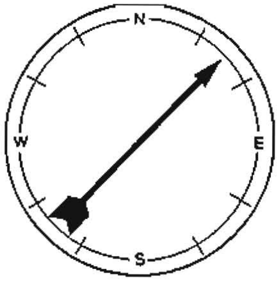
The Northeast Corridor Improvement Project

BY
Louis S. Thompson
Associate Administrator for Intercity Programs
Federal Railroad Administration
U. S. Department of Transportation
Washington, D. C.

Eighteenth
Henry M. Shaw Lecture in Civil Engineering
School of Engineering
North Carolina State University
November 10, 1982

NORTHEAST CORRIDOR IMPROVEMENT PROJECT NECIP

The NORTHEAST CORRIDOR



– A LARGE COMPLEX SERIES OF INTERRELATED PHYSICAL IMPROVEMENTS TO THE OPERATIONAL RAILROAD WASHINGTON, DC – BOSTON, MA

TO:

D. M. Callahan
Mike Child
H. Cooper
J. A. Dernan
B. N. Maruska
Gail Ornstein
Gene Soune
P. S. Wells
Pete Wilke

Who Remain Railroad Men and Women

The Northeast Corridor Improvement Project

BY
LOUIS S. THOMPSON

Mr. Chairman, Members of the Faculty, Students, Ladies and Gentlemen:

Though I have given speeches, this is the first chance I have had to speak before an academic audience—and I must say the experience has been a very educational one for me. In my opinion at least part of the reason for my being invited to address you here tonight is revenge on the part of Professor Heimbach. As you may know, he spent approximately a year at the Department of Transportation where he occupied the status of an academic who worked with operating Federal programs. I think he thoroughly enjoyed that experience and I think he found it a challenging one. He now has helped to have me invited down here to observe the other side of the process: that is, how does an operating manager translate his experience into the academic environment. It is a challenge and an opportunity.

Introduction

As you know, this is the 18th in the Henry M. Shaw Lecture series in Civil Engineering. In looking back over the previous Shaw lectures, I find that this is the first speech primarily concerned with a railroad topic. It seems both intriguing and significant that the mode which carries some 38 percent of the nation's freight ton-miles and consumes over nine percent of the net federal civilian outlay on *all* transportation has never been the subject of a lecture in this series. The reasons are I think clear: the historic competitive position of rail for both freight and passenger has eroded, and the rails' share of traffic has by and large been stable or has even been shrinking. For example, railroad track mileage owned has shrunk by more than 25 percent over the past 50 years, and the number of passenger rail cars in service has fallen by over 80 percent.

The advantages of rail—fuel efficiency and effective land use—simply have not stood up well against the convenience of the auto, the speed of air and truck, and the very low operating cost of barges. Also, the rails have remained in the private sector, whereas air and highway transportation have been public issues. As a result, I believe that the sources of information, and the degree of public and academic interest in rail technology and development have historically been rather limited.

Events over the past ten years have acted strongly to end the isolation of railroads from public discussion. As many of you know, the Penn Central Railroad entered bankruptcy in 1970. After several years of struggling to reorganize, Penn Central and Congress threw in the towel and created ConRail, an umbrella organization which absorbed six bankrupt railroads in the Northeast. The ConRail experience has thus far generated a public outlay of over $7 billion. The more recent bankruptcies and reorganizations of the Rock Island Railroad and the Milwaukee Railroad have further added to the public involvement in railroad freight operations.

The rail passenger area has seen a similar development. In 1971, after many years of decline, the railroad passenger business was reorganized under the new National Railroad Passenger Corporation, popularly known as Amtrak. Since its formation, the Federal government has spent more than $6.5 billion on Amtrak, and the process of authorizing and appropriating this money has led to heated public debate about Amtrak's future and its purposes. In the light of the intensifying public interest in both rail freight and rail passenger, it is about time you had a Shaw lecture on rail.

In reading over the past topics of these lectures, I am struck also by the predominance of attention devoted to technical issues. I don't mean this to be critical, of course; this is an engineering school and you are here to learn the basic academic skills and techniques without which we would all be helpless. But technique and skill are not the whole story. Step II in the process of engineering development involves putting those techniques into practice. This means you have to: 1) fit the techniques to the problem at hand in order to find the most appropriate solution for reaching the desired objective, and 2) someone must manage the available people and resources, within given constraints, in order to achieve the objective.

I think that increased emphasis on these broader topics—the selection of appropriate engineering techniques, and effective program implementation—is especially important in an age when engineers and scientists are repeatedly being asked to examine and understand the broader social significance of their actions. These questions become particularly acute when you encounter, as many of you will, a project which spans every issue from the purely technical to the purely social.

Thus the theme of this lecture is the use of a very recent and still ongoing case study to emphasize the need to focus on all three elements of engineering management: command over the basic skills and techniques; the fitting of these techniques to reach an appropriate solution to the problem; and the management of the effort required to reach the desired objective.

In pursuing this theme, I want especially to focus on a new kind of project, which, for lack of a better label, I will call a "mega-project." A mega-project is one which, because of a combination of its sheer size, the location and the identity of its management, and its impact on social objectives among other characteristics, assumes a character far broader than the normal engineering project.

The traditional engineering project, which much of your training has aimed toward, has a definable client, a known problem and a given budget. Under these circumstances, the client and the engineer together can set the objectives and control all the variables. Within the limits of their skill they can act almost at will. The project can be walled off, scheduled and completed without a great deal of interference from outside sources.

The mega-projects of which I speak are very different. First, because of their impact on the economy, they cannot simply be walled off. Instead, they are subject to all the constraints we normally impose on public institutions. Second, again because of their broad implications, mega-projects unavoidably have social objectives as well as purely economic ones. Third, as a result of their social objectives, mega-projects are inevitably a target for conflicting political and social pressure. Finally, by their very nature, these mega-projects often require managers to make judgements, or to assume responsibility for judgements, in areas which are beyond their expertise or their ability to control.

None of this is intended to suggest that mega-projects are inherently bad: they are a fact of life with which we must contend. My point, instead, is that mega-projects are qualitatively and quantitatively different from the traditional project. Whether we like it or not, I think the future will see more mega-projects emerge. I hope this lecture will alert future "mega managers" to the very different nature of a mega-project so that these managers can be adequately prepared and, perhaps more important, so that the public which defines and pays for these projects can have a better idea of what to expect. My hope is that, by recognizing mega-projects in advance, we can improve the management process and maintain public confidence in the ability of our institutions to deliver against objectives set by the political process.

Figure 2* will give you the basic layout of the Northeast Corridor. As you can see, this is the railroad which runs from Washington, D.C. to Boston, Massachusetts via New York City and a number of the other major population centers in the Northeast. Beginning in the middle sixties, this transportation corridor received increasing academic and public attention. As Figure 3 shows, the 456-mile line from Washington to Boston encompasses about 20 percent of the nation's population on two percent of its land area, serves a major share of the nation's industry, and attracts a great deal of business and tourist travel.

The past studies of this corridor focused on the fact that both highway and airport capacity were becoming increasingly congested. At the same time, it was highly expensive to create more highway or air capacity, and the noise pollution, air pollution and energy consumption impacts of these modes compelled thorough examination of available alternatives.

The most desirable alternative was, and is, an upgrading of the railroad line. Transportation studies in the United States and abroad had consistently shown that where adequate population density existed, and if the service were adequate, railroads can compete very effectively with air and highway travel. By the early '70s, all of the studies had supported the conclusion that, at least in the Northeastern United States, upgraded rail passenger, rail commuter, and freight deserved serious attention for federal assistance. It was from these studies that the concept of a Northeast Corridor Improvement Project (NECIP) emerged. Figure 4 shows the initial—and changed—goals of the Project. Very broadly, the so called 4R Act, (which was passed in February of 1976), established the Project and set forth a series of goals. Congress asked that we improve the railroad so that trip times between New York City and Washington could be reduced to 2 hours 40 minutes (with appropriate stops) and

* All Figures appear in back section.

to 3 hours 40 minutes from Boston to New York City. Congress asked that this be completed within 5 years. NECIP was to be designed so that further upgrading and improvement could be carried out without losing the value of the initial work and was to be executed in such a way as to produce maximum benefits to unemployed labor. While achieving these objectives, NECIP was to facilitate rail commuter services and mass transit operations and was to be implemented to improve, or at least not to degrade, freight operations. The initial budget for all of this work was $1.75 billion.

Figure 4 also shows that the objectives of the Project were changed over time. For example, in the Passenger Railroad Rebuilding Act of 1980, the completion deadline was extended to 9 years and 8 months, the improvement priorities were more clearly stated and reordered, and we were given the explicit mandate to promote urban development around the railroad stations. At the same time, Congress increased the program budget to $2.5 billion in recognition of the fact that the early program estimates were overly optimistic.

In February of 1981, President Reagan's Economic Recovery Program led to a decision to reduce the total budget of the project by some $310 million and to deemphasize the trip time goals somewhat.

This was the broad target—I might add a moving target—toward which the NECIP has been aiming.

Technical and Railroad Issues

Figure 5 will give you a broad overview of what a railroad is. In one sense you can view this as a collection of physical structures and assets. Figure 6—Trains, as you know, run on tracks. Figure 7—The speed, and the direction in which the trains run, are controlled by the signalling system. Figure 8—When rivers are encountered bridges must be constructed. Figure 9—For really high speed railroading, it is advantageous to use electric traction rather than the more traditional diesel traction. Figure 10—Passengers get on and off the railroad through stations. Figure 11—Other kinds of physical barriers cause tunnels to be built. Figure 12—If the physical property is to be maintained properly there must be facilities available to store equipment, and to organize the labor force. Figure 13—We must also maintain the equipment which operates on the line, and equipment maintenance requires its own special maintenance facility.

While it is interesting to describe a railroad as a separate set of civil engineering efforts, the *operating* railroad is actually a very sensitive and sophisticated system which ties all of these elements together. It is absolutely vital to understand that, sometimes in very subtle ways, each of these elements affects the way in which the overall system operates. Even minor changes in the track, for example, can cause a change in the signal system. A change in bridge design or operating speed can similarly impact on signal design and, ultimately on system capacity. For these reasons, railroad projects may be uniquely complex in the fact that objectives must be set and changes accommodated with a view to every element in the entire system.

The Application of Engineering Techniques to the Problem at Hand

Return to Figure 4. Let's go back to the NECIP goals and restate the objectives as they bear on engineering techniques. First, we are to meet a set of trip time goals. Second, we are to try to improve, or certainly not degrade, the ability of commuters and freight railroads to use the same track which we are improving for passenger service. Finally, everything is to be done with an eye toward improving operating reliability and, perhaps most important, toward insuring that all of the users can operate safely together. As you can see, speaking in engineering terms alone, we are not able to focus on just intercity passengers: instead, we explicitly have a multi-purpose system. "Multi-purpose" means compromise and trade-off: we can probably do a *good* job for everybody, but we can't do a *complete* job for anybody.

