annual riders on three daily round-trips. Annual ridership on the *San Diegans* is now running at an historic high of approximately 1.8 million. State and local governments have invested $37 million in line improvements and new stations.

- **Oakland-Bakersfield.** Topography has always created difficulties for railroads serving the Great Valley of California, which is bounded on three sides by mountains. Amtrak has effectively avoided a dead-end operation to Bakersfield by using a network of eleven dedicated bus routes to link the trains to off-line cities. Not only did this greatly increase the number of possible origin-destination pairs, it dramatically reduced travel times over for trips between Los Angeles and the Bay Area. One-half of the riders on the *San Joaquins* use a bus to extend their rail trip. Since 1980 service has expanded from one to three daily round-trips, and annual ridership increased proportionately, from 140,000 to 450,000.

- **Seattle-Portland.** Two of the three daily round-trips in the Seattle-Portland corridor are provided by long-distance trains, one coming from Chicago and the other from Los Angeles. This, combined with low average speeds severely constrains the demand for rail service and prevents the corridor from reaching its full potential. Ridership proved volatile in the early 1980s, slipping from a high of almost 112,000 in 1981 to a low of 53,000 two years later. Since 1986, ridership has increased steadily and 1991 ridership is expected to exceed 90,000.

A more detailed analysis of these corridors with supporting data can be found in Appendix E.

C. RIDERSHIP PROJECTIONS

1. Scenarios and Assumptions

The number of trips taken by rail depend both on changes in overall travel demand and the relative attractiveness of the service. Projections for a five-year horizon (1996) were developed for the following three scenarios:

- I. Existing Service - 7 round-trips (RT) on weekdays; 5 on Sat, Sun, holidays
- II. Moderate Enhancement - 10 RTs on weekdays; 7 on Sat, Sun, holidays
- III. High Enhancement - 14 RTs on weekdays; 10 on Sat, Sun, holidays

In each case the current practice of adding an extra westbound trip on Friday evenings with a return on Sunday evenings was continued.

The rail market was assumed to consist of round-trips combining an outbound leg with an inbound or return leg. Six market segments were recognized: commutation, weekday discretionary (hereafter called discretionary), and weekend discretionary (referenced as weekend), each with orientations eastward toward Philadelphia (PHL) and westward toward Harrisburg (HAR). The orientation refers to the direction of the outbound leg. Segment shares, were calculated from a detailed analysis of origin/destination data by train for September 1990. (Table III-4.)

A two-step process was used to estimate ridership. First, changes in travel demand were forecast by estimating growth in population and employment, and second, the impact of service changes will be gauged. The market for work trips is determined by both population (production) and employment (attraction). Past experience in southeastern Pennsylvania indicates that employment growth is 2.37 times more important than population growth in determining changes in work trips. It has also been found necessary to increase rail ridership by an additional ten percent in order to match observed commutation patterns.

I.e., (Ridership growth) = {[(Pop. growth) + 2.37 x (Emp. growth)]/3.37} x 1.1,

where growth is specified in percent. For discretionary and weekend trips, it was assumed that attractions will remain constant, at least for a five-year horizon, and change in overall demand will be proportional to changes in population.

The analysis was complicated by the need to include service provided by the following longer distance Amtrak trains, as well as the *Keystone* (PHL-HAR) trains:

No.	Name	Origin	Dest.	Frequency
42	*Pennsylvanian*	Pittsburgh	New York	Ex Sun
43	*Pennsylvanian*	New York	Pittsburgh	Daily
44	*Pennsylvanian*	Pittsburgh	New York	Sun
642	*Big Apple*	Harrisburg	New York	Sat, Sun
643	*Susquehanna*	New York	Harrisburg	Sat
645	*Susquehanna*	New York	Harrisburg	Sun

In this analysis, *Keystone* ridership includes passengers on the Harrisburg-Atlantic City trains, provided their trip does not extend east of Philadelphia. It was necessary to estimate ridership for the total market and then subtract that for the above trains in order to obtain *Keystone* ridership. In FY90, the above trains carried approximately 58,000 passengers whose entire trip lay within the Philadelphia-Harrisburg range. This number was estimated by counting the number of trips taken in the geographic range of interest for September 1990 and multiplying by twelve. It was assumed that the level of service provided by these trains will remain constant, and that riders will be distributed among all trains operating within the appropriate time block. Ridership estimates for the line do not include trips in the Parkesburg-Philadelphia range; these were assumed to be served by SEPTA.

Scenario I was based on existing service and change in ridership was determined solely by change in travel demand. Scenario II represents an approximate 40 percent increase in service, and Scenario III a doubling of service. Since travel times were not change and fares were expected to increase in line with inflation, the only parameter to affect ridership will be trip frequency.

- Scenario I represented a continuation of the existing pattern of service carried five years into the future. The market share captured by rail was assumed to remain constant, Thus, any change in ridership was driven by a change in the total travel market, which is determined by changes in population and employment.

  Population trends, based on 1980 and 1990 Census data, for the counties lying along the corridor, and for municipalities in the catchment areas for the Lancaster and Harrisburg stations, are shown in Table III-5 The catchment area for Harrisburg included the city and suburbanized areas in Dauphin, Cumberland, and Perry counties. That for Lancaster was entirely contained within Lancaster County. A tighter catchment area was defined for commutation to Harrisburg.

  Overall the population along the *Keystone Corridor* is not growing rapidly, only increasing by 1.7 percent in the decade between 1980 and 1990. Indeed, Philadelphia and Delaware counties lost population, and Dauphin

Table III-5

POPULATION TRENDS AND PROJECTIONS

	1980	1990	1980-90 % Change
County			
Philadelphia	1,688,210	1,585,577	-6.08
Montgomery	643,621	678,111	5.36
Delaware	555,007	547,651	-1.33
Chester	316,660	376,396	18.86
Lancaster	362,346	422,822	16.69
Dauphin	232,317	237,813	2.37
Cumberland	179,625	195,257	8.70
Total	3,977,786	4,043,627	1.66
Municipal			
Harrisburg Catchment Area			
Derry Twp	18,115	18,408	1.62
Harrisburg City	53,264	52,376	-1.67
Highspire Boro	2,959	2,668	-9.83
Hummelstown Boro	4,267	3,981	-6.70
Lower Paxton Twp	34,830	39,162	12.44
Lower Swatara Twp	6,772	7,072	4.43
Middletown Boro	10,122	9,254	-8.58
Paxtang Boro	1,649	1,599	-3.03
Penbrook Boro	3,006	2,791	-7.15
Royalton Boro	981	1,120	14.17
Steelton Boro	6,484	5,152	-20.54
Susquehanna Twp	18,034	18,636	3.34
Swatara Twp	18,796	19,661	4.60
W Hanover Twp	6,115	6,125	0.16
Camp Hill Boro	8,422	7,831	-7.02
E Pennsboro Twp	13,955	15,185	8.81
Hampden Twp	17,732	20,384	14.96
Lemoyne Boro	4,178	3,959	-5.24
Lower Allen Twp	14,077	15,254	8.36
Mechanicsburg Boro	9,487	9,452	-0.37
Cumberland Boro	8,051	7,665	-4.79
Shiremanstown Boro	1,719	1,567	-8.84
Silver Spring Twp	7,148	8,369	17.08
Upper Allen Twp	10,533	13,347	26.72
W Fairview Boro	1,426	1,403	-1.61
Wormleysburg Boro	2,772	2,847	2.71
Marysville Boro	2,452	2,425	-1.10
Total	287,346	297,693	3.60

Table III-5 (cont.)

	1980	1990	1980-90 % Change
Lancaster Catchment Area			
E Hempfield Twp	15,152	18,597	22.74
E Lampeter Twp	9,760	11,999	22.94
E Petersburg Boro	3,600	4,197	16.58
Lancaster City	54,725	55,551	1.51
Lancaster Twp	10,833	13,187	21.73
Manheim Twp	26,042	28,880	10.90
Manor Twp	11,474	14,130	23.15
Millersville Boro	7,668	8,099	5.62
W Lampeter Twp	6,836	9,865	44.31
Total	146,090	164,505	12.61
Lancaster-Harrisburg Commuter Corridor			
Middletown Boro	10,122	9,254	-8.58%
Royalton Boro	981	1,120	14.17%
Londonderry Twp	5,138	4,926	-4.13%
W Donegal Twp	4,862	5,605	15.28%
Elizabethtown Boro	8,233	9,952	20.88%
Mt Joy Twp	5,128	6,227	21.43%
E Donegal Twp	4,063	4,484	10.36%
Mt Joy Boro	5,680	6,398	12.64%
Rapho Twp	7,157	8,211	14.73%
W Hempfield Twp	8,239	12,942	57.08%
E Hempfield Twp	15,152	18,597	22.74%
E Petersburg Boro	3,600	4,197	16.58%
Manheim Twp	26,042	28,880	10.90%
Lancaster City	54,725	55,551	1.51%
Lancaster Twp	10,833	13,187	21.73%
E Lampeter Twp	9,760	11,999	22.94%
W Lampeter Twp	6,836	9,865	44.31%
Total	186,551	211,395	13.32%

Sources: 1980 and 1990 Census Data

County at the western end only increased by 2.4 percent. Most of the growth is now occurring along the middle of the corridor with Chester and Lancaster counties increasing by 18.9 and 16.7 percent, respectively. This is one reason why Lancaster now exceeds Harrisburg in station boardings, even though little white collar employment lies within easy reach of the station. The residential catchment area for Lancaster grew by 12.6 percent, in contrast to 3.6 percent for that surrounding Harrisburg.

Ridership on *Keystone* trains was projected to 1996 for each of the six market segments, but first ridership figures for 1990 will be factored upward by 5.1 percent, which represents the annual rate of increase observed in the first six months of FY91 (October through March). Five-year growth factors for population and employment are shown in Table III-6. These were calculated by taking the square root of the 1980 to 1990 growth factors.

Most of the market for work trips toward Philadelphia will come from Lancaster County, as residents in Chester County can use a substantially cheaper SEPTA service and Dauphin County is probably too far removed to generate a significant number of work trips. The population of the Lancaster catchment area is expected to increase by 6.1 percent in the next five years. The largest number of jobs are concentrated in the Philadelphia CBD, though additional jobs can be found in other parts of the city and the western suburbs. Center City employment is expected to grow by 4.4 percent in the same period. Using coefficients developed for southeastern Pennsylvania, these factors should increase demand for rail commutation to Philadelphia by 10.8 percent.

Though Harrisburg comprises a smaller job market, the commutation market at the western end of the line is growing faster. The population with good access to stations at Middletown, Elizabethtown, Mount Joy, and Lancaster should grow by 6.4 percent in the five-year period, and downtown employment in Harrisburg by 8.3 percent. This should increase the market for commutation at the western end of the corridor by 8.5 percent. Replacing the Middletown and Mount Joy stations with new stations, as recommended in Chapter II, should not affect the estimates, as the catchment areas do not change.

The discretionary and weekend markets are driven by population only. As with commutation, the residents of the Lancaster catchment area can be expected to take trips in either direction, but in addition, the population in the Harrisburg area contributes to the market for trips destined to the east, and that in Philadelphia, Montgomery, Delaware, and Chester counties to

Table III-6

POPULATION AND EMPLOYMENT GROWTH BY MARKET AREA

Area	1980 Census	1990 Census	5-Year Growth
Population			
Philadelphia (incl. Chester, Delaware, and Montgomery counties)	3,203,498	3,187,735	-0.25%
Lancaster (catchment area)	146,090	164,505	+6.12%
Harrisburg (catchment area)	287,346	297,693	+1.78%
Lancaster + Harrisburg (catchment areas)	433,436	462,198	+3.26%
Lancaster + Philadelphia (catchment area + four counties)	3,349,588	3,352,240	+0.04%
Lancaster-Harrisburg (commuter corridor)	186,551	211,395	+6.45%
Employment			
Philadelphia (Center City)	263,549	287,075	+4.37%
Harrisburg (city)			+8.32%

Sources: 1980 & 1990 Census Data
Bureau of Economic Analysis
Delaware Valley Regional Planning Commission
Tri-County Regional Planning Commission
Lancaster County Planning Commission

the market for trips headed west. The number of trips headed east (Philadelphia orientation) should increase by 3.3 percent, while those headed west (Harrisburg orientation) should remain essentially flat. The expected growth in travel demand by market is shown in Table III-7.

Corridor ridership on Amtrak trains in 1990 totaled 393,307, which included 58,344 trips taken on non-*Keystone* trains. The former represents the 1990 base ridership for the analysis to follow.

Since Scenario I represents a continuation of existing service, ridership was obtained by factoring the segment markets by the appropriate growth in travel demand. Ridership on non-*Keystone* trains was obtained by scaling 1990 ridership up by the appropriate factors for discretionary travel. None of the latter trains operate during commutation hours.

The next step was to separate the trips by direction and assign them to the appropriate service block, so that service could be designed to meet demand. Outbound trips on weekdays were assumed to occur in the morning and return trips in the afternoon and evening. Trains scheduled during the peak hours carry both commuters and passengers taking discretionary trips, while train during the midday and evening hours carry only discretionary riders. Here discretionary means any trip taken on a weekday for purposes other than daily commutation. Outbound trips on weekends were assumed to occur on Friday evenings and on Saturdays before 6:00 pm, with return trips made on Saturday evenings and on Sundays. While not strictly accurate, it does account for weekend excursions and Saturday day trips.

During the six-year period from 1990 to 1996 annual ridership on *Keystone* trains should increase to 366,600, of which 42.4 percent will be for work commutation. The weekend share of the total market should remain constant at 20.7 percent. Ridership on other Amtrak trains should increase by 5.2 percent to 61,400.

- **Scenarios II and III.** These scenarios represented expanded levels of service, with the number of round-trips operated weekly rising from 46 in Scenario I to 65 and 91 for Scenarios II and III, respectively. These service levels included all Amtrak trains carrying passengers within the corridor. Ridership were estimated by applying appropriate service elasticities to that estimated for Scenario I.

How do rail riders in corridor markets respond to changes in service level? The experience of other corridors may be relevant. In the *Hiawatha Corridor*

Table III-7

GROWTH IN TRAVEL DEMAND BY MARKET SEGMENT

Market	Determinants	1990-96 Growth 5-Year	1990-96 Growth Adjusted[a]
Philadelphia commuter	Lancaster population Philadelphia employment	+5.38%	+10.75%
Harrisburg commuter	Lancaster-Harrisburg corridor population Harrisburg employment	+8.54%	+14.08%
Philadelphia discretionary and weekend	Lancaster + Harrisburg population	+3.26%	+8.53%
Harrisburg discretionary and weekend	Lancaster + Philadelphia population	+0.04%	+5.14%

[a]Adjusted upward to reflect observed 1990-91 growth.

(Chicago-Milwaukee) service was increased from three to four (+33.3%) daily round-trips in 1984 and to six (+50%) round-trips in 1989. Ridership jumped by 30.8 and 51.2 percent, respectively, almost in direct proportion to the service increase. Another example can be found in California's *San Joaquin* service between Oakland and Bakersfield. In 1980 service was doubled from one to two round-trips per day, and ridership increased by 26.7 percent. A third round-trip was added in the fall of 1990, and ridership went up by 24.7 percent. In this corridor the immediate effect of adding service was to increase ridership by one-half of the percentage change in level of service. However, it should be noted that the ridership in this corridor has been increasing steadily, even in the absence of a service increase. Since 1980, a period which saw a tripling of service, ridership has increased by a factor of four. The experience in the *Keystone Corridor* has been with reductions in service. In 1983 service was cut by 7.8 percent and ridership went down by 8.2 percent. Service was again reduced in 1986, this time by 30.5 percent, and ridership declined by 28.5 percent, again almost in direct proportion to service.

The observed service elasticity for specific cases varies significantly, but many other factors other than service levels, such as fares, speed, reliability, comfort, safety, and promotion, also affect ridership. Further, different market segments may behave differently. Typically, commuters show less elasticity than those taking discretionary trips. Currently, the *Keystone* service is protected by some of the oldest equipment in Amtrak's fleet. If service is increased using this equipment and no improvements in station amenities are made, the elasticity [(percent change in ridership)/(percent change in service)] is likely to be minimal. If instead, new equipment with reclining seats and better acceleration is provided, and station parking and access are improved, the elasticity should be much higher and may approach one. In order to show the impact these differences can have on demand, two levels of elasticity were used to estimate ridership for Scenarios II and III. For the minimum case, elasticities were set at 0.3 for commutation trips and at 0.5 for non-work trips, and for the enhanced case at 0.4 and 1.0, respectively.

Before ridership for Scenarios II and III could be estimated, it was necessary to assign the additional trains to appropriate service blocks. In Scenario II weekday service was increased from seven to ten daily round-trips, with three trains assigned to Philadelphia commuters, two to Harrisburg commuters, and four to midday. Evening service was unchanged with one round-trip. Weekend service was increased from five round-trips each day to seven, with extra one-way trips on Friday and Sunday evenings.

Four additional round-trips were added on weekdays in Scenario III, with the Harrisburg commuters now having a choice of three trains, matching the service provided to commuters at the eastern end of the line. Midday service was raised to seven eastbound and six westbound trips, and the evening service to one eastbound and two westbound. Weekend service was set at ten round-trips per day plus the extra one-ways on Friday and Sunday evenings.

In Scenario I ridership was stratified by direction, time of day (weekday and weekend), and trip purpose. The elasticities assumed in the earlier discussion were then used to generate estimates reflecting the increased levels of service proposed for Scenarios II and III, which in turn were combined to determine ridership by market. Ridership on the non-*Keystone* trains were estimated by distributing the ridership in each time block over all available trains. If the elasticity for discretionary trips is less than one, than these trains will lose riders as *Keystone* service is added and passengers are redistributed. The resulting ridership and train assignments are shown in Tables III-8 and III-9, respectively. For an explanation of how the assignments were made and the ridership calculated, see Appendix F.

In the low elasticity case, where minimal improvements are made to the quality of service, annual ridership on *Keystone* trains rose to 461,800 for Scenario II and to 570,100 for Scenario III. Ridership on other Amtrak trains for Scenarios II and III, as riders were redistributed among the increasing number of *Keystone* trains. In the high elasticity case, *Keystone* ridership increased to 523,800 for Scenario II and 717,100 for Scenario III.

F. SUMMARY

During the 1980s the *Keystone Corridor* lost 67 percent of its riders, declining from 1,025,000 trips per year at the beginning of the decade to 335,000 at the end. Reductions in service were responsible for some of the loss. The number of weekday roundtrips were reduced from 13 to 11 in 1981 and then to 7 in 1983, and the steepest drop in ridership coincided with the 1983 cut. Average speeds fell by about 5 mph during the decade, but this is not enough to have a marked effect on ridership. This reduction only adds about ten minutes to the schedule between Philadelphia and Harrisburg. Though some problems with schedule reliability were experienced earlier in the decade, these problems have largely been corrected and today the corridor consistently ranks among the best of Amtrak's routes in terms of on-time performance.

Table III-8

ANNUAL RIDERSHIP BY MARKET SEGMENT

	1990	1996									
				Low Elasticity Assumption[a]				High Elasticity Assumption[b]			
		Scenario I		Scenario II		Scenario III		Scenario II		Scenario III	
Market		All Trains	Keystone Only	All Trains	Keystone Only	All Trains	Keystone Only	All Trains	Keystone Only	All Trains	Keystone Only
PHL commuter	97,147	107,594	107,594	124,533	124,533	124,533	124,533	129,947	129,947	129,947	129,947
HAR commuter	42,084	48,007	48,007	53,144	53,144	62,806	62,806	54,754	54,754	67,638	67,638
PHL discretionary	106,193	115,247	115,247	149,733	149,733	190,730	190,730	183,140	183,140	265,135	265,135
HAR discretionary	45,230	47,556	19,794	55,936	31,129	74,353	54,516	63,770	36,008	100,603	72,841
PHL weekend	48,377	52,501	36,437	61,340	47,276	76,767	64,473	69,739	53,675	100,592	84,528
HAR weekend	54,276	57,067	39,512	70,739	56,008	86,101	73,026	83,810	66,255	114,533	96,978
Total	393,307	427,972	366,591	515,425	461,823	615,290	570,084	585,160	523,779	778,448	717,067

[a] Low Elasticity Assumption (Commuter = 0.3; Discretionary = 0.5)
[b] High Elasticity Assumption (Commuter = 0.4; Discretionary = 1.0)

Source: DVRPC

Table III-9

RIDERSHIP BY DIRECTION AND TIME OF DAY

	September 1990		1996					
			Scenario I		Scenario II		Scenario III	
Period	No. of Trains	Daily Pass.	No. of Trains	Daily Pass.	No. of Trains	Daily Pass.	No. of Trains	Daily Pass.
A. LOW ELASTICITY								
Weekday Eastbound								
AM peak	2	260	2	286	3	337	3	337
midday	3	200	3	215	4	254	7	361
PM peak	1	95	1	107	2	124	3	150
evening	1	22	1	23	1	23	1	23
Total	7	577	7	631	10	738	14	871
Weekday Westbound								
AM peak	2	119	2	132	2	142	3	170
midday	2	147	2	158	4	237	6	316
PM peak	2	235	2	259	3	303	3	303
evening	1	43	1	47	1	47	2	70
Total	7	544	7	596	10	729	14	859
Weekend Eastbound								
Friday PM[a]		221		240		280		360
Saturday	5	290	5	313	7	371	10	462
Sunday	6	500	6	526	8	613	11	745
Total	11	1011	11	1079	15	1264	21	1567
Weekend Westbound								
Friday PM[a]	1	273	1	287	1	344	1	402
Saturday	5	294	5	312	7	392	10	489
Sunday	5	404	5	438	7	526	10	658
Total	11	971	11	1037	15	1262	21	1549

Source: DVRPC

Table III-9 (cont.)

	September 1990		1996					
			Scenario I		Scenario II		Scenario III	
Period	No. of Trains	Daily Pass.	No. of Trains	Daily Pass.	No. of Trains	Daily Pass.	No. of Trains	Daily Pass.
B. HIGH ELASTICITY								
Weekday Eastbound								
AM peak	2	260	2	286	3	367	3	367
midday	3	200	3	215	4	292	7	507
PM peak	1	95	1	107	2	134	3	174
evening	1	22	1	23	1	23	1	23
Total	7	577	7	631	10	816	14	1071
Weekday Westbound								
AM peak	2	119	2	132	2	145	3	189
midday	2	147	2	158	4	316	6	475
PM peak	2	235	2	259	3	327	3	327
evening	1	43	1	47	1	47	2	93
Total	7	544	7	596	10	835	14	1084
Weekend Eastbound								
Friday PM[a]		221		240		320		480
Saturday	5	290	5	313	7	429	10	610
Sunday	6	500	6	526	8	701	11	964
Total	11	1011	11	1079	15	1450	21	2054
Weekend Westbound								
Friday PM[a]	1	273	1	287	1	402	1	517
Saturday	5	294	5	312	7	472	10	668
Sunday	5	404	5	438	7	614	10	877
Total	11	971	11	1037	15	1488	21	2062

Source: DVRPC

[a]In addition to normal weekday service or ridership.

However, Amtrak is not the only carrier in the carrier in the corridor. In 1980 local commuter service west of Paoli was limited to single weekday round trip starting in Downingtown. This train was discontinued in 1983, but reinstated in 1985. Since then SEPTA has been steadily expanding its presence in western Chester County and now operates 13.5 round trips on weekdays and 11 on Saturdays. If the 585,000 trips that SEPTA carried west of Paoli are added to the Amtrak total, it is seen that the actual decline in ridership over the decade is reduced to about 18 percent. Though some erosion in rail traffic did occur, it appears that many passengers simply moved over to SEPTA.

Further evidence of this shift is provided by an analysis of Amtrak's markets. In 1983, which is the first year for which detailed origin-destination data was available, about 48 percent of Amtrak's passengers on the line were taking trips which did not extend west of Parkesburg. By 1990 this portion of the market was reduced to 16 percent. In 1983 commuters constituted 42 percent of the total market, but by 1990 the share had fallen to 35 percent. The weekend share of the market is now about 26 percent, whereas in 1983 it was only 15 percent. Traffic is also more evenly balanced by direction. In 1983 almost three-fourths (73%) of the trips were oriented toward Philadelphia, i.e., the outbound leg was headed east, but in 1990 the share was reduced to 57 percent.

Nine other Amtrak corridors around the country were examined for relevancy to the *Keystone Corridor*. While each had attributes unique to their specific circumstances, several observations can be made. The investment that the State of New York has made in the *Empire Corridor* between New York and Buffalo has resulted in quicker running times and increased ridership (up by 41% since 1980). Over one-half of the riders in the *Hiawatha Corridor* (Chicago-Milwaukee) were lost after service cuts in the early 1980s. In 1985, however, after the service was enhanced with new equipment and an additional round trip, ridership jumped by 31 percent. Two more round trips were added in 1989, bringing the total to six, passenger demand increased by another 51 percent. Service has also been added in the Los Angeles-San Diego corridor, but in this case ridership has increased steadily (6% per year) since 1983, rather than at the point of increase. It is not clear whether service was added to accommodate increasing demand or vice versa. Ridership on the *San Joaquins* has seen increases of almost 13 percent per year over the decade. Not only was service tripled from one to three daily round trips, dedicated bus connections to off-line points were added and aggressively promoted. Today, one-half the train riders are also taking a bus. Some corridors did not fare well. Chicago-St. Louis has suffered from poor track and low running speeds, and Seattle-Portland passengers have had to depend on less reliable long-distance trains for two-thirds of their service.

Ridership on the *Keystone Corridor* was projected ahead five years to a 1996 horizon for three service scenarios. Scenario I assumed a continuation of existing service (7

RTs on weekdays, 5 on weekends), Scenario II considered a moderate level of enhancement to 10 weekday round trips (plus 7 on weekends), and Scenario III doubled service to 14 and 10 round trips on weekdays and weekends, respectively. To allow for uncertainties in passenger responses to changes in service, two sets of service elasticities were used. For the low elasticity case, the elasticity for commuters was set at 0.3 and for discretionary trips at 0.5. If new equipment and adequate parking at stations are provided, it was assumed that ridership would show a greater response to additional service, and the elasticities were raised to 0.4 for work trips and to 1.0 for other trips.

The results indicate that between 1990 and 1996, annual ridership on *Keystone* trains will increase by 9.4 percent to 366,600, if no changes are made to the service. If few improvements and amenities are provided, other than adding three daily round-trips on weekdays and two on weekends, *Keystone* ridership should increase by an additional 26.0 percent. If service is doubled from existing levels (seven new round-trips on weekdays and five on weekends), then the increase in ridership is estimated at 55.5 percent. However, if additional improvements are made that raise the quality of service, higher elasticities can be assumed and ridership should increase by 42.8 and 95.6 percent, respectively, for Scenarios II and III.

Higher levels of service and improved amenities tend to attract more new discretionary trips than commuting trips, both because the number of work trips taken within the corridor is limited and because day trippers and weekend travelers often require extra inducements to get them on the train. If parking is constrained, the available spaces tend to be taken by commuters, shutting out midday travelers. At the highest levels of service and amenities the share of trips taken by commuters falls to 27.6 percent from the 41.6 percent observed in 1990, and weekend ridership rises to 25.3 percent from 21.2 percent in 1990.

These projections assumed that the service will be operated reliably and that fares increase no faster than inflation. The low elasticity case assumes a continuation of the current quality of service, i.e., equipment, stations, and speeds. In the high case, better equipment; higher speeds; station amenities, including improved access and adequate parking; and promotional fares combined with good marketing are provided. These improvements should also allow the line to attract riders from a greater distance, i.e., increase the size of the catchment area. Basically, a capital investment in new equipment and line improvements can increase ridership, and thus raise cost recovery and reduce the level of operating subsidy.

IV - ASSESSMENT OF EQUIPMENT NEEDS

Suitable rolling stock is as important to attracting ridership as is a good fixed infrastructure. The equipment must be reliable, attractive, and offer amenities appropriate to the market. In addition, beyond what is apparent to the passenger, the choice of equipment carries implications with respect to maintainability and efficiency and affects the costs of operation. The market projections developed in the previous chapter determine train lengths and the size of the equipment pool needed. Choices must be made whether to use locomotive-hauled coaches or self-propelled equipment. The latter is often referred to as multiple unit (MU) and is commonly used in shorter consists. Other choices must be made concerning the choice of power. The line is electrified, but it may be cheaper to use diesel. These choices are discussed in this chapter.

A. EQUIPMENT NEEDS

The equipment operating in the existing Amtrak *Keystone* Service trains includes 12 cars and four locomotives made up into four, three-car formations for the weekday schedule.[4] The coaches are high capacity, Heritage type in a pool based at Penn Coach Yard, Philadelphia. This pool also supplies cars for the remaining New York - Philadelphia *Clocker* trains which Amtrak operates.[5] The assigned locomotives are F40PH diesels, also based at Philadelphia in a pool which serves the diesel-powered trains operating through Philadelphia including the Atlantic City trains and the long-haul *Broadway Limited* and *Pennsylvanian*. If F40PHs are not available, AEM7 electric locomotives are used. Because the cars and locomotives for the *Keystone* Service are not in a dedicated pool, it is not possible to specify how many pieces of equipment are held as protection to handle extra travel demand, recovery from service disruptions, and fill in for equipment undergoing maintenance and overhaul. Generally, the planned margin is 10 to 20 percent. If this were a stand alone service, one additional locomotive and two additional cars would be assigned as protection.

The existing equipment noted above does not include trains that operate between New York and Harrisburg or beyond (the *Broadway Limited*, *Pennsylvanian*, *Keystone*

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[4]Based on operation of Atlantic City trains #693 and #696 between Philadelphia and Harrisburg only with Keystone equipment.

[5]*Clocker* trains operate between Philadelphia and New York, and were named after a big clock at the old Broad Street Station in Philadelphia from which the trains operated on the hour.

State Express, *Big Apple*, and the *Susquehanna*). Although these trains occupy schedule slots in the Harrisburg-Philadelphia timetable, they use different equipment from different pools. The New York-Harrisburg through trains (*Keystone State Express*, *Susquehanna*, and *Big Apple)* each use an AEM7 locomotive, and are the only Amtrak trains on the line that are regularly assigned electric locomotives.

Estimates of ridership in 1996 are presented in the Delaware Valley Regional Planning Commission's report on Travel Demand and Service Levels for three operating scenarios (I, II and III) with projections for two levels of elasticity under each of Scenarios II and III. In each of these scenarios, ridership figures are given for the *Keystone*-only trains. Those figures are used in the following analysis to estimate equipment needs for the *Keystone* Service trains. Equipment projections for the non-*Keystone* trains are not addressed here, as their capacity demands are driven by other travel markets which are not the subject of this report.

Operating Scenario I calls for the existing service with a 9.5 percent increase in weekday ridership on the *Keystone*-only trains. This ridership could still be handled with four train sets of three cars each with some additional capacity for higher growth.

Under Scenario II, the number of weekday round trips of *Keystone* Service increases from six to nine. In the eastward direction, there is an additional AM peak train, AM off-peak train and PM peak train while in the westward direction there is an additional AM off-peak train, an additional PM off-peak train and an additional PM peak train. Scenario II projects both a low elasticity and high elasticity ridership increase. Although the schedules of these additional trains have not been set forth, it is reasonable to assume that the additional PM peak train operating from each end point will require two additional train sets. Equipment turns during the rest of the day could be arranged so that all other trains could also be covered with existing equipment. Because there is so much unused capacity on the off-peak trains, even the high elasticity ridership increase of 56 percent, which more heavily impacts discretionary travel on off-peak trains, can be accommodated with three-car train consists. The equipment needed for operation under both the low and high elasticity versions of Scenario II would be 18 cars, either unpowered or self-propelled electric multiple unit (EMU) cars, and six locomotives, if unpowered cars are used. With one spare locomotive and two spare cars each at Philadelphia and Harrisburg, the Scenario II fleet would total 22 EMU cars or 22 cars unpowered cars and eight locomotives.

Under Scenario III, as compared with present *Keystone* Service, the number of weekday round trips increases from six to thirteen. There is one additional AM peak train, three additional AM off-peak trains, one additional PM off-peak train and two additional PM peak trains. In the westward direction, there is one additional AM peak train, two additional AM off-peak trains, two additional PM off-peak trains, one additional PM peak train and finally, one additional evening train. Again, schedules for these trains have not been established, but in light of the fact that there are two additional eastward trains and one additional westward train during the afternoon peak period, it is reasonable to assume that three additional three-car sets of equipment are required, which would accommodate the ridership projected at both low and high enhancement. Adding one spare locomotive and two spare cars each at Philadelphia and Harrisburg would provide a total fleet of 25 EMU cars or 9 locomotives and 25 unpowered cars.

Weekday equipment requirements have been taken as the basis to establish the size of the fleet for this service because weekday equipment usage (particularly Friday, when an extra one way trip is run) is greater than weekend usage. Equipment needs are summarized in Table IV-1.

B. ALTERNATIVE TYPES OF EQUIPMENT

1. Existing Equipment and Condition

The equipment currently used in the *Keystone* Service is owned, operated and serviced by Amtrak. It is all locomotive-hauled electric head-end-power (HEP) coaches with diesel-electric[6] or straight electric locomotives for traction and auxiliary power. There currently is no self-propelled EMU or rail diesel car (RDC) equipment in this service.

The coaches are part of a pool of 29 Budd-built stainless steel cars assigned to the *Keystone* and Philadelphia-New York *Clocker* services.

Nineteen of the cars are 1951 vintage originally built for the Pennsylvania Railroad's New York-Washington *Congressional*. They were rebuilt and converted from steam to electric auxiliary HEP by Amtrak in the 1978-80 period. As part of that overhaul/conversion, all of the cars were equipped with fixed seating. Eleven of the cars were overhauled as straight coaches with 88 seats per car, and eight of the cars as coaches with 85 seats per car and provisions for the wheelchair handicapped. The handicap provisions include a wheelchair tie-down, a wheelchair accessible toilet, and a 32-inch wide opening on the body end door next to the toilet. The cars, as rebuilt, retain the open dump type toilet hoppers which discharge directly onto the tracks. The other ten cars are 1953 vintage originally built by The Budd Company for the

[6]In a diesel-electric locomotive, a diesel engine drives an electric generator and the electric power drives electric traction motors mounted on the axles. Hereafter, these locomotives will be identified as diesel. Head end power means that the coaches draw electric power from the locomotive for heating, cooling, and lighting.

TABLE IV-1

EQUIPMENT NEEDS FOR KEYSTONE SERVICE TRAINS

	Line Requirements		Spares (stand alone basis)		Total	
	Cars[a]	Locomotives[b]	Cars[a]	Locomotives[b]	Cars[a]	Locomotives[b]
Present	12	4	2	2	14	6
Scenario I[c]	12	4	2	2	14	6
Scenario II[c,d]	18	6	4	2	22	8
Scenario III[c,d]	21	7	4	2	25	9

Source: LTK Engineering Services; RLBA

[a]Unpowered or self-propelled.

[b]If unpowered cars are used.

[c] Service Scenarios

		Daily Round Trips	
		Weekdays	Weekends
Scenario I.	Existing Service	6	3
Scenario II.	Moderate Enhancement	9	5
Scenario III.	High Enhancement	13	8

Plus westbound trip on Fri evening and eastbound trip on Sun for each Scenario.

[d]Requirements same for low- and high-elasticity projections of ridership.

Santa Fe Railway. They were rebuilt and converted to electric HEP and high-density seating configuration by Amtrak in 1982/83 and assigned to these services.

Amtrak's planned overhaul for this equipment is an in-kind overhaul every four years, although the actual overhaul cycle has been running approximately five to six years. The condition of the cars and the 5- to 6-year actual overhaul cycle indicates that these cars have been through one in-kind overhaul since rebuilding and are ready for another.

The *Pennsylvanian* and *Keystone State Express* use "Amfleet I" equipment from Amtrak's East Coast pool, which is separate from the pool used by the Harrisburg-Philadelphia *Keystone* trains.

Until early this year, electric locomotives were operated on all *Keystone* trains, but now diesel locomotives are regularly used, with electric locomotives serving as back-up. Usually the diesel locomotives are F40OH units manufactured by the Electro-Motive Division (EMD) of General Motors, and the electrics are EMD/ASEA model AEM7 units from the Amtrak Northeast pool. Amtrak assigns the diesel F40PH units to the *Keystone* trains out of Philadelphia. The *Keystone State Express*, *Big Apple*, and *Susquehanna* are the only trains that are now regularly assigned electric AEM7 locomotives.

2. Other Potential Equipment

Other motive power potentially available for locomotive-hauled trains in this service are rebuilt units from Morrison-Knudsen (M-K) as being purchased by a number of commuter agencies or the new diesel locomotives being purchased by Amtrak from General Electric. If long term plans call for the retention of electrification, the ALP-44 electric locomotive being purchased by NJ TRANSIT from ASEA-Brown Boveri (ABB) would be a possibility for locomotive-hauled trains.

New unpowered coaches for this service could be provided by Bombardier in their aluminum commuter car configuration, as owned by NJ TRANSIT, SEPTA, Metro North and Massachusetts Bay Transportation Authority (MBTA), or the "Horizon" configuration purchased by Amtrak. Two other potential coaches are the stainless steel Nippon Sharyo car built for the Maryland Rail Commuter Service (MARC) or the Mitsui/Mafersa car built for the Northern Virginia Commuter Service. These cars have been train-lined for push-pull operation, in which a locomotive is placed at one end of the train and a cab-control coach at the other. This permits operation in either direction without the necessity of turning the train or running the locomotive around the train.

All but the "Horizon" car interior configuration and layout would require changes to the seats and luggage racks to provide the two-two seating and solid bottom luggage racks with reading lights as on the present "Heritage" and "Amfleet" equipment.

SEPTA purchased its EMU "Silverliner IV" cars from General Electric in the mid-1970s, but that car has long been out of production and no equivalent type is manufactured today. Nippon Sharyo car has recently built EMU cars for the Northern Indiana Commuter Transportation District with 1500-V d.c. propulsion. It could be produced with a.c. controls similar to those used on the SEPTA "Silverliners", as currently being provided by General Electric for the Metro North "M-6" car, or with a.c. inverters similar to that being fitted to the rebuilt NJ TRANSIT "Arrow III" cars. Nippon Sharyo considered offering this type of vehicle to SEPTA during the inquiry for what became the Bombardier order for seven AEM7 locomotives and 35 push-pull cars, but its suppliers could not meet the short delivery times required by SEPTA to conclude a safe harbor leasing arrangement.

