Chapter 1
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At the request of the Subcommittee on Transportation of the House Committee on Appropriations, the Senate Committee on Commerce, Science and Transportation, and the House Committee on Energy and Commerce, OTA examined five questions concerning high-speed rail and magnetic levitation (maglev) passenger technology, and railcar manufacturing:*

1. What is the status of high-speed rail technologies and passenger service abroad?
2. What activities are underway to bring such technologies and service to the United States?
3. What is the outlook and what are the implications of introducing high-speed passenger rail systems in the United States?
4. What is the status of maglev technologies?
5. What is the status and outlook for the U.S. passenger railcar manufacturing industry?

The information for this assessment was obtained through analysis of technical literature, supplemented by interviews and workshops with experts in the field of passenger rail technology.** OTA did not evaluate the economic feasibility of any individual corridor proposal. However, based on foreign experience and analysis of market factors likely to affect rail ridership, OTA did draw some general conclusions regarding high-speed rail application in the United States. The following is a discussion of these conclusions.

***For purposes of this study high-speed rail was defined as systems with maximum design speeds of 125 mph and above. Chapters 2, 3, 4, 5, and 6 focus on technology, economic and institutional considerations pertinent to intercity transportation. The focus of** *Chapter 7: U.S. Passenger Railcar Manufacturing* **includes manufacture of intercity, commuter, and urban transit railcars.**

****A complete bibliography of literature reviewed for this study is available from the OTA Science, Transportation, and Innovation Program Office.**

MAJOR FINDINGS

High-Speed Passenger Rail Systems and Technologies

Foreign Experience

The development of high-speed passenger rail technologies has taken place almost entirely in France, Great Britain, and Japan. These countries consistently have placed a high priority on passenger rail service as a matter of explicit national policy and have developed extensive passenger rail networks that are, in varying degrees, government subsidized. Development of rail systems with improved speed is underway in other countries as well, though not studied in this report.

The Japanese, in the mid-1960's, were the first to introduce regular high-speed passenger rail service with the Shinkansen, or "bullet train, " service between Tokyo and Osaka. That line, and the later high-speed extension between Tokyo and Hakata, are the only dedicated high-speed lines in the world to have earned a profit and repaid capital investment costs. In the mid-1970's, the British began to introduce high-speed rail service on existing, upgraded routes throughout their national system. In 1981, the initial segment of the new French high-speed line between Paris and Lyon—the TGV—began operation, with service over the entire line scheduled for 1983. The French are confident of profitability and the British achieve a satisfactory return, repaying all but 10 to 15 percent of operating and capital costs.

The Three Foreign Systems

The three foreign high-speed systems differ significantly; each is tailored to its particular topography, transport needs, demographic conditions, and economic circumstances.

Japan .-The Japanese chose to construct entirely new track and equipment, because they had no alternative. The existing narrow gage rail lines were unsuitable for high-speed service and heavily overloaded with traffic. There was a fully developed transit feeder system. The early bullet trains attracted a large ridership—85 million on the Tokyo-Osaka line in 1970. Ridership for the entire Shinkansen system in 1980 was approximately 125 million.

Great Britain.—The British, concerned that their existing passenger rail network increasingly would lose riders to competing travel modes, decided in the early 1970's to introduce high-speed service. They considered the construction of an entirely new high-speed railway, but rejected it on the grounds of projected high costs and probable environmental opposition. Instead they chose to employ conventional technology and designed trains with maximum speeds of 125 mph that could share existing track with freight and commuter trains.

France.—To ease severe congestion on the Paris-Lyon line, the French chose to build a new high-speed line to divert a major part of the intercity passenger train traffic away from that area. The new high-speed track runs through sparsely populated country between Paris and Lyon, where the line connects with existing track on the outskirts of the two cities. Because the new system was designed to traverse steep grades (avoiding the expense of tunneling) and sparsely populated areas, the construction costs reportedly have been low. In just over a year, the French have carried 5.6 million riders on the Paris-Lyon run and expect to attract *16* million riders annually when the network is completed. The French Government has also encouraged TGV travel by restricting intercity bus travel along highway routes.