The first question to emerge when trying to meet trip time goals is, why don't we run the trains faster? This is one of those simple questions which turns out to have a surprisingly complex answer. Figure 14 shows that, when trains go faster, the sharpest curve radius we can allow begins to increasing exponentially. Right-of-way cost studies conducted in the Department have indicated that right-of-way costs increase almost directly in proportion to increasing minimum curve radius. Thus an increase in speed leads to a significant increase in the cost of new right-of-way. Figure 15 illustrates a point not often recognized: a high speed railroad is a *precision* instrument. The faster you wish to go, the more stringent the standards are for allowable variations in track geometry. As you can well understand, for any given level of traffic over the track, maintenance costs increase more or less geometrically as the track standards become stricter.

Figure 16 shows another kind of price we pay for increasing top

speed. Railroads, as you know, are extremely efficient low-speed carriers because of the very low friction between steel wheels and steel rails. As speed increases, however, other factors generating resistance begin to predominate. As speeds increase beyond about 60 mph, wind resistance begins to be a major factor and the power required to overcome wind resistance increases roughly as the cube of speed. As a result, we pay a very heavy price in energy consumption for increased speed.

Perhaps the most interesting observation about increasing speed is shown in Figure 17. What I have done here is to plot the time required to traverse one mile as a function of the cruise speed and, in the lower curve, the time saved per mile by increasing the cruise speed for that mile by 10 mph. The vital point here is that time savings are much more important at the low end of the speed scale than they are at the high end. In other words, we can save 30 seconds by increasing speed for one mile from 30 mph to 40 mph. If you wanted to save the same 30 seconds by increasing speed from 120 mph to 130 mph, you would have to upgrade over thirteen miles of track. Since we've already shown that the cost of upgrading increases exponentially with speed, we can clearly establish that the focus ought to be on avoiding going slow rather than trying so hard to go extremely fast.

Figure 18 shows a new method we have developed for demonstrating the real payoff from speed increases. The lower part of this Figure shows the time to be saved by changes in operating speed—but this lower part has a linear ordinate which means that the time actually being saved changed as speed is increased. The upper part of this Figure has the vertical axis transformed to make due allowance for the phenomenon discussed in Figure 17, that time savings decrease as speed increases. By comparing these two Figures, we get a more useful graphical tool for evaluating the impact of proposed track or signal changes.

The next concept to be stressed is that the Northeast Corridor is a multi-purpose facility. It is not just a high speed intercity passenger railroad; it must also carry lower speed commuter service and even lower speed freight service. Figure 19 is a map of the Corridor showing the locations where the different commuter and freight operators are encountered. Making this point a different way, Figure 20 is a graphical representation of the actual traffic levels by type of traffic in various locations along the Corridor. All told, we have calculated that there are more than 1,000 trains per day in the Corridor, of which less than one-third are intercity trains. Clearly, the intercity traffic should not have a free hand. Equally clearly, returning to the point we have just made about the need to avoid low-speed operations, anything we can do to disentangle the high speed intercity passenger operations from commuter and freight operations will have a disproportionate benefit for all three types of service. Figures 21 and 22 were selected to establish yet another point: we did not start with a clear plot of earth and the opportunity to build a brand new railroad. In fact, we inherited the result of many years of past operations. Especially since the bankruptcy of the Penn Central and the New Haven Railroad, many years of normal maintenance were deferred because the operating railroads simply did not have the financial resources required to keep the track up to proper condition. It should go without saying that, if a poorly maintained track will not sustain high speed operations, it will certainly not sustain reliable operations for any kind of user, nor in many cases, is it safe to operate. Figure 23 brings yet another perspective to this issue. What I have attempted to do here is compare the relative speeds and energy consumption rates for the various modal choices available to travelers in the Northeast Corridor. This Figure shows that there are real energy advantages to rail transportation. It suggests, as we have discussed earlier, that reliable rail operations with acceptable trip times can effectively compete with other modes and can yield energy savings benefits.

Let's go back to the earlier Figure 5 now on which I showed the various parts of a railroad and examine the budget allocations to each of these parts. What you see is a budget which is not primarily dedicated to increasing maximum speeds. Instead, it is a budget targeted toward rehabilitation (about 70% of the dollars are related to rehabilitation) and it is oriented toward a series of reconfigurations which will simplify the operation of the railroad and disentangle the operations of the various users. This, we believe, is the best way to meet our overall objectives of saving trip time, improving reliability, and improving safety for all of the users of the Corridor.

Management Goals for Mega-Project

Figure 24 shows the general management structure for the Northeast Corridor Project. The Federal Railroad Administration is the overall manager of the budget, of project specifications, program definitions and planning. Amtrak owns the railroad, operates the railroad and maintains it. Therefore, Amtrak has the major role in carrying out the construction, especially on the operating parts of the railroad. Finally, DeLeuw, Cather/Parsons (DCP), a joint venture between the Ralph M. Parsons Company and DeLeuw Cather Company, is the prime architect and engineering firm under contract to the

Federal Railroad Administration. DCP provides both design and program management services. As Figure 25 shows, this broad chart really oversimplifies the problem. Each piece of the project ends up having its own management organization; for example, Figure 25 shows the design organization associated with the construction and rehabilitation of the equipment maintenance shop in Washington, D.C. This $54 million project involves not only FRA and Amtrak but also DCP in five different guises and some seven subcontractors and suppliers. Nor is this yet the whole story: the successful bidder for the construction contract will probably have an organization of suppliers and subcontractors which is far more complex than this design organization.

Figure 26, which I have called "Real Life Program Management" is the central Figure in the entire lecture. What I have attempted to do here is illustrate the process whereby an initial idea is translated into a final product. One point to be drawn from this Figure is the extreme complexity and richness of the problem we faced. As you can see, completion of the NECIP has involved consideration of a wide number of issues probably unique in their diversity.

An equally important problem which this Figure underlines is what I would call the feedback nature (or "vicious circle" characteristic) of a number of problems of program management. We started the project with a number of initial factors and job constraints. Each of these constraints generated resulting problems. These problems were not constant over time; instead, they were affected by a number of dynamic (or changing) factors. Finally, all of our actions had to be filtered through a series of external objectives and constraints. The crucial point I want to emphasize is that each stage of the process can cause a requirement to go back to the beginning—at least to some degree. Unfortunately, as we discussed earlier, an operating railroad system is a uniquely seamless web. You simply cannot make one minor change without risking a cascade or ripple effect throughout all the rest of the system. The net result of this feedback loop is a very great risk of extra cost and time delays until the system finally settles down to its ultimate configuration.

By way of explaining Figure 26, the Figure 27 shows the dates on which the various pieces of the Northeast Corridor were originally constructed. In American terms, the Northeast Corridor is almost incredibly old. The latest link in the system was completed in 1918, and some of the earlier links were completed within a very few years after the first railroad operation in the United States. For example, Figure 28 shows the Canton Viaduct just outside Boston. This is an absolute marvel of early railroad engineering and was, and is, one of the largest stone-arch bridges in the United States. Believe it or not it was completed in 1835. Figure 29 shows the Heilgate Bridge just north of New York City. This bridge, when it was constructed, was the longest steel arch bridge in the world and still remains one of the three or four longest. It is a relative youngster, having been completed in 1918. Figure 30 shows the first piece of high voltage, alternating current, railroad electric traction built in the United States. This was built on the New Haven railroad around 1905 and served as the forerunner of virtually all intercity railroad electrification that exists in the world today.

Figure 31 shows (my old friend) the Baltimore and Potomac Tunnel. This tunnel, just south of Baltimore, is 8,000 feet long and was *completed* in 1873. It still carries every bit of railroad traffic that traverses the Northeast Corridor.

This discussion of the Northeast Corridor history illustrates two points. First, and most obvious, is the fact that great age is likely to imply a need for a great deal of rehabilitation in order to correct problems of deferred maintenance. That is true, but it is not all. Many of the engineering achievements in the construction of the Northeast Corridor are real pieces of our Nation's engineering and cultural history: many, many civil engineering achievements were invented here. We do not start with a clean slate. The best we can hope to do is write another chapter in a long and distinguished history and, with any luck, we can hope to continue the tradition of excellence which has been so well established.

Another vitally important aspect of the NECIP is that everything we do has to be carried out at the same time as the full daily traffic load is handled.

I said earlier that about 1,000 trains per day operate over the Northeast Corridor. While these don't all pass the same point each day, construction work on the Corridor is enormously complicated by the need to provide for operation of all the diverse kinds of traffic which the Corridor carries.

Construction during operation has an obvious impact on the efficiency of the construction work: for example, it has been calculated that roughly 50 percent of the productive time of laborers on the south-end below New York City is lost because they must cease work when trains are passing a working site. More important than the day-to-day impact of passing traffic on labor productivity, we also find that the need to continue to operate the railroad imposes rather drastic constraints on our ability to schedule construction operations in the first place. It simply is not possible to take certain parts of the

railroad out of service for very long periods of time. As a result, construction operations must be planned for absolute minimum track occupancy. Having scheduled track occupancy though, we must then insert as much additional construction into that track segment as is possible so that the overall needs for track occupancy will be a minimum.

This has led to one of the most sophisticated construction scheduling operations I have ever seen. Figure 32 will give you an indication of the complexity of this problem. As you can see from this Figure, we must schedule each operation not only by the type of operation and its time duration, but we must specifically indicate which track and in which location this construction operation will occur. Any deviation from this schedule can obviously have rather dramatic impacts on other construction operations.

Yet another limitation on the ability to manage construction is the fact that certain construction operations have traditionally been set aside for railroad labor unions. Essentially all labor work which is related to the "live" railroad is reserved for railroad labor union. This reservation of work means that there is no competition—certainly no free market competition—for a large share of the work being done on the Northeast Corridor Project. In addition, because Amtrak is rightfully sensitive to having large swings in their level of employment of railroad labor personnel, we have had to make a major effort to level out the amount of work being done over the years. I certainly don't intend to suggest by this that there is anything wrong with reserving a share of the work for the railroad labor unions. Quite the contrary, the railroad labor unions are probably the most efficient sources of trained personnel for doing certain kinds of jobs. Use of these unions does, however, pose a certain constraint which would not exist if all work were available for outside competition.

It is not often recognized that sheer size of a project can dramatically affect its character. The Northeast Corridor Project illustrates a number of superlatives. It is the largest project the Department of Transportation has ever attempted to manage directly. This is true both in terms of dollars and in terms of the geographic extent of the project. To the best of our ability to determine, this is the largest *railroad* project carried out in this century and it is certainly the largest rehabilitation project in living memory. Our signal contracts alone were each the largest contracts ever received by either of the two American railroad signal manufacturing companies.