3. Costs of Equipment

The following costs per unit of equipment are estimated in 1991 dollars:

• Locomotives		
a. Diesel		
Remanufactured units by M-K		$1,200,000
New EMD model F40PH or G.E. Amtrak type		1,900,000
b. Electric		
ABB model ALP44		$4,700,000
• Unpowered Coaches		
a. Overhaul Heritage Cars		
Amtrak: In-kind at Beech Grove		$150,000
Plus new seats		50,000
Plus Retention Toilets		50,000
Plus Lighting & A.C. Upgrading		50,000
Coach Overhaul Price	Subtotal	$300,000
New ADA Requirements		25,000
With Updated Handicapped Provisions	Total	$325,000

b. New Coaches

Bombardier, Nippon Sharyo or Mitsui/ Mafersa Commuter Cars[7]

Coach	$950,000
Coach with Handicap Facilities and Toilet	1,000,000
Cab Car with Handicap Facilities and Toilet	1,150,000

Amtrak Horizon Coaches:

With Toilets	$1,050,000
With Toilets and Handicap Facilities	1,100,000
With Toilets, Handicap Facilities and Snack Bar	1,375,000
Cab Car with Toilet	1,200,000

- New EMU Car of SEPTA/NJ TRANSIT Design

a. Married Pair[8]

With handicap facilities and toilet on one car of pair with commuter configuration and at least a 30 car order

Per EMU car (average)	$2,250,000
Per married pair	4,500,000

With Amtrak type interior

Per EMU car (average)	$2,350,000
Per married pair	4,700,000

b. Single Car

Configured with a cab in each end vestibule and all auxiliary equipment required to operate alone

With commuter interior	$2,430,000
With Amtrak interior	2,530,000
With Amtrak interior and snack bar	2,805,000

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[7]Equipped with 3-2 seating, fixed or walkover, open luggage racks, strip lighting on either side of aisle.

[8]A married pair consists of one car with a power pickup system through which power is transmitted to the other car.

4. Equipment Capacity and Availability

The "Heritage" cars as currently configured seat 88 people per coach and 85 people per handicap equipped car.

The new locomotive-hauled commuter car configuration with vestibules and steps at each end and 3-2 seating can seat:

Coach without Toilet	130 passengers
Coach with Handicap Facilities & Toilet	120 passengers
Cab Car with Handicap Facilities & Toilet	112 passengers

New locomotive-hauled cars with vestibules and steps at each end of the car in the Amtrak 2-2 seating interior layout have the following seated rider capacities:

Coach with Toilets	82 passengers
Coach with Toilets and Handicap Facilities	77 passengers
Coach with Toilets, Handicap Facilities and Snack Bar	51 passengers

EMU cars with no center doors and end vestibules with steps in a commuter car configuration (3-2 seating) would seat 125 without toilets and 115 with handicap facilities and toilets. If handicap facilities and toilets are provided on every other car (one car per pair) the average seating per car for the EMU commuter car configuration would be 120. In the Amtrak interior configuration with 2-2 seating, the capacity is 82 per coach with toilets and 77 per coach with toilets and handicapped provisions (same capacity as the locomotive-hauled intercity configuration). If every other car has handicapped provisions, the average seating per car for the 2-2 seating configuration is 79.5.

The availability of new equipment will depend on the factory loading at the time an order is placed. At the present time, delivery of diesel locomotives and locomotive--hauled cars would begin approximately 12 to 15 months after contract date and progress at a rate of 4 to 8 per month. The delivery of electric locomotives and EMU cars would begin 26 to 30 months after contract and proceed at a rate of 4 to 6 per month.

Since Amtrak has had discussions with NJ TRANSIT about taking over the Atlantic City service between Philadelphia and Atlantic City and the *Clocker* service between Philadelphia and New York, several equipment possibilities become evident for the *Keystone* Service. Amtrak could in that case make more "Heritage" cars available for the *Keystone* Service, if it no longer requires them for the *Clocker* service. The State could tack onto an order for more commuter coaches with any of the agencies listed in this report to provide new equipment for this service as they are needed. If SEPTA should become the operator of the *Keystone* Service, another possible option would be for the State to provide SEPTA with the funds to purchase 26 to 28 EMU cars and shift the existing SEPTA AEM7 locomotive and "Comet" car fleet to the *Keystone* service. These seven locomotives and 35 cars, which would satisfy the capacity needs through the study period, will be due for a general overhaul in 1995/96. At that time, the seating could be changed to the 2-2 Amtrak style and retention toilets installed as part of the outfitting of the toilet room.

The features and costs of alternatives types of equipment for the *Keystone* Service are displayed in Table IV-2, and equipment diagrams appear in Appendix G.

5. Equipment Analysis

In evaluating the alternative types of equipment available for the *Keystone* Service, a comparison should first be made of electric- and diesel-powered vehicles. The costs of acquiring a train set of new equipment of each type are shown below:

Type of Equipment		Cost (Millions)	
		Per Unit	Per Train set
Electric			
Locomotive-Hauled			
Locomotive		$4.700	$4.700
Cars		1.225 (avg)	3.675
	Total		$8.375
Self-Propelled Cars		2.502 (avg)	$7.505
Diesel			
Locomotive-Hauled			
Locomotive		$1.900	$1.900
Cars		1.225 (avg)	3.675
	Total		$5.575

The train sets are assumed to be include three coaches, including one snack bar-coach that is handicapped-accessible. For locomotive-hauled trains the last (or first) coach is a cab-control car. An Amtrak (intercity) configuration is used for coach seating. Although the cost of $1.9 million each for new diesel locomotives was used in this comparative analysis of electric and diesel power, high quality remanufactured diesel locomotives can be acquired at a cost of approximately $1.2 million each, making rebuilt equipment a more attractive alternative for diesel power.

Adding to the acquisition cost advantage of diesel equipment would be the avoidance of rehabilitating the electric traction system west of Parkesburg at a cost estimated

TABLE IV-2

SUMMARY OF EQUIPMENT FEATURES AND COSTS

	Diesel-Electric				Straight Electric
	Remanufacture		New		
a. Locomotives					
1. Potential Suppliers[a]	M-K	Others	EMD	G.E.	ABB
2. Type Unit	GP-40FH	---	F-40	Amtrak	ALP-44
3. Cost per Unit (millions)	$1.2	$1.2	$1.9	$1.8-$1.9	$4.7
4. Availability	12-15 mo	12-15 mo	12-15 mo	12-15 mo	25-30 mo
5. Life Expectancy	15 years	15 years	20 years	20 years	30 years
6. New/Remanufactured	Remanuf.	Remanuf.	New	New	New

	Locomotive-Hauled				Electric Self-Propelled
b. Car Types	Overhauled				
1. Possible Cars	Heritage	New			
2. Manufacturer[a]	Budd	BBD	N.S.	M/M	N.S
3. Age	40 years	New	New	New	New
4. Commuter Configuration					
a. Seats - Coach	---	130	130	130	125
- Handicap Coach	---	120	1250	120	115
b. Cost - Coach	---	0.95	0.95	0.95	2.05
(mill.) - Handicap Coach	---	1.00	1.00	1.00	2.15
c. Life Expectancy	---	30 years	30 years +	30 years +	30 years +
d. Carbody Material[a]	---	Alum	S.S	S.S	S.S
e. Availability	---	12-15 mo	12-15 mo	12-15 mo	25-30 mo
5. Intercity Configuration					
a. Seats - Coach	88	82	82	82	82
- Handicap/Toilet	85	77	77	77	77
b. Cost - Coach	$0.300	$1.05	$1.05	$1.05	$2.15
(mill.) - Handicap/Toilet	$0.325	$1.10	$1.10	$1.10	$2.25
c. Life Expectancy	15 years	30 years	30 years +	30 years +	30 years +
d. Carbody Material[a]	S.S	Alum	S.S	S.S	S.S
e. Availability	12-15 mo	12-15 mo	12-15 mo	12-15 mo	25-30 mo

Source: LTK Engineering Services

[a]ABBREVIATIONS:

ABB = ASEA Brown Boveri
Alum = Aluminum
BBD = Bombardier, Inc.
EMD = Electro Motive Division - General Motors
G.E. = General Electric Company
M-K = Morrison-Knudsen
M/M = Mitsui/Mafersa
N.S. = Nippon Sharyo
S.S. = Stainless Steel

at $5.25 million[9](see Chapter II). Further, the cost of fuel and maintenance per train-mile of diesel-powered trains would be lower than the cost of power and maintenance of electric trains, as can be seen in the following table:

Equipment Type	Cost per Train-Mile		
	Fuel/Power	Maintenance	Total
Diesel locomotive	$1.80	$3.11	$4.91
Electric locomotive	3.16	4.11	7.27
EMU cars	1.44	3.00	4.44

Although the economics favor diesel-powered trains, electrically-powered trains offer several advantages, including:

- The ability to operate beyond 30th Street Station to Suburban (Penn Center) and Market East stations in Center City Philadelphia;
- The ability to operate through trains to Pennsylvania Station in New York without the need to change locomotives;
- The ability to operate EMU equipment;
- Better operating characteristics, namely higher acceleration, that would permit faster running times and cutting ten minutes from the schedule between Philadelphia and Harrisburg;
- Improved air quality, thus helping the region meet the requirements of the Clean Air Act Amendments of 1990; and
- Reduced dependence on imported oil.

As compared with electric locomotive-hauled trains, self-propelled EMU cars have the following advantages:

- Lower capital and operating costs;
- Greater flexibility (e.g., could be coupled to SEPTA trains);

[9]Regardless of whether the electric traction system is used to power the Harrisburg trains, it will still be required east of Parkesburg to support local SEPTA service. The cost of rehabilitating this segment was estimated in Chapter 2 at $4.63 million.

- With each car powered, if one unit fails the train is not dead as with a locomotive failure.

C. SUMMARY

The equipment operating in the existing Keystone service includes twelve "Heritage" type 1951-1953 vintage cars and four model F40PH diesel locomotives when available, and model AEM7 electric locomotives when diesels are unavailable. This analysis excludes trains that operate between New York and Harrisburg or beyond.

The 1996 ridership estimates developed in Chapter II were used to determine the train consists needed to protect the service. Even using the high end of the ridership range three-car consists should be adequate to handle the projected demand. After allowing for spares, the following fleet size will be needed for the three operating scenarios:

Scenarios	Cars[10]	Locomotives[11]
I	14	6
II[12]	22	8
III[12]	25	9

The unit costs for the alternative types of equipment suitable for the Keystone Service are:

	Avg. Cost Per Unit (millions)
Locomotives	
Remanufactured Diesel Units	$1.20
New Diesel Units	1.90
New Electric Units	4.70
Unpowered Cars	
Overhauled Heritage Cars	0.31
New Cars	1.23
New Self-Propelled EMU Cars	2.56

[10]Either unpowered or self-propelled.

[11]If unpowered cars are used.

[12]Requirements same for low and high elasticity ridership projections.

The capital costs of required fleets of the alternative types of equipment are set out below:

Equipment Type	Capital Cost (millions)		
	Scenario I	Scenario II	Scenario III
Remanufactured Diesel Locomotives and Overhauled Heritage Cars	$11.6	$16.5	$18.6
Remanufactured Diesel Locomotives and New Cars	24.4	36.7	41.5
New Diesel Locomotives and New Cars	28.6	42.3	47.8
New Electric Locomotives and New Cars	45.4	64.7	73.0
New Self-Propelled Electric Cars	35.8	56.6	64.1

Although diesel-powered equipment is more economical to acquire and maintain, electric trains offer several advantages, including the ability to operate to Center City Philadelphia, the ability to operate through trains to New York, reduced scheduled running times, improved air quality, and reduced dependence on petroleum-based fuels.

As compared with electric locomotive-hauled trains, self-propelled EMU cars offer lower capital and operating costs, greater flexibility in combining and cutting cars, and greater reliability, as the failure of a single unit does not stop the train.

V. EVALUATION OF MANAGEMENT OPTIONS

This chapter discusses and evaluates the management options for operating the Philadelphia-Harrisburg train service. Historically, the Philadelphia-Harrisburg service was operated by the Pennsylvania Railroad (PRR), which had full responsibility for managing the service and maintaining the line. After the Southeastern Pennsylvania Transportation Authority (SEPTA) was formed in February 1964, it contracted with the PRR to provide local service east of Downingtown. However, the PRR continued to operate the Harrisburg trains as part of its intercity service. This arrangement was continued with the Penn Central after it was formed from the merger of the PRR with the New York Central in February 1968. In April 1971 the National Rail Passenger Corporation (Amtrak) was established and accepted responsibility for most intercity trains, including the Philadelphia-Harrisburg trains, though in actuality, Penn Central continued to operate the trains under contract from Amtrak. Five years later (April 1976) the Consolidated Rail Corporation (Conrail) was formed from the remains of six bankrupt railroads in the Northeast and Midwest, and as part of the reorganization Amtrak received title to most of the Northeast Corridor (NEC), as well as the spurs to Springfield and Harrisburg. For the first time Amtrak was a railroad running on its own track. Conrail took over operation of the Paoli-Philadelphia trains under contract from SEPTA, plus one weekday round-trip to Downingtown. This restructuring relieved Amtrak of the need to pay others for the right to operate on the line, and it now received trackage payments for handling freight and local passenger trains, but it had the burden of maintaining and renewing the infrastructure. Since 1980 the Pennsylvania Department of Transportation (PennDOT) has been providing financial support for one weekday round-trip and two on Sunday. Early Amtrak schedules listed the trains under *Silverliner Service*, but the name was changed to *Keystone Service* in October 1981, when the Budd-built self-propelled electric cars were replaced by locomotive-hauled equipment. SEPTA assumed direct operation of the local trains at the beginning of 1983. At first no SEPTA service was run west of Paoli, but gradually service was expanded westward to Downingtown and Parkesburg.

A. OWNERSHIP, MANAGEMENT, AND OPERATION OPTIONS

Basically there are three separate functions to consider in looking at alternatives to Amtrak service; line ownership, policy management, and operations. Though a single entity, Amtrak, now controls all three functions, there is no inherent reason why this has to remain the case. In most of the country Amtrak operates on the tracks of host railroads, and on the NEC other operators pay Amtrak for the privilege of running trains. Policy management refers to the power to make decisions regarding the quantity and type of service, fares, marketing and promotion, investment, and also includes oversight functions. Day-to-day management will remain under the control of whoever operates the trains. Maintenance of right-of-way will be the responsibility of whoever owns the line.

Local service on the NEC from Boston to Washington provides illustrations of several operational arrangements. From north to south, these are:

Segment	Owner	Manager	Operator
Boston to MA/RI Line	MBTA	MBTA	Amtrak
MA/RI Line to Providence	Amtrak	MBTA	Amtrak
Old Saybrook to New Haven	Amtrak	ConnDOT	Amtrak
New Haven to CT/NY Line	ConnDOT	Metro North	Metro North
CT/NY Line to New Rochelle Jct	Metro North	Metro North	Metro North
New York (Penn Sta) to Trenton	Amtrak	NJ TRANSIT	NJ TRANSIT
Trenton to Wilmington	Amtrak	SEPTA	SEPTA
Perryville to Washington	Amtrak	MARC	Amtrak
PHILADELPHIA TO PARKESBURG	AMTRAK	SEPTA	SEPTA

In these eight segments, five distinct combinations of functional arrangements can be seen. In three cases Amtrak owns the line and contracts to operate the service. In Massachusetts Amtrak operates its own trains, as well as a local contracted service, on tracks owned by the regional transportation authority; but in New York the entire package from track ownership to train operation is handled by Metro North. In New Jersey and Pennsylvania, Amtrak owns track on which NJ TRANSIT and SEPTA operate local service.

1. Ownership

In southeastern Pennsylvania most of the rail right-of-way used by passenger trains is either owned by Amtrak (the NEC and the Harrisburg Line) or by SEPTA. In addition, a few segments important for moving freight and owned by Conrail are used by SEPTA, and Amtrak also uses a Conrail freight line to move its trains west of Harrisburg. The principal advantage of ownership is that it gives the owner control of the line and the right to dispatch trains in accordance with its needs. It also eliminates the need to pay for trackage rights and provides income when other parties run trains on the line. However, it also means that the owner is responsible for maintenance and repairs, as well as generating capital investment needed to renew or upgrade the fixed infrastructure. Making the capital investment decisions does give the owner the power to reconfigure or rationalize the physical plant in ways deemed desirable.

Basically, there are two realistic options regarding ownership. Amtrak can continue to own and maintain the line. After all, regardless of what happens to the *Keystone* trains, Amtrak will continue to operate three daily long-distance trains over the line. A disadvantage of this arrangement is that Amtrak may not give the line as high a priority as Pennsylvania desires, nor configure the line properly to accommodate local trains. For example, currently SEPTA is required to run its Parkesburg trains 12 miles west to Leaman Place in order to reverse direction, because Park Tower (Parkesburg) is no longer manned and the interlocking there cannot be used.

State ownership could rectify some of these problems, but this would require a substantial investment, at a time of general financial constraints, and the establishment of an administrative mechanism that would allow the State to acquire an operating railroad. Of course, all the benefits of ownership would now accrue to the people of Pennsylvania, who would now enjoy direct control over the State's most important intercity rail corridor.

Another possible option is SEPTA ownership. SEPTA does have experience in owning and maintaining electric railroads, and to acquire the Harrisburg Line would constitute a relatively straightforward expansion, though to date, SEPTA has not owned any lines beyond the five counties that provide local support. Since any funds needed to acquire and improve the line would have to come from the State, from a financial perspective there is probably little meaningful distinction to be made between State and SEPTA ownership. However, SEPTA ownership could be seen by some outside the Philadelphia area as conceding control of the line to Southeastern Pennsylvania, and this could complicate the process of obtaining the legislative approval needed to buy and upgrade the line. This option can be considered as a subset of state ownership, rather than as a separate option.

The line could also be put up for bid in the hopes that a private buyer would be interested in acquiring the line for short line operation. This offers the possibility of enhanced freight service to local shippers and would preserve the line for passenger service. However, Amtrak needs the line as part of its national network and it is doubtful that a purchaser would have the resources needed to maintain the line at Class IV standards. Amtrak's limited experience with regional or short-line operators generally has not been good (Chicago-St. Louis provides a good example), and in addition, a public subsidy would still be needed to support the *Keystone Service*. This is probably not a realistic option.

2. Policy Management

Currently, all policy decisions regarding the *Keystone Service* are made by Amtrak, though PennDOT wields some influence over the 13 weekly trips supported under the 403(b) program. The only realistic alternative to Amtrak management is to pass control to the State. If Amtrak retains management control of the service, it is likely to insist on retaining operational control as well. Though several states have contracted with Amtrak to operate their local trains, Amtrak does not contract out operation of its own trains. (In its early years train and engine crews were provided by the railroads over which Amtrak operated.)

A good illustration of the policy management function is provided by the Maryland Rail Commuter (MARC) Service, where local rail service is provided on three lines in the Baltimore-Washington area. MARC, which is a state agency, makes all policy decisions, sets fares and levels of service, and handles marketing and promotion, but owns no lines nor operates any trains. Though seen by the public as MARC trains, the trains run on lines owned by either Amtrak or CSX and are operated by the host railroad.

In theory, SEPTA could provide policy management, but since State resources would be required to acquire, upgrade, maintain, and operate the line, PennDOT would probably insist on retaining the right to set policy, either directly or through a subsidiary agency.

3. Operation

The operator is responsible for all the aspects of day-to-day operation of trains and is the principal point of contact with the public. Trains must be run on time and maintained in safe operating condition; tickets and passes must be sold; stations must be staffed and maintained. The State could establish its own agency to run the trains, but this would probably only make sense if service on additional lines were anticipated. NJ TRANSIT is a statewide public agency that does operate its own trains, but it has a network of eleven lines and enjoys an economy of scale.

More commonly, states with regional or suburban rail service hire a contractor to run the trains. Amtrak itself could be the operator and should be considered as an option here. Currently, it operates local trains at the north end of the NEC for the Massachusetts Bay Transportation Authority (MBTA) and at the south end for MARC. It is also expected to operate local trains south of Washington for the Virginia Rail Express, starting in the fall of 1991.

SEPTA could operate the trains. Since SEPTA has been steadily expanding its Route R5 westward, this might be seen as a natural extension. Certainly the regional authority has the demonstrated capability to run passenger trains, but funding for the operation would have to come from beyond southeastern Pennsylvania. By extending Route R2 to Wilmington with support from the State of Delaware, SEPTA has already set a precedent for contract operation.

An independent contractor could be hired to run the service, which would open the process to competitive bidding. An example of this is supplied by Florida's Tri-Rail operation, which uses the Urban Transportation Development Corporation, a Canadian firm based in Toronto, to operate local trains between West Palm Beach and Miami.

B. SELECTION OF OPTIONS

Continued ownership, control, and operation by Amtrak will be considered as the base case against which all other combinations are compared. This is not meant to imply that the current arrangement should be considered as an option. Amtrak regards the *Keystone* corridor as a poor performer and may further reduce the level of service in the absence of institutional changes. In any event Amtrak, given higher priorities elsewhere, is not likely to make the capital investment required to keep the corridor in good operating condition nor to acquire new rolling stock. And certainly there are few prospects for service upgrades, if the status quo is maintained.

Though the exact form of the surface transportation reauthorization bill, now wending its way through Congress, is not yet apparent, it will in all likelihood give the states greater flexibility in shifting Federal funds between highway and rail projects. This will allow states to choose solutions that best meet their transportation needs and should make it easier to finance rail capital projects or to provide operating support.

The principal alternative to continued Amtrak ownership is to sell or transfer the line to a State agency, who will then be responsible for the capital improvements described in Chapter II and maintenance. Estimates of maintenance costs can be based on SEPTA's experience in maintaining electric railroads. State ownership will also have impact on operational costs by allowing the State to receive trackage payments from Amtrak for the operation of through trains over the Philadelphia-Harrisburg segment and from Conrail for freight movements. Amtrak will also purchase electricity for traction, though it can be assumed that trains running west of Harrisburg will make the switch between diesel and electric locomotives at 30th Street in Philadelphia. Conrail relies entirely on diesel power. SEPTA will be relieved of the responsibility of making payments to Amtrak for Route R5 trains (Route R6 also uses the line for a short segment). [It is not clear at this point what institutional arrangements would exist between SEPTA and PennDOT. Since PennDOT provides operational support to SEPTA, any payments should be regarded as internal transfers.] PennDOT would also cease making 403(b) payments to Amtrak for support of *Keystone* services.

Costs for managing the service will be largely administrative costs. MARC's experience in Maryland may prove helpful here. If any changes at all are made to the existing service configuration, it will be to pass control of the service from Amtrak to PennDOT. So all options other than the base case will assume PennDOT control.

Train operating costs can depend markedly on who is running the trains and the equipment used. Equipment costs should be based on the results of Chapter IV and the particular cost structure of each operating entity. Costs should be estimated for operation by Amtrak under contract, by a State agency, by SEPTA, and by an independent contractor. Since SEPTA has an organizational framework in place and to the extent that excess capacity may exist at existing maintenance facilities, marginal costs may be used for SEPTA.

The choices can be summarized as follows:

	Owner	Manager	Operator
Base Case:	Amtrak —	Amtrak —	Amtrak
Alternatives:	Amtrak PennDOT } —	PennDOT —	{ Amtrak SEPTA Contractor

With two ownership options that can be combined with each of the three operational choices, there are six possible configurations for the *Keystone Service*. Rather than analyze each combination as an independent entity, it would be more useful to consider the financial implications of each of the ownership and operational choices separately. Costs connected with shifting control to PennDOT would be the same regardless of which of the alternatives to the base case is chosen.

However, there are interrelationships between line ownership and operation that must be considered. If Amtrak owns the line, any operator other than Amtrak is going to have to buy trackage rights, and even though operating costs will vary with the choice of operator, the cost of buying trackage rights can be assumed to remain constant. Each of the alternative configurations will incur capital and operating costs that must be tracked. These are outlined in Table V-1. Any costs to Amtrak that can be attributed to the *Keystone Service* are assumed to be covered by contractual payments. Fares and other revenues will be applied to operating costs, and if these are covered, the excess can be applied to capital investments. All configurations assume that the State will manage the service, supply rolling stock, and have some responsibility for stations.

Station ownership will likely reside with whoever owns the line, though the operator may lease the smaller stations and assume responsibility for maintenance. This essentially the arrangement now in place between Amtrak and SEPTA for stations on the NEC and the Harrisburg Line. Other arrangements are possible, however, as in New Jersey, it is NJ TRANSIT that owns the stations and Amtrak that is the lessee.

Also common to all the alternatives is the elimination of State 403(b) payments to Amtrak for selected *Keystone* trips. Payments would continue in support of the

Table V-1

COST ELEMENTS TO PENNSYLVANIA OF ALTERNATIVE CONFIGURATIONS

Owner	Manager	Operator	Capital	Operating
Amtrak	PADOT	Amtrak	Rolling stock Stations ROW upgrade	Contract train operation Station maintenance
Amtrak	PADOT	Contractor	Rolling stock Stations ROW upgrade	Contract train operation Trackage rights Station maintenance
Amtrak	PADOT	PADOT SEPTA	Rolling stock Stations ROW upgrade	Trackage rights Train operation & maintenance Station maintenance
PADOT	PADOT	Amtrak Contractor	Rolling stock Stations ROW purchase & upgrade	Receive trackage payments from Amtrak & Conrail Contract train operation ROW maintenance Station maintenance
PADOT	PADOT	PADOT SEPTA	Rolling stock Stations ROW purchase & upgrade	Receive trackage payments from Amtrak & Conrail Train operation & maintenance ROW maintenance Station maintenance

Source: DVRPC

Pennsylvanian, though some reduction may be in order if Amtrak ceases to own the line between Harrisburg and Philadelphia.

In addition to the service configurations already discussed, other choices need to be made before the entire package can be costed. Do the advantages of electric propulsion outweigh its costs, or would diesel power prove to be more cost effective in the long run? And how much service should be provided? The options are listed in Table V-2. Altogether forty-eight combinations of choices are possible. However, the choices in each column are largely independent of those in other columns.

The capital and operating costs dependent on the choice of propulsion are briefly summarized in Table V-3. If electrification is kept, investment will be needed to renew the distribution system. Chapter II indicated that the system is reasonably good shape, considering its age, but that approximately $9 million will be needed to replace worn catenary and upgrade transformers. Whatever decision is made regarding the *Keystone Service*, electrification will have to be maintained on the eastern half of the line in order to support local SEPTA service, and this will reduce the potential for cost saving by switching to diesel. Electric locomotives also cost more than diesels and often, depending on the cost of electric power, have higher operating costs, but generally are more powerful, have a longer service life, and cost less to maintain. Better acceleration characteristics allow electric trains to cover a route in less time, thereby reducing crew costs and making the service more attractive.

The costs connected with increasing levels of service can be obtained by calculating the service parameters required (train-miles, car-miles, man-hours, etc.) and using the unit costs of each operator. Costs of equipment and supplies should be independent of the choice of operator.

Established operators may be in a better position to operate the *Keystone Service*, than newcomers. Both Amtrak and SEPTA have experience in running trains, have administrative machinery in place, and own facilities and equipment for maintaining locomotives, cars, and right-of-way, though an independent contractor may have a lower cost structure or be burdened by procedures designed for other times and places.

Finally, external factors may affect decisions. The willingness of Amtrak to respond to State and local needs, to upgrade the line, or to operate more service may play a role. But to make good choices, good information on costs, advantages, disadvantages, and operating characteristics are needed.

Table V-2

SERVICE, OWNERSHIP, AND OPERATOR OPTIONS

Propulsion	Service	Ownership	Operator
Electric	Scenario I (7 RT Mo-Fr; 5 RT Sa, Su)	Amtrak	Amtrak
Diesel		PADOT	PADOT
	Scenario II (10 RT Mo-Fr; 7 RT Sa, Su)		SEPTA
			Contractor
	Scenario III (14 RT Mo-Fr; 10 RT Sa, Su)		

Table V-3

COST ELEMENTS DEPENDENT ON CHOICE OF PROPULSION

	Capital	Operating
Electric	ROW investment needed to renew electric distribution system Locomotives	Catenary maintenance Locomotive maintenance Electric power Crew
Diesel	Locomotives	Locomotive maintenance Fuel Crew

Source: DVRPC

C. SUMMARY

Though Amtrak currently owns the Philadelphia-Harrisburg Rail Line and operates the *Keystone* trains, as well as other longer distance trains, there is no inherent reason why this has to remain the case. Amtrak's primary mission is to provide intercity rail passenger service nationwide, and in this context, it does not regard the *Keystone Service* as ranking very high in its scale of priorities. Other institutional arrangements are possible that would increase the level of local control and lead to improved service.

Three separate functions must be considered when looking at alternatives to Amtrak service: line ownership, policy management, and operations. Even if ownership of the line were to pass to another entity, Amtrak would continue to run its longer-distance trains (such as the *Broadway Limited* and *Pennsylvanian*) over the line, but it would now have to buy trackage rights from the owner. Policy management refers to the power to set policy and make decisions at the broadest level. Day-to-day management would be provided by whoever operates the trains, with the policy manager providing oversight. The existing arrangement where Amtrak controls all three functions will serve as the base case to which all other options are compared.

The most likely alternative to Amtrak ownership is for control of the line to be transferred to the State of Pennsylvania, either PennDOT or an entity established for the purpose. The State would then be responsible for capital investment and maintenance, but it would have control of the level and timing of these investments, and could also ensure that the interests of the *Keystone Service* were protected. SEPTA could also own the line, though the resources for its acquisition and improvement would still have to come from the State. SEPTA does have the capability in place to manage and maintain rail lines. Since in either case financial responsibility would reside with the State, State ownership should be seen as the principal alternative to Amtrak ownership.

No changes in the institutional configuration of the service are possible unless policy control passes from Amtrak to another entity. Amtrak is not likely to retain responsibility for line ownership and train operation, unless it can determine the parameters for delivering the service.

Even if Amtrak does not own the line and control the *Keystone Service*, it could still contract to operate the trains. There is precedence for Amtrak operation of local trains at under contract elsewhere in the Northeast Corridor. SEPTA could operate trains to Harrisburg as an extension of its Route R5 service to Chester County. It already runs more train-miles on the line than does Amtrak. The service could also be put out to bid for operation by an independent contractor. The problem here is that few contractors currently have the capability to provide rail passenger service, and by not being able to build upon existing operations, they would suffer by being at the bottom end of the learning curve. The State could establish an agency to operate the trains, such as was done in New Jersey, but there seems to be little inclination to do this. By operating only a single line, neither the State nor an independent contractor would be able to enjoy an economy of scale. It appears that Amtrak and SEPTA are the only realistic options for operating a State-controlled *Keystone Service*.

Two options should be considered as alternatives to Amtrak ownership and operation. In both the State acquires the line, provides the investment needed for capital improvements, and sets policy regarding the service. In the first, a contract is negotiated with Amtrak to operate the Philadelphia-Harrisburg trains, and in the second, train operations are turned over SEPTA. Both have the capability and experience to run the service.

In addition to choosing a suitable management configuration, at least two other major decision points must be passed. The first, and most important, is whether to maintain the electrification or not. If it is decided to use diesel locomotives, the $9 million required to renew the electric traction system on the western half of the line is avoided, cheaper diesel equipment can be purchased, and the operator can enjoy lowered operating costs. However, dropping the electrification precludes the flexibility of routing trains into Center City Philadelphia and operating trains with electric self-propelled equipment. It also moves against the thrust of clean air requirements and forces SEPTA to assume all the costs of electrification on the eastern end. If electric propulsion is used, a second decision of whether to use locomotive-hauled or self-propelled equipment. This is straightforward decision based mainly on economics and the availability of equipment, and regardless of the decision, does not interfere with the larger goals of the service.

VI - ANALYSIS OF FINANCIAL REQUIREMENTS

In the previous chapters various options regarding the infrastructure, service levels, equipment, and institutional arrangements have been discussed. Each of these have financial consequences that should be addressed before any decisions can be taken.

In Chapter II recommendations were made concerning the repairs and improvements needed to restore the line to good operating condition. Here the choices are fairly limited and hinge mainly on whether or not the electrification is kept west of Parkesburg. Three service scenarios were discussed in Chapter III. The choice will affect ridership (and hence revenue), the investment needed for rolling stock, and operating costs. Equipment choices were considered in Chapter IV, and these will have a significant impact on the type of service offered and the cost of providing it. The institutional options considered in Chapter V determine who pays for what and affect the financial options available.

This chapter covers the last substantive task of the project, which is to consider the total cost of the various options and the financing strategies available for meeting them.

A. REVENUES

The ridership projections made in Chapter III for the high elasticity case will be used to estimate the 1996 operating revenue earned by the *Keystone* trains. Six market segments were defined in that chapter: commuter, weekday discretionary, and weekend discretionary, each split into Philadelphia and Harrisburg orientations. For revenue estimation purposes, a representative trip was assigned to each of the market segments. The operating revenue for 1996 was then obtained by multiplying the ridership by the trip fare. As current fares were used, the revenues are stated in 1991 dollars.

Since SEPTA is now carrying most of the commuters from Chester County to Philadelphia, it was assumed that Amtrak commuters would originate further west in Lancaster. Lancaster was also assumed to generate most of the commuters at the western end of the line, since it is in the middle of the range originating work trips to Harrisburg, as well as handling the most boardings. It was also assumed that commuters would buy ten-trip tickets (W210 in the Amtrak fare codes), which in the summer of 1991 cost $77 for ten trips between Lancaster and Philadelphia and $41 between Lancaster and Harrisburg.

With respect to the discretionary markets, it was assumed that travelers headed toward Philadelphia travelers would also originate in Lancaster, as that station now boards more passengers than Harrisburg, but that those headed toward Harrisburg would come from Philadelphia. Here it is expected that passengers will buy excursion tickets (code: CRB2), which cost $17 for a round trip between Lancaster and Philadelphia and $27 between Philadelphia and Harrisburg.

Annual ridership for 1996 by market segment for each operating scenario with the resulting annual revenues are shown in Table VI-1. If conditions conducive to a high elasticity response by riders to service increases are not present, the ridership and revenue will be lower by as much as 22 percent. These conditions include new equipment, infrastructure renewal, and the ability to operate trains to Center City Philadelphia.

B. CAPITAL COSTS

To develop annual costs for the recommended capital investment, four assumptions are presented regarding the portion of the costs to be placed on a pay-as-you-go basis (PAYG) and the portion to be financed with debt. These are in order of increasing debt: (a) 100 percent PAYG; (b) 50 percent financing and 50 percent PAYG; (c) 100 percent financing of the equipment costs and 100 percent PAYG for infrastructure improvements; and (d) 100 percent financing of the full costs. The suitability of the approaches depends on who owns the line. Amtrak can use Federal appropriations to cover capital investments, though these are rarely at a level deemed sufficient. In contrast the State has no source of revenue that could manage the heavy up-front costs. Thus, the 100 percent PAYG approach was considered appropriate for Amtrak ownership, but not if PennDOT acquires the line. Conversely, full financing was ruled out for Amtrak ownership, but was considered appropriate for PennDOT, partly because the State can issue tax-free bonds and partly because of Amtrak's need to minimize the cost of debt service. Accordingly, approaches (a) through (c) were used for Amtrak ownership, and (b) through (d) for PennDOT ownership.

1. Summary of the Capital Costs

Capital costs for the *Keystone Service* were estimated in Chapter II for infrastructure improvements and in Chapter IV for rolling stock. These are summarized in Tables VI-2 and VI-3 for each of the three operating scenarios. The first includes the cost of rehabilitating the electrification plant and acquiring self-propelled electric cars, whereas the second assumes that diesel equipment will be used. However, it should be noted that even if the *Keystone* trains operate with diesel locomotives, SEPTA will still require the electrification east of Parkesburg. The $4.6 million required to rehabilitate this portion has not been included in Table VI-3.

Table VI-1

PROJECTED 1996 RIDERSHIP AND REVENUE

Market Segment	Ridership (000)			Fare	Revenue (millions of 1991 dollars)		
	Scenario				Scenario		
	I	II	III		I	II	III
Commuter:							
Lancaster to Philadelphia	107.6	129.9	129.9	$ 7.70	$ 828	$1,001	$1,001
Lancaster to Harrisburg	48.0	54.8	67.6	$ 4.10	197	224	277
Discretionary:							
Lancaster to Philadelphia	151.7	236.8	349.7	$ 8.50	1,289	2,013	2,972
Philadelphia to Harrisburg	59.3	102.3	169.8	$13.50	801	1,381	2,292
Total:	366.6	523.8	717.1		$3,115	$4,619	$6,542

Source: DVRPC and RLBA

Table VI-2

CAPITAL COSTS WITH ELECTRIC TRACTION

(millions of 1991 dollars)

	Year 1	Year 2	Year 3	Year 4	Total
			Scenario I		
Track	2.20	2.20	2.20	2.20	8.80
Electric Traction	2.27	2.27	2.28	2.28	9.10
Stations	1.40	-	-	-	1.40
Bridges	0.50	0.50	-	-	1.00
Subtotal	6.37	4.97	4.48	4.48	20.30
Equipment[a]	35.80	-	-	-	35.80
Total Costs	42.17	4.97	4.48	4.48	56.10
			Scenario II		
Track	2.20	2.20	2.20	2.20	8.80
Electric Traction	2.27	2.27	2.28	2.28	9.10
Stations	1.40	-	-	-	1.40
Bridges	0.50	0.50	-	-	1.00
Subtotal	6.37	4.97	4.48	4.48	20.30
Equipment[a]	56.60	-	-	-	56.60
Total Costs	62.97	4.97	4.48	4.48	76.90
			Scenario III		
Track	2.20	2.20	2.20	2.20	8.80
Electric Traction	2.27	2.27	2.28	2.28	9.10
Stations	1.40	-	-	-	1.40
Bridges	0.50	0.50	-	-	1.00
Subtotal	6.37	4.97	4.48	4.48	20.30
Equipment[a]	64.10	-	-	-	64.10
Total Costs	70.47	4.97	4.48	4.48	84.40

Source: Chapters II and IV

[a]Self-propelled electric cars.

