GAO

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Report to the Chairman, Committee on Energy and Commerce, House of Representatives

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HIGH-SPEED GROUND TRANSPORTATION

Issues Affecting Development in the United States

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GAO United States
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Resources, Community, and
Economic Development Division

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The Honorable John D. Dingell
Chairman, Committee on Energy
and Commerce
House of Representatives

Dear Mr. Chairman:

This report provides a preliminary response to your January 22, 1993, request that we review issues relating to the development of high-speed ground transportation in the United States. Since receiving your request, we have testified before several congressional committees, including the Subcommittee on Transportation and Hazardous Materials, House Committee on Energy and Commerce. This report consolidates the information presented in those testimonies and makes recommendations on allocating resources to ensure the maximum impact of federal funds.

This work was performed under the direction of Kenneth M. Mead, Director, Transportation Issues, who can be reached on (202) 512-2834 if you or your staff have any questions. Major contributors to this report are listed in appendix I.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Because many parts of the nation's highway and aviation systems are reaching capacity, transportation decisionmakers must determine how best to meet future transportation needs. High-speed ground transportation (HSGT) systems could free capacity on some of the nation's congested highways and airports. Legislation currently pending in the House and Senate would increase federal support for HSGT.

The Chairman, House Committee on Energy and Commerce, asked GAO to describe HSGT technologies, analyze issues related to HSGT financing, and assess HSGT's social benefits, such as congestion relief and potential environmental advantages, as possible criteria for targeting federal funds for HSGT development. This report provides an overview of these objectives and highlights the major points that require consideration in implementing HSGT systems.

Background

HSGT systems include trains and magnetic levitation (maglev) systems capable of traveling at 125 mph or faster. High-speed trains can reach 150 mph; very-high-speed trains, such as the French TGV (train à grande vitesse), can attain nearly 200 mph; and maglev systems are expected to exceed 250 mph. High-speed and very-high-speed trains have operated for years in Japan and Europe. No high-speed maglev is yet operating commercially anywhere in the world, but Germany has certified a prototype maglev system as ready for commercial operation. The U.S. government discontinued its support for HSGT research in the mid-1970s but then began appropriating funds for improvements to the Northeast Corridor (NEC) that have permitted some high-speed operations.

Results in Brief

Through incremental improvements—such as electrifying rights-of-way, eliminating grade crossings, installing new tracks and signals, and acquiring new trains—existing railroad systems could allow passenger trains to operate at speeds of up to 150 mph. Such improvements could make rail trip times competitive with those of air or automobile travel in some corridors. Incremental improvements can be built for about $10 million per mile, making them less costly than other HSGT options and more likely to be built in the near term. The Federal Railroad Administration (FRA) is exploring low-cost protection systems at grade crossings and developing a high-speed nonelectric locomotive. If successful, these initiatives could lower the costs of incremental improvements by up to 25 percent.

Amtrak's incremental improvements in the NEC between New York City and Washington, D.C., have permitted electric-powered trains to reach speeds of 125 mph along portions of that route. Amtrak is now extending electrification to Boston. Elsewhere, rights-of-way are owned by freight railroads, which can be expected to raise liability concerns if it is proposed that high-speed passenger trains operate on their tracks.

HSGT systems that operate at speeds faster than 150 mph require new rights-of-way. Existing U.S. rights-of-way have many curves and carry slow traffic, precluding travel at very high speeds. Very-high-speed rail systems, which could cost about $20 million per mile, could stand alone or supplement the incremental approach, providing higher speeds in rural areas where land acquisition costs might be lower than in urban areas. Maglev systems could cost about $30 million per mile because they require specialized, expensive guideways in addition to relatively straight and level rights-of-way. These systems could compete with air travel in longer corridors.

Although more than a dozen HSGT projects have been proposed outside the NEC, the federal government has appropriated very few funds for these projects but has instead relied on the private sector. However, private investors have avoided HSGT projects, considering them unlikely to be profitable. In the absence of public and private funding, no very-high-speed rail or maglev systems have been built in the United States. According to investment brokers, substantial federal investment in HSGT is needed to attract significant private investment.

The administration has proposed spending about $1 billion over 5 years, and the Congress is considering authorizing legislation. These funds will be combined with at least equal funding from state governments and may be augmented by private-sector investment. If any individual projects—all of which are costly—are to be completed, federal funds will have to be invested strategically in a few projects. These projects will also have to demonstrate that their potential social benefits, such as reduced congestion on highways and at airports, will justify their costs. The anticipated level of social benefits depends on ridership forecasts that must be carefully examined before substantial federal resources are committed. The Department of Transportation (DOT) is currently assessing its staffing needs to ensure that it has the expertise to evaluate the costs and benefits of HSGT proposals.

GAO's Analysis

Incremental Improvements Are Most Likely for the Near Term

The incremental approach is the least costly high-speed option. Between 1976 and 1993, the federal government appropriated $3.9 billion (in 1992 dollars) to upgrade the 450-mile NEC. Amtrak is currently testing European high-speed trains to develop specifications for 26 new high-speed trains to run in the NEC. These new trains and further improvements in the corridor will permit speeds of up to 150 mph and will cost about $1 billion, according to Amtrak estimates. The total cost of improvements in the NEC would be nearly $5 billion, or about $11 million per mile.

On proposed high-speed routes, as many grade crossings as possible will need to be eliminated to allow high-speed trains to pass them at full speed. Eliminating a grade crossing by creating grade separations could cost between $3 million and $20 million. FRA is currently testing several proposals for grade crossing protection systems that cost substantially less. FRA and Amtrak are also pursuing development of a high-speed nonelectric locomotive that could eliminate the $2-million-per-mile cost of electrifying rights-of-way, which would otherwise be necessary to permit high speeds. However, the savings would be partially offset by increased fuel costs and possibly higher maintenance costs for nonelectric locomotives.

Freight railroads, which own most rights-of-way outside the NEC, may benefit from some aspects of incremental improvement programs. To the extent that freight railroads share the costs of improvements, the need for public funds can be reduced. However, freight railroads believe that incremental improvements will generally provide few benefits for their freight operations, and they therefore plan to bear little of the cost. Furthermore, freight railroads have stated that they want total indemnification from liability for passenger train accidents.

Faster Alternatives Require Costly New Rights-Of-Way

Although very-high-speed trains use the same basic technology as conventional trains, they require straight, relatively level, and dedicated rights-of-way at speeds over 150 mph. The need to acquire land and lay new track raises the cost of these systems to about $20 million per mile. Maglev systems, which utilize a different technology than conventional trains and require specialized guideways, are expected to cost about $30 million per mile. However, cost estimates for maglev are speculative because no commercial maglev system has been built. For fiscal year 1994, the Congress appropriated $20 million for maglev research and analysis, separate from previously authorized funds for maglev prototype development.

Increased Federal Support Is Needed to Encourage Private Investment

Investment brokers told GAO that little private investment in HSGT is likely without substantial federal support. Private investors believe that (1) passenger fares will not cover capital and operating costs; (2) construction delays and cost overruns are likely to undermine financial viability; and (3) compliance with federal, state, and local permitting requirements could also delay projects and escalate costs. Brokers told GAO that more private investment in HSGT would be forthcoming if the federal government underwrote a substantial portion of the risk.

Strategic Approach Is Needed to Focus Federal HSGT Dollars

Under the administration's proposal, federal funds, when combined with state and private-sector funds, must be sufficient to ensure completion of an element of an improvement program. An element is a discrete portion of a project that provides a demonstrable transportation benefit; thus, an element could range from making improvements on a single bridge at a cost of less than $1 million to a package of signaling and track upgrades costing over $100 million. To achieve speeds of 125 mph in a 200-mile corridor, many elements will likely be required, at a total cost of about $2 billion. If federal funds are spread over many projects, the proposed $1 billion may be exhausted before any one project reaches completion. Although the administration believes that the proposed $1 billion could possibly leverage up to $2 billion in state and private funding, most state planning officials and private investment analysts that GAO contacted were skeptical that leveraging would occur to the extent envisioned by the administration.

To identify the most beneficial HSGT development projects from among the many that are expected to compete for funds, the proposed legislation would require consideration of each project's projected ridership, revenues, and subsidy requirements, as well as social benefits, such as reductions in congestion and pollution. An in-depth analysis would be required to determine the comparability of the data on the projects and the reasonableness of the underlying assumptions. DOT has requested funding to hire additional staff to review and analyze the corridor development proposals that would compete for HSGT grants. Acquiring this expertise is important if federal funds are to go to the most beneficial projects.

Recommendations

GAO recommends that the Secretary of Transportation, in addition to following through on research on low-cost grade crossing systems and on a high-speed nonelectric locomotive, (1) focus available federal funds on a limited number of projects to ensure that combined federal, state, and private funding is sufficient to move these projects to completion and (2) ensure that FRA has the expertise to evaluate corridor development proposals to select those that could provide the most benefits.

Agency Comments

GAO discussed a draft of this report with representatives of Amtrak and FRA. Amtrak officials generally agreed with the draft, and GAO incorporated their comments where appropriate. FRA considered GAO's draft recommendation that federal funds be focused on only two or three projects too constricting because the administration expects that federal funding will leverage significant state and private funding. GAO recognizes the potential for leveraging and modified the recommendation accordingly. However, GAO also notes that the prevailing view of investment analysts and state planners is that substantial private investment and state overmatching (that is, providing more than the matching funds required) are unlikely. Without these additional funds, a maximum of $2 billion would be available for high-speed corridor development. If $2 billion were spread over as few as five projects, each would receive only $400 million—far short of the estimated $2 billion cost of improving a single 200-mile corridor to permit speeds of 125 mph.

FRA also considered GAO's draft estimates of the costs of incremental improvements too high and emphasized that FRA is exploring low-cost grade crossing protection systems and the potential development of a high-speed nonelectric locomotive. GAO believes that the data provided in this report, which are based on National Research Council (NRC) and Amtrak estimates, represent a realistic approximation of the costs of incremental improvements. NRC estimated that incremental improvements to permit speeds of 125 mph would cost about $10 million per mile and that improvements to permit speeds of 150 mph would cost about $13 million per mile. Although NRC's estimates were based on assumptions about the characteristics of a hypothetical corridor, the estimates are consistent with Amtrak's experience in the NEC, where improvements will have cost about $11 million per mile when completed. However, GAO agrees that FRA's efforts to test lower-cost grade crossing systems and develop a high-speed nonelectric locomotive, if successful, would lower incremental improvement costs and added relevant information to this report. GAO also added information on how NRC's cost estimates were developed. As agreed, GAO did not request written agency comments on a draft of this report.

Contents

Abbreviations

AAR	Association of American Railroads
ATCS	Advanced Train Control System
DOT	Department of Transportation
FRA	Federal Railroad Administration
HSGT	high-speed ground transportation
ICC	Interstate Commerce Commission
ICE	Intercity Express (Germany)
ISTEA	Intermodal Surface Transportation Efficiency Act
maglev	magnetic levitation
NEC	Northeast Corridor
NRC	National Research Council
NMI	National Maglev Initiative
OTA	Office of Technology Assessment
TGV	train à grande vitesse (France)

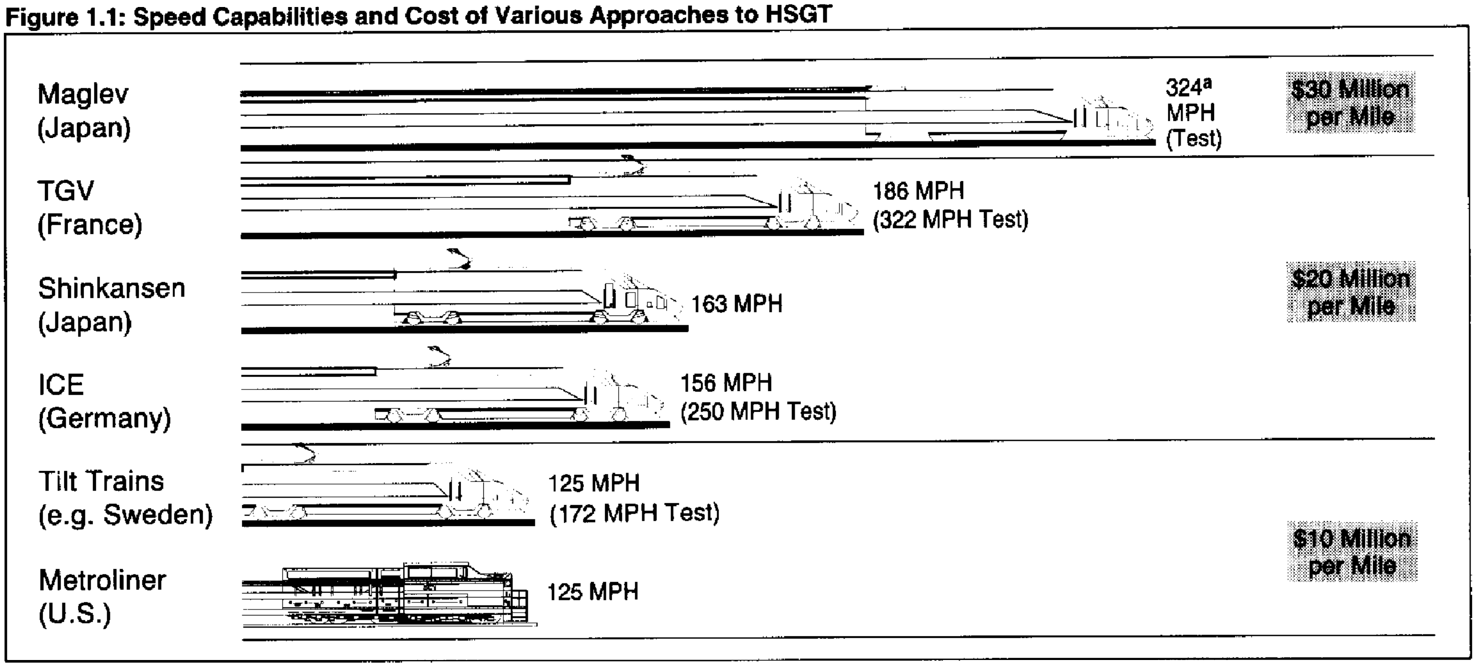
Introduction

The United States pioneered research in high-speed ground transportation (HSGT) but discontinued funding in the early 1970s. Japan, France, Germany, and other countries continued research and development and implemented HSGT systems. Economic, demographic, and historical conditions have been more conducive to developing HSGT in these countries. In the United States, increased congestion at airports and highways in some transportation corridors have fostered interest in HSGT. The Clinton administration has proposed the High-Speed Rail Development Act of 1993, which would authorize federal assistance to develop HSGT.