In the face of a project of this extremely large size, I think it is fair to say that none of the organizations involved were prepared at the outset. As I said, the Department of Transportation had never directly taken on a project like this. By the terms of the 4R Act, Amtrak both acquired the Corridor and assumed its role in NECIP on February 5, 1976. Thus, Amtrak was required to assume ownership and operation of the most complicated passenger railroad in the United States and simultaneously take on a major share of the largest railroad construction project in this century with nothing to build upon but an organization which had primarily been required to stretch every single dollar during many years of bankruptcy. The third party, DCP, was also a brand new organization at the outset of this project. In other words, we all started from scratch in the face of one of the most difficult projects in this century.

Unfortunately, while the problem was difficult and the organizations unproven, the expectations were unreasonably high. As is common with a project of this size, the proponents generously promised magnificent achievements while the opponents offered a subminimum budget. The net result was that one side promised while the other refused to pay.

These unrealistic expectations were, to be fair, not solely a result of the political process. There are many railroad enthusiasts in the United States and they had, for many years, wanted to undertake a project of this nature.

The NECIP was seen as the last and best chance to accomplish a number of objectives. I think the railroad community also expected far more of the NECIP than anyone could have delivered.

Going back to our earlier Figure 26, these initial factors and job constraints led to a series of very typical problems; first, we bit off more than we could ever chew and attempted to build far too much. Second, especially because this was a rehabilitation job on a railroad which is many years old, it was almost impossible to tell at the outset the true condition of the railroad plant and the cost which would be required to repair it. Also, because of the systemwide impact of any action taken and the extreme complexity of railroad scheduling, any failure to meet a plan or schedule would immediately cascade backward into required scope changes. Finally, there were literally no decisions which could be made without a great deal of discussion and coordination with and among many other authorities. As a result, decisions were slow and often reflected a least-common-denominator compromise which was hard to implement.

As you may also know, the world normally refuses to stand still in the face of these kinds of problems. On the favorable side, we learned from many of our mistakes and our performance improved. We acquired a better understanding of the problem and a better ability to estimate cost and schedules. On the minus side, much of the work of the NECIP has been carried out during the worst inflationary period in the Nation's history. At the outset of the project, we were predicting multi-year inflation at around 7 percent and were using this number as a result of the mandate of the Office of Management and Budget. Within one or two years into the project, however, it became clear that inflation rates were going to run well above 7 percent. We have recently calculated that, for the same ultimate scope, the total cost swing between a 7 percent constant inflation rate and a 12 percent constant inflation rate would be well over $250 million. This meant that I was constantly faced with the task of second-guessing the best economists in the United States in deciding what inflation rate or escalation rate we would use in predicting. Parenthetically, I might add that second guessing economists is not all that difficult and, by adopting a healthy cynical attitude, we have been able to keep ahead of inflation.

Another, perhaps even less predictable, set of forces was the result of changing attitudes on the part of policy makers. In the 4R Act, passed in 1976, an initial set of goals and budgets were established. Going back to Figure 4, you can see that these goals and budgets changed rather significantly over time. In the case of the Passenger Railroad Rebuilding Act of 1980, the Carter Administration had proposed these changes more than a year before they were finally passed. This meant that, for about one year, the entire budgeting and scheduling of the Northeast Corridor Project was carried out in speculation as to an action of Congress. Conversely, President Reagan decided that his Economic Recovery Program required that the total cost of the Northeast Corridor be cut by somewhat more than 10 percent. Although we tried to implement these cuts in a way that would cause the least ultimate disruption, changes such as these inevitably cause at least a partial return to ground zero in budgeting and scheduling.

Even if the program authorization had not changed, year-to-year appropriations are subject to annual fluctuations and broad funding priorities. The program schedules and budgets for each year are established years in advance and are based on a reasonable projection as to the most efficient way in which the project can be built. If, as frequently happens quite legitimately, national economic priorities do not permit funding levels which are consistent with the most efficient conduct of the project, then the project must be scheduled in order to fit other national priorities.

Going back to the program management Figure 26, we should also discuss the fact that the typical mega-project must deal with a number of external objectives and constraints which are not legitimately related to the content of the project itself. For example, any project action or plan required a wide range of coordinated activities with other agencies. These included other Department of Transportation agencies as well as the Corps of Engineers, nine States and somewhere between 200 and 250 cities and municipalities. As Figure 33 shows, in fact, there are about four different owners of pieces of the Corridor and some eight agencies operate over various parts of the Corridor. Because of the systemic impact of any decision, essentially every decision had to be cleared with every one of these agencies.

Going back to Figure 2, showing the map of the Corridor, you can easily see that much of the Corridor passes through some of the most environmentally sensitive areas in the United States. For example, all of the Corridor along the Connecticut shoreline passes through an extremely scenic area, but also one which is filled with wetlands and marshlands which are environmentally sensitive. As Figure 34 shows, the Northeast Corridor Project has been engaged in one of the largest pieces of environmental investigation ever conducted. According to our calculation, we have produced over 7,000 pages of documentation dealing with environmental issues alone.

Related to environmental issues are the historical and cultural assets which are represented by various pieces of the Northeast Corridor. One of our major historical issues, and one which consumed a great deal of my time, was the preservation of these ticket windows in the Stamford Station shown in Figure 35. Before the issues of preservation of these ticket windows were resolved, we had delayed a $20 million project by some 2 months. The cost of this delay alone was probably in excess of $200,000 (which is far greater than the value of the ticket windows). Figure 36 shows a set of stained glass roundels which are in the entryway to the station in Baltimore, Maryland. These roundels date from the era when the railroad station was the most important expression of civic pride and achievement. They had been covered by black paint since World War II, when apparently someone feared that the Germans were going to bomb the station. We have had them cleaned and restored to their former glory and I think this station will become an important focus for civic pride in Baltimore.

In a related vein, one of the later objectives which was attached to the Northeast Corridor Project was the promotion of economic development in urban areas around the railroad stations. This is an opportunity which we have seized. Figure 37 shows downtown Providence as it appears today. Figure 38 is a drawing of the area shown in the picture. As you can see, the railroad tracks serve as a kind of barrier which has permanently divided a major developable area from the existing downtown. Figure 39 shows what will happen when we relocate the railroad and the railroad station in downtown Providence. As a result of this relocation, which will cost somewhere in the vicinity of $100 million for total completion, about 60 acres of property in one piece will be added to the downtown area in Providence. We believe this will literally transform the face of the city of Providence.

A similar picture emerges in Stamford, Connecticut. Figure 40 shows what the Stamford station looks like today and Figure 41 shows what it will look like in the future, including an intermodal transportation center which will re-form traffic circulation in downtown Stamford and, we believe, significantly contribute to the development of Stamford.

There are two other social objectives which are often attached to programs large enough to carry them. These objectives are the promotion of minority-owned enterprises known as MBEs and the promotion of equal employment opportunity for minorities and women. The Northeast Corridor Project was started under Secretary William T. Coleman who felt that NECIP should serve as a centerpiece and an example for what could be accomplished in the minority business area. As a result of Secretary Coleman's determination, the Corridor project adopted a goal of awarding 15 percent of its contracts or subcontracts to minority- or women-owned business enterprises. This is, to my knowledge, the highest percentage goal and the largest project employing such a goal of any Federal project. We have, in fact, met that goal to date. We have awarded approximately 15 percent of our projects to minority- and women-owned firms, and these awards have totalled somewhat in excess of $100 million so far.

In a similar vein, the project adopted the goal of having 26 percent minority and female employees. According to our most recent report, well over 30 percent of our employees are in these categories.

Yet another area in which Federally funded projects are expected to operate is the promotion of, or at least the introduction of, new methods of technology, which private industry can evaluate and adopt if desirable. Figure 42 shows a very recent invention in railroad reconstruction work called the track laying system (TLS). It will totally renew a piece of track including replacing rail and the old wood ties with new concrete ties. Figure 43 is a different view of this same machine. Figure 44 shows yet another piece of technology called the panel replacement system (PRS). Using this system, a complete switch can be replaced as a prefabricated panel, obviating the necessity for piece-by-piece replacement of ties and steel. Figure 45 is another view of that same machine, giving you a better perspective on how it operates. In another area of technology introduction, we have pioneered the use of what is called an undercutter in the United States. Over many years of use, railroad ballast is slowly ground up and fragmented and forms fine particles which clog the ballast and prevent acceptable drainage. Figure 46 shows how the undercutter reaches under the track, hauls the old ballast out, and cleans it, and Figure 47 shows the ballast being put back into position. A combination of the undercutter, the PRS and the TLS means that we have totally mechanized the process of renewal of track. No other railroad in the United States uses such advanced technology.

Let's go back to Figure 26 on program management now and reiterate the way in which the feedback process operates. We started out with a series of initial constraints and job factors. This led to the formulation of an initial set of plans which were totally unrealistic. Stage 1, then, was to recycle these highly unrealistic plans and to produce a plan which appeared to be more realistic. This plan was fed through into learning experience, inflationary pressures and the other dynamic pressures. This caused the initial set of plans, having been refined once, to be fed back into the meat grinder for yet another refinement. After completing another stage of refinement, these plans were fed into the whole series of interagency agreements, environmental controls, urban development objectives and technological methods. Each of these had a necessary impact on the plans and they were taken back to ground zero once again. Each time the plans were taken back for revision, of course, the systemic nature of railroad engineering meant that every change had an inevitable impact on every other part of the system.

The net result was, at least initially, a great deal of time delay and redesign effort. As an offset, I did discuss the dynamic factor called learning experience. This meant that, although we made many mistakes, we tended to make fewer and fewer of them as time went on. Over the past year, for example, the planned scope of the program has remained essentially constant which has finally permitted us to do an adequate job of project scheduling and cost control. Even so, any change or any proposed change can always start the vicious circle again.

Results

Despite the problems we have encountered, we have, after a slow start, begun to achieve a great deal. I showed you Figures 42 and 43 on the TLS earlier. Using this machine, we have installed about 400 miles of concrete ties which look very much like those shown in Figure 48. This results in some of the finest and safest railroad track which exists anywhere in the world. Figure 49 shows where that track is and just how much of it is already providing a better ride for rail passenger travelers. Figure 50 shows a new maintenance-of-way base which was opened this year in Perryville, Maryland. This is one of three new maintenance-of-way bases which have been opened in the last 6 months at a cost of approximately $5 million each. Figure 51 shows the status of the B&P Tunnel as we were well into the job. This was, I believe, one of the most difficult and certainly one of the dirtiest jobs ever undertaken. Just last Friday, we reached the halfway mark. Figure 52 shows an inadvertent result of our construction work. Because the tunnel is 100 years old, the exact status and strength of the walls were uncertain when we began our work. As a result of some vigorous excavation combined with leaks in the city's water main, the walls of the tunnel moved, permitting settlement in the houses above. Needless to say, the Northeast Corridor Project was not well received in this area of Baltimore for several months.

