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IMPROVED PASSENGER SERVICE FOR THREE CORRIDORS

APRIL 1973

FINAL REPORT

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Prepared for

DEPARTMENT OF TRANSPORTATION

FEDERAL RAILROAD ADMINISTRATION

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

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16. Abstract

This study identifies and estimates the cost of right-of-way facility improvements necessary to provide for improved passenger trains operating at maximum speeds of 120-150 mph in three transportation corridors; Chicago-Detroit, Portland-Seattle, and Los Angeles-San Diego.

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 rail operation. A train interference analysis indicated facility modifications were required to relieve the congestion caused by the improved passenger service at specified frequencies. This investment includes upgrading additional tracks and providing additional interlockings. Additional investment is required to improve stations, yards, maintenance shops, and traction power systems.

In the Chicago-Detroit Corridor the total cost of modifications is $64 million; in the Portland-Seattle Corridor the total cost of modifications is about $27 million; and in the Los Angeles-San Diego Corridor the total cost of modifications is $26 million.

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Major portions of the analysis were performed by subcontractors to whom recognition and thanks are due. 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 from Mr. Kenneth L. Lawson, the Technical Officer, and his assistant, Mr. Steven R. Ditmeyer, was much appreciated.

LIST OF FIGURES

1. 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 addresses improved passenger service for three corridors: Chicago - Detroit, Los Angeles - San Diego and Seattle - Portland. The other volume, entitled "Improved Passenger Service for the Northeast Corridor", deals with improvements of service between Boston and Washington. 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 analyses reported in this volume required the collection of base data on the configuration and condition of tracks and the current patterns of freight and commuter traffic for each of the corridors studies. The analyses of improved passenger train (IPT) service in these corridors consisted of computer analyses of train performance and graphic analyses of interference and congestion. The study could not, as was the case in the Northeast Corridor, rely on an extensive body of previous analyses, simulation and cost estimating.

In addition, there are several other limitations deserving recognition. The graphic analysis of interference was limited to a single typical day. Neither the base data nor proposed modifications 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)

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

Currently, Penn Central rules prevent freight trains and other trains operating in excess of 100 mph from passing each other on adjacent tracks. This problem, which would affect the Detroit - Chicago Corridor, has not been resolved.

In presenting the results of the study, this volume 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 are presented.

2. SUMMARY OF FINDINGS

In general, the provision of Improved Passenger train (IPT) service in the three corridors studied requires facility modifications to permit higher speeds and to reduce interference between IPT's and freight and commuter trains. The estimated costs of construction to complete these modifications are summarized in Figure 2-1. These estimates are based on 1975 traffic levels and 1972 dollars.

In the Chicago - Detroit Corridor, the total cost of modifications is estimated to be $64 million. The improvements needed to provide high speed performance and miscellaneous items are estimated to cost approximately $50 million. Because of the many grade crossings, this investment will permit maximum speeds of 120 mph rather than 150 mph as in the other corridors. The resulting non-stop time is about 3 1/2 hours, assuming no delays. Additional analysis showed that the judicious selection of additional grade crossings for elimination and curves for greater super-elevation could significantly improve on this performance. Equipment capable of 150 mph speeds could achieve an additional savings of 20 minutes if 35 key grade crossings were eliminated. In this corridor it appears wise to invest more in grade crossing elimination and less in high speed equipment and curve work.

The additional modifications needed to relieve congestion in the Chicago - Detroit Corridor will cost approximately $14 million. Nearly $11 million of this investment is for an additional running track in the Toledo Station area. This is required because the IPT's both enter and leave Toledo via the same tracks, using facilities that are currently highly congested.

The Seattle-Portland IPT service provides non-stop running times of approximately 3 hours for $27 million investment in facility improvements. Approximately $17 million is needed for improvements to achieve higher speeds and for miscellaneous items. The major limitation on performance in this corridor is the high frequency of curves and their associated speed limitations. Although the equipment is capable of 150 mph maximum speeds, actual speeds seldom exceed 120 mph and are usually below 100 mph. IPT service in this corridor also requires approximately $10 million worth of facilities to relieve congestion. Almost $8 million of this is for an additional track to avoid interference with slow moving freights south of Vancouver.

The San Diego - Los Angeles Corridor requires an estimated $26 million in improvements almost all of which are required to meet high speed standards. This would provide running times of about 1 3/4 hours. Although this route is single track for major portions, it appears to have excess capacity at current traffic densities. As a result, the

Figure 2-1

IPT IMPROVEMENTS ANALYSIS
SUMMARY OF RESULTS, 1975 VOLUMES

Corridor	Distance in miles	Non-stop Running Time (1) (Hours:min.)	Frequency of IPT Service (trains per day)	Contract Cost of Improvements (In Millions of 1972 Dollars)			
				To Achieve Higher Speeds	To Relieve Congestion	Miscellaneous	Total
Chicago - Detroit	292	3:28	8	$ 27.6	$ 13.7	$ 22.4	$ 63.7
Seattle - Portland	187	3:08	8	$ 9.7	$ 9.7	$ 7.0	$ 26.4
San Diego - Los Angeles	128	1:40	8	$ 14.7	$ .3	$ 10.8	$ 25.8

(1) From Train Performance Calculations

investment required to relieve congestion is minimal. Analyses for 1985 and 1995 traffic volumes showed that in most cases, no additional facilities would be needed after the 1975 investments.

3. APPROACH AND METHODOLOGY

The identification and costing of the additional facilities needed for IPT 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, and safety facilities needed to permit higher maximum speeds and are necessary regardless of the volume of passenger or other rail services.

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 IPT, freight, and commuter services using the same track. Simulation of interference between trains using the same facilities was performed manually for all three corridors. The interference analysis 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. 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 units and resistance of the trailing load to find incremental times and distances. The tractive effort of the power units is a function of its weight and horsepower. The equipment specifications and necessary operating assumptions summarized in Figures 3-2, 3-3, and 3-4 will be discussed in more detail below.

