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Analysis of Rail Line Abandonment Priorities

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Recent reorganization of railroads in the Northeast faced many kilometers of rail lines with service abandonment. The cost to the taxpayer of rail service continuation subsidies was judged to be "less than the cost of abandonment of rail service in terms of lost jobs, energy shortages, and degradation of the environment." Legislation provided federal funds and left the decision to individual states, who were required to submit state rail plans. This paper explains the process used by the New York State Department of Transportation to select analysis variables, importance weights, and impact indexes for establishing line abandonment priorities. Sensitivity testing and interpretations of the analysis are reported.

In 1970 the Penn Central Transportation Company declared bankruptcy. This failure, along with that of four other railroads in the Northeast and Midwest, created a unique and potentially dangerous economic situation, possibly affecting the entire country. To minimize the impact of these bankruptcies, Congress enacted the Regional Rail Reorganization (3R) Act of 1973. The act's major purpose was to reorganize the bankrupt railroads into one or more rail system(s) capable of meeting the rail service needs of the 17-state region at the lowest possible cost to the taxpayer.

Congress recognized from the outset that any attempt to reorganize existing railroads into a self-supporting system would mean large-scale abandonment of light density branch lines. To ease the impact of abandonment, Title IV of the 3R Act provided federal subsidies for a 2-year period to assist state and local governments either in financing the continuation of essential rail services for that period or in systematically phasing out services on lines not selected for reorganization.

Section 401 of the 3R Act emphasized that "under certain circumstances the cost to the taxpayer of rail service continuation subsidies would be less than the cost of abandonment of rail service in terms of lost jobs, energy shortages, and degradation of the environment." The act, however, left to the individual 17 states the decision of whether avoiding the negative social impacts of discontinuing rail service justified continuation subsidies. In December 1975 the New York State Department of Transportation's (NYSDOT) preliminary rail plan was presented, and, after a series of public hearings throughout the state, the final state rail plan was adopted.

As part of the planning process, it was essential that a procedure be developed for quantitatively comparing the potential social impacts—on lines, rail shippers, and communities—of lines threatened with discontinued rail service. Of the long list of variables suggested, five were ultimately selected—consumer costs, employment, tax effects, sales effects, and environmental effects—according to the variable's perceived importance by members of the rail planning staff and local officials, its ability to be quantified, and the availability of relevant data. Scaling and weighting techniques were then developed to pool the measures of satisfaction of the variables. Linear scaling was done by using statistical measures (mean and variance) of independent variables. A small sample survey was conducted to derive weights for pooling scaled values.

This paper briefly explains the process employed by the NYSDOT in selecting their variables, assigning the level of importance weights to them, computing a single "impact index" for each line, and ultimately ranking the lines by their respective impacts. Several hypothetical importance weights are then applied, and the resulting line priority implications are observed and discussed. Conclusions about this decision-assisting process, its sensitivity to values, and the proper interpretation of results are presented.

SOCIAL IMPACT ANALYSIS

When a rail line is abandoned, each of its users must choose one of three courses: using alternate means of transportation for commodities previously carried by the line, relocating to another site having rail service, or ceasing at least that portion of business involving use of rail service. Each user is influenced by many variables such as the availability and cost of the alternative compared to rail service at the user's original site, the availability of suitable alternate sites, the user's market area, the amount of investment required at a new site, and the profitability of the business (1).

Few commodities carried by rail could not in theory be transported by other modes. There are some notable exceptions, such as very large electric generators, transformers, and so forth, but movement of such commodities is relatively infrequent. Usually when a firm says they depend on rail for some portion of their transport needs, they really mean that the cost of using an alternative is prohibitively high.

In general, abandoning rail lines will leave former users with no direct transport facilities other than highways. In the past, some shippers faced with such a situation have elected to use trucks between the plant and an alternate rail station; others have diverted their traffic entirely to trucks for the full haul. In the former the added costs of the transfer between modes in terms of both time and money is an essential consideration.

It is the so-called rail-dependent firms that will either shut down or relocate in the event of rail service abandonment. A certain amount of managerial judgment is necessary in determining whether the costs of alternatives are tolerable for a given firm or not.