Figure 53 shows that the work on the Wilmington Station is well underway. And Figure 54 shows us installing one of more than 50 bungalows which contain the very complicated instrumentation which runs the signal system. Each of these bungalows costs in the neighborhood of $1 million and contains about up to 1,000 different pieces of electrical equipment.

Figure 55 summarizes our overall progress to date. Overall, we have completed approximately 95 percent of the trackwork which was planned and we are somewhat more than halfway through the total project. In the process, as Figure 56 shows, Amtrak's performance has improved. In the first year of work, Amtrak did about half the work they should have done for the money they spent. In 1981, they were almost exactly on the budget and the same will be true in 1982.

I have to be honest and say that this improvement is at least partly related to our ability to predict the budget adequately, as well as to our ability to improve Amtrak's productivity. In either case, our ability to predict, budget and manage has enormously improved. Figure 57 shows that we have also gotten much better at estimating the cost of competitively-bid construction contracts. In fact, over the past several years, we have consistently awarded contracts at a significant percentage below the budget established for them.

I would add, by the way, that consistent overestimation of project cost can sometimes be nearly as bad as underestimating those costs. The real advantage of conservative estimating, though, is that it permits us to avoid the very pernicious recycling which we discussed before. As a result, we have consistently adopted a practice of attempting to overestimate project costs so that we can maintain maximum flexibility. Thus far we have been able to do so with some success.

Figure 58 gives a different measure of progress to date. The many years of deferred maintenance had, by 1976, resulted in a railroad in which much of the track had been placed under what is called a "slow order"—a condition in which trains are required to slow down because the track is unsafe at higher speeds. As you can see, by the end of 1981, all of those slow orders had been eliminated and all of the track had been returned to a safe condition for high speed operation. We expect this situation to continue and we expect no further speed limitations as a result of deferred maintenance.

Figure 59 shows the final payoff. As you can see, after initial deterioration as a result of extremely heavy construction and rehabilitation work, we have now gotten the schedules back to, and even below, the best levels in prior history. In fact, we will come very, very close to the original Congressional deadline of schedule objective at a price considerably lower than was authorized. At the same time, the lower curve shows that the ontime reliability of intercity passenger operations has improved dramatically. Overall, while we have not achieved all of our objectives, and may never do so, I believe we are well on the way toward getting our money's worth.

Lessons

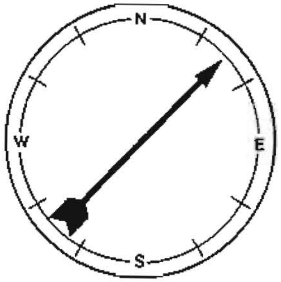
For those of you who may be forced take on one of these mega-projects some day, or who may be involved in the process of formulating one for someone else to manage, I think the Northeast Corridor Project is an excellent case history providing some lessons which I have summarized in Figure 60. One lesson is the extreme importance of a good start. If the initial objectives are reasonable and if the initial budgets and schedules are accurate, the project can avoid the extremely disruptive and costly recycling which the Northeast Corridor Project encountered. Next, the manager of a mega-project should make a conscious effort to understand not just the engineering

issues, but also the historical, social, environmental and cultural aspects of the project to be undertaken. This will permit the manager to carry out the program effectively and to deliver a program which has the maximum benefit to the society which is paying for it. At the same time, there should be a continuing dialogue with the policy managers. This is especially important in order to be sure that the social objectives which are being imposed upon the project are appropriate and desirable and do not impose unacceptable cost. Next, if at all possible, the project manager should not be held responsible for predicting or managing factors beyond his control. An outstanding example of this kind of factor is inflation. At the outset of the project, and during its pendency, there was literally no economist in the United States who could accurately predict the cost of inflation. Unfortunately, inflation had a major impact on the cost of completing the Northeast Corridor Project. It would have been much better if the initial authorization had explicitly been stated in constant dollars rather than in current dollars so that the responsibility for predicting inflation could have been lifted from the shoulders of the project manager. Finally, and I think most important, both the project managers and the project formulators should promote the realization that mega-projects contain a multitude of objectives which are not always compatible and which, in some cases, are mutually contradictory. It is not fair, either to the manager or to the public, to pretend that all of these objectives can be fully achieved. We all need continually to insure that the public realizes that successful project management means a balanced and partial realization of all the objectives. We can't do everything perfectly: we can do most of the things reasonably well.

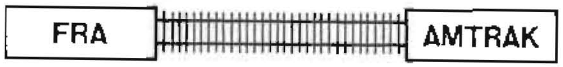
Thank you very much for your invitation, for your time and for your attention. I have never had a better experience or enjoyed myself more than in the process of managing the Northeast Corridor Project. I hope my sense of enthusiasm and of challenge has been communicated to you and I hope that this lecture will lead to a renewed sense of the partnership we all share in getting jobs done.

FIGURES

NORTHEAST CORRIDOR IMPROVEMENT PROJECT | NECIP



The NORTHEAST CORRIDOR



– A LARGE COMPLEX SERIES OF INTERRELATED PHYSICAL IMPROVEMENTS TO THE OPERATIONAL RAILROAD WASHINGTON, DC – BOSTON, MA

Figure 1.

NORTHEAST CORRIDOR IMPROVEMENT PROJECT | NECIP

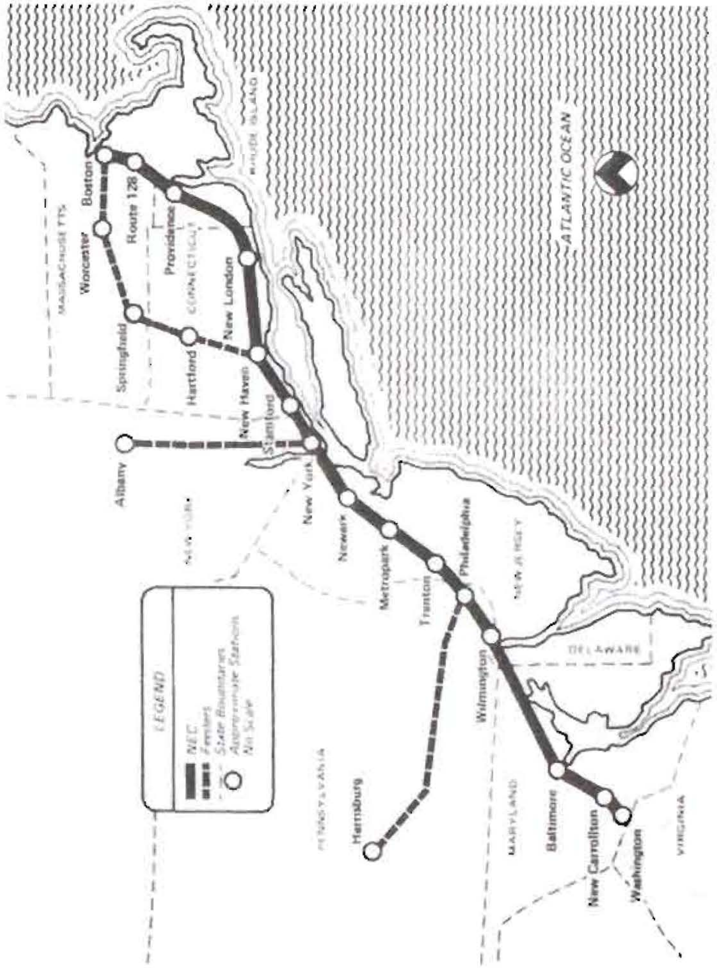


Figure 2. Corridor Map

NORTHEAST CORRIDOR IMPROVEMENT PROJECT | NECIP

● THE COMPELLING REASONS FOR THE NECIP

- THE 456-MILE CORRIDOR FROM WASHINGTON TO BOSTON ENCOMPASSES:
  - ABOUT 20 PERCENT OF NATION'S POPULATION } DENSITY
  - ON ROUGHLY 2 PERCENT OF ITS LAND } DENSITY
  - MAJOR SHARE OF OUR INDUSTRY
  - CITIES ATTRACTING BUSINESS AND TOURISTS
- OPPOSITION TO MUCH MORE HIGHWAY AND AIRPORT CONSTRUCTION
  - AIR AND NOISE POLLUTION
- ENERGY COSTS AND CONSERVATION, ESPECIALLY SINCE 1974 OIL EMBARGO
- HEAVY GOVERNMENT SUBSIDIES FOR LIMITED USE REQUIRED ACTION
  - SOME PRIOR EXPERIENCE SHOWS HIGH PROBABILITY THAT PATRONS WILL RIDE FAST, RELIABLE INTERCITY RAIL SERVICE
- IMPROVEMENTS TO THE CORRIDOR WILL ASSIST COMMUTER AND FREIGHT NEEDS IN THE NORTHEAST

Figure 3. Reasons for NECIP

NORTHEAST CORRIDOR IMPROVEMENT PROJECT | NECIP

NECIP GOALS

	4R Act 1/ (Feb. 5, 1976)	PRRA 80 2/ (May, 1980)	President's Economic Recovery Program (February, 1981)
o	2 hrs. 40 min. NYC to D.C. 3 hrs 40 min. Boston to NYC	---	2:50 NYC to D.C. 4:10 Boston to NYC
o	Complete within 5 years	Complete within 9 years, 8 mos.	---
o	Improvements Permit Further Upgrading and produce maximum labor benefits	Priorities for Improvements: - Safety - Ridership - Reliability - Trip Time - Cost effective maintenance cost reduction - Minimize impact of construction - Produce immediate benefits	Deemphasize trip time objective
o	Facilitate Rail Commuter Service & Mass Transit	Promote Urban Development Around Stations	---
o	Facilitate Freight	Separate Passenger and Freight	---
o	$1.75 billion	$2.5 billion	$2.19 billion

1/ Railroad Revitalization and Regulatory Reform Act of 1976.
2/ Passenger Railroad Rebuilding Act of 1980.