Figure 3-1

FLOW DIAGRAM OF IPT INTERFERENCE
ANALYSIS AND COST ESTIMATION PROCEDURE

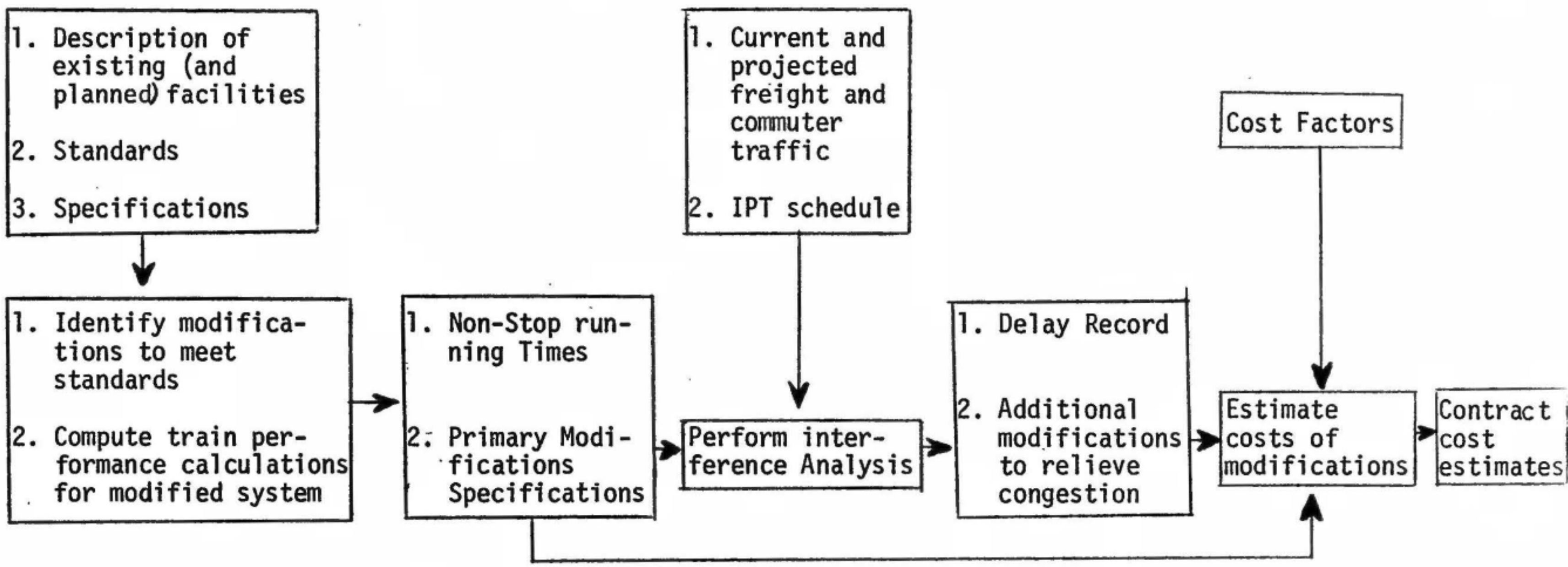

Figure 3-2

EQUIPMENT SPECIFICATIONS AND OPERATING ASSUMPTIONS

Chicago to Detroit

1.	Equipment	
	Tractive effort	Equal to Metroliner
	Deceleration	Equal to Metroliner
	Maximum authorized speed	120 miles per hour
	Maximum curve speed	Equal to Metroliner(1)
2.	Maximum Authorized Speed Over Highway Crossings	100 miles per hour. Train not to accelerate from a crossing unless there is a minimum distance of one mile before next crossing.
3.	Schedules	
	Frequency	Every 2 hours
	Initial station departures	Chicago - 8 AM and every 2 hours until last train at 10 PM. Detroit - Same as Chicago
	Intermediate station stops	South Bend, Toledo
4.	Limits on Modifications	Alignment changes not to be considered. Use existing station sites.

(1) The original planning accepted AAR recommendation of a 3 1/2 inch unbalance. This is now limited to 3 inches by the Federal regulation.

Figure 3-3

EQUIPMENT SPECIFICATIONS AND OPERATING ASSUMPTIONS

Seattle to Portland

1.	Equipment	
	Tractive effort	Equal to Turbo Train
	Deceleration	Equal to Turbo Train
	Maximum authorized speed	150 miles per hour
	Maximum curve speed	FRA standard plus 40%
2.	Maximum Authorized Speed Over Highway Crossings	110 miles per hour. Train not to accelerate from a crossing unless there is minimum distance of one mile before next crossing.
3.	Schedules	
	Frequency	Every 2 hours
	Initial station departures	Seattle - 8AM and every 2 hours until last train at 10 PM.
		Portland - 8:30 AM and every 2 hours until land train at 10:30 PM.
	Intermediate station stops	Centralia, Tacoma
4.	Limits on Modifications	Alignment changes not to be considered. Use existing station sites.

Figure 3-4

EQUIPMENT SPECIFICATIONS AND OPERATING ASSUMPTIONS

Los Angeles to San Diego

1. Equipment

Tractive effort	Equal to Turbo Train
Deceleration	Equal to Turbo Train
Maximum authorized speed	150 miles per hour
Maximum curve speed	FRA standard plus 40%

2. Maximum Authorized Speed Over Highway Crossings — 110 miles per hour. Train not to accelerate from a crossing unless there is minimum distance of one mile before next crossing.

3. Schedules

Frequency	Every 2 hours
Initial station departures	Los Angeles - 8 AM and every 2 hours until last train at 10 PM.
	San Diego - Same as Los Angeles
Intermediate station stops	Anaheim

4. Limits on Modifications — Alignment changes not to be considered. Use existing station sites.

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 were abstracted from track charts furnished by the carriers in each corridor.

The equipment specifications used in the study are given below. The Turbotrains specifications were used in the Los Angeles - San Diego and Portland - Seattle corridors, while Metroliner specifications were used in the Chicago - Detroit corridors.

	Metroliners	Turbo Train
Builder	Budd Company	United Aircraft
Power Units	6	2
Trailer Units	0	3
Revenue Units	6	5
Train Weight	505.2 tons	164.3 tons
Train Length	510 feet	297 feet
Train Axles	24	8
Train Horsepower	7200	3060

The program also recognizes artificial restraints on speed imposed by administrative or engineering practice. This information was abstracted from track charts, employee timetables, 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 Chicago - Detroit Corridor to take advantage of the deck of track cards already developed by the PC.

3.3 INTERFERENCE ANALYSIS

The interference analysis employed a graphic representation of a sample day's actual track activities by time, location, and track number. Proposed IPT service was then superimposed on the graph of actual traffic, and conflicts were resolved by reassignment of tracks and identification of additional facility modifications.

Data were extracted from dispatcher's records of train movements and Centralized Train Control (CTC) computer based graphs of train movements in sections where CTC was operative. 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 has 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 interlocking. 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. The CTC graphs, when available, gave a more detailed record of train movements including track assignments. The data were taken from this source whenever possible.

The projected schedules for the IPT's were then superimposed in 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 cross-overs 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, one 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 IPT's 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.

3.4 SELECTION OF ADDITIONAL FACILITIES TO RELIEVE CONGESTION - 1975 TRAFFIC VOLUMES

The train graph analysis for each of the corridors produced records of the delays caused to each class of train at key locations. The identification of the additional facilities needed to relieve congestion was based upon the delay records and upon the description of existing facilities provided by timetables, track charts, and interlocking diagrams. It is important to note that because of time constraints, none of the proposed facility modifications have, at this time, been field checked.

The objective in identifying additional facilities was to fully eliminate IPT caused delays. As a result, the facilities and associated costs represent an upper limit. Additional analysis of the minutes of delay avoided per dollar of facility cost and subsequent negotiation of "acceptable" delay levels with the railroads may reduce the required costs.