The method used to determine and analyze the impact of particular rail abandonments was based on individual rail customers' selecting of one of the three courses of action: going out of business, relocating, or switching to alternate modes. Each was asked for a probable decision, and the impacts of their replies were evaluated. No attempt was made to verify or second guess the actual decision or to screen out "survey sophisticated" responses.

Assumptions and Standards

Several assumptions were made to allow for consistent estimates and statewide comparison of the impact of alternate actions on each line.

1. Team Tracking. All rail users who indicated that they would use an alternate means such as trucking over the entire haul, piggybacking, or team tracking were grouped into the team tracking category. The location selected as the proposed team tracking facility was the nearest station on a rail line not threatened with service discontinuance.

2. Types of Commodities. For the analysis, several of the factors, such as shipping costs and transfer facilities, required an indication of the type of commodity being shipped. A general breakdown of bulk and nonbulk was selected. Bulk commodities include such materials as coal, stone, grain, and fertilizer; nonbulk commodities include lumber, furniture, and grocery goods.

3. Direct Versus Secondary Impacts. Local firms supplying materials or services to a plant that curtails operations or shuts down as a result of an abandonment will be affected according to the proportion of their business derived from the defunct firm. If such suppliers suffer significant enough losses, they may be forced to reduce the sizes of their work forces. This phenomenon is sometimes called the "multiplier effect" of business closings. Because time and reliable information did not allow for more than the development of a single typical multiplier, which would have entailed factoring each line in the analysis by the same value, quantifying this effect was not pursued.

Selection of Social Impact Factors

Many sources were used to initially draft the list of factors for consideration in the analysis. One such guide (2) was published by the Rail Services Planning Office (RSPO) of the Interstate Commerce Commission (ICC) on June 9, 1975. The criteria contained in the guide were only advisory and were not intended to be all inclusive or necessarily appropriate in all cases. Three general subject-oriented categories of factors—economic, social, and environmental—were presented for consideration. Under each of these three major factors, several basic factors and one or more elements for analysis or measurement were suggested.

Some of the factors in the guide were readily identifiable and measurable in generally accepted quantitative terms, while others would have been impractical, if not impossible, to satisfactorily define or identify, in quantitative terms. Although some of these factors and elements were redundant and lacked definite means of identification and measurement, RSPO's recommended factors provided a logical starting point for establishing a working set of criteria.

In developing the final set of criteria to be utilized in the state rail plan, the RSPO list of factors was screened to eliminate marginally significant factors and overlapping categories. Next, a second RSPO report (3) and another report (4) were used to identify those factors for which broadly accepted definitions and measures were available. The proposed criteria, impacts, and appropriate (and available) measures shown below are the result of this screening process.

Criterion	Impacts and Measures
Employment	Railroad employees
	Shipper employees
	Related service employees
Consumer costs	Transportation costs
	Competition effects
Taxes and community economics	Income tax
	Sales tax
	Property tax
	Corporate tax
Pollution	Energy use
	Air quality
	Aesthetics
	Traffic congestion
Community cohesiveness	Population shifts
	Urban and rural composition
	Land use or zoning disruption
	Public investment

Opinion Survey

The perspectives from which individuals would view these suggested criteria and the values they would assign to them were expected to vary considerably. For this reason, a survey of the planning staff and local officials was undertaken to gather opinions on (a) the relative importance of each type of criterion, (b) the definition of criteria or factors within a social benefit index, and (c) the most descriptive and feasible measures to use in quantifying those factors.

Each survey participant was asked to consider the nature and probable application of each of the five social impact factors and to assign it a percentage weight. The weights indicated how important they judged one factor to be in relation to the others. Zero weights were acceptable, and additional factors could be defined and added to the list. The sum of the weights assigned was to equal 100 percent.

Sixty-seven survey forms were returned, of which all but one contained usable responses. Of the 66 usable returns, 19 were from downstate (New York City area) and 47 from upstate. Forty-six forms were returned by state officials (both main office and regional); the remaining 20 were completed by local officials, people in industry, or members of various special interest groups. Importance weights as calculated for the entire survey group are presented below.

Factor	Weight (%)
Employment	31
Consumer costs	19
Tax effects (property and sales)	18
Environmental effects	12
Community cohesiveness	13
Other	7

The number of returns in the survey was quite small, and the sampling procedure was not controlled, so the statistical significance of the results could not be ascertained. Individual responses did vary, however, and there appeared to be patterns. For instance, downstate residents seemed to be more concerned with air pollution than upstate residents.

