FRA-ORD & D- 74-3

IMPROVED PASSENGER SERVICE FOR THE NORTHEAST CORRIDOR

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Washington, D.C. 20036

APRIL 1973
FINAL REPORT

Document is available to the public through the
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Springfield, Virginia 22151

Prepared for

DEPARTMENT OF TRANSPORTATION

FEDERAL RAILROAD ADMINISTRATION

Office of Research, Development, and Demonstrations
Washington, D.C. 20590

23
2684|34
no. FRA-ORD+D-74-3

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FRA-ORD&D-74-3		

4. Title and Subtitle	5. Report Date
IMPROVED PASSENGER SERVICE FOR NORTHEAST CORRIDOR	April 2, 1973
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
9. Performing Organization Name and Address PAN-TECHNOLOGY CONSULTING CORPORATION, INC. 1747 Pennsylvania Avenue, NW, Room 931 Washington, D. C. 20006	10. Work Unit No. 11. Contract or Grant No. DOT-FR-20080
12. Sponsoring Agency Name and Address OFFICE OF RESEARCH, DEVELOPMENT AND DEMONSTRATIONS FEDERAL RAILROAD ADMINISTRATION WASHINGTON, D.C. 20590	13. Type of Report and Period Covered FINAL 14. Sponsoring Agency Code FRA-ORD&D

15. Supplementary Notes Subcontractors:

TRANSPORTATION AND DISTRIBUTION ASSOCIATES, INC.
100 West 6th Street
Media, Pennsylvania 19063

URBAN ENGINEERS, INC.
19th Street and Delancey Place
Philadelphia, Pennsylvania 19103

16. Abstract

This study evaluates the costs of additional improvements of the current Northeast Corridor (Boston to Washington) Metroliner Service, employing improved facilities on existing rights-of-way and improved passenger equipment capable of maximum speeds of 150 mph.

An examination was made of the existing track condition and alignment, curve elevations and spiral lengths, bridge conditions, and fencing requirements for safety, in order to identify the necessary system changes necessary to permit a high speed operation. The costs of these modifications were estimated to be about $300 million.

A train interference analysis indicated that an investment of approximately $90 million is needed to relieve the congestion caused by the improved passenger service at the specified frequencies. This investment includes upgrading additional tracks and providing additional interlockings.

In addition to the improvements to increase speed and relieve congestion, an investment of about $160 million is required to improve stations, yards, maintenance shops and traction power systems.

17. Key Words	18. Distribution Statement
Northeast Corridor, passenger trains, costs, capacity, interference	Availability Unlimited Available through National Technical Information Service Springfield, Va. 22151

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	78	

Form DOT F 1700.7 (8-69)

ACKNOWLEDGEMENTS

This study is the combined effort of Pan Technology, its associate EarthSat, and its two sub-contractors, Transportation and Distribution Associates and Urban Engineers. Pan Tek collected the necessary data, performed the train graph interference analyses, and was responsible for the general coordination and integration of the final results. Dr. H. Theodore Heintz and Ms. Dianne Cormier were participants in the team effort.

Acknowledgements are due to the prior high speed ground transportation reports, expecially to the reports prepared by Louis T. Klauder, Inc. for their cost estimations and text relating to the Northeast Corridor.

Major portions of the analysis were performed by subcontractors to whom recognition and thanks are given. The simulation analysis of the New York-Washington system was performed by Transportation and Distribution Associates, Inc. (TAD) under the direction of Mr. Edward Sierleja. TAD also identified the facility modifications required to permit the new passenger train service. The cost estimates for the modifications and, when necessary, the determination of hypothetical engineering specifications and route selections for costing purposes, were made by Urban Engineers, Inc., under the supervision of Mr. Daniel B. Wessells.

The guidance and help obtained form Mr. Kenneth L. Lawson, the Technical Contract Officer, and his assistant, Mr. Steven R. Ditmeyer, was much appreciated.

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I. INTRODUCTION AND OBJECTIVES

The improvement of passenger transportation in our nation's urban corridors has been a subject of increasing importance and urgency. Projected congestion in highway and air systems has focused this concern on means of revitalizing rail passenger service. This report presents the results of a study for the Federal Railroad Administration (FRA) of the capital costs of alternatives for future high speed ground transportation.

The results of this study are reported in two volumes. This volume concerns the provision of improved passenger service in the Northeast Corridor (Boston to Washington). This service, a further improvement of current Metroliner service, would employ improved facilities on existing rights of way and improved passenger equipment capable of maximum speeds of 150 mph. The other volume, entitled "Improved Passenger Service for Three Corridors", addresses similar improved passenger service for Chicago - Detroit, Los Angeles - San Diego and Seattle - Portland corridors. The two volumes contain estimates of the costs of modifying the existing facilities to permit higher operating speeds and to reduce interference between the new passenger service and projected freight and commuter service.

The analysis of improved passenger service in the Boston - Washington Corridor reported in this volume was more detailed than that for the other corridors. This was possible because of the extensive work done in the past on improved rail transportation and because of the existence of a computer program for simulation of the rail system between New York and Washington. In the Northeast Corridor it was possible to consider and add to previous studies of the needed facilities in the other corridors, the analysis began essentially from zero.

In addition, there are several other limitations deserving recognition. The graphic analysis of the New York to Boston segment of the Northeast Corridor was limited to a single typical day. The quality of the analysis would have been greatly improved had the time and funds been available to use TRANSIM III, the computer model used in the analysis of the Washington to New York segment. The traffic congestion between Penn Station and Harold caused by the commuter trains during peaks hours is too severe to permit adequate analysis with the train graphs. Therefore, modifications to relieve this congestion are not included in this report.

Currently, Penn Central's rules prevent freight trains and any other train operating in excess of 100 mph from passing each other on adjacent tracks. This problem was not solved.

It was found that the modifications proposed to relieve congestion in the Washington to New York segment are adequate for 1975 - 1985 traffic volumes but after 1985 are no longer adequate. Additional modifications for traffic levels higher than 1985's have not been suggested in this report.

Neither the base data nor the proposed modifications recommended in this report have been field checked. The cost estimates are not based on detailed site specific designs; nor do they include the usual planning contingency for unanticipated conditions, changes or factors inadvertently omitted. Costs were estimated only for capital expenditures with no consideration given to operating costs.(1)

In presenting the results of the study, this report first summarizes in Section 2 the findings of the study. Section 3 then presents the approach and methodology used, including basic assumptions, input data and analytical techniques. In Section 4 the detailed results and conclusions are presented.

(1)Some investment outlays were required to compensate for deferred maintenance on tracks to be used for high speed operations.

2. SUMMARY OF FINDINGS

The further improvement of passenger service beyond that provided by current Metroliners requires a further increase of speeds and higher frequency of departures. The specifications and assumptions reflecting these requirements are shown in Figures 2-1 and 2-2.

The costs of providing this improved passenger service in the Northeast Corridor reflect the complexity of the rail system, the high traffic density on that route, and the high frequency of improved service specified for analysis by FRA. The cost estimates for construction needed to provide improved passenger service for the Northeast Corridor are summarized in Figure 2-3.

The total capital costs are estimated to be about $550 million. An investment of about $300 million is required to achieve the speeds that yield non-stop running times (assuming no delays) of about 2 hours for New York - Washington and about 2 hours, 20 minutes for New York - Boston. In addition, an investment of approximately $90 million in improvements is needed to relieve the congestion caused by the improved service at the specified frequencies. Most of these additional improvements address major interference problems that occur between the new passenger trains and commuter trains servicing Wilmington, Philadelphia, Long Island and Westchester County - Connecticut. To alleviate the resulting delays, additional tracks need to be upgraded for high speeds and additional interlockings provided. In addition to the improvements to increase speed and relieve congestion, an investment of about $160 million is required to improve stations, yards, maintenance shops and traction power systems.

Figure 2-1

EQUIPMENT SPECIFICATIONS AND OPERATING ASSUMPTIONS

Washington to New York

1. Equipment

Tractive effort	Equal to Metroliner
Deceleration	Equal to Metroliner
Maximum authorized speed	150 miles per hour
Maximum curve speed	Equal to Metroliner (The original planning accepted AAR's recommendation of a 3 1/2" unbalance. This is now limited to 3" by Federal regulation.)

2. Maximum Authorized Speed Over Highway Crossings — Not applicable - all crossings proposed to be removed.

3. Schedules

Frequency	Every 30 minutes except Philadelphia to New York every 15 minutes.
Initial station departures of Northbound trains	Washington - 4:25 AM, 5:55 AM, and every 30 minutes to 7:40 PM, 8:40 PM, 9:25 PM. Philadelphia - 6:10 AM and every 15 minutes to 7:40 PM, 8:40 PM, 9:25 PM, 10:25 PM, 11:25 PM. New York - 4:25 AM, 5:55 AM, and every 30 minutes until 9:55 PM, 10:55 PM, 11:55 PM.
Intermediate station stops	Capital Beltway, Baltimore, Wilmington, Philadelphia, Trenton, Metro Park, Newark. Washington to New York trains stop at 5. Philadelphia to New York trains stop at 1.

Figure 2-1 (Cont'd)

EQUIPMENT SPECIFICATIONS AND OPERATING ASSUMPTIONS

Washington to New York

4. Limits on Modifications	Alignment changes not to be considered. Changes required to provide access for EL and CNJ trains to Manhattan were assumed to be provided by other agencies.

Figure 2-2

EQUIPMENT SPECIFICATIONS AND OPERATING ASSUMPTIONS

New York to Boston

1.	Equipment	
	Tractive effort	Equal to Metroliner
	Deceleration	Equal to Metroliner
	Maximum authorized speed	150 miles per hour
	Maximum curve speed	Equal to Metroliner (The original planning accepted AAR's recommendation of a 3 1/2" unbalance. This is now limited to 3" by Federal regulation.)
2.	Maximum Authorized Speed Over Highway Crossings	Not applicable - all crossings proposed to be removed.
3.	Schedules	
	Frequency	Every 30 minutes
	Initial station departures for Northbound trains	New York to New Haven 7:00 AM and every 30 minutes until last train at 10:00 PM. New Haven - 7:06 AM and every 30 minutes until last train at 11:36 PM. Boston - 7:00 AM and every 30 minutes until last train at 10 PM.
	Intermediate station stops	Rye, New Haven, Providence, Route 128.
4.	Limits on Modifications	Alignment changes not to be considered. Changes required to provide access for EL and CNJ trains to Manhattan were assumed to be provided by other agencies.

Figure 2-3

SUMMARY OF ESTIMATES OF COST OF CONSTRUCTION
FOR NORTHEAST CORRIDOR IHSR-1A PLAN

	Estimated Contract Cost in Millions		
	Washington to New York	New York to Boston	Total Northeast Corridor
Improvements to Permit Higher Level Speeds	$ 79.0	$ 217.1	$ 296.1
Facilities to Relieve Congestion	70.2	15.6	85.8
Improvements to Station Yards and Shops	38.0	32.7	70.7
Miscellaneous	45.0	46.0	91.0
Total Estimated/Budgeted Costs for Northeast Corridor	$232.2	$ 311.4	$ 543.6

(1) Contract costs include costs of design, labor, material, contractor's contingency, overhead, and profit. They do not include costs incurred to the owner such as insurance, owner's overhead, and the cost of obtaining money. The costs also do not include the usual planning contingency for unanticipated conditions or changes nor do they include factors inadvertently omitted. Cost estimations are in 1972 dollars.

3. APPROACH AND METHODOLOGY

The identification and costing of the additional facilities needed for improved service required several steps. The general flow of the analysis is shown in Figure 3-1. The first step taken was to establish the "baseline" of existing or planned facilities. By comparing these facilities with standards and specifications for high speed operation, the modifications needed to meet the required performance levels were identified. These are generally roadway improvements, signal changes, catenary system improvements, and safety facilities needed to permit higher maximum speeds and are necessary regardless of the volume of passenger or other rail services. Many of the required modifications had been identified in past studies. One version of these, the IHSR plan, was used as a baseline for the analysis.

The speed and elapsed time profiles for the new passenger trains running non-stop at maximum performance were then computed using Train Performance Calculators (TPC's). These profiles, combined with the specified frequency of service and station stops, provided the time and distance schedules for the interference analysis. The interference analysis considered the congestion resulting from the volume of passenger service, freight, and commuter services using the same tracks. Simulation of interference between trains using the same facilities was performed manually for the New York - Boston segment and by computer for the New York - Washington segment. Both simulations of interference produced delay records from which the needs for additional modifications to relieve congestion were identified. Costs were then estimated for each of the facility modifications required.

The following sections present in detail the assumptions, analytical techniques and data used in each of these steps.