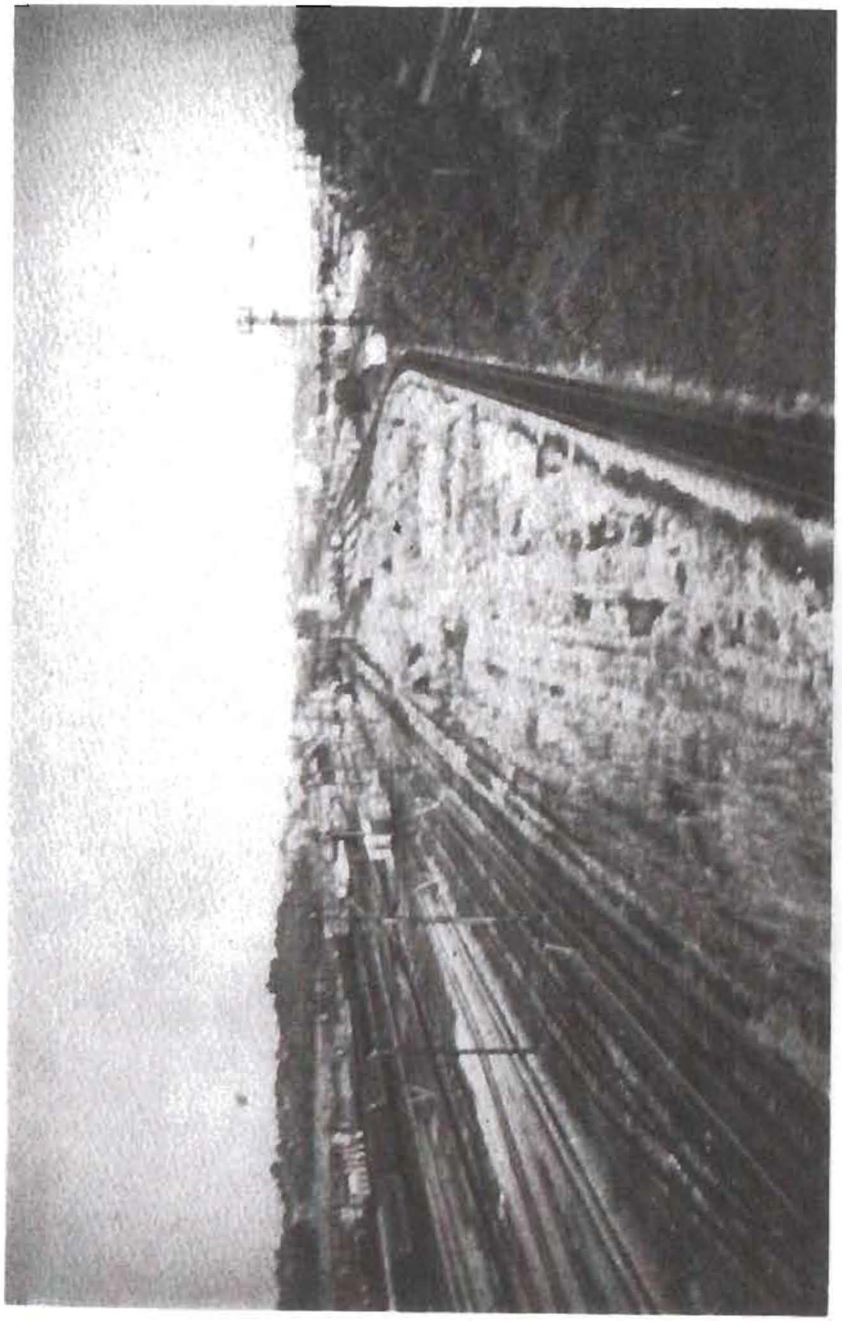


Figure 13. Ivy City

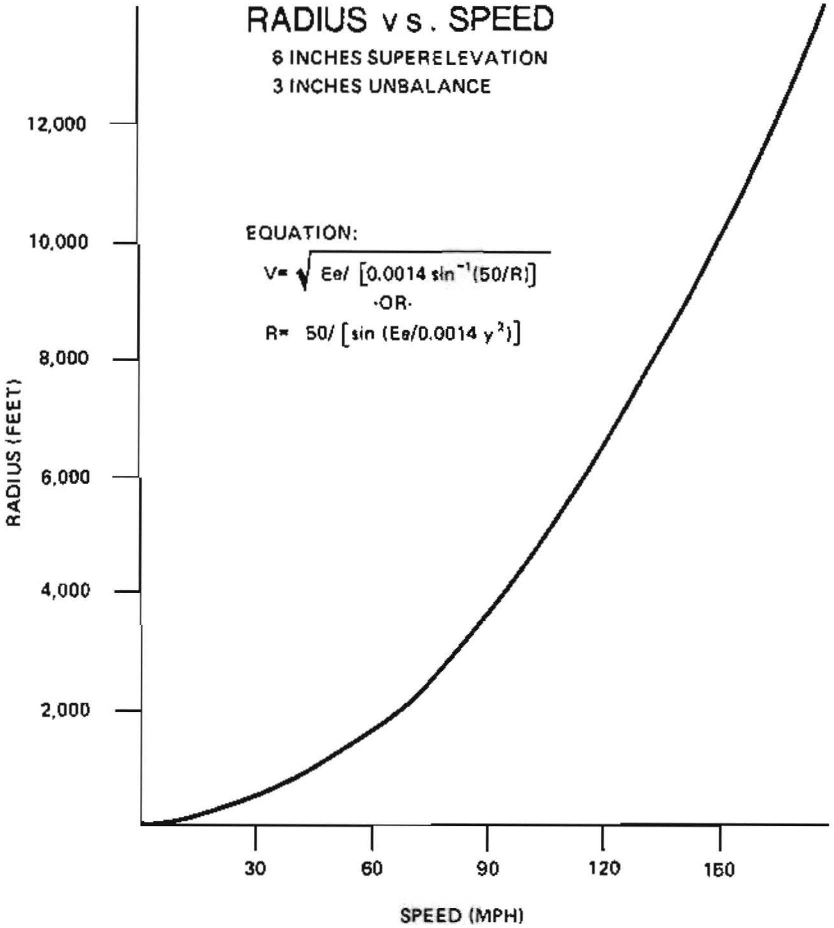


Figure 14. Speed vs. Curve Radius

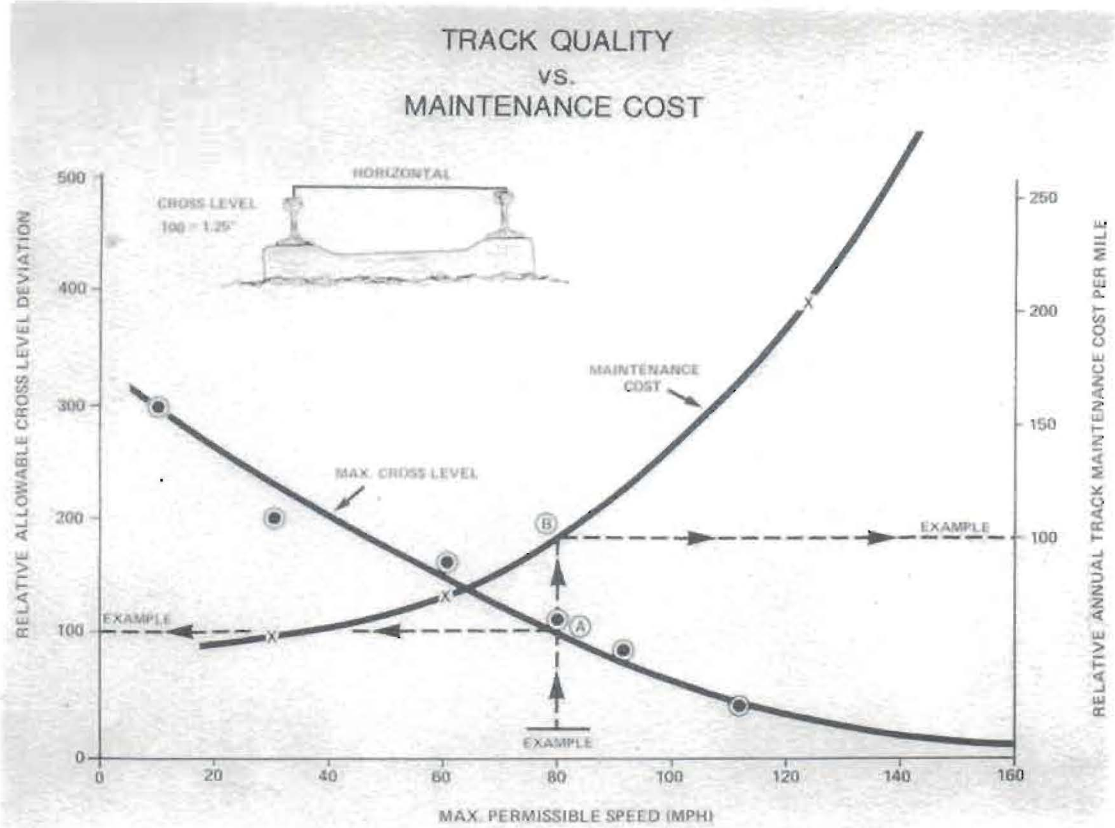
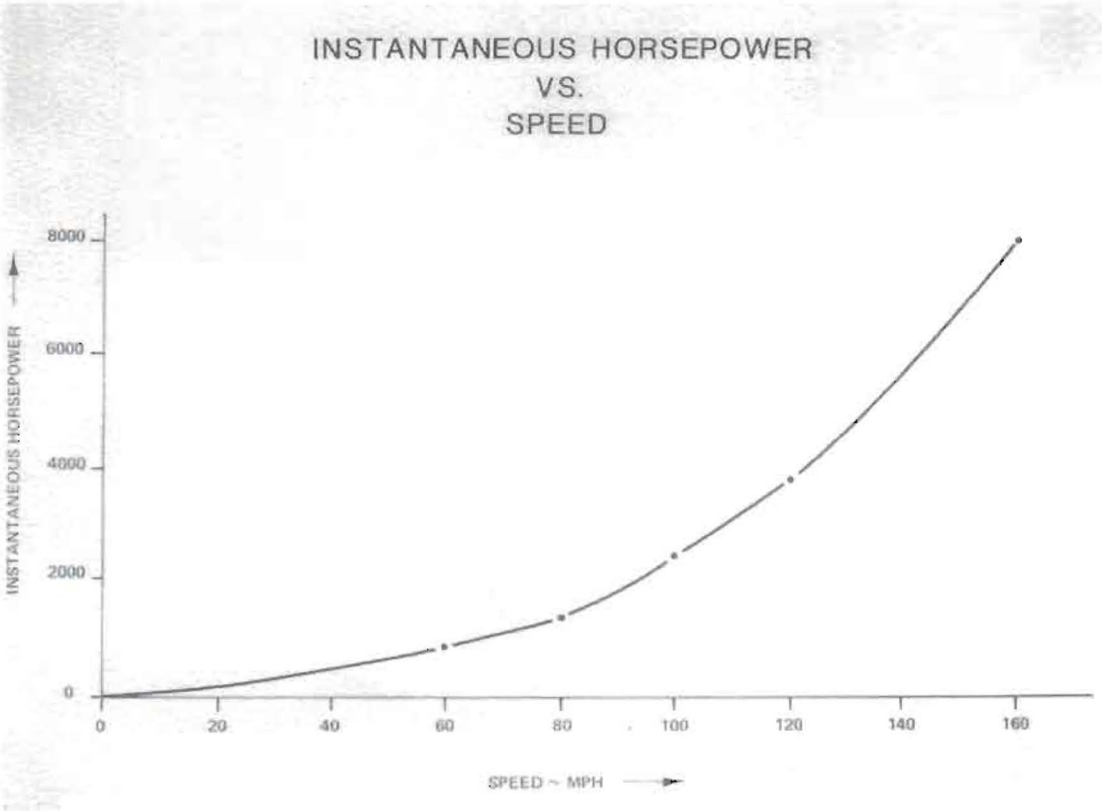