Table VI-3

CAPITAL COSTS WITHOUT ELECTRIC TRACTION

(millions of 1991 dollars)

	Year 1	Year 2	Year 3	Year 4	Total
			Scenario I		
Track	2.20	2.20	2.20	2.20	8.80
Stations	1.40	-	-	-	1.40
Bridges	0.50	0.50	-	-	1.00
Subtotal	4.10	2.70	2.20	2.20	11.20
Equipment[a]	28.60	-	-	-	28.60
Total Costs[b]	32.70	2.70	2.20	2.20	39.80
			Scenario II		
Track	2.20	2.20	2.20	2.20	8.80
Stations	1.40	-	-	-	1.40
Bridges	0.50	0.50	-	-	1.00
Subtotal	4.10	2.70	2.20	2.20	11.20
Equipment[a]	42.30	-	-	-	42.30
Total Costs[b]	46.40	2.70	2.20	2.20	53.50
			Scenario III		
Track	2.20	2.20	2.20	2.20	8.80
Stations	1.40	-	-	-	1.40
Bridges	0.50	0.50	-	-	1.00
Subtotal	4.10	2.70	2.20	2.20	11.20
Equipment[a]	47.80	-	-	-	47.80
Total Costs[b]	51.90	2.70	2.20	2.20	59.00

Source: Chapters II and IV

[a]New diesel locomotives and cars for push-pull operation.

[b]Does not include $4.6 million needed to renew electrification for SEPTA operation.

As Table VI-2 shows, total capital costs based on retaining the electric traction system range from $56 to $84 million, depending on the operating scenario selected. Equipment replacement with new self-propelled EMU cars requires a substantial portion of the total costs, ranging from $36 to $64 million depending on the scenario. Infrastructure improvements, regardless of the scenario chosen, account for $20 million. The track and electric traction programs are allocated over four years, bridge work over two years, and the balance is programmed in the first year.

Table VI-3 is based on the option of diesel locomotive-hauled trains, under which the total capital costs would range from $40 to $59 million for the three operating scenarios. Infrastructure cost would amount to $11 million, and equipment cost (new diesel locomotives and cars, configured for push-pull operation) ranges from $29 to $48 million for the three operating scenarios.

2. Current Funding Sources For Capital Investment

As the owner and operator of the *Keystone Service*, Amtrak is responsible for the capital costs of maintaining the rail infrastructure and providing the equipment. Funding for Amtrak's capital needs is met through several means. The primary source, particularly for infrastructure improvements, is through Federal appropriations. For equipment purchases and certain real estate activities, Amtrak has utilized private markets to provide capital resources through debt-equity instruments.

PennDOT paid Amtrak approximately $499,000 in FY1991 as its share of Amtrak's operating costs under the 403(b) program, but only $173,000 of this amount is directly attributable to *Keystone* trains. Most of this money is used to support the *Pennsylvanian*. Though PennDOT has the statutory authority to seek capital appropriations in support of intercity rail service, to date no state funds have been provided for capital investment.

Through the efforts of PennDOT, the *Keystone Service* data is included in the UMTA Section 15 Report which is the basis for distributing UMTA Section 9 funds. This service accounts for $4 million in Section 9 funds for the DVRPC region, however, these funds are currently being used to support SEPTA service.

3. Funding Sources Under Each Ownership/Management/Operating Option

The various ownership/operation options have an effect on the capital costs, as well as upon funding sources. Although the operator of the service is not material in funding for capital costs, ownership is significant. The funding sources for each option are summarized in Table VI-4.

As can be seen, ownership has an impact on the sources of funding. For instance, Amtrak appropriations are available only if Amtrak is the owner/operator of the

Table VI-4

POTENTIAL FUNDING SOURCES

Amtrak Ownership

Source of Funding	Capital Asset Acquired: Infrastructure Improvements	Stations	Equipment
Amtrak Appropriations	X	X	X
Federal Highway Administration	X	X	X
Pennsylvania General Obligation Bonds	X	X	X
Private Developer		X	
UMTA Section 9			X
Equipment Manufacturer			X

PennDOT Ownership

Source of Funding	Capital Asset Acquired: Infrastructure Improvements	Stations	Equipment
UMTA Section 9	X	X	X
Federal Highway Administration	X	X	X
Pennsylvania General Obligation Bonds	X	X	X
Pennsylvania Turnpike	X		X
Private Developer		X	
Local Government		X	
SEPTA		X	
Equipment Manufacturer			X

Source: Canby Associates

service. While funding might technically be available under several ownership scenarios, the feasibility of each source varies depending on the owner/operator.

Federal highway funds could be used for parking facilities under current law, however, these costs are not included in the estimates. Depending on the final disposition of the reauthorization of the surface transportation program by Congress, PennDOT could allocate Federal highway funds for improvements in this corridor.

Certain UMTA Section 9 funds currently used by SEPTA could be used for capital improvements in support of this service. Assuming that SEPTA applies the maximum amount of Section 9 funds allowable for operating expenses, any portion of these funds which could be applied to this *Keystone Service* is assumed to be capital money.

In addition to these Federal funding sources, several potential new sources are suggested. There may be opportunities for private developer or local government participation in the cost of station improvements, if there are development opportunities at any of the stations.

Finally, because the Pennsylvania Turnpike roughly parallels the rail line to Harrisburg, it is conceivable that the Turnpike Commission could finance some portion of the improvements in lieu of expanding the toll road capacity.

4. Financing Costs

To develop an estimate of financing costs, four funding approaches have been used: a) 100 percent for each of the two ownership options. If Amtrak retains ownership, the infrastructure improvements would be funded from Federal appropriations on a pay-as-you-go basis, but funding for rolling stock would range from full appropriations to full financing. If the line is transferred to State ownership, it was assumed that at least one-half of the total capital cost would be financed. In this case, the funding approaches also considered financing the equipment and full financing of all capital expenses. Tables VI-5 and VI-6 present the annual costs with and without electric traction for the two ownership options under each operating scenario and funding approach. The interest rate assumed for Amtrak is 9.5 percent and that for PennDOT is 7.0 percent, based on the ability of the State to issue tax-free bonds. All financing is based on a 20-year term.

5. Feasibility of Funding Sources

Amtrak's principal source of capital funds derives from Federal appropriations. Private financing has been utilized for the procurement of rolling stock using a leveraged lease structure with debt and equity elements and the debt service costs to be covered by operating revenue.

Table VI-5

ANNUAL CAPITAL COSTS WITH ELECTRIC TRACTION

Scenario I
(millions of 1991 dollars)

Funding Options Under Amtrak Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
A. 100% Pay-as-You-Go							
Cost	42.18	4.97	4.48	4.47			56.10
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	1.00	2.49	2.77	3.01	3.16	51.22	63.65
Appropriations	21.09	2.49	2.24	2.23	___	___	28.05
Total	22.09	4.98	5.01	5.24	3.16	51.22	91.70
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	1.70	4.03	4.02	4.02	4.02	63.46	81.25
Appropriation	6.38	4.97	4.48	4.47	___	___	20.30
Total	8.08	9.00	8.50	8.49	4.02	63.46	101.55

Funding Options under PennDOT Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	0.74	2.06	2.28	2.49	2.62	42.77	52.96
Approriation	21.09	2.49	2.24	2.23	___	___	28.05
Total	21.83	4.55	4.52	4.72	2.62	42.77	81.01
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	1.25	3.35	3.34	3.35	3.34	52.97	67.60
Appropriation	6.38	4.97	4.48	4.47	___	___	20.30
Total	7.63	8.32	7.82	7.82	3.34	52.97	87.90
D. 100% Financing							
Cost	1.48	4.12	4.56	4.98	5.24	85.54	105.92

Table VI-5 (Continued)

Scenario II
(millions of 1991 dollars)

Funding Options Under Amtrak Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
A. 100% Pay-as-You-Go							
Cost	62.98	4.97	4.48	4.47			76.90
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	1.50	3.66	3.93	4.18	4.32	69.64	87.73
Appropriations	31.49	2.49	2.24	2.23	___	___	38.45
Total	32.99	6.15	6.17	6.41	4.32	69.64	125.68
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	2.69	6.38	6.37	6.36	6.35	100.30	128.45
Appropriation	6.38	4.97	4.48	4.47	___	___	20.30
Total	9.07	11.35	10.85	10.83	6.35	100.30	148.75

Funding Options under PennDOT Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	1.10	3.04	3.25	3.46	3.60	58.16	72.61
Approriation	31.49	2.49	2.24	2.23	___	___	38.45
Total	32.59	5.53	5.49	5.69	3.60	58.16	111.06
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	1.98	5.29	5.29	5.29	5.28	83.70	106.83
Appropriation	6.38	4.97	4.48	4.47	___	___	20.30
Total	8.36	10.26	9.77	9.76	5.28	83.70	127.13
D. 100% Financing							
Cost	2.20	6.07	6.50	6.93	7.20	116.31	145.21

Table VI-5 (Continued)

Scenario III
(millions of 1991 dollars)

Funding Options Under Amtrak Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
A. 100% Pay-as-You-Go							
Cost	70.48	4.97	4.48	4.47			84.40
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	1.67	4.07	4.35	4.60	4.74	76.32	95.75
Appropriations	35.24	2.49	2.24	2.23	___	___	42.20
Total	36.91	6.56	6.59	6.83	4.74	76.32	137.95
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	3.04	7.21	7.22	7.21	7.20	113.62	145.50
Appropriation	6.38	4.97	4.48	4.47	___	___	20.30
Total	9.42	12.18	11.70	11.68	7.20	113.62	165.80

Funding Options under PennDOT Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	1.23	3.38	3.61	3.82	3.94	63.70	79.68
Approriation	35.24	2.49	2.24	2.23	___	___	42.20
Total	36.47	5.87	5.85	6.05	3.94	63.70	121.88
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	2.24	5.99	5.99	5.99	5.99	94.81	121.01
Appropriation	6.38	4.97	4.48	4.47	___	___	20.30
Total	8.62	10.96	10.47	10.46	5.99	94.81	141.31
D. 100% Financing							
Cost	2.47	6.76	7.21	7.64	7.89	127.39	159.36

Source: Chapters II and IV; Canby Associates

Table VI-6

KEYSTONE SERVICE ANNUAL CAPITAL COSTS WITHOUT ELECTRIC TRACTION

Scenario I
(millions of 1991 dollars)

Funding Options Under Amtrak Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
A. 100% Pay-as-You-Go							
Cost	32.70	2.70	2.20	2.20			39.80
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	0.78	1.90	2.04	2.17	2.24	36.03	45.16
Appropriations	16.35	1.35	1.10	1.10	___	___	19.90
Total	17.13	3.25	3.14	3.27	2.24	36.03	65.06
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	1.36	3.22	3.22	3.21	3.21	50.70	64.92
Appropriation	4.10	2.70	2.20	2.20	___	___	11.20
Total	5.46	5.92	5.42	5.41	3.21	50.70	76.12

Funding Options under PennDOT Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	0.57	1.58	1.70	1.79	1.86	30.05	37.55
Apporiation	16.35	1.35	1.10	1.10	___	___	19.90
Total	16.92	2.93	2.80	2.89	1.86	30.05	57.45
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	1.00	2.68	2.68	2.67	2.67	42.30	54.00
Appropriation	4.10	2.70	2.20	2.20	___	___	11.20
Total	5.10	5.38	4.88	4.87	2.67	42.30	65.20
D. 100% Financing							
Cost	1.15	3.16	3.39	3.58	3.72	60.10	75.10

Table VI-6 (Continued)

Scenario II
(millions of 1991 dollars)

Funding Options Under Amtrak Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
A. 100% Pay-as-You-Go							
Cost	46.40	2.70	2.20	2.20			53.50
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	1.10	2.68	2.81	2.93	3.00	48.18	60.70
Appropriations	23.20	1.35	1.10	1.10	____	____	26.75
Total	24.30	4.03	3.91	4.03	3.00	48.18	87.45
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	2.01	4.76	4.76	4.76	4.75	74.93	95.97
Appropriation	4.10	2.70	2.20	2.20	____	____	11.20
Total	6.11	7.46	6.96	6.96	4.75	74.93	107.17

Funding Options under PennDOT Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	0.81	2.22	2.33	2.44	2.50	40.18	50.48
Approriation	23.20	1.35	1.10	1.10	____	____	26.75
Total	24.01	3.57	3.43	3.54	2.50	40.18	77.23
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	1.48	3.96	3.95	3.95	3.95	62.58	79.87
Appropriation	4.10	2.70	2.20	2.20	____	____	11.20
Total	5.58	6.66	6.15	6.15	3.95	62.58	91.07
D. 100% Financing							
Cost	1.62	4.43	4.67	4.87	5.00	80.36	100.95

Table VI-6 (Continued)

Scenario III
(millions of 1991 dollars)

Funding Options Under Amtrak Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
A. 100% Pay-as-You-Go							
Cost	51.90	2.70	2.20	2.20			59.00
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	1.23	2.99	3.12	3.24	3.31	53.03	66.92
Appropriations	25.95	1.35	1.10	1.10	____	_____	29.50
Total	27.18	4.34	4.22	4.34	3.31	53.03	96.42
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	2.27	5.38	5.37	5.38	5.37	84.70	108.47
Appropriation	4.10	2.70	2.20	2.20	____	_____	11.20
Total	6.37	8.08	7.57	7.58	5.37	84.70	119.67

Funding Options under PennDOT Ownership

	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6 - 20	Total
B. 50% Financing and 50% Pay-as-You-Go							
Debt Service	0.91	2.47	2.59	2.69	2.76	44.25	55.67
Apporiation	25.95	1.35	1.10	1.10	____	_____	29.50
Total	26.86	3.82	3.69	3.79	2.76	44.25	85.17
C. 100% Financing of Equipment and 100% Pay-as-You-Go of Infrastructure							
Debt Service	1.67	4.47	4.47	4.47	4.46	70.71	90.25
Appropriation	4.10	2.70	2.20	2.20	____	_____	11.20
Total	5.77	7.17	6.67	6.67	4.46	70.71	101.45
D. 100% Financing							
Cost	1.82	4.95	5.18	5.38	5.51	88.51	111.35

Source: Chapters II and IV; Canby Associates.

Should Amtrak be willing to purchase equipment for this service, and if the purchase were to be financed, the interest rate would be roughly 250 basis points higher than that available to PennDOT based on current rates. This translates to a cost variance ranging from $2 to 6 million for the first five years, if the equipment were financed.

Since it is not likely that the operating revenue for this service would produce a surplus which could be applied to capital costs, it would be difficult to structure a cost effective debt instrument. Therefore, it appears that the only source of capital funds for Amtrak to invest in new equipment would be Federal appropriations.

As noted earlier, other sources of funds could be used to make capital improvements in either the infrastructure or the equipment. For instance, PennDOT could procure rolling stock and lease it to Amtrak for this service. For infrastructure improvements, PennDOT could provide state funding under certain conditions to improve the track structure, provide parking facilities, and to assume responsibility for bridge work. PennDOT could also allocate FHWA funds to certain aspects of these improvements, depending on the final form of the surface transportation reauthorization bill. UMTA funds which are currently being used by SEPTA could be reallocated to support this service. If $2 million were shifted, the debt service under the 50 percent financing options would be covered.

Clearly, the least costly funding approach would be direct Federal appropriations to Amtrak for the entire capital costs. However, due to the nature of the service, it is considered unlikely that Amtrak would give a high priority to upgrading this infrastructure or purchasing new equipment, and consequently would be reluctant to request capital funds from a very limited source, i.e. Federal appropriations. The likelihood of PennDOT investing in fixed facilities not owned by the state is low, since it would be difficult for PennDOT to finance improvements on property which it did not own without some form of asset transfer. Likewise, UMTA is likely to be reluctant to permit the use of funds of facilities which are not owned by the funding recipient. Therefore, under Amtrak ownership, Federal appropriations would appear to be the only feasible source of funds for infrastructure improvements.

New equipment could be purchased by PennDOT and leased to Amtrak for this service. This would leave only the infrastructure costs for Amtrak to fund. If PennDOT were to finance the equipment, the UMTA Section 9 funds would almost cover the annual debt service costs (including principal) under the assumptions used.

Full funding through appropriations was not examined, because PennDOT has not structured its intercity rail program in this fashion and it is unlikely that 100 percent state funds would be appropriated for this service. However, if there are substantial changes in the current Federal surface legislation, then there could be new options involving Federal highway funds and state match.

Under PennDOT ownership, there are several potential sources of funding which could be used to support of capital investment in this rail corridor. UMTA Section 9 funds could be applied to infrastructure improvements. (These funds would no longer be available to SEPTA.) If $2 million, which represents half of the funds generated by the *Keystone Service*, were to be applied to the capital costs, all of the debt service costs could be covered under the 50 percent financing option. For the "pay-as-you--go" costs, there are several sources which could be used. FHWA funds could be applied to rail infrastructure costs. Eligible items will vary depending on the outcome of the reauthorization of Federal transportation legislation. Local government development funds could be applied to station improvements along with private developer funding in situations where there are development opportunities. For instance, if a new station is developed at the Harrisburg Airport site, there would be potential for development and consequently, developer and/or local government participation. Pennsylvania Turnpike revenues may also be used for rail infrastructure improvements and equipment purchase.

If some portion of the costs is to be financed, then ownership becomes a central issue since it is unlikely that there would be market acceptability of debt for improvements to facilities which are not owned by the issuer without an asset transfer. Another element is that the costs of financing are lower under PennDOT ownership than under Amtrak due to the ability of the Commonwealth to issue tax exempt debt.

C. OPERATING EXPENSES

1. Maintenance of Way and Structures

Major increases in *Keystone Service* would add only incremental, and not proportional, maintenance costs. Most materials, ties for example, have service lines that are time dependent as well as traffic related. Much labor, such as inspection, is largely independent of rail traffic. The primary exception is rail, for which service life is usually measured in gross tons of traffic.

Incremental costs were estimated for two levels of service: increasing weekday *Keystone Service* from 6 to 9 and from 6 to 13 round trips, and increasing Friday evening, Saturday and Sunday service from 7 to 11 and from 7 to 17 round trips. This service is in addition to Amtrak daily round trips between New York and Chicago, New York and Pittsburgh, New York and Harrisburg, and Atlantic City and Harrisburg.

Incremental costs were developed in a three step process. First, annual maintenance costs for track, signals, and communications were developed using a build-up of wages, benefits, materials, and miscellaneous costs based on current Amtrak staffing and practice. Bridge maintenance was excluded, because most structure maintenance will vary little with traffic over the line. Next, the cost of track work (rail and cross tie installations and surfacing) needed annually to keep the track from deteriorating was estimated. Rail and tie installations were based on total units divided by expected lives. Surfacing was based on an average of the last two years work. The final step was to apply a speed-factored gross tons formula to derive the incremental addition to estimated maintenance and capital costs attributable to increased *Keystone Service*. These costs reflect what must be spent annually to keep the property in satisfactory condition, while rehabilitation costs represent past deferrals that must be replaced to operate trains efficiently at planned speeds.

Although maintenance costs increase incrementally as *Keystone Service* increases, maintenance cost allocation among line users likely would be proportional to use. Based upon train-miles operated by Amtrak on the line in total and for the *Keystone* trains, the latter's maintenance of way expenses are estimated to be:

	Operating Scenario		
	I	II	III
	($000)		
Estimated Maintenance of Way Costs:			
With Electric Traction	5,840	6,842	7,744
Without Electric Traction	5,353	6,274	7,101

2. Maintenance of Equipment

The unit costs of maintaining equipment are estimated at $1.25 per diesel locomotive unit-mile, $.62 per unpowered car-mile and $1.00 per self-propelled car-mile. Based on a run of 104 miles between Philadelphia and Harrisburg, the 1996 costs (in 1991 dollars) of maintaining the locomotives and/or cars with and without electric traction for the *Keystone Service* are estimated at the following levels:

	Operating Scenario		
	I	II	III
	($000)		
Cost of Equipment Maintenance:			
With Electric Traction (EMU Cars):	1,200.6	1,817.1	2,660.7
Without Electric Traction:			
Locomotives	500.2	757.1	1,108.6
Cars	744.4	1,126.6	1,649.7
Total:	1,244.6	1,883.7	2,758.3

3. Transportation

- **Power/Fuel.** The cost of power with electric traction for EMU cars is estimated at $0.48 per car-mile (6.25 kW-h per car-mile x $0.0768 per kW-h). Fuel cost for diesel locomotives pulling three cars is estimated at $1.80 per locomotive unit mile (3.0 gallons x $.60 per gallon). Based on these costs the 1996 costs of power or fuel (in 1991 dollars) are estimated as set out below:

	Operating Scenario		
	I	II	III
	($000)		
Power Cost with Electric Traction:	577.8	874.5	1,280.6
Fuel Cost without Electric Traction:	720.3	1,090.3	1,596.4

- **Train Crews.** Transportation cost projections are based upon standard operating practices, including self-propelled EMU Cars and diesel locomotive-hauled trains operating in the push-pull mode. Sample schedules, grounded upon the three 1996 operating scenarios, were constructed to form the basis for crew cost projection. Meeting likely travel demand was the first priority in schedule design; adjustments were made to optimize crew assignments only when it was possible to do so without reducing the utility of the service. More precise schedule planning in the course of service implementation likely would identify opportunities to reduce crew costs through schedule adjustments which are too fine at this level of analysis; thus crew costs presented here are on the conservative (high) side. Annual crew costs were estimated by applying representative Amtrak pay rates (engineers: $20.00 per hour; conductors: $17.00) and work rules (such as those governing overtime and split shifts) to the sample train schedules.

	Operating Scenario		
	I	II	III
	($000)		
Train Crew Costs with or without Electric Traction:	1,294	2,406	3,328

Crew size is one area which may provide opportunities for cost savings in the course of implementing enhanced service. Crew costs have historically been based upon use of a three-person crew: one engineer, one conductor and one assistant conductor. This is an appropriate and conservative assumption, however, Amtrak operates some "Clocker" trains with two-person crews (one engineer and one conductor) and has expressed a willingness to consider operating new commuter service with two-person crews. Amtrak's chief concern with regard to two-person crews is collecting or verifying each passenger's fare. Should fare collection and validation be done by other means, such as proof-of-purchase or controlled-entry, it may be feasible to operate *Keystone Service* with two-person crews. However, it is unknown whether two-person crews would be acceptable for this service, either to Amtrak or the United Transportation Union (the conductors' labor organization), even in the light of proposed service increases. Accordingly, no such assumption has been made for purposes of cost estimation.

- **Supervision and Material and Purchased Services.** Transportation supervision was estimated at 15 percent of direct train crew labor and fringe benefits; five percent was allowed for material and purchased services. Dispatching costs would be relatively constant rather than varying in proportion to train crew wages. Annual dispatching costs were estimated to be $270,000 and a 50 percent share ($135,000) was allocated to *Keystone Service*; the remaining 50 percent was assumed to be borne by other line users.

4. General and Administrative

General and administrative expenses are estimated to total $699,000 under Scenario I and are based upon the assumption that a staff of seven persons would be needed to provided all administrative support. This staff would be comprised of a general manager, assistant general manager, finance manager, accountant, accounting clerk, secretary and administrative assistant, which would incur total salary costs of $293,000 plus fringe benefits equal to 45 percent of salary costs. Expenses were estimated to be $102,000 per year which include the expenses such as computers, office supplies, telephones and travel. In addition to these estimated expenses an allowance, equal to five percent of transportation revenues was included, in order to allow for commissions to sellers of tickets, and $.04 per passenger for injuries and damage.

General and administrative expenses associated with Scenario II are estimated to total $842,000. These expenses are based upon those developed in Scenario I plus the addition of an assistant general manager and accountant, which would be half-time positions, with fringe benefits and a pro rata increase in expenses.

Under Scenario III, general and administrative expenses are estimated to be $1,023,000. As was the case in Scenario II, these expenses are based upon those developed under Scenario I. However, the half-time positions are assumed to become full-time and expenses are increased.

5. Total Operating Expenses

Total estimated annual operating expenses, as described above, are summarized in Table VI-7. These expenses exclude depreciation and amortization costs since the cost to the State of purchasing the Philadelphia to Harrisburg line has not been provided by DVRPC and Amtrak's investment in the line is not available.

D. NET OPERATING RESULTS

The net annual operating results are obtained by subtracting total operating expenses from the total revenues as set out below:

	Operating Scenario		
	I	II	III
	------(thousands of 1991 dollars)------		
With Electric Traction:			
Revenue	$ 3,115	$ 4,619	$ 6,542
Operating Expense	10,006	13,397	16,837
(Loss)	(6,891)	(8,778)	(10,295)
Without Electric Traction:			
Revenue	3,115	4,619	6,542
Operating Expense	9,704	13,112	16,606
(Loss)	(6,589)	(8,493)	(10,064)

Although the absolute operating deficit increases by almost 50 percent when the service is doubled, i.e., comparing Scenario III with Scenario I, it should be noted that the unit deficit, or loss per passenger, declines by more than 20 percent. When restated on a per passenger basis, the operating results become:

	Operating Scenario		
	I	II	III
With Electric Traction:			
Revenue	$ 8.50	$ 8.82	$ 9.12
Operating Expenses	27.29	25.58	23.48
(Loss)	(18.79)	(16.76)	(14.36)
Without Electric Traction:			
Revenues	8.50	8.82	9.12
Operating Expenses	26.47	25.03	23.16
(Loss)	(17.97)	(16.21)	(14.04)

Table VI-7

SUMMARY OF ANNUAL OPERATING EXPENSES

(Thousands of 1991 dollars)

Element	With Electric Traction Scenario:			Without Electric Traction Scenario:		
	I	II	III	I	II	III
Maintenance of Way and Structures	$5,840	$6,842	$7,744	$5,353	$6,274	$7,101
Maintenance of Equipment	$1,201	1,817	2,661	1,244	1,884	2,758
Transportation:						
Power/Fuel	578	874	1,281	720	1,090	1,596
Train Crews	1,294	2,406	3,328	1,294	2,406	3,328
Supervision	194	361	499	194	361	499
Material and Purchased Service	65	120	166	65	120	166
Train Dispatching	135	135	135	135	135	135
General and Administrative:						
Salaries, Fringes and Expenses	684	821	994	684	821	994
Injuries and Damage	15	21	29	15	21	29
Total:	$10,006	$13,397	$16,837	$9,704	$13,112	$16,606

Source: LTK; RLBA

The preceding table assumes that ridership, and hence revenue, do not depend on whether electric or diesel power is used. In reality, diesel trains are likely to attract fewer passengers than electric trains, both because of the inability to access the center city stations in Philadelphia and the extra schedule time demanded by their poorer operating characteristics. This will reduce the impact that the choice of propulsion has on the operating deficit.

E. SUMMARY

Options of ownership of the Philadelphia-Harrisburg rail line and management and operation of the intercity rail passenger service (Keystone Service) on this line were selected in Chapter V for study as follows:

Option	Ownership	Management	Operation
1	Amtrak	Amtrak	Amtrak
2	PennDOT	PennDOT	Contractor[13]

Three levels of service (operating scenarios) were selected in Chapter III, under which weekday service would range from 6 to 13 round trips and weekend service ranging from a total of 7 to 17 round trips. Annual ridership and revenues (in 1991 dollars) were projected at the following levels for 1996:

	Operating Scenario		
	I	II	III
Ridership (000)	366.6	523.8	717.1
Revenues ($000)	$3,115	$4,619	$6,542

Capital costs with and without electric traction are estimated at levels shown below:

	Operating Scenario		
	I	II	III
	(millions 1991 dollars)		
With Electric Traction	$56.1	$76.9	$84.4
Without Electric Traction	39.8	53.5	59.0

Potential funding sources for various portions of these costs under continued Amtrak ownership of the line would include Amtrak appropriations, Federal Highway

[13]Amtrak, SEPTA, or an independent contractor.

Administration, Pennsylvania general obligation bonds, private developer, UMTA Section 9 and the equipment manufacturer(s). Under PennDOT ownership, additional sources would include the Pennsylvania Turnpike for infrastructure and equipment, and local government and SEPTA for stations.

Annual capital costs were developed for four funding approaches involving different mixes of pay-as-you-go (PAYG) and borrowing: (a) 100 percent PAYG; (b) 50 percent PAYG and 50 percent financing; (c) PAYG for infrastructure and full financing for equipment; and (d) 100 percent financing. Which is suitable and the financing costs depend on who owns the line. Approach (a) was considered inappropriate for Amtrak ownership and approach (d) was ruled out if PennDOT acquires the line. All financing is for a 20-year term. Total costs for the various combinations of options are shown below:

Electric Traction	Ownership	Funding	Operating Scenario I	Operating Scenario II (millions 1991 dollars)	Operating Scenario III
With	Amtrak	a	$ 56.1	$ 76.9	$ 84.4
		b	91.7	125.7	138.0
		c	101.6	148.8	165.8
	PennDOT	b	81.0	111.1	121.9
		c	87.9	127.1	141.3
		d	105.9	145.2	159.4
Without	Amtrak	a	39.8	53.5	59.0
		b	65.1	87.4	96.4
		c	76.1	107.2	119.7
	PennDOT	b	57.4	77.2	85.2
		c	65.2	91.1	101.4
		d	75.1	101.0	111.4

Annual operating expenses with and without electric traction and under each of the three operating scenarios are estimated at the following levels:

	Operating Scenario I	Operating Scenario II (thousands 1991 dollars)	Operating Scenario III
With Electric Traction	$10,006	$13,397	$16,837
Without Electric Traction	9,704	13,112	16,606

These operating expenses and the projected revenues would produce the following annual operating deficits:

	Operating Scenario		
	I	II	III
	(thousands 1991 dollars)		
With Electric Traction	$6,891	$8,778	$10,295
Without Electric Traction	6,589	8,493	10,062

The actual differences in the operating deficit between electric and diesel power is likely to be narrower, because of reduced ridership if diesel power is used.

VII. FINDINGS AND RECOMMENDATIONS

The 103-mile line between Zoo Interlocking in Philadelphia and the Harrisburg Terminal was built by the Pennsylvania Railroad (PRR) to first-class standards. The railroad was electrified, equipped with automatic block signals, provided four-track capacity east of Parkesburg, and used flyovers to provide grade separation at major interlockings. The line was heavily used for both passenger and freight service, carrying a mix of local and through trains. The physical plant is still largely intact, though it is aging and requires modernization and renewal, if it is to continue to remain serviceable. The major changes since PRR operation consist of capacity reductions west of Paoli and elimination of sidings and branch lines used for freight.

Some rationalization of station service patterns is in order, as some stations which once generated significant volumes of travel no longer do so, and other locations which could generate additional trips are not currently served. Many stations lack adequate highway access for today's needs, and parking is a constraint, especially at the eastern end. Deferred maintenance and security are also problems at some stations.

Amtrak has reduced its service between Philadelphia and Harrisburg in steps from 13 weekday round trips in 1980 to seven in 1990, while SEPTA has steadily expanded its local service in Chester County in order to meet a growing commuter market. This does leave open the question of whether other markets, such as commutation to Harrisburg, business travel, and trips originating from eastern Lancaster County, are adequately served. It also raises the question of what are the proper roles for Amtrak and SEPTA in serving these markets.

Most of Amtrak's *Keystone* trains are currently operated with three "Heritage" coaches pulled by a diesel locomotive. Seats do not recline and no food or beverage service is provided. Assigning equipment on the basis of availability, rather than suitability, may be unnecessarily suppressing ridership and raising costs. It seems that Amtrak does not assign a high priority to the *Keystone Service* in its long-range plans for the corridor. The steady erosion of service and ridership, lack of capital investment, down-sizing of the physical plant, deferred maintenance, and the recent switch from electric to diesel propulsion are all ominous.

A. INFRASTRUCTURE

The majority (57%) of running track used by Amtrak has been laid with welded rail, with most of the remaining jointed rail located either east of Paoli or west of

Lancaster. Most (81%) of the track with welded rail now permits 90 mph (Class 5) operation, the principal exceptions being the commuter territory east of Paoli and where speeds are restricted by curves. Amtrak limits speeds to 80 mph on jointed rail, and east of Paoli speeds are further limited to 70 mph because of signal spacing and traffic density.

Raising speeds to 90 mph west of Paoli would require replacing all of the jointed rail west of Paoli with welded rail, but this is not recommended as the resulting savings in running time would not justify the expense. Much of this rail has more than one-half its useful life left. Instead, it is recommended that as rail is replaced, it be replaced with welded rail, with the exception that six track-miles east of Lancaster now laid with jointed rail be upgraded to welded rail. The latter would permit running 90 mph between Paoli and Lancaster, and would allow track gangs to focus their efforts on the maintenance-intensive sections west of Lancaster. It is estimated that this replacement plus some necessary surfacing should cost about $1.9 million. An additional $20.9 million would be required to eliminate all remaining sections of jointed rail.

The weakest element in the track structure, and the element most responsible for slow orders, is the ties. This is particularly true in those sections laid with jointed rail, as improperly supported joints lead to poor ride quality and increased maintenance costs. Approximately 17 percent of the ties (about 133,000) should be replaced in the within the next four years. The first two years should concentrate on raising speeds on the jointed-rail sections to 80 mph. Year 3 should be used to upgrade the welded-rail sections between Paoli and Lancaster to 90 mph, and Year 4 should focus on the commuter territory east of Paoli. Total cost for tie replacement is estimated at $6.9 million. Approximately $1.2 million of this total would be used to upgrade tracks east of Paoli that are primarily used by SEPTA.

At the end of the four-year program, the line will be fully laid with welded rail between Paoli and Lancaster, permitting 90-mph operation except where restricted by curves. Jointed rail will still prevail between Lancaster and Harrisburg, limiting speeds to 80 mph, but the ride quality will be much improved and slow orders removed. In the commuter territory between Philadelphia and Paoli, speeds will still be restricted to 60 and 70 mph, but the track structure will be in good operating condition.

Resulting time savings from track improvements will be minimal, 4.2 minutes in the westbound direction and 4.7 minutes eastbound. The real advantages accrue from greater reliability, enhanced safety, improved ride quality, and reduced maintenance costs.

It makes sense to raise limits to 90 mph between Paoli and Lancaster, as the welded rail already in place will permit this speed once the tie replacement program is completed. The only extra cost will be $1.9 million for upgrading six miles of track now laid with jointed rail. This expenditure will eliminate an isolated stretch of jointed rail, reducing ongoing maintenance costs and permitting a more orderly deployment of track gangs. In contrast, the expenditure of $20.9 million needed to replace the 63 miles of jointed rail between Lancaster and Harrisburg does not appear to be cost-effective and is not recommended.

While the electrification plant is still basically sound, it is aging and components are showing wear. The principal components that will require attention within the next five years are the substations and the overhead catenary. Currently, the line uses eleven substations, containing 24 transformers and 35 circuit breakers, and 253 miles of electrified track. Since the system was originally designed to handle higher levels of traffic and to power connecting freight lines that are no longer electrified, it is possible that the size of the plant could be reduced through restructuring. However, it has been assumed that any investment at this time will be used to upgrade existing components, rather than to build a new and slimmer system.

Contact wire is generally replaced after wear has reduced the cross-sectional area by 20 percent. Based on spot checks it is estimated that 80 percent of the contact wire will have to be replaced within five years at a cost of approximately $7.8 million. This is a worst-cost estimate, and it is possible that a detailed inspection could reduce this estimate by $2 million.

The coolant in each of the transformers should be tested and filtered (or replaced where appropriate). Based on a 25 percent failure rate, this should cost about $79,000. The oil-filled circuit breakers are antiquated and should be replaced by modern 12-kV switchgear. This replacement will cost about $1.2 million.

The total estimated cost for renewing and upgrading the electrification plant in its current configuration is $9.1 million. This assumes that the *Keystone Service* will be operated as an electrified railroad. If diesel locomotives are used, electrification could be dropped west of Parkesburg, assuming that adequate provision is made for turning SEPTA trains. This would save approximately $4.4 million.

The line uses an automatic block signaling system supplemented by cab signals. Though old, it is still serviceable and west of Paoli, adequate for 90 mph. Two of the three protected grade crossings in Lancaster County are currently set for 70 mph operation. The warning circuits should be lengthened to accommodate 90 mph, but this entails only minor expense. East of Paoli the signal spacing is too short to accommodate speeds much above 70 mph, but curves, interlockings, and traffic also limit speeds in this area. In short, replacing the signal system simply to achieve higher speeds is not justified. On the basis that there is useful life left in the signaling system, no cost has been assigned for improvements.

The almost 200 bridges on the line were built to last, and today most are in good structural condition. Only structures carrying the line over roads, waterways, or other railroads are counted. Bridges crossing the line were not considered in this study. Only one bridge was found in need of repairs, and this was at the St. Davids Station and over Chamounix Road. Significant internal corrosion of the supporting steelwork was indicated, though the worst girders were under now unused station platforms. A more detailed inspection is needed, but $1 million has been included in the capital program for possible replacement.

Two of the stations, Coatesville and Parkesburg, were found to be in poor condition and without adequate protected waiting space for passengers. The platforms are also in poor condition. It is recommended that the platforms be rebuilt and that prefabricated shelters with heat, lights, and a telephone be installed at these two stations. The estimated cost is $120,000 per station. The station building at Elizabethtown is an attractive stone structure in good condition, but is currently closed. It is recommended that $60,000 be allocated for opening a waiting room for passengers. Total cost for improvements to existing stations is $300,000.

Almost all of the stations will require significant modifications in order to be fully accessible to the handicapped by the year 2010, as required by the Americans with Disabilities Act of 1990. These costs have not been estimated and are not included in the capital program. Every station from Downingtown east is in need of more parking. While it is SEPTA's R5 service that generates most of the demand for parking, its lack hinders Amtrak's ability to attract additional passengers to the *Keystone Service*. No costs have been included for parking expansion.

Keystone trains currently serve 14 stations, but the station spacing is very uneven, ranging from one to 26 miles. Some restructuring is in order, as too many stations close together interfere with the ability to deliver fast service, and at the same time large gaps leave potential markets unserved. Accordingly, it is recommended that stops at Malvern and Whitford be eliminated, and a new station be established in eastern Lancaster County. Malvern is only one mile from Paoli, a major stop served by all Amtrak and SEPTA trains, and similarly, Whitford is one mile from Exton. There seems to be little reason to maintain these stations as *Keystone* stops, though both would remain open to serve local SEPTA trains. They do provide the line with additional parking capacity.