3.5 INTERFERENCE ANALYSIS - 1985, 1995 TRAFFIC VOLUMES

The basic train graph analysis was conducted at 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. 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.

Forecasts of traffic volumes for 1985 and 1995 were used to determine the number of other trains that would be operating on the same facilities. The forecasts were stated as percentage increases over the base year of 1975. These forecasts are displayed in Figure 3-5. They were projected from estimates of rail demand prepared for the DOT.[1]

After the forecasts were made, it was necessary to translate the percentage increases in Figure 3-4 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 would be used directly to calculate increases in trains.

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

Figure 3-5

FREIGHT VOLUME FORECASTS - 1985 AND 1995

Percent Increase Over 1975[1]

	1985	1995
Chicago-Detroit	27	61
Los Angeles-San Diego	25	56
Portland-Seattle	25	56

[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.

4. IPT RESULTS

For each corridor, four types of results will presented:

1. Description of the Modifications
2. Velocity Profile
3. Summary of Delays
4. Costs of Establishing the IPT's.

The descriptions of the modifications are the improvements recommended for the respective railroad systems. To determine the improvements necessary, the train graph was analyzed to identify at what points excessive delay occurred to the various classes of trains. In some instances, consideration was given to determining where traffic was congested enough to cause massive delays when a track obstruction takes place. The curve geometry was also examined to determine changes which would result in an improvement in IPT running time.

Some improvements to the systems are necessary to permit high level running speeds, thereby reducing running times and fully using the IPT's capacity. Others are necessary to ease congestion which will result from the increased traffic which the system will need to accommodate.

The velocity profiles as shown in Figures 4-1, 4-11, and 4-19 indicate the average speeds over the designated distances. The profiles demonstrate the speed restrictions inherent in the modified railroad system as discussed in Section 3.2.

The summaries of delays, as shown in Figures 4-2, 4-12, and 4-20 are derived from the 1975 train graph analyses and are the bases for those improvements to the present railroad systems recommended to ease congestion. It was determined by further analyses that the modifications will be adequate for the functioning of the system in 1985 and 1995, though some additional improvements will possibly be necessary after 1995 in all corridors.

The cost estimates are contract costs of construction. The summary and some detail cost estimates for Detroit-Chicago are found in Figures 4-3 through 4-10; for Portland to Seattle, in Figures 4-13 through 4-18; and for San Diego to Los Angeles in Figures 4-21 through 4-24. They include cost 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, nor the cost of obtaining money. They also do not include the usual planning contingency for unanticipated conditions or changes, nor factors inadvertently omitted. All types of upgrading presented in these sections are considered capital improvements and the higher cost of better annual and continuing maintenance should be considered separately. The reader should be warned against a false appearance of accuracy in the estimates given by the detailed costs having not been rounded to their approximate level of inherent accuracy. All cost estimates are in 1972 dollars.

4.1 RESULTS OF THE CHICAGO - DETROIT ANALYSIS

The main problems in this corridor are the potential congestion caused by using one set of tracks for trains both entering and leaving Toledo, and the numerous grade crossings which the IPT's must cross at restricted speeds. The suggested remedy of an additional track in the Toledo area is the largest item of those necessary to relieve track congestion. The grade crossing problem was not resolved. The track profile reflects this restriction of the IPT's average speed.

4.1.1 Descriptions of Modifications - Detroit to Chicago.

4.1.1.1 Upgrade Track. Considering the age and condition of some of the existing tracks, it will be necessary to replace or rehabilitate some of the trackage. The cost estimates were based on an analysis of maintenance records for a sample portion of the track. Pennsylvania Central indicated that track conditions throughout the corridor were uniform, particularly with regard to rail type and age, and tie age.

This cost is for replacement of rail and surface raise along 80% of the route: replacement of 130 ties per mile (4%); placement of ballast with surface raise on 54% of the track not receiving replacement rail; and rebuilding of the main track components of all switches. The unit cost was applied only to route segments where present speeds would be increased.

4.1.1.2 Curve revisions to increase super-elevation and lengthen spirals. The selection of curves to be revised was made by comparison of the speed made possible by increasing super-elevation or lengthening the spiral with other constraints such as grade crossings, ordinances, bridges, etc. If the latter constraint still controlled the operating speed, there is not a proposed modification.

4.1.1.3 Signal revisions to permit higher speeds are as follows:

1. Respace Signals - The maximum authorized speed of 120 mph will require respacing of signals to compensate for the increased braking distance. This will entail the following work: revisions and additions to signal control machines; installation of insulated joints, signal bridges, battery boxes and associated equipment; and revision of signal circuits. The respacing of signals will be necessary in the following segments:

   West Detroit to Swan creek
   Swan Creek to Whiting

2. Install Automatic Train Stop- In order to comply with Federal regulations, it will be necessary to provide an automatic train stop where it does not now exist and where IPT's will operate in excess of 79 mph. It is, therefore, recommended that an automatic train stop be provided in the following segments:

   Mill to Swan Creek
   Swan Creek to Whiting

3. Revise grade crossing protective signals. Existing protective signals must be retimed at ten locations to provide for higher train speeds. (Train speeds above 100 mph will not be permitted at any highway grade crossing.)

4.1.1.4 Loop track at Toledo Station. Construction of a loop track at Toledo Station will reduce trip time by permitting a through operation. Dwell time will be reduced by avoidance of brake checks and the change of control position at the end of the train.

4.1.1.5 New main track is necessary to relieve congestion as follows:

1. Problem: Traffic congestion, Toledo Station to Nasby. This is a congested route at the present time. The addition of IPT's will contribute to greater congestion especially between Swan Creek and the Station where the same train will traverse the route twice.

Modification: Provide an additional main train with reverse signals between CP 288 and Nasby.

2. Problem: Bottleneck, Lake Branch. This connecting link between the Main Line, Buffalo to Chicago and the Main Line, Pittsburgh to Chicago is constrictive because it is only a single track.

   Modification: Provide an additional main track with reverse signals between Whiting and Lake Junction.

4.1.1.6 Signal revisions to permit reverse operation.

Problem: Lack of flexibility, South Bend to Chicago Union Station and West Detroit to Swan Creek. The IPT's must have the flexibility to run around slower moving freight. Some of these segments do not have reverse signals which are necessary for this flexibility.

Modification: Provide reverse signals in the following segments:

HF to JD	Both tracks
NE to HC	Both tracks
Colehour Jct. to Englewood	Tracks 1, 2, 4
Englewood to South Branch Bridge	Tracks 1, 2
Mill to Dunbar	Both tracks
Dunbar to LaSalle	Southward track
LaSalle to Swan Creek	Both tracks

4.1.1.7 Interlocking Revisions and Additions

Problem: Traffic congestion, West Detroit to Swan Creek. The addition of IPT's will cause congestion and delays to freight trains in this area. Most of this railroad does not have reverse signals and some interlockings are not complete.