3.1 MODIFICATIONS TO MEET HIGH SPEED PERFORMANCE STANDARDS

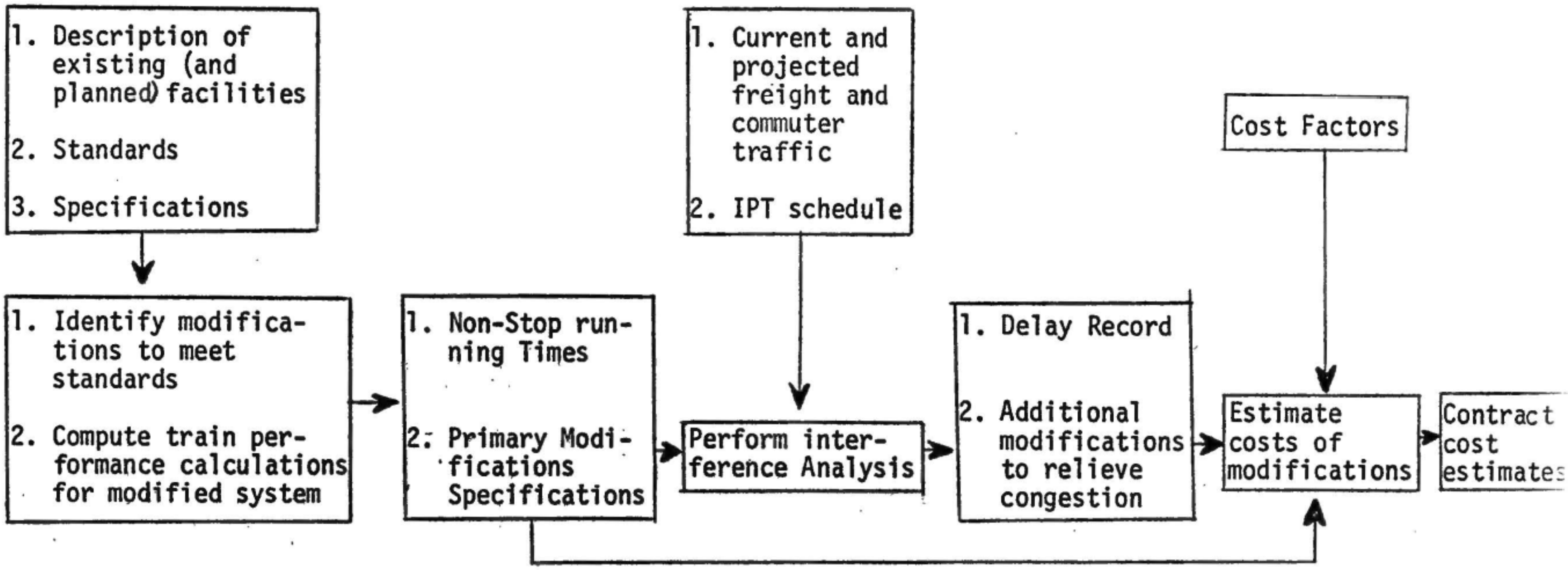
The baseline of existing and planned facilities was established by gathering track charts, maintenance records, and interlocking diagrams from the railroad companies who own the rights-of-way under consideration. The present condition and configuration of facilities was then compared with standards for high speed operation. Modifications called for by the IHSR plan were listed and included. Facility improvements to meet the standards were based on these comparisons.

3.2 TRAIN PERFORMANCE CALCULATOR (TPC)

The TPC is a deterministic computer model which utilizes the laws of dynamics based upon tractive effort of the power

Figure 3-1

FLOW DIAGRAM OF IPT INTERFERENCE
ANALYSIS AND COST ESTIMATION PROCEDURE



units and resistance of the trailing load to find incremental distances and times. The tractive effort of the power units is a function of its weight and horsepower. The equipment specifications and necessary operating assumptions summarized in Figure 2-1and 2-2 will be discussed in more detail below.

The rolling resistance of the trailing load is a function of the following parameters:

- Grade of Track
- Curvature of Track
- Velocity of Train
- Weight of Train
- Length of Train
- Axle Loading of Train.

The data for each of the first two parameters was abstracted from track charts furnished by the carriers in each corridor.

The specifications used in the study are given below for metroliner type equipment.

Builder	Budd Company
Power Units	6
Trailer Units	0
Revenue Units	6
Train Weight	505.2 tons
Train Length	510 feet
Train Axles	24
Train Horsepower	7200

The program also recognizes artificial restraints on speed imposed by administrative or engineering practice. This information was abstracted from track charts, employee time-tables, book of rules, and special instructions as furnished by the carriers. Typical speed restraints are caused by

- Curve Geometry
- Bridges
- Grade Crossings
- Municipal Ordinances
- Angle of Turnout
- Maximum Speed Policy
- Signal System Specifications

The Penn Central Transportation Company (PC) TPC program was used in the PC corridors to take advantage of the deck of track cards already developed by the PC.

3.3 INTERFERENCE ANALYSIS

The interference analysis to identify facility modifications needed to relieve congestion employed two methods. In the New York - Washington segment, a computer program, TRANSIM III, was used to simulate the operation of freight, commuter, and passenger service over the rail system. In the New York - Boston segment, a manual train graph was used. This section describes the methodology used in both approaches.

3.3.1 TRANSIM Simulation. The simulation of the New York to Washington corridor was accomplished by use of a computer simulation model of all train operations on the main tracks. This model was initially developed by the TRANSIM Group at the University of California at Los Angeles and Penn Central Transportation Company and funded by the U. S. Department of Transportation.

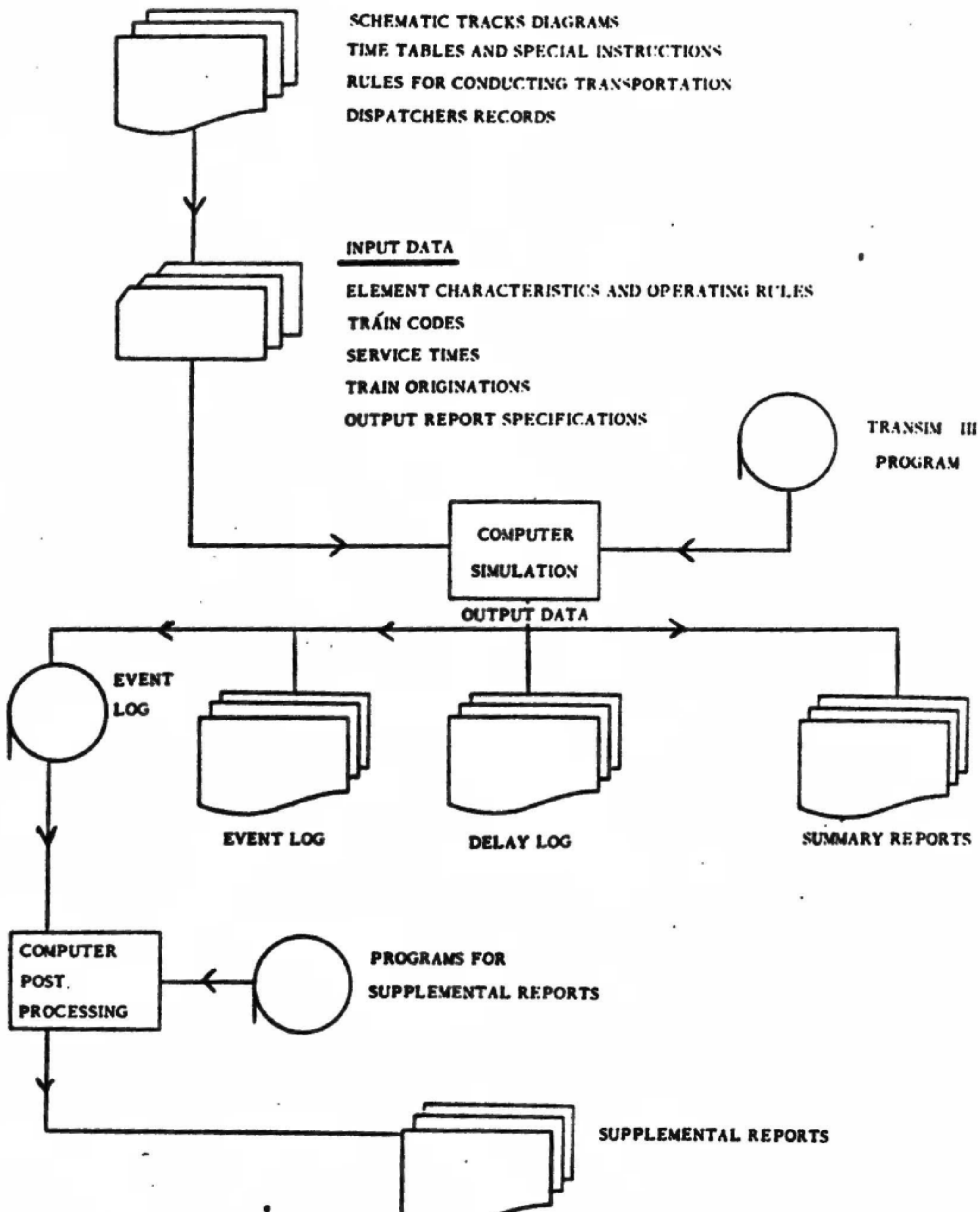
The TRANSIM III program is a general purpose simulator, which has been designed to be applicable to transportation type problems. The model consists of the basic computer program called TRANSIM III and the input data, which describes the facility and operation. The input data is made up of descriptions of the track layout and related facilities, trains, operating rules, characteristics of each block (element) of the track layout or related facility, and specifications for output records. The model, its operation, and the outputs are charted in Figure 3-2.

The version developed for the New York - Washington Penn Central facilities was written in FORTRAN IV, which makes the program useable on any computer capable of handling FORTRAN IV and with core capacity sufficient for the particular model. Since the program is general purpose, it can be used for many different applications without any modifications. New problems can be analyzed by development of a new set of input data describing the physical plant, traffic units, operating rules, and element characteristics. The new input data can then be operated with the same basic TRANSIM III program used for the preceding problem.

The simulated railroad consists of the main tracks between Pennsylvania Station in New York City and Union Station in Washington, D. C. - a distance of 227 miles (Figure 3-3). Within this distance, there are two to six main tracks, 104 locations at which trains enter or leave the main tracks, 64 interlockings at which trains can be stopped or diverted from one main track to another, 8 major passenger stations, and 70 minor passenger stations.

Figure 3-2

TRANSIM SIMULATION PROCESS[1]



(1) "Simulation for Planning Railroad Operations", a paper presented by Mr. Edward J. Sierleja at the National Transportation Engineering Meeting of the American Society of Civil Engineers and the American Society of Mechanical Engineers in Seattle, 1971.

The development of the model started with the preparation of a schematic diagram representing tracks, interlockings, stations, train origination (source) or departure (sink) points, and normal traffic directions. The southern end of this diagram is shown in Figure 3-4. This diagram was prepared after examination of track charts, interlocking diagrams, employee timetables, visual observation from train riding, and interviews with train dispatchers.

As one would expect for a plant of this size, the traffic volume is very large and complex. There are approximately 570 train originations each day. A snapshot look at the trains on the railroad at about 5:30 P.M. would find about 45 passenger trains and 10 freight trains. The types of trains include new passenger trains - 100 MPH or 150 MPH; conventional express passenger trains - 80 MPH; commuter passenger trains - 65, 75 and 100 MPH; preference freight trains - 60 MPH; conventional freight trains - 50 MPH; mineral freight trains - 40 MPH, and local freight trains, which are delivering and picking up cars at patrons' sidings. Trains are identified in the model by use of a six digit code. The digits identify direction of movement, class of train (which identify priority in a conflict situation), and the specific train identification. The coding pattern is displayed in Figure 3-5

The operating logic was developed from examination of the same documentation used to prepare the schematic diagram plus the current "Rules for Conducting Transportation", Timetable Special Instructions, and interviews with dispatching personnel. Typical of the type of rules which had to be considered and encoded in the model were:

1. Priority rules, which govern situations in which trains compete for the same track: These rules specify which trains shall use the track first. The order of descending priority is Metroliners, express passenger trains, and freight trains.

2. Routing rules, which dictate allowable paths through the track layout: As an example, the model does not allow freight trains to be routed through 30th Street Station at Philadelphia.

Figure 3-3

TRACK CHART: WASHINGTON TO NEW YORK[1]

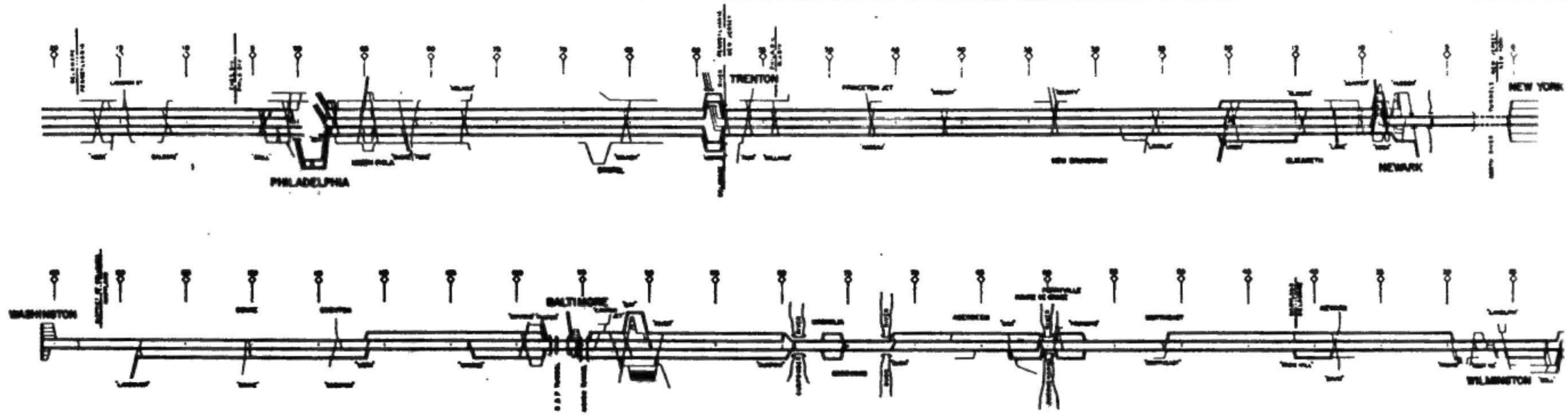
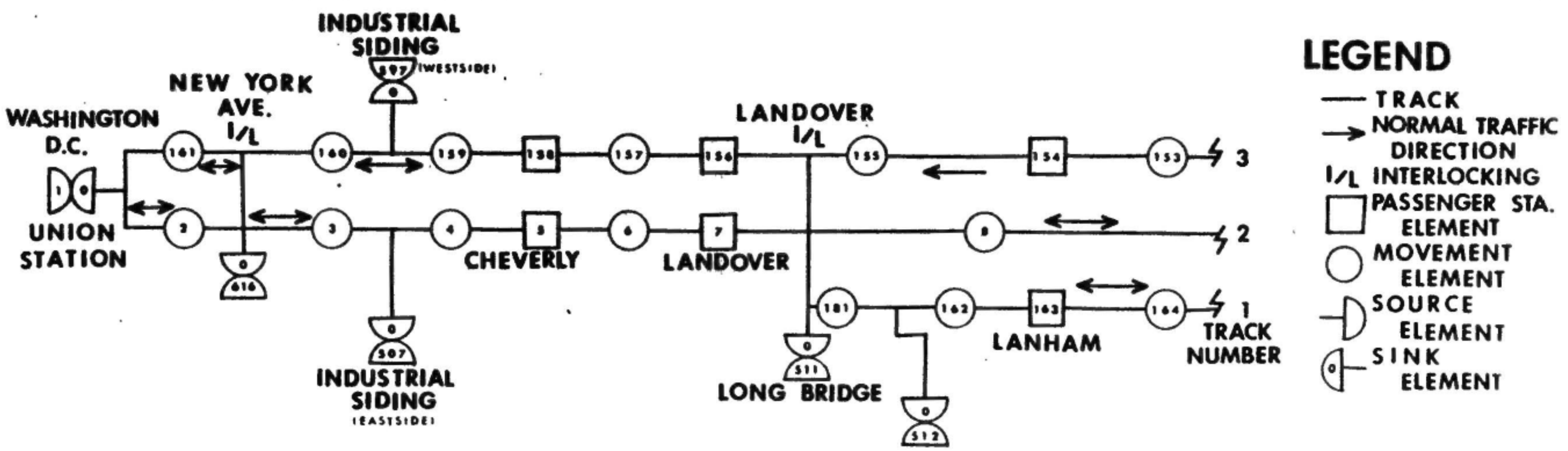


Figure 3-4

SAMPLE TRANSIM TRACK MODEL[1]



(1) E. Sierleja, Ibid.