One or two new stations are recommended to fill the 26-mile gap between Parkesburg and Lancaster. Eastern Lancaster County represents the largest untapped market along the line. Both Kinzer and Bird-in-Hand have sites that would be suitable for development as stations and offer reasonable highway accessibility. An alternative would be to open a single new station at Paradise, which could provide connections with the tourist-oriented Strasburg Railroad.

The drawing power of some of the existing stations, which are now in poor or relatively inaccessible locations, could be improved by moving them to new locations. If SEPTA extends its R5 service west to Atglen, as is currently proposed, then the *Keystone Service* should shift its stop from Parkesburg to Atglen. The latter is directly accessible from PA 41, and the move would eliminate the need for station improvements at Parkesburg. Similarly, accessibility at Mount Joy could be improved by shifting the station from its present location in a cut to Eby Cheques Road at the eastern end of town. Mount Joy is currently the least patronized station on the line. Since Middletown is also a weak traffic generator, it is recommended that this station be replaced by a new one that could serve Harrisburg International Airport and the Harrisburg Campus of Pennsylvania State University. No estimates of the costs required to move or establish new stations have been made.

The restoration of the line to a state of good repair will require an investment of $20.3 million, which can be categorized as follows:

Ties	$6.9 million	Replace 133,000 ties (17% of total)
Rail	1.9	Replace 6 mi.; line and surface 111 mi.
Stations	1.4	Improve 3 stations; add 4 new stations
Electrification	9.1	Replace 35 circuit breakers; refill 6 transformers; replace 223 mi. of catenary wire
Bridges	1.0	Replace 1 bridge
Total	$20.3	

When completed the track structure will be able to support 90-mph operation between Paoli and Lancaster and 80-mph west of Lancaster to Harrisburg. The program does not include modernization of the signaling system, or any costs to acquire land or expand parking capacity. Although no detailed allocation of costs between through, *Keystone*, and SEPTA trains has been made, approximately $4.4 million of the preceding total could be assigned to SEPTA's local service. The cost to renew the electric traction system could be reduced by $4.5 million, if electrification is not maintained to Harrisburg. In this event SEPTA's share would increase by an additional $2.3 million, as it would then be the sole user of electric power on the line.

B. SERVICE AND DEMAND

Several reasons can be advanced to explain the drop in *Keystone* ridership from 1,025,000 in 1980 to 335,000 in 1990. Weekday service was cut from 13 to 11 round trips[14] in 1983, and then to seven round trips in 1986. Ridership fell by a relatively mild eight percent in response to the first cut, but the second provoked a 45 percent loss. It may be that the latter cut reduced the service below the point of utility for many prospective riders, but the reintroduction of SEPTA service west of Paoli in October 1985 also played a role.

SEPTA has steadily expanded its service to western Chester County and in 1990 carried 585,000 on trips extending west of Paoli. If these passengers are added to the Amtrak ridership, it is seen that the line is now carrying 920,000 annual passengers, which is only 18 percent lower than the total riding in 1980.[15] It appears that many former Amtrak passengers simply moved over to SEPTA. Origin-destination data obtained from Amtrak's Passenger Accounting System supports this contention. In 1983 almost one-half (48%) of the Amtrak trips were completely contained east of Parkesburg. By 1990 only 16 percent of the trips were in this range. Other trends are also apparent. Though Philadelphia provides the strongest trip attraction along the line, the share of Amtrak trips oriented toward Philadelphia[16] has declined from 73 percent in 1983 to 57 percent in 1990. More than one-fourth (26%) of Amtrak's riders are now riding on weekends, when SEPTA service is sparser, as compared with 15 percent in 1983.

Ten minutes were added to the Philadelphia-Harrisburg schedule in 1988, but this was probably not enough to affect ridership. Its main impact was to improve on-time performance[17], which since 1988 has averaged about 95 percent. In this regard, the *Keystone Corridor* consistently ranks among Amtrak's best.

Other rail corridors have shown a good response to service upgrades. A good example is provided by the *Hiawatha Corridor* (Chicago-Milwaukee), where ridership jumped by 31 percent 1985 when the number of weekday round trips was increased from three to four, and again by 51 percent in 1990 when the service went to six daily round trips. Ridership has grown steadily on the *San Joaquins* (Oakland-Bakersfield) in California, but there the stimulus has been dedicated bus connections to off-line points. The number of connecting routes has grown to 17, and in 1990

[14]Indicated service levels include non-*Keystone* trains with traffic rights in the Philadelphia-Harrisburg range.

[15]Until 1983 Conrail operated a single weekday round trip from Downingtown under contract to SEPTA.

[16]Orientation is defined by the destination of the outbound trip.

[17]For short-distance trains, this is defined as the percent of trains arriving at their destination within 15 minutes of the scheduled time.

more than one-half the riders use a combined bus-rail ticket. Rail service has been added in response to ridership growth.

Population growth in the corridor is now occurring mainly in the middle. Though overall population along the line has only grown by two percent since 1980, Chester County has grown by 19 percent and Lancaster County by 17 percent. Because of this growth, Lancaster now boards more passengers than does Harrisburg. Therefore, it is important to improve highway access to stations in these two counties and to add one or two new stations in eastern Lancaster County.

In the next five years the catchment area for the Lancaster station is expected to grow by six percent and that for Harrisburg by two percent. The population at the eastern end is expected to remain static. Employment in Philadelphia's Center City and within easy reach of Main Line stations is expected to grow about four percent, and that in Harrisburg at eight percent. Though the demographics are expected to produce a modest increase in trip demand, it is clear a rail service can only gain a significant increase in ridership by increasing its modal share through enhanced service, better amenities, and astute promotion.

In order to project ridership for differing levels of service, six market segments were considered: work commutation, weekday discretionary, and weekend, each of which could be oriented toward either Philadelphia or Harrisburg. In Scenario I, total service levels were assumed to remain unchanged at seven daily round trips on weekdays and five on weekends. Total service includes non-Keystone trains that carry passengers between Philadelphia and Harrisburg. Scenario II raised the weekday round trips to ten and those on weekends to seven; and Scenario III doubled the existing service to 14 and ten round trips, respectively. The projections were made for a five-year horizon, and in Scenario I simply reflect the market growth that is expected to occur, assuming that the service is run reliably. Since forecasting is an inexact science and to account for non-quantifiable factors, such as marketing and passenger amenities, two sets of elasticities were used in order to create a range of estimates for Scenarios II and III. At the low end, commuters were expected to respond to service increases with an elasticity[18] of 0.3 and discretionary travelers with 0.5. To estimate the high end, the elasticities were increased to 0.4 and 1.0, respectively. A lower elasticity is used for work trips, as they have to be made and often are taken under congested conditions when the driving alternative is less attractive.

Doubling the total service offered can be expected to increase ridership somewhere in the range of 55 to 95 percent. In the high elasticity case for Scenario III, this translates into daily ridership of 2,048 on Monday through Thursday, 2,965 on Friday,

[18]An elasticity of 0.3 means that a 10% percent increase in service should increase ridership by 3%.

985 on Saturday, and 1,490 on Sunday. If the low elasticity case is valid, the daily ridership is reduced to 1,654 on Monday through Thursday, 2,356 on Friday, 733 on Saturday, and 1,136 on Sunday.

Assumed service levels and projected annual ridership for the three operating scenarios are summarized in the following table for *Keystone* trains only:

	Daily Round Trips[19]				Annual Ridership (000)			
	Scenario				1990	1996 Scenario		
	I	II	III	Elasticity		I	II	III
Mo-Fr	6	9	13	Low	335	367	462	570
Sa, Su	3	5	8	High			524	717

This table does not include passengers traveling in the corridor on longer distance trains, nor on SEPTA trains.

C. EQUIPMENT

The ridership projections indicate that individual train loads normally will not exceed 160, implying that three-car consists should provide adequate capacity. Seating capacity of coaches in intercity configuration ranges from 51 to 82 depending on whether the car carries a snack bar and/or is fitted with handicapped facilities. Peak train loads are expected during the Friday afternoon rush hour, when weekend discretionary trips are added to work trips. Since the evening peak normally requires one less consist to protect the schedule, it should be possible to borrow extra coaches from the equipment pool, if more are needed during times of high demand. Some savings may be obtained if consists are reduced to two cars during times of light demand. At least one car in each consist must be handicapped accessible. This would normally be the snack bar coach, if the decision is made to carry them.

Policy decisions should be made concerning the choice of traction power, whether to use locomotive-hauled or self-propelled coaches, and whether to provide food and beverage service. Each has implications regarding capital and operating costs, availability of equipment, and quality of service. The first, and most important, decision is whether to keep the electrification or to switch to diesel power. The Pennsylvania Railroad first electrified the line to Paoli in 1911, in order to support its dense local service to the Main Line suburbs, and in 1938 extended the electrification to Harrisburg. For four decades electric power was used to move both passengers and freight over the line, but in the early 1980s Conrail retired its electric locomotives and has since relied on diesels to power their trains. Amtrak followed suit, first

[19] Plus extra westbound trip on Friday evening and eastbound trip on Sunday.

switching its long-distance trains to diesel power, and then in 1990-91 most of the remaining trains.

There are three principal advantages to diesel power: cost, ready availability of equipment, and the ability to run beyond electric territory. The last is only of importance to the extent that *Keystone* trains are run through to Atlantic City, but the first two are of immense importance. New diesel locomotives suitable for passenger use can be bought for $1.9 million and rebuilt units are available for $1.2 million, whereas a new electric locomotives cost $4.7 million. Rebuilt electrics are not available. The market for diesel equipment is competitive, and this holds down the price, increases the variety of models offered, and ensures quicker delivery. In contrast, Amtrak and a handful of regional transportation authorities are almost the only users of electric equipment in the U.S.

Until 1988 Suburban Station (Penn Center) in Philadelphia was used as the eastern terminus of the service. In order to gain the flexibility to use diesel locomotives, which are not permitted in the Center City Tunnel, Amtrak retracted the service to 30th Street Station. Use of electric propulsion would allow the trains to return to Suburban Station and even proceed beyond to Market East Station. Extension to Center City would greatly strengthen the *Keystone*'s ability to capture work and business trips. Electric power also permits operation of through trips to New York.

Electric trains also have better operating characteristics. Higher acceleration allows them to cover a given route in less time and reduces the time penalty for adding station stops. This advantage is particularly important where trains make frequent stops and can be enhanced through the use of self-propelled or multiple-unit (mu) equipment. While self-propelled diesel cars have been used in the past by both Amtrak and SEPTA, this type of equipment is no longer available. If MU cars are to be used, they must be electric.

Electric trains confer environmental benefits, as they run quieter and emit no on-site air pollutants.[20] Use of electric propulsion will help the region meet the air quality targets set by the Clean Air Amendments of 1990. It also reduces the demand for imported oil, and contributes to the nation's goal of energy self-sufficiency.

If the electrification is kept, the next step in the decision tree is whether to use locomotives or MU equipment. The introduction of push-pull equipment, which made it easier to reverse direction, has reduced the advantages of self-propelled cars. Without traction motors, ordinary coaches are cheaper to buy and easier to maintain.

[20]Coal-fired generating stations, of course, do emit stack gases, but the volume is much less than if diesel fuel is consumed in a locomotive. In any event, the western half of the line is fed from the hydroelectric facility at Safe Harbor.

However, the *Keystone Service* will operate with at most a three-car consist, and using a locomotive to haul such a short train is relatively inefficient. In addition to faster acceleration, MU equipment offers greater flexibility in adjusting consist lengths by making it easier to cut cars in or out of trains.

The inclusion of a snack bar coach in the consist would improve the marketability of the service, especially to business travelers, but it also adds costs and requires an attendant. Historically, snack bar coaches have not been provided, though the PRR did provide a on-board vendor that sold sandwiches and drinks from a cart.

Amtrak uses six locomotives and 14 coaches[21] to protect the existing service, and the capital costs to equip Scenario I are predicated on this level. Scenario II, which calls for nine weekday round trips for *Keystone* trains, will require eight locomotives and 22 coaches. To support Scenario III (13 weekday round trips) the pool must be increased to nine locomotives and 25 coaches. The above includes an allowance for spares. If self-propelled cars are used, the locomotives can be eliminated.

If the current fleet size is adequate, the cars themselves are not. At a minimum the cars should be fitted with reclining seats, and at least one car in each consist must be able to accommodate handicapped passengers. The existing coach fleet is over 40 years old and rebuilding is probably not cost-effective. Buying new equipment offers the options of using either electric MU equipment or locomotive-hauled push-pull cars.

Following are unit prices of representative equipment deemed suitable for *Keystone* operation:

• Locomotives - EMD model F40PH	$1.90 million
• Unpowered Coaches - Amtrak "Horizon"	$1.05 million
Handicap Facilities	Add $50,000
Snack Bar	Add $275,000
Cab Control	Add $150,000
• Self-propelled Electric Coaches[22]	
Single	$2.53 million
Married Pair	$4.70 million
Snack Bar	Add $275,000

[21]In the fall of 1991, a typical consist used a diesel locomotive (either an F40PH or a GP40TC) followed by three "Heritage" coaches. The label "Heritage" is used to identify older rebuilt heavyweight equipment. An electric AEM7 locomotive may substitute for the diesel.

[22]Single units and one car of married pair are fitted with handicap facilities.

An Amtrak interior configuration with reclining 2-2 seating is assumed. The cost per train set, assuming a three-car consist carrying a snack bar and with two cars equipped to accommodate handicapped persons, is:

- Diesel locomotive-hauled $5.575 million
- Electric self-propelled $7.505 million

The cost could be reduced by $275,000 per train set if food and beverage service is deleted, and by another $50,000 if only one car is made handicapped-accessible.[23] If rebuilt locomotives are used, the cost can be reduced by an addition $700,000, though the life expectancy of the locomotive is shortened by five years.

The following summarizes the equipment required and its total cost for each of the operating scenarios:

	Equipment Required				Equipment Cost (millions of 1991 dollars)		
	I	II	III	Propulsion	I	II	III
Train Sets[24]	4	6	7	Electric	$35.8	$56.6	$64.1
Spare Cars[25]	2	4	4	Diesel	28.6	42.3	47.8

The difference in capital cost between electric and diesel equipment is reduced when the life expectancy is taken into account. Assigning a useful life of 30 years to coaches and electric MU cars, 20 years to new diesel locomotives, and 15 years to rebuilt diesels, the cost per year per train set becomes:

- Diesel locomotive-hauled
  - New $217,500
  - Used $202,500
- Electric self-propelled $250,200

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[23]Making two cars accessible adds flexibility and provides the potential to operate one- or two-car consists.

[24]Three coaches, plus locomotive if needed.

[25]Plus two spare locomotives, if diesel power is used.

D. EVALUATION OF MANAGEMENT OPTIONS

Since Amtrak operates the *Keystone Service* on its own line, it has almost sole decision making power to control the level of service and the schedule of investments in the line. Though the service is important to the Commonwealth of Pennsylvania, Amtrak views it from a different perspective. The service is not a key component of the national system[26], and as a corridor, it ranks near the bottom in terms of most performance indicators. Other institutional arrangements are possible that would grant greater control to local interests, and yet preserve Amtrak's interest in maintaining access to the route. Three separate functions should be considered: ownership of the line, policy management, and train operations.

Amtrak can continue to own the line and still turn over operation of the *Keystone* trains to another party. The operating agency would simply buy trackage rights from Amtrak for whatever trains it chooses to operate. The disadvantage of this arrangement is that Amtrak retains control over investment decisions, and the needs of the *Keystone Service* will continue to receive low priority. The only realistic alternative to Amtrak ownership is State ownership, which grants Pennsylvania the right to set priorities. The principal disadvantage is that the State must then produce the funds needed for renewal and improvements, and this might be difficult, though the reauthorization of the Surface Transportation Act does give states added flexibility in the allocation of transportation monies.

If any changes in the institutional arrangements are made, they should include passing control of policy decision making to the State, since it is the people of Pennsylvania that have a primary interest in upgrading the service. Though day-to-day management would be provided by whoever operates the service, the State should retain the right to set general policy regarding service, fares, promotion, and capital investment. The State would also maintain oversight control over the operator.

The State could contract with either SEPTA, Amtrak, or an independent contractor for train operation. The choice depends to a great extent on the particular terms that can be negotiated. From SEPTA's perspective, the *Keystone Service* would be seen as a natural extension of its R5 service to Parkesburg. Better equipment with a higher level of onboard amenities would be required, but SEPTA has the experience and background that would permit a smooth takeover of service. Amtrak also has the experience and capability to provide reliable service. If Amtrak operated the service under State control, the trains would lose their Amtrak identity and be marketed as a local service. Amtrak currently operates trains under state contract in New England, Maryland, and California, but the unique aspect here is that this would constitute the

[26]The route itself is important to the national use, as Amtrak needs it to handle the New York-Chicago *Broadway Ltd.*

first time that Amtrak had turned over its service to a state for contract operation.[27] Finally, the service could be contracted to an independent operator. This has the potential of being the lowest cost option, but the difficulty will be finding an operator that has the capability, experience, and staying power to handle the service.

The institutional choices can be summarized in the following diagram:

	Owner	Manager	Operator
Base Case:	Amtrak	Amtrak	Amtrak
Alternatives:	Amtrak PennDOT	PennDOT	Amtrak SEPTA Contractor

An aspect of the *Keystone Service* that should be kept in mind is identification of its proper role with respect to other rail services operating on the line. Essentially, there are three types of service now running on the line: Amtrak long-distance, *Keystone*, and SEPTA. Historically, all three were operated by the PRR and passengers could interchange between them with common ticketing, though some of the long-distance trains did not accept local passengers. This flexibility conferred benefits on the passengers by expanding their choice of trains, and hence gave the railroad a useful marketing tool. However, this flexibility was lost in 1971 when Amtrak was formed and the local trains were separated from those kept in the national system. Reestablishing this link would help expand the discretionary market for rail travel. For instance, on weekdays Amtrak schedules five trains and SEPTA three trains in each direction that stop at Parkesburg. With common tickets, travelers would have a choice of eight daily departures. However, it is also important that *Keystone* trains honor Amtrak tickets, as this would retain Amtrak's ability to sell through tickets to off-line points, such as Parkesburg to Pittsburgh.

E. FINANCIAL ANALYSIS

About $20.3 million will be required to bring the existing infrastructure to a state of good repair and to add four new stations, as recommended. If diesel power is used, this cost is reduced to $11.2 million.[28] Equipment costs range from $28.6 to $64.1

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[27]MARC's Washington-Martinsburg train is derived from Amtrak's *Blue Ridge*, but this train is now operated by CSX with support from West Virginia.

[28]This total does not include the $4.6 million required to renew the electrification plant east of Parkesburg. This will still be needed for operation of SEPTA trains.

million, depending on the choice of traction power and the level of service provided. The total capital costs are:

Propulsion	Scenario I	Scenario II	Scenario III
	(millions of 1991 dollars)		
Electric	$56.1	$76.9	$84.4
Diesel	39.8	53.5	59.0

All costs are expressed in 1991 dollars. Though the above includes the cost of building four new stations, no allowance has been made for the purchase of land, or for improving access and parking at new or existing stations. If the decision is made to transfer ownership of the line to PennDOT, the terms must be negotiated and any cost will be in addition to those stated. The estimate for renewing the electrification plant was based on the pessimistic assumptions that 80 percent of the catenary wire would have to be replaced within five years and that all of the circuit breakers would also be replaced. A more detailed analysis of power requirements and a full field inspection may show that the work program can be reduced by as much as $2.15 million. Even if diesel power is used, electrification must be maintained east of Parkesburg for use by SEPTA trains. However, since these costs are not attributable to the *Keystone Service*, they have not been included. Also no costs have been included for improvements to the signaling system, as the existing system is considered serviceable and adequate, though antiquated.

Capital spending can be put on a pay as you go basis, or can be spread over the useful life of the project by borrowing and amortizing the debt. Pay as you go is more feasible with the infrastructure improvements, as the costs are spread over four years. However, using this approach for the acquisition of new rolling stock poses a problem, since costs are incurred upfront, and in addition constitute the larger part of the total costs. Four funding approaches were considered in the analysis:

- 100% from current appropriations;
- 50% financing and 50% from appropriations;
- 100% financing of equipment and 100% appropriations for infrastructure;
- 100% financing.

If Amtrak owns the line, it can use Federal appropriations to pay costs as they are incurred or it can borrow money using debt-equity instruments. For purposes of comparison, the interest rate has been set at 9.5 percent, with the loans to be retired over a 20-year period. The last approach was not used for Amtrak ownership, because it would add unduly to the corporation's debt burden.

The first approach offers the least total cost, but requires that all of the cost for acquiring new rolling stock be loaded into the first year. In the "worst" case from a financial perspective, electric propulsion and Scenario III, the total cost is estimated to be $84 million, but $70 million of this must be paid in the first year. By financing one-half of the needed investment, the second approach reduces the first-year cost, but significantly increases the total cost. The third approach offers the least initial cost, but has the highest total cost. The first-year charge for the "worst" case is now $9 million, but the total rises to $166 million.

The first approach clearly offers the most favorable terms, but may be difficult considering the constraints placed by the size of Amtrak's appropriation and the higher priorities assigned elsewhere. The third approach may be the only feasible option, and that only if another party were to finance the equipment. If PennDOT were to finance the equipment, Section 9 funds from UMTA that are generated by the service would cover a major share of the debt service.

The cost of financing would be lower if PennDOT were to acquire the line, as the State can issue general obligation bonds on a tax-free basis. This would lower interest rates to 7 percent. Another advantage of PennDOT ownership is that it may be easier for the State to invest money into a line that it owns than into one owned by Amtrak. However, relying on a pay as you go approach is probably now not feasible, because of the difficulty in meeting the first-year load. Accordingly, the first financing approach was dropped from consideration and replaced by the fourth which calls for full financing of the entire project. The second and third approaches remain the same as they were under Amtrak ownership.

The second approach would have the highest initial cost but least total expenditure. This is because one-half of the cost of rolling stock must be loaded into the first year. Now the total in the "worst" case is reduced to $122 million, but the first-year expenditure becomes $36.5 million. The third approach offers a compromise. By spreading the equipment costs over 20 years, the upfront costs are kept manageable, and by paying for the infrastructure improvements in the first four years, the total cost of debt service is reduced. The last approach, full financing, has the least initial cost as it spreads much of the costs into the out years, but requires the largest total expenditure. For the "worst" case, the total reaches $159 million, though the first year expenditure is a comfortable $2.5 million.

The first year and total expenditures are summarized in the following table for electric traction and Scenario III operations for the funding approaches using various combination of financing and pay as you go (PAYG):

Funding Approach	Expenditure	Ownership Amtrak (millions of 1991 dollars)	Ownership PennDOT
100% PAYG	1st Year	$70.5	
	Total	84.4	
50% Financing	1st Year	36.9	36.5
50% PAYG	Total	138.0	121.9
Equipment (100% Finance)	1st Year	9.4	8.6
Infrastructure (100% PAYG)	Total	165.8	141.3
100% Financing	1st Year		2.5
	Total		159.4

Using electric traction does entail a higher level of investment, on the order of $40 million for most operating scenarios and financing approaches, but there are several mitigating factors. Some of these costs could be shared by SEPTA. Indeed, turning off the electricity west of Parkesburg will raise SEPTA's operating costs significantly, by forcing it to assume all of the costs of maintaining the catenary and substations. In addition, at the end of the 20-year financing period, the diesel locomotives must be replaced, or rebuilt, whereas the electric equipment will still have ten years of useful life left. It is recommended that a more detailed analysis be conducted comparing the full life-cycle costs of electric and diesel propulsion. This would take into account the differing life expectancies, operating costs, and maintenance requirements of the rolling stock. The analysis should also include the capital investment, suitably amortized, and ongoing costs needed to upgrade and maintain the electrification fixed plant in a state of good repair, but exclude all investment and other costs required to maintain SEPTA's train operations.

The cost of operating trains is almost independent of who owns the line, though it still depends heavily on the choice of propulsive power and the level of service provided. The annual operating costs for electric traction range from $10.0 million for Scenario I to $16.8 million for Scenario III. If diesel power is used, the costs are $9.7 and $16.6 million for Scenarios I and III, respectively. Thus, the penalty for electrification is much less on the operating side than it is on the capital side.

The operating budget for electric and diesel traction, assuming ridership is unaffected by the choice of power, and for the three operating scenarios is:

Propulsion	Scenario I	Scenario II	Scenario III
	(millions of 1991 dollars)		
Electric:			
Expenses	$10.00	$13.40	$16.84
Revenues	3.11	4.62	6.54
Deficit	$6.89	$8.78	$10.30
Diesel			
Expenses	9.70	13.11	16.61
Revenues	3.11	4.62	6.55
Deficit	6.59	8.49	10.06

However, ridership may not be completely independent of the choice of propulsion. Diesel-powered trains accelerate slower and will take longer to cover the route, and in addition they will be unable to enter the Center City Tunnel in Philadelphia. Both factors will make the service less attractive. If the low end of the projections is used, annual revenue for Scenario III falls to $5.1 million, and this increases the deficit for diesel propulsion to $11.5, which is larger than that same as for electric traction.

Assuming that the line is upgraded according to schedule, that new equipment has been provided, and that the service is operated reliably and marketed effectively, the high end of the range of the ridership projections should be attainable. On this basis, estimated annual revenues range from $3.1 million for Scenario I to $6.5 million for Scenario III, which in turn will produce annual operating deficits in the range of $6.9 to $10.3 million for electric traction, and $6.6 to $10.1 for diesel operation.

Though the operating deficit does increase as service is added, the cost recovery improves. This is because discretionary trips increase faster than work trips as service increases, and discretionary travelers, whether for business or pleasure, pay higher fares than do commuters. With electric traction, the cost recovery increases from 31 percent in Scenario I to 39 percent in Scenario III.

This may be an opportune time for the State of Pennsylvania, and other interested parties, to express their concerns and accept an increased responsibility for the service. Regardless of any outcome with respect to the *Keystone Service*, it is expected that Amtrak will continue to use the line for its longer-distance trains.

APPENDICES

APPENDIX A

Philadelphia - Harrisburg Line Track Inspection

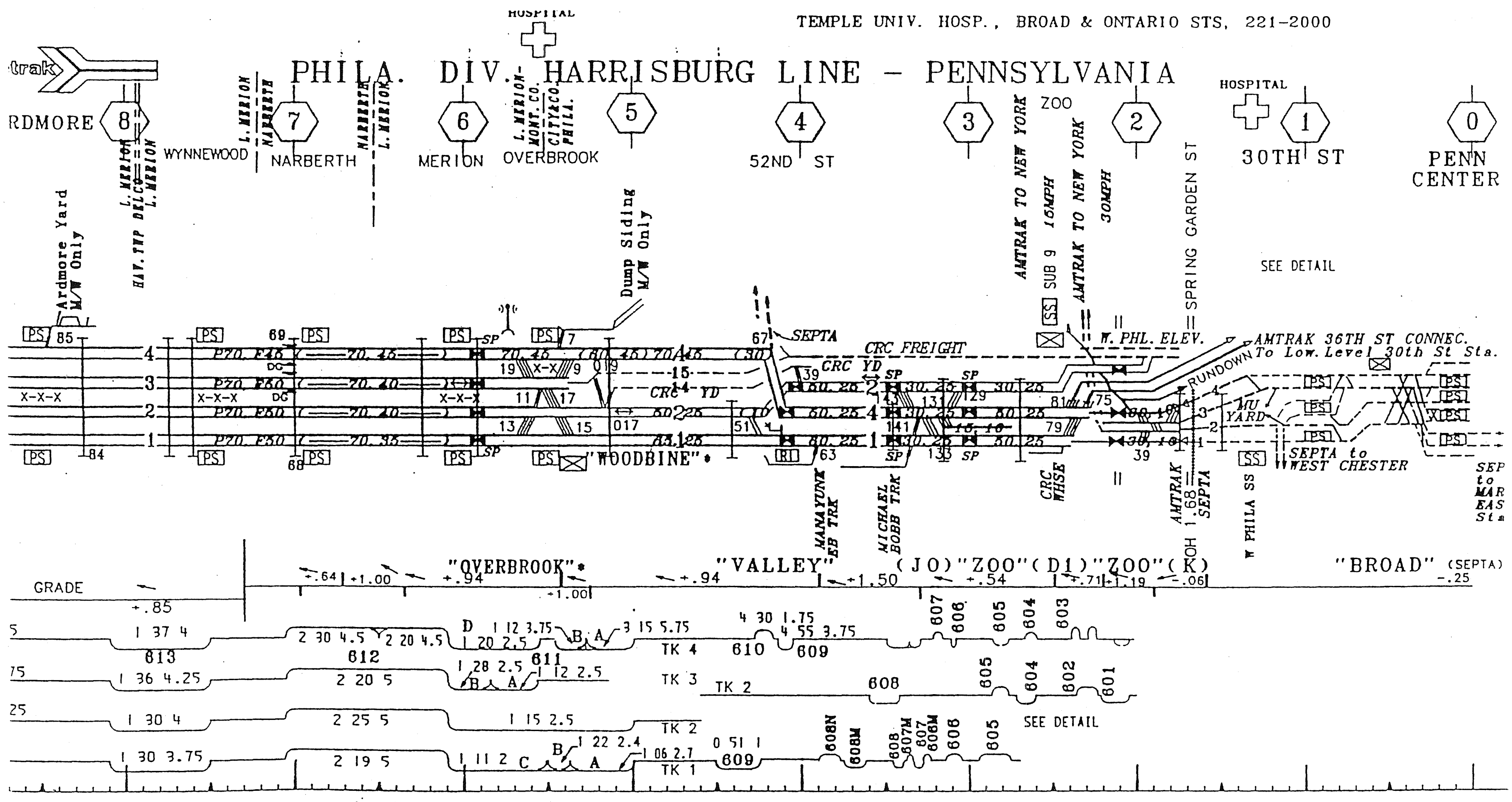
APPENDIX A

PHILADELPHIA - HARRISBURG LINE TRACK INSPECTION

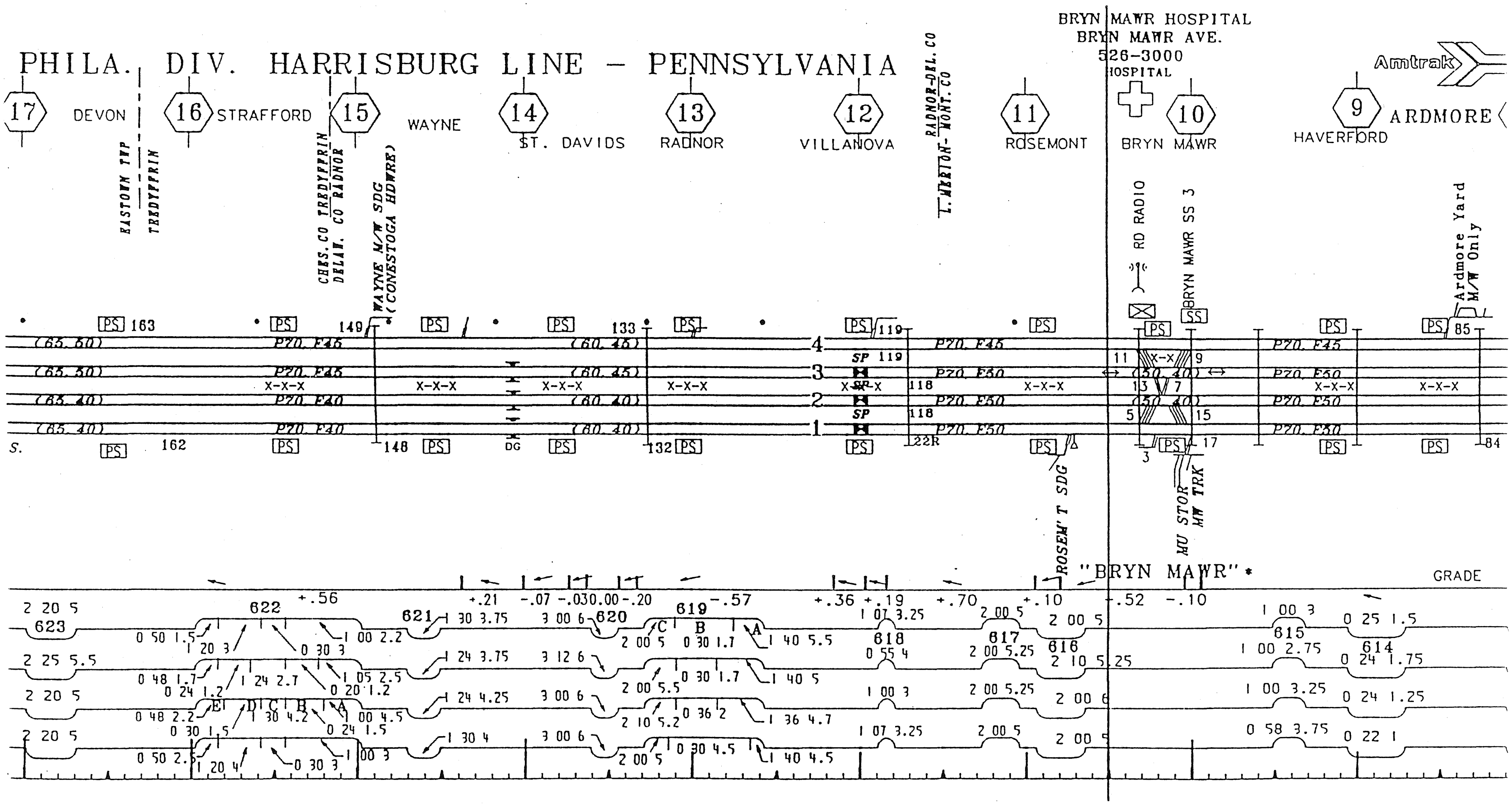
Location MP	Track	Speed	Rail Wt	Type	Year	Wear	Bad Ties	5 Yr. Ties	Comments
12.6	1-4	70	133						New For Blue Route
13.8	1	70	131	BOLT	1942	2/16	15	28	
13.8	2	70	140	BOLT	1960	3/16	15	31	
13.8	3	70	152	CWR	1936	2/16	9	16	
19.5	1	70	131	BOLT	1936	2/16	26	51	Pocket/Needs L/S
25.3	4	90	140	CWR	1977	1/16	6	16	25% NEW TIES
43.7	1	70	155	BOLT	1949	3/16	9	19	Park to be reconfigured
43.7	4	70	152	BOLT	1941	3/16	11	26	Park to be reconfigured
44.2	1	70	140	CWR	1964	2/16	10	21	Park to be reconfigured
44.2	4	70	152	BOLT	1937	6/16	15	29	Park to be reconfigured
51.4	1	50							Curve Wear 6/16
51.4	4	55							Curve Wear 10/16
52.0	1	80	131	CWR	1946	1/16	10	23	
52.0	4	90	140	CWR	1979	0/16	10	28	
53.0	1	80							Curve Wear 3/16
53.0	4	75							Curve Wear 7/16
53.8	1	80	131	BOLT	1945	1/16	10	19	
53.8	4	90	140	CWR	1979	0/16	8	18	
56.6	1	70	131	BOLT	1945	2/16	5	17	
56.6	4	90	140	CWR	1982	0/16	1	9	
57.3	1	90	140	CWR	1967	2/16	3	19	
57.3	4	90	131	CWR	1945	3/16	8	21	
61.0	1	90	140	CWR	1967	2/16	8	16	
61.0	4	90	131	CWR	1943	5/16	1	9	South Rail
61.0	4	90	140	CWR	1965	1/16			North Rail
61.9	1	90	140	CWR	1970	1/16	5	22	
61.9	4	90	140	CWR	1965	2/16	7	25	
64.4	1	90	140	CWR	1964	3/16	4	13	
64.4	4	70	140	BOLT	1947	2/16	12	45	
66.0	1	70	140	BOLT	1964	3/16	5	16	
66.0	4	70	140	BOLT	1962	3/16	8	18	
66.3	1	70	152	BOLT	1937	3/16	9	25	
72.6	1	90	155	CWR	1957	2/16	10	23	
72.6	2	70	152	BOLT	1936	3/16	8	19	
75.1	1	70	152	BOLT	1945	2/16	10	17	
75.1	2	70	152	BOLT	1937	2/16	8	16	
77.8	1	70	152	BOLT	1945	2/16	10	27	Needs L/S
77.8	2	70	152	BOLT	1940	2/16	5	29	
82.1	1	70	152	BOLT	1940	2/16	10	23	
82.1	2	70	131	BOLT	1942	2/16	8	22	
86.0	1	60	152	BOLT	1944	4/16	15	29	
86.0	2	70	131	BOLT	1951	3/16	8	21	
91.7	1	60	152	BOLT	1941	3/16	12	24	
91.7	2	70	131	BOLT	1943	2/16	10	20	
93.9	1	60	140	BOLT	1951	2/16	5	20	10% New Ties
93.9	2	70	140	BOLT	1951	3/16	12	35	
95.5	1	90	140	CWR	1965	1/16	3	22	
95.5	2	70	140	BOLT	1942	4/16	2	13	