Modification: The provision of reverse signals from Mill to Dunbar is recommended in the preceding category. In addition to these signal changes, there is need for interlocking changes as follows:

LaSalle - Change the No. 10 crossover to a No. 20 and add a No. 20 crossover in the opposite direction.

Alexis - Change the No. 15 crossover to a No. 2 and add a No. 20 crossover in the opposite direction.

4.1.1.8 Miscellaneous. Platform revisions are needed to make them compatible with IPT's equipment needs. Station improvements and refurbishments, train maintenance and inspection facilities, and right-of-way fencing are budgeted figures, i.e., a detailed estimate was not done but the costs given should provide adequate funds.

Figure 4-1

IPT VELOCITY PROFILE
FROM DETROIT TO CHICAGO

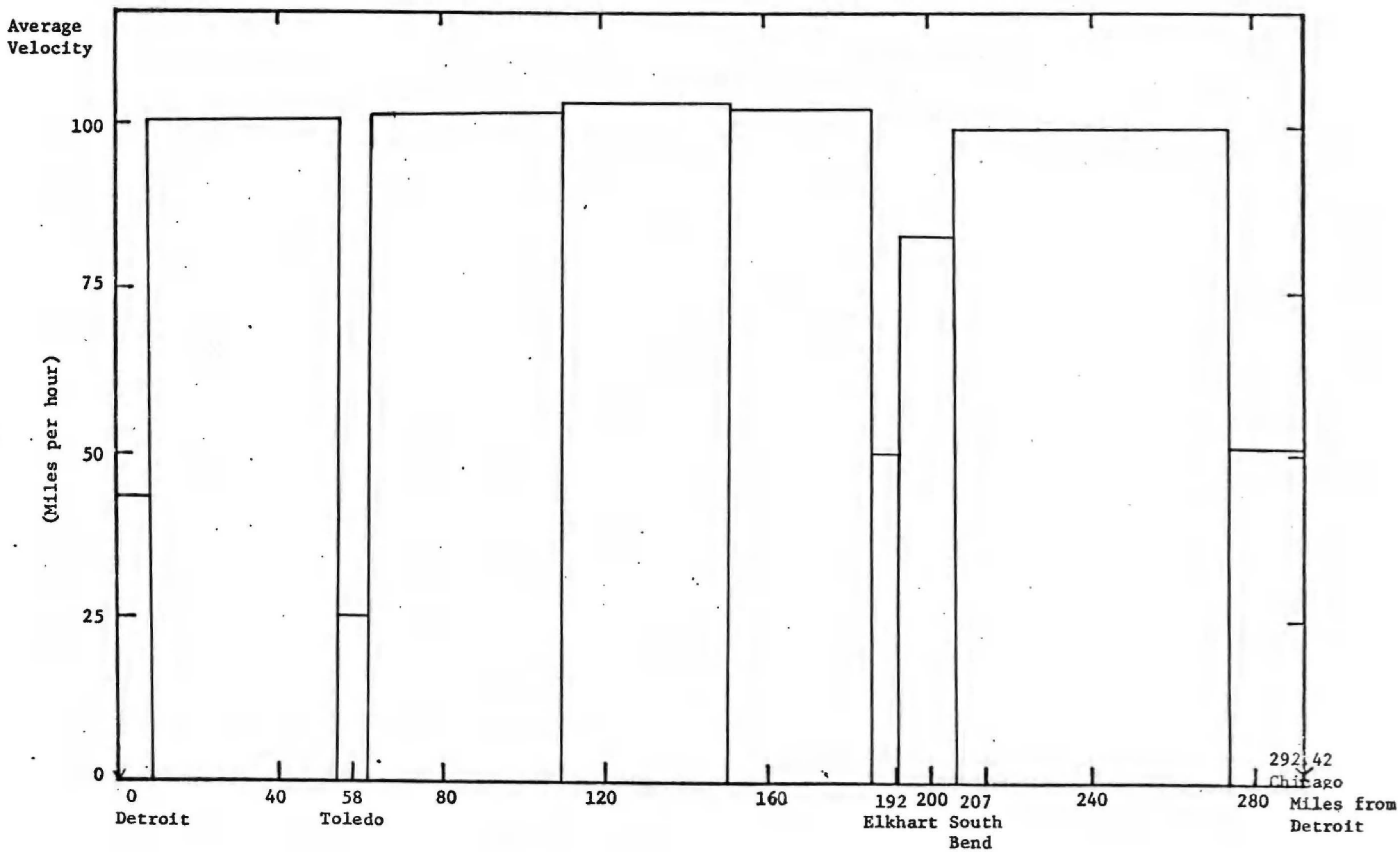

Figure 4-2

DELAYS INCURRED DUE TO IPT INTERFERENCE IN THE CHICAGO TO DETROIT CORRIDOR (1)

Type of Train / Location of interference	IPT			Freight		
	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed (2)	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed (2)
Lake Jct.	1	2.0	6			
W. Po				1	12.0	3
JO				2	31.0	5
WR	2	4.5	12			
HF, So. Bend	2	3.5	12			
CP-WG				2	2.0	5
CP-395				1	7.0	3
CP-379	1	18.0	6			
Cr-317				1	24.0	2
Alexis				2	22.5	5

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

(2) This is the percentage of delayed trains in each class at each point. For example: 6% of the IPT's which passed Lake Jct. during the course of the day were delayed, 94% were not; 3% of the freight trains which passed W. Po during the course of the day were delayed, 97% passed without delay.

Figure 4-3

SUMMARY OF THE ESTIMATED COST
OF CONSTRUCTION FOR THE
DETROIT - CHICAGO IPT

	Contract Cost (Millions of 1972 Dollars)
Improvements to Permit Higher Level Speeds	
Upgrade Track	$ 17.8
Bridge Repairs (1)	--
Curve Revisions to Increase Super-elevation and Lengthen Spirals	3.2
Signal Revisions to Permit Higher Speeds	4.8
Loop Track at Toledo Station	1.8
Sub Total	$ 27.6
Improvements to Ease Track Congestion	
New Main Track	$ 11.7
Signal Revisions to Permit Reverse Operation	1.5
Interlocking Revisions and Additions	.5
Sub Total	$ 13.7
Miscellaneous	
High Level Platforms at Detroit, Toledo & Chicago Union Station	$ 2.4
Other Station Improvements & Refurbishments	5.0
Train Maintenance Facilities	5.0
Right-of-Way Fencing	10.0
Sub Total	$ 22.4
TOTAL	$ 63.7

(1) Not evaluated

Figure 4-4

UPGRADE TRACK TO
PERMIT HIGHER SPEEDS

Detroit - Chicago

Location		Net Route	Unit Cost	Contract Cost
From Mile Post	To Mile Post	Miles	($ thousands)	($ thousands)
5	55	50		
60	187	127		
196	206	10		
208	274	66		
TOTAL		253	$70.3	$17,786