Figure 15. Track Quality & Maintenance Cost vs. Speed



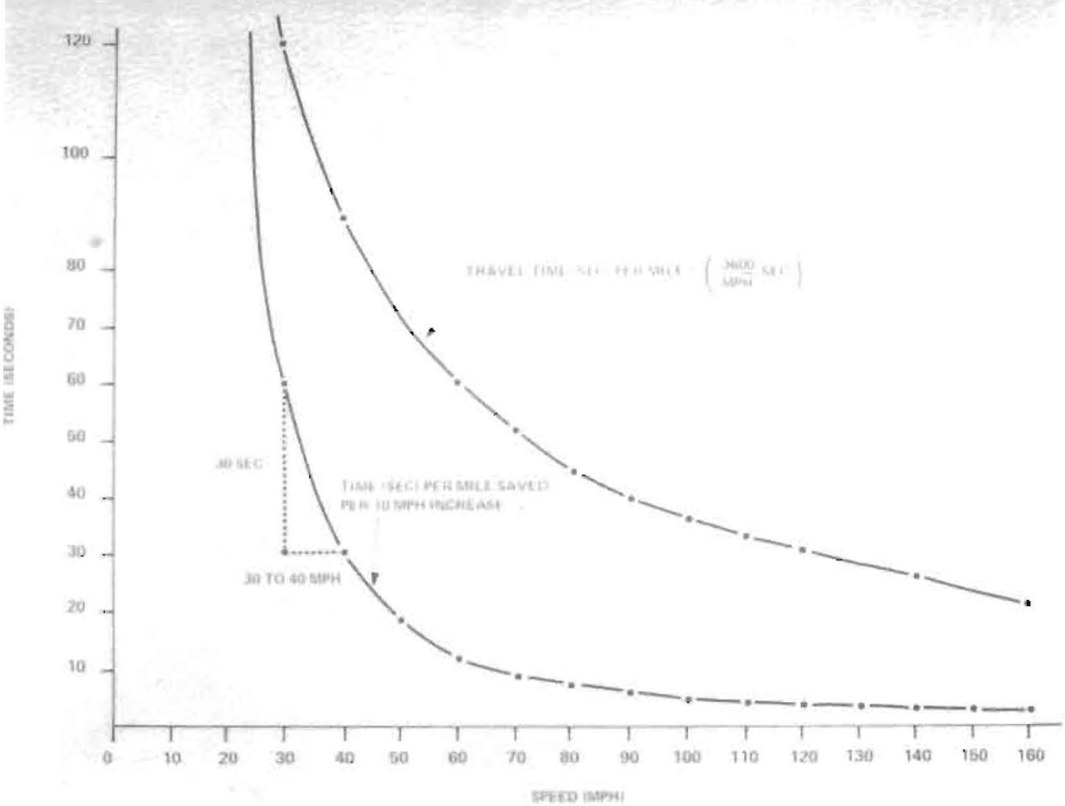


Figure 17. Relative Importance of Speed Changes

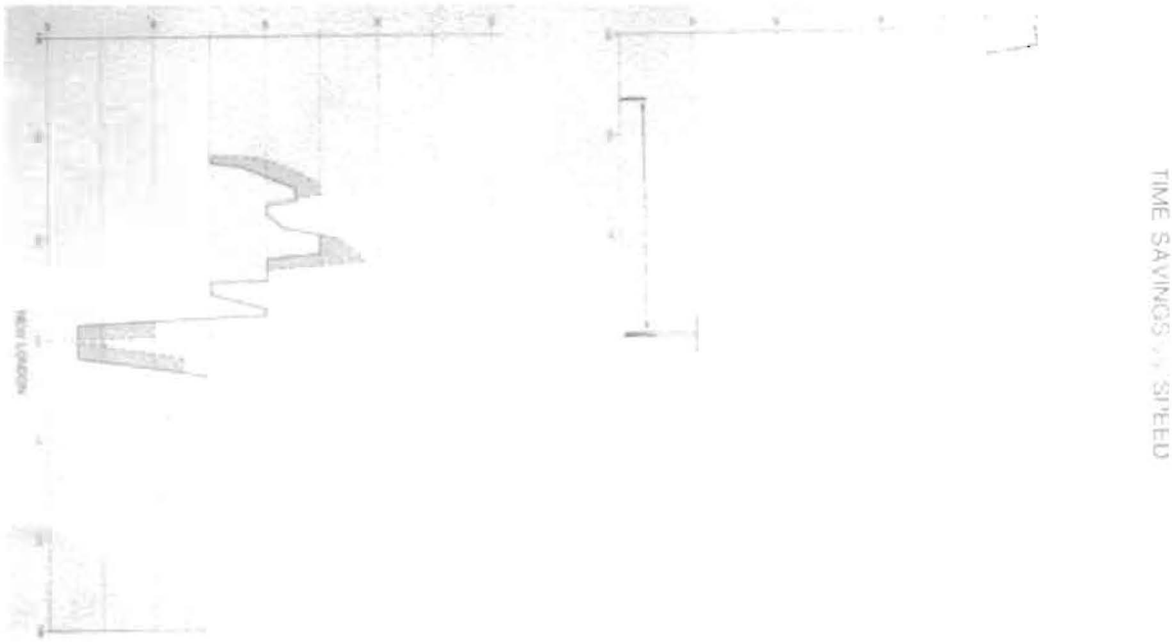


Figure 18. Time Savings vs. Speed - New Projection

NORTHEAST CORRIDOR IMPROVEMENT PROJECT NECIP

...Associated areas of commuter train and freight operational interests

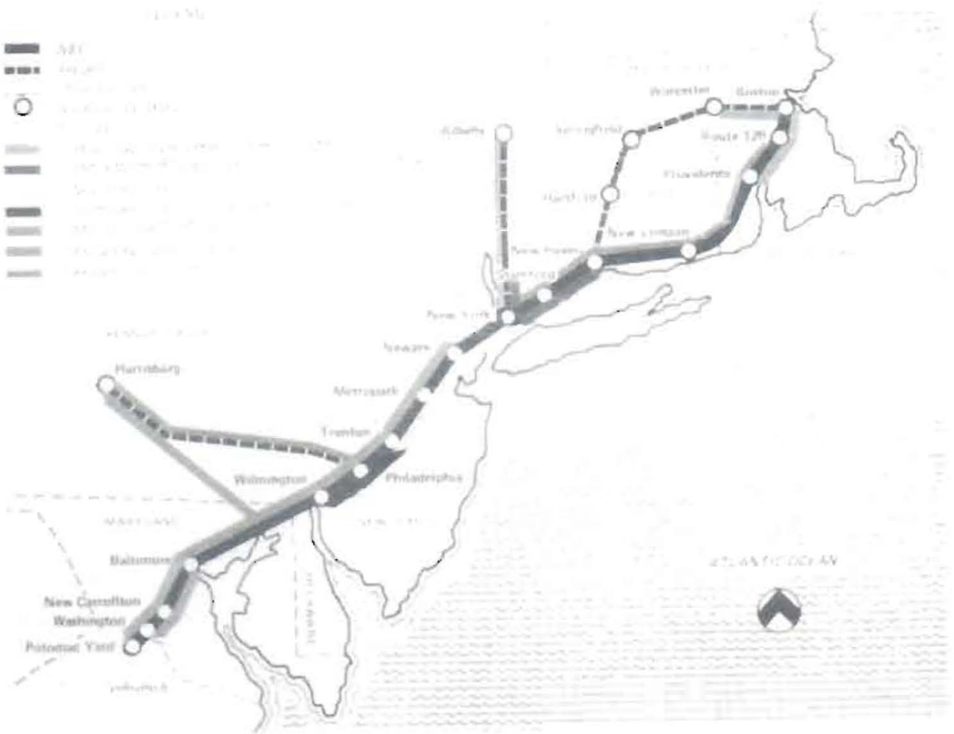