APPENDIX B

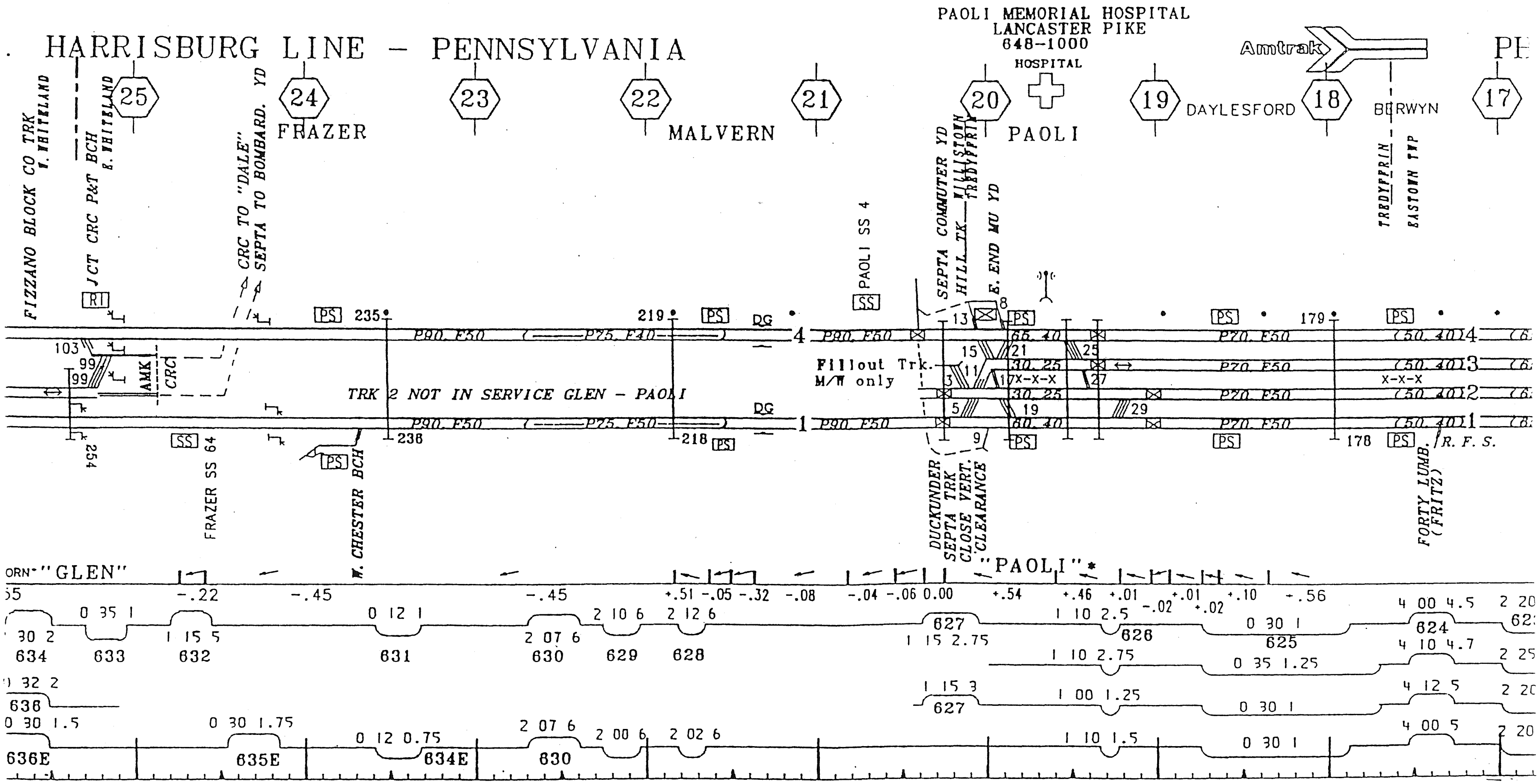
Philadelphia - Harrisburg Line Track Chart

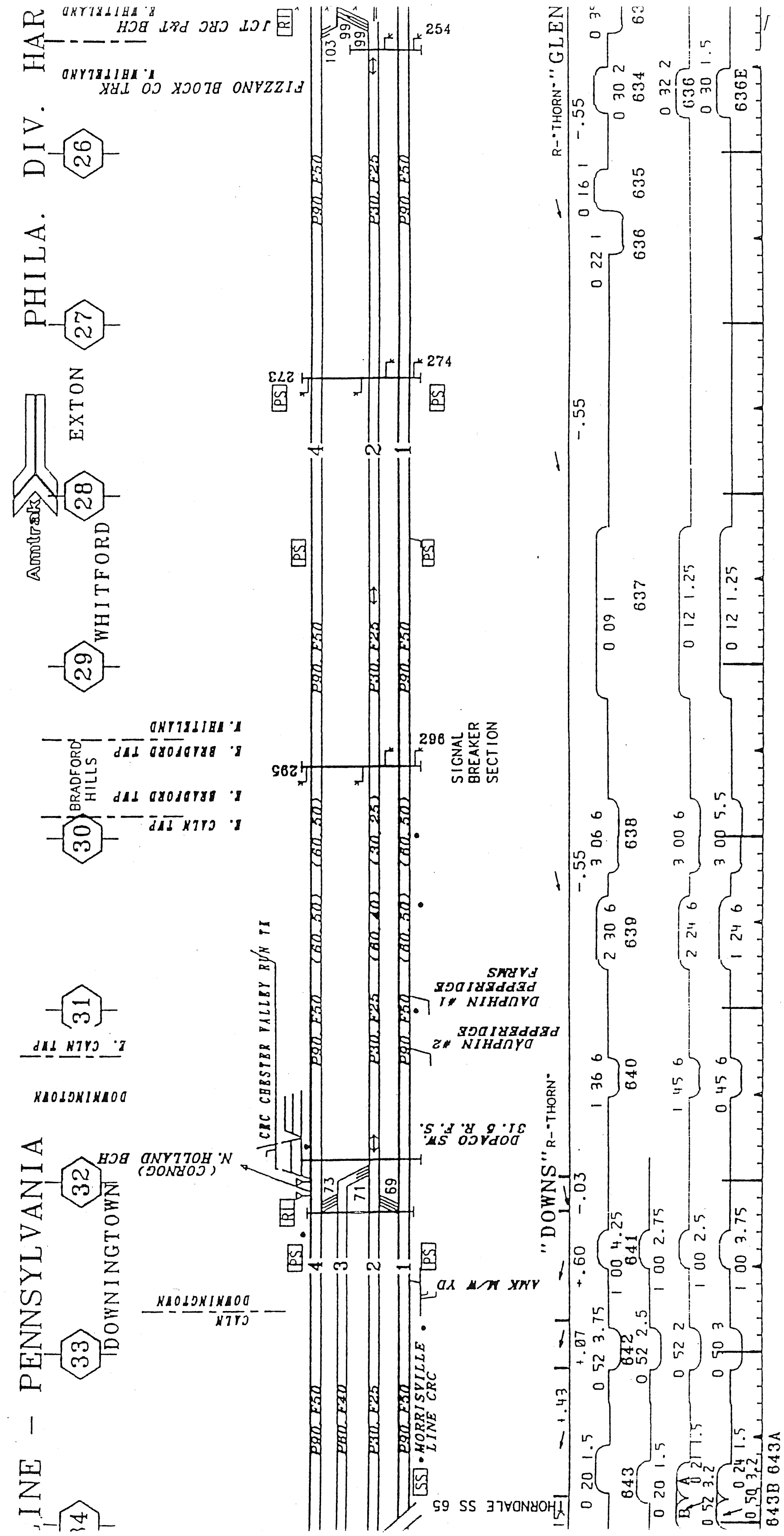

TEMPLE UNIV. HOSP., BROAD & ONTARIO STS, 221-2000
PHILA. DIV. HARRISBURG LINE - PENNSYLVANIA
HOSPITAL
ARDMORE
WYNNEWOOD
NARBERTH
MERION
OVERBROOK
52ND ST
ZOO
30TH ST
PENN CENTER
SPRING GARDEN ST
SEE DETAIL
Ardmore Yard M/W Only
Dump Siding M/W Only
AMTRAK TO NEW YORK
SUB 9 15MPH
AMTRAK TO NEW YORK 30MPH
W. PHIL. ELEV.
AMTRAK 36TH ST CONNEC. To Low. Level 30th St Sta.
RUNDOWN
MU YARD
SEPTA to WEST CHESTER
W PHILA SS
SEPTA
CRC FREIGHT
CRC YD
"WOODBINE"
MANAYUNK EB TRK
MICHAEL BOBB TRK
CRC WHSE
AMTRAK
SEPTA
GRADE
"OVERBROOK"
"VALLEY"
(JO)"ZOO"(D1)"ZOO"(K)
"BROAD" (SEPTA)
TK 4
TK 3
TK 2
TK 1

PHILA. DIV. HARRISBURG LINE – PENNSYLVANIA

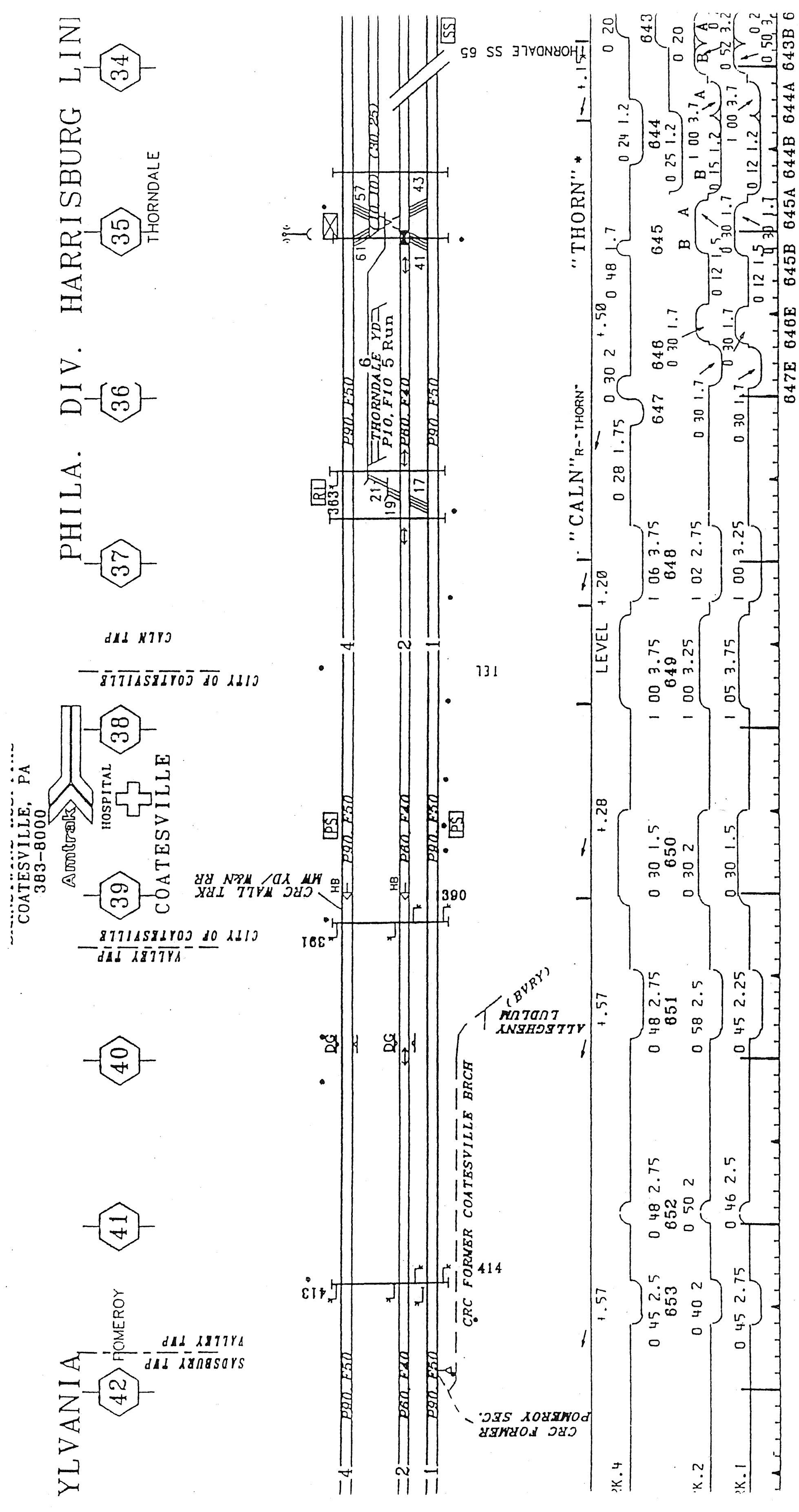


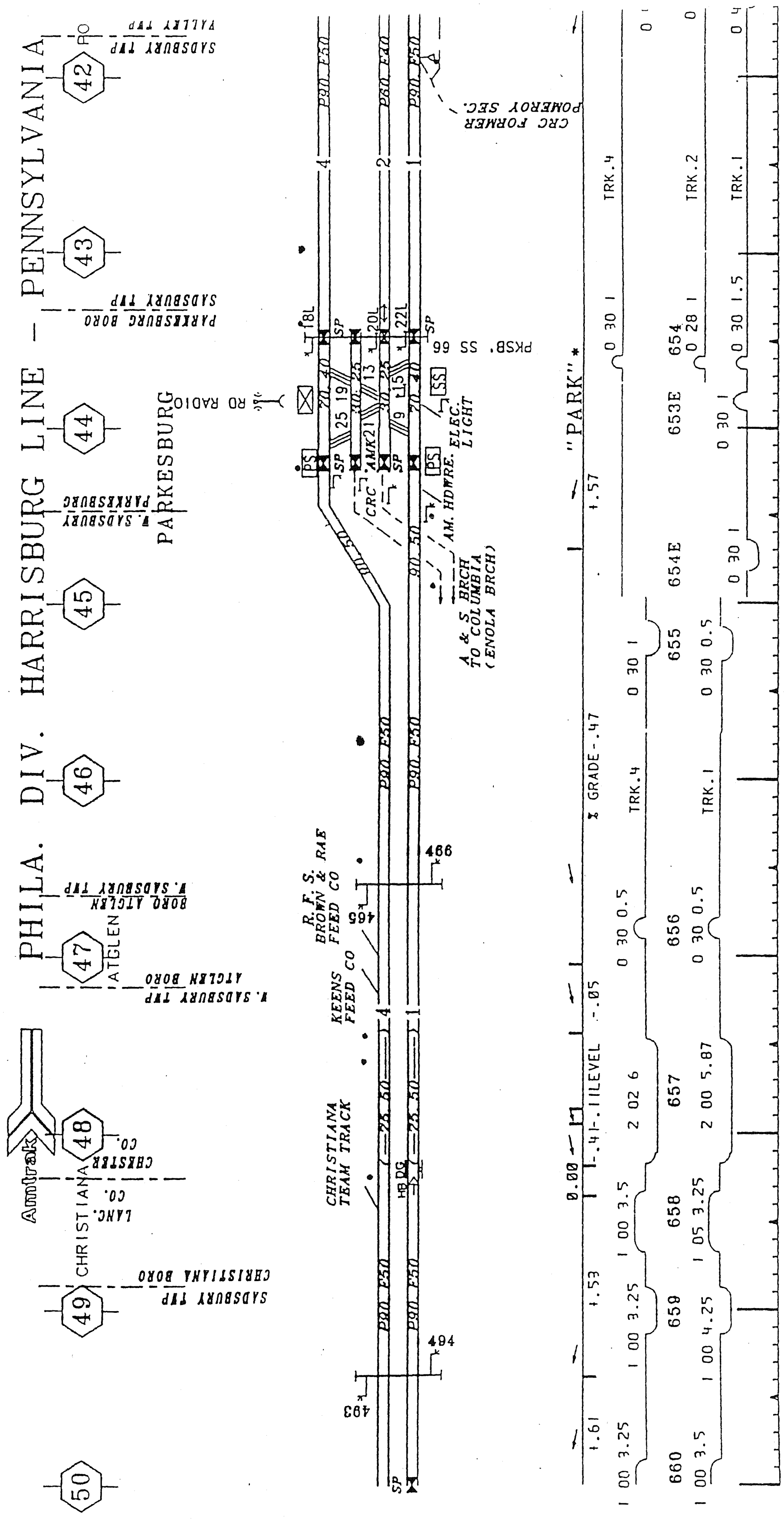
HARRISBURG LINE - PENNSYLVANIA





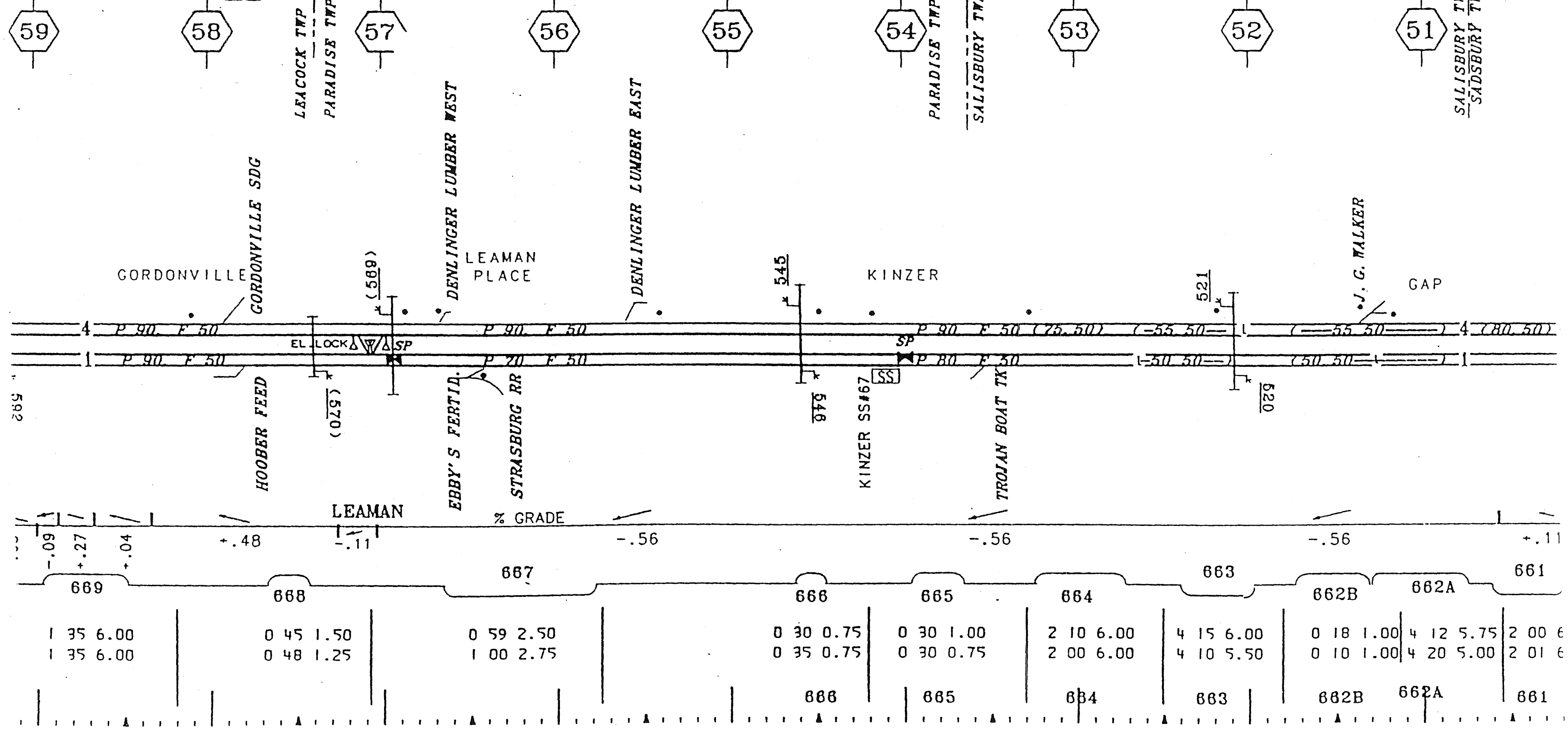
LINE - PENNSYLVANIA
PHILA. DIV. HAR
DOWNINGTOWN
EXTON
WHITFORD
BRADFORD HILLS
Amtrak
SIGNAL BREAKER SECTION
MORRISVILLE LINE CRC
"DOWNS" R-"THORN"
R-"THORN" "GLEN


PHILA. DIV. HARRISBURG LINE
PENNSYLVANIA
34
35
THORNDALE
36
37
38
39
40
41
42
COATESVILLE
HOSPITAL
COATESVILLE, PA
383-8000
Amtrak
POMEROY
CITY OF COATESVILLE
CALN TWP
VALLEY TWP
SADSBURY TWP
THORNDALE SS 65
THORNDALE YD
CRC WALL TRK
CRC FORMER COATESVILLE BRCH
ALLEGHENY LUDLUM
CRC FORMER POMEROY SEC.
"THORN"
"CALN"
LEVEL
647E 646E 645B 645A 644B 644A 643B

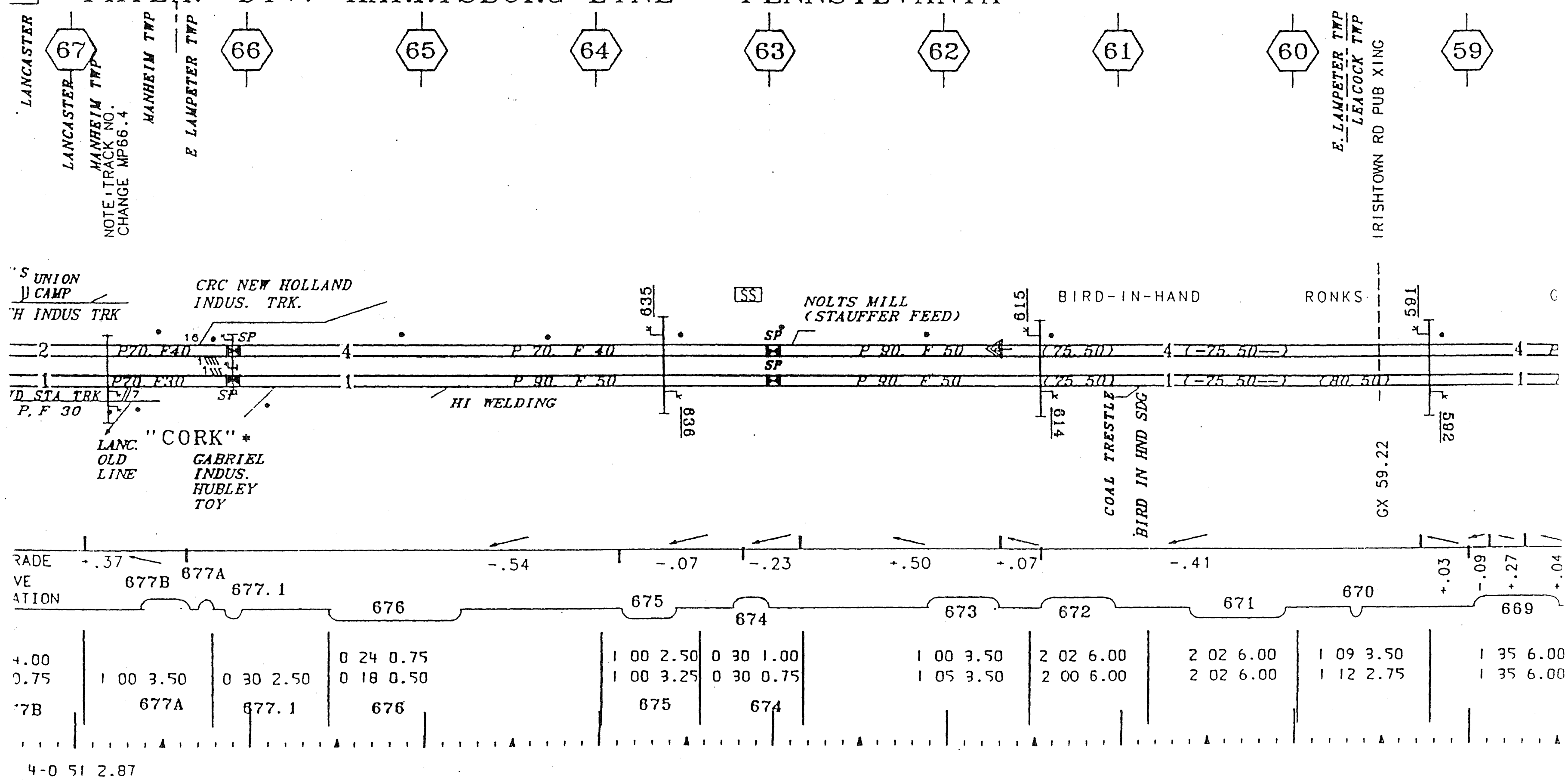

PHILA. DIV. HARRISBURG LINE - PENNSYLVANIA
PARKESBURG
ATGLEN
CHRISTIANA
Amtrak
SADSBURY TWP
VALLEY TWP
PARKESBURG BORO
W. SADSBURY
W. SADSBURY TWP
BORO ATGLEN
ATGLEN BORO
CHESTER CO.
LANC. CO.
CHRISTIANA BORO
RO RADIO
PKSB' SS 66
CRC FORMER POMEROY SEC.
A & S BRCH TO COLUMBIA (ENOLA BRCH)
AM. HDWRE. ELEC. LIGHT
R. F. S. BROWN & RAE FEED CO
KEENS FEED CO
CHRISTIANA TEAM TRACK
"PARK"
GRADE -.47
TRK. 4
TRK. 2
TRK. 1
654
653E
654E
655
656
657
658
659
660

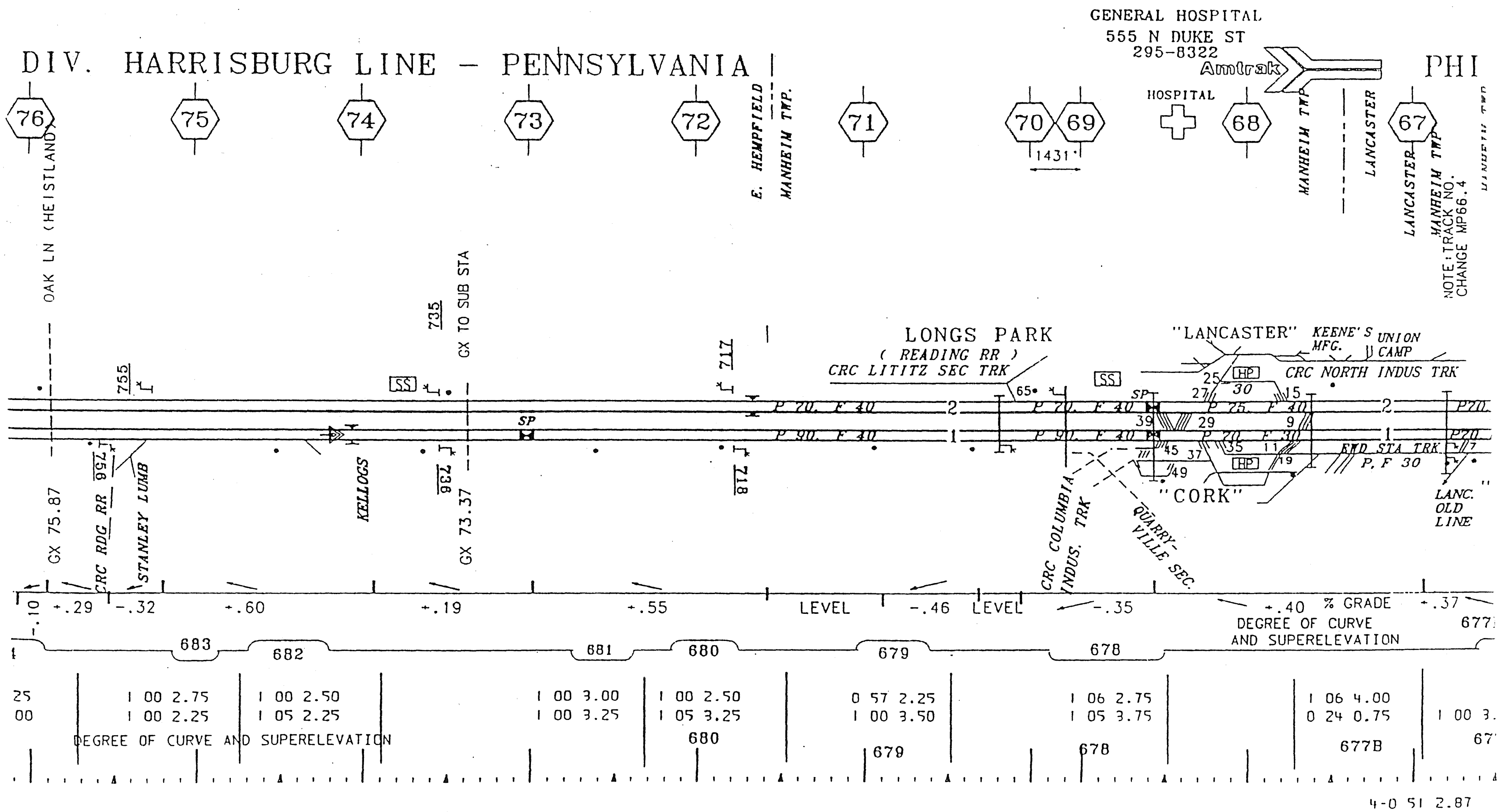
Amtrak

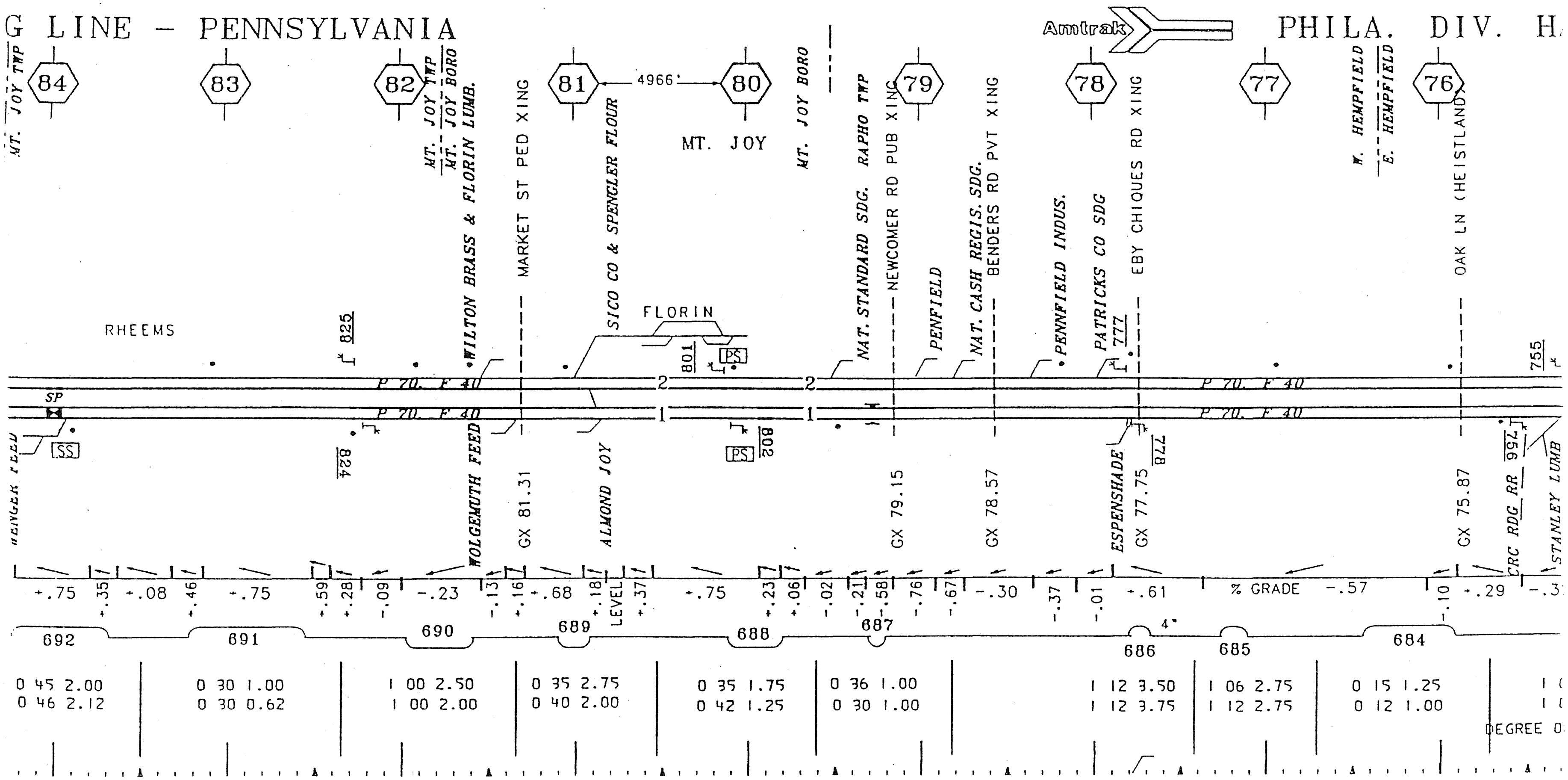
PHILA. DIV. HARRISBURG LINE - PENNSYLVANIA

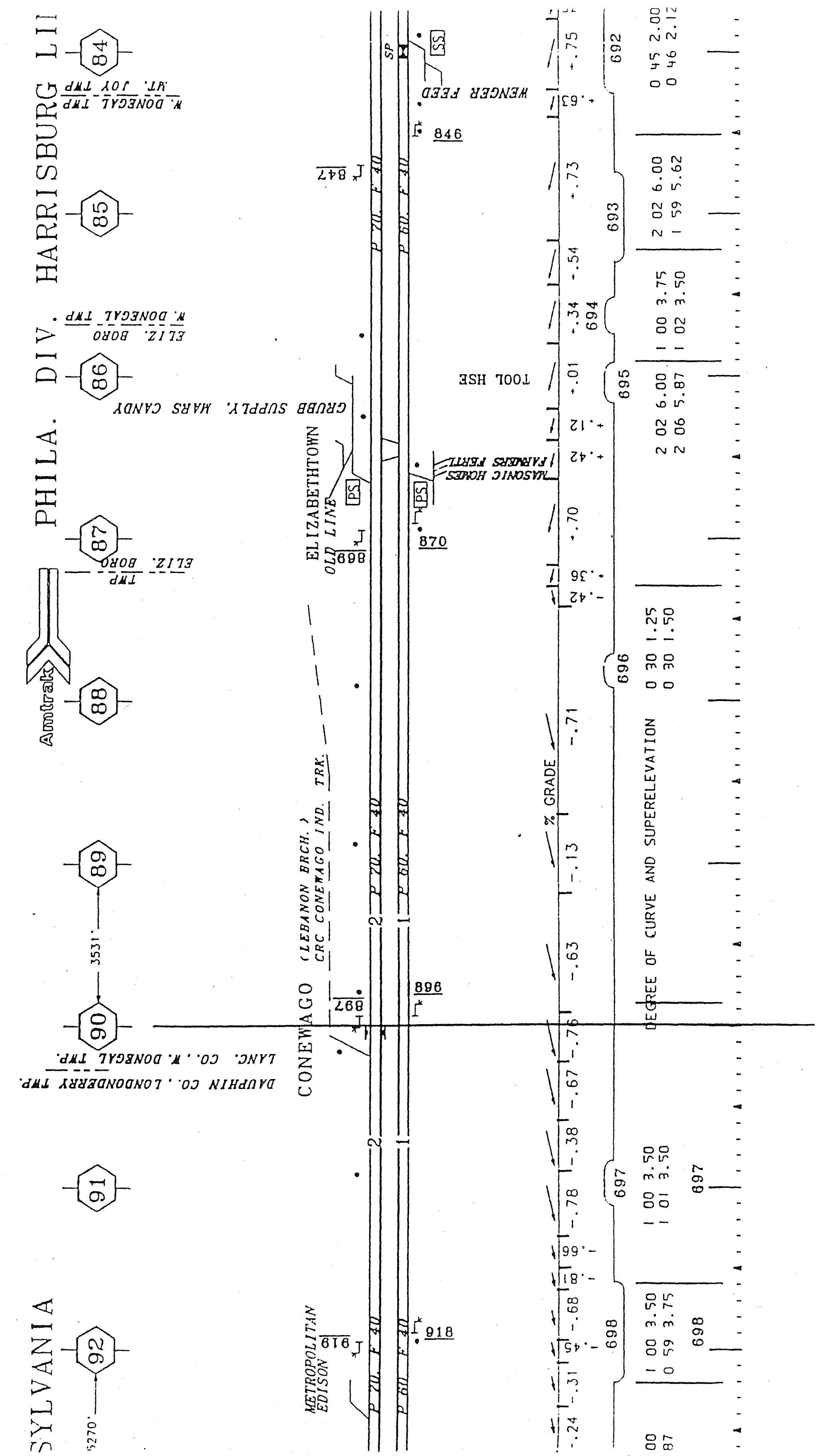


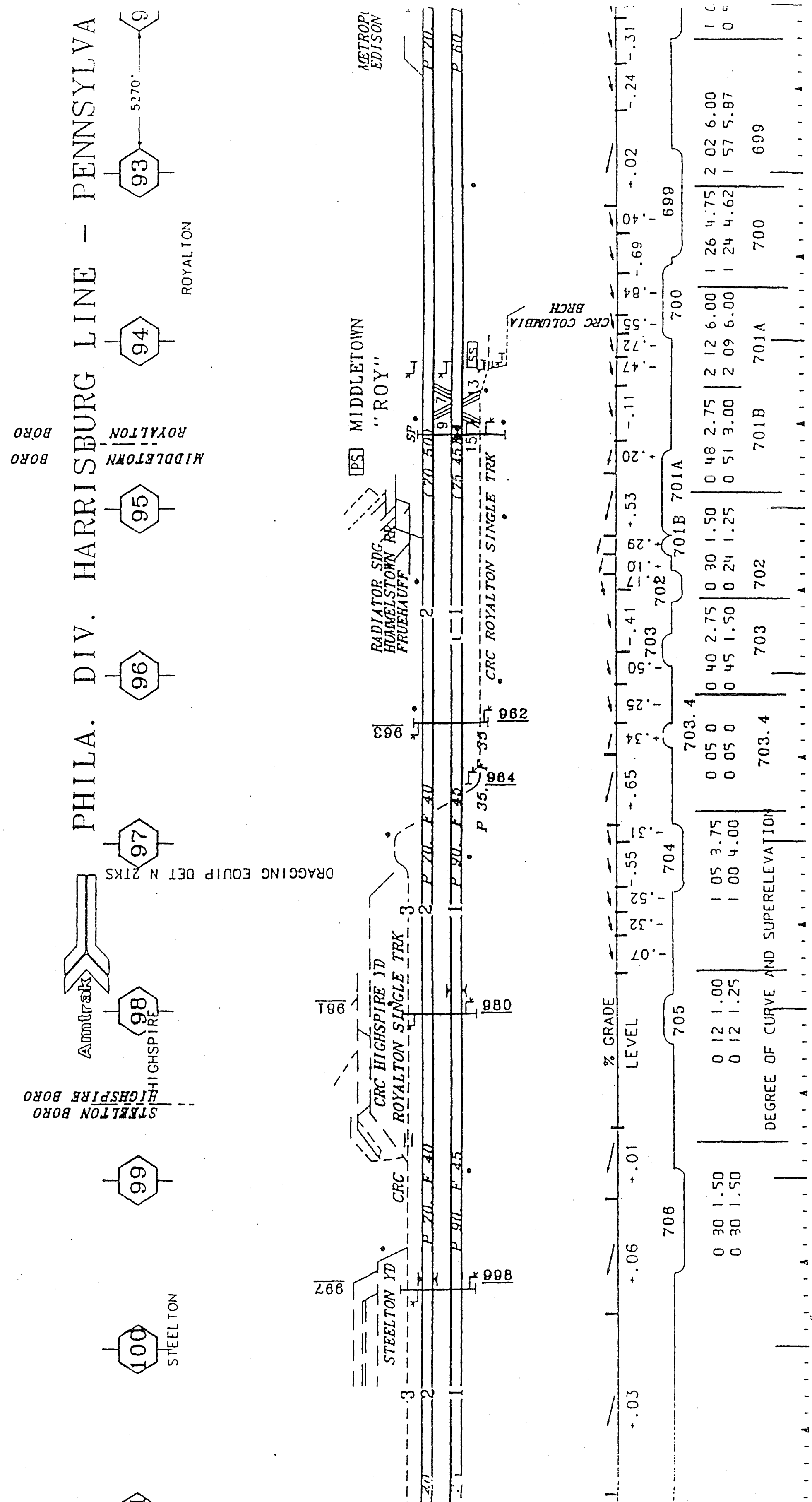
PHILA. DIV. HARRISBURG LINE - PENNSYLVANIA