HSGT Choices Exist

HSGT, which we define as rail or magnetic levitation (maglev) systems capable of speeds of 125 miles per hour or more, could be developed in a number of ways. HSGT developers can (1) make incremental improvements to tracks, signaling systems, and grade crossings and purchase modern trains that would permit speeds of between 125 mph and 150 mph on existing rights-of-way; (2) build completely new rail infrastructures to support very-high-speed operations of up to 200 mph; or (3) build maglev systems that could permit speeds of over 250 mph. Figure 1.1 groups several HSGT systems into these three categories, shows their speed capabilities, and provides a cost estimate for each approach.

Figure 1.1: Speed Capabilities and Cost of Various Approaches to HSGT



[a]Germany's "Transrapid 07" has achieved speeds of 270 mph.

In addition to high speeds, these approaches also provide a smooth ride because they employ modern suspension systems.

The cost estimates shown in figure 1.1 are based on those developed by the National Research Council (NRC) for its study of HSGT.[1] NRC developed cost estimates for six alternatives that ranged from improving speeds in some corridors to 79 mph to building a maglev system capable of speeds of 250 mph. Figure 1.1 shows the estimates for three of the alternatives that provide "order of magnitude" benchmarks to demonstrate how costs increase with speed.

In reality, the line between incremental improvements to provide speeds up to 150 mph and very-high-speed systems may eventually be blurred. Trains capable of traveling over 150 mph may one day operate at reduced speeds over conventional and incrementally improved tracks in areas where acquiring new rights-of-way is impractical, while they may operate on new infrastructure at speeds over 150 mph in rural areas, where land acquisition costs may be lower. This is the way European high-speed

[1]In Pursuit of Speed: New Options for Intercity Passenger Transport (Washington, D.C.: National Research Council, 1991).

trains operate. However, to clearly describe the operating requirements of each approach, we discuss each separately in this report.

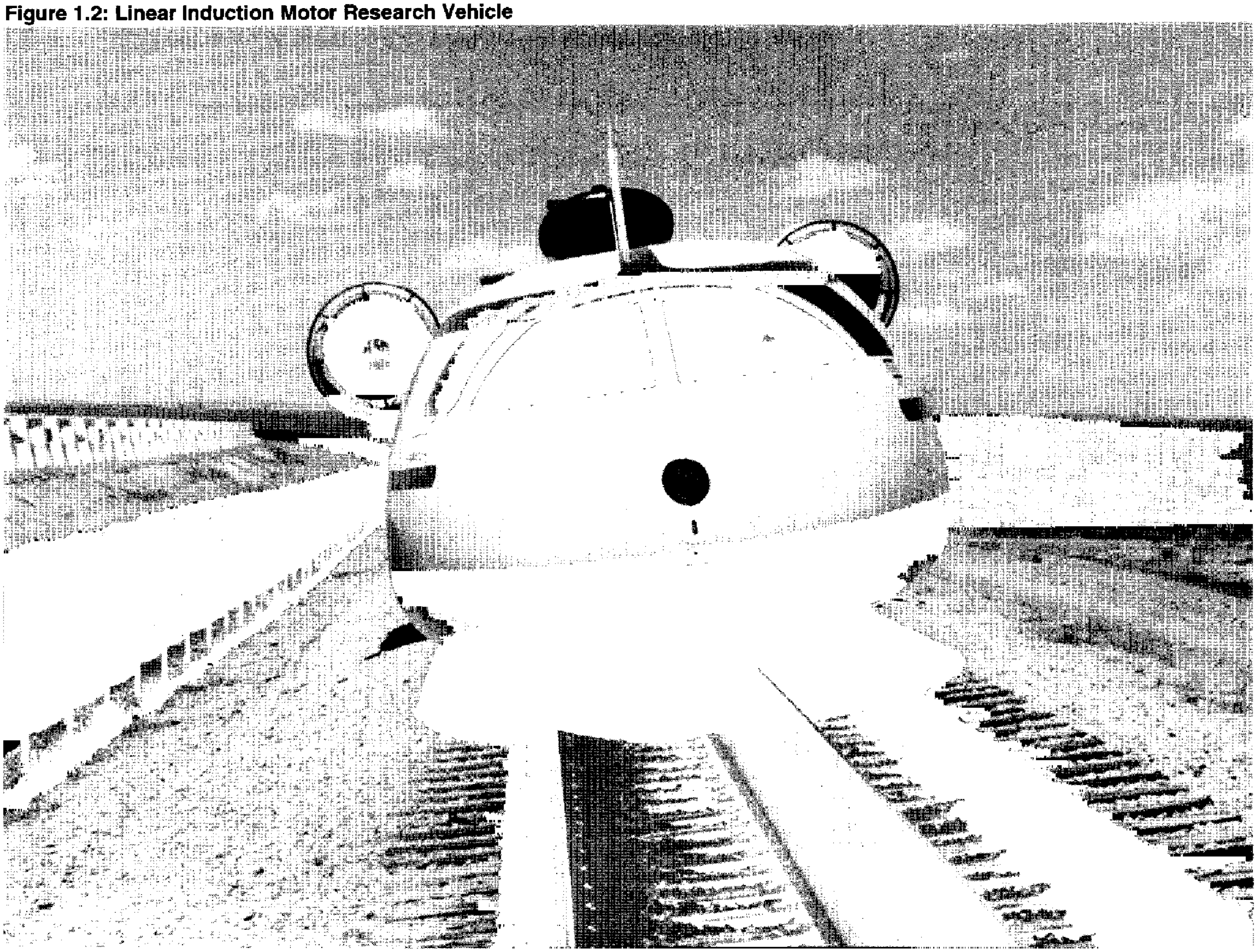
Each cost estimate in figure 1.1 was based on a number of assumptions about existing infrastructure, grade crossing improvements, and land acquisition costs, among others. Because these conditions will vary for specific HSGT projects, actual costs may be higher or lower for any given project. Furthermore, because the estimates were based on 1991 costs, the actual cost of these systems would no doubt be higher because of inflation.

The United States Discontinued, While Other Countries Continued, HSGT Research

Until the mid-1970s, the United States led the field in HSGT research. In 1974, the Department of Transportation (DOT) tested a linear induction research motor vehicle, shown in figure 1.2, at 255.4 mph at its test center in Pueblo, Colorado. However, in 1975 federal funding for HSGT research was suspended on the premise that the nation's interstate and air transport systems contained sufficient capacity to accommodate future growth in intercity travel.[2]

[2]The Benefits of Magnetically Levitated High-Speed Transportation for the United States, Maglev Technology Advisory Committee (Bethpage, N.Y.: 1989). The Maglev Technology Advisory Committee was formed at the request of Senator Daniel Patrick Moynihan to examine the technical and economic feasibility of maglev systems in the United States.

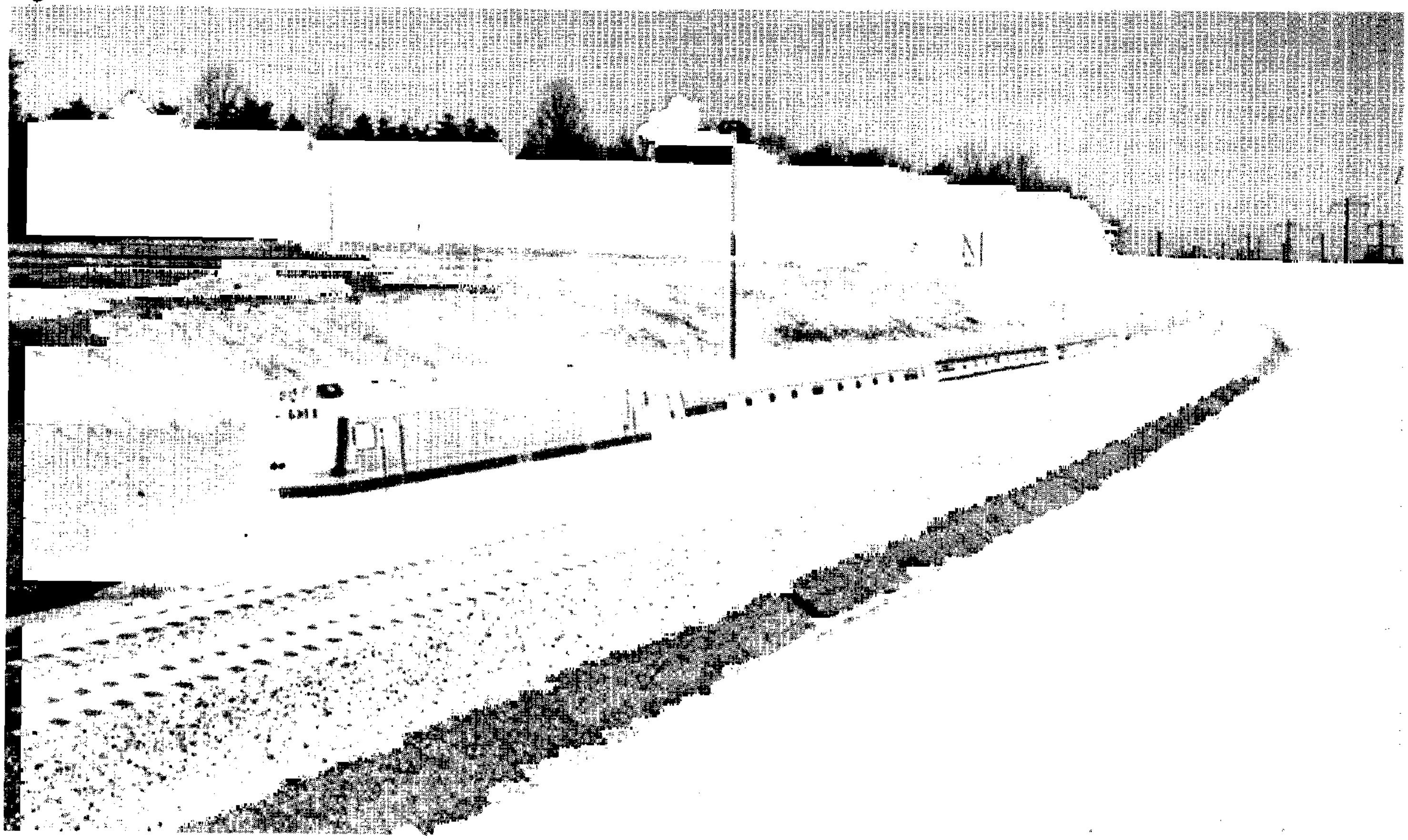
Figure 1.2: Linear Induction Motor Research Vehicle



Although federally funded research was terminated in the mid-1970s, the federal government initiated a program to improve the rail network in the Northeast Corridor (NEC)—the route between Washington, D.C., and Boston. Federal appropriations between 1976 and 1993 totaled about $3 billion, or $3.9 billion in 1992 dollars, for improvements throughout the corridor. As a result of improvements to the segment between Washington, D.C., and New York City, Amtrak's Metroliner trains, shown in figure 1.3, now travel at speeds of up to 125 mph along that portion of the corridor.