Figure 19. Map Showing Commuter Areas

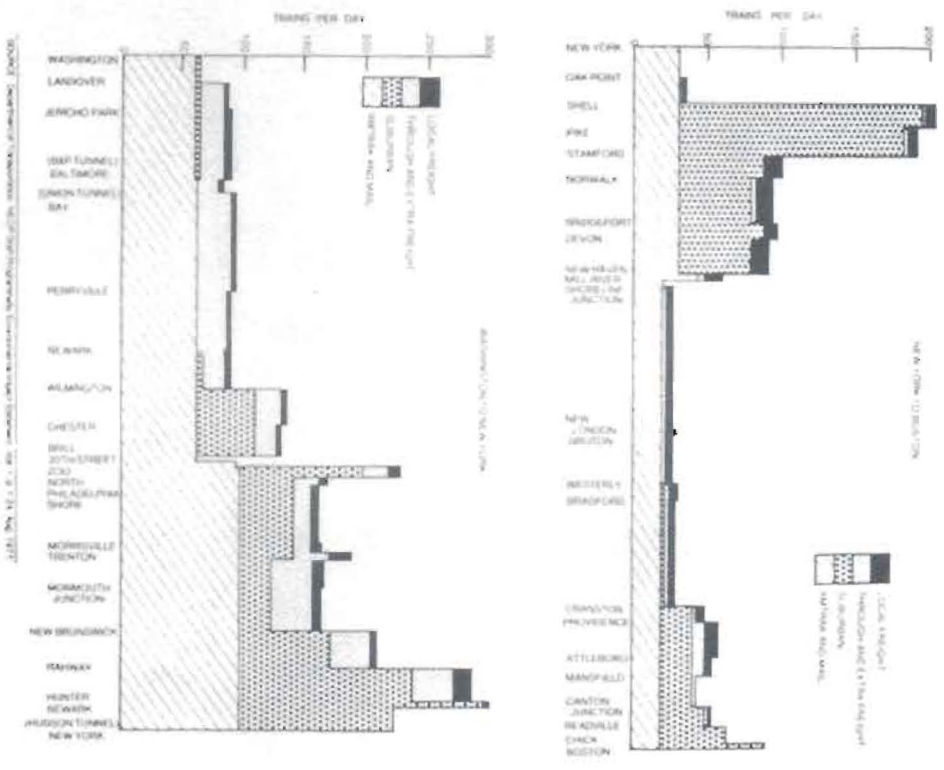


Figure 20. Rail Traffic Density on the NEC

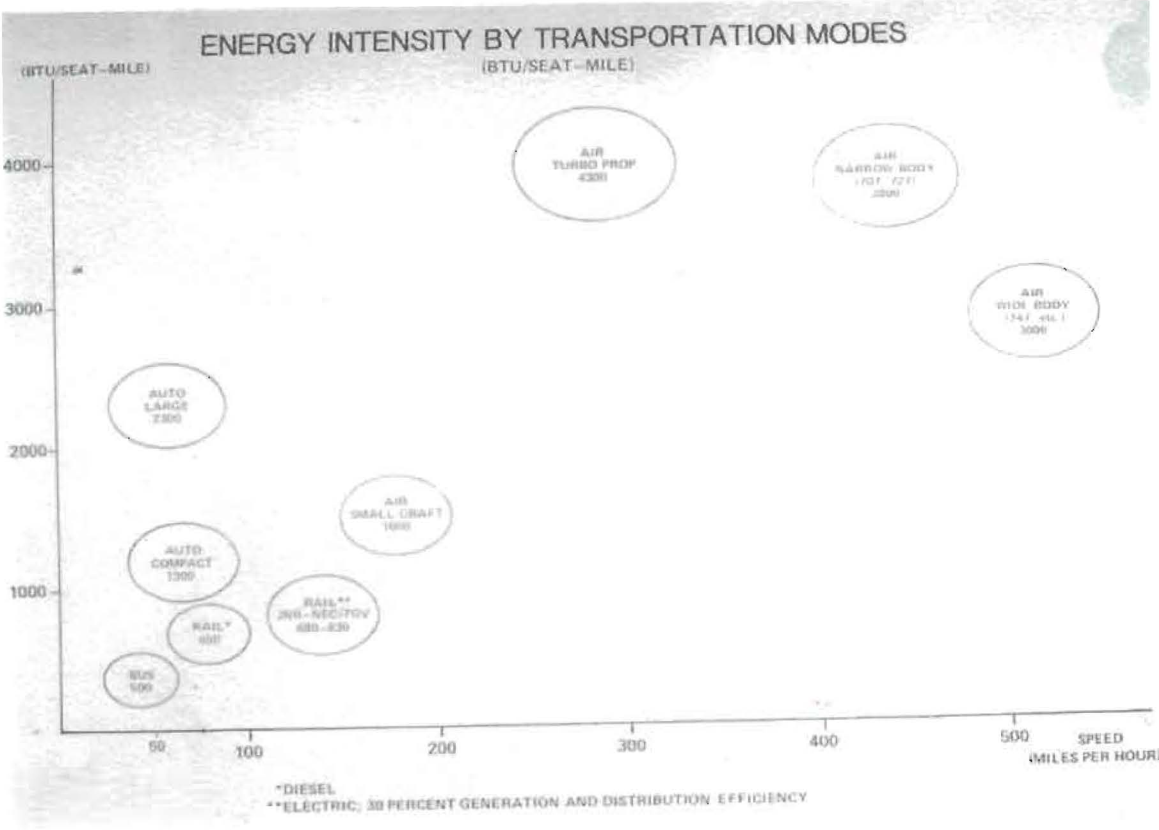


Figure 23. Energy Intensity by Transportation Modes

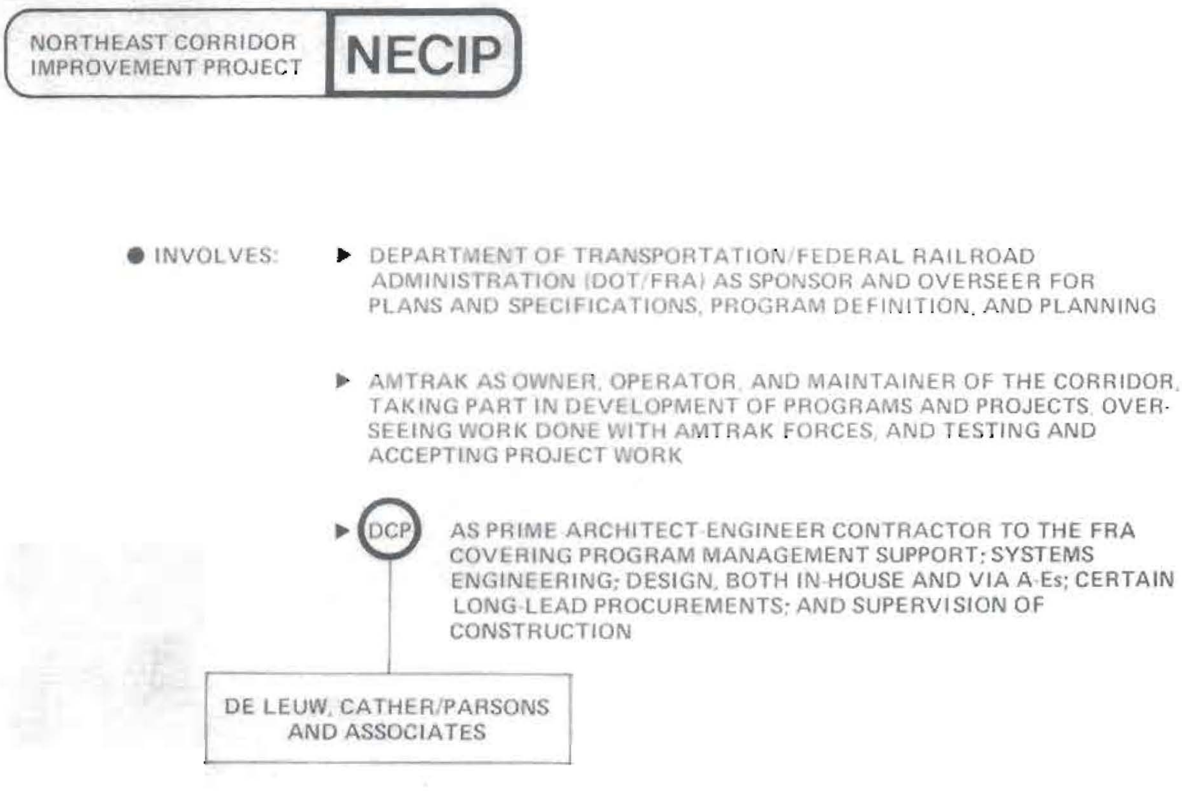


Figure 24. Overall Management Structure

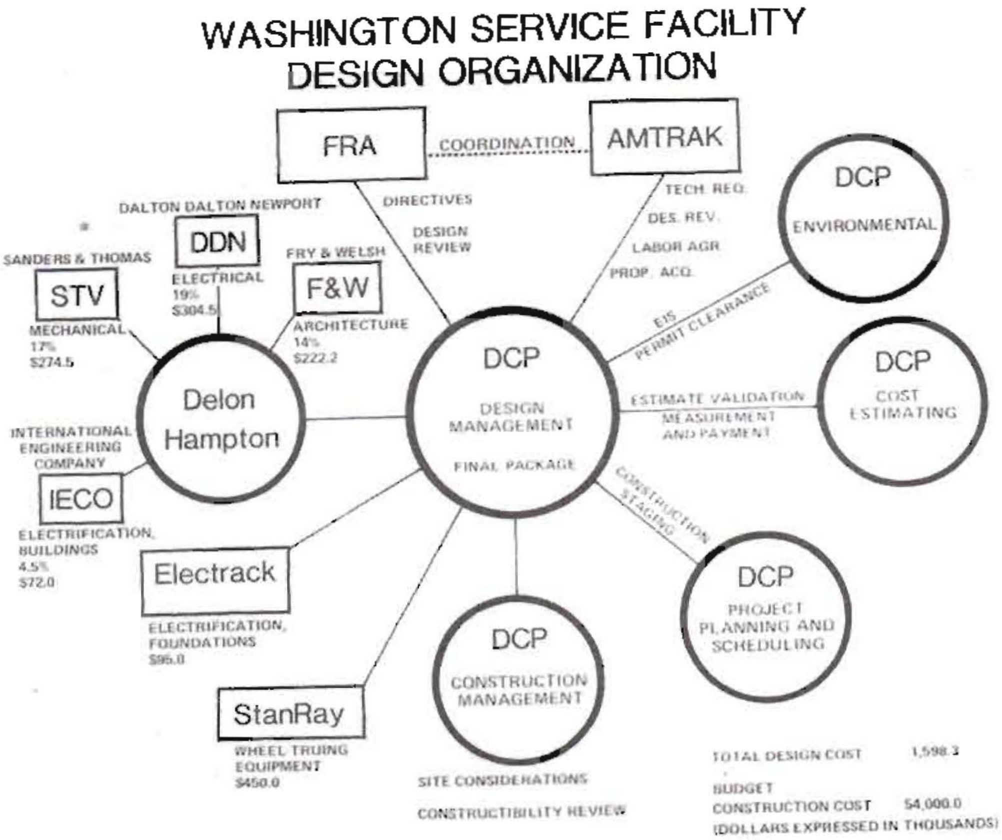
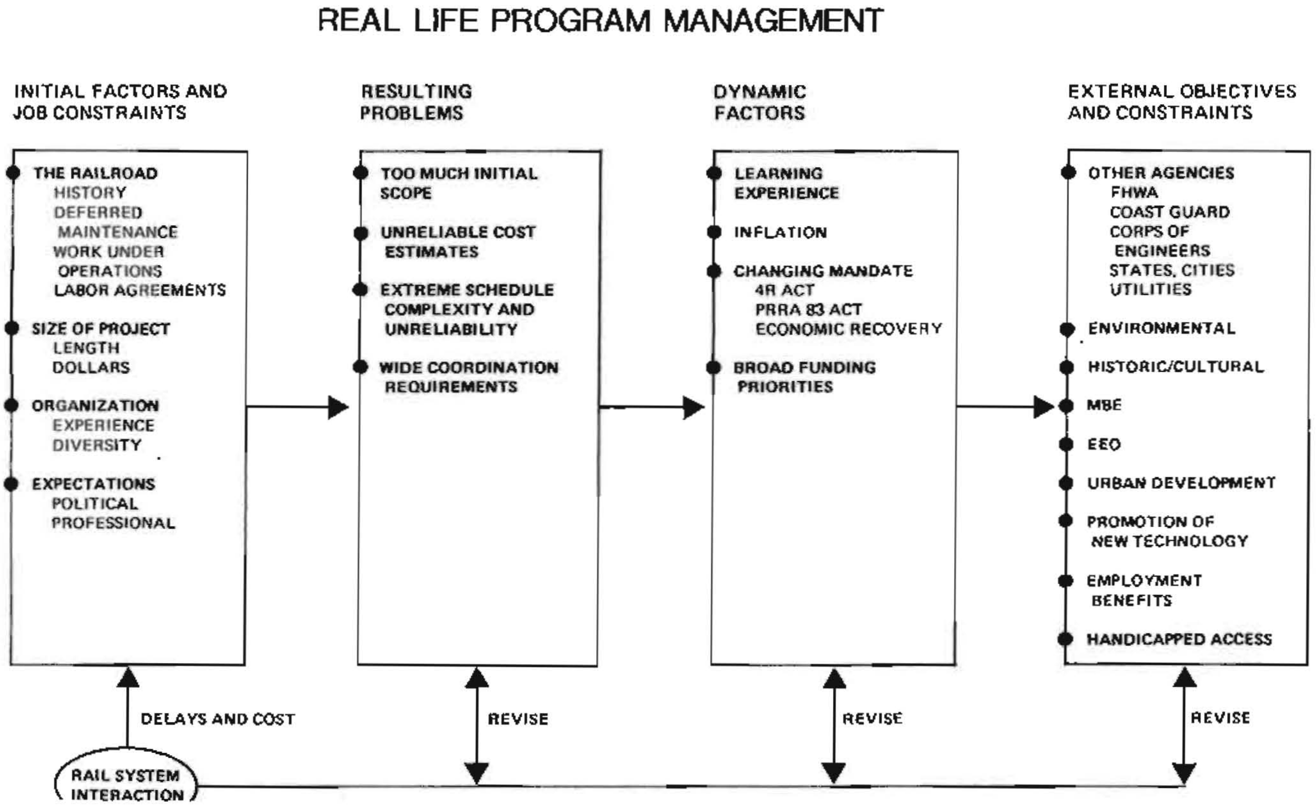