Figure 4-5

CURVE REVISIONS

Detroit-Chicago

Contract Cost (In Thousands of Dollars)

	Mile Post From	Mile Post To	Throw Feet	Prepare Roadbed	Throw Track	Revise Switches	Revise Hwy Crossings	Revise Bridges	Total
M.P. From Detroit	5.2	5.3	3.1	$ 3	$ 13	--	--	$ 200	$ 216
	5.9	6.6	2.0	14	55	$ 20	$ 8	200	297
	6.7	6.9	2.9	5	20	--	--	--	25
	7.8	7.9	3.9	3	14	--	8	--	25
	17.1	17.3	3.1	5	19	20	--	--	44
	35.8	36.0	3.1	5	19	--	16	--	40
	39.9	40.0	2.3	6	14	--	--	--	20
	47.0	47.2	2.0	5	21	--	--	200	226
	56.0	56.8	3.1	14	58	20	8	200	300
M.P. From Buffalo	290.1	290.3	1.6	5	20	--	--	--	25
	421.0	421.9	3.2	16	64	60	24	200	364
	422.4	422.7	2.0	7	28	--	--	200	235
	436.5	436.7	3.1	5	19	--	24	--	48
	436.9	437.3	1.9	8	34	40	24	--	106
	451.9	452.6	1.6	14	55	--	--	--	69
	470.4	470.8	2.4	9	35	--	--	--	44
	471.0	471.7	0.3	--	54	--	--	--	54
	472.1	472.8	1.2	14	54	--	--	200	268
	473.8	474.1	0.2	--	27	--	--	--	27
	484.1	485.3	0.5	--	88	20	--	400	508
	503.0	503.2	1.9	5	18	20	--	--	43
	503.9	504.1	2.0	6	22	--	--	--	28
M.P. From Pitt.	452.4	453.3	2.3	17	67	--	--	--	84
	455.2	455.5	2.8	7	29	--	--	--	36
	460.3	460.4	2.6	3	13	--	--	--	16
	462.0	462.1	2.3	3	11	--	--	--	14
	462.4	462.8	2.0	8	32	--	--	--	40
	462.9	463.0	2.1	3	11	--	--	--	14
	TOTAL	--	--	$190	$914	$200	$112	$1,800	$3,216

Figure 4-6

SIGNAL REVISIONS TO PERMIT HIGHER SPEEDS

Detroit - Chicago

Location	Number of Locations	Unit Cost ($ thousands)	Contract Cost ($ thousands)	Item Subtotal ($ thousands)
I. Respace Signals				
W. Detroit to Swan Creek	11	$ 40	$ 440	
Swan Creek to Whiting	38	40	1520	
Sub Total				$ 1960
II. Install ATS				
Mill to Swan Creek	36	$ 16	$ 576	
Swan Creek to Whiting	120	16	1920	
Sub Total				2496
III. Revise Grade Crossing Protective Signals				
Detroit to Chicago	42	$ 8	$ 336	
Sub Total				336
TOTAL				$4792

Figure 4-7

LOOP TRACK AT TOLEDO STATION

Detroit - Chicago

Item	Number	Unit Cost ($ thousands)	Contract Cost ($ thousands)
Undergrade bridge	2	320	$ 640
Grade Right-of-Way	4000 r.f.[1]	.8/r.f.	320
Track	4000 r.f.	.8/r.f.	320
Turnouts	2	80	160
Station Area Revision			320
TOTAL			$1760

(1) r.f. = route feet

Figure 4-8

NEW MAIN TRACK
DETROIT-CHICAGO

Location	Item	Quantity	Unit Cost ($ thousands)	Contract Cost ($ thousands)
CP 288 to Nasby (4 mi) (Toledo Station Area)	Property Acquisition	---	---	$ 1,016
	RR Overpasses	3	400	1,200
	New Highway Overpasses	9	400	3,600
	New Grade Crossings, Protected	23	40	920
	Highway & Utility Changes	15	---	800
	Widen Right-of-Way (3)	4 mi.	422/mi.	1,688
	Install Track	4 r.m. (1)	338/t.f. (2)	1,352
	Install Turnouts (less signals)	2	52	104
	Signal Facilities & controls to Permit Reverse Operation	---	---	96
Subtotal				$10,776

(1) r.m. = route mile

(2) t.f. = track feet

(3) Widening the right-of-way includes clearing, demolition, mucking, filling and cutting, lengthening culverts, relocating signal/communication lines, and relocating grade crossing signals and gates.

Figure 4-8

NEW MAIN TRACK (Continued)
DETROIT-CHICAGO

Location	Item	Quantity	Unit Cost ($ thousands)	Contract Cost ($ thousands)
Whiting to Lake Jct (.6 mi)				
	Property Acquisition			$ 380
	Widen Right-of-Way (1)	.6 mi.	422/mi.	253
	Install Track	.6 tk. mi.	422/tk. mi.	253
	Signal Facilities & Controls To Permit Reverse Operation	.6 tk. mi.	16/tk. mi.	10
Subtotal				$ 896
Total				$11,672

(1) Widening the right-of-way includes clearing, demolition, mucking, filling and cutting, lengthening culverts, relocating signal/communication lines, and relocating grade crossing signals and gates.

Figure 4-9

SIGNAL REVISIONS TO PERMIT REVERSE OPERATION

Detroit - Chicago

Location	Number of Track Miles	Unit Cost ($ thousands)	Contract Cost ($ thousands)
Mill to Dunbar	54.6		
Dunbar to LaSalle	3.6		
LaSalle to Swan Creek	34.0		
HF to JD	53.8		
NE to HC	6.2		
Calehout Jct. to Englewood	21.3		
Englewood to So. Branch Bridge	10.8		
TOTAL	184.3	$8	$1,474

Figure 4-10

REVISE AND ADD INTERLOCKINGS

Detroit - Chicago

Location	Contract Cost ($ thousands)
LaSalle	$ 220
Alexis	240
TOTAL	$ 460

4.2 RESULTS OF THE PORTLAND - SEATTLE ANALYSIS

The present alignment in this corridor is restrictive to high speeds. The topography along parts of the right-of-way (bluffs and highways) is such that there is no economically viable remedy to the situation.

4.2.1 Descriptions of Modifications Portland - Seattle

4.2.1.1 Upgrade Track. Considering the age of some of the existing tracks and the top condition which will be required of all tracks in the IPT Corridors, it will be necessary to replace or rehabilitate some of the trackage. This entails placement of new welded rail and ties, and resurfacing. Trackage will be upgraded in sections where proposed speeds will be above 80 mph.