Figure 3-5

TRANSIM CODING PATTERN[1]

TRAIN CODES - 6 DIGITS

DIGIT 1 DIRECTION

0 = NORTH OR EAST
1 = SOUTH OR WEST

DIGIT 2 DIRECTION AND CLASS OF TRAIN

0 = SOUTH OR WEST FREIGHT TRAIN
1 = SOUTH OR WEST COMMUTER TRAIN
2 = SOUTH OR WEST EXPRESS PASSENGER TRAIN
3 = SOUTH OR WEST METROLINER
4 = NORTH OR EAST FREIGHT TRAIN
5 = NORTH OR EAST COMMUTER TRAIN
6 = NORTH OR EAST EXPRESS PASSENGER TRAIN
7 = NORTH OR EAST METROLINER

DIGIT 3 THROUGH 6 PASSENGER TRAINS

ACTUAL TRAIN NUMBER IN TIMETABLE

DIGIT 3 TYPE OF FREIGHT TRAINS

7 = 60 MPH
8 = 50 MPH
9 = MINERAL, LOCAL OR OTHER

DIGIT 4 ORIGIN OF FREIGHT TRAIN

0 = LANDOVER AND LANE	5 = ARSENAL
1 = FAIR	6 = PERRYVILLE
2 = MORRIS	7 = BAY VIEW
3 = SHORE-FORD	8 = OTHER AS REQUIRED
4 = ZOO	9 = OTHER AS REQUIRED

DIGIT 5 DESTINATION OF FREIGHT TRAIN

SAME AS DIGIT 4

DIGIT 6 AS REQUIRED FOR FREIGHT TRAIN

FREIGHT TRAIN SAMPLES

047401 - TRAIN TT2) 047402 - TRAIN TT4)	FASTBOUND - 60 MPH - ORIGINATION AT ZOO- DESTINATION AT LANE.
108025 - TRAIN SWC1)	WESTBOUND - 50 MPH - ORIGINATION AT LANE - DESTINATION AT MORRIS

(1) E. Sierleja, Ibid.

3. Limiting capacities of certain elements: As an example, the model does not allow more than one train at the same time in any Newark Station track.

4. Minimum train spacing: The model provides the minimum spacing between trains which in real life is controlled by the automated block system.

5. Scheduled leaving time for passenger trains at stations: Trains are not allowed to leave a station ahead of the published time, even if they have completed their service time.

Each element in the model requires a service time, either running time (excluding delay) or standing time for stations, for each type of train. This data was collected from Train Dispatcher's historical records, which had been selected to reflect different climatic conditions and different traffic mixes. The time-data was analyzed and arranged in cumulative frequency distribution tables for entry into computer files. Any running time, which included delay caused by traffic congestion or conflict, was excluded from the distribution tables. This type of delay is developed by operation of the model. Figure 3-6 has an example of a table of running times and a table of times trains were not ready for departure at origin.

The service time distributions for the improved trains were developed by operating the TPC program and projecting distribution curves from those results and from experience with distribution curves of Metroliner actual running times.

The computer operates the railroad model during a simulation run in the same manner as the Train Dispatcher and the signal system do in real life. Trains are allowed to enter an element of the model if there are no approaching trains which will conflict; they are delayed if there is conflict. Trains stop at required stations and depart from the model at designated locations (elements). As congestion occurs, trains are diverted to alternate routes, if available, and if none are available, are delayed. Slower trains preceding faster trains in the same element cause delay to the following trains.

Figure 3-6

SAMPLE TRANSIM TABLE OF RUNNING TIMES [1]

SERVICE TIME TABLES

RUNNING TIMES IN MINUTES

EXPRESS NY/NEWARK										CURVE NUMBER
0.0	13.5	*0.012*	14.5	*0.58*	15.5	*0.91*	16.5	*0.967*	17.5	183
0.978	18.5	*0.989*	19.5	*1.0*	26.5					183

NOT READY FOR DEPARTURE TIMES IN MINUTES

0.0	0.0	*0.73*	0.0	*0.89*	1.0	*0.96*	4.0	*0.98*	10.0	*1.0*	20.0	218

ITALICS - CUMULATIVE PERCENT

(1) E. Sierleja, Ibid.

The TRANSIM simulation process provides various standard printed output formats which contain the history of the computer simulated period. These include an Event Log, which is a record of every transaction; a Delay Log, which is a record of every transaction containing delay, and a Summary Report, which is a summary of all the history for a specified train or trains. In addition to the standard printed outputs, data on the output tape can be post-processed by supplemental programs to assist in the analysis and solution of specific problems.

Figure 3-7 shows samples of Event and Delay Logs. The Event Log is a chronological list of the record of the movement of each train through each element. Identified are train number; element number; day, hour, and minute the train entered the element; elapsed time in running; elapsed time in delay; total elapsed time; day, hour and minute the train left the element; element number the train was routed to; and, if any, cause of delay.

The Delay Log is in the same column format as the Event Log but contains only those transactions which have record of delay. Figure 3-8 explains the various possible causes of delay as recognized by the program.

The Summary Report shown in Figure 3-9 is a statistical analysis of the simulation history. It provides an analyst with the ability to make a quantitative comparison of elapsed times and delays resulting from simulation runs of two or more sets of alternatives. There are many options available for specifying report content. All of the information printed in italics in Figure 3-9 is variable.

The TRANSIM analysis was performed at current traffic volumes and at those projected for 1975, 1985 and 1995. The projections used are described in Section 3.5.

3.3.2 Train Graph Analysis. The train graph analysis was based on a graphic representation of a sample day's actual track activities by time, location, and track number. Proposed new passenger service was then superimposed on the graph of actual traffic, and conflicts were resolved by reassignment of tracks and identification of additional facility modifications.

Figure 3-7

SAMPLE TRANSIM OUTPUT [1]

DELAY LOG

Train Number	Element Number	Time Entered	Running Time	Delay Time	Elapsed Time	Time Departed	Routed to Element	Cause of Delay	
		D H M	H M	H M	H M	D H M			
172	290	3 1248	0 1	0 2	0 3	3 1251	292	Control time	
130	199	3 1251	0 3	0 4	0 7	3 1258	36	Train 2104 at	35
3736	325	3 1256	0 2	0 2	0 4	3 1300	326	Capacity	
3736	326	3 1300	0 0	0 1	0 1	3 13 1	328	Following train	5322
8202	327	3 1255	0 1	0 8	0 9	3 13 4	319	Train 3924 at	394
130	36	3 1258	0 5	0 2	0 6	3 13 5	37	Following train	2104

EVENT LOG

Train Number	Element Number	Time Entered	Running Time	Delay Time	Elapsed Time	Time Departed	Routed to Element	Cause of Delay
		D H M	H M	H M	H M	D H M		
3704	327	0 556	0 1	0 0	0 1	0 558	319	No delay
3704	319	0 558	0 0	0 0	0 0	0 558	320	No delay
8067	184	0 554	0 4	0 0	0 4	0 558	185	No delay
9543	67	0 543	015	0 0	015	0 558	68	No delay
140	294	0 553	0 6	0 0	0 6	0 6 0	295	No delay
140	295	0 6 0	0 0	0 0	0 0	0 6 0	297	No delay
8601	136	0 419	141	0 0	141	0 6 0	137	No delay
3704	320	0 558	0 2	0 0	0 2	0 6 0	321	No delay
5552	346	0 616	0 7	0 7	014	0 630	83	Control time

(1) E. Sierleja, Ibid

Figure 3-8

DESCRIPTIONS OF THE CAUSES OF DELAY IN TRANSIM [1]

1.	Control Time	The subject train's service time at a passenger station element had been completed earlier than the leaving time as published to the public. The train is then held or delayed until that time.
2.	Train 2104 at 35	The subject train was not released from its element at the earliest possible time because of a conflicting move by a higher priority train (2104) in another element (35) and because no other routes were available.
3.	Capacity	The subject train was not allowed to enter an element because the current train occupancy in that element was equal to a capacity restriction in quantity of trains as specified in the model.
4.	Following Train 5322	The subject train had a faster running time than a preceding train (5322) in the same element and reached the allowed headway spacing before leaving the element.

(1) E. Sierleja, Ibid

Figure 3-9

SAMPLE TRANSIM SUMMARY REPORT[1]

SUMMARY *NY WASH EXPRESS* *WEST SOUTH*
REPORT PERIOD FROM DAY *0* TO DAY *8*
FROM ELEMENT *77* TO ELEMENT *300*
TRAFFIC UNIT TYPES *120145*

ELAPSED TIME • INCLUDING DELAYS

TOTAL TIME 27 HRS 29 MIN 39 SEC
MAXIMUM TIME 4 HRS 1 MIN 41 SEC OCCURRED ON DAY 4
BEGINNING AT TIME 15 8

AVERAGE TIME 3 HRS 55 MIN 40 SEC
MINIMUM TIME 3 HRS 48 MIN 28 SEC OCCURRED ON DAY 6
BEGINNING AT TIME 15 8

DELAY TIME

TOTAL DELAY 0 HRS 47 MIN 29 SEC
MAXIMUM DELAY 0 HRS 13 MIN 12 SEC OCCURRED ON DAY 4
BEGINNING AT TIME 1612

AVERAGE DELAY 0 HRS 6 MIN 47 SEC
MINIMUM DELAY 0 HRS 1 MIN 41 SEC OCCURRED ON DAY 6
BEGINNING AT TIME 1611

HRS	MIN	SEC		HRS	MIN	SEC	FREQUENCY	PERCENT
			LESS THAN	*3*	*20*	*0*	0	0.0
3	*20*	*0*	TO	*3*	*40*	*0*	0	0.0
3	*40*	*0*	TO	*4*	*0*	*0*	5	71.4
4	*0*	*0*	TO	*4*	*20*	*0*	2	28.6
4	*20*	*0*	TO	*4*	*40*	*0*	0	0.0
4	*40*	*0*	TO	*5*	*0*	*0*	0	0.0
5	*0*	*0*	OR MORE				0	0.0
			TOTAL NUMBER				7	

			LESS THAN	*0*	*5*	*0*	3	42.9
0	*5*	*0*	TO	*0*	*10*	*0*	2	28.6
0	*10*	*0*	TO	*0*	*20*	*0*	2	28.6
0	*20*	*0*	TO	*0*	*30*	*0*	0	0.0
0	*30*	*0*	TO	*0*	*45*	*0*	0	0.0
0	*45*	*0*	TO	*1*	*0*	*0*	0	0.0
1	*0*	*0*	OR MORE				0	0.0
			NUMBER DELAYED				7	

(1) E. Sierleja, Ibid.

Data were extracted from dispatcher's records of train movements. The study team visited the offices of the railroad companies in charge of each segment to collect data and to discuss with knowledgeable people the selection of the sample day to be graphed. An attempt was made to choose a typically heavy day in the past year. For example, if winter was the heaviest season because of fluctuations in industry's production rate in that area, and if Friday was the heaviest day of the week, the sample day was a typical Friday in the winter. Those days which had an unusual occurrence such as a derailment were excluded.

The dispatcher's sheets provided the times during a 24-hour period at which each train passed a number of locations, usually interlockings. These were plotted on a time-distance graph and connected with straight lines, thus making the expedient assumption of constant speeds between designated locations. The dispatcher's sheets usually provided track assignments for each train by location. These were noted by color coding each of the train lines on the graph. In the absence of track assignment data, Eastward and Westward trains were coded on their conventionally assigned tracks. In the case of commuter trains in the New York area, timetables provided an additional indication of track assignments because the appearance of frequently scheduled station stops implies the use of outer tracks with station platforms.

The projected schedules for new passenger service were then superimposed on the graph. The simulated run times were developed by the addition of station dwell times to the TPC times. This provided the cumulative elapsed times from the departure point to each interlocking along the route. All trains required by the specified frequency of service were plotted using the same elapsed times.

An overlay was then prepared assigning tracks to the new passenger trains and reassigning freight and commuter trains in a manner consistent with priority rules and existing interlocked crossovers and turnouts to passing sidings.

The interference analysis consisted of determining points of conflict between IPT's and existing freight and commuter traffic, then resolving the conflict by reassigning tracks and/or delaying trains. Reassignments were generally chosen to minimize delays. The geographic locations of the crossovers and passing sidings that could be used were determined from track charts and interlocking diagrams.

A typical interference problem in a two track system would be a situation in which, within one block of track, track was occupied by a Westward train, and there were two Eastward trains on the other track, one projected to pass the other. Unless there is a passing siding within that block of track, a delay was said to have occurred while the overtaking train slows down and follows the slower one. Alternate solutions would be to delay the slower train on a siding in a previous block while the overtaking train passes it or to delay the Westward train before it enters the block to allow both tracks to be used by the Eastward trains.

Often the solution chosen was based on the analyst's judgment and foresight gained from the train graph. This involved weighing such factors as the classes of trains to be delayed, the respective delay times, and additional interference caused by the track reassignments. Normally trains with the lowest priority were delayed the most. Some consideration, however, was given to situations in which the trade-offs of possible delays would yield greatly reduced delays for lower priority trains at the expense of slightly greater delays to higher priority trains. In these cases the higher priority train was delayed. In general, the new passenger trains were given highest priority in avoiding delays, commuters second, through freights third, and local freights last. The delays resulting from track reassignments thus represent a relatively optimum solution, given existing facilities and priorities. Actual operations in similar situations would most probably result in somewhat greater delays because of operational constraints on the foresight and flexibility of dispatching decisions.