Photo credits: TGV America

SNCF Train a Grande Vitesse (TGV) first class car (interior view). Maximum seating of 111 passengers in first class, 275 passengers for second class

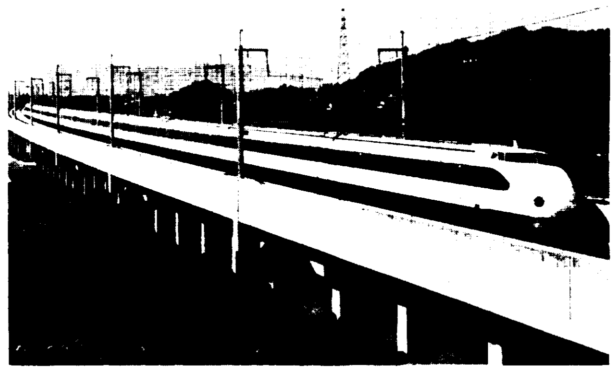

Photo credit: Japanese National Railways

Shinkansen, "Bullet Train," on elevated guideway

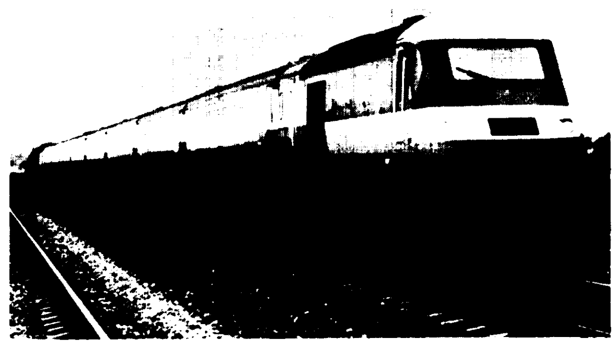

Photo credit: TRANSMARK

British Rail High Speed Train

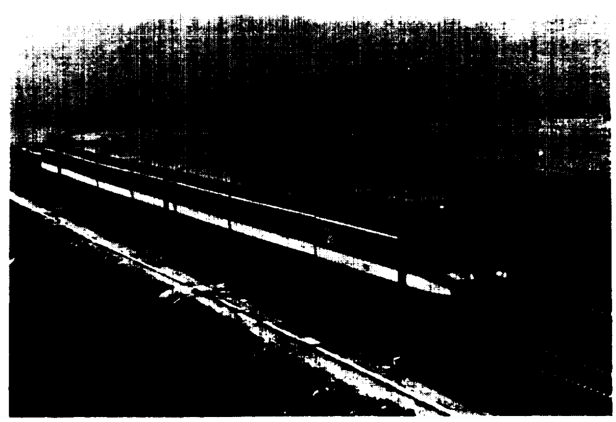

Photo credit: TGV America

SNCF Train a Grande Vitesse

U.S. Activity

In the United States, a number of private and State-sponsored initiatives to introduce either high-speed rail or maglev are at different stages of planning—notably in California, Florida, Michigan, New York, Vermont, Nevada, Wisconsin, Ohio, Pennsylvania, and Texas. In addition, a Midwest Rail Compact of States interested in high-speed rail has been formed to investigate a possible five-State network. These efforts are being promoted, in part, by U.S. and foreign firms that might undertake corridor development or supply the technology. Some advocates of these ventures have suggested some form of Federal assistance will be needed, while others claim none or very little will be required.

Technology Options

The basic technology options for high-speed rail service include combinations of equipment, track, and propulsion systems. All equipment and track options and several of the propulsion options are in use or under development abroad.

Equipment and Track Options.—

- *Improved conventional equipment on upgraded existing track (Great Britain).* This */east-cost option* uses conventional equipment at a maximum speed of 125 mph on existing track, shared to some degree with freight and/or commuter trains. (The Northeast Corridor (NEC) now is operating trains at speeds up to 120 mph on certain segments of the corridor.)
- *Advanced technology on existing track (Great Britain, Canada).* Great Britain and Canada as well as others are developing different versions of a “tilt-body” train that can provide improved schedules on existing track, because of its ability to take curves at higher speeds than conventional trains. However, technical problems with the tilt-body equipment make transforming prototype equipment into an attractive commercial operation difficult.
- New *equipment, part new track, or totally new track (France, Japan).* For its new TGV high-speed service between Paris and Lyon, France uses state-of-the-art equipment on existing track into and out of Paris and Lyon, and on new track between the two cities. The amount of new track constructed, the terrain, and the population density determine the costliness of this option. Japan used state-of-the-art equipment on totally new track, including access to cities, for its Shinkansen service because the original narrow gage track was not suitable for new high-speed trains.
- *Very high-speed new modes beyond steel wheel on rail—maglev (West ‘Germany, Japan).* Japan and West Germany currently are conducting development work on maglev systems, which are capable