Figure 25. **Washington Service Facility Design Organization**



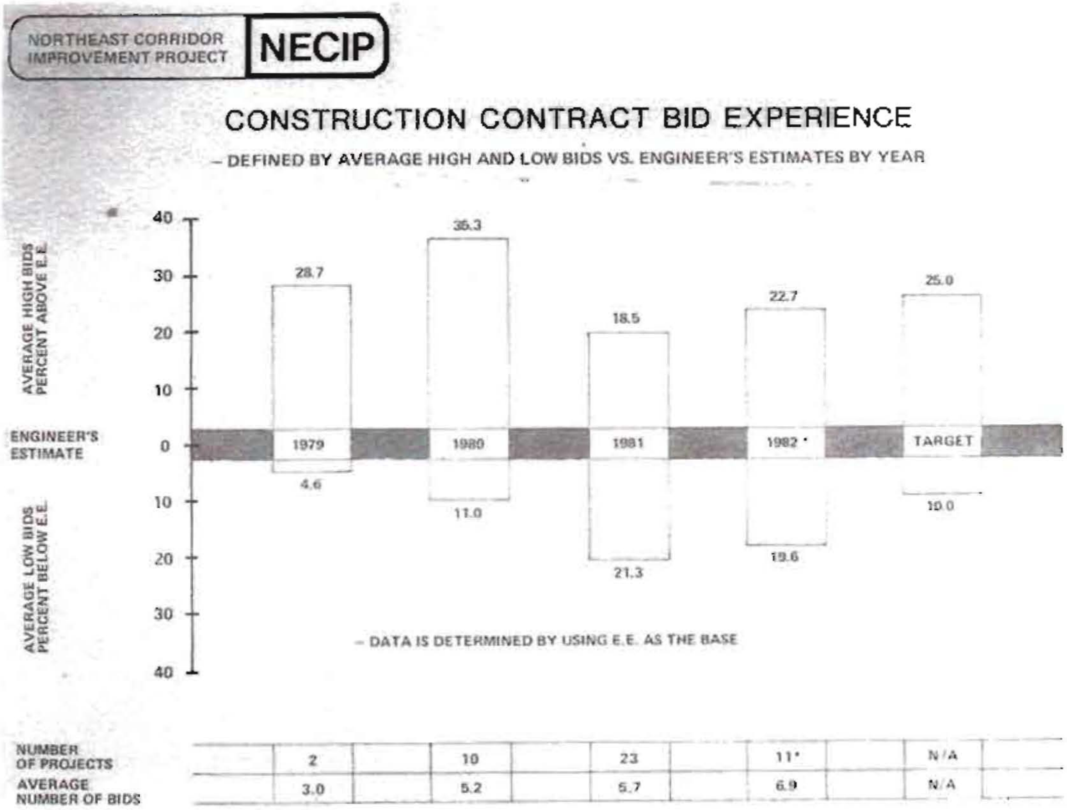
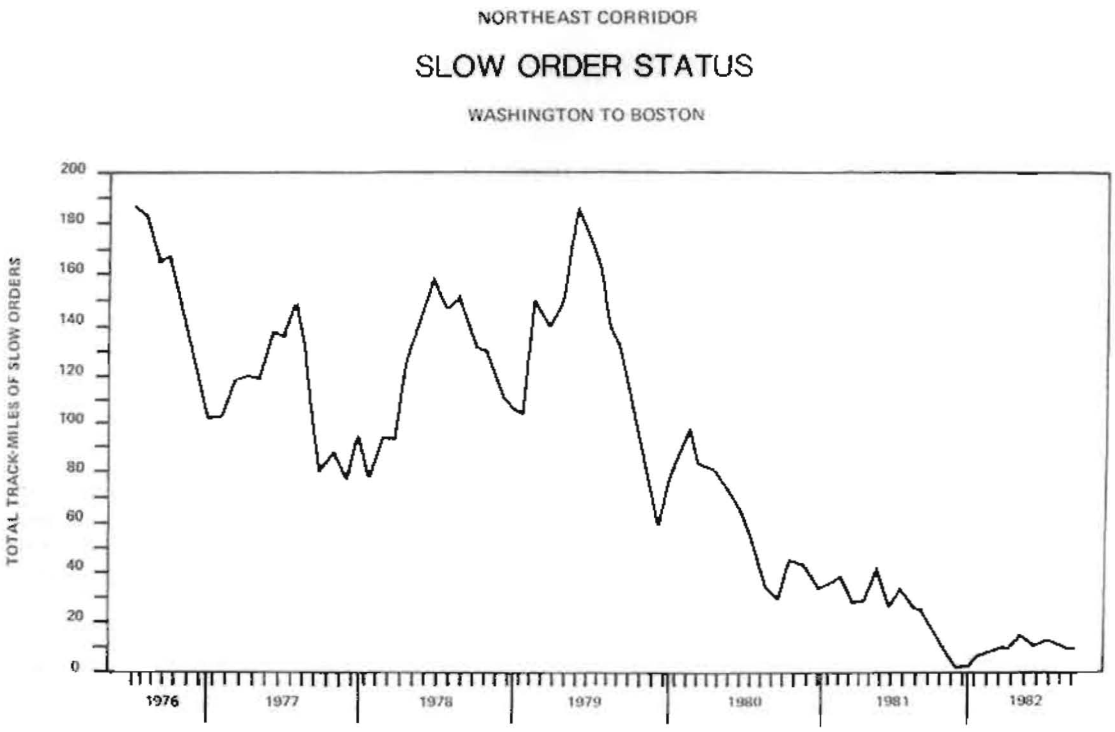


Figure 57. Bid Experience



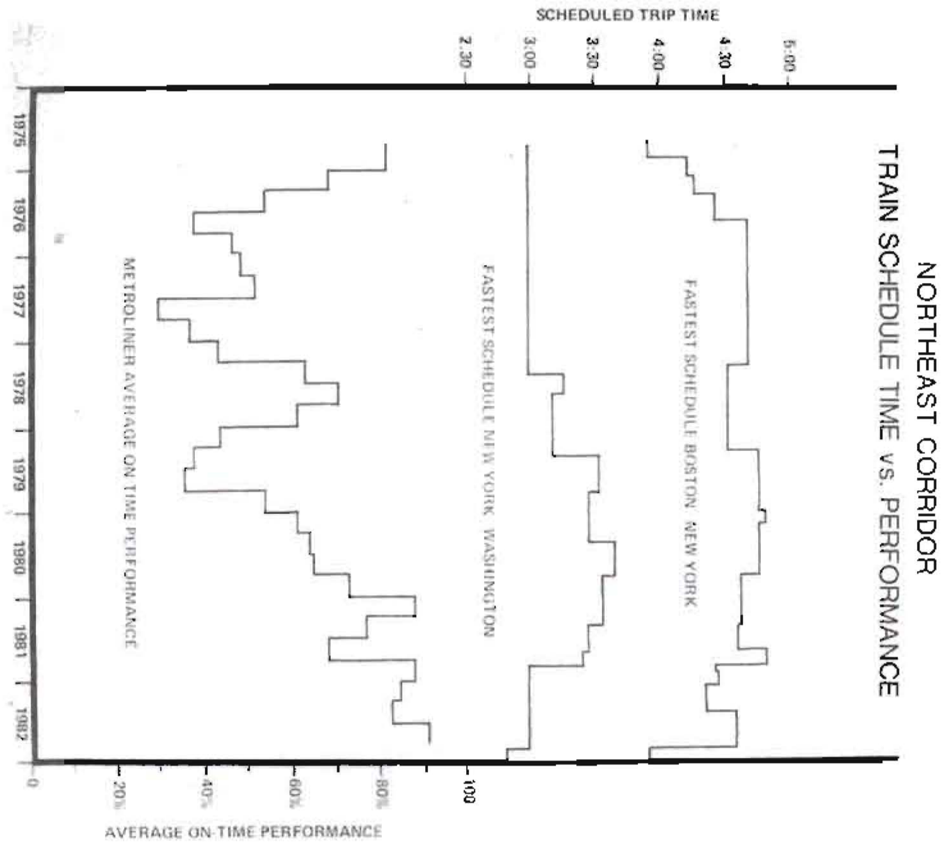


Figure 59. Train Schedule Time vs. Performance

NORTHEAST CORRIDOR IMPROVEMENT PROJECT **NECIP**

LESSONS

o Extreme importance of a good start - avoid recycling and change.

o Engineering manager needs broadest possible understanding of program going far beyond technical issues.

o Continuing dialogue with policy makers is vital in order to define external objectives, agree on acceptable cost, and avoid mid-course changes.

o Where possible, engineering managers should not be held responsible for predicting or managing factors beyond expertise such as inflation.

o Promote recognition that we should look for a balanced, partial achievement of all objectives. Can't do everything.

5
x

Figure 60. Lessons