Amtrak has operated European high-speed trains in demonstration service on the NEC at 135 mph and has tested one of them at over 160 mph.

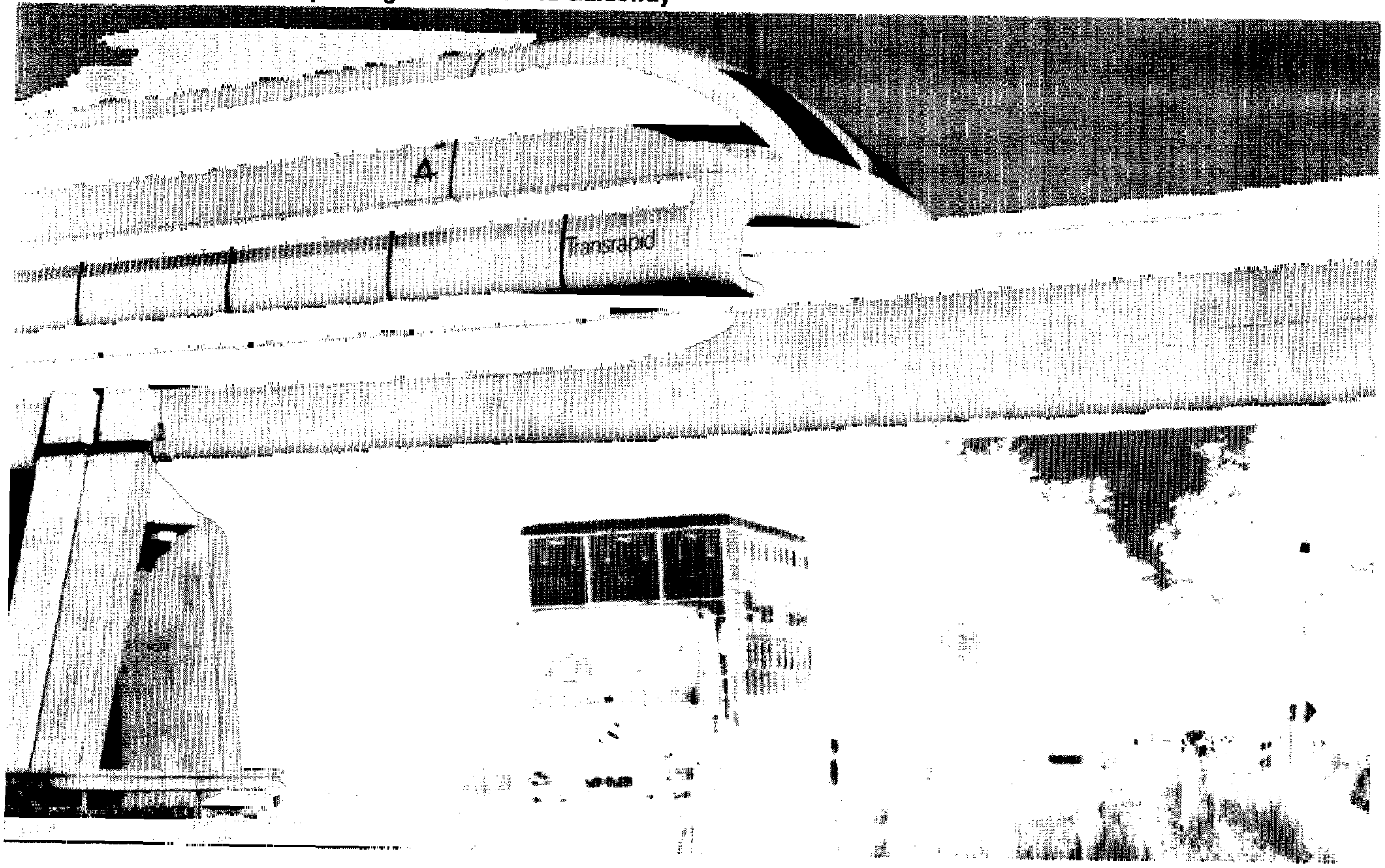
Figure 1.3: Amtrak's Metroliner Train



These higher speeds have been possible in large part because the right-of-way between Washington, D.C., and New Haven is electrified. High speeds are not currently feasible between New Haven and Boston because the tracks are not electrified and the route has numerous curves. Amtrak plans to electrify the northern portion of the corridor and make additional improvements throughout the corridor, including the purchase of new trains. Improvements between New York City and Boston will permit speeds of 150 mph on that segment. Amtrak estimates that these improvements will cost an additional $1 billion and be completed by the year 2000. Currently, the Washington, D.C., to New York City route provides the only high-speed service in the country.

Germany, Japan, France, and other countries continued to develop HSGT and achieved advances in maglev and steel-wheel/steel-rail technologies. While no high-speed maglev system has been placed in commercial service, Japan has developed and tested a maglev vehicle at over 320 mph, and Germany has certified its maglev system, shown in figure 1.4, as ready for revenue service.

Figure 1.4: German Transrapid Maglev Vehicle and Guideway



France has tested its very-high-speed rail TGV (train à grande vitesse) system at 322 mph and operates TGV trains, shown in figure 1.5, in commercial service at 186 mph. Germany, Italy, Japan, Spain, and Sweden also operate intercity passenger trains at speeds of between 125 and 175 mph. Figures 1.6 and 1.7 show the Swedish and German high-speed trains.

Figure 1.5: French TGV Very-High-Speed Train

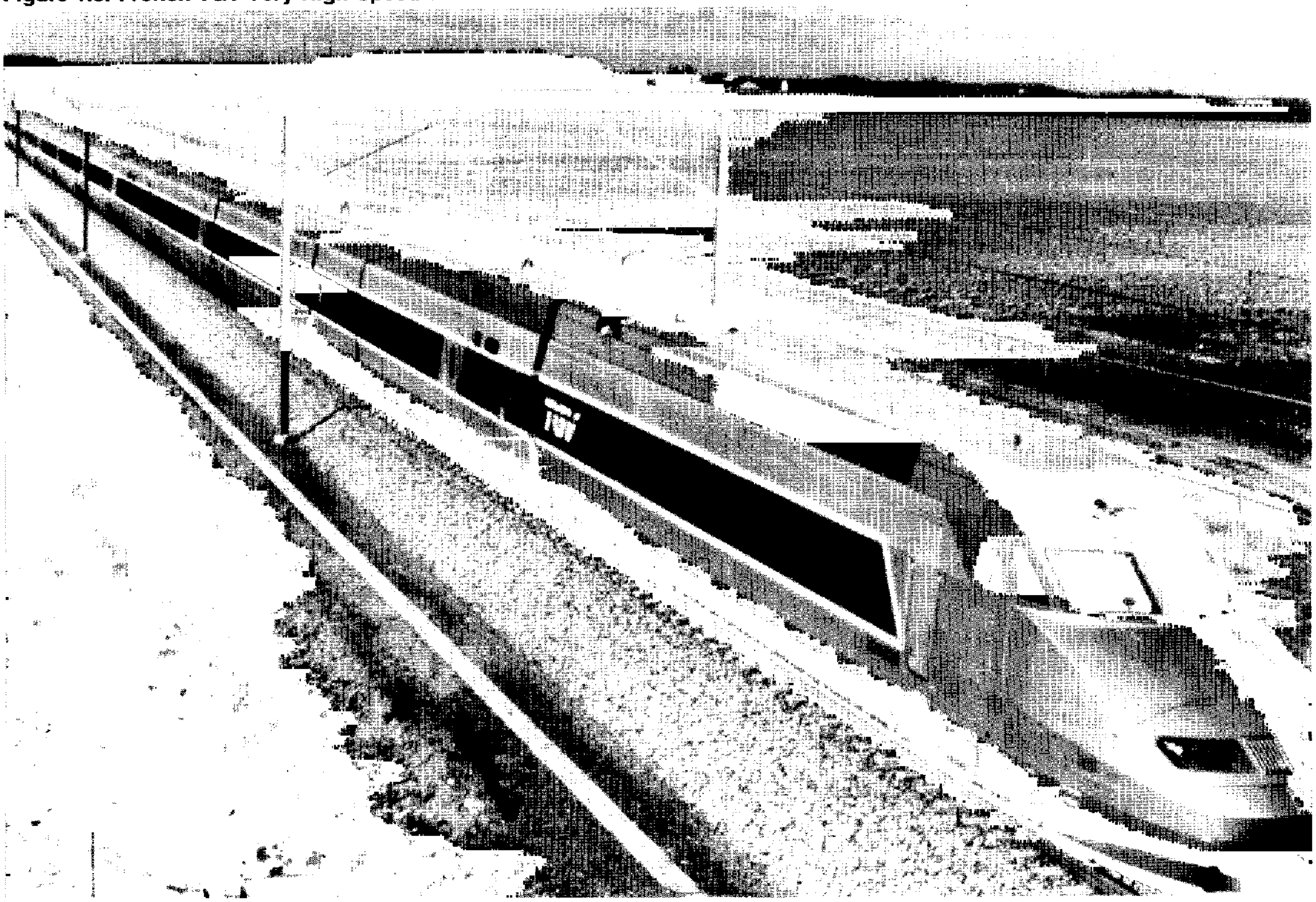


Figure 1.6: Swedish x2000 High-Speed Train With Amtrak Logo for U.S. Demonstration Program