DIV. HARRISBURG LINE - PENNSYLVANIA
PHI
76
75
74
73
72
71
70
69
68
67
1431'
GENERAL HOSPITAL
555 N DUKE ST
295-8322
Amtrak
HOSPITAL
E. HEMPFIELD
MANHEIM TWP.
MANHEIM TWP
LANCASTER
NOTE: TRACK NO. CHANGE MP66.4
OAK LN (HEISTLAND)
GX 75.87
755
756
CRC RDG RR
STANLEY LUMB
KELLOGS
SS
735
GX TO SUB STA
736
GX 73.37
SP
717
718
P 70, F 40
P 90, F 40
LONGS PARK
(READING RR)
CRC LITITZ SEC TRK
CRC COLUMBIA INDUS. TRK
QUARRY-VILLE SEC.
"LANCASTER"
KEENE'S MFG.
UNION CAMP
CRC NORTH INDUS TRK
"CORK"
END STA TRK
P, F 30
LANC. OLD LINE
% GRADE
DEGREE OF CURVE AND SUPERELEVATION
-.10
+.29
-.32
+.60
+.19
+.55
LEVEL
-.46
LEVEL
-.35
+.40
+.37
683
682
681
680
679
678
677
1 00 2.75
1 00 2.25
1 00 2.50
1 05 2.25
1 00 3.00
1 00 3.25
1 00 2.50
1 05 3.25
0 57 2.25
1 00 3.50
1 06 2.75
1 05 3.75
1 06 4.00
0 24 0.75
677B
4-0 51 2.87

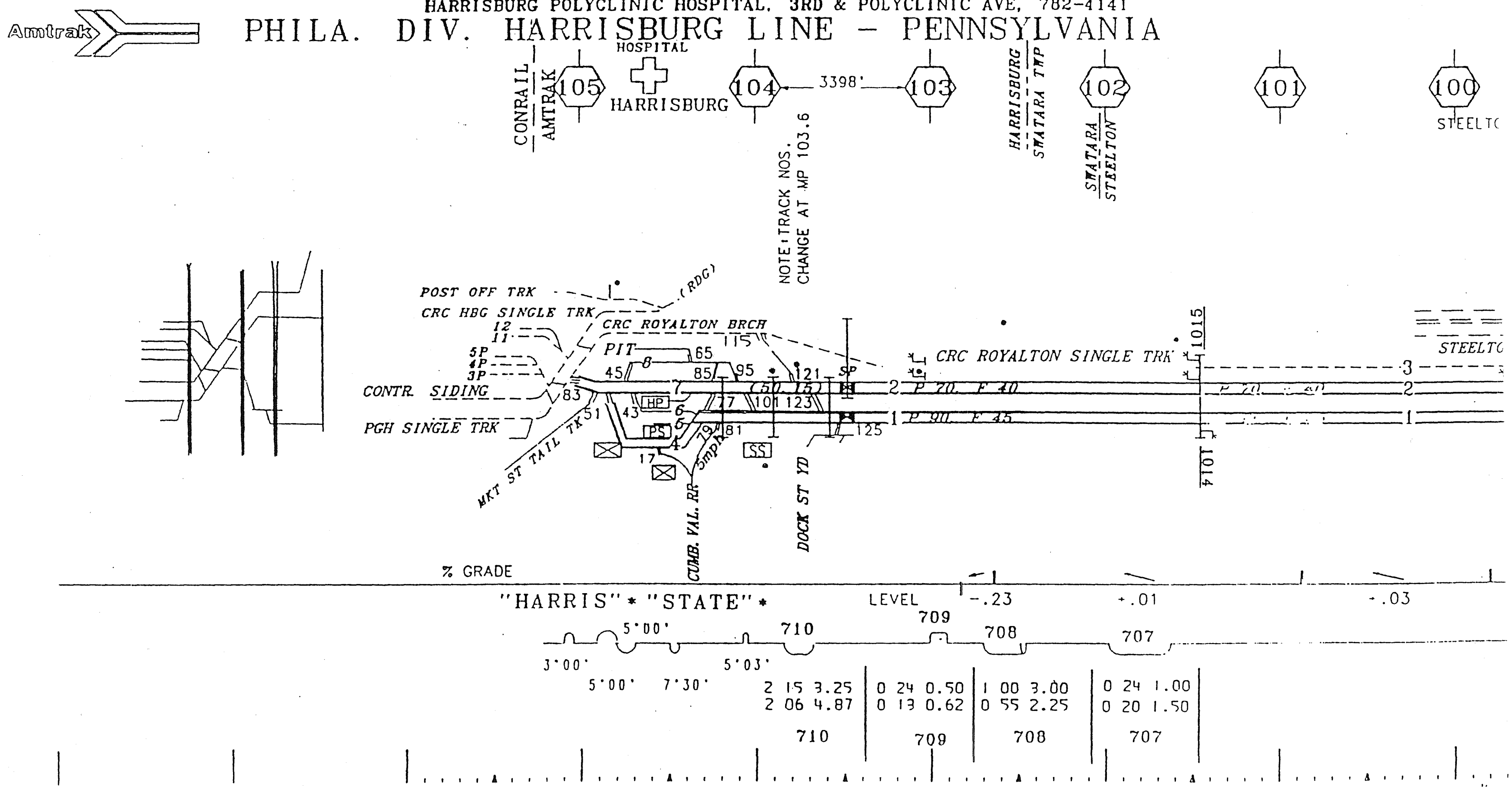

G LINE - PENNSYLVANIA
PHILA. DIV. H
Amtrak
84
83
82
81
80
79
78
77
76
4966'
MT. JOY
MT. JOY TWP
MT. JOY TWP
MT. JOY BORO
MT. JOY BORO
WILTON BRASS & FLORIN LUMB.
MARKET ST PED XING
SICO CO & SPENGLER FLOUR
FLORIN
NAT. STANDARD SDG. RAPHO TWP
NEWCOMER RD PUB XING
PENFIELD
NAT. CASH REGIS. SDG.
BENDERS RD PVT XING
PENNFIELD INDUS.
PATRICKS CO SDG
EBY CHIQUES RD XING
W. HEMPFIELD
E. HEMPFIELD
OAK LN (HEISTLAND)
RHEEMS
825
801
777
755
P 70. F 40
SP
SS
PS
824
802
778
756
WOLGEMUTH FEED
GX 81.31
ALMOND JOY
GX 79.15
GX 78.57
ESPENSHADE
GX 77.75
GX 75.87
CRC RDG RR
STANLEY LUMB
+.75 +.35 +.08 +.46 +.75 +.59 +.28 -.09 -.23 -.13 +.16 +.68 +.18 LEVEL +.37 +.75 +.23 +.06 -.02 -.21 -.58 -.76 -.67 -.30 -.37 -.01 +.61 % GRADE -.57 -.10 +.29 -.3
692 691 690 689 688 687 686 685 684
4°
0 45 2.00
0 46 2.12
0 30 1.00
0 30 0.62
1 00 2.50
1 00 2.00
0 35 2.75
0 40 2.00
0 35 1.75
0 42 1.25
0 36 1.00
0 30 1.00
1 12 3.50
1 12 3.75
1 06 2.75
1 12 2.75
0 15 1.25
0 12 1.00
DEGREE O


PHILA. DIV. HARRISBURG LI
SYLVANIA
Amtrak
84
85
86
87
88
89
90
91
92
3531'
5270'
W. DONEGAL TWP
MT. JOY TWP
ELIZ. BORO
W. DONEGAL TWP
TWP
ELIZ. BORO
LANC. CO., W. DONEGAL TWP.
DAUPHIN CO., LONDONDERRY TWP.
GRUBB SUPPLY, MARS CANDY
ELIZABETHTOWN
OLD LINE
CONEWAGO
(LEBANON BRCH.)
CRC CONEWAGO IND. TRK.
METROPOLITAN EDISON
WENGER FEED
TOOL HSE
FARMERS FERTI
MASONIC HOMES
SS
PS
SP
P 70. F 40
P 60. F 40
846
847
869
870
897
896
919
918
% GRADE
DEGREE OF CURVE AND SUPERELEVATION
692
693
694
695
696
697
698


PHILA. DIV. HARRISBURG LINE - PENNSYLVA
93
94
95
96
97
98
99
100
5270'
ROYALTON
MIDDLETOWN BORO
ROYALTON BORO
HIGHSPIRE BORO
STEELTON BORO
HIGHSPIRE
STEELTON
Amtrak
DRAGGING EQUIP DET N 2TKS
METROPOLITAN EDISON
MIDDLETOWN
"ROY"
RADIATOR SDG
HUMMELSTOWN RR
FRUEHAUFF
CRC ROYALTON SINGLE TRK
CRC COLUMBIA BRCH
CRC HIGHSPIRE YD
ROYALTON SINGLE TRK
STEELTON YD
963
962
964
981
980
997
998
% GRADE
LEVEL
DEGREE OF CURVE AND SUPERELEVATION
699
700
701A
701B
702
703
703.4
704
705
706

HARRISBURG HOSPITAL, FRONT & MULBERRY STS, 782-3131
HARRISBURG POLYCLINIC HOSPITAL, 3RD & POLYCLINIC AVE, 782-4141

PHILA. DIV. HARRISBURG LINE - PENNSYLVANIA



APPENDIX C

Relevant Portions of FRA Track Safety Standards

APPENDIX C

RELEVANT PORTIONS OF FRA TRACK SAFETY STANDARDS

These records must be kept available for inspection or copying by the Federal Railroad Administrator during regular business hours.

§ 213.9 Class of track: operating speed limits.

(a) Except as provided in paragraphs (b) and (c) of this section and §§ 213.57(b), 213.59(a), 213.113(a), and 213.137(b) and (c), the following maximum allowable operating speeds apply:

Over track that meets all of the requirements prescribed in this part for—	*The maximum allowable operating speed for freight trains is—*	*The maximum allowable operating speed for passenger trains is—*
Class 1 track	10 m.p.h.	15 m.p.h.
Class 2 track	25 m.p.h.	30 m.p.h.
Class 3 track	40 m.p.h.	60 m.p.h.
Class 4 track	60 m.p.h.	80 m.p.h.
Class 5 track	80 m.p.h.	90 m.p.h.
Class 6 track	110 m.p.h.	110 m.p.h.

(b) If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class of track for which it does meet all of the requirements of this part. However, if the segment of track does not at least meet the requirements for Class 1 track, operations may continue at Class 1 speeds for a period of not more than 30 days without bringing the track into compliance, under the authority of a person designated under § 213.7(a), who has at least one

year of supervisory experience in railroad track maintenance, after that person determines that operations may safely continue and subject to any limiting conditions specified by such person.

(c) Maximum operating speed may not exceed 110 m.p.h. without prior approval of the Federal Railroad Administrator. Petitions for approval must be filed in the manner and contain the information required by § 211.11 of this chapter. Each petition must provide sufficient information concerning the performance characteristics of the track, signaling, grade crossing protection, trespasser control where appropriate, and equipment involved and also concerning maintenance and inspection practices and procedures to be followed, to establish that the proposed speed can be sustained in safety.

§ 213.11 Restoration or renewal of track under traffic conditions.

If during a period of restoration or renewal, track is under traffic conditions and does not meet all of the requirements prescribed in this part, the work on the track must be under the continuous supervision of a person designated under § 213.7(a) who has at least one year of supervisory experience in railroad track maintenance. The term "continuous supervision" as used in this section means the physical presence of that person at a job site.

SUBPART D—TRACK STRUCTURE

§ 213.101 Scope.

This subpart prescribes minimum requirements for ballast, crossties, track assembly fittings, and the physical conditions of rails.

§ 213.103 Ballast; general.

Unless it is otherwise structurally supported, all track must be supported by material which will—

(a) Transmit and distribute the load of the track and railroad rolling equipment to the subgrade;

(b) Restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment and thermal stress exerted by the rails;

(c) Provide adequate drainage for the track; and

(d) Maintain proper track crosslevel, surface, and alinement.

§ 213.109 Crossties.

(a) Crossties shall be made of a material to which rail can be securely fastened.

(b) Each 39 foot segment of track shall have:

(1) A sufficient number of crossties which in combination provide effective support that will:

(i) Hold gage within the limits prescribed in § 213.53(b);

(ii) Maintain surface within the limits prescribed in § 213.63; and

(iii) Maintain alignment within the limits prescribed in § 213.55.

(2) The minimum number and type of crossties specified in paragraph (c) of this section effectively distributed to support the entire segment; and

(3) At least one crosstie of the type specified in paragraph (c) of this section that is located at a joint location as specified in paragraph (d) of this section.

(c) Each 39 foot segment of: Class 1 track shall have five crossties; Classes 2 and 3 track shall have eight crossties; Classes 4 and 5 track shall have 12 crossties; and Class 6 track shall have 14 crossties, which are not:

(1) Broken through;

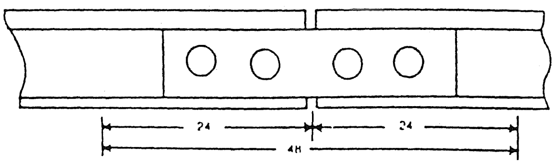
(2) Split or otherwise impaired to the extent the crossties will allow the ballast to work through, or will not hold spikes or rail fasteners;

(3) So deteriorated that the tie plate or base of rail can move laterally more than ½ inch relative to the crossties; or

(4) Cut by the tie plate through more than 40 percent of a ties' thickness.

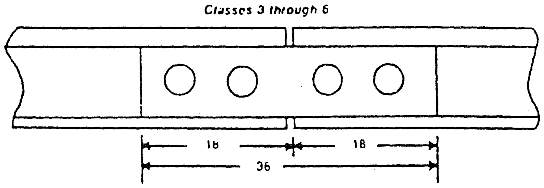
(d) Class 1 and Class 2 track shall have one crosstie whose centerline is within 24 inches of the rail joint location, and Classes 3 through 6 track shall have one crosstie whose centerline is within 18 inches of the rail joint location. The relative position of these ties is described in the following table.

Classes 1 and 2



Each rail joint in Classes 1 and 2 track shall be supported by at least one crosstie specified in paragraph (c) of this section whose centerline is within the 48" shown above

Classes 3 through 6



Each rail joint in Classes 3 through 6 track shall be supported by at least one crosstie specified in paragraph (c) of this section whose centerline is within the 36" shown above

§ 213.113 Defective rails.

(a) When an owner of track to which this part applies learns, through inspection or otherwise, that a rail in that track contains any of the defects listed in the following table, a person designated under § 213.7 shall de-

termine whether or not the track may continue in use. If he determines that the track may continue in use, operation over the defective rail is not permitted until—

(1) The rail is replaced; or

(2) The remedial action prescribed in the table is initiated:

Remedial Action

Defect	Percent of rail head cross-sectional area weakened by defect: Less than	Percent of rail head cross-sectional area weakened by defect: But not less than	If defective rail is not replaced, take the remedial action prescribed in note
Transverse fissure	20		B.
	100	20	B.
		100	A.
Compound fissure	20		B.
	100	20	B.
		100	A.
Detail fracture, Engine burn fracture, Defective weld	20		C.
	100	20	D.
		100	A or E and H.

Remedial Action

Defect	Length of defect (inch)		If defective rail is not replaced, take the remedial action prescribed in note
	More than	But not more than	
Horizontal split head / Vertrical split head	0	2	H and F.
	2	4	I and G.
	4		B.
	([1])	([1])	A.
Split web / Piped rail / Head web separation	0	½	H and F.
	½	3	I and G.
	3		B.
	([1])	([1])	A.
Bolt hole crack	0	½	H and F.
	½	1½	G.
	1½		B.
	([1])	([1])	A.
Broken base	0	6	E.
	6		A or E and I.
Ordinary break			A or E.
Damaged rail			C.

[1]Break out in rail head.

Notes:

A. Assigned person designated under § 213.7 to visually supervise each operation over defective rail.

B. Limit operating speed over defective rail to that as authorized by a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance.

C. Apply joint bars bolted only through the outermost holes to defect within 20 days after it is determined to continue the track in use. In the case of Classes 3 through 6 track, limit operating speed over defective rail to 30 mph until angle bars are applied; thereafter limit speed to 60 mph or the maximum allowable speed under § 213.9 for the class of track concerned, which ever is lower.

D. Apply joint bars bolted only through the outermost holes to defect within 10 days after it is determined to continue the track in use. In the case of Classes 3 through 6 track, limit operating speed over the defective rail to 30 mph or less as authorized by a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance, until angle bars are applied; thereafter, limit speed to 60 mph or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.

E. Apply joint bars to defect and bolt in accordance with § 213.121 (d) and (e).

F. Inspect rail 90 days after it is determined to continue the track in use.

G. Inspect rail 30 days after it is determined to continue the track in use.

H. Limit operating speed over defective rail to 60 mph or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.

I. Limit operating speed over defective rail to 30 mph or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.

(b) As used in this section—

(1) "Transverse Fissure" means a progressive crosswise fracture starting from a crystalline center or nucleus inside the head from which it spreads outward as a smooth, bright, or dark, round or oval surface substantially at

a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it.

(2) "Compound Fissure" means a progressive fracture originating in a horizontal split head which turns up or down in the head of the rail as a smooth, bright, or dark surface progressing until substantially at a right angle to the length of the rail. Compound fissures require examination of both faces of the fracture to locate the horizontal split head from which they originate.

(3) "Horizontal Split Head" means a horizontal progressive defect originating inside of the rail head, usually one-quarter inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the rail head.

(4) "Vertical Split Head" means a vertical split through or near the middle of the head, and extending into or through it. A crack or rust streak may show under the head close to the web or pieces may be split off the side of the head.

(5) "Split Web" means a lengthwise crack along the side of the web and extending into or through it.

(6) "Piped Rail" means a vertical split in a rail, usually in the web, due to failure of the shrinkage cavity in the ingot to unite in rolling.

(7) "Broken Base" means any break in the base of a rail.

(8) "Detail Fracture" means a progressive fracture originating at or near the surface of the rail head. These fractures should not be confused with transverse fissures, compound fissures, or other defects which have internal origins. Detail fractures may arise from shelly spots, head checks, or flaking.

(9) "Engine Burn Fracture" means a progressive fracture originating in spots where driving wheels have slipped on top of the rail head. In developing downward they frequently resemble the compound or even transverse fissures with which they should not be confused or classified.

(10) "Ordinary Break" means a partial or complete break in which there is no sign of a fissure, and in which none of the other defects described in this paragraph are found.

(11) "Damaged Rail" means any rail broken or injured by wrecks, broken, flat, or unbalanced wheels, slipping, or similar causes.

§ 213.115 Rail end mismatch.

Any mismatch of rails at joints may not be more than that prescribed by the following table:

Class of track	Any mismatch of rails at joints may not be more than the following— On the tread of the rail ends (inch)	On the gage side of the rail ends (inch)
1	1/4	1/4
2	1/4	3/16
3	3/16	3/16
4, 5	1/8	1/8
6	1/8	1/8

§ 213.121 Rail joints.

(a) Each rail joint, insulated joint, and compromise joint must be of the proper design and dimensions for the rail on which it is applied.

(b) If a joint bar on classes 3 through 6 track is cracked, broken, or because of wear allows vertical movement of either rail when all bolts are tight, it must be replaced.

(c) If a joint bar is cracked or broken between the middle two bolt holes it must be replaced.

(d) In the case of conventional jointed track, each rail must be bolted with at least

two bolts at each joint in classes 2 through 6 track, and with at least one bolt in class 1 track.

(e) In the case of continuous welded rail track, each rail must be bolted with at least two bolts at each joint.

(f) Each joint bar must be held in position by track bolts tightened to allow the joint bar to firmly support the abutting rail ends and to allow longitudinal movement of the rail in the joint to accommodate expansion and contraction due to temperature variations. When out-of-face, no-slip, joint-to-rail contact exists by design, the requirements of this paragraph do not apply. Those locations are considered to be continuous welded rail track and must meet all the requirements for continuous welded rail track prescribed in this part.

(g) No rail or angle bar having a torch cut or burned bolt hole may be used in classes 3 through 6 track.

§ 213.123 Tie plates.

(a) In classes 3 through 6 track where timber crossties are in use there must be tie plates under the running rails on at least eight of any 10 consecutive ties.

§ 213.127 Rail fastenings.

Each 39 foot segment of rail shall have a sufficient number of fastenings which, in the determination of a qualified Federal or State track inspector, effectively maintain gage within the limits prescribed in § 213.53(b). The term "qualified State track inspector" as used in this section means a track inspector who meets the qualification requirements of 49 CFR 212.203. (Formerly § 212.75).

§ 213.133 Turnouts and track crossings generally.

(a) In turnouts and track crossings, the fastenings must be intact and maintained so as to keep the components securely in place. Also, each switch, frog, and guard rail must be kept free of obstructions that may interfere with the passage of wheels.

(b) Classes 4 through 6 track must be equipped with rail anchors through and on each side of track crossings and turnouts, to restrain rail movement affecting the position of switch points and frogs.

(c) Each flangeway at turnouts and track crossings must be at least 1½ inches wide.

§ 213.135 Switches.

(a) Each stock rail must be securely seated in switch plates, but care must be used to avoid canting the rail by overtightening the rail braces.

(b) Each switch point must fit its stock rail properly, with the switch stand in either of its

closed positions to allow wheels to pass the switch point. Lateral and vertical movement of a stock rail in the switch plates or of a switch plate on a tie must not adversely affect the fit of the switch point to the stock rail.

(c) Each switch must be maintained so that the outer edge of the wheel tread cannot contact the gage side of the stock rail.

(d) The heel of each switch rail must be secure and the bolts in each heel must be kept tight.

(e) Each switch stand and connecting rod must be securely fastened and operable without excessive lost motion.

(f) Each throw lever must be maintained so that it cannot be operated with the lock or keeper in place.

(g) Each switch position indicator must be clearly visible at all times.

(h) Unusually chipped or worn switch points must be repaired or replaced. Metal flow must be removed to insure proper closure.

§ 213.137 Frogs.

(a) The flangeway depth measured from a plane across the wheel-bearing area of a frog on class 1 track may not be less than 1⅜ inches, or less than 1½ inches on classes 2 through 6 track.

(b) If a frog point is chipped, broken, or worn more than five-eighths inch down and 6 inches back, operating speed over the frog may not be more than 10 miles per hour.

(c) If the tread portion of a frog casting is worn down more than three-eighths inch below the original contour, operating speed over that frog may not be more than 10 miles per hour.

§ 213.139 Spring rail frogs.

(a) The outer edge of a wheel tread may not contact the gage side of a spring wing rail.

(b) The toe of each wing rail must be solidly tamped and fully and tightly bolted.

(c) Each frog with a bolt hole defect or head-web separation must be replaced.

(d) Each spring must have a tension sufficient to hold the wing rail against the point rail.

(e) The clearance between the holddown housing and the horn may not be more than one-fourth of an inch.

§ 213.141 Self-guarded frogs.

(a) The raised guard on a self-guarded frog may not be worn more than three-eighths of an inch.

(b) If repairs are made to a self-guarded frog without removing it from service, the guarding face must be restored before rebuilding the point.

§ 213.143 Frog guard rails and guard faces; gage.

The guard check and guard face gages in frogs must be within the limits prescribed in the following table:

Class of track	Guard check gage: The distance between the gage line of a frog to the guard line[1] of its guard rail or guarding face, measured across the track at right angles to the gage line,[2] may not be less than—	Guard face gage: The distance between guard lines,[1] measured across the track at right angles to the gage line,[2] may not be more than—
1	4′ 6⅛″	4′ 5¼″
2	4′ 6¼″	4′ 5⅛″
3, 4	4′ 6⅜″	4′ 5⅛″
5, 6	4′ 6½″	4′ 5″

[1]A line along that side of the flangeway which is nearer to the center of the track and at the same elevation as the gage line.

[2]A line ⅝ inch below the top of the center line of the head of the running rail, or corresponding location of the tread portion of the track structure.

SUBPART E—TRACK APPLIANCES and TRACK-RELATED DEVICES

§ 213.201 Scope.

This subpart prescribes minimum requirements for certain track appliances and track-related devices.

APPENDIX D

Daily Ridership - 1983 and 1990

September 1983

TRAIN NUMBER	Th 1	F 2	Sa 3	Su 4	Labor Day 5	Tu 6	W 7	Th 8	F 9	Sa 10	Su 11	M 12	Tu 13	W 14	Th 15
Eastbound															
600	335	317				381	358	338	356			391	359	334	328
42	7	3				14	7	7	4			4	5	5	6
602	200	108				265	256	230	235			295	278	263	260
604	116	114				164	168	126	153			145	84	155	142
44			102	37	23					93	68				
630			88		30					43					
606	58	72				109	92	70	72			72	73	84	92
608	90	115	114	61	80	95	55	66	83	52	79	74	65	75	65
610	89	116	56	45	80	99	78	62	106	46	62	54	46	58	73
612	80	113		47	76	64	115	61	98		70	45	74	62	79
46	10	49	47	10	45	27	13	25	48	39	51	18	20	26	34
614	122	160	42		43	118	117	91	173	55		104	107	116	119
616	92	140		65	130	94	90	127	111		113	109	80	61	90
618	30	86	56	65	149	43	24	29	63	36	106	31	28	40	38
Sub-total	1,229	1,393	505	330	656	1,473	1,373	1,232	1,502	364	549	1,342	1,219	1,279	1,326
PHL commuter	658	542				824	789	701	748			835	726	757	736
Midday	327	465				394	353	284	407			263	278	305	343
HAR commuter	214	300				212	207	218	284			213	187	177	209
evening	30	86				43	24	29	63			31	28	40	38
Westbound															
601	107	97				126	114	106	96			113	111	100	127
603	59	60				76	60	75	[a]			84	76	100	94
605	35	37	70		18	38	57	36	101	50		42	53	50	49
607	44	40	79	58	33	42	29	35	30	44	46	18	29	48	38
47	22	73	74	23	28	25	29	27	49	53	28	40	26	25	39
609	118	198	159	73	88	104	122	115	151	92	98	90	91	83	97
611	112	165		57	50	107	121	118	118	54		104	120	112	126
613	61	93				73	70	58	87			60	66	64	89
615	221	256	96	31	63	239	223	210	261	60	83	227	235	249	236
617	302	308			53	395	389	366	382			402	383	355	365
43	40	74				46	47	41	73			29	44	44	46
45			75	56	63					33	78				
619	61	140	60	42	90	44	72	57	80	26	96	55	52	88	56
Sub-total	1,182	1,541	613	340	486	1,315	1,333	1,244	1,428	412	429	1,264	1,286	1,318	1,362
HAR commuter	166	157				202	174	181	96			197	187	200	221
Midday	392	606				389	428	389	536			354	385	382	438
PHL commuter	523	564				634	612	576	643			629	618	604	601
evening	101	214				90	119	98	153			84	96	132	102
Total	2,411	2,934	1,118	670	1,142	2,788	2,706	2,476	2,930	776	978	2,606	2,505	2,597	2,688

[a]Train annulled.

September 1983

TRAIN NUMBER	F 16	Sa 17	Su 18	M 19	Tu 20	W 21	Th 22	F 23	Sa 24	Su 25	M 26	Tu 27	W 28	Th 29	F 30
Eastbound															
600	351			332	350	392	339	266			406	382	358	351	373
42	4			9	6	5	3	5			7	9	4	5	15
602	278			296	294	223	279	260			277	281	320	245	237
604	145			159	158	150	150	134			157	137	164	148	135
44		77	61						96	48					
630		77							67						
606	72			97	68	70	67	68			99	80	78	60	78
608	76	68	130	64	56	68	49	92	56	78	65	51	57	68	97
610	114	69	83	52	50	60	66	117	56	45	64	67	53	63	128
612	108		76	39	55	95	54	119		97	44	65	55	67	134
46	50	24	65	28	43	21	36	62	53	39	25	25	25	27	60
614	183	55		125	103	113	123	210	52		206	97	91	115	191
616	122		126	103	94	88	78	141		120	98	88	101	91	123
618	62	53	117	41	29	21	29	57	47	135	29	41	32	31	70
Sub-total	1,565	423	658	1,345	1,306	1,306	1,273	1,531	427	562	1,477	1,323	1,338	1,271	1,641
PHL commuter	778			796	808	770	771	665			847	809	846	749	760
Midday	420			280	272	314	272	458			297	288	268	285	497
HAR commuter	305			228	197	201	201	351			304	185	192	206	314
evening	62			41	29	21	29	57			29	41	32	31	70
Westbound															
601	111			138	187	118	100	101			113	121	134	116	112
603	79			85	36	82	79	74			97	82	89	69	85
605	42	60		48	30	54	48	44	46		51	63	38	32	44
607	33	47	49	37	45	38	19	45	41	47	47	29	24	39	40
47	49	49	45	45	20	36	32	45	54	45	40	32	20	23	40
609	178	80	97	89	78	105	90	157	96	91	105	113	78	115	202
611	213	85		111	119	128	135	193	53		123	127	142	82	184
613	120			66	65	55	72	107			67	72	67	70	107
615	264	102	92	233	256	298	383	274	88	92	406	259	290	221	283
617	369			378	363	409	402	366			394	348	325	342	359
43	73			36	46	41	41	78			38	31	38	40	94
45		45	138						84	103					
619	96	36	77	72	58	66	60	93	36	91	61	52	77	75	85
Sub-total	1,627	504	498	1,338	1,303	1,430	1,461	1,577	498	469	1,542	1,329	1,322	1,224	1,635
HAR commuter	190			223	223	200	179	175			210	203	223	185	197
Midday	635			396	357	416	396	591			433	436	369	361	617
PHL commuter	633			611	619	707	785	640			800	607	615	563	642
evening	169			108	104	107	101	171			99	83	115	115	179
Total	3,192	927	1,156	2,683	2,609	2,736	2,734	3,108	925	1,031	3,019	2,652	2,660	2,495	3,276

September 1983 Keystone Trains (600 series) only

TRAIN NUMBER	Percent Share					Passengers					
Eastbound	REV	ZZZ	UNK	EMP	USA	REV	ZZZ	UNK	EMP	USA	Total
600	9.4%	49.9%	1.3%	39.5%		692	3,688	95	2,922		7,397
42											
602	13.8%	70.7%	0.5%	15.0%		743	3,803	25	809		5,380
604	35.5%	58.1%	1.0%	5.5%		1,065	1,744	31	164		3,004
44											
630	86.6%	8.2%	2.0%	3.3%		264	25	6	10		305
606	71.7%	19.0%	3.4%	6.0%		1,169	309	55	98		1,631
608	85.5%	8.3%	2.8%	3.4%		1,919	186	63	76		2,244
610	85.7%	7.5%	2.4%	4.4%	0.1%	1,848	162	51	95	1	2,157
612	84.0%	5.8%	1.7%	8.5%		1,673	116	34	169		1,992
46											
614	60.8%	34.0%	1.2%	4.0%		1,842	1,031	37	121		3,031
616	57.3%	37.7%	1.6%	3.4%		1,533	1,008	42	92		2,675
618	89.3%	3.2%	2.7%	4.9%		1,445	51	43	79		1,618
Sub-total	45.2%	38.6%	1.5%	14.7%	0.0%	14,193	12,123	481	4,635	1	31,434
Westbound											
601	23.1%	64.3%	2.1%	10.5%		566	1,575	51	256		2,448
603	51.3%	42.6%	1.1%	4.9%		791	657	17	76		1,541
605	68.2%	13.9%	10.2%	7.7%		843	172	126	95		1,236
607	78.2%	3.4%	11.7%	6.7%		933	41	139	80		1,193
47											
609	64.9%	9.7%	17.5%	8.0%		2,175	324	587	267		3,353
611	51.4%	23.7%	9.5%	15.5%		1,573	723	290	473		3,059
613	44.6%	37.3%	2.5%	15.6%		709	593	39	248		1,589
615	24.6%	48.1%	4.1%	23.2%		1,533	2,998	253	1,446		6,231
617	13.3%	61.7%	2.5%	22.6%		1,033	4,781	191	1,750		7,755
43											
45											
619	56.6%	13.2%	25.1%	5.1%		1,163	271	516	104		2,054
Sub-total	37.2%	39.8%	7.2%	15.7%	0.0%	11,319	12,136	2,208	4,796	0	30,459
Total	32.4%	43.4%	6.8%	17.4%	0.0%	15,048	20,186	3,168	8,096	0	46,499

Fare Codes

REV - Revenue
ZZZ - Commuter
EMP - Employee
USA - RailPass

September 1990

TRAIN NUMBER			Labor												
Eastbound	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
600				149	124	122	127			129	197	116	113	138	
640				4	1	1	4			4	2	1	3	2	
602				128	126	125	106			121	131	131	103	112	
642	53	20	26					67	23						57
606	62	37	48	127	90	66	53	47	31	98	66	72	75	99	60
608	114			107	56	60	87	98		85	56	63	63	99	85
612		74	134						83						
42	59			76	44	66	104	38		56	70	78	74	108	26
614		53	83						87						
616	64			112	112	89	155	31		83	90	95	115	170	62
44		39	90						58						
618			116	44	37	19	57		80	22	11	23	20	67	
Sub-total	352	223	497	747	590	548	693	281	362	598	623	579	566	795	290
PHL commuter				281	251	248	237			254	330	248	219	252	
Midday				310	190	192	244			239	192	213	212	306	
HAR commuter				112	112	89	155			83	90	95	115	170	
evening				44	37	19	57			22	11	23	20	67	
Westbound															
601				58	59	49	60			56	61	50	49	50	
603				72	77	57	58			70	62	68	89	61	
43	92	65	48	54	29	40	39	57	47	46	51	54	51	71	99
609	118	95	85	97	104	119	159	77	104	75	95	100	107	171	112
615			46	126	119	133	182			110	109	136	131	193	
617	81			127	101	104	122	54		91	75	98	114	154	46
641				3	5	2	5			4	3	3	9	19	
645		74	42						115						
643	52							38							41
621	29	65	55	44	38	48	82	24	53	45	37	62	49	87	29
619			25				47		36					50	
Sub-total	372	299	301	581	532	552	754	250	355	497	493	571	599	856	327
HAR commuter				130	136	106	118			126	123	118	138	111	
Midday				151	133	159	198			121	146	154	158	242	
PHL commuter				256	225	239	309			205	187	237	254	366	
evening				44	38	48	129			45	37	62	49	137	
Total	724	522	798	1,328	1,122	1,100	1,447	531	717	1,095	1,116	1,150	1,165	1,651	617

September 1990

TRAIN NUMBER	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Eastbound															
600		168	180	129	98	115			159	121	117	105	113		
640		1	3	1	6	1			7	1	1	0	1		
602		141	129	129	109	98			163	118	86	113	73		
642	34						39	26						66	19
606	48	81	90	65	75	76	77	55	104	80	88	83	82	90	65
608		74	86	56	28	106	71		53	56	67	50	134	52	
612	133							170							142
42		69	30	48	50	155	52		41	73	49	64	107	54	
614	137							131							135
616		98	101	83	102	186	46		97	82	102	81	207	49	
44	94							80							70
618	101	21	19	15	31	47		97	32	22	14	24	51		102
Sub-total	547	653	638	526	499	784	285	559	656	553	524	520	768	311	533
PHL commuter		310	312	259	213	214			329	240	204	218	187		
Midday		224	206	169	153	337			198	209	204	197	323		
HAR commuter		98	101	83	102	186			97	82	102	81	207		
evening		21	19	15	31	47			32	22	14	24	51		
Westbound															
601		51	49	54	41	44			55	29	75	55	48		
603		73	60	55	57	51			47	77	73	61	49		
43	40	40	47	41	47	51	59	63	37	33	39	45	40	71	63
609	127	98	114	149	114	176	82	115	82	66	107	125	181	118	142
615		122	127	82	125	221			147	132	133	163	167		
617		80	196	107	112	163	72		88	100	103	103	167	66	
641		1	5	1	1	8			4	2	0	7	8		
645	151							135							128
643							31							44	
621	53	40	52	49	38	84	38	70	47	39	27	33	88	16	73
619	31					38		47					18		24
Sub-total	402	505	650	538	535	836	282	430	507	478	557	592	766	315	430
HAR commuter		124	109	109	98	95			102	106	148	116	97		
Midday		138	161	190	161	227			119	99	146	170	221		
PHL commuter		203	328	190	238	392			239	234	236	273	342		
evening		40	52	49	38	122			47	39	27	33	106		
Total	949	1,158	1,288	1,064	1,034	1,620	567	989	1,163	1,031	1,081	1,112	1,534	626	963

September 1990 Keystone Trains (600 series) only

TRAIN NUMBER	Percent Share					Passengers					
Eastbound	REV	ZZZ	UNK	EMP	USA	REV	ZZZ	UNK	EMP	USA	Total
600	43.0%	36.3%	1.1%	19.6%	0.0%	1,084	915	28	493	0	2,520
640											
602	79.1%	16.6%	0.6%	3.5%	0.1%	1,774	373	14	79	2	2,242
642											
606	91.6%	4.4%	1.1%	2.3%	0.5%	2,007	97	23	51	12	2,190
608	92.0%	3.8%	1.4%	2.5%	0.4%	1,661	68	25	45	7	1,806
612	97.7%	0.1%	0.4%	0.4%	1.4%	719	1	3	3	10	736
42											
614	97.4%	1.0%	0.3%	0.8%	0.5%	610	6	2	5	3	626
616	82.5%	14.6%	1.3%	1.5%	0.1%	1,990	353	32	35	2	2,412
44											
618	95.7%	0.8%	0.8%	1.7%	0.9%	1,026	9	9	18	10	1,072
Sub-total	79.9%	13.4%	1.0%	5.4%	0.3%	10,871	1,822	136	729	46	13,604
Westbound											
601	60.6%	37.4%	0.2%	1.6%	0.2%	602	371	2	16	2	993
603	87.8%	9.0%	1.8%	1.1%	0.2%	1,069	110	22	13	3	1,217
43											
609	90.4%	4.3%	1.6%	3.1%	0.6%	3,087	148	53	107	19	3,414
615	69.9%	15.2%	1.6%	12.9%	0.4%	1,891	411	42	349	11	2,704
617	68.4%	23.3%	0.8%	7.2%	0.3%	1,727	589	19	181	8	2,524
641											
645											
643											
621	82.9%	4.1%	10.6%	1.8%	0.6%	1,238	61	159	27	9	1,494
619	89.9%	6.6%	1.6%	1.9%	0.0%	284	21	5	6	0	316
Sub-total	78.7%	11.8%	2.7%	6.4%	0.4%	8,227	1,230	278	670	47	10,452
Total	79.4%	12.7%	1.7%	5.8%	0.4%	19,098	3,052	414	1,399	93	24,056

Fare Codes

REV - Revenue
ZZZ - Commuter
EMP - Employee
USA - RailPass

APPENDIX E

Comparable Corridors

APPENDIX E

COMPARABLE CORRIDORS

Eight Amtrak corridors outside Pennsylvania were selected for comparison with the Philadelphia-Harrisburg *Keystone* Corridor. The unique characteristics of each corridor were identified, and the response of ridership to changes in level of service, travel times, and fares analyzed. Table III-A1 summarizes trends in these parameters since 1980 for the selected corridors. Service characteristics and fares are those in effect during the winter of each fiscal year. Since not every train operates everyday, the number of daily round-trips was calculated by dividing the number of weekly one-way trips (both directions) by 14. Average speed was based on the time scheduled for all trips, including station dwell time, in both directions between the end points and the indicated distance, and is weighted by the number of trips per week. Fares reflect the lowest one-way and round-trip coach fares available. Where no excursion fare existed, twice the one-way fare was used. A blank means the fare was not known.