4.2.1.2 Curve revisions to increase super-elevation and lengthen spirals. The selection of curves to be revised was made by comparison of the speed made possible by increasing super-elevation or lengthening the spiral with other constraints such as grade crossings, ordinances, bridges, etc. If the latter constraint still controlled the operating speed, there is not a proposed modification.

4.2.1.3 Signal revisions to permit higher speeds are as follows.

1. Respace signals. The maximum authorized speed of 150 mph will require respacing of signals to compensate for the increased braking distance.

   It is, therefore, necessary to respace signals in the segments, Willbridge to McCarver Street and Reservation to M.P. 5.3.

2. Install automatic train stop. In order to comply with Federal regulations it will be necessary to provide automatic train stop where the IPT's will operate in excess of 79 mph.

It is, therefore, recommended that automatic train stops be provided in the segments, Willbridge to McCarver Street and Reservation to M.P. 5.3.

3. Install and revise grade crossing protective signals. Protective signals consisting of flashing lights and gates must be installed at twenty-three locations in segments where train speeds will be raised.

   Existing signals must be revised at 66 locations to provide for higher train speeds. (Train speeds above 100 mph will not be permitted at any highway grade crossing.)

4.2.1.4 Additional track.

Problem: Congestion, Willbridge to Vancouver. This territory is congested with slow moving freight which will be delayed by IPT's.

Modification: Provide additional freight main track with reverse signals between Willbridge and North Portland Junction.

4.2.1.5 Signal Revisions to Permit Reverse Operation.

Problem: Lack of Flexibility, Portland to Vancouver and Wabash to Seattle. The IPT's must have the flexibility to run around slower moving freight.

Modification: Provide reverse signals on both tracks.

4.2.1.6 Interlocking Revisions and Additions.

Problem: Traffic congestion Portland to Vancouver, and Wabash to Seattle. The addition of IPT's will cause congestion and delays to freight trains in this area.

Modification: There is a need for interlocking changes as follows:

Willbridge:	Provide trailing No. 20 crossovers.
Tenino Jct.:	New interlocking - 2 No. 20 crossovers.
Nisqually:	New interlocking - 2 No. 20 crossovers.

U.P. Jct.:	Change 2 existing crossovers to No. 20 crossovers.
Reservation:	Change 2 No. 9 crossovers to No. 20 crossovers.
Black River:	Provide facing No. 20 crossover at M.P. 10. Change No. 9 crossover to a No. 20 crossover.
Argo:	Provide trailing No. 20 crossover East of present crossover.

Miscellaneous. Platform revisions are needed to make their specifications compatible with IPT equipment's needs. Station improvements and refurbishments, train maintenance and inspection facilities, and right-of-way fencing are budgeted figures, i.e., a detailed estimate was not done but the costs given should provide adequate funds for the respective purposes.

Figure 4-11

IPT VELOCITY PROFILE
FROM PORTLAND TO SEATTLE

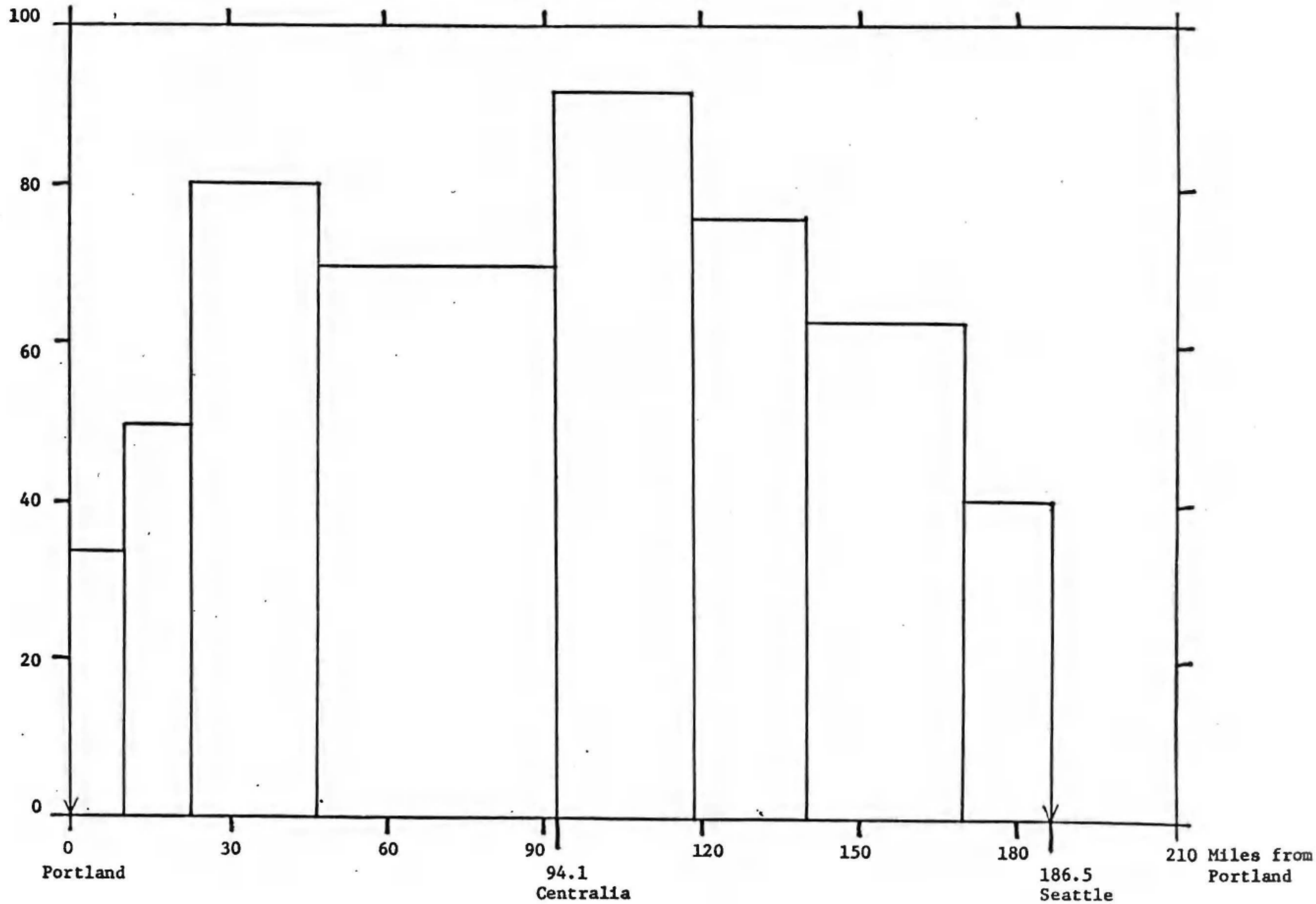

Figure 4-12

DELAYS INCURRED DUE TO INTERFERENCE IN THE PORTLAND TO SEATTLE CORRIDOR (1)

Location of Interference \ Type of Train	IPT			Freight		
	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed (2)	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed (2)
Vancouver	1	3	6			
Vancouver Jct				1	9	6
Vader	1	3	6			
Wabash				2	7	13
Tenino Jct				1	11	7
Nisqually	1	12	6			
Titlow				1	27	7
Reservation				1	23	5
Kent				2	23	13
Orillia				1	9	7

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

(2) This is the percentage of delayed trains in each class at each point. For example: 6% of the IPT's which passed Vancouver during the course of the day were delayed, 94% were not; 13% of the freight trains which passed Wabash during the course of the day were delayed, 87% passed without delay.