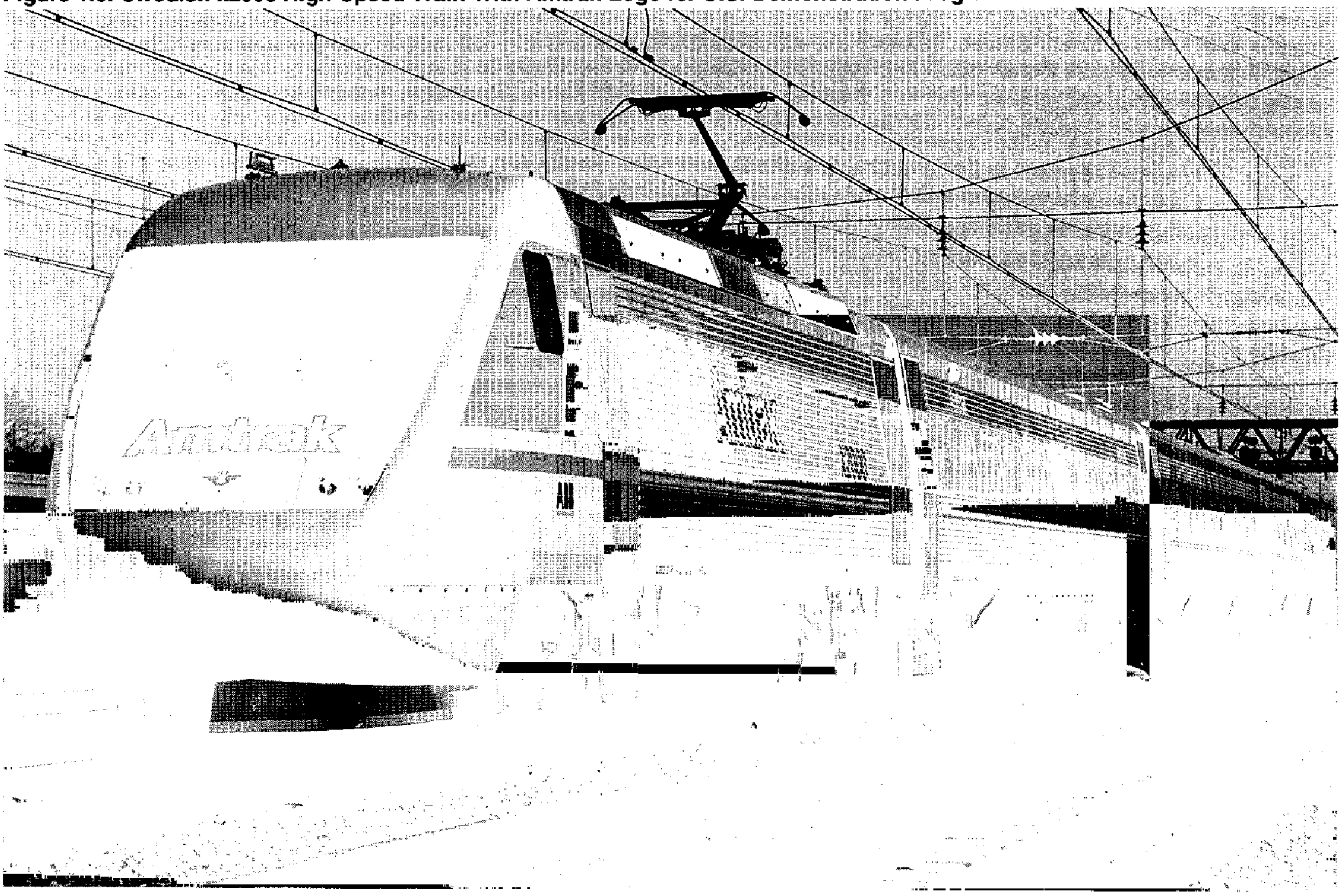
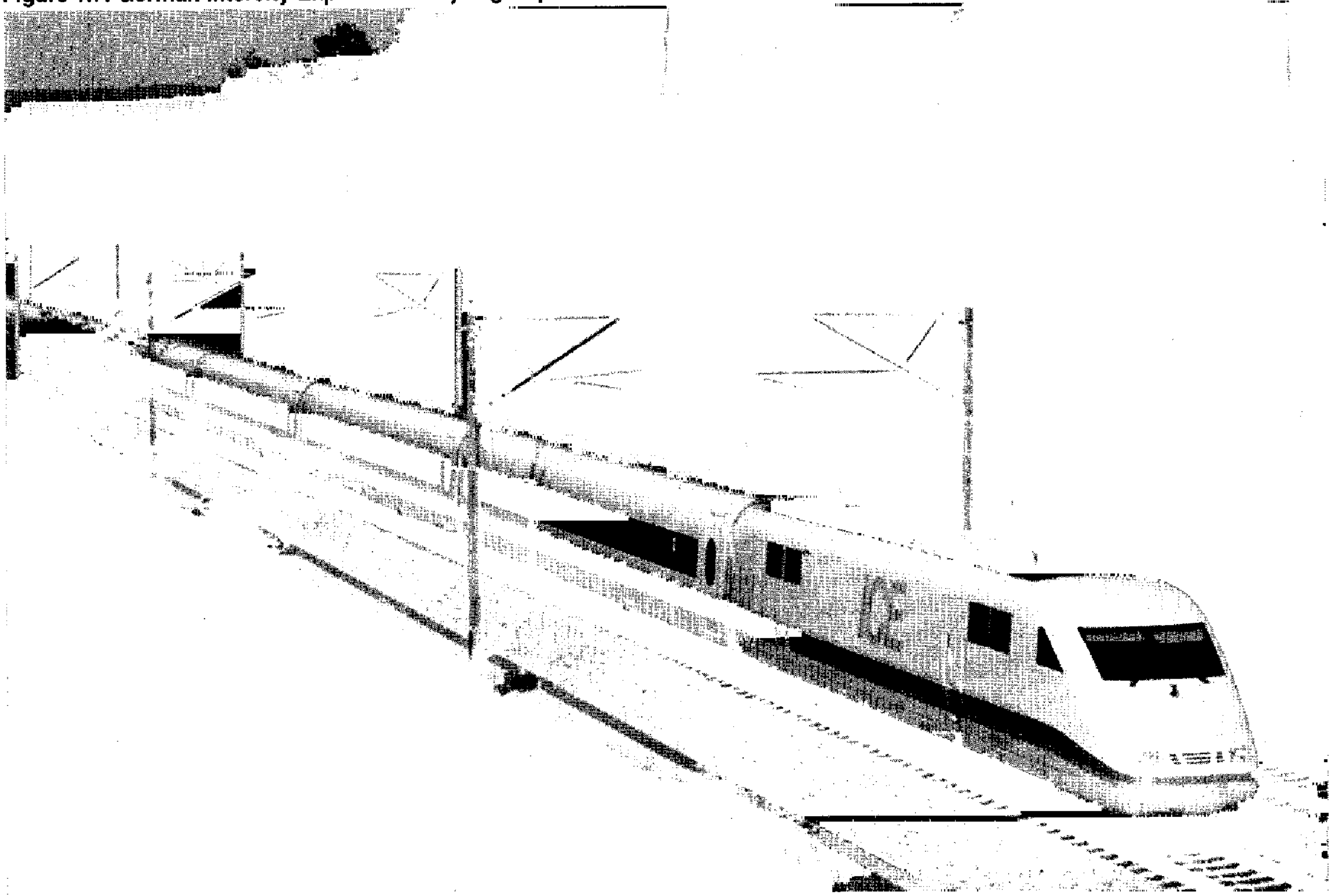


Figure 1.7: German Intercity Express: a Very-High-Speed Train



A number of social and economic factors encourage travel by rail in Europe. High population densities in European countries favor rail travel. In Europe, high domestic air fares and gasoline taxes discourage travel by airplane and automobile and encourage travel by rail. In the United States, less expensive gasoline, a well-developed highway network, and competitive air fares have encouraged travel by airplane and automobile at the expense of travel by rail. However, as evidenced by congestion and delays, many parts of our highway and aviation systems are now reaching capacity.

HSGT Could Benefit the U.S. Transportation System

HSGT might provide a viable alternative to travel by airplane or automobile in corridors that (1) are heavily traveled, (2) have congested airports or highways, and (3) are between 150 and 600 miles in length. In the report cited earlier, NRC listed 32 city pairs separated by 600 miles or less that are projected to have over 1 million air passengers traveling between them annually by the year 2010.

If HSGT attracts substantial numbers of airline passengers or automobile drivers, it could increase airport efficiency and reduce the pressure to build or expand airports and highways. A number of U.S. airports are experiencing congestion delays, and the Federal Aviation Administration projects that additional delays will occur as air travel increases. Additionally, many airports are planning expansion to accommodate anticipated growth in air traffic, and some cities are considering building new airports to meet the expected demand. If convenient intermodal connections are provided, HSGT could divert passengers from short-haul, connecting flights, which could free airport capacity for long-haul, higher-capacity aircraft.

U.S. Interest in HSGT Is Increasing

U.S. interest in HSGT has grown in recent years. A number of HSGT studies have cited HSGT's potential benefits. Public interest in HSGT has been aroused by Amtrak's demonstration of European high-speed trains on U.S. tracks. In April 1993, the Clinton administration proposed the High-Speed Rail Development Act of 1993, which would provide federal support for developing rail corridors outside the NEC and for developing HSGT technology.

Objectives, Scope, and Methodology

Under our basic legislative responsibility, we initiated a review of the issues relevant to HSGT development in the United States. We surveyed the literature and discussed HSGT development issues with experts in the field. We met with senior Amtrak officials to obtain their perspectives on HSGT issues. We also met with members of the Texas High-Speed Rail Authority to obtain information on the status of, and issues involved in, the development of a very-high-speed rail system in that state. We met with officials of Southwest Airlines to obtain a critic's perspective. We also contacted several local planning authorities to determine the status of the HSGT projects they have planned.

In addition, we rode on Amtrak's rail inspection car to observe firsthand the physical barriers to achieving higher speeds in the NEC. To obtain information on the federal government's role in developing HSGT systems, we met with the Administrator of the Federal Railroad Administration (FRA). We met with officials of freight railroads and representatives of the Association of American Railroads (AAR) to discuss the impact of operating high-speed passenger trains on rights-of-way owned by freight railroads. To obtain information on the issues associated with financing and predicting demand for HSGT systems, we met with a number of analysts in the federal government and in private industry.

Because the incremental approach has received the bulk of recent attention and appears to be the most likely option for providing HSGT in the near term in the United States, we developed data on the cost of the improvements required to upgrade existing rail corridors. As a point of departure, we used cost data NRC developed for incremental improvements that would permit speeds of up to 125 mph.[3] We deleted the costs of purchasing new rights-of-way but added the costs of upgrading the existing track. We used costs provided by Amtrak when costs were not readily available in the NRC study or when Amtrak could provide more accurate data (e.g., electrification costs). We believe these data represent the most realistic available estimate of the costs to be anticipated in an incremental improvement project. We recognize that because conditions vary substantially among rights-of-way, not all of the improvements we list may be required on every project, and individual improvements may cost more or less than the estimates we provide. For example, some proposals for incremental improvement submitted to FRA show individual improvements and total costs that are considerably lower than NRC and Amtrak estimates. We did not assess the reasonableness of these estimates or determine the reasons for the variance.

On January 22, 1993, while our work was in progress, the Chairman, House Committee on Energy and Commerce, requested that we (1) describe the basic types of HSGT technologies available, their potential applications, and the relative advantages and disadvantages of each; (2) analyze financing issues and alternatives; and (3) describe the potential socioeconomic, transportation, and environmental impacts of introducing alternative HSGT systems in the United States. The Chairman requested that our studies summarize the federal involvement to date and the need for further federal involvement in HSGT efforts and examine possible changes in policy or legislation that could foster the development of HSGT projects in the United States. This report provides a general overview of these issues. Our future reports will review the social benefits (congestion relief, emissions

[3]In Pursuit of Speed: New Options for Intercity Passenger Transport.

reduction, safety impacts, and changes in energy consumption) of HSGT in greater detail and explore the issues that arise when freight and high-speed passenger trains share rights-of-way.

We conducted our work between June 1992 and September 1993 in accordance with generally accepted government auditing standards.

The Incremental Approach Is the Most Likely for the Near Term

Compared with other HSGT approaches, the incremental approach provides a lower-cost, near-term option for developing high-speed passenger service in the United States. Rights-of-way are already in place between major cities, greatly reducing the need to acquire land, while funds for more costly very-high-speed rail and maglev systems are lacking. Incremental costs include those for eliminating grade crossings, improving track and signaling, modifying bridges, and electrifying rights-of-way. Electrification—a major cost component of incremental improvements—could be avoided if a high-speed nonelectric locomotive was developed. The cost of eliminating grade crossings could also be reduced if current demonstrations of new technology prove fruitful. Because incremental improvement programs outside the NEC will likely occur on rights-of-way owned by freight railroads, freight railroads are likely to require indemnification from liability for passenger train accidents.

Incremental Costs Vary by Corridor

The cost of the improvements needed to permit high speeds in a specific corridor will depend on the condition of the existing right-of-way, which varies by corridor. NRC estimated that incremental improvements to permit speeds of 125 mph would cost about $10 million per mile, and improvements to permit speeds of 150 mph, $13 million per mile. When developing these estimates, NRC made a number of assumptions about the characteristics of a hypothetical corridor. For example, NRC assumed that all grade crossings in high-speed segments would be closed (by dead-ending roads) or grade-separated (by building under- or overpasses) and that additional rights-of-way would be purchased to allow some curves to be straightened. In addition, NRC's estimate assumes that a single-track right-of-way would be replaced with two new tracks.

Although NRC's estimate substantially exceeds those developed by state planning agencies for their respective incremental improvement programs, NRC's estimate is lower than the expected cost of the NEC Improvement Program. When the improvements in the NEC are completed, Amtrak expects to have spent $4.9 billion, or about $11 million per mile (in 1992 dollars). FRA believes that incremental costs in the NEC are high because the NEC is more complex than other corridors, containing multiple tracks and carrying a variety of traffic.

On the other hand, when the federally funded NEC Improvement Program began, the NEC already possessed many of the characteristics required for high-speed passenger service. As FRA stated, it had multiple tracks, which allowed high-speed passenger trains to pass slower freight trains. Electrification was in place between Washington and New Haven in 1976. On other routes where high-speed passenger service is proposed, only one or two tracks exist. Additional track construction, right-of-way acquisition, and bridge widening may be needed to allow high-speed passenger trains to pass slower freight trains, especially on routes where numerous freight trains currently operate daily. NRC's estimate assumes the cost of these improvements. Speeds on most routes outside the NEC are restricted to below 80 mph because of track and signaling limitations. NRC's estimate includes the cost of track and signal improvements that will be needed to permit speeds of 125 mph.

Table 2.1 identifies the types of improvements required to permit speeds of 125 mph and the cost of each improvement. Because the incremental approach, as we have defined it, requires little or no right-of-way acquisition, we based our estimate on assumptions that varied in some respects from those used by NRC. We assumed that no new rights-of-way would be purchased and that the existing right-of-way contained enough space to add a second track. We also assumed that the existing track would need to be upgraded to continuous-welded rail and concrete ties, both of which are typically required for high-speed operations.[4]

[4]The costs shown in table 2.1 are derived from estimates provided by Amtrak and NRC. The costs of continuous-welded rail and concrete ties were provided by Amtrak. The estimate for electrification is based on Amtrak's cost of installing electrification in the NEC. The remaining costs are based on NRC's estimates.

Table 2.1: Upgrades and Approximate Funding Needed to Achieve 125-mph Speeds in a Hypothetical 200-Mile Corridor

Dollars in millions

Upgrades and other costs	Total cost
Bridge repair/modification	$414
Electrification	$400
Grade crossings	$207
Added track	$167
Signaling	$89
Concrete ties	$79
Stations	$58
Maintenance facilities	$50
Continuous-welded rail	$31
Interlockings	$14
Central control, reservations	$10
Fencing	$4
Planning costs and contingencies	$585
New rolling stock	$215
Total	**$2,323**

Sources: Amtrak and New Options for Intercity Passenger Transport (Washington, D.C.: National Research Council, 1991).

If all the costs shown in table 2.1 were incurred, the improvements would average $11.6 million per mile—somewhat higher than NRC's estimate but similar to the expected costs of improvements in the NEC. A specific corridor might not need all of these improvements, and the costs of individual items could be higher or lower.