Quantification of Social Impact Factors

The five factors quantified in the analyses are consumer costs, employment, taxes, sales, and environment. The following is the formulation of the impact for each factor.

Consumer Costs

Those firms required by rail service termination to use an alternate means of transport will generally have to pay more for their raw materials and for shipping their goods. In all likelihood, this increase will be passed on to the consumer. This, then, must be considered a negative impact of rail service discontinuance.

To estimate the increased transport costs for firms switching to team tracking, three sources were utilized (4, 5, 6). The first report contained and referenced the basic operating and transfer costs per megagram by commodities; the second report related costs and distance to the team tracking facility; and the third contained information on shipping and transfer of bulk commodities. The application of these three reports yields the procedure shown below.

Case I. Change from private siding to team tracking facility

For bulk commodities the added cost is $6.78 per Mg ($6.15 per ton) times T plus $0.12 per Mg-km ($0.18 per ton-mile) times T times d, where T is the number of megagrams shipped, and d is the over-the-road distance difference between old and new loading location, in excess of 8 km (5 miles).

For nonbulk commodities the added cost is $4.57 per Mg ($4.15 per ton) times T plus $0.05 per Mg-km ($0.08 per ton-mile) times T times d.

Case II. Change of team tracking location

For all commodities the added cost is $2.37 per Mg ($2.15 per ton) times T plus $0.05 per Mg-km ($0.08 per ton-mile) times T times d.

Employment

Before predicting increases in unemployment, one must first predict the impacts of abandonment on rail users and probable action they will take. The numbers of employees in those firms going out of business were determined from the inventories cited. For those businesses that indicated reduced activity, a reduced number of employees was estimated.

Current rail users who indicated that they would use team tracking or trucking as a substitute for rail service (without a decrease in employment) might in fact create new jobs for truck drivers and truck helpers. Although this number is quite small, an estimate of these created jobs was made and included as a positive attribute, canceling some of the unemployment effects of closed businesses.

Local railroad job loss was determined to be insignificant in view of the dispersion of potentially affected lines and the labor protection provisions of the reorganization process. Estimating the number of jobs created by a switch to team tracking was based on the same references used in estimating the consumer costs (5, 6). The computation procedure follows.

Case I. Change from private siding to team tracking facility

For bulk commodities the added jobs are 0.170 jobs per 1000 Mg (0.154 jobs per 100 tons) times T plus 0.0014 jobs per 1000 Mg-km (0.002 jobs per 1000 ton-miles) times T times d, where T is the number of megagrams shipped annually, and d is the over-the-road distance differential between old and new loading location, in excess of 8 km (5 miles).

For nonbulk commodities the added jobs are 0.115 jobs per 1000 Mg (0.104 jobs per 1000 tons) times T plus 0.0014 jobs per 1000 Mg-km (0.002 jobs per 1000 ton-miles) times T times d.

Case II. Change of team tracking location

For all commodities the added jobs are 0.060 jobs per 1000 Mg (0.054 jobs per 1000 tons) times T plus 0.0014 jobs per 1000 Mg-km (0.002 jobs per 1000 ton-miles) times T times d.

Community Economics

The loss of business caused by discontinued rail service could affect revenue resources at all levels: reduced sales taxes from reduced buying, lost property taxes and corporate taxes from firms closing or relocating, lost income tax and higher unemployment in the area, and so on. A wide variety of types of variables could represent community economics. However, in view of the fact that the respondents in the opinion survey emphasized the importance of impact on community property and sales taxes (together with the various difficulties in creating reasonable estimates for other measures), only these two factors were included in the analysis.

For most communities, the most important and frequently the only significant source of tax revenue is the property tax. Any reduction in this tax base is likely to require a compensating increase in the property tax rate, which affects the entire community. The two direct tax sources affected by rail abandonment are property owned by the railroad and that owned by a present rail user who will close or relocate. Only the latter was considered in the analysis because of the varied status of rail lines relative to tax relief and debt accrual and because of the uncertain outlook for the future. Although federal subsidy could cover taxes, the state rail plan recommended that taxes be waived.