Figure 4-13

SUMMARY OF THE ESTIMATED COST OF CONSTRUCTION FOR THE SEATTLE-PORTLAND IPT

Improvements to Permit Higher Level Speeds	Contract Cost (Millions of 1972 Dollars
Upgrade Track	$ 4.8
Rebuild Bridges Which are Restrictive to Speed (1)	---
Curve Revisions to increase curve super-elevation and lengthen spirals	1.0
Signal Revisions to Permit Higher Speeds	3.9
Subtotal	$ 9.7
Improvements to Ease Track Congestion	
Additional (3rd) track Willbridge to N. Portland Jct.	7.8
Signal Revisions to Permit Reverse Operation	.8
Interlocking Revisions	1.1
Subtotal	$ 9.7
Miscellaneous	
Revisions to station platforms	1.3
Train Maintenance and Inspection Facilities	1.7
Right-of-way Fencing	4.0
Subtotal	$ 7.0
TOTAL	$26.4

Figure 4-14

UPGRADE TRACK TO PERMIT HIGHER SPEEDS

Seattle - Portland

Track Section	Track Miles Upgraded	Unit Cost ($ thousands)	Contract Cost ($ millions)
N - 162	28	$94.0 (1)	$2.63
Stateline-South Seattle	142	15.0 (2)	2.13
Total			$4.76

(1) This cost includes placement of new welded rail and ties, and resurfacing.

(2) This cost includes resurfacing and replacement of ties.

Figure 4-15

INCREASE CURVE SUPER-ELEVATION
AND LENGTHEN SPIRALS

Seattle - Portland

Track Section	Track Miles	Unit Cost ($thousands)	Contract Cost ($ millions)
N-142	8.0		
N-161	6.0		
N-162	3.0		
N-261	7.5		
N-263	4.0		
N-264	4.0		
S-277	4.0		
S-271	4.0		
TOTAL	40.5	$25.0	$ 1.01

Figure 4-16

SIGNAL REVISIONS TO PERMIT HIGHER SPEEDS
SEATTLE-PORTLAND

Location	Number of Locations	Unit Cost ($ thousands)	Contract Cost ($ thousands)	Item Subtotal ($ millions)
I Respace Signals				
N-142	2			
N-162	6			
N-163	8			
N-261	3			
N-263	11			
N-264	8			
S-277	2			
Subtotal	40	$40	$1,600	$1.6
II Install ATS				
			$1,920	$1.9
Subtotal				
III Revise Grade Crossing Protective Signals				
a) Retime existing crossings	66	$3.2	$ 211	
		$8.0	$ 184	
b) Install new crossing signals	23			
Subtotal				$ .4
TOTAL				$3.9

Figure 4-17

SIGNAL REVISIONS TO PERMIT REVERSE OPERATION

SEATTLE-PORTLAND

Location	Route Miles	Number of Blocks	Unit Cost ($ thousands)	Contract Cost ($ millions)
Portland to Vancouver	10	5	16/block	$ .08
Seattle to Wabash	90	45	16/block	.72
				$ .80

Figure 4-18

INTERLOCKING REVISIONS AND ADDITIONS

SEATTLE-PORTLAND

Location	Contract Cost ($ millions)
Portland to Centralia	$ .1
Centralia to Seattle	1.0
TOTAL	$1.1

4.3 RESULTS OF THE SAN DIEGO - LOS ANGELES ANALYSIS.

There is at present excess capacity in this corridor. Therefore, minimal changes are necessary to relieve track congestion caused by the IPT's. These minor changes should be fully adequate through the year 1995.

4.3.1 Descriptions of Modifications - Los Angeles to San Diego.

4.3.1.1 Upgrade Track. Considering the age of some of the existing tracks and the top condition which will be required of all tracks in the IPT corridors, it will be necessary to replace or rehabilitate some of the trackage. The cost estimate includes the replacement of rail which is older than ten years, as well as, the replacement of approximately 200 ties per mile in these areas.

4.3.1.2 Curve revisions to increase super-elevation and lengthen spirals. The selection of curves to be revised was made by comparison of the speed made possible by increasing super-elevation or lengthening the spiral with other constraints such as grade crossings, ordinances, bridges, etc. If the latter constraints still controlled the operating speed, there is not a proposed modification.

Ten curves are located near bridges and field surveys are necessary to determine feasibility of lengthening spirals.

4.3.1.3 Signal revisions to permit higher speeds are as follows:

1. Respace Signals. The maximum authorized speed of 150 mph will require respacing of signals to compensate for the increased braking distance.

   It is, therefore, necessary to respace signals in the segments between Miramar, MP 253, and Hobart, MP 147.

2. Install Automatic Train Stop. In order to comply with Federal regulations it will be necessary to provide automatic train stops where the IPT's will operate in excess of 79 mph.

It is therefore recommended that automatic train stops be provided between Santa Ana and Hobart, MP 147.

3. Install and Revise Grade Crossing Protective Signals. Protective signals consisting of flashing lights and gates must be installed at twenty-five locations in segments where train speeds will be revised. Existing protective signals must be re-timed at nine locations to provide for higher train speeds. (Train speeds above 100 mph will not be permitted at any highway grade crossing).

4.3.1.4 Signal Revisions to Permit Reverse Operations.

Problem: Lack of flexibility, Fullerton to Mission Tower. The IPT's must have the flexibility to run around slower moving freight. Some of this segment does not have reverse signals which are necessary for this flexibility.

Modification: Provide reverse signals in the following segments:

Fullerton to DT Junction	Both Tracks
First Street to Mission Tower	Both Tracks

4.3.1.5 Miscellaneous. Platform revisions are needed to make their specifications compatible with IPT equipment's needs. Station improvements and refurbishments, train maintenance and inspection facilities, and right-of-way fencing are budgeted figures, i.e., a detailed estimate was not done but the costs given should provide adequate funds for the respective purposes.