Bridges May Need Modification or Improvement

Some bridges may require structural reinforcement to handle high-speed trains, and some may need widening to accommodate additional tracks so that high-speed passenger trains can pass slower conventional and freight trains. The cost of these improvements will depend on the condition and number of bridges and on the need to modify bridges to accommodate additional tracks.

Grade Crossings Present Challenges for Developers

How to deal with grade crossings is a difficult issue in incremental improvement programs. Grade crossings can occur as frequently as once per mile on routes where incremental improvement programs are being considered. No clear guidance specifies the maximum safe speed at which passenger trains can travel through grade crossings. FRA has issued no such regulations. Trains are generally limited only by the maximum allowed speeds for the class of track over which they are traveling. The maximum speed for class VI track, FRA's highest classification, is 110 mph. Amtrak's trains travel at 125 mph in portions of the NEC because FRA waived this restriction, but there are no grade crossings where trains operate at these speeds.

Amtrak believes that 100 mph should be the maximum speed for passenger trains passing over any grade crossing, regardless of the degree of protection. At speeds over 100 mph, Amtrak believes that grade crossing accidents can cause derailments and severe injuries to passengers. At speeds below 100 mph, Amtrak believes that there is less risk that grade crossing accidents will derail trains.

Because of these concerns, eliminating as many grade crossings as possible will be critical to maintaining high speeds. Eliminating grade crossings by providing grade separation is costly, ranging between $6 million and $20 million for each project, according to estimates for one proposed high-speed corridor. In the NEC, estimates for similar projects range between $3 million and $8 million each. In view of these costs, providing grade separation at all grade crossings on a high-speed route would be prohibitively costly. A less expensive option would be to close crossings (i.e., dead-end the road at the railroad tracks). FRA officials believe that because grade crossings often occur in groups—several grade crossings may be within about a mile of each other—several crossings could be eliminated by building one grade separation. Such action would eliminate several crossings with minimal expense and traffic disruption. However, in other cases, potential disruption to local traffic patterns could make closing grade crossings impractical. Improving protective devices at grade crossings is another option, but Amtrak policy would require high-speed trains to slow to 100 mph at these crossings. Throughout a corridor, a combination of eliminating grade crossings by providing grade separations or closing crossings and enhancing grade crossing protection is the likely solution. The $207 million estimate for grade crossings developed by NRC and listed in table 2.1 assumes such a combination.

Several Additional Improvements May Be Needed

In addition, most rights-of-way will need other major enhancements. Continuous-welded rail and concrete ties are typically required to help maintain the precise track alignment necessary for high-speed operations. High-speed switches are also needed. High-speed operations require cab signaling—that is, train control signals that are displayed in the locomotive cab. Furthermore, a system is needed to automatically slow or stop the train if the operator fails to respond properly to a signal. On routes with substantial freight traffic or conventional passenger service, additional track may be needed to allow high-speed passenger trains to pass slower trains. Portions of rights-of-way may need to be fenced to protect pedestrians and prevent vandalism.

To provide the enhanced service, new trains will be required. Amtrak officials said their aging coaches cannot provide a smooth ride at high speeds. NRC estimated that, for a 200-mile corridor, 13 trainsets would be required, costing $15 million each. The trainsets would consist of an electric locomotive and seven coaches. The estimate in table 2.1 includes a 10-percent allowance for contingencies.

Finally, planning costs and allocations for other contingencies make up a major portion of incremental improvement costs. Major construction projects such as HSGT involve substantial costs for design, construction management, insurance, and start-up. On the basis of existing studies, NRC estimated planning costs to be 20 percent of construction costs for incremental improvements to permit speeds of 125 mph. NRC also estimated a contingency cost to account for unknown cost factors at about 20 percent of construction costs. Therefore, the $585 million for planning costs and contingencies reflects 40 percent of the construction costs shown in the table.

Incremental Improvement Costs Could Be Reduced

As table 2.1 shows, dealing with grade crossings and providing electrification are among the most costly components of an incremental improvement program. FRA has awarded technology demonstration funds to test a number of ideas that, if proven successful, could substantially reduce costs associated with grade crossings. FRA and Amtrak are also examining the potential for a high-speed nonelectric locomotive that could avoid the cost of electrification. The public costs of incremental improvement programs could be reduced if planners are successful in persuading freight railroads to pay for a portion of incremental improvement costs.

Low-Cost Grade Crossing Systems Are Being Tested

FRA recently awarded funds authorized in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) for several technology demonstration projects that could substantially lower the cost of eliminating grade crossings on high-speed lines. FRA will test a "friendly mobile barrier" that would be installed at a rural grade crossing in Virginia. The barrier would rise out of the roadbed to prevent a vehicle from crashing through a lowered gate and entering the grade crossing. The barrier would be made of an energy-absorbing material to prevent fatal injury to the vehicle's occupants. The state of Florida will use demonstration funds to test an innovative, low-cost design for grade crossing separations that would cost about $300,000. These proposals could reduce the expense of eliminating grade crossings and enable trains to maintain high speeds on existing rights-of-way.

The state of Connecticut will test the grade crossing protection system currently used in Sweden, where the x2000 high-speed train operates through grade crossings at speeds of up to 125 mph. The system blocks both sides of the roadway rather than only the travel-direction lane, as is common in the United States. Blocking both sides of the road prevents a motorist from driving around a lowered barrier. The system also notifies the locomotive engineer that the crossing gates have been activated and indicates whether a vehicle is occupying the grade crossing.

The precise amount of savings that these low-cost grade crossing alternatives could produce, if they are successful, is difficult to estimate. As previously stated, eliminating all grade crossings through grade separation would be prohibitively costly, and a combination of grade separations, closings, and enhanced crossing protection systems is likely. The costs will vary depending on the combination chosen. Additionally, NRC's estimate assumed that a grade crossing protection system similar to that used in Sweden would be used extensively throughout the hypothetical route. Therefore, NRC has already accounted for the savings resulting from implementing this system in its $10 million-per-mile estimate. If the other low-cost grade crossing alternatives result in halving NRC's estimate of $207 million to improve grade crossings, they would reduce NRC's estimated costs by about 5 percent.

A High-Speed Nonelectric Locomotive Could Lower Incremental Costs

Because electrifying a right-of-way is a major expense, the development of a high-speed, nonelectric locomotive could reduce costs. Currently, there are no diesel-powered or other nonelectric powered locomotives that are designed to U.S. standards and are capable of traveling at 125 mph or more. In Europe and Japan, electric-powered locomotives are standard in high-speed and very-high-speed rail passenger operations. Electrification costs about $2 million per mile, representing about 20 percent of the cost of an incremental improvement project.[5] Outside the NEC, where most rights-of-way are not electrified, rail services are provided by diesel locomotives, which can achieve speeds of only 110 mph under the best track conditions. In the absence of a high-speed nonelectric locomotive, these rights-of-way will require electrification for high-speed service.

No high-speed nonelectric locomotives have been developed for use in the United States, mainly because there has been no market for them. In their present condition, most U.S. rights-of-way cannot support speeds of over 80 mph.[6] However, the growing interest in HSGT in the United States could provide the incentive for the development of a high-speed nonelectric locomotive. Several states now have plans for upgrading railroad corridors to permit 125-mph service.

Amtrak has been pursuing the development of a high-speed nonelectric locomotive since 1991. In its 1991 appropriations, Amtrak received $14 million to procure a high-speed, nonelectric locomotive for use on the unelectrified portions of the NEC. The appropriation was made at a time when funds to electrify the northern portion of the NEC seemed in doubt. When funds for electrification were provided, Amtrak continued with the procurement action, planning to use the nonelectric locomotives between Albany and New York City, where the infrastructure could otherwise support high speeds. Amtrak received proposals from three vendors, but the locomotives were, in Amtrak's opinion, too expensive, too heavy, or too slow.

In cooperation with the New York Department of Transportation, Amtrak plans to test a nonelectric high-speed trainset. Amtrak will provide a turbine-powered train, which the New York Department of Transportation will retrofit with new-generation gas turbine engines. Amtrak will also upgrade a set of Metroliner coaches to the standards of European high-speed trains. Amtrak has used turbine locomotives in the past but claims their maintenance costs are high. However, turbine locomotives can achieve high speeds because they are lighter than diesel locomotives.

Amtrak plans to place the train in operation on the Albany-New York City route to test performance and gather data on operating and maintenance costs. The New York Department of Transportation recently received

[5]The cost estimate of $2 million per mile assumes that a two-track corridor would be electrified.

[6]Eighty mph is the maximum allowable speed for FRA class IV track. Few freight railroads maintain track above class IV standards.

$3 million in ISTEA technology demonstration funds to retrofit the turbine train.

FRA Plans Further High-Speed Rail Technology Development

The administration's proposed High-Speed Rail Development Act of 1993 would authorize about $300 million for high-speed rail technology development. FRA plans to use $75 million of these funds to develop specifications for a high-speed nonelectric locomotive and to fund research and development on improved, lower-cost grade crossing protection and signal systems.

Contributions From Freight Railroads Would Reduce Public Funding Requirements

Financial assistance from the freight railroads, which own most railroad rights-of-way outside the NEC, could reduce the public funding component for incremental improvement projects. Although freight railroads are not required to pay for any of the costs that arise from allowing passenger trains to use their tracks, they could help to pay for incremental improvements in proportion to the benefits they would receive. Improvements, such as closing grade crossings and implementing elements of the Advanced Train Control System, could benefit the freight railroads.

The freight railroads, however, believe that most improvements to permit high-speed passenger train operations would not significantly benefit freight operations. For example, the Association of American Railroads (AAR), which represents the nation's major railroads, believes that only 5 percent of the cost of eliminating grade crossing hazards, 25 percent of the cost of providing continuous-welded rail, and 25 percent of the cost of installing fencing would be of value to freight railroads. We have not validated AAR's figures.

Amtrak Continues to Improve High-Speed Service in the NEC

Amtrak's NEC Improvement Program illustrates the incremental approach to HSGT. Since the initial appropriation in 1976, Amtrak has been upgrading the entire 450-mile corridor. Electrically powered Metroliner trains can now travel between Washington, D.C., and New York City at speeds of up to 125 mph. Because the track north of New Haven is not electrified, trains traveling toward Boston must switch there to slower diesel locomotives. Travel between New Haven and Boston is further slowed by numerous curves along the route.

Amtrak is now working toward improving speeds between New York City and Boston. Amtrak's goal is to reduce the running time between New York City and Boston from 4 hours to 3 hours and to achieve top speeds of 150 mph. A key component of the project is extending electrification from New Haven to Boston at a cost of $350 million. Amtrak also plans to spend between $450 million and $500 million for 26 new trainsets that can negotiate curves at higher speeds and/or accelerate faster coming out of curves. These trainsets will be used throughout the corridor. Other components of the program include modifying overhead bridge clearances and upgrading rail overpasses, improving the train signal and track system, and upgrading stations. Amtrak estimates the total cost of the remaining improvements in the NEC will be about $1 billion.

Amtrak hired an electrification contractor in 1992 and expects the contractor to complete design work by December 1993 and to begin construction in the spring of 1994. Amtrak expects that the electrification and other infrastructure improvement projects will be completed by 1997 if sufficient funds are available. However, the commencement of 3-hour service between New York City and Boston will depend on how soon Amtrak can acquire the new trains. Amtrak plans to take delivery of two new trains by 1997 and to take delivery of additional trains at a rate of one per month for the following 2 years.

Amtrak plans to model its new trains on high-speed trains currently operating in Europe. The Swedish x2000 high-speed train arrived in the United States in late 1992 for testing and trial commercial service in the NEC. The x2000 employs a tilting mechanism that permits higher speeds through curves while maintaining passenger safety and comfort. In June 1993, the German Intercity Express (ICE) very-high-speed train arrived for similar testing and trial commercial service. Although the ICE train does not tilt, it has superior acceleration capabilities. Amtrak will use the results of these trials to develop a set of high-speed train specifications that will meet U.S. passenger preferences and performance requirements. Amtrak's request for proposals will also include a requirement for two high-speed nonelectric locomotives. The new trains will be built in the United States.

Freight Railroads Seek Liability Indemnification

Outside the NEC, freight railroads own most of the rights-of-way over which Amtrak trains operate. AAR has stated that freight railroads will require indemnification from "any and all" liability for passenger train accidents. The freight railroads' liability concerns stem from the 1987 collision of a Conrail freight train and an Amtrak passenger train in Chase, Maryland, in which the Amtrak engineer and 15 passengers died and 174 passengers were injured. Conrail paid about $95 million in out-of-court settlements, according to Conrail officials. Amtrak has stated that it cannot afford to give an unconditional guarantee against liability risks and has requested the Congress and the administration to examine how best to approach the liability issue. According to a senior FRA official, the agency has been working with the Congress to develop alternatives for addressing this issue.