Lost property tax from rail discontinuance was estimated by identifying those current rail customers who would close or relocate out of state. For those firms, the assessed property value was recorded and multiplied by the local tax rate (7, Table 1). For each rail line the tax effects of these firms were then totaled.

In addition to effects on property tax, survey respondents indicated a desire to include a factor that would reflect the impacts of community sales lost as a result of losing local industries. The dollar value of potentially affected annual sales was selected as a substitute for the many and varied effects of industry on local economics that go beyond direct payroll and property taxes.

Lack of shipper information on annual sales made it necessary to approximate the measure from statewide relations among sales, type of industry, and number of employees (8, Table D-8). Sales losses were calculated by multiplying the payroll value of firms closing or leaving the state by the sales per payroll ratio as developed from the Statistical Yearbook. For each rail line the sales effects of these firms were then totaled.

Table 1. Statistics of measures for all lines compared with composite index for a single line.

Factor	All Sample Lines Combined		Composite Index for Single Sample Line		
	Mean	Standard Deviation	Actual Social Impact Value	Social Impact Value Scaled by Standard Deviations	Final Weighted Impacts
Consumer costs, $	81 650	77 000	4 968	0.32	0.06
Employment, no. of jobs	87	274	114	2.08	0.64
Tax effects, $	27 200	50 700	140 385	13.85	1.22
Sales effects, $	11 900	19 600	62 745	15.96	1.42
Environmental effects, kg	-2 082	2 159	1 607	-3.75	-0.42
Composite index					2.92

Note: 1 kg = 2.2 lb.

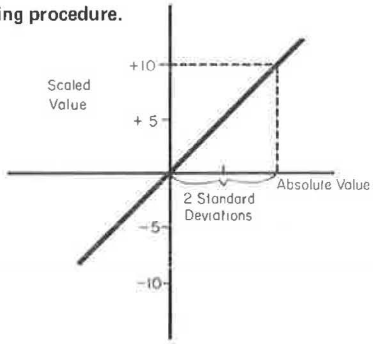

Figure 1. Scaling procedure.

Environmental Effects

Other impacts quantified in connection with a change in mode were energy use and environmental effects. The appropriate energy use measure is fuel consumption of rail versus the alternative. The environmental factors normally include air, noise, and water pollution. However, because noise and water pollution vary widely with project details, only air pollution was quantified. The amount of pollutants emitted is a direct function of the amount of fuel consumed; therefore air pollution from rail service versus team tracking was substituted for energy and environmental factors.

An estimate of the amount of fuel consumed by truck and by rail was obviously needed to calculate pollution. Truck fuel consumption was estimated by taking the number of rail cars needed to be team tracked from the existing station to the proposed team tracking facility multiplied by the number of kilometers between the two locations, multiplied by conversion factors of four trucks per rail car (9, Table 6) and 0.47 L/km (0.2 gal/mile) (10). The fuel consumed by rail was estimated by using the number of hours needed to service the rail line under existing conditions, the proposed future number of annual trips, and the factor of 45.4 L/h (12.0 gal/h) of fuel consumed by a locomotive (5). The following calculations for the round-trip, over-the-road distance (d) between the private siding and the new loading location were made.

1. Truck loads per year equal carloads (rail) per year times d times 4 trucks per carload (rail) times 0.47 L per truck-km (0.2 gal per truck-mile).
2. Locomotive loads per year equal hours per trip times trips per year times 45.4 L per locomotive hour (12.0 gal per locomotive hour).

Because the amount of air pollution is a direct result of the amount of fuel consumed, the difference between rail and truck emissions was also selected to indicate energy use from rail discontinuance. Pollution rates were taken from an Environmental Protection Agency (EPA) publication (10) using the locomotive sizes (3). The rates for trucks were taken from a supplement to the above EPA publication (11).

Other Factors

Other factors, such as community cohesiveness, were collectively assigned a weight of 20 percent, but no reasonable or available measures were proposed. As a result, these factors did not enter the impact index but remained important subjective input.

Development of a Single Impact Index

The computation of the impacts for each factor for each line resulted in the measures and statistics shown in Table 1. Since the measures are not similar, it is impossible to directly total them to determine a single net impact for each line. Therefore, it was necessary to first convert the measures to a common unit.