1. New York - Albany - Buffalo

The State of New York has invested $84 million since 1975 to upgrade the *Empire* corridor, which connects New York City with Albany and continues west to Syracuse, Rochester, and Buffalo, and the result has been steadily increasing ridership (up 41% between 1980 and 1990). In reality, the corridor can be considered as two, a relatively short corridor between New York and Albany with dense service carrying a large number of day trips, and a longer one extending to Buffalo carrying both long-haul and segment passengers.

Several factors can account for the increasing ridership. First, as a result of the investment in infrastructure, the average speed increased by almost 18 percent (50.3 to 57.3 mph) in the five years from 1980 to 1985, but has since declined by 7.5 percent to 54.4 mph. Second, service between New York and Albany has increased by 29 percent to 10.3 round-trips per day. However, in the longer corridor to Buffalo, service has remained relatively level, fluctuating between three and four round-trips per day. Third, promotional round-trip excursion fares were used to attract passengers, especially in the latter half of the 80s and for longer distances. Since 1986, $7 return fares have been in effect for long-haul trips in the corridor. And fourth, in the early 80s PeoplExpress, a no-frills airline, offered fares between New York City and upstate cities that undercut Amtrak. However, the airline found itself weakened by rising costs and competitive pressure, and disappeared as an independent entity in 1987.

The completion in April 1991 of the West Side connection in New York City enabled Amtrak to terminate *Empire* Corridor trains at Pennsylvania Station, instead of at

Grand Central Station, thus providing direct connections to the Northeast Corridor, as well as to local trains operated by the Long Island Rail Road and NJ TRANSIT. This eliminated the inconvenience of transferring between stations for through passengers. Though none are currently scheduled, the connections offers the potential of run-through trains to cities along the Northeast Corridor or Long Island points.

2. Chicago - Detroit

This corridor is comparable to the New York-Buffalo corridor in that it is moderately long (279 miles) and with three daily round-trips. However, unlike the previous corridor, ridership has not been growing. Ridership declined by 38 percent from 1981 to 1988, though it has since rebounded by 26 percent. Several factors may have been responsible for this result.

Fares were increased annually through 1985, but the following year one-way fares were significantly reduced, and then in 1988 an excursion fare priced only $1 higher than the one-way fare was introduced. Both one-way and round-trip fares were again reduced in 1990, with the result that in 1991 one can travel round-trip by train cheaper than one could in 1980.

Unfortunately, the route was suffering from poor track, with over one-half the trains arriving late at their destination, and ridership did not respond to the fare reductions. In 1987 thirty minutes was added to the schedule, lengthening the Chicago-Detroit running time to six hours. Continuing track work allowed speeds to be gradually increased to where it stood in 1980, slightly better than 50 mph.

The period from 1986 to 1990 also saw some diminution in service when one of the former daily round-trips was reduced to a tri-weekly service. This was restored to daily operation with the October 1990 timetable change.

Another factor affecting ridership in the early 1980s was the economic recession, which hurt manufacturing employment in Michigan particularly and reduced overall travel demand. There is little that either Amtrak or the states can do to counteract a loss of intrinsic travel demand, except to improve competitiveness and seek to increase market share.

Thus, in the first half of the decade ridership suffered from the combination of a weak economy and rising fares. Promotional fares were introduced by the middle of the decade, but falling reliability, increased travel times, and reduced service continued to suppress ridership. However, by the end of the decade, things started coming together. Speeds were increased, reliability improved (though still not great), service returned to three daily round-trips, and fares were the lowest they had been in years. Ridership responded, with FY90 seeing a 22 percent increase over FY89. Preliminary results for FY91 show the number of passengers up by another 10 percent.

3. Chicago - Indianapolis

This corridor has the sparsest service of all the corridors examined. Indianapolis was not included in the original Amtrak network, and hence lost all service when the railroad was established in 1971. After a ten-year hiatus, service resumed with a single daily round-trip between Chicago and Indianapolis. The later reroute of the tri-weekly New York-Chicago *Cardinal* through Indianapolis allowed a slight increase in service starting in October 1987.

In 1981, the first year of resumed operation, the line carried about 83,000 passengers, but has not carried that many since. Ridership fell steadily until 1987 when it was 38 percent below the initial figure, and then over the next three years recovered slightly. It is difficult to develop a market in a 195-mile corridor with service limited to one round-trip buttressed by a tri-weekly long-haul. However, the redevelopment of the Indianapolis station into a retail-hotel complex, combined with promotional fares, resulted in a 79 percent increase in ridership for FY91 over that observed a year earlier. Here Amtrak's pricing strategy focussed on the one-way fare, reducing it by 37 percent. This gave Amtrak a low fare it could market, and allowed it to attract one-way travelers. By holding the reduction in round-trip excursion fares to 9 percent, Amtrak was able to minimize any erosion in revenue from existing riders.

In addition to sparse service, low average speeds have been a problem in this corridor. They have increased by 12 percent since 1984, but at 46 mph are still low. Currently, the faster train requires 4 hours 10 minutes to get over the line. Though a new station and promotional fares can provide a needed stimulus, it does require more service and quicker travel times if this corridor is to reach its potential.

4. Chicago - St. Louis

This is another route that has suffered from limited service and poor track condition, and here too, ridership has been disappointing. At 282 miles and with three daily round-trips, it is comparable to the Chicago-Detroit corridor, though fares are higher and ridership only 68 percent of that on the Michigan line.

Changing ownership and inadequate maintenance have been continuing problems for the line. An Illinois Central Gulf mainline at the time of Amtrak's formation, the line was subsequently downgraded to secondary status. The line was transferred to a new regional railroad, the Chicago, Missouri & Western, in 1987 and returned to mainline status. However, expected revenues failed to materialize and the CM&W was forced into bankruptcy. With insufficient resources devoted to track maintenance average speeds fell to 47 mph and in spite of lengthened running times, in some months barely 11 percent of trains were able to arrive at their destination within 15 minutes of the scheduled time. The line was subsequently transferred to the St. Louis Southwestern Railway, better known as the Cotton Belt. The railroad is a subsidiary of Southern Pacific, and it is hoped that the new owner can provide adequate support. The State of Illinois has contributed money toward a line upgrade.

Some effort has been made to use promotional fares to stimulate ridership. Though one-way fares remain relatively high, a $1 return fare was introduced in 1986. While this initially produced a response, growth has since stagnated. Speeds and on-time performance are still too low to compete successfully with the automobile.

5. Chicago - Milwaukee

The 86-mile *Hiawatha* corridor has been one of Amtrak's success stories. The corridor is anchored at each end by large cities with healthy downtowns, is short enough that airline competition is not a factor, and connecting highways are heavily trafficked. This corridor shares some attributes with the *Keystone* corridor. They are of comparable length and both have a local operator providing a high level of local rail service at one end.

Ten years ago prospects for the corridor were not so rosy. Ridership had fallen 54 percent by 1982 from what it was just two years earlier, but then service had been cut by 43 percent (to three daily round-trips) and fares had been raised by 38 percent over the same period, and the nation was in a recession. However, ridership began creeping up as the economy improved and a fourth round-trip was added in 1985. Then in 1990 the service was revamped with the states of Illinois and Wisconsin providing funds to add two more daily round-trips. Individual train names were replaced by the collective *Hiawatha Service*, and an intensive marketing campaign was mounted. Annual ridership jumped by more than 100,000 (51%). Additional weekend service was provided in October 1990 and ridership increased by another 7 percent in FY91.

Speeds have not changed significantly over the past decade, and have been maintained at a consistent 55 mph, nor have other aspects affecting the quality of service changed. On-time performance has been generally good, though it did dip to 83 percent in mid-1988. Since then, however, it has bounced back to 92 percent. Neither, have promotional fares been used to stimulate ridership, though reduced excursion fares for round-trips were introduced in 1989. They were dropped two years later in 1991.

The success of the *Hiawatha* corridor must be attributed to an increasing level of service, support from the states, effective promotion, and a travel demand that supports good service.

6. Los Angeles - San Diego

The *San Diegans* serve Amtrak's second busiest corridor (after the Northeast Corridor between Boston and Washington). When Amtrak assumed operation in 1971, the line was served by three daily round-trips carrying an annual ridership of only 380,000. Service was incrementally increased, one round-trip at a time, until by 1980 service had doubled to six round-trips, and annual ridership had increased to 1.23 million, more than three times the passengers carried just nine years earlier. Ridership then hit a plateau and even the addition of a seventh round-trip in 1982 failed to raise passenger demand, but fares were rising at better than 10 percent per year and for the most of the period the route lacked a promotional excursion fare. A short-lived experiment with a premium-priced Metroliner service in 1983 actually further depressed demand. Round-trip fares fell by 28 percent when Amtrak introduced a $7 return fare, and ridership resumed its upward climb. An eighth round-trip was added in 1989 and 1990 returned the highest ridership in the line's history, 1.78 million riders. In the first half of FY91, ridership was running four percent above the previous year.

Though improving service and exogenous factors, such as increasing congestion on the parallel interstate highway (I-5) and fuel shortages during the 1970s, have been major factors increasing demand for rail travel, the State of California has also played an important role. The State has invested over $12 million in new stations or improvements and local governments have added another $25 million. The new stations proved an important factor in attracting new ridership. Smaller amounts of money were used to provide or improve passing sidings, which were needed to handle additional trains.

This is a corridor largely created by Amtrak and California. The predecessor railroad, the Atchison, Topeka, and Santa Fe, never provided as much service as is running now and ridership is at an all-time high. Judicious investment was used to upgrade the line and rolling stock. The demand was there, the highways congested enough, and the service good enough that the ridership responded.

7. Oakland - Bakersfield

The *San Joaquins* constitute another success story for Amtrak corridor service, but for reasons quite distinct than those found for the *San Diegans*. The route has always posed a problem to the railroads, as direct access to Los Angeles at the southern end is blocked by the San Bernardino Mountains, and a circuitous routing with a ferry connection was required to reach San Francisco at the northern end. Not even included in the original 1971 route structure, this line did not see any Amtrak service until 1974, when a single round-trip was mounted. A second round-trip was added in 1980, and a third in 1990. The ridership has responded, with each successive year since 1980 showing an increase. The number of passengers doubled between 1980 and 1985, and almost doubled again by 1990.

The key to the route's success is the array of bus connections that feed it traffic. Ridership was somewhat static until 1980 when the first connection, a bus link to Sacramento was established. The following year saw the corridor extended to Los Angeles using a dedicated bus connection at Bakersfield. More connections to off-line points, such as San Jose, Chico, Yosemite, Santa Barbara, and Barstow, were added over the years, until today connecting service is provided on 17 routes. Fully one-half of the riders on the *San Joaquins* now use a connecting bus to reach their train or to complete their journey, and half of these are traveling to or from the Los Angeles area.

Thirty-five minutes were cut from the timetable in 1982, which reduced the scheduled running time between Oakland and Bakersfield to an even six hours. However, this worsened on-time performance. By 1987 only 58 percent of the trains were able to reach their final destination within fifteen minutes of the scheduled time, and to correct this problem Amtrak added five minutes to the schedule in 1988 and an additional five minutes in 1990. On-time performance has since improved to 90 percent.

8. Seattle - Portland

This is another corridor that has the potential for developing a rail market, but suffers from sparse service and a reliance on long-distance trains. The service level of three daily round-trips has not changed over the last decade, but only one of these trips is provided by a short-haul corridor train. The other two are long-haul trains originating (or terminating) in Chicago and Los Angeles, respectively. This means that schedules are set to meet the needs of long-distance travelers, reservations are required and can be partially blocked out at times of peak demand, running times are increased to accommodate consists and extra dwell times at stations, and on-time performance is degraded when trains originate from distant cities. [The *Pioneer* (Chicago-Denver-Salt Lake City-Portland-Seattle) operates on the longest route (2689 miles) in the Amtrak network.] On-time performance for the corridor train, The *Mount Rainier*, is reasonably good, typically 85 to 90 percent, but the *Pioneer* is one of Amtrak's worst trains for reliability. Speeds are relatively low and now average only 46 mph.

This is a corridor with some potential, but to realize it will require additional short-haul trains that are run reliably at higher speeds.

APPENDIX F

RIDERSHIP ESTIMATION

APPENDIX F

RIDERSHIP ESTIMATION

The following steps were used to estimate 1996 ridership on *Keystone* trains for the three operating scenarios. Table F-1 is paired with Table F-2 for the estimation of ridership in the low-elasticity case, and Table II-B-3 with Table II-B-4 for the high-elasticity case.

In the first step Amtrak's accounting data for September 1990 were used to partition the total market carried by Amtrak within the Philadelphia-Harrisburg (PHL-HAR) range into six market segments. The results, which include passengers on non-*Keystone* trains, are shown in Table III-4 on page 80. Annual ridership for 1990, which was obtained by multiplying the weekly figures by 52.3, are shown of Columns 1 and 2 of Tables F-1 and F-3. Daily ridership by direction and market segment are shown in Columns 1 through 5 of Tables F-2 and F-4.

In the second step, natural growth factors, derived from population and employment and shown in Table III-7 on page 90, were used to estimate 1996 ridership, assuming no change in service. The results constitute the ridership for Scenario I and are shown in the top third of Tables F-1 and F-3 and Columns 6 through 10 of Tables F-2 and F-4. Riders were prorated between *Keystone* and non-*Keystone* trains on the basis of the number of trains of each type running in a given market segment and direction.

The third step entailed expanding the ridership in response to the service increases represented by Scenarios II and III. In both the low- and high-elasticity cases the discretionary markets were considered to be more elastic than the commuter markets. Passengers were again apportioned between *Keystone* and non-*Keystone* trains based on the number available.

A more detailed explanation of the calculation follows:

1. Tables F-1 and F-3

<u>1990 Ridership</u>

Col. 1 1990 Market share taken from Table III-4.

Col. 2 (col 1) x (1990 ridership); Ridership includes all Amtrak passengers in PHL-HAR range.

1990-1996 Growth

Col. 3 Taken from Table III-8.

Scenario I

Col. 4 through 7 refer to all Amtrak passengers traveling in the PHL-HAR range.

Col. 4 (col 2) x [1 + (col 3)]; Annual one-way (OW) trips in 1996 with no change in rail share.

Col. 5 (col 4)/52.3; OW trips per week.

Col. 6 (col 5)/10; Round trips (RT) per weekdays.

Col. 7 (col 5)/2; Weekend RTs.

Col. 8 through 11 refer to Amtrak passengers on non-*Keystone* trains traveling in the PHL-HAR range.

Col. 10 Average of westbound (WB) AM off-peak and eastbound (EB) PM off-peak. [Tables F-2 and F-4, col 10]
Only non-*Keystone* train operating on weekdays is #42/43 (*Pennsylvanian*), which serves HAR discretionary market.

Col. 11 Two trains in each direction on Sat and on Sun are non-*Keystone* trains. Trips are distributed evenly to all available trains in the appropriate period. [Tables F-2 and F-4, col 11]

Col. 8 and 9 are derived from col 10 and 11.

Col. 12 through 15 refer to passengers on *Keystone* trains only. Entries are obtained by subtracting 'Other Trains' from 'All Trains'.

Scenarios II and III

The results of Tables F-2 and F-4 (col 13-15 for Scenario II and col 18-20 for Scenario III) are used to calculate weekday and weekend RTs for 'All Trains' (col 6 and 7). These are in turn used to generate annual and weekly ridership (col 4 and 5). Ridership on 'Other Trains' (col 8-11) is obtained from Table 10 by distributing passsengers evenly among available trains in each appropriate time block. *Keystone* riders (col 12-15) are then obtained by subtracting 'Other' riders from 'All' riders.

2. Tables F-2 and F-4

<u>1990 Service and Ridership (Col. 1 through 5)</u>

Based on Amtrak's Passenger Accounting System for September 1990 and schedules in effect at that time. Entries are for a specified direction and time block.

Col. 1 Number of scheduled Amtrak trains.

Col. 2 Number of *Keystone* trains.

Col. 3 Weekday work trips taken.

Col. 4 Weekday non-work trips taken.

Col. 5 Total trips taken.

<u>Scenario I</u> (Col. 6 through 10)

Service levels same as 1990, but trips are factored by growth for appropriate market as specified in Table II-8.

Markets are delineated as follows:

PHL comm	EB (AM peak)	WB (PM peak)
HAR comm	WB (AM peak)	EB (PM peak)
PHL disc	EB (AM)	WB (PM)
HAR disc	WB (AM)	EB (PM)
PHL wkend	EB (Fri PM, Sat day)	WB (Sat eve, Sun)
HAR wkend	WB (Fri PM, Sat day)	EB (Sat eve, Sun)

<u>Scenarios II and III</u> (Col. 11 through 20)

Service levels increased to level specified. All Amtrak trains are included in count, but all added trains are *Keystone* trains. Ridership increased by following factor:

$$1 + \epsilon\ (\Delta S/S_I),$$

where ϵ = service elasticity
ΔS = change in service
S_I = Scenario I service level

Table F-1

RIDERSHIP BY MARKET
(Low Elasticity)

SCENARIO I

Col. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	1990			All Trains				Other Trains				Keystone Only			
Market	Share	Trips	1990-6 Growth	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs
PHL commuter	24.7%	97,147	10.75%	107,594	2,058	206						107,594	2,058	206	
HAR commuter	10.7%	42,084	14.08%	48,007	918	92						48,007	918	92	
PHL discretionary	27.0%	106,193	8.53%	115,247	2,204	220						115,247	2,204	220	
HAR discretionary	11.5%	45,230	5.14%	47,556	910	91		27,762	531	53		19,794	379	38	
PHL weekend	12.3%	48,377	8.53%	52,501	1,004		502	16,064	307		154	36,437	697		348
HAR weekend	13.8%	54,276	5.14%	57,067	1,091		546	17,555	336		168	39,512	756		378
Total	100.0%	393,307		427,974	8,203	609	1,048	61,381	1,174	53	321	366,592	7,011	556	726

SCENARIO II

	All Trains				Other Trains				Keystone Only			
Market	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs
PHL commuter	124,533	2,382	238						124,533	2,382	238	
HAR commuter	53,144	1,016	102						53,144	1,016	102	
PHL discretionary	149,733	2,864	286						149,733	2,864	286	
HAR discretionary	55,936	1,070	107		24,807	474	47		31,129	595	60	
PHL weekend	61,340	1,173		587	14,065	269		134	47,276	904		452
HAR weekend	70,739	1,353		676	14,731	282		141	56,008	1,071		536
Total	515,425	9,858	733	1,263	53,603	1,025	47	275	461,822	8,833	686	988

SCENARIO III

	All Trains				Other Trains				Keystone Only			
Market	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs
PHL commuter	124,533	2,382	238						124,533	2,382	238	
HAR commuter	62,806	1,201	120						62,806	1,201	120	
PHL discretionary	190,730	3,648	365						190,730	3,648	365	
HAR discretionary	74,353	1,422	142		19,837	379	38		54,516	1,043	104	
PHL weekend	76,767	1,468		734	12,294	235		118	64,473	1,233		617
HAR weekend	86,101	1,647		823	13,075	250		125	73,026	1,397		698
Total	615,290	11,768	865	1,557	45,206	865	38	243	570,084	10,903	827	1,315

Service Elasticity (Commutation): 0.30
Service Elasticity (Other): 0.50

Table F-2

RIDERSHIP BY DIRECTION AND TIME OF DAY
(Low Elasticity)

	Sep 1990					1996 - Scenario I (Existing Service)					1996 - Scenario II (Moderate Enhancement)				
Col. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	No. of trains		Passengers			No. of trains		Passengers			No. of trains		Passengers		
Period	All	Key-stone	Com-muter	Discre-tionary	Total	All	Key-stone	Com-muter	Discre-tionary	Total	All	Key-stone	Com-muter	Discre-tionary	Total
WEEKDAY EASTBOUND															
AM peak	2	2	187	73	260	2	2	207	79	286	3	3	238	99	337
AM off-peak	2	2		142	142	2	2		154	154	3	3		193	193
PM off-peak	1			58	58	1			61	61	1			61	61
PM peak	1	1	81	14	95	1	1	92	15	107	2	2	102	22	124
evening	1	1		22	22	1	1		23	23	1	1		23	23
Total	7	6	268	309	577	7	6	300	332	632	10	9	340	398	738
WEEKDAY WESTBOUND															
AM peak	2	2	81	38	119	2	2	92	40	132	2	2	102	40	142
AM off-peak	1			43	43	1			45	45	2	1		68	68
PM off-peak	1	1		104	104	1	1		113	113	2	2		169	169
PM peak	2	2	187	48	235	2	2	207	52	259	3	3	238	65	303
evening	1	1		43	43	1	1		47	47	1	1		47	47
Total	7	6	268	276	544	7	6	300	297	596	10	9	340	389	729
WEEKEND EASTBOUND															
Fri PM*					221					240					280
Sat day	4	2			243	4	2			264	5	3			297
Sat evening	1	1			47	1	1			49	2	2			74
Sun	6	4			500	6	4			526	8	6			613
Total	11	7			1011	11	7			1079	15	11			1264
WEEKEND WESTBOUND															
Fri PM*	1	1			273	1	1			287	1	1			344
Sat day	3	1			229	3	1			241	5	3			321
Sat evening	2	2			65	2	2			71	2	2			71
Sun	5	3			404	5	3			438	7	5			526
Total	11	7			971	11	7			1037	15	11			1262

* In addition to normal weekday service or ridership

1996 - Scenario III
(High Enhancement)

Col. No.	(16)	(17)	(18)	(19)	(20)
	No. of trains		Passengers		
Period	All	Key-stone	Com-muter	Discre-tionary	Total
AM peak	3	3	238	99	337
AM off-peak	5	5		270	270
PM off-peak	2	1		91	91
PM peak	3	3	120	29	150
evening	1	1		23	23
Total	14	13	358	513	871
AM peak	3	3	120	50	170
AM off-peak	3	2		90	90
PM off-peak	3	3		226	226
PM peak	3	3	238	65	303
evening	2	2		70	70
Total	14	13	358	501	860
Fri PM*					360
Sat day	7	5			363
Sat evening	3	3			99
Sun	11	9			745
Total	21	17			1566
Fri PM*	1	1			402
Sat day	7	5			401
Sat evening	3	3			88
Sun	10	8			658
Total	21	17			1549

* In addition to normal weekday service or ridership

Table F-3

RIDERSHIP BY MARKET
(High Elasticity)

SCENARIO I

Col. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	1990			All Trains				Other Trains				Keystone Only			
Market	Share	Trips	1990-6 Growth	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs
PHL commuter	24.7%	97,147	10.75%	107,594	2,058	206						107,594	2,058	206	
HAR commuter	10.7%	42,084	14.08%	48,007	918	92						48,007	918	92	
PHL discretionary	27.0%	106,193	8.53%	115,247	2,204	220						115,247	2,204	220	
HAR discretionary	11.5%	45,230	5.14%	47,556	910	91		27,762	531	53		19,794	379	38	
PHL weekend	12.3%	48,377	8.53%	52,501	1,004		502	16,064	307		154	36,437	697		348
HAR weekend	13.8%	54,276	5.14%	57,067	1,091		546	17,555	336		168	39,512	756		378
Total	100.0%	393,307		427,974	8,185	609	1,048	61,381	1,174	53	321	366,592	7,011	556	726

SCENARIO II

	All Trains				Other Trains				Keystone Only			
Market	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs
PHL commuter	129,947	2,485	249						129,947	2,485	249	
HAR commuter	54,754	1,047	105						54,754	1,047	105	
PHL discretionary	183,140	3,503	350						183,140	3,503	350	
HAR discretionary	63,770	1,220	122		27,762	531	53		36,008	689	69	
PHL weekend	69,739	1,334		667	16,064	307		154	53,675	1,027		513
HAR weekend	83,810	1,603		801	17,555	336		168	66,255	1,267		634
Total	585,161	11,192	825	1,468	61,381	1,174	53	321	523,780	10,018	772	1,147

SCENARIO III

	All Trains				Other Trains				Keystone Only			
Market	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs	Annual	Weekly	Weekday RTs	Weekend RTs
PHL commuter	129,947	2,485	249						129,947	2,485	249	
HAR commuter	67,638	1,294	129						67,638	1,294	129	
PHL discretionary	265,135	5,071	507						265,135	5,071	507	
HAR discretionary	100,603	1,924	192		27,762	531	53		72,841	1,393	139	
PHL weekend	100,592	1,924		962	16,064	307		154	84,528	1,617		808
HAR weekend	114,533	2,191		1,095	17,555	336		168	96,978	1,855		927
Total	778,449	14,888	1,077	2,057	61,381	1,174	53	321	717,067	13,714	1,024	1,736

Service Elasticity (Commutation): 0.40
Service Elasticity (Other): 1.00

Table F-4

RIDERSHIP BY DIRECTION AND TIME OF DAY
(High Elasticity)

Col. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Sep 1990					1996 - Scenario I (Existing Service)					1996 - Scenario II (Moderate Enhancement)				
	No. of trains		Passengers			No. of trains		Passengers			No. of trains		Passengers		
Period	All	Key-stone	Com-muter	Discre-tionary	Total	All	Key-stone	Com-muter	Discre-tionary	Total	All	Key-stone	Com-muter	Discre-tionary	Total
WEEKDAY EASTBOUND															
AM peak	2	2	187	73	260	2	2	207	79	286	3	3	249	119	367
AM off-peak	2	2		142	142	2	2		154	154	3	3		231	231
PM off-peak	1			58	58	1			61	61	1			61	61
PM peak	1	1	81	14	95	1	1	92	15	107	2	2	105	29	134
evening	1	1		22	22	1	1		23	23	1	1		23	23
Total	7	6	268	309	577	7	6	300	332	632	10	9	353	464	817
WEEKDAY WESTBOUND															
AM peak	2	2	81	38	119	2	2	92	40	132	2	2	105	40	145
AM off-peak	1			43	43	1			45	45	2	1		90	90
PM off-peak	1	1		104	104	1	1		113	113	2	2		226	226
PM peak	2	2	187	48	235	2	2	207	52	259	3	3	249	78	327
evening	1	1		43	43	1	1		47	47	1	1		47	47
Total	7	6	268	276	544	7	6	300	297	596	10	9	353	481	834
WEEKEND EASTBOUND															
Fri PM*					221					240					320
Sat day	4	2			243	4	2			264	5	3			330
Sat evening	1	1			47	1	1			49	2	2			99
Sun	6	4			500	6	4			526	8	6			701
Total	11	7			1011	11	7			1079	15	11			1449
WEEKEND WESTBOUND															
Fri PM*	1	1			273	1	1			287	1	1			402
Sat day	3	1			229	3	1			241	5	3			401
Sat evening	2	2			65	2	2			71	2	2			71
Sun	5	3			404	5	3			438	7	5			614
Total	11	7			971	11	7			1037	15	11			1488

* In addition to normal weekday service or ridership

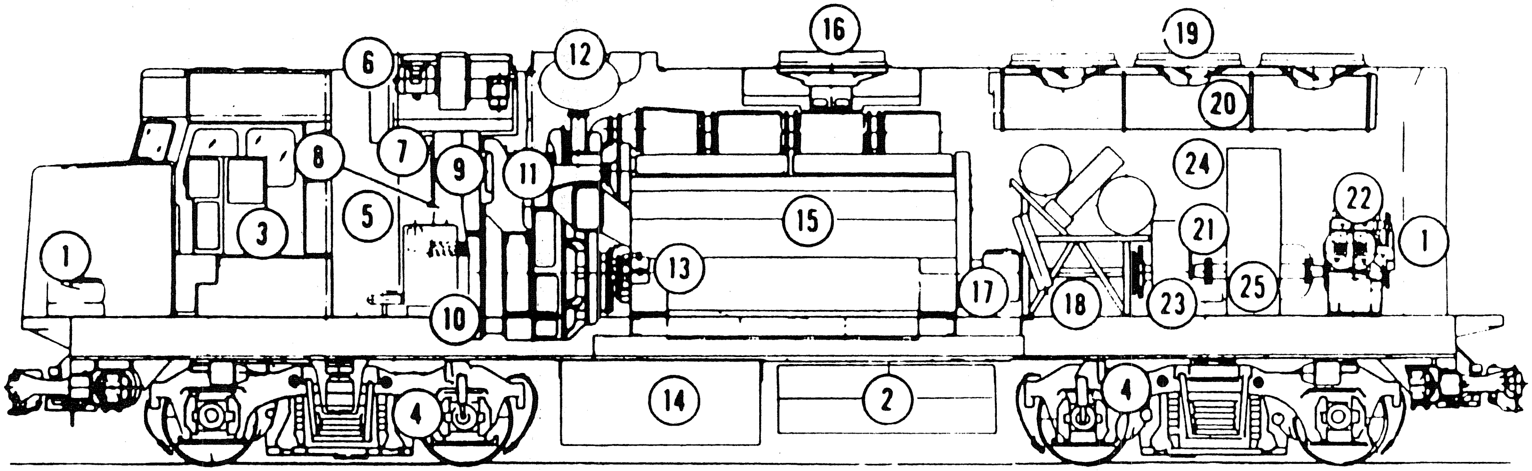
1996 - Scenario III
(High Enhancement)

Col. No.	(16)	(17)	(18)	(19)	(20)
	No. of trains		Passengers		
Period	All	Key-stone	Com-muter	Discre-tionary	Total
AM peak	3	3	249	119	367
AM off-peak	5	5		385	385
PM off-peak	2	1		122	122
PM peak	3	3	129	44	174
evening	1	1		23	23
Total	14	13	378	693	1071
AM peak	3	3	129	60	189
AM off-peak	3	2		136	136
PM off-peak	3	3		339	339
PM peak	3	3	249	78	327
evening	2	2		93	93
Total	14	13	378	706	1084
Fri PM*					480
Sat day	7	5			462
Sat evening	3	3			148
Sun	11	9			964
Total	21	17			2053
Fri PM*	1	1			517
Sat day	7	5			562
Sat evening	3	3			106
Sun	10	8			877
Total	21	17			2061

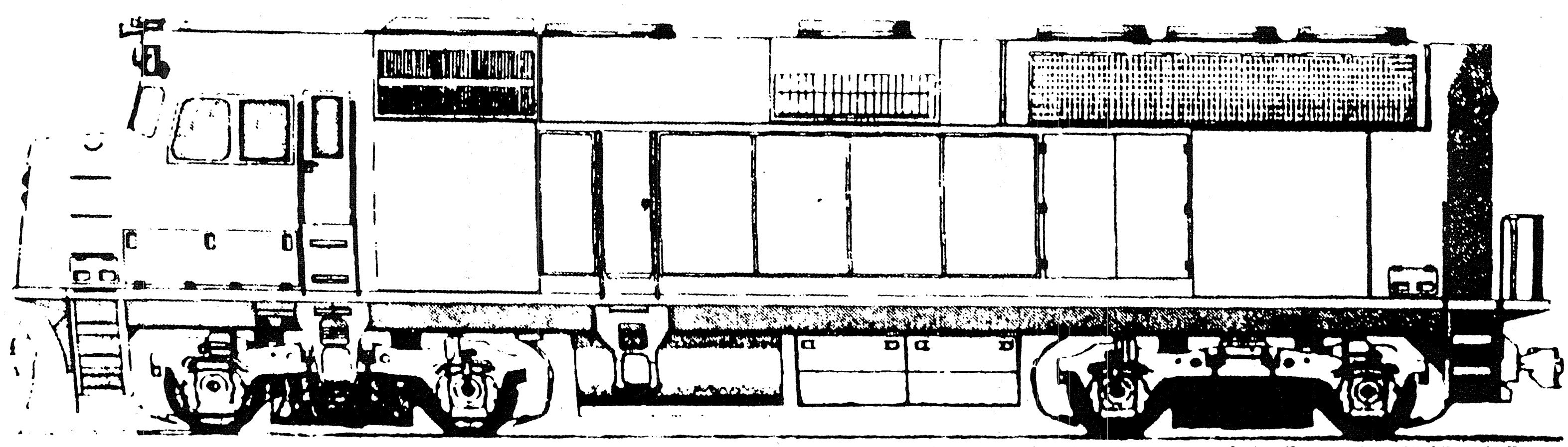
* In addition to normal weekday service or ridership