Conclusions

The incremental approach is the most likely approach to HSGT for the United States, at least for the near term. This approach is the least costly and could be even less costly if current ideas for grade crossings bear fruit. The development of a high-speed, nonelectric locomotive could make the incremental approach even more attractive by avoiding the need for electrification. Although no such locomotive exists, officials at Amtrak and FRA stated that its cost would be no greater than that of an electric locomotive. Negotiations with freight railroads to contribute financially in proportion to the benefits they receive could lead to reductions in the portion of incremental improvements funded through public sources.

Planners of incremental programs outside the NEC can expect the freight railroads that own the rights-of-way to raise the liability issue. The requirement for indemnification from “any and all” liability is intended to protect freight railroads from liability for an accident such as the one that occurred in Chase, Maryland, in which gross negligence was alleged. Determining whether or how to meet the railroad’s liability requirements is outside the scope of this report but will be reviewed in future work.

Views of Agency Officials

Although we did not request written agency comments, we discussed a draft of this report with FRA officials. These officials believe that NRC’s $10 million-per-mile estimate is too high and that the states’ estimates for planned incremental improvements, which are lower than NRC’s estimate, more accurately represent the costs of incremental improvements. The officials said that although NRC’s estimate is near the cost of improvements in the NEC, the NEC represents a very complex example of an incremental improvement program. The officials also cited proposals for low-cost grade crossing improvements and plans to develop a high-speed nonelectric locomotive that could lower incremental improvement costs.

NRC's estimate assumed that a four-quadrant protection system (all lanes in both travel directions) similar to that being tested in the United States would be used extensively throughout the hypothetical corridor. Therefore, savings resulting from that technology are already assumed in NRC's estimate. We do agree, however, that other low-cost grade crossing improvements and a high-speed nonelectric locomotive could reduce incremental improvement costs, and we have recognized their potential benefit in this report. NRC's estimate assumes that electrification is required to achieve speeds of 125 mph and that other low-cost grade crossing alternatives are not in use—assumptions that still stand today. Therefore, we believe that NRC's estimates provide a realistic assessment of the likely costs for incremental improvements. Amtrak's $1 billion estimate to complete improvements in the NEC, when combined with past expenditures of $3.9 billion (1992 dollars), equates to $11 million per mile—slightly higher than NRC's estimate. Our estimate, which uses a combination of NRC and Amtrak data, was $11.6 million per mile. Although agency officials stated that the NEC represents a complex incremental improvement program, other corridors will require costly improvements, some of which were not required in the NEC. For example, most corridors where high-speed passenger service is planned have only one or two tracks. Additional tracks may be needed to allow high-speed passenger trains to pass slower freight trains. Adding track may require widening the right-of-way, which could in turn require purchasing land and widening bridges. These costs are included in NRC's estimates. The NEC, by contrast, already contained multiple tracks in many areas when the federally funded NEC Improvement Program began in 1976.

Very-High-Speed Rail and Maglev Systems Could Serve Certain Corridors

Speeds of over 150 mph require straight and level rights-of-way that are free of grade crossings and of slower passenger and freight train traffic. Therefore, HSGT systems that operate at speeds of over 150 mph—both very-high-speed rail and maglev—require substantially new infrastructure and significant land acquisition, both of which increase costs. Maglev's costs are further increased because of the need for costly, specialized guideways. Very-high-speed rail and maglev systems could play a role in longer transportation corridors, where very high speeds are required to provide trip times that are competitive with those of air travel.

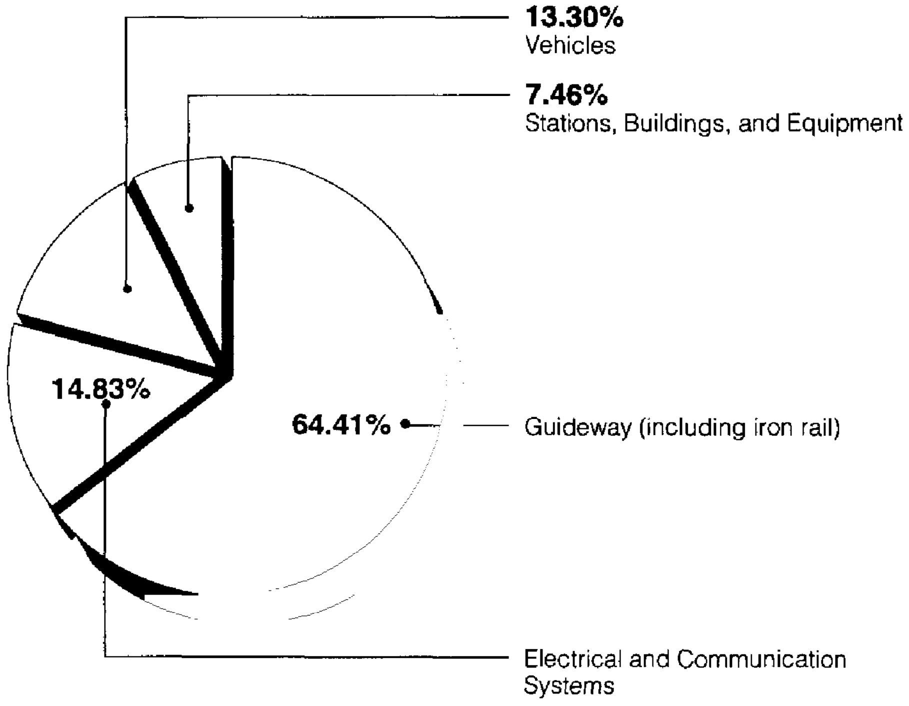
Very-High-Speed Rail Systems Require Dedicated Rights-of-Way

Because European very-high-speed rail systems use the same basic technology as other trains, they can and do operate on conventional railroad tracks at times. However, to take full advantage of their speed potential, these systems require relatively straight and level rights-of-way that are free from grade crossings and slower freight or conventional passenger rail traffic. These trains could not sustain speeds of over 150 mph on existing U.S. rights-of-way because these rights-of-way were not designed for high-speed operations. They often have numerous sharp curves and carry slower-speed passenger, freight, and commuter traffic that would interfere with very-high-speed-operations. In urban areas, where acquiring new rights-of-way might be impractical, very-high-speed rail systems could use existing rights-of-way at slower speeds. NRC estimated that the capital costs for a very-high-speed rail system could exceed $3.5 billion for a 200-mile system, or more than $17 million per mile. NRC estimated that acquiring and preparing land, improving bridges and grade crossings, and relocating utilities would cost substantially more for a very-high-speed system than for an incremental improvement program to allow speeds of 125 mph. In addition, NRC assumed that a much higher percentage of the right-of-way would be fenced and that some tunnels would be required in a very-high-speed system, whereas no tunnels were assumed in the 125-mph estimate.

Maglev Requires Specialized Guideways

A maglev system could allow even faster speeds but would require special, expensive guideways. Although successfully tested at over 320 mph in Japan and 270 mph in Germany, no high-speed maglev system has ever been operated commercially. NRC estimated that a 200-mile maglev system would cost about $6.4 billion, or about $32 million per mile. FRA recently estimated maglev construction costs in a number of corridors. The costs ranged from $27 million per mile to $45 million per mile.[7] Guideway costs make up nearly 65 percent of maglev's cost, as figure 3.1 shows. Acquiring rights-of-way in urban areas, building guideways, and separating the maglev right-of-way from existing roads and railroad tracks in urban areas account for much of the increase in costs over those of very-high-speed rail systems.

Figure 3.1: Cost Components of Maglev Construction



Advances in materials for building guideways and new ideas for substantially lighter-weight maglev vehicles could lower guideway costs. System concept studies conducted for FRA have quoted maglev system costs of about $20 million per mile, excluding right-of-way acquisition costs.

Preliminary plans for developing a maglev prototype in the United States are outlined in ISTEA. ISTEA authorizes $725 million for a three-phased

[7] Final Report on The National Maglev Initiative, Federal Railroad Administration (Washington, D.C.: 1993).

prototype development program.[8] The maglev system would be built on an interstate right-of-way to avoid the cost of acquiring new rights-of-way. However, U.S. interstate highways were built with curves and hills to accommodate automobile travel at speeds of 70 mph. Traversing these curves and hills on a maglev at speeds over 250 mph could interfere with passengers' safety and comfort. U.S. maglev engineers hope to design a system that can be adapted to the curves in existing rights-of-way by combining banked guideways with vehicles capable of tilting to reduce centrifugal forces on passengers.

Maglev systems planned for operation along interstate highways face additional challenges. As we reported last year, maglev systems built alongside interstate highways or in the median strips must contend with numerous obstacles, including bridges, overpasses, and interchanges.[9] Also, concerns have been raised about the possibility that a "startle effect" on automobile drivers could occur when a maglev traveling at 250-300 mph suddenly appeared. Data supporting these concerns are scarce.

A U.S.-Developed Maglev Could Provide Benefits, but More Research Is Needed

Maglev supporters believe that the United States should develop a domestic version of maglev that could generate jobs and create opportunities in a new high-technology industry. In addition, maglev research and development could provide spin-off improvements in other areas. A 1990 FRA report states that significant advances in superconductor technology—an important facet of maglev research and development—could find applications in computers, advanced electronics, medical diagnosis, electric motors, and magnetic separators.[10] A Maglev Technology Advisory Committee reported to the Senate Committee on Environment and Public Works in 1989 that maglev offers uniquely attractive solutions for U.S. transportation needs and is destined to soon become a significant part of the world's transportation market.[11] The report stated that if the United States does not become seriously involved in maglev development, foreign developers will attain an insurmountable lead in the field.

[8]No funds have been appropriated to implement these plans. DOT requested $27.8 million for fiscal year 1994 to begin developing a U.S. maglev prototype but received no appropriation.

[9]High-Speed Ground Transport: Acquiring Rights-of-Way for Maglev Systems Requires a Flexible Approach (GAO/RCED-92-82, Feb. 10, 1992).

[10]Assessment of the Potential for Magnetic Levitation Transportation Systems in the United States—A Report to Congress, Federal Railroad Administration (Washington, D.C.: 1990).

[11]The Benefits of Magnetically Levitated High-Speed Transportation for the United States, Maglev Technology Advisory Committee (Bethpage, N.Y.: 1989).

The U.S. Office of Technology Assessment (OTA) agrees that maglev offers notable potential for technological leadership but also cites significant hurdles that the United States faces in developing its own maglev technology. In 1992, OTA testified that the United States is 5 to 6 years behind Japan in maglev development and about 10 years behind Germany.[12] OTA stated that U.S. maglev technology has not yet advanced to the point that a commercial operation could be developed in 5 or 6 years, as envisioned in ISTEA. OTA recommended that funding for maglev research and development continue at the modest level of about $30 million per year for 5 or 6 years. Such an effort could move U.S. maglev technology to the point that it would be ready for operational testing. A 20-mile test track would be required at a cost of about $500 million, bringing the total cost near the $725 million currently authorized in ISTEA for developing a maglev prototype.

Accordingly, FRA has proposed modifying ISTEA's maglev prototype development program to culminate in a prototype vehicle and test track rather than a commercially operated demonstration system, as called for in the legislation. According to FRA, additional funds beyond those currently authorized in ISTEA would be needed to develop a commercial system because a test track should have sharp curves and grades to stress a vehicle's tolerances. The test track might also be configured in a loop to permit continuous, nonstop operation. Such characteristics are inconsistent with those of a commercial system. For fiscal year 1994, the Congress has appropriated $20 million for maglev research and analysis. These funds are separate from the $725 million for prototype development that ISTEA authorized.

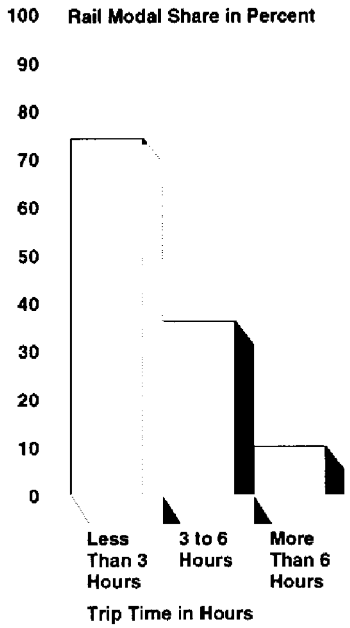
Opinions Differ on the Best HSGT Approach

Two schools of thought exist on how to increase passenger rail speeds in the United States. The first school of thought envisions a demand-led series of incremental improvements, to which further improvements would be made only if the initial improvements substantially increased ridership. The second school of thought assumes that HSGT will generate substantial demand only if it is competitive with the airplane or, in some cases, the automobile. In corridors of about 200 miles, trains traveling between 125 mph and 150 mph might reduce rail trip times sufficiently to be competitive with air or automobile travel. In longer corridors, higher speeds, such as those achieved by very-high-speed rail or maglev, may be needed to draw travelers from other modes.