To arrive at a single index, we scaled each factor of each line according to the magnitude of its impact as compared to the impacts of all other lines. The means and standard deviations of all the impacts were calculated for each factor. Because of the enormous differences among impacts for each line, the standard deviations for each factor were atypically large—for example, that for tax effects among the various lines was approximately twice the mean. A relation was then established by which an impact of one standard deviation was equivalent to five units on the scale; a standard deviation of two, then, was given a scale value of 10. A zero impact read as zero on the scale, and the values on the scale were allowed to be both positive (social disadvantage from abandonment) and negative (social advantage from abandonment). Figure 1 shows the scaling relation, and Table 1 shows an example of how the scaled values of the variables are pooled into an impact index by using importance factors.

Applications

The results of the social impact analysis of rail line abandonment can be utilized in a number of ways. For example, we identified those rail lines whose abandonments would have no net negative social effects on the rail users and communities along the lines. This result might be useful in decisions on light density rail lines by the recent rail reorganization in the Northeast or in analyzing rail lines faced with service abandonment as a result of normal abandonment cases before the ICC.

A second result of the analysis is an indicator of the social benefits of each rail line relative to the others—an importance ranking. The lines with significant impacts can then be distinguished from other lines and ranked according to their perceived levels of importance based on the social impact factors and criteria weights used in the analysis.

A third significant and useful result of our work is the use of the social impact index to construct a benefit-cost index for each line. This index would include not only the

Figure 2. Ranking under various weighting schemes.

Rank		Scheme A	B	C	D
1	Top Third	A	C	A	D
2		B	D	B	A
3		C	E	D	E
4		D	A	C	C
5		E	B	F	J
6		F	H	E	L
7		G	G	G	N
8		H	J	I	P
9	Middle Third	I	K	O	K
10		J	M	N	I
11		K	F	R	M
12		L	O	L	Q
13		M	Q	U	X
14		N	V	J	S
15		O	P	T	W
16		P	L	H	Y
17	Bottom Third	Q	S	P	R
18		R	N	M	F
19		S	I	K	T
20		T	W	Q	G
21		U	T	S	V
22		V	R	X	U
23		W	X	V	H
24		X	Y	W	O
25		Y	U	Y	B

social impacts associated with each line but also an indication of the cost of maintaining the line. As used in the New York State rail plan, the benefit portion of the benefit-cost index was the index of avoidable social impacts. The cost factor was the operating subsidies needed to continue the line plus the rehabilitation costs for restoring the line to proper operating condition. For those analyses where only a short-term relation is desired, the long-term rehabilitation costs could be excluded. Selecting appropriate costs and time periods, however, is quite important and will obviously directly affect the benefit-cost index and consequently vary the ultimate priority ranking of the lines.

The benefit-cost index ranking will present a more cost-effective measure for using limited funding sources. For example, an investment into those lines with the highest benefit-cost index would be expected to yield the greatest return in avoiding social impacts per dollar invested. This guidance is particularly useful when money is not available for continuing rail service on all lines in question or for rehabilitating lines to higher standards or when manpower or equipment shortages reduce the ability to serve all lines.

TEST OF SENSITIVITY TO IMPORTANCE WEIGHTS

As previously mentioned, the results of the social impact survey tended to indicate but could not establish significant differences in category weights among the several subgroups of survey participants. Distribution of the survey was limited, and statistical conclusions were not possible. In all likelihood, however, a more rigorously controlled survey of special interest groups, such as environmentalists or rail users, would result in significantly different sets of weights. We tested the sensitivity of the ranking procedure, which utilized several different hypothetical weighting schemes, along with the actual results of the opinion survey.

The table below shows four distinct sets of hypothetical weights and their percentages of importance.

Factor	A	B	C	D
Employment	31	10	10	10
Consumer costs	19	50	10	10
Community economics	18	10	50	10
Environment	12	10	10	50

Set A contains the weights that were actually developed by a small survey and applied in the state rail plan. The others were chosen to emphasize individual factors. Twenty-five rail lines faced with possible service discontinuance as a result of the recent railroad reorganization process provided the data for the sensitivity analysis. For each line the composite social impact index was calculated from each of the four importance sets. Figure 2 depicts the results by comparing each hypothetical ranking with the survey-based ranking. To provide a perspective on the results, the list is broken into thirds, and the changing relative locations of several lines are traced.