APPENDIX G

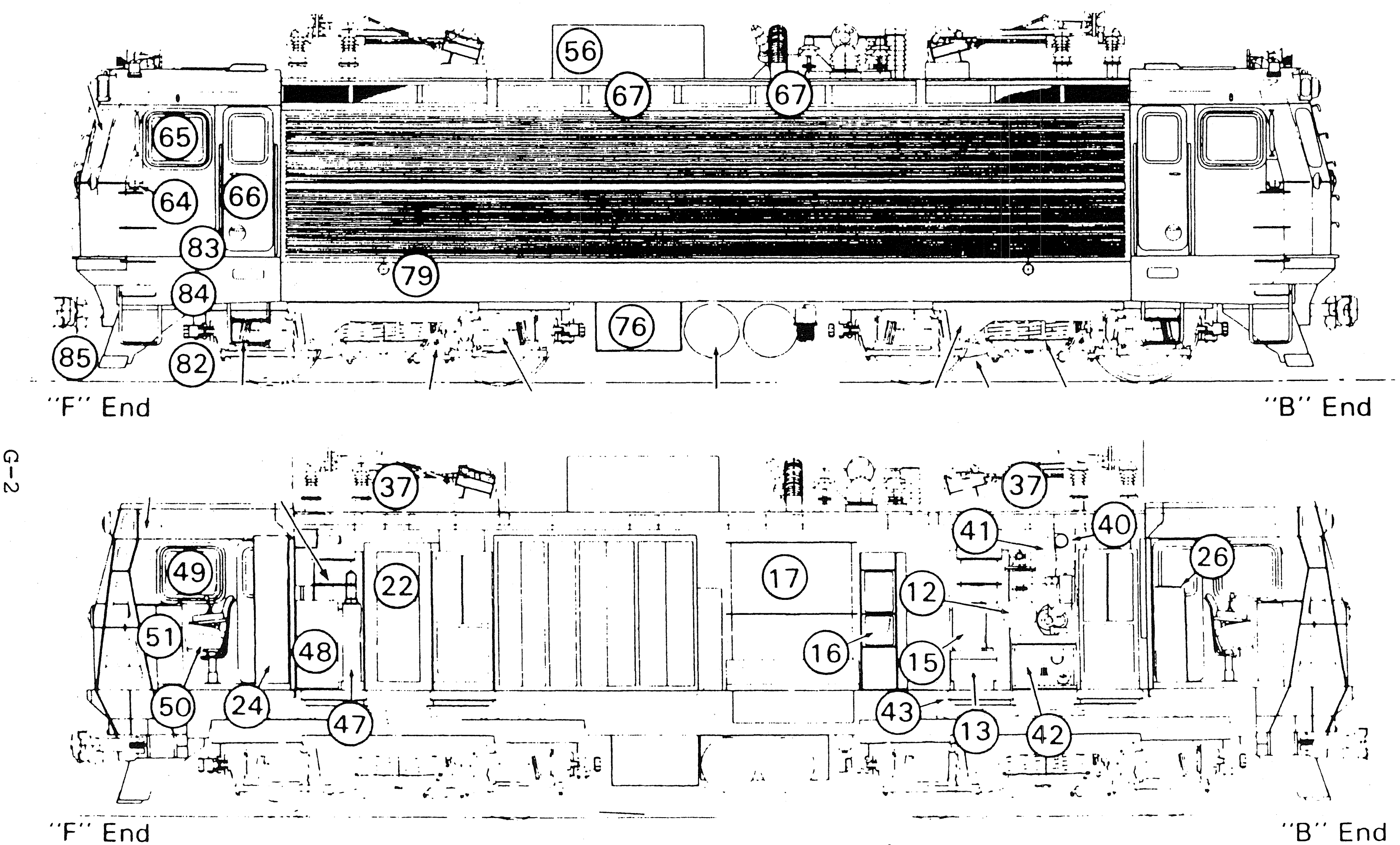
Locomotive and Car Diagrams



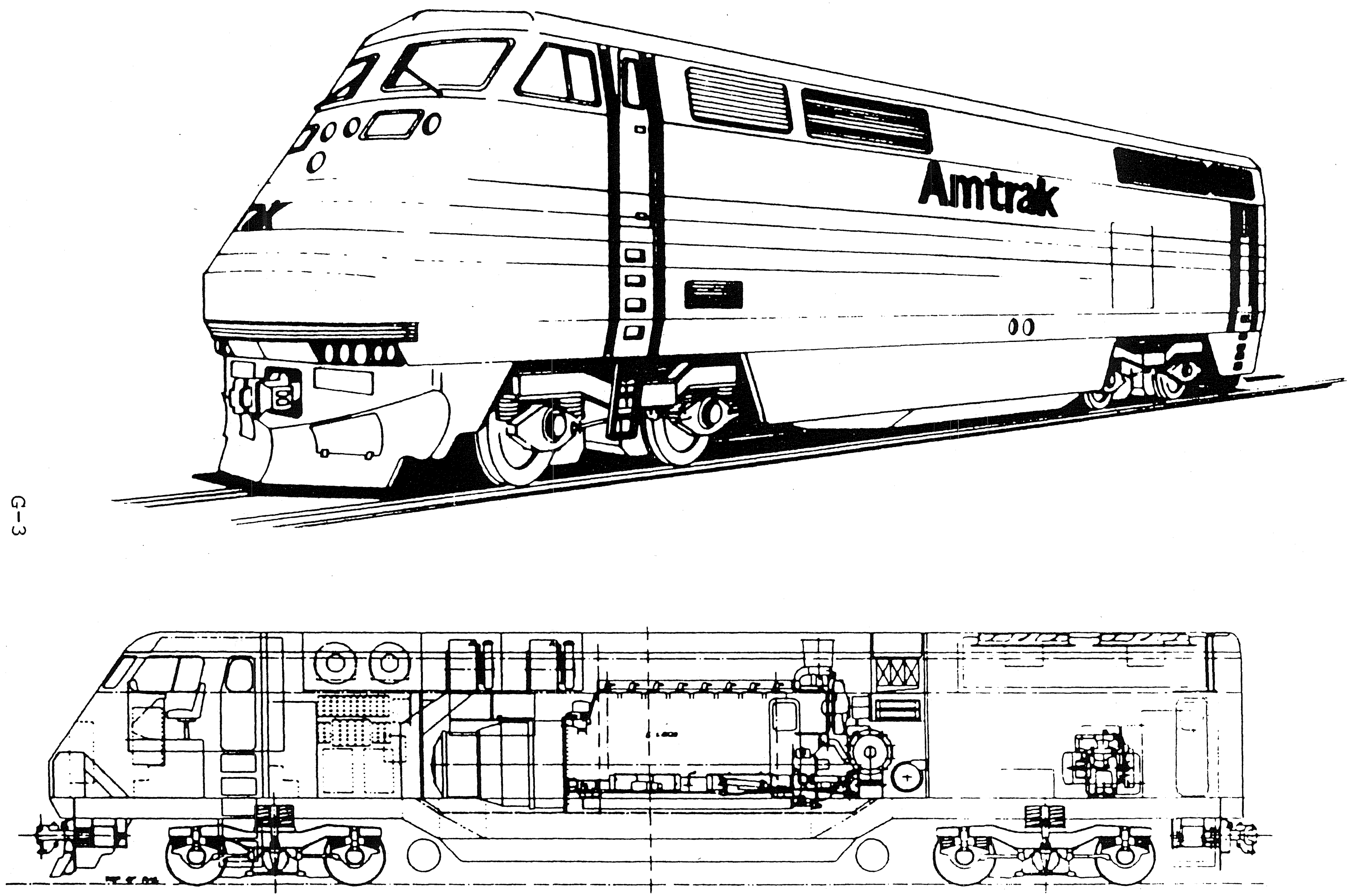
1. Sand Box
2. Battery
3. Control Stand
4. Truck
5. Electrical Cabinet
6. Inertial Filter Blower
7. Engine Air Filter
8. Traction Motor Blower
9. Generator Blower
10. Main Generator
11. DC Auxiliary Generator
12. Exhaust Silencer
13. Starting Motors
14. Fuel Tank
15. Diesel Engine
16. Dynamic Brake Blower
17. Lube Oil Strainer
18. Equipment Rack
19. Cooling Fans
20. Radiators
21. Head End Generator
22. Air Compressor
23. Gear Box
24. Head End Power Control Cabinet
25. Head End Contactor Cabinet



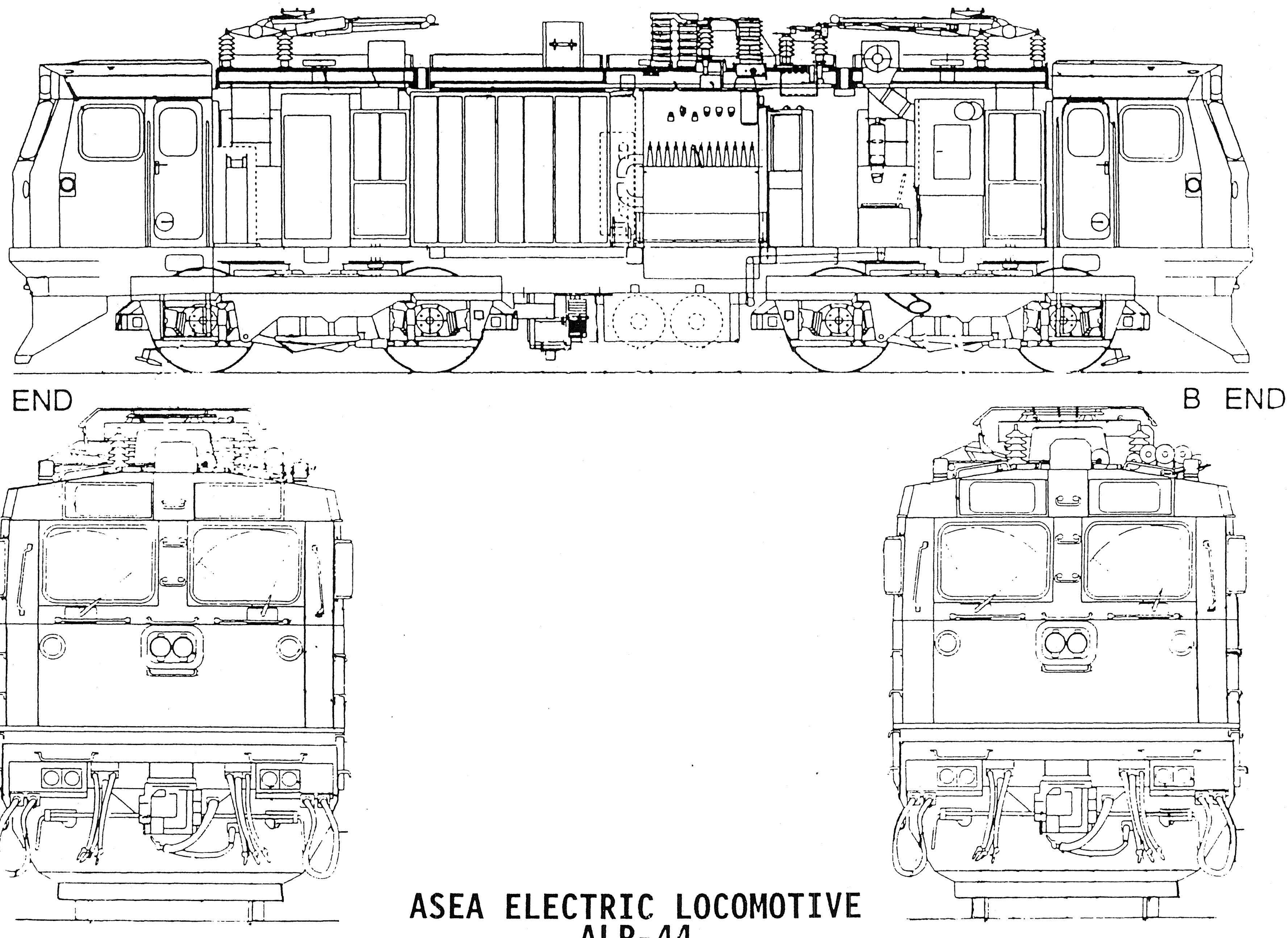
EMD DIESEL ELECTRIC LOCOMOTIVE F40PH



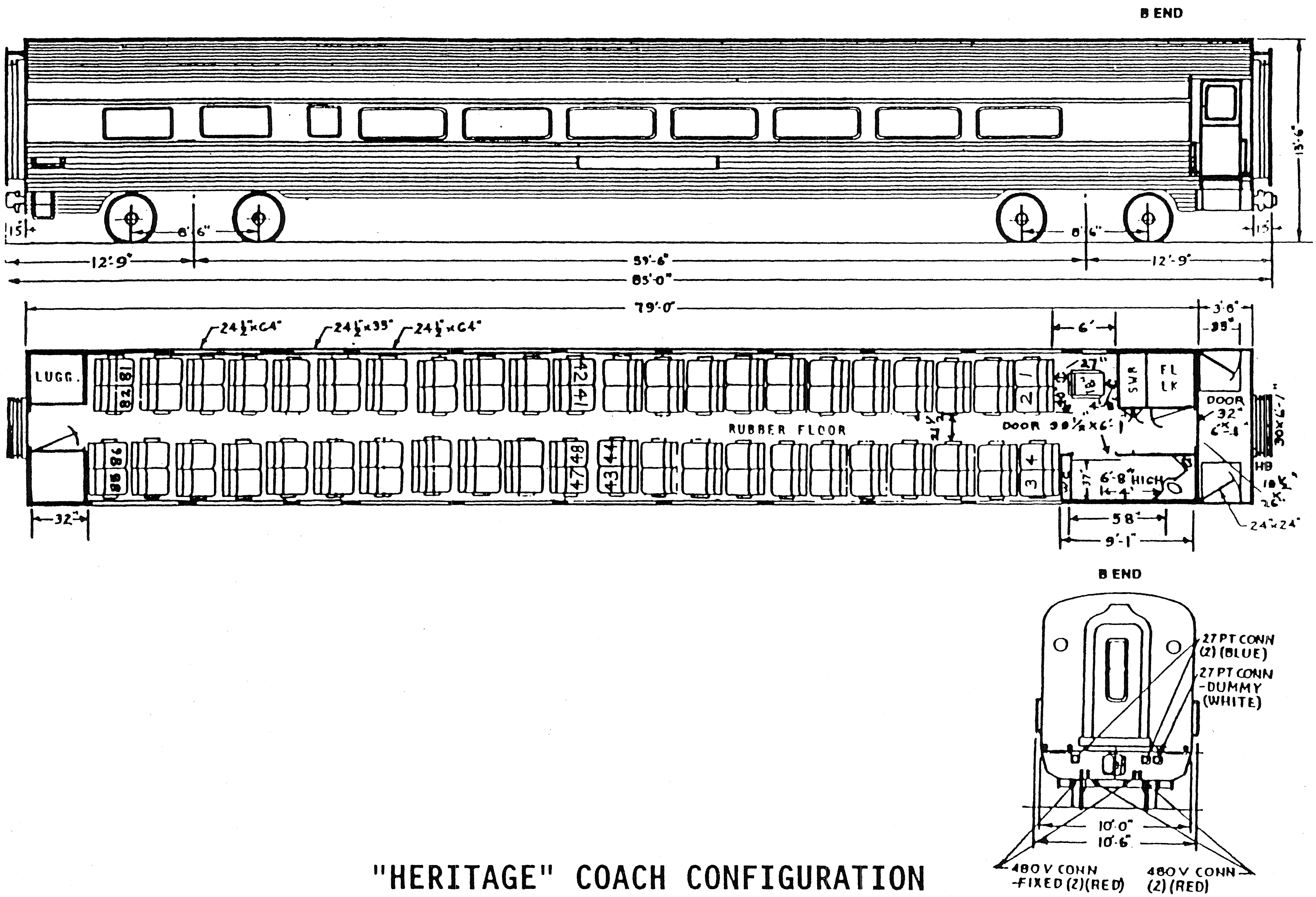
**EMD/ASEA ELECTRIC LOCOMOTIVE
AEM-7**



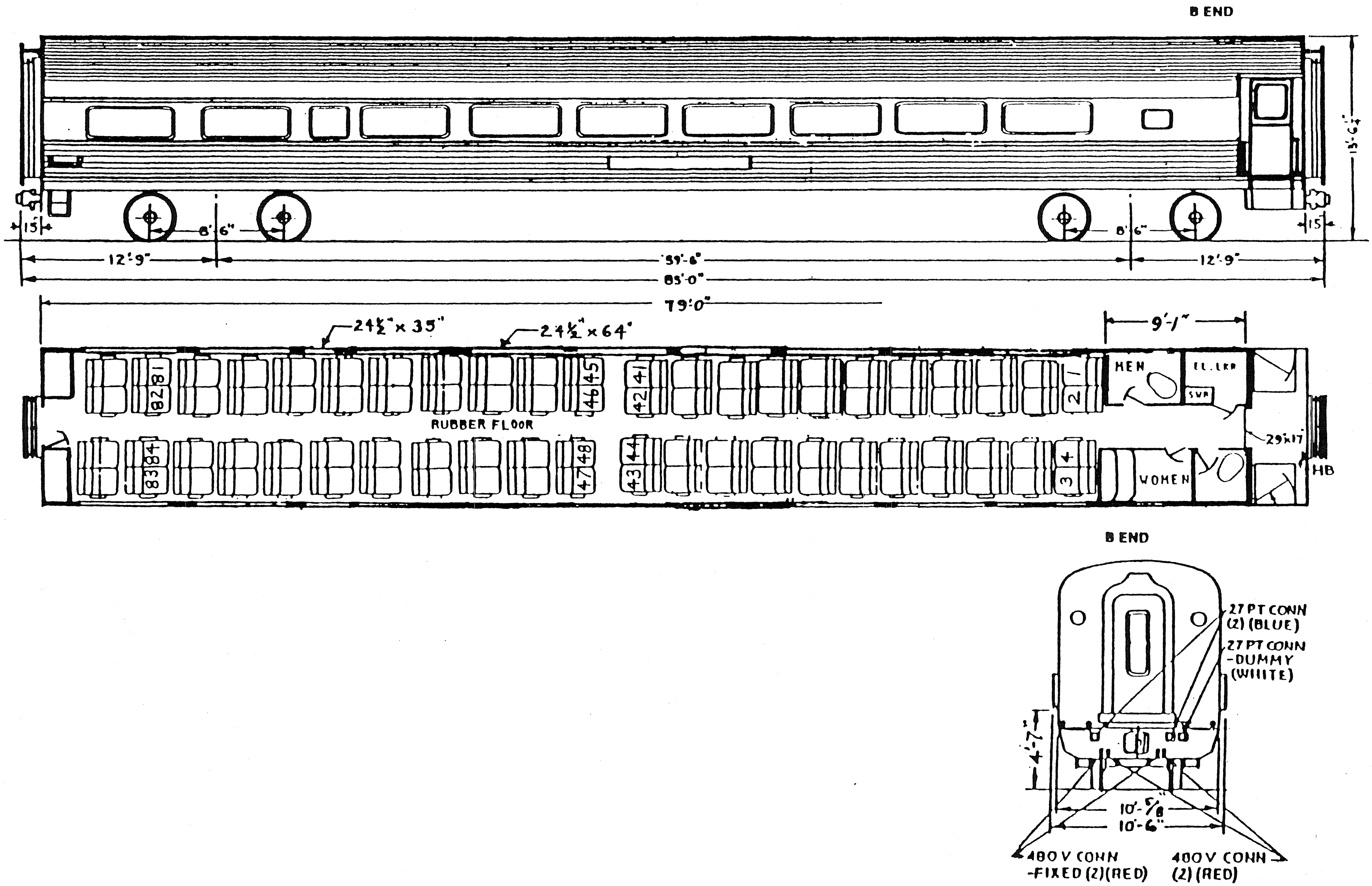
GENERAL ELECTRIC AMTRAK LOCOMOTIVE
CLASS AMD-103



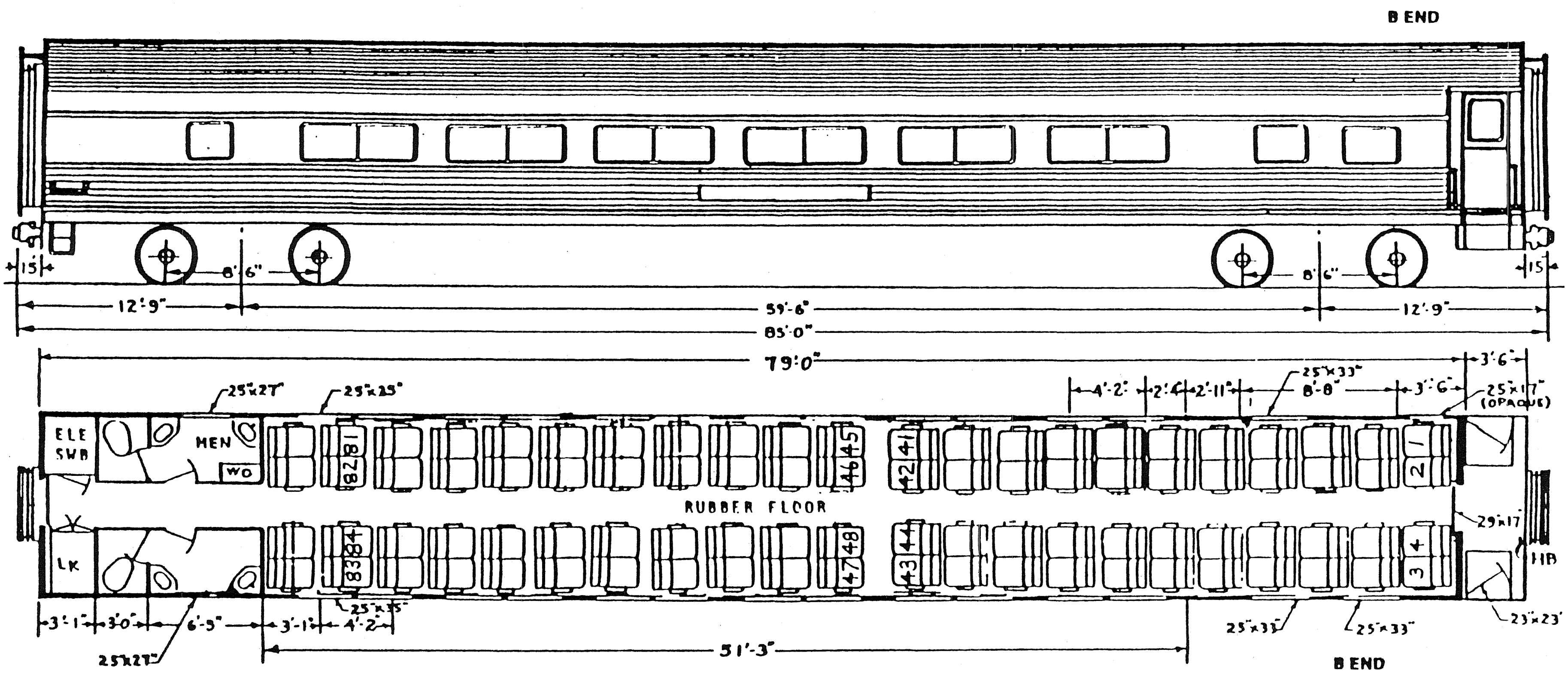
ASEA ELECTRIC LOCOMOTIVE
ALP-44

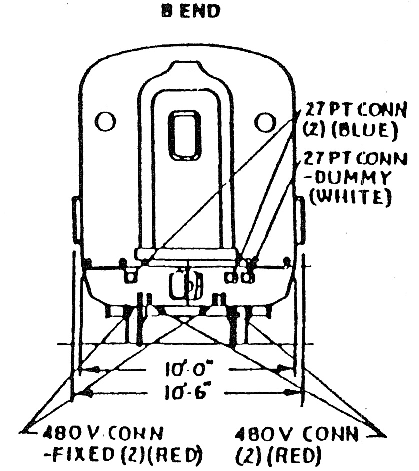


"HERITAGE" COACH CONFIGURATION
7000-7007

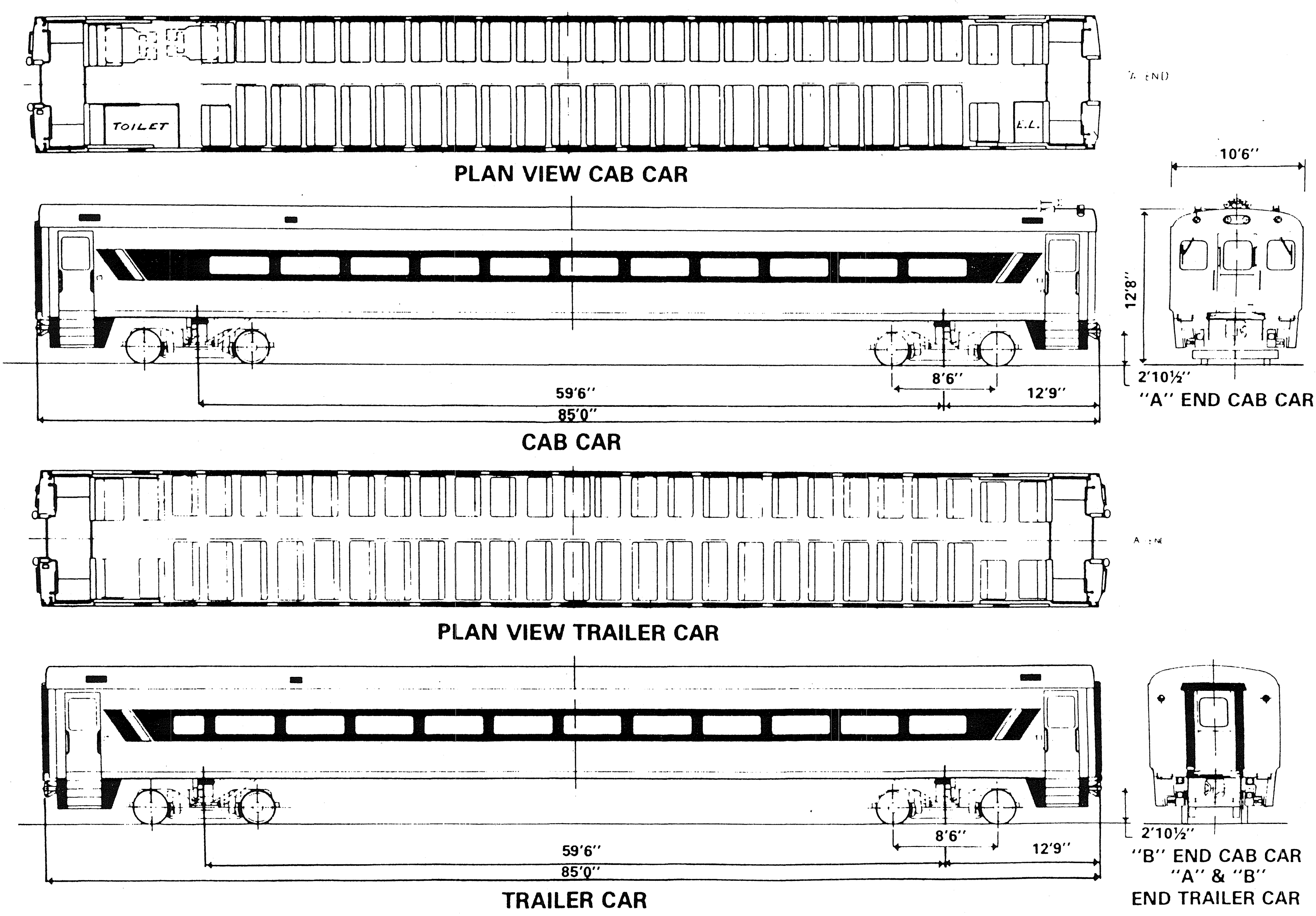


"HERITAGE" COACH CONFIGURATION
7600-7618

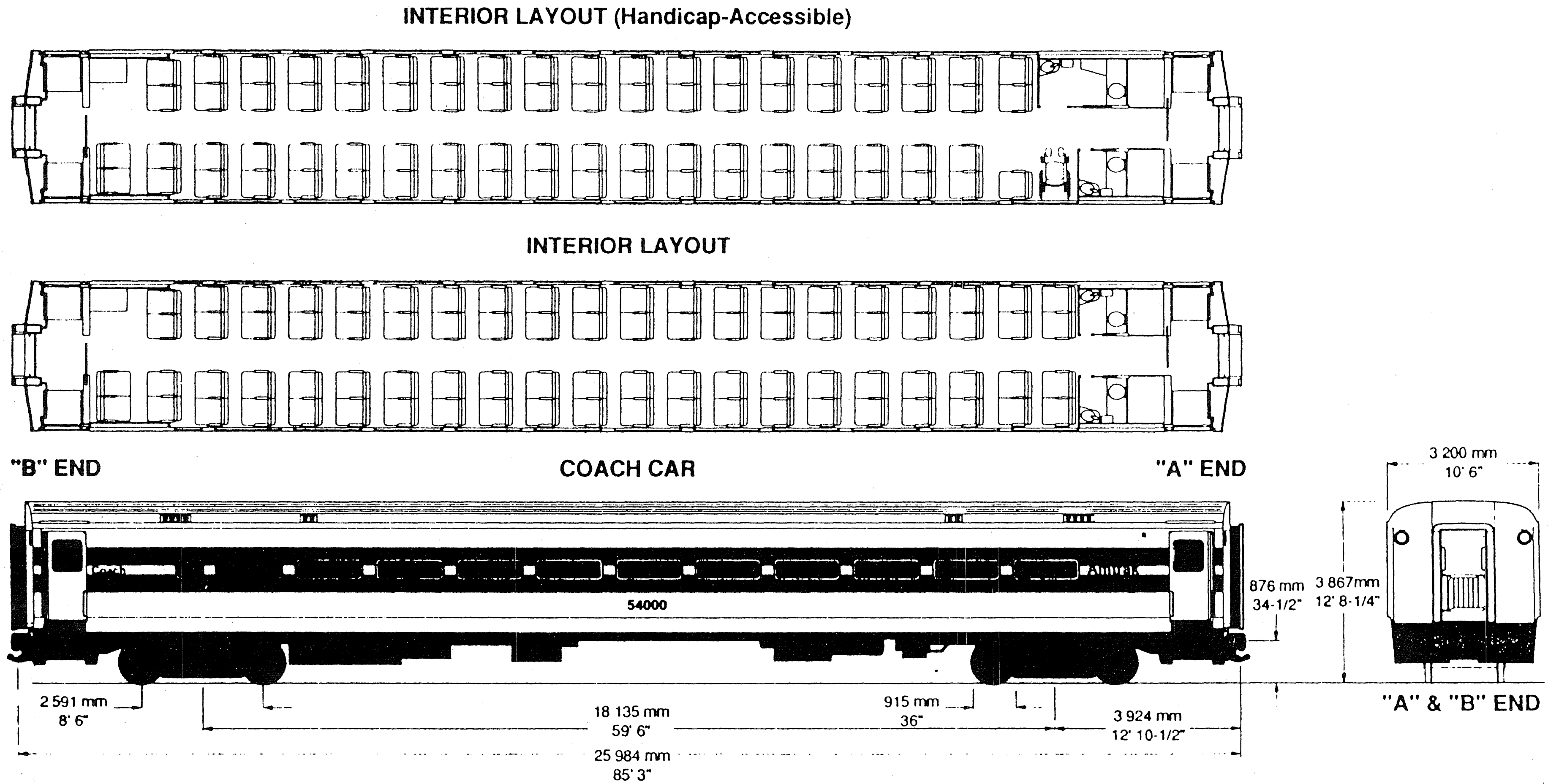




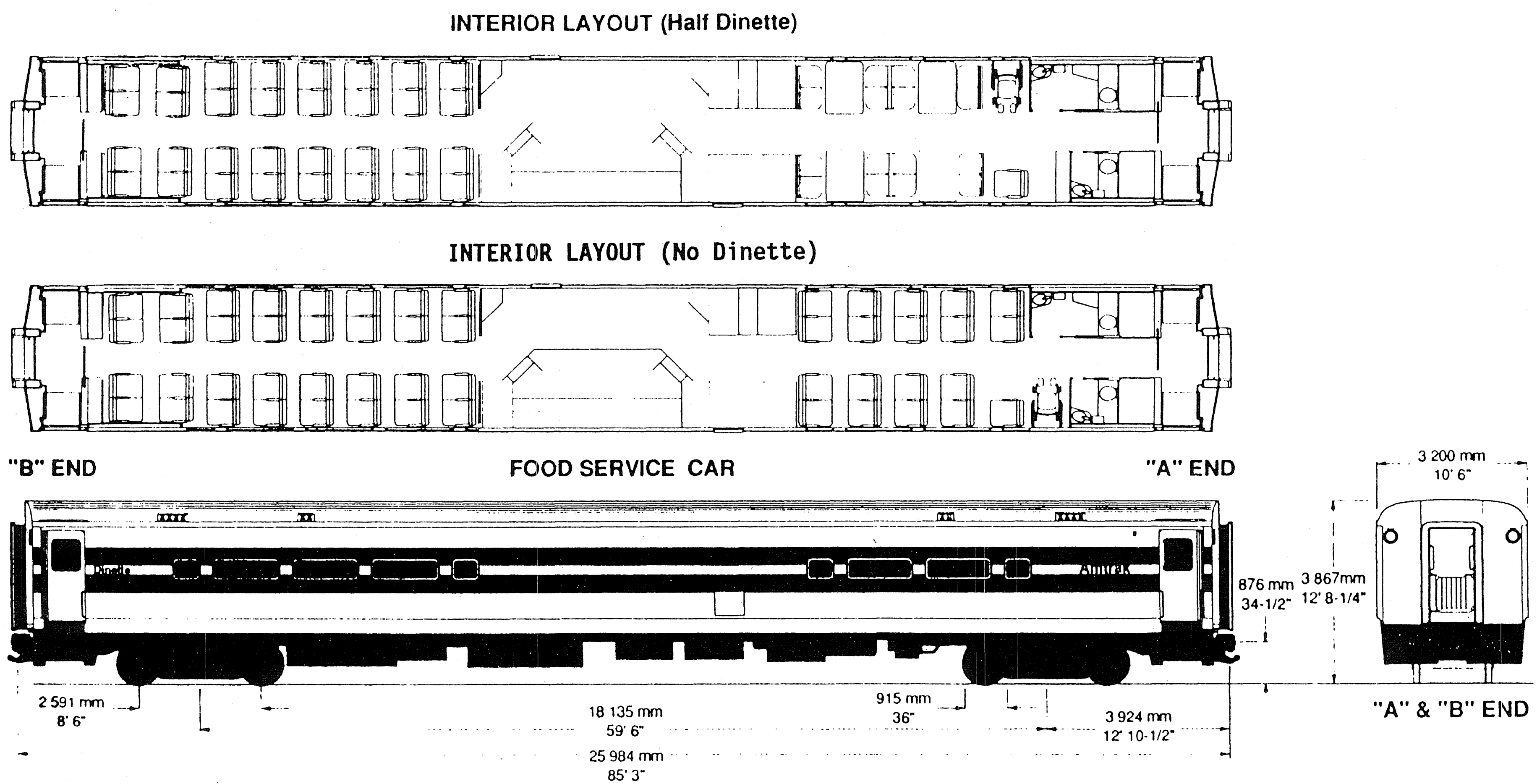
"HERITAGE" COACH CONFIGURATION 7620-7629



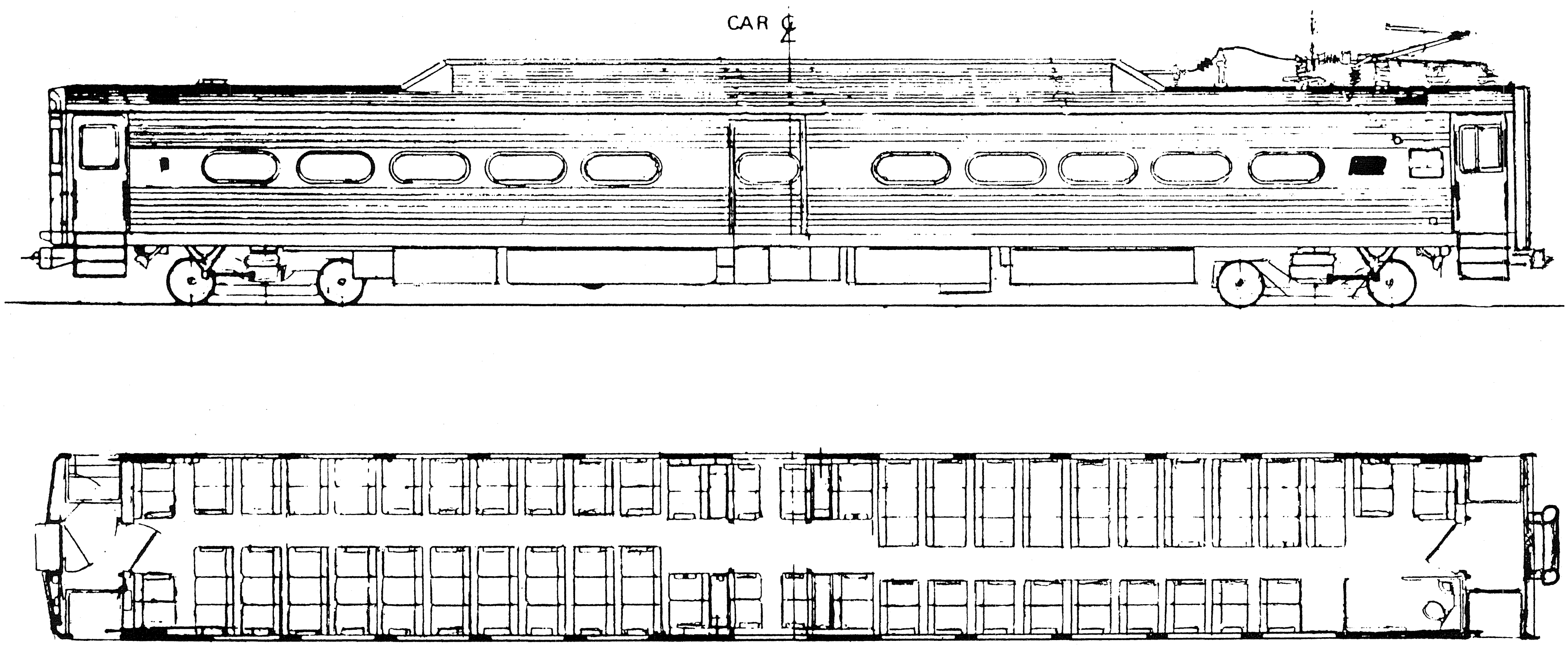
COMMUTER CAR CONFIGURATION



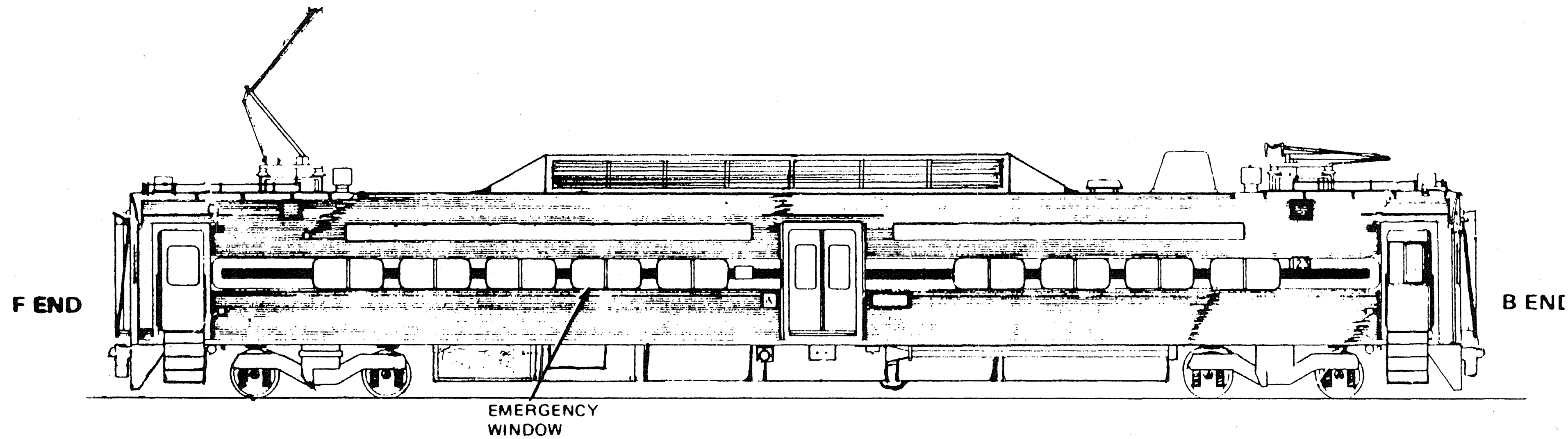
AMTRAK "HORIZON" CAR CONFIGURATION

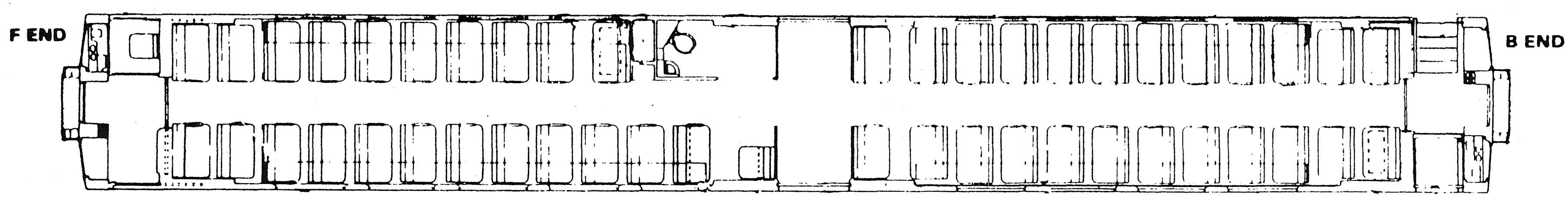


"HORIZON" FOOD SERVICE CAR CONFIGURATION



EMU MARRIED PAIR CAR CONFIGURATION
WITH
COMMUTER SEATING AND TOILET





EMU SINGLE CAR CONFIGURATION
WITH
CENTER DOORS, HANDICAP PROVISIONS AND TOILET