[12] Department of Transportation and Related Agencies Appropriations for 1993, Hearings Before a Subcommittee of the Committee on Appropriations, House of Representatives (Washington, D.C.: 1993), pp. 425-457.

Some empirical data support the school of thought that focuses on competing with the trip times of alternative modes. As figure 3.2 shows, ridership data from Amtrak's NEC indicate that the rail mode attracts a significant share of the market between cites when the rail trip takes less than 3 hours.

Figure 3.2: Rail Share of Combined Air-Rail Market Between Cities in the NEC



Note: The data are for train trips from Washington, D.C., to Boston, Mass., in 1986.

These city pairs are less than 230 miles apart. Rail trips of less than 3 hours can compete with air travel even when the air travel time from takeoff to landing is considerably less than the station-to-station time for rail. Airport access and egress times are generally assumed to be longer than those for railroad stations, although these times vary widely from corridor to corridor.

Rail travel now competes favorably with air travel in the New York City-Washington segment of the NEC. Amtrak carries 40 percent of the rail and air travelers between these cities, even though the trip by rail takes at least 2 hours and 35 minutes, compared with about 1 hour by air. Air travel time is increased by the time spent traveling to and from the airport, making the total trip times about equal for either mode. Amtrak's goal of 3-hour service between New York City and Boston is projected to attract a market share similar to that of the New York-Washington route. The New York-Boston route is about 1 hour by air, and Boston's Logan Airport is located close to the city, as is Washington's National Airport.

Airport access and egress times in other 200-mile corridors could make high-speed rail even more competitive than it is in the NEC. While airports in Washington and New York City are relatively close to the central business districts, a number of other airports, such as Chicago's O'Hare Airport, are located further away from the city's core.

Amtrak does not expect that its improvements in the NEC will allow it to capture a substantial portion of the traffic between the end-point cities of Boston and Washington. Even after Amtrak completes the improvements, the total trip by high-speed rail between Washington and Boston would take over 5 hours, compared with about 1.5 hours of actual flight time between those cities. However, Amtrak believes that high-speed rail will compete favorably with automobile travel between intermediate points, such as Boston-Providence or New Haven-New York City and between city pairs on opposite sides of New York City, such as Stamford-Newark. Consequently, Amtrak expects ridership to increase between these cities as rail speeds increase.

Conclusions

Clearly, each HSGT approach has its advantages and disadvantages. Incremental improvements, while the least costly, will require coordination between passenger and freight railroads, as well as a number of site-specific improvements. Very-high-speed rail or maglev systems do not require coordination with the freight railroads because they require substantially new infrastructures. However, these systems will probably require new rights-of-way, whose acquisition could be costly and time-consuming. Maglev is the most costly of the HSGT options, but some believe that it promises the greatest long-term benefit for the United States, in terms of both higher speeds and opportunities for technology leadership. Some HSGT planners believe that it is best to make initial incremental improvements to allow modest increases in speed and then wait to see whether increases in ridership warrant further improvements. While this approach appears to be rational and fiscally conservative, it may not attract many new riders if the increases in speed do not make rail trip times competitive with trip times for door-to-door air or highway travel. Thus, this approach could result in large operating losses and dampen enthusiasm for further HSGT funding from private sources, state and local governments, or the federal government. Therefore, incremental improvement programs will probably work best in intercity corridors, where such improvements can reduce trip times to provide a time-competitive alternative to air or automobile travel.

Private Sector Is Unlikely to Build HSGT Without Substantial Federal Participation

To date, federal support for HSGT has focused on the NEC, where Metroliner trains achieve speeds of 125 mph between Washington and New York City. Many other HSGT systems have been planned, but none has been built. Until recently, the federal government has taken the position that HSGT systems outside the NEC should be built mainly with private funds. Private investors have avoided HSGT because they believe it poses unacceptable risks. Substantial federal participation to reduce these risks might encourage private investment in HSGT.

Past Funding Has Focused on the NEC and on Studies

To date, most federal HSGT assistance has gone toward improvements in the NEC. Table 4.1 summarizes federal support for HSGT in recent years.

Table 4.1: Federal Support for HSGT

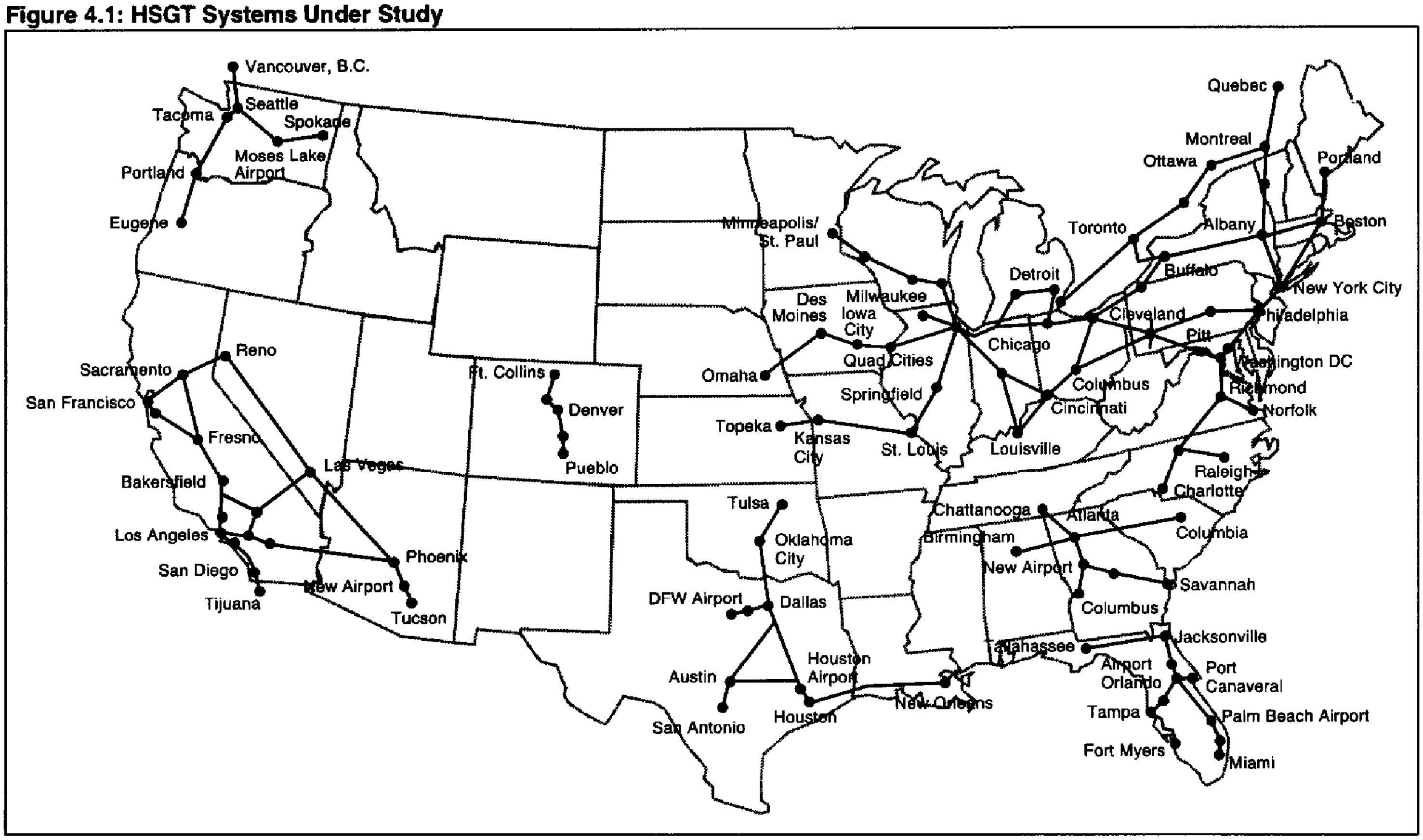
Activity	Federal support
NEC improvements	Nearly $3 billion was appropriated between 1976 and 1993.[a]
HSGT corridor studies	For studies of specific HSGT corridors, $3 million was appropriated in 1991 and 1992.
HSGT technology demonstration	The Congress appropriated $3.5 million for fiscal year 1994.
Grade crossing hazard elimination	ISTEA authorized $30 million for work on grade crossings in up to five corridors. DOT has released the first $5 million of this sum.
HSGT loan guarantees	ISTEA authorized up to $1 billion in loan guarantees. The Congress has not enacted budget authority to implement this provision.
Maglev studies	FRA, with the U.S. Army Corps of Engineers and the Department of Energy, conducted a $32 million study called the National Maglev Initiative (NMI) to assess the potential role of maglev in the United States.
Maglev prototype development	ISTEA authorized $725 million. None of these funds have been appropriated.
Maglev research and analysis	The Congress appropriated $20 million for fiscal year 1994.

[a]When inflation is taken into account, $3 billion represents about $3.9 billion in 1992 dollars. The Congress appropriated $225 million for fiscal year 1994 for NEC improvements.

Numerous HSGT Projects Have Been Proposed but Not Built Because Funding Has Not Been Available

Plans to introduce HSGT systems have been proposed in more than a dozen locations around the nation, as figure 4.1 shows.

Figure 4.1: HSGT Systems Under Study



Source: High-Speed Rail/Maglev Association.

A proposed HSGT project in Texas would link the cities of Houston, Dallas, and San Antonio using TGV technology. Maglev proponents have also planned to build a system connecting Anaheim, California, with Las Vegas, Nevada. In Florida, a 13.5-mile maglev system is planned to connect the Orlando International Airport with International Drive, the location of numerous hotels serving the area's tourist attractions.

To date, however, speeds of 125 mph are achieved only in the NEC between Washington and New York City. Initiatives to build very-high-speed rail or maglev systems have been advanced by groups other than Amtrak that hope to secure private funding for the proposed systems. However, no federal funds have been appropriated for these projects, and private investment has been insufficient to move any of these projects beyond the planning stage.

HSGT Risks Limit Private Investment

According to members of the financial community, a number of risks have discouraged private investment in HSGT projects. First, investors do not believe that HSGT will produce enough revenues to cover its debts and provide a cushion—up to 150 percent of the total debt—to offset various uncontrollable events that could reduce revenues. Because the United States has had little experience with HSGT, investors believe that forecasts of ridership and revenue may be exaggerated. Moreover, evolving technologies, such as tilt-rotor aircraft and videoconferencing, may compete successfully with all forms of intercity transportation, including HSGT. These factors make HSGT unattractive to investors.

Second, the large scale of proposed HSGT projects increases the likelihood that construction delays and cost overruns could undermine financial feasibility. Generally, projects that issue debt to raise capital will need to begin repaying the debt by a specific date. Private investors fear that unless adequate revenues or other cash are available on that date, the project could go into default. Furthermore, system start-up delays cause interest to accrue on outstanding debt, further increasing the project's total cost.

Third, large-scale projects like HSGT systems face a number of political risks, in part because many jurisdictions at different levels of government will be involved in issuing the permits and other clearances needed to build and operate the systems. According to an Amtrak official, improvements to the NEC between New York City and Boston will be subject to several clearances, including an environmental impact statement and public hearings. States must certify that the project complies with the Coastal Zone Management Act. The Clean Water Act requires that the states and Army Corps of Engineers certify that the project is consistent with state and federal regulations. Finally, the project could be subject to local zoning, conservation commission, and historical preservation clearances from up to 41 communities between New Haven and Boston.

These risks impose obstacles for HSGT planners in obtaining commercial lines of credit or attracting lenders. Equity investments are often needed before commercial lines of credit can be obtained or investment-grade debt can be issued. However, equity investors often demand high rates of return and a relatively quick payback, while lenders generally seek secure investments with guaranteed returns over time. HSGT projects do not meet either of these requirements. In light of these risks, members of the financial community familiar with large-scale projects told us that unless the federal government assumes a major role in HSGT development, thereby reducing the perceived investment risks, private capital generally will not be available.

Conclusions

No matter how creatively high-speed rail developers plan to finance their proposals, it is apparent that the private sector alone will not assume all, or even a substantial share, of the risks associated with financing HSGT development. If such projects are to be built in this country, the federal government will need to assume a substantial portion of the risk, thereby transferring risk from the private sector to the taxpayer. Such a transfer may be justifiable when the private sector will not pay for projects and the benefits are sufficient to warrant the federal investment.

Federal Funding for HSGT Needs to Be Focused

On April 28, 1993, the Clinton administration proposed legislation that would increase federal assistance to HSGT. The administration concurrently proposed to spend $1.3 billion for corridor development and research for HSGT over 5 years. While these initiatives would provide more federal support to HSGT than in past years, the sum is still quite modest compared with the cost of HSGT systems. Federal funds will be most effective if they are strategically focused to ensure that when combined with state, local, and private funding, they provide maximum assistance to a few, well-chosen corridors. The proposed legislation would use several criteria, including social benefits, to select among corridor improvement proposals for federal funding. Evaluating an HSGT corridor's potential benefits will be a complex task, requiring an assessment of the validity of the assumptions and data used to develop ridership forecasts, as well as knowledge of the potential limitations and drawbacks of assessing social benefits through modeling.