Facility modifications to relieve congestion were identified with the objective of reducing the delays remaining after track reassignments. There is one exception to this procedure: reverse signalling was found to be so essential to relieving congestion that it was assumed to be available in making track reassignments. The delays recorded thus reflect those that would remain after the installation of reverse signalling.

The basic train graph analysis was conducted at 1972-1975 volumes. To conduct the interference analysis for 1985 and 1995, each corridor was broken up into sections which appeared to have approximately the same number and mix of trains. At one location in each section the number of each class of train was determined. These numbers were then scaled upward by the projected growth rates. The traffic projections are discussed in Section 3.5. An attempt was made to distribute the additional trains over time in the same relative frequency as presently exists. A second analysis was then done to determine if any facilities would be needed other than those needed at 1975 volumes.

3.4 SELECTION OF ADDITIONAL FACILITIES TO RELIEVE CONGESTION

For the New York - Washington segment, the TRANSIM model was prepared to represent the facilities and trains that existed in October, 1971. The report specifications were planned to produce summary histories of time of train operation for each of 22 different classes or groups of trains, and a chronological listing of all delays. The model was then operated to simulate seven days of operation and produce the specified reports.

After operation of the model with 1971 conditions, the model was revised to reflect the changes in facilities and equipment as proposed in the IHSR plan. The traffic characteristics were changed to reflect the new passenger service. After these changes the model was operated to simulate seven days of operation and produce reports as in the 1971 simulation.

The interference analysis then began by comparing the summary reports from operation of the 1971 model with like reports from operation of the IHSR model. Each class of train was analyzed to determine if the IHSR plan resulted in a significant increase in delay and total elapsed time. If so, the major delays were traced back to the delay log to determine location and cause. Where the problem was repetitive, engineering judgment was used to select a facility modification which would eliminate or reduce the problem.

After completing the selection of modifications to the IHSR plan it was necessary to determine the benefits which would result from each. This was done by revising the model once again. This time the revisions reflected the proposed modifications to the IHSR plan. Then, each class of train was analyzed to determine if the proposed modifications resulted in a significant increase in delay and total elapsed time.

In addition, summary reports were used to determine the extent of use of each modification. The modified IHSR plan was identified for future reference as the IHSR-1A plan.

3.5 INTERFERENCE ANALYSIS - 1975, 1985, 1995 TRAFFIC VOLUMES

The simulation was conducted separately for each of three different traffic volume forecasts. The first was for volumes assumed for 1975 and was the basis for selecting necessary modifications to produce the IHSR-1A plan. The 1975 traffic volumes were assumed to be the same as the actual in 1971 for freight and commuter service. The frequency of new passenger service is detailed in Figure 3-10.

Forecasts of traffic volumes for 1985 and 1995 were used to determine the number of other trains operating on the same facilities. The forecasts were stated as percentage increases or rider trip increases over the base year of 1975. These forecasts are displayed in Figure 3-11. They were projected from estimates of rail demand prepared for the DOT[1] and the various commuter agencies and railroads.

In addition to these forecasts in Figure 3-11, the City of Philadelphia is planning to inaugurate a new rail service from the center of the city to Philadelphia International Airport. This service will occupy the Washington - New York segment between Arsenal and Brill.

After the forecasts were made, it was necessary to translate the percentage increases in Figure 3-11 into an increase in the quantity of trains. Since the forecastors declined to translate the tonnage or rider trip increases into increases in trains, the assumption was made that the percentage increases in Figure 3-10 would be used directly to calculate increases in trains. The results of these calculations are in Figure 3-12.

[1] U.S. Department of Transportation. Transportation Projections, 1970 and 1980. Washington, D.C. July, 1971.

Figure 3-10

FREQUENCY OF THE
NEW PASSENGER TRAINS - 1975

NEC Segment	Number of Trains/Day
Washington - Philadelphia	31
Philadelphia - New York	61
New York - Boston	31

Figure 3-11

PERCENTAGE VOLUME FORECASTS - 1985 and 1995

Class of Service and Traffic Unit	Percent Increase Over 1975[1] 1985	1995
New service - Rider trips	0%	35%
Freight - Net tons	28%	64%
Commuter - Rider trips		
Trenton - New York	0%	0%
New Brunswick - New York	0%	0%
Rahway - New York	82%	133%
Trenton - Philadelphia	13%	22%
Philadelphia - Wilmington	13%	22%
New York - Stamford [2]		
New York - New Haven[2]		
Providence - Boston [2]		
Mansfield - Boston [2]		

(1) Data figures from 1972 were used for the 1975 analysis. It was assumed that the growth rate in this period was not large enough to cause distortion in the results.

(2) Projections not obtainable.

Figure 3-12

TRAIN FREQUENCY FORECASTS - 1985 AND 1995

Class of Service		Increase in Trains Per Day vs. 1975 1985	1995
New Service	Philadelphia - New York City	0	10
	Washington - New York City	0	10
Freight	Landover - Lane	6	12
	Trenton - Lane	2	4
	Zoo - Lane	2	4
	Shell - Stamford	4	10
	Stamford - New Haven	5	12
	New Haven - Boston	5	11
Commuter	Rahway - New York City	62	101
	Philadelphia - Trenton	4	7
	Wilmington - Philadelphia	4	7
	Philadelphia Airport[1]	84	84

[1] No service in 1975

4. RESULTS

For each corridor, four types of results will be presented:

1. Velocity Profiles
2. Summary of Delays
3. Descriptions of Modifications
4. Costs of Establishing the New Service

4.1 VELOCITY PROFILES

The velocity profiles as shown in Figures 4-1 and 4-2 indicate average speeds over the designated distances. The profiles demonstrate the speed restrictions inherent in the modified railroad system as discussed in Section 3.2.

4.2 SUMMARY OF DELAYS

The availability of the TRANSIM computer program for modeling the Washington to New York segment makes possible a more detailed analysis of this portion of the corridor. A similar modeling of the Boston to New York segment would facilitate the identification of the needed modifications and thus improve the quality of the analysis.

4.2.1 Delays-Boston to New York. The summary of delays is to be found in Figure 4-3 for the 1975 interference analysis. It was determined by further analysis that the modifications will be adequate for the functioning of the system in 1985, but that in 1995 the system will be about filled to capacity.

4.2.2 Delays-Washington to New York. The proposed modifications and equipment specifications result in a great improvement in the potential schedule of the new passenger train service compared to current advertised Metroliner schedules. The new passenger service for Washington to New York schedules as shown in Figure 4-4 are based on an expected 80% on-time performance and the frequency distribution of elapsed times resulting from the simulation.

The relatively slight increase in duration of trip time in 1985 and 1995 is somewhat misleading. This results from an operating rule in the simulation that gives the new passenger trains priority over any other class of train when there is competition for a route. Since in reality this priority may not operate at all times, it is expected that new passenger trip times will be longer in 1985 and 1995 because of the increased traffic levels.

Figure 4-1

NEW PASSENGER TRAIN VELOCITY PROFILE
FROM WASHINGTON TO NEW YORK

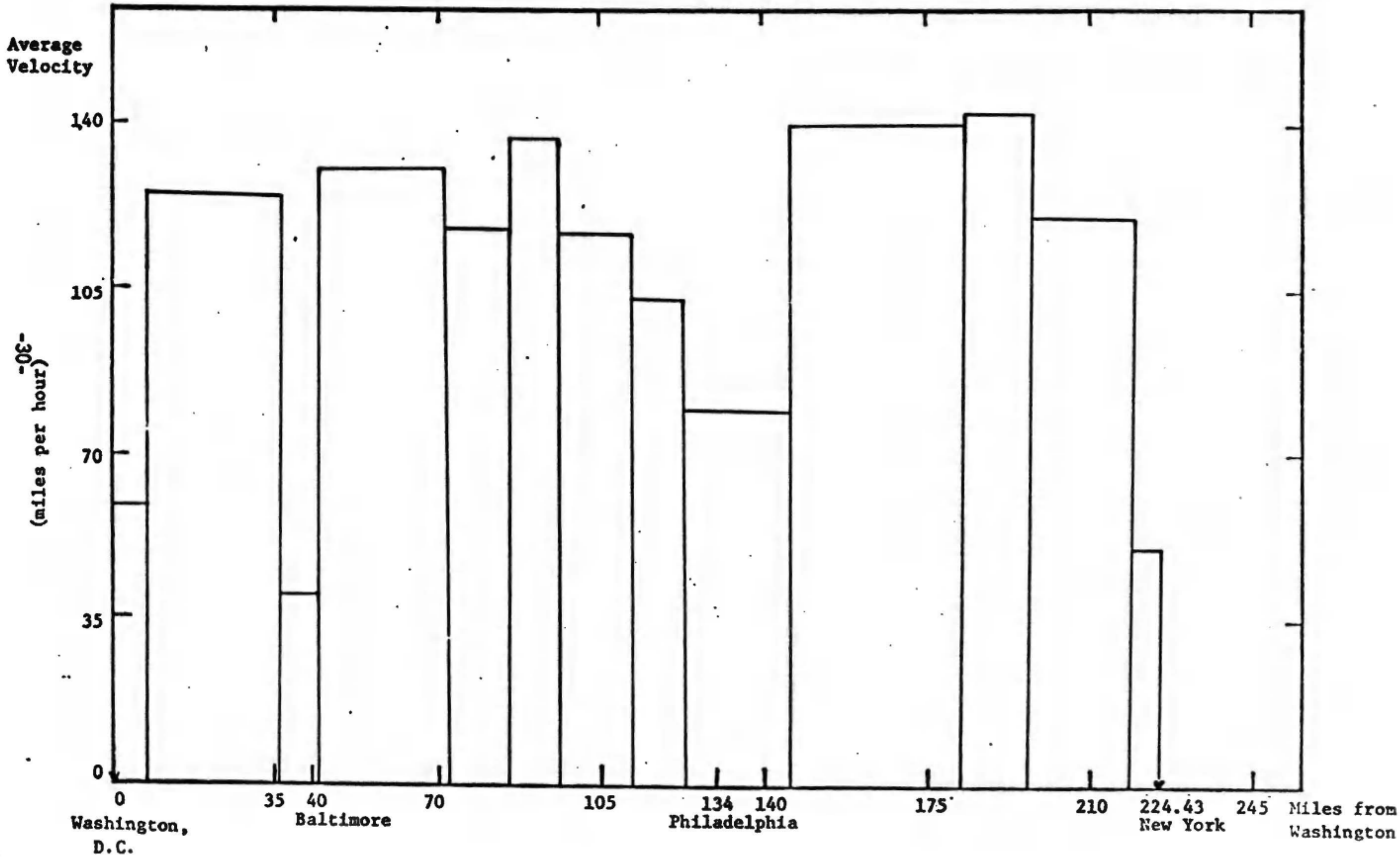


Figure 4-2

NEW PASSENGER TRAIN VELOCITY PROFILE
FROM NEW YORK TO BOSTON

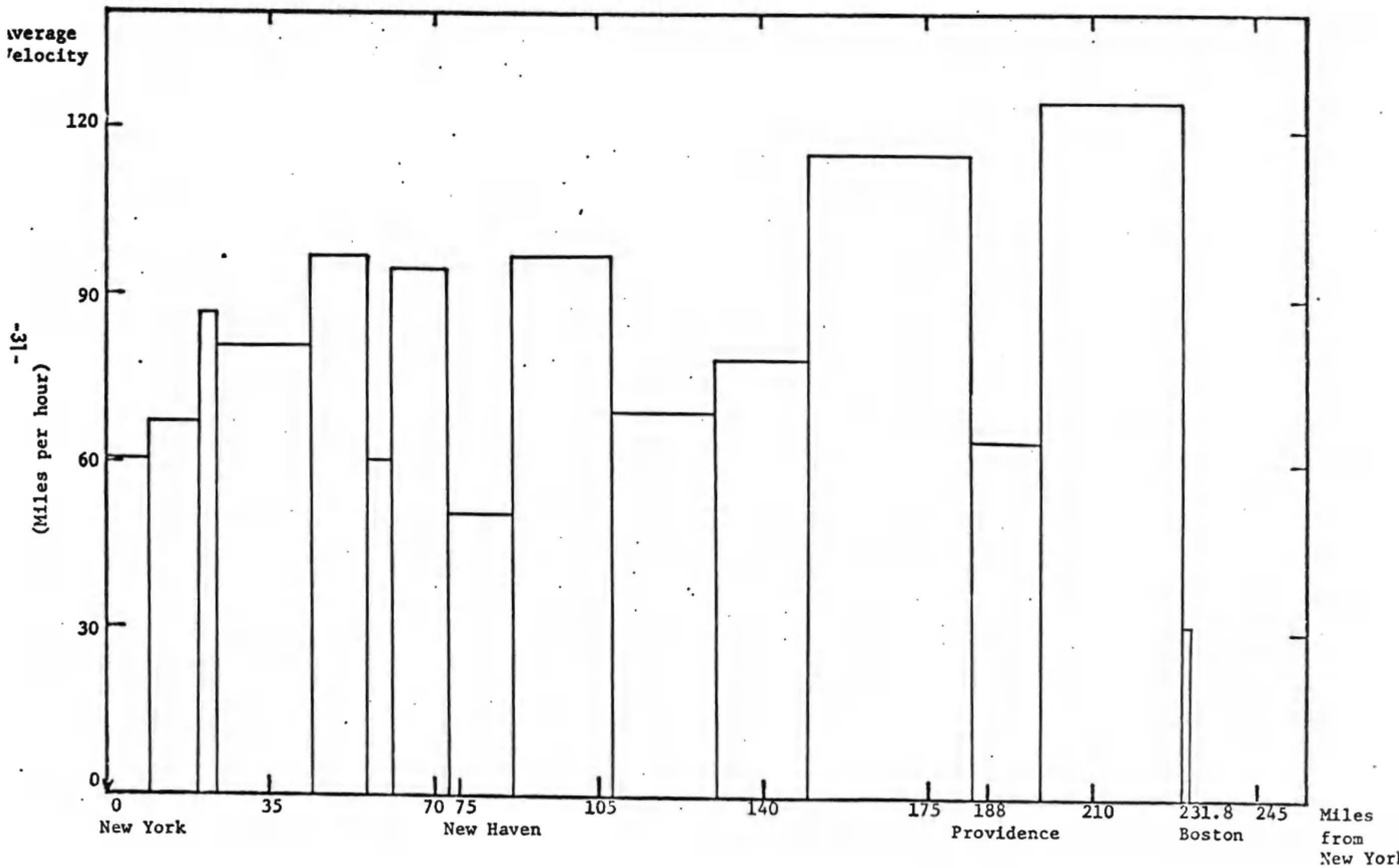


Figure 4-3

DELAYS INCURRED DUE TO NEW PASSENGER TRAIN INTERFERENCE IN THE BOSTON TO NEW YORK CORRIDOR[(1)]

Location of interference \ Type of Train	Commuter			New Passenger Service			Freight		
	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed
Readville				1	2.0	2			
Rte. #128	1	8.0	4	1	3.0	2			
Canton	2	3.5	8				2	4.5	13
Mansfield				1	3.0	2			
Attleboro	1	4.0	7						
Providence							1	3.0	7
Davisville				1	6.0	2			
New London							1	6.0	5
Devon	1	2.0	1						
Peck							1	61.0	5
Burr Road				1	1.0	1			
Walk	1	2.0	1						
Berk	2	2.0	3	2	3.0	2			
Stamford	2	2.5	1	1	2.0	1			
Cob	1	3.0	1				1	3.0	6
Green	3	6.3	1	7	3.3	6			
Pike	14	5.2	8	10	3.1	8	1	6.0	6
Shell	8	3.3	5	3	5.0	2			
Pelham Bay				2	4.5	2			
Market				1	6.0	1			
Harold	3	4.0		6	13.0	5 (2)			

(1) These figures assume reverse signalling is in operation for the entire corridor.

(2) New train delays were caused by unusually slow commuter trains using the Penn Central track. It is speculated that this was caused by overloaded facilities in Penn Station, and that the Penn Central track was being used as a holding track.

Figure 4-4

NEW PASSENGER SERVICE SCHEDULE

Washington - New York

		Philadelphia-New York		Washington-New York	
		Northbound	Southbound	Northbound	Southbound
1972 Metroliner Schedule	No Stops	1'-12"	1'-13"	None	None
	Stops	1'-19"	1'-18"	3'-02"	3'-04"
New Passenger Trains - 1975	No Stops	0'-54"	0'-56"	2'-18"	2'-21"
	Stops	1'-00"	1'-03"	2'-30"	2'-34"
New Passenger Trains - 1985	No Stops	0'-58"	0'-56"	2'-22"	2'-21"
	Stops	1'-04"	1'-03"	2'-34"	2'-34"
New Passenger Trains - 1995	No Stops	0-59"	0'-58"	2'-25"	2'-22"
	Stops	1'-04"	1'-05"	2'-37"	2'-35"

4.2.3 Extent of Interference. The extent of interference which results to each class of service as determined by the TRANSIM simulator has been determined for each plan and volume forecast for 1975, 1985 and 1995. These include the present operation (1971), the proposed IHSR plan with the 1975 volume, the revised IHSR-1A plan or IHSR-1A plan with the 1975 volume, and the IHSR-1A plan with 1985 and 1995 volumes. The results of each projected plan are displayed in Figures 4-5, 4-6, 4-7 and 4-8.

1. IHSR - 1A Plan - 1975. The interference in the IHSR - 1A plan is not a significant increase over the level established in simulating 1971 conditions. When taking into consideration that the frequency of new passenger trains is not expected to arrive at the level used for 1975 simulation until 1985, the actual interference level in the IHSR-1A plan will initially be considerably less than portrayed in Figure 4-6.

2. IHSR-1A Plan - 1985. The interference level in the 1985 simulation is increased for freight service in both the number of trains delayed and in the average delay to each of those delayed. Commuter service interference did not show any significant increase. Although the increase is small, it is indicative that capacity is reached under the IHSR-1A plan.

3. IHSR-1A Plan - 1995. The interference level in the 1995 simulation increased significantly over the 1975 simulations for all classes of service including the new trains. This increase occurred in both the number of trains delayed and in the average delay to each of those delayed. The increases are large enough and extensive enough to indicate that capacity in this corridor will be exceeded by 1995 unless additional modifications are provided.

4.3 DESCRIPTION OF MODIFICATIONS

This section describes the modifications that the analysis shows to be required. Sections 4.3.1 through 4.3.7 describe system improvements to permit higher speeds. Section 4.3.8 describes those site specific improvements necessary to ease traffic congestion. Section 4.3.9 describes miscellaneous improvements. Sections 4.3.10 through 4.3.13 describes necessary improvements to stations, yards, and shops. Detailed

4.3 DESCRIPTION OF MODIFICATIONS (Cont'd)

cost estimates are included in Figures in Section 4.4. The summary of the costs is found in Figure 4-9.

Figure 4-5
COMPARISON OF SIMULATION HISTORIES
1971 VS. IHSR PLAN
NEW YORK CITY TO WASHINGTON

Class of Train	1971 Conditions					IHSR Plan				
			Delays (1)					Delays (1)		
	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed
Trenton-NY Commuter	162	1:22	81	0:05	50	157	1:24	102	0:04	65
New Brunswick-NY Commuter	269	1:03	143	0:06	53	269	1:03	177	0:05	65
Rahway-NY Commuter	286	0:46	113	0:05	40	286	0:46	131	0:05	46
Trenton-Phila. Commuter	236	0:55	103	0:04	44	236	0:56	123	0:04	52
Chestnut Hill Commuter	447	0:12	79	0:02	18	447	0:13	108	0:02	24
Phila.-Wilmington Commuter	305	0:50	180	0:04	59	305	0:51	211	0:05	69
Phila.-NY Express	54	1:51	34	0:04	63	0	0	0	0	--
NY-Phila. Express	83	1:46	54	0:03	65	0	0	0	0	--
NY-Washington Express	86	4:00	77	0:08	90	0	0	0	0	--
Washington-NY Express	72	4:06	66	0:12	92	0	0	0	0	--
NY-Phila. Metroliner	0	0	0	0	0	224	1:00	122	0:05	55
Phila-NY Metroliner	0	0	0	0	0	224	1:02	141	0:04	63
NY-Washington Metroliner	69	3:03	29	0:04	42	147	2:38	83	0:06	56
Washington-NY Metroliner	70	3:03	57	0:04	81	147	2:26	108	0:06	74
Turn around Locals	186	6:18	136	3:24	73	186	6:34	148	3:20	80
Amtrak & Mail to West	38	1:38	24	0:05	63	38	1:39	28	0:06	74
Freights from Newark	96	3:13	52	0:17	54	96	3:09	62	0:16	64
Freights from Trenton	35	3:07	23	0:58	66	35	3:00	27	0:39	77
Freights from Phila.	79	2:29	34	0:24	43	79	2:13	41	0:19	52
Freights from Perry/Wilm.	66	2:53	41	0:15	62	66	2:50	37	0:16	56
Freights from Baltimore	20	1:06	11	0:27	55	20	1:10	12	0:27	60
Freights from Landover	64	5:31	49	0:27	76	64	5:32	56	0:29	88

(1) Delays are recorded in the simulation whenever a train is slowed or stopped because of interference with another train.

Figure 4-6
COMPARISON OF SIMULATION HISTORIES
1971 VS. IHSR-IA PLAN
NEW YORK CITY TO WASHINGTON

	1971 Conditions					IHSR-IA Plan				
			Delays (1)					Delays (1)		
Class of Train	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed
Trenton-NY Commuter	162	1:22	81	0:05	50	157	1:24	94	0:04	60
New Brunswick-NY Commuter	269	1:03	143	0:06	53	269	1:04	177	0:05	66
Rahway-NY Commuter	286	0:46	113	0:05	40	286	0:42	175	0:05	61
Trenton-Phila. Commuter	236	0:55	103	0:04	44	236	0:55	94	0:04	40
Chestnut Hill Commuter	447	0:12	79	0:02	18	0	0	0	0	--
Phila.-Wilmington Commuter	305	0:50	180	0:04	59	305	0:50	193	0:04	63
Phila.-NY Express	54	1:51	34	0:04	63	0	0	0	0	--
NY-Phila. Express	83	1:46	54	0:03	65	0	0	0	0	--
NY-Washington Express	86	4:00	77	0:08	90	0	0	0	0	--
Washington-NY Express	72	4:06	66	0:12	92	0	0	0	0	--
NY-Phila. Metroliner	0	0	0	0	0	224	1:00	88	0:05	39
Phila-NY Metroliner	0	0	0	0	0	224	1:02	128	0:05	57
NY-Washington Metroliner	69	3:03	29	0:04	42	218	2:29	125	0:05	57
Washington-NY Metroliner	70	3:03	57	0:04	81	218	2:26	154	0:06	71
Turn around Locals	186	6:18	136	3:24	73	86	6:19	145	3:44	78
Amtrak & Mail to West	38	1:38	24	0:05	63	38	1:38	20	0:05	53
Freights from Newark	96	3:13	52	0:17	54	96	3:03	62	0:21	65
Freights from Trenton	35	3:07	23	0:58	66	35	2:56	27	0:16	77
Freights from Phila.	79	2:29	34	0:24	43	79	2:13	54	0:16	68
Freights from Perry/Wilm.	66	2:53	41	0:15	62	66	2:57	39	0:17	59
Freights from Baltimore	20	1:06	11	0:27	55	80	1:16	12	0:25	60
Freights from Landover	64	5:31	49	0:27	76	64	5:44	53	0:29	83

(1) Delays are recorded in the simulation whenever a train is slowed or stopped because of interference with another train.

Figure 4-7
COMPARISON OF SIMULATION HISTORIES
IHSR-IA: 1975 VS. 1985 VOLUMES
NEW YORK CITY TO WASHINGTON

Class of Train	IHSR-IA Plan: 1975 Volumes					IHSR-IA Plan: 1985 Volumes				
			Delays (1)					Delays (1)		
	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed
Trenton-NY Commuter	157	1:24	94	0:04	60	157	1:24	101	0:04	64
New Brunswick-NY Commuter	269	1:04	177	0:05	66	269	1:03	171	0:05	64
Rahway-NY Commuter	286	0:42	175	0:05	61	410	0:38	259	0:05	63
Trenton-Phila. Commuter	236	0:55	94	0:04	40	252	0:56	107	0:04	42
Chestnut Hill Commuter	0	0	0	0	--	0	--	--	--	--
Phila.-Wilmington Commuter	305	0:50	193	0:04	63	335	0:51	241	0:04	72
Phila.-NY Express	0	0	0	0	--	0	--	--	--	--
NY-Phila. Express	0	0	0	0	--	0	--	--	--	--
NY-Washington Express	0	0	0	0	--	0	--	--	--	--
Washington-NY Express	0	0	0	0	--	0	--	--	--	--
NY-Phila. Metroliner	224	1:00	88	0:05	39	224	1:00	116	0:04	52
Phila-NY Metroliner	224	1:02	128	0:05	57	224	1:04	164	0:06	73
NY-Washington Metroliner	218	2:29	125	0:05	57	218	2:31	153	0:06	70
Washington-NY Metroliner	218	2:26	154	0:06	71	218	2:28	186	0:07	85
Turn around Locals	186	6:19	145	3:44	78	186	6:37	146	3:24	78
Amtrak & Mail to West	38	1:38	20	0:05	53	38	1:40	26	0:06	68
Freights from Newark	96	3:03	62	0:21	65	135	3:42	94	0:26	70
Freights from Trenton	35	2:56	27	0:16	77	44	2:46	33	0:22	75
Freights from Phila.	79	2:13	54	0:16	68	87	2:32	59	0:27	68
Freights from Perry/Wilm.	66	2:57	39	0:17	59	66	2:54	38	0:19	58
Freights from Baltimore	20	1:16	12	0:25	60	20	1:08	9	0:34	45
Freights from Landover	64	5:44	53	0:29	83	87	6:11	76	0:36	87

(1) Delays are recorded in the simulation whenever a train is slowed or stopped because of interference with another train.

Figure 4-8
COMPARISON OF SIMULATION HISTORIES
IHSR-IA: 1975 VS. 1995 VOLUMES
NEW YORK CITY TO WASHINGTON

	IHSR-IA Plan: 1975 Volumes					IHSR-IA Plan: 1995 Volumes				
			Delays(1)					Delays(1)		
Class of Train	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed	Number of Trains	Average Elapsed Time	Number of Trains	Average Per Train	Percent Delayed
Trenton-NY Commuter	157	1:24	94	0:04	60	157	1:25	120	0:05	76
New Brunswick-NY Commuter	269	1:04	177	0:05	66	269	1:04	186	0:06	69
Rahway-NY Commuter	286	0:42	175	0:05	61	448	0:38	314	0:04	70
Trenton-Phila. Commuter	236	0:55	94	0:04	40	252	0:56	130	0:04	52
Chestnut Hill Commuter	0	0	0	0	--	0	--	--	--	--
Phila.-Wilmington Commuter	305	0:50	193	0:04	63	335	0:52	244	0:05	73
Phila.-NY Express	0	0	0	0	--	0	--	--	--	--
NY-Phila. Express	0	0	0	0	--	0	--	--	--	--
NY-Washington Express	0	0	0	0	--	0	--	--	--	--
Washington-NY Express	0	0	0	0	--	0	--	--	--	--
NY-Phila. Metroliner	224	1:00	88	0:05	39	307	1:01	209	0:05	68
Phila-NY Metroliner	224	1:02	128	0:05	57	305	1:05	253	0:06	83
NY-Washington Metroliner	218	2:29	125	0:05	57	288	2:31	229	0:06	80
Washington-NY Metroliner	218	2:26	154	0:06	71	287	2:30	253	0:09	88
Turn around Locals	186	6:19	145	3:44	78	186	6:36	156	3:13	84
Amtrak & Mail to West	38	1:38	20	0:05	53	38	1:39	26	0:07	68
Freights from Newark	96	3:03	62	0:21	65	165	4:22	135	0:49	82
Freights from Trenton	35	2:56	27	0:16	77	52	2:40	40	0:21	77
Freights from Phila.	79	2:13	54	0:16	68	94	2:27	67	0:30	71
Freights from Perry/Wilm.	66	2:57	39	0:17	59	66	2:56	44	0:16	67
Freights from Baltimore	80	1:16	12	0:25	60	20	1:38	16	0:56	80
Freights from Landover	64	5:44	53	0:29	83	105	6:52	96	1:03	91

(1) Delays are recorded in the simulation whenever a train is slowed or stopped because of interference with another train.

Figure 4-9

ITEM SUMMARY OF ESTIMATES OF COST OF CONSTRUCTION

FOR NORTHEAST CORRIDOR IHSR-1A PLAN

1. System Improvements to Permit High Speeds

	Contract Cost in Millions[1]		
	Washington to New York	New York to Boston	Total Northeast Corridor
Upgrade Track	$ 29.0	$ 73.4	$ 102.4
Bridge Repairs	.9	5.3	6.2
Curve Revisions to increase super elevations and lengthen spirals	16.0	9.0	25.0
Revise Signal System	12.6	106.9	119.5
Right-of-Way Fencing	20.5	22.5	43.0
Sub Total	$ 79.0	$217.1	$ 296.1

2. Site Specific Improvements to Ease Congestion

	$ 70.2	$ 15.6	$ 85.5
Sub Total	$ 70.2	$ 15.6	$ 85.5

[1] Contract costs include costs of design, labor, material, contractor's contingency, overhead, and profit. They do not include costs incurred to the owner such as insurance, owner's overhead, and the cost of obtaining money. The costs also do not include the usual planning contingency for unanticipated conditions or changes nor do they include factors inadvertently omitted. Cost estimations are in 1972 dollars.

Figure 4-9

ITEM SUMMARY OF ESTIMATES OF COST OF CONSTRUCTION

FOR NORTHEAST CORRIDOR IHSR-1A PLAN (Cont'd)

3. Miscellaneous

Rehabilitated and New Electric Traction Power System - Budget	$ 45.0	$ 46.0	$ 91.0
Sub Total	$ 45.0	$ 46.0	$ 91.0

4. Improvement to Stations, Yards & Shops[1]

	Contract Cost in Millions		
	Washington to New York	New York to Boston	Total Northeast Corridor
Gating of intermediate commuter stations to permit safe high speed operation on outside tracks	$ 4.4	$ 1.5	$ 5.9
Additional car storage yards at New York (Sunnyside rehabilitation) and Boston (South Station Yard) of fifty (50) car capacity each	.8	1.0	1.8
(Incremental cost of $450,000 per additional fifty car storage capacity)			
Car maintenance shop with sufficient capacity for 200 car fleet, location Philadelphia	4.0	-	4.0
(Incremental cost of $1,000,000 per additional 50-car capacity)			
Passenger station, station access and station parking improvements-budget	28.8	12.0	40.8
New Station at Rye, N.Y.	-	18.2	18.2
Sub Total	$ 38.0	$ 32.7	$ 70.7
Total	$232.2	$311.4	$543.6

(1) These figures are budgeted in accordance with other reports submitted to FRA.

4.3.1 Upgrade Track. Track condition is fair to excellent on the two tracks used presently for the high-speed Metroliner demonstration between Washington and New York, including the third and fourth tracks in the Philadelphia to New York sections. Track condition is fair to poor between New York and Boston. This study estimates that 192 of the 252 track miles of main running track between New York and New Haven and 234 of the 292 track miles between New Haven and Boston will need replacement.

The upgrading of track consists of: laying new rail; renewing switches and frogs; renewing ties; raising the surface and the track; surface grind; cleaning ballast; cleaning ditches; and purchase of additional track maintenance equipment. The cost estimates for these items are detailed in Figures 4-10 and 4-11 in Section 4.4. It will provide a structure which can be maintained to these standards with reasonable effort.

The track work discussed here does not include upgrading of track work proposed under the category "New and Revised Facilities to Ease Congestion".

4.3.2 Bridge Repairs. We have considered bridges to be inadequate only where present condition requires authorized speeds below that otherwise attainable by the IHSR trains. Where inadequacies do exist, correction is considered only if it can be achieved by routine repair and maintenance, as opposed to replacement of structure. The estimated costs are for that work required to place bridges in a condition equalling the system average. Figures 4-12 and 4-13 list the estimated costs for required bridge repairs.

4.3.3 Curve Revisions to Increase Superelevation and Lengthen Spirals. Changes to track geometry are limited to increasing the superelevation of all restrictive curves to a six (6) inch maximum and resetting spiral lengths to AAR Standards (where the distance between reverse curves permits) to match superelevation and achievable speeds.

The estimates of the costs of these changes consider track and catenary realignment; corresponding minor changes to roadbed shoulder and drainage facilities; and revision or replacement of structures as required to maintain clearance where track throws are necessary for introduction of new spirals. The estimates assumed that all construction work would be phased in a manner sufficient to prevent major interruption to existing rail traffic. Figures 4-14 and 4-15 in Section 4.4 detail the work required by subsections of the Northeast Corridor.

4.3.4 Revise Signal System. Revision of the signal system between Washington and New York requires respacing of signals and addition to the number of aspects in order to permit both safe stopping distances and short headways. Between New York and Boston, the signals and some interlockings need to be respaced. They also need to be modernized and equipped for cab signals, Automatic Train Control, and Centralized Train Control operated from New Haven. The cost estimate includes only fixed facilities. It does not include equipping rolling stock with cab signals and train control.

The New York to New Haven section must be made uniform in signal aspect with the facilities west of New York. Signals between New Haven and Boston must be completely revised for operation with an electric traction power system.

This item also includes costs to provide remote control of interlocking plants at South Mt. Vernon, Rye, Greenwich, South Norwalk, Norwalk River Drawbridge, Saugatuck River Drawbridge, and Pequonnock River Drawbridge. Existing plants are obsolete mechanical types which cannot be remotely controlled from central tower locations. Costs in this item include replacement of mechanical switches with electrically activated power operated switch machines. Figures 4-16 and 4-17 detail the work required and the estimated costs.

4.3.5 Right-of-Way Fencing. The high speed trains create a potentially dangerous situation to children playing on the track and to people using the track as a shortcut. This makes necessary the complete right-of-way fencing to meet the safety requirement. The estimates (Figures 4-18 and 4-19) are based upon chain link fencing being used.

4.3.6 Grade Crossing Elimination. Elimination of all grade crossings is considered essential to meet safety requirements. Funds for this improvement are provided under the Federal Highway Act of 1970. They, therefore, have not been included in the summary of estimates.

4.3.7 New Communication Facilities. Existing communication facilities presently used by the Penn Central Railroad can be used. Therefore, there was no cost estimated for this item.

4.3.8 Site Specific Improvements to Ease Congestion. Minor changes to track arrangement and signal facilities are essential to the proposed additions of high-speed Corridor service to current levels of railroad traffic. Where new trains are to be operated with the existing freight and passenger service, the high sppeds will require clearing of slower speed trains sufficiently far ahead to provide stopping distance; the required high level of on-time performance necessitates spare track capacity to permit bypassing of all types of off-schedule or stalled traffic, and the proposed short headways of high speed trains will add greatly to the traffic levels. The improvements needed to relieve congestion are listed in Figure 4-20 and 4-23. Figures 4-21 and 4-22 contain some detailed itemization in the New York to Washington segment.

In the New York to Washington segment, the delay log of the TRANSIM run which included the IHSR plan modifications disclosed that excessive delays would occur to certain classes of trains at some points. The identified problems provided the basis for the following reccomendations made to relieve the congestion in addition to those included in the IHSR plan.

1. Problem: Commuter train delay at Wilmington. Northbound Wilmington commuter trains and high-speed trains must both occupy No. 1 track from Bell to Hook.

   Modification: Upgrade No. 2 track Bell to Hook, and change 12 crossover at Bell from a No. 10 to a No. 20. This will allow new passenger trains to use either No. 2 or 1 tracks from Bell to Hook. It will also reduce the new service running time by about 1 minute because normally it will not be necessary to make the diverting move at Hook.

2. Problem: Commuter train delay at Hook. Southbound Wilmington commuter trains and new passenger trains must both occupy No. 4 track between Hook and Bell. This, along with the number 1 problem above, caused an additional 31 trains to be delayed in the seven day simulation.

Modification: Upgrade No. 3 track, Hook to Bell, and change 13 and 26 crossovers from No. 19 to No. 20 crossovers. This will allow high speed trains to use either No. 3 or 4 tracks from Hook into Wilmington Station. It will also reduce the high speed train running time by about 1 minute because it will not be necessary to make the diverting movement at Hook.

3. Problem: Freight train delay at Zoo. Westbound freight trains are delayed at 33rd Street by the new train and commuter trains. This amounts to approximately 3 trains per day at 5 minutes each.

   Modification: Remove Zoo turnout 195 and relocate it into No. 2 track to the tail track. Provide crossover from No. 1 track, Suburban Line, to No. 4 track, River Line. This will allow Westbound high speed trains to move from No. 3 track to the River Line without using the duck under track. The interference to the freight trains is then removed.

4. Problem: Freight trains not routed to new No. 5 track between North Philadelphia and Zoo. Westbound freight trains were not allowed to use this track because of its use by yard engines as a switching lead at Margie Yard. This caused some delay to freight trains on No, 3 or 4 tracks.

   Modification: Provide a switching lead for Margie Yard that will allow Westbound freight trains to use No. 5 track without interfering with the yard operations.

5. Problem: Freight train delay at Linden. The Eastbound freight trains that must work at Linden during the commuter rush are usually delayed approximately 1 1/2 hours. This in turn causes the Eastbound high speed trains to be diverted to No. 3 or No. 1 track with delay of 2 to 3 minutes.

   Modification: Provide a holding track for freight trains so they can continue to work, which will reduce freight train delay and eliminate delay to high speed trains.

In the New York to Boston segment the train graph was analyzed to determine at what points excessive delay would occur to the various classes of trains. Consideration was also given to determining where traffic will be heavy enough to potentially cause massive delays when a track obstruction takes place. The track facility was also examined to determine where changes such as longer crossovers could reduce the running time of the high speed trains. The recommended improvements, additional to the IHSR Plan, to alleviate each of the problems identified are presented below.

1. Problem: Lack of flexibility on high speed crossovers at interlockings. Some interlockings are not complete, thereby restricting certain desirable diversions. In addition, some interlockings require high speed trains to use number 10 or 15 crossovers, which results in excessive loss of time.

   Modification: Make interlocking changes as follows:

   Market - Change the No. 10 crossover to a No. 15.
   Green - Change 41 crossover from a No. 15 to a No. 20.
   Stamford - Change 34 crossover from a No. 10 to No. 20.
   Berk - Change the 2 No. 10 crossovers between tracks 1 and 2 to No. 20 crossovers.
   Burr Road - Add a facing No. 20 crossover from No. 2 to No. 1 track.
   Central - Add a facing No. 20 crossover from No. 2 to No. 1 track.
   Woodmont - Add a facing No. 20 crossover from No. 2 to No. 1 track.
   Guilford - Restore interlocking and change 2 No. 15 crossovers to No. 20 crossovers.
   Groton - Change 2 No. 15 crossovers to 2 No. 20 crossovers.
   High Street - Change 1 No. 10 crossover and 1 No. 15 crossover to 2 No. 20 crossovers.

Modification: (Cont'd)

Kingston - Change 1 No. 10 crossover and 1 No. 15 crossover to 2 No. 20 crossovers.
Attleboro - Change 2 No. 15 crossovers to 2 No. 20 crossovers.
Canton Junction - Change 2 No. 15 crossovers to 2 No. 20 crossovers.

2. Problem: Lack of siding at West Kingston. Delay is incurred because of lack of a siding on the South side of the main tracks for holding freight trains.

   Modification: Provide a passing side for 160 car freight trains on the South side.

There were a number of problems and potential problems which do not have cost estimates associated with them in this report. These are discussed below.

The Westbound Chestnut Hill and Trenton commuter trains must occupy the same track at the tunnel at Zoo. This causes delay to the commuter trains. In one simulated day, 14 trains had an average delay of 3 minutes each at this point. The City of Philadelphia project to provide a physical connection between the Reading and Penn Central commuter stations in the center of the city contains a possible proposal to connect the Penn Central Chestnut Hill trains to operate over the Reading line into the center of the city. This operation will relieve the congestion at Zoo and it is proposed that the Northeast Corridor project progress under the assumption that this will take place and the cost of the connection will be absorbed by another agency.

Westbound freight trains that were routed to the new No. 5 freight track between Ford and North Philadelphia were delayed an average of 12 minutes by Chestnut Hill commuter trains. By assigning Westbound commuter trains from Trenton to this No. 4 track, Westbound high speed trains to No. 3 plus any open track, and Westbound freight trains to No. 4 during high speed train operation, delays to Westbound freight trains will be eliminated.

There are two main tracks between Penn Station and Harold which are jointly used by the Penn Central and Long Island Railroads. Analysis of the train graph indicates that during the morning and evening Long Island commuter peaks the high speed trains create interference which will result in considerable delay to both classes of service. On the operation day selected for graphing, there were Westbound Long Island trains that occupied the Harold to JO block as long as 20 minutes compared to the normal 7 minutes. This would cause an overtaking problem to high speed trains and resulting delay. If this blocking occurs frequently, the problem would be significant. There is also a problem at Harold where the Westbound high speed trains must mix with the Westbound Long island trains and also compete for route with other Long Island trains westbound for lines 3 and 4 into Penn Station. The high speed trains were plotted on the graph as per proposed schedule without consideration for daily variability. The variability can be expected to cause additional interference which is not reflected by the graph. The complexity of the problem dictates the need for a study in more depth before it is feasible to select suitable modifications to relieve the interference.

It is possible that the City of Boston and the State of Massachusetts will acquire the Penn Central main line between Back Bay and Readville for highway and rapid transit right-of-way. In this event, it will be necessary to reconstruct the Penn Central Dorchester Branch to provide railroad access to central Boston.

The high density of commuter service from Westchester County and Connecticut to New York presents a potential for severe interference between Shell, New York and Stamford, Connecticut. Major improvements to the commuter service are planned and underway. The assumption was made that the schedules of the new high speed trains and the commuter trains would be sufficiently integrated to provide the equivalent of four per hour frequency between New York and New Haven. This assumes a 30 minute new passenger service schedule.

4.3.9 Rehabilitated and New Electric Traction Power System. This includes revisions to existing catenaries from Washington to New Haven to permit higher speeds. It also provides for a new electric traction power system from New Haven to Boston. The Metropolitan Transit Authority and Connecticut DOT are now planning a new power source to provide 60 hz. power between New Rochelle and New Haven.

4.3.10 Commuter Station Gating. Flexible use of track is necessary to avoid congestion. This could require high speed trains to pass crowded platforms. Where the speed of trains is in excess of 100 m.p.h., injury to persons standing on the platforms adjacent to the tracks could easily result. A gating system is therefore needed to prevent passengers from entering a platform when a high speed train is due to pass. Costs for this system, to be installed at all commuter stations where speeds in excess of 100 m.p.h. can be expected, are shown in Figures 4-24 and 4-25.

4.3.11 Additional Car Storage Yards in New York and Boston. Presently car storage yards at Sunnyside in New York are being abandoned and the car storage yards in Boston may be torn down when South Station is renewed. Therefore, facilities for storage and for light maintenance, such as cleaning the insides of cars, making routine inspections, and performing minor adjustments, must be provided. The size of these facilities are dependent upon the fleet size with an incremental cost of $450,000 per additional fifty car storage capacity.

4.3.12 Maintenance Shops. Repair of multiple-unit type cars now operated by the Penn Central is done at the Paoli, Pennsylvania; the Wilmington, Delaware; and the Stamford, Connecticut shops. None of these are adequate in terms of capacity or condition. The Penn Central Company has long considered construction of a new facility at Penn Coach Yard in Philadelphia, which would be designed to handle maintenance of all m-u type commuter cars used in the New York, Philadelphia, Baltimore and Washington regions, as well as the existing Metroliner fleet. The ultimate 5-day, 3-shift capacity of their proposed shop could handle 190 high speed trains and 347 commuter m-u's. Beyond that fleet size, shop additions would be required. The cost estimate is for a shop addition to service a high speed train fleet of 200 cars. For additional fleet sizes, a cost of $1 million per 50 Metroliner-car increment would be required.

It is assumed that this shop will provide service in the form of major inspections and maintenance for the entire Northeast Corridor.

4.3.13 Passenger Stations, Station Access, and Station Parking Improvements. The cost estimates provided in this category are budgeted figures corresponding to suggested figures in other reports submitted to FRA. They do not include sums for the planned replacement of Union Station in Washington nor the planned replacement of the Lanham (Capital Beltway) station. The funds for these facilities are being budgeted by other agencies.

The high speed train schedule requires a station stop in the vicinity of Rye. There is a need for a new station with both inside and outside platforms. If the platforms of the suggested station were on the outside track, as they presently are, each train making a station stop would have to cross over from an inside to an outside track. This would cause a loss of time to the high speed train and congestion with the commuter trains.

Rye is in a built-up section and therefore the cost of land needed for expansion is expensive. The curvature in the Rye trackage needs to be rectified. The majority of the Rye costs are attributable not to the station structure but to necessary trackwork to provide space for the new platforms.

.4 COST ESTIMATES FOR MODIFICATIONS IN THE NORTHEAST CORRIDOR

This section presents cost estimates of the modifications of existing rail facilities required to permit operation of the new high speed trains in the Northeast Corridor. The estimates are contract costs; i.e. they include costs of design, labor, material, contractor's contingency, overhead and profit. They do not include costs incurred to the owner such as insurance, owner's overhead, and the cost of obtaining money. The costs also do not include the usual planning contingency for unanticipated conditions or changes nor do they include factors inadvertantly omitted. All types of upgrading presented in these sections are considered capital improvements and the higher cost of a better annual and continuing maintenance should be considered separately.

The cost estimates were based on (1) the initial IHSR Plan extracted from reports prepared by Louis T. Klauder, Inc., for the Department of Commerce and (2) modifications to the IHSR Plan suggested on the basis of this study's analysis. The Klauder reports are: "Estimated Capital Costs for Three High Speed Rail Systems in the Northeast Corridor, Report No. 1C-80-66, AM4", "Reports on Improvements to Railroad Passenger Service between New York and Washington", and "Preliminary Engineering Report on Possible Improvements to Railroad Passenger Service between New York and Boston".

The initial Klauder study of track upgrading, done in 1964 and 1965, examined railroad operations at 150 mph maximum to achieve 2 hour and 2 1/2 hour trip times between Washington and New York, and New York and Boston, respectively. In determining necessary track modifications, the studies entailed detailed field trips and cost analyses in co-cooperation with railroad officials. A supplementary Klauder report in 1970 reflected changes in services requirements, the deteriorating physical condition of railroad facilities and escalation of construction costs.

Where improvements recommended in this report were considered also in earlier studies, our cost estimates were based on such earlier studies. To the earlier costs, this study has escalated costs to 1972 dollars based on general heavy construction cost indices which were determined from the Engineering News Record. These cost escalation figures were adjusted by region within the Northeast Corridor. Typical multipliers used were: 1.9 for 1963 to 1972, 1.6 for 1968 to 1972, and 1.18 for 1971 to 1972. Where appropriate, costs for certain railroad specialty work were obtained from industry sources.

The changes from the Klauder report cost estimates reflect both the work performed for the Metroliner demonstration program and the continuing deterioration of other tracks. Track upgrading estimates were based on limited data on current maintenance levels supplied by Penn Central. The funds of this study precluded field inspections of the track.

This study's cost estimates for improvements to right-of-way facilities were based on reports on the necessarily high proportion of idle time incurred through the need to maintain rail traffic. Improvements to passenger stations and non right-of-way facilities are given as budget figures since insufficient information was supplied on projected passenger volume and the required level of user convenience.

Figure 4-10

UPGRADE TRACK

Washington - New York

Location	Contract Cost ($ millions)
Washington - Capital Beltway	$ .4
Capital Beltway - Baltimore	4.5
Baltimore - Wilmington	9.3
Wilmington - Philadelphia	3.6
Philadelphia - Trenton	4.6
Trenton - Metropark	2.0
Metropark - Newark	3.6
Newark - New York	1.0
Total (Washington - New York)	$29.0

Figure 4-11

UPGRADE TRACK

New York - Boston

Location	Contract Cost ($ millions)
New York - New Haven	$ 31.3
New Haven - Providence	32.3
Providence - Rte. 128	6.9
Rte. 128 - Boston	2.9
Total (New York - Boston)	$ 73.4

Figure 4-12

BRIDGE REPAIRS
UNDERGRADE BRIDGES NEEDING RENEWAL OR STRENGTHENING

Washington - New York

Location and Mile Post	Work	Contract Cost ($ Thousands)
16/35, Main Street Trainer, Pennsylvania	Renew Superstructure	$144
8/32 Glenolden, Pennsylvania	Renew Superstructure	776
Total (Washington - New York)		$920

Figure 4-13

BRIDGE REPAIRS

UNDERGRADE BRIDGES NEEDING RENEWAL OR STRENGTHENING
New York to Boston

LOCATION AND MILE POST	WORK	CONTRACT COST ($ thousands)
New York - New Haven		
7/73 Pelham Bay (Movable Span)	Correct deferred maintenance and install new miter rails	$450
3/13 Wolfe Lane	Correct deferred maintenance	12
8/18 Fenimore Road	Correct deferred maintenance	35
21/24 Atlantic Ave.	Correct deferred maintenance	110
32/26 Squgatuck River (Movable Span)	Correct deferred maintenance and install new miter rails	400
43/88 Pognomrock River (Movable Span)	Correct deferred maintenance and install new miter rails	400
Viaduct between bridges 42 and 43	Correct deferred maintenance	120
Miscellaneous		200
Subtotal		$1,727

Figure 4-13

BRIDGE REPAIRS (continued)

UNDERGRADE BRIDGES NEEDING RENEWAL OR STRENGTHENING
New York to Boston

LOCATION AND MILE POST	WORK	CONTRACT COST ($ thousands)
New Haven - Providence		
6/33 Farm River	Correct deferred maintenance	$ 35
34/65 Connecticut River (Movable Span)	Correct deferred maintenance and install new miter rails	425
50/41 Shaws Cove (Movable Span)	Correct deferred maintenance and install new miter rails	185
1/05 Thames River (Movable Span)	Correct deferred maintenance and install new miter rails	245
6/50 Palmers Cove	Correct deferred maintenance	85
23/35 Pawcatuck River	Correct deferred maintenance	95
0/11 Providence	Renew Superstructure	2,495
Subtotal		$ 3,565
Providence - Boston		
No Work		
Total (New York - Boston)		$5,292

Figure 4-14

CURVE REVISIONS TO INCREASE SUPERELEVATIONS AND LENGTHEN SPIRALS

Washington to New York

Curve Locations Name	Between Mile Posts	Contract Cost ($ thousands)
Washington - Capital Beltway		
Ardwick	127.38 - 127.80	164
Sub-total		164
Capital Beltway - Baltimore		
Springfield	121.83 - 122.16	84
Jericho Park	119.03 - 119.73	216
Severn Reverse	109.30 - 110.10	114
Patapsco	104.36 - 104.79	280
Halethorpe	102.74 - 103.13	196
Louden Park	100.07 - 100.42	144
Sub-total		1,034
Baltimore - Wilmington		
Chase	80.46 - 82.89	1,589
Perryman	69.69 - 71.26	898
Short Lane	66.15 - 66.77	351
Charlestown	54.30 - 55.70	330
Red Mill	45.27 - 46.04	456
Big Elk	43.60 - 44.81	399
Iron Hill	41.78 - 41.98	114
Christiania River	39.41 - 40.51	752
Ruthby	35.77 - 35.89	114
Newport	30.81 - 30.99	137
Sub-total		5,140

Figure 4-14

CURVE REVISIONS TO INCREASE SUPERELEVATIONS AND LENGTHEN SPIRALS (continued)

Washington to New York

Curve Locations Name	Between Mile Posts	Contract Cost ($ thousands)
Wilmington - Philadelphia		
Trainer	16.40 - 16.47	102
Highland Avenue	15.87 - 15.91	102
South of Chester	14.75 - 15.02	395
Sub-total		599
Philadelphia - Trenton		
East of 33rd Street	87.19 - 87.44	1,007
Ridge Avenue	86.32 - 86.46	182
Margie Street	85.38 - 85.52	354
North Philadelphia	84.80 - 85.14	593
Tacony	78.16 - 78.56	205
Cornwells Heights	72.11 - 72.61	274
East of Croyden	68.53 - 68.72	182
West of Bristol	66.55 - 68.04	2,090
Sub-total		4,887
Trenton - Metropark		
East of Trenton	55.99 - 56.40	113
Lawrence	50.21 - 50.63	262
East of Monmouth Junction	39.00 - 40.51	488
West of New Brunswick	33.72 - 34.27	631
East of New Brunswick	31.05 - 31.40	768
Janeway	30.15 - 30.72	486
Stelton	28.79 - 29.01	98
Sub-total		2,846

Figure 4-14

CURVE REVISIONS TO INCREASE SUPERELEVATIONS AND LENGTHEN SPIRALS (continued)

Washington to New York

Curve Locations Name	Between Mile Posts	Contract Cost ($ thousands)
Metropark - Newark		
East of Colonia	20.37 - 20.77	410
Rahway	19.39 - 19.42	34
West of North Rahway	18.86 - 19.02	57
East of North Rahway	18.22 - 18.46	23
West of Lane	12.26 - 12.55	627
Sub-total		1,151
Newark - New York		
Kearney Substation	7.27 - 6.90	228
Sub-total		228
Total (Washington - New York)		16,049

Figure 4-15

CURVE REVISIONS TO INCREASE SUPERELEVATIONS AND LENGTHEN SPIRALS

New York - Boston

Location	Number of Curves[1]	Route Miles	Contract Cost ($ thousands)
New York - New Haven	21	10.2	$ 5,322
New Haven - Providence	13	5.5	2,152
Providence - Boston	9	3.9	1,526
Total (New York - Boston)			$ 9,000

(1) These are curves which will not be revised in the process of upgrading or other required work. There are 21 curve revisions from New York to New Haven, 23 from New Haven to Providence, and 12 from Providence to Boston which are costed in other categories.

Figure 4-16

REVISED SIGNALS FOR HIGH SPEED OPERATION

Washington to New York

	Add 3 Codes In Direction Of Traffic And Provide for ATC	Replace Signals	Total Contract Cost ($ Thousands)
Washington - Capital Beltway	263	--	$ 263
Capital Beltway - Baltimore	1,571	--	1,571
Baltimore - Philadelphia	3,738	1,296	4,834
Philadelphia - Trenton	1,239	324	1,563
Trenton - Metropark	2,189	--	2,189
Metropark - Newark	910	906	1,816
Newark - New York	355	--	355
Total (Washington - New York)			$12,591

Figure 4-17

REVISED SIGNALS FOR HIGH SPEED OPERATION

New York to Boston

	Revisions & Additions for CTC	Revisions & Additions for ATC	Replace Signals	Total Contract Cost ($ thousands)
Sunnyside - New Rochelle	500	400		$ 900
New Rochelle - New Haven (1)(2)			28,000	28,000
New Haven - Boston			78,000	78,000
Total (New York to Boston)				$106,900

(1) All components of signal system will be replaced except reusable block and track components, switch power circuits, and signal control circuits.

(2) This estimate excludes improvements recently installed or now planned by MTA and ConnDOT.

Figure 4-18

RIGHT-OF-WAY FENCING

Washington - New York

Location	Approximate Requirement (fence miles)	Contract Cost ($ thousands)
New York Avenue to Fulton	70.0	
Union Jct. to Perryville	60.0	
Perryville to Wilmington	65.0	
Wilmington to Chester	19.0	
Chester to 30th Street	17.8	
Zoo to Morrisville	56.8	
Trenton to N. Elizabeth	84	
N. Elizabeth to S. Street	3.4	
Hudson to Portal	9.0	
Mileage Total	385.0	
Total Cost: 385 miles @ $53,000/fence mile =		$20,500

Figure 4-19

RIGHT-OF-WAY FENCING

New York - Boston

Location	Approximate Requirement (fence miles)	Contract Cost ($ thousands)
Sunnyside Jct. to Hell Gate approach	3.0	
Hunts Point to Pelham Bay	10.0	
Pelham Bay to Division Post (New Rochelle)	6.0	
New Rochelle to Norwalk	64.0	
Norwalk to New Haven	50.0	
New Haven to Boston	292.0	
Mileage Total	425.0	
Total Cost: 425 miles @ $53,000/fence mile =		$22,500

Figure 4-20

IMPROVEMENTS TO EASE CONGESTION
Washington - New York

Location	Contract Cost ($ Millions)
Washington to Capital Beltway	
Upgrade freight tracks for high speed operation. (1)	$ .4
Sub-total	$ .4
Capital Beltway to Baltimore	
Upgrade freight tracks for high speed operation (1)	$ 4.8
Reverse signal No. 1 track, Bowie to Odenton	.2
Reverse signal No. 2 track, Gwynn to Fulton.	.1
Additional track No. 4, east of Bowie (2)	2.4
Sub-total	$ 7.5
Baltimore to Wilmington	
Upgrade freight tracks for high speed operation. (1)	$ 8.6
Reverse signal No. 2 and 3 tracks, Landlith to Bell.	.2
Additional track No. 4, Charleston to Northeast. (2)	7.3
Additional tracks No. 1 and 4, Magnolia to Bush River. (2)	11.7
Sub-total	$27.8

Figure 4-20

IMPROVEMENTS TO EASE CONGESTION
Washington - New York

Location	Contract Cost ($ Millions)
Wilmington to Philadelphia	
Upgrade freight tracks for high speed operation (1)	$ 5.8
Electrify No. 5 track, Naaman to Hook.	.8
Install crossover, No. 5 to No. 4 tracks, Naaman.	.2
Install crossover, No. 1 to No. 4 tracks, Brill.	.2
New connection and upgrading of tracks No. 2 and 3, Hook to Bell (2 & 3)	1.0
New crossovers, revision to signals and catenary, Lamokin. (2)	1.2
New crossovers, revision to signals and catenary, Baldwin. (2)	.6
Sub-total	$9.8
Philadelphia to Trenton	
Electrify No. 0 track, Zoo to Shore.	$ 1.5
Install crossover, No. 4 to No. 5 tracks, Ford.	.2
Electrify No. 5 track, with new secondary track (for access to Margie Yard), Ford to North Philadelphia. (2 & 3)	1.3
Convert No. 0 siding to freight track, Grundy to Morrisville. (2)	1.9
Relocate No. 2 turnout at Zoo to connect rail track. (2)	.1
Install crossover, No. 1 to No. 4, Zoo (2)	.2
Sub-Total	$ 5.2

Figure 4-20

IMPROVEMENTS TO EASE CONGESTION (Cont'd)
washington - New York

Location	Contract Cost ($ Millions)
Trenton to Metropark	
Realign main and platform tracks, Trenton	$ 2.9
Lay additional track, County to Adams	1.2
Install turnout, No. 0 to No. 1 tracks, west of Adams.	.6
Install crossovers, No. 2 to No. 3 and No. 3 to No. 4 tracks, Edison	.5
New crossovers, revision to signals and catenary, New Brunswick. (2)	2.0
New crossovers, revision to signals and catenary, Colona. (2)	2.0
Convert track No. 6 to holding track, county to Mile 36. (2)	2.1
Sub-Total	$11.3
Metropark to Newark	
Install crossover No. A to No. 1 tracks, Rahway.	$ .2
Setoff tracks, Waverly and Passaic Branches.	3.1
Install turnouts at Lane jumpover.	.5
Lay additional track, (1 - 1 1/2 miles, including bridge).	1.0
Electrify new track.	.3

Figure 4-20

IMPROVEMENTS TO EASE CONGESTION (Cont'd)
Washington - New York

Location	Contract Cost ($ Millions)
New crossovers, revision to signals and catenary, Elmora and Lane. (2)	1.8
Holding track at Linden. (2 & 3)	.9
Sub-total	$ 7.8
Newark to New York	
Realign tracks, No. 0 to No. 5, Newark Station.	$ .4
Sub-total	$ .4
Total (Washington - New York)	$70.2

(1) Detailed estimate, Figure 4-21

(2) Detailed estimate, Figure 4-22

(3) Cost for this item was not included in previous IHSR study.

Figure 4-21

UPGRADING OF FREIGHT TRACKS
FOR USE BY HIGH SPEED TRAINS

Washington - New York

Location	Gross Track Miles	Less Minor Curve Easements	Net Mileage	Block	Mileage	Total Block Miles
			Track Miles			
No. 1 Track, Landover to Beltway	2.2	--	2.2	Wash - CB[1]	2.2	2.2
No. 1 Track, Landover to Vern	16.8	1.5	15.3	CB - Balt	15.3	
No. 3 Track, Vern to Winans	8.0	.8	7.2	CB - Balt	7.2	
No. 1 & 4 Winans to Gwynn	8.2	.8	7.6	CB - Balt	7.6	30.1
No. 1 & 3 River to Gunpow	20.0	4.9	15.1	Balt - Wilm	15.1	
No. 3 Bush Harve de Grace	24.0	2.2	21.8	Balt - Wilm	21.8	
No. 3 Northeast to Ragan	20.3	3.6	16.7	Balt - Wilm	16.7	53.6
No. 1 & 4 Bell to Brill	36.6	.6	36.0	Wilm - Phila	36.0	36.0

(1) CB: Capital Beltway

Wash: Washington, D. C.
Balt: Baltimore
Wilm: Wilmington
Phila: Philadelphia

Figure 4-21

UPGRADING OF FREIGHT TRACKS
FOR USE BY HIGH SPEED TRAINS (Continued)

Washington - New York

Location	Track Miles		Contract Cost ($ Million)
Washington to Capital Beltway	2.2		$ .4
Capital Beltway to Baltimore	30.1	Unit Cost $160,000 per Mile	4.8
Baltimore to Wilmington	53.6		8.6
Wilmington to Philadelphia	36.0		5.8
Total			$19.6

Figure 4-22

ADDITIONAL RUNNING TRACK, SIDINGS CONVERTED TO RUNNING TRACK, AND FREIGHT BY-PASS ROUTES
Washington - New York

Item	Quantity	Contract Cost ($ Million)
Additional track No. 4 position east of Bowie (5.7) routes miles)		
Install track on existing subgrade and bridges	5.7 miles	$ 1.6
Install contact wire	5.7 miles	.3
Traction power feeder connection		.03
Signal changes		.3
Turnouts, interlocked, electrified		.2
Total		$ 2.4
Additional track No. 4 position, Charlestown to Northeast (Mile 51.4 to 55.4)		
Revise undergrade bridge	5 each	$ 1.7
Realign existing track	8 miles	1.2
Realign contact wire	8 miles	.2
Realign crossover	2 each	.1
Prepare subgrade	4 miles	1.0
Install track	4 miles	1.1
Install turnout, interlocked, electrified	2 each	.2
Install crossovers, interlocked, electrified	3 each	.7
Revise support structure for catenary	L.S. (1)	.6
Install contact wire	4 miles	.2
Traction power feeder connection	L.S.	.02
Signal revision	L.S.	.3
Total		$ 7.3

(1) L.S. Lump Sum

Figure 4-22

ADDITIONAL RUNNING TRACK, SIDINGS CONVERTED TO RUNNING TRACK, AND FREIGHT BY-PASS ROUTES (continued)
Washington - New York

Item	Quantity	Contract Cost ($ Million)
Additional track No. 1 and 4 positions, Magnolia to Bush River		
Realign track	9 miles	$ 1.4
Prepare subgrade	9 miles	2.4
Lay new track	9 miles	2.6
Revise support structure for catenary	L.S.	2.0
Install contact wire	9 miles	.5
Traction power feeder connection	15 each	.1
Realign existing contact wire	9 miles	.3
Signal change	L.S.	.9
Turnout, interlocked, electrified	4 each	.5
Crossover, interlocked, electrified	4 each	1.0
		$11.7
Realign and connect tracks to provide for high-speed move from No. 2 and No. 3 tracks between Hook and Bell to enable use of north and southbound passenger tracks at Wilmington Station		
Remote control turnouts	3 each	$ .4
Track changes and realignment	L.S.	.1
Catenary and signal changes	L.S.	.2
Grading	L.S.	.1
Changes to undergrade bridges	L.S.	.2
Total		$ 1.0

Figure 4-22

ADDITIONAL RUNNING TRACK, SIDINGS CONVERTED TO RUNNING TRACK, AND FREIGHT BY-PASS ROUTES (continued)
Washington - New York

Item	Quantity	Contract Cost ($ Million)
Additional interlocking, Wilmington to Newark, New Jersey		
New crossovers, revision to signals and catenary	Lamakin	$ 1.2
New crossovers, revision to signals and catenary	Baldwin	.6
New crossovers, revision to signals and catenary	Zoo	.2
New crossovers, revision to signals and catenary	New Brunswick	2.0
New crossovers, revision to signals and catenary	Colonia	2.0
New crossovers, revision to signals and catenary	Elmora & Lane	1.8
Total		$ 7.8

Item	Quantity	Contract Cost ($ Million)
Electrify No. 5 track, with new secondary track for access to Margie Yard, Ford to Philadelphia		
Upgrade track	9,000 tf (1)	$ .2
Electrify track	9,000 tf	.4
Upgrade main line turnout	2 each	.1
New turnout, electrified and signalled	4 each	.5
New secondary track	2,000 ft.	.1
Total		$1.3

(1) tf = track feet

Figure 4-22

ADDITIONAL RUNNING TRACK, SIDINGS CONVERTED TO RUNNING TRACK, AND FREIGHT BY-PASS ROUTES (continued)
Washington - New York

Item	Quantity	Contract Cost ($ Million)
Relocate No. 2 turnout at Zoo to connect rail track		
Track relocations		
Catenary revisions		
Signal revisions		
Total		$ .1
Siding converted to freight tracks: Track No. 0, Grundy to Morrisville		
Rebuild track	31,800 tf	$ .7
Rebuild turnout	12 each	.2
Renew contact wire, adjust hangers	31,800 tf	.2
Added signals	L.S.	.4
Fencing	31,800 tf	.4
Total		$ 1.9

Figure 4-22

ADDITIONAL RUNNING TRACK, SIDINGS CONVERTED TO RUNNING TRACK, AND FREIGHT BY-PASS ROUTES (continued)
Washington - New York

Item	Quantity	Contract Cost ($ Million)
Convert Track No. 6 to holding track: County to Mile 36		
Rebuild track	16,000 tf	$ .3
Rebuild turnout	8 each	.04
Replace turnout	1 each	.03
Install contact wire system	16,000 tf	1.3
Signal revision	L.S.	.2
Fencing	16,000 tf	.2
Total		$ 2.1
Holding track at Linden		
R-W acquisition (20' wide over 1/2 length)	2 acres	$ .04
Grading	18,000 sy(1)	.06
Relocate catenary poles	5 each	.4
New track	8,000 tf	.3
Turnouts	2 each	.1
Total		$ .9

(1) sy = square yards

Figure 4-23

FACILITIES TO RELIEVE CONGESTION
New York to Boston

Item		Contract Cost ($ millions)
Grade Separation at Sunnyside Yard		$ 7.8
Replace Track and Crossover on New York Connecting RR		.7
Revisions to Interlockings South of New Haven		
Green, Berk @600,000	$ 1.2	
Market, Stamford, Burr Rd., Central, Woodmont @300,000	1.5	2.7
Revisions of Interlocking at New Haven Station and Cedar Hill		1.0
Revisions of Interlockings North of New Haven		
Canton Jct., Guilford, Groton Attleboro, Saybrook @175,000	$ .9	
Kingston @45,000	.4	
High St. @30,000	.3	
		1.6
Siding at W. Kingston		1.8
Total (New York - Boston)		$ 15.6

Figure 4-24

STATION GATING & ASSOCIATED FACILITIES
NECESSARY TO PERMIT SAFE HIGH SPEED
OPERATION ON OUTSIDE TRACKS

Washington - New York

Item	Contract Cost ($ thousand)
Capitol Beltway to Baltimore	
Seabrook, Bowie, Jerico Park, Odenton, Halethorp, Frederick Rd. - $50,000/station	$ 300
Baltimore to Wilmington	
Aberdeen, Newark - no protection	--
Wilmington to Philadelphia	
Edge Moor, Claymont, Naaman, Marcus Hook, Trainer, Highland Ave., Lamokin, Chester, Eddystone, Baldwin, Crum Lynne, Ridley Park, Moore, Norwood, Glenolden, Folcroft, Sharon Hill, Curtis Park, Darby - $100,000/station	1,900
Philadelphia to Trenton	
Frankford, Bridesburg, Wissonoming, Tacony, Holmesburg, Torresdale, Andalusia, Cornwells Heights, Eddington, Croydon, Briston. Levittown - $100,000/station	1,200
Trenton to Metro Park	
Princeton Junction, New Brunswick, Edison, Metuchen - $100,000/station	400
Metro Park to New York	
Iselin, Colonia, Rahway, N. Rahway, Linden, N. Elizabeth - $100,000/station	600
Total (Washington - New York)	$4,400

Figure 4-25

STATION GATING & ASSOCIATED FACILITIES
NECESSARY TO PERMIT SAFE HIGH SPEED
OPERATION ON OUTSIDE TRACKS

New York - Boston

Item	Contract Cost ($ thousand)
New York to New Haven	
Larchmont, Mamaroneck, Greenwich, Cos Cob, Riverside, Old Greenwich, Stamford, Glenbrook, Noroton, Strafford, Milford - $100,000/station	$ 1,100
New Haven to Providence	--
Providence to Route 128	
Attleboro, Mansfield, E. Foxboro, Sharon, Canton, - $50,000/station	250
Route 128 to Boston	
Hyde Park, Mount Hope - $50,000/station	100
Total (New York to Boston)	$ 1,450

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