Figure 4-19

IPT VELOCITY PROFILES
FROM LOS ANGELES TO SAN DIEGO

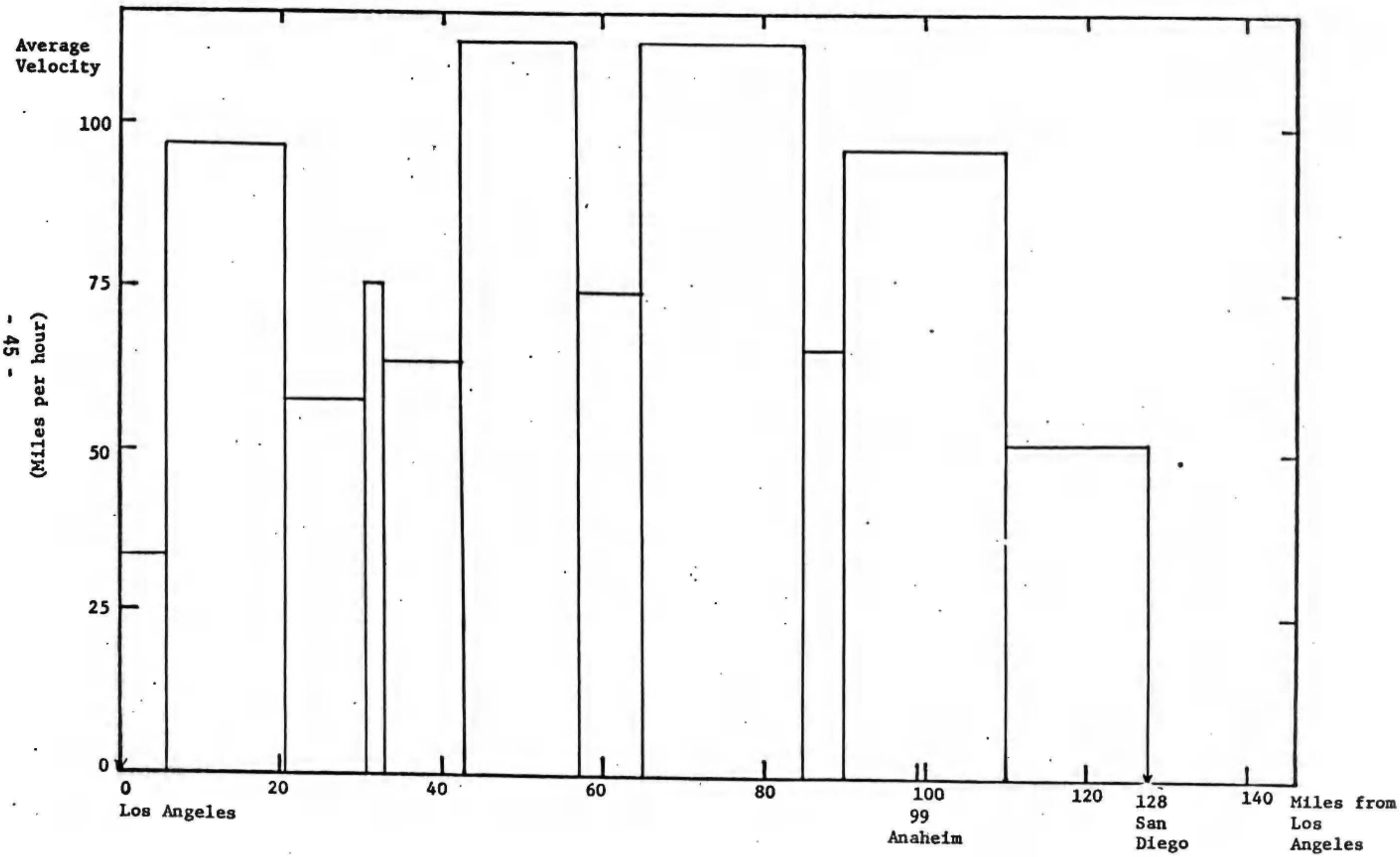

Figure 4-20

DELAYS INCURRED DUE TO IPT INTERFERENCE IN THE SAN DIEGO TO LOS ANGELES CORRIDOR (1)

Type of train / Location of Interference	Freight		
	Number of Delayed Trains	Average Minutes of Delay	% of Class Delayed (2)
Hobart	1	58	6
Irvine	1	15	5
El Toro	1	24	5

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

(2) This is the percentage of trains delayed in each class at each point. For example: 6% of the freight trains passing Hobart during the course of the day were delayed. (In this corridor it was not necessary to delay IPT's, only low priority, slow-moving freight trains, as the corridor essentially has excess capacity.)

Figure 4-21

SUMMARY OF THE ESTIMATED COST OF CONSTRUCTION FOR THE SAN DIEGO-LOS ANGELES IPT

Improvements to Permit Higher Level Speeds	Contract Cost (Millions of 1972 Dollars)
Upgrade Track	$ 8.5
Bridge Repairs (1)	---
Curve Revisions to Increase Super-elevations and Lengthen Spirals	2.7
Signal Revisions to Permit Higher Speeds	3.3
Subtotal	$ 14.5
Improvements to Ease Track Congestion	
Signal Revisions to Permit Reverse Operation	$ .3
Subtotal	$ .3
Miscellaneous	
High Level Platforms at San Diego, Los Angeles, and Anaheim Stations	$ .8
Other Station Improvements and Refurbishments	2.0
Train maintenance and inspection facilities	2.0
Right-of-way Fencing	6.0
Subtotal	$ 10.8
Total	$ 25.6

(1) Not evaluated

Figure 4-22

UPGRADE TRACK TO PERMIT HIGHER SPEEDS

Los Angeles - San Diego

Location		Tracks to be		Unit Cost	Contract Cost
From Mile Post	To Mile Post	Upgraded	Net Track Miles	($ thousands)	($ thousands)
143	152 + 0611	North & South	18.22		
165 + 1000	175.4	North	10.22		
165 + 0130	175.4	South	10.38		
175.4	179.1	North & South	7.40		
179.1	252 + 4918	Single	73.83		
252 + 4918	257 + 0643	North & South	8.38		
257 + 4782	264	Single	6.10		
TOTAL			134.53	$63.4	$8529

Figure 4-23

SIGNAL REVISIONS TO PERMIT HIGHER SPEEDS

Los Angeles - San Diego

Location	Number of Locations	Unit Cost ($ thousands)	Contract Cost ($ thousands)	Item Subtotal ($ thousands)
I. Respace Signals				
Miramar to Hobart (1)	20	$30	$ 600	
	7	$40	$ 280	
Sub Total				$ 880
II. Install ATS				
Santa Anna to Hobart	134	$16	$2144	
Sub Total				2144
III. Revise Grade Crossing Protective Signals				
a) Retime Existing Signals	9	$ 8	$ 72	
b) Install New Crossing Protection	25	10	250	
Sub Total				322
TOTAL				$3346

(1) The two unit costs used reflect the amounts of work required to respace signals in different locations.

Figure 4-24

SIGNAL REVISIONS TO PERMIT
REVERSE OPERATION

Los Angeles - San Diego

Location	Number of locations	Unit Cost ($ thousands)	Contract Cost ($ thousands)
Fullerton to DT Jct.	13		
First St. to Mission Tower	5	—	—
TOTAL	18	16	288

62219