RESULTS AND DISCUSSION

The results of the sensitivity tests showed that variations in the weights assigned to various factors can produce changes in the relative ordering of the actions or projects being considered. To what extent these changes are important depends on the intended application of the resulting list order. At one extreme, such a list might be used simply for administrative priority determination on a single action decision; at the other, each ranking on the list might indicate a different type or degree of action. It is not uncommon for an analyst to decide how to use the list and how to select appropriate critical rankings before actually applying the model to developing the list. One selected set of factor weights would then be developed and applied and the results accepted. However, the results of this particular research effort tend to imply that a slightly different, more cautious approach might be prudent.

Caution is necessary both in developing the factor weights and in viewing the resulting rank-ordered list. First, in order to properly define the importance weights, the analyst must have a good feel for the affected parties. This is particularly important if actual weights are to be ascertained by an opinion survey. If a decision on whether or not to subsidize rail freight services is actually going to be made, the analyst could choose to survey the shipper who would benefit from the subsidy, or the taxpayer who will have to share the burden of the subsidy program and who is generally conditioned to react negatively to added public burden and is not interested in or able to make trade-offs for the general welfare, or the responsible public officials who theoretically represent the consensus and appropriate balances.

With the participants chosen, an opinion survey can be administered, although it may be necessary to employ sampling techniques. Careful selection of participants and survey strategy is advisable. It is recommended that, for awareness and appreciation of the abilities and limitations of this type of structured decision-assisting process, the analyst take the time to create and analyze sensitivity tests for specific applications. Statistics on the distribution of responses observed in the opinion survey will prove useful here in selecting test input.

Finally, in addition to the ranking of potential actions or projects, the numerical value of the measure the ranking is based on can provide useful guidance and should not be disregarded. It would be difficult to defend cut-off points or subdivisions of the list based solely on ranks, particularly when it turns out that the cut-off point discriminates between actions that differ very little in terms of the numerical measure that forms the basis of the ranking. Moreover, the actual distribution of numerical values can provide support for the selection of cut-off points.

In this regard one should recognize the mode or modes of the distribution; their presence and location might assist the analyst in selecting the number of different treatments or types of actions, and the troughs between modes might prove convenient and defensible cut-off points for assigning treatments.

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Optimum Fleet Sizing in the Northeast Corridor

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The Regional Railroad Reorganization Act of 1973 mandated the U.S. Department of Transportation to undertake engineering and planning studies for improved passenger rail service in the Northeast Corridor. In order to obtain fleet estimates and to analyze the effects of management strategies a calculation of the optimum number of cars required for a design day service in the Northeast Corridor was undertaken. A linear programing model that determines fleet requirements for several different formulations of the objective function was formulated. Minimum fleet size was then calculated from a demand forecast based on the service standards prescribed in the Railroad Revitalization and Regulatory Reform Act of 1976. Minimum car-kilometers per day and maximum load factor were also found. The analysis indicated that the most heavily traveled portion of the corridor, Philadelphia to New York, might be better served by adding trains between these two cities.

In 1973, Congress passed the Regional Railroad Reorganization (3R) Act. This complex piece of legislation dealt with passenger as well as freight operations and called for the U.S. Department of Transportation (DOT) to improve passenger rail service in the Northeast Corridor (NEC) as recommended in the 1971 Northeast Corridor Report. The NEC is defined as the rail line extending from Boston to Washington. It is 734 km (456 miles) long and crosses eight states and the District of Columbia. Included in the corridor are four major metropolitan areas: Washington, Philadelphia, New York, and Boston.

With the mandate of Congress, the Federal Railroad Administration (FRA) undertook several major studies to examine in detail

1. Ridership that might be expected with high-speed service,
2. Investment required to achieve high-speed service, and
3. Financial viability of the improvement project.

The Transportation Systems Center, supporting the Office of Northeast Corridor Development in FRA, provided the major analytical effort in the areas of financial analysis and demand forecasting. The results of these efforts, as well as those of the engineering studies, provided the necessary background for passage of the Railroad Revitalization and Regulatory Reform (4R) Act that was signed into law in February 1976. This legislation provides $1.9 billion for improving rail service between Boston and Washington and requires the following trip times by February 1981.