Proposed Legislation Would Increase Federal Support for HSGT

The Clinton administration recently proposed the High-Speed Rail Development Act of 1993 and requested $1.3 billion for fiscal years 1994-98 to develop high-speed corridors outside the NEC and to underwrite HSGT research and development.[13] This proposal will provide maximum assistance to HSGT development in the near term only if the funds are strategically focused. Of the $1.3 billion, the administration plans to provide about $1 billion to develop high-speed rail corridors and to use the remainder to advance HSGT technology.[14] Over 5 years, $1 billion translates into $200 million per year, assuming that the Congress appropriates the full amount.[15] If these funds are spread over as few as five corridors, each will receive, on average, only $40 million each year. Inflation will further reduce the value of these funds to the extent that these expenditures occur in the future.

Under the proposed legislation, states would be required, as a minimum, to provide funding that matches their share of federal funding, or a total of $1 billion. FRA officials believe that the federal commitment of $1 billion will encourage states to overmatch, that is, contribute more than, their

[13]According to the proposed legislation, NEC improvements would continue to be funded separately.

[14]The House Committee on Energy and Commerce has reported to the full House an alternative bill based on the administration's proposal. The alternative bill would increase authorizations for corridor development to about $1.2 billion and would reduce authorizations for research and development to $75 million.

[15]When inflation is taken into account, the purchasing power of $1 billion will likely be less than it is today, especially since the bulk of these funds may not be spent until later years.

federal grants and that the private sector will also contribute funding. FRA believes that funds from these combined sources could reach a total of $2 billion. To the extent that states and the private sector make large contributions, federal funds can be effectively spread over additional corridors. However, the state planning officials and Wall Street investment analysts we spoke with were generally not optimistic that leveraging would occur to the extent that FRA anticipates.

Because each project is costly compared with the resources available, there is a risk in spreading federal funds too thinly. The proposed legislation requires that any federal funding be sufficient to ensure completion of at least one element of a corridor development project. An element is a discrete portion of a high-speed corridor development program that results in a demonstrable improvement in transportation. According to FRA, an element could include simply improving a single bridge, or could include an extensive package of track and signaling improvements. Improving a single bridge could cost less than $1 million, while track and signal improvements could cost well over $100 million. Completing all improvements to permit speeds of 125 mph on a hypothetical 200-mile corridor could cost over $2 billion, according to NRC and Amtrak estimates. Allocating small amounts of federal funds to simultaneously complete individual elements of several projects could exhaust the proposed $1 billion in federal funds before any one project is completed. Although Amtrak's NEC Improvement Project is not eligible for the proposed federal funding, it provides an example of the cost of an incremental improvement program. The Congress appropriated approximately $217 million per year (in 1992 dollars) between 1976 and 1993 to improve the corridor. Amtrak estimates that completing these improvements will cost an additional $1 billion.

Several Options Exist for Federal Support of HSGT

In addition to providing direct appropriations, such as those that the Congress has provided for improvements in the NEC, other less direct means of support are also available. The federal government could provide loan or revenue guarantees, establish revolving loan funds, and provide financial assistance in a project's early planning stages that could help HSGT developers obtain lines of credit. The federal government recently provided for one means of indirect support by removing a restriction on the amount of tax-exempt bonds that could be issued to finance high-speed rail lines.

The federal government could provide loan guarantees for different components of a project or become a guarantor of revenues for HSGT projects. Federal guarantees could be particularly helpful during the first few years of operations, giving a system time to build up ridership and revenues. The French TGV system was financed in part through government guarantees. Investment bankers told us that federal guarantees would be the single most significant stimulus for private investment, given private investors' concerns about HSGT's ability to recover costs through revenues. Under ISTEA, HSGT is eligible for loan guarantees authorized by the Railroad Revitalization and Regulatory Reform Act of 1976. However, no budget authority currently exists for this program. The Federal Credit Reform Act of 1990 requires that appropriations be made to cover expected future losses on federally guaranteed loans.

Providing direct loans through a revolving loan program is another possibility for federal support of HSGT. Some members of the financial community, as well as the Commission to Promote Investment in America's Infrastructure,[16] have suggested that the federal government establish its own revolving loan fund for infrastructure development or provide funds to establish funds at the state level. Capitalizing such a fund would require either a large initial appropriation or several smaller appropriations over several years. However, loans from such a fund would presumably carry below-market interest rates. Thus, the loans could help lower the cost of capital for HSGT and enhance the financial feasibility of projects.

Given the large scale of HSGT projects, it seems likely that some combination of these options will be necessary to bring an HSGT project from conception to reality. Different financing methods could be used at different "risk points" during a project's development period. For example, the Texas TGV Corporation plans to use different financing techniques in various phases of its plan to use TGV technology to link the cities of Dallas, Houston, and San Antonio. The plan includes using initial equity contributions, tax-exempt debt backed by long-term letters of credit, and, after operations and revenues become steady, a public stock offering.[17] Such a combination of approaches spreads, and therefore minimizes, risk

[16]ISTEA established the Commission to Promote Investment in America's Infrastructure to study, among other things, methods to encourage public and private investment in infrastructure facilities.

[17]The system was originally scheduled to begin service in 1998. Obstacles, including financial ones, have caused the schedule to slip. Initial revenue operation is now expected around the year 2000.

over time and across investors and creditors, making investment in such a project more feasible.

Federal financial and administrative assistance during the initial development and construction phase of HSGT projects could be particularly helpful. As mentioned previously, private investors are reluctant to invest in the high-risk, early stages of a project, but equity investment is generally required before commercial lines of credit can be obtained for a project. Several analysts suggested that the federal government is the entity best suited to be the principal provider of equity capital during the early phase of an HSGT project. Such early federal investment could facilitate access to commercial lines of credit for a project.

The federal government recently provided indirect support to high-speed rail development by removing restrictions on the amount of development bonds that could be issued to finance high-speed rail lines, provided a government entity owns the property. Previously, 25 percent of any tax-exempt bond issue for high-speed rail had to fall within the state's volume cap for private activity bonds. Because of the high cost of high-speed rail projects, the restriction effectively eliminated the option of issuing tax-exempt bonds to finance them. Removing the restriction places high-speed rail on an equal footing with airports and waterways for tax-exempt bonds. This action had long been sought by high-speed rail developers because it provides a lower-cost means of obtaining financing.

Comparing Corridors Will Require Specialized Expertise

Designating the best corridors for the limited federal funds likely to be available will be a complex process. The proposed legislation requires that states petition the Secretary of Transportation for eligibility to receive federal funding. In addition, it provides that the Secretary, when reviewing these petitions, will consider, among other things, projected ridership, revenues, subsidy requirements, relief from congestion on other travel modes, and reduction in air pollution. Anticipated relief from congestion and improvements in air quality are social benefits that, we have testified, should be considered in deciding where to invest federal funds.[18] However, accurate estimates of ridership are prerequisites to accurate estimates of social benefits, revenues, and subsidies, since these factors depend on how many people ride the system.

Predicting ridership for HSGT is currently more of an art than a science. Existing intercity travel databases do not include information on origins

[18] High-Speed Ground Transportation: Financing Issues (GAO/T-RCED-93-14, Mar. 4, 1993).

and destinations for automobile trips, which would be an important factor since 80 percent of all intercity travel is via automobile. Ridership forecasts must also assume how much induced demand—that is, travel that occurs only because the new system exists—is likely. Other assumptions include the price of HSGT fares compared with airline fares, and whether and to what extent the airlines would lower their fares in an effort to retain passengers in the face of competition from HSGT. Because no HSGT system exists in the United States outside the NEC, there is little basis for judging the validity of the assumptions used by demand forecasters.

The Environmental Protection Agency's model for predicting automobiles' emissions is based on trip characteristics, including the number of starts and stops and the length of the trip, according to an agency official who works with the model. Such patterns vary, depending on whether a trip is a short urban trip or an extended intercity trip. More starts and stops and slower speeds, which are typical of urban driving, produce higher emission rates. The Environmental Protection Agency has developed a set of national default parameters that are based on the trip patterns typical of urban travel. If these parameters are used to predict the impact on air quality of removing intercity vehicles from the road, the results could be overstated. However, these parameters could be adjusted to approximate intercity trip patterns. Transportation decisionmakers will need to be aware of whether and how these parameters were adjusted when they evaluate predictions of improvement in air quality resulting from a proposed HSGT project. Furthermore, most air pollution exists over urban areas and is caused by intra-urban travel, while HSGT would primarily affect intercity automobile travel. Any improvements in air quality stemming from HSGT would be spread over a large area and might be dissipated as a result.

In addition to ridership and social benefits, the proposed legislation will require consideration of (1) the extent to which the rail corridor is integrated into a state's overall transportation plans, (2) the degree to which the proposal provides multimodal connections, (3) the level of financial commitment of state and local governments, (4) the effect of the rail corridor on other modes of transportation in operation or under development, and (5) the support of freight railroads that own the rights-of-way.

When analyzing competing HSGT proposals, federal officials must be prepared to ask hard questions such as the following: How will a proposed

HSGT system reduce air pollution when most air pollution is generated from urban automobile travel, while HSGT systems would affect primarily intercity automobile travel? Were the parameters used in modeling automobile emissions adjusted to account for the type of travel (intercity or urban)? What will happen to predicted ridership if the airlines lower their fares to minimize diversions to HSGT? What assumptions underlie predictions of induced demand, and are they reasonable? What transportation problem will the HSGT system solve? Are alternative solutions, such as expanding airports or highways, less costly?

DOT officials told us they have begun hiring staff to help develop the high-speed rail program. They have requested funding to hire environmental engineers, financial analysts, and others to evaluate corridor development proposals if the proposed legislation passes. Having the expertise on hand to conduct a rigorous analysis of these proposals will be important to ensure that only the most viable projects receive federal funds.

Conclusions

The past policy of relying largely on the private sector to develop HSGT in the United States has not led to its development outside the NEC. A substantial federal investment will be required if HSGT is to become a reality in this country. There are many approaches that the federal government might pursue to assist in the development of HSGT, but regardless of the approach taken, the fact that federal resources are scarce, and will continue to be scarce for the foreseeable future, means that the federal government will need to guard against spreading funds too thinly across a large number of projects and not giving any one project enough assistance to progress to completion. Federal funds should be concentrated on those corridors where (1) cost-benefit analyses justify the expenditure and (2) the combined federal, state, and private funding will ensure that high-speed passenger service becomes a reality.

Forecasting and evaluating public benefits will not be easy. Because ridership projections are sensitive to the underlying assumptions and methodologies used, taking projections at face value will not be sufficient. Planners will need to determine what assumptions were used and whether the assumptions were realistic in order to judge the effect on projected demand. Although public benefits could result from shifting traffic from airplanes and automobiles to HSGT, analyzing the balance of costs and benefits continues to be an inexact science. Nevertheless, reasonably accurate measures of the value of relief from congestion, reductions in pollution, and other social benefits are necessary to gauge the proper level of public investment. The federal government will need to acquire the human and other resources needed to make these calculations.

Recommendations

In addition to following through on the high-speed nonelectric locomotive and research on low-cost grade crossing systems, GAO recommends that the Secretary of Transportation (1) focus available federal funds on a limited number of projects to ensure that combined federal, state, and private funding is sufficient to move these projects to completion and (2) ensure that FRA has the expertise to evaluate corridor development proposals to select those that could provide the most benefits.

Views of Agency Officials

The draft that we provided to agency officials for informal comments stated that federal funds should be focused on no more than two or three corridors. FRA officials expressed concern that concentrating funds on such a small number of corridors was overly restrictive and that federal funds would leverage up to an additional $1 billion in state and private funding beyond the required $1 billion in total state matching funds. These additional funds, officials said, would permit federal funds to be allocated over more than two or three corridors.

We added information to the report to reflect the possibility of additional leveraging. However, most state planning officials and investment experts with whom we spoke did not expect the federal funding to leverage additional state and private sector contributions to the extent envisioned by FRA. Without such leveraging, only $2 billion would be available (assuming states can match federal grants). Incremental improvements to a single 200-mile corridor could cost $2 billion, and a number of proposals will be competing for federal funds. If the $1 billion in federal funds were allocated to as few as five corridors, each would receive only $400 million—$200 million in federal funding plus an equal amount in state matching funds—to build a high-speed system. This is far short of the amount required to build an HSGT system. Therefore, we continue to believe that high-speed passenger service stands a better chance of becoming a reality in the United States if federal funds are strategically targeted to a limited number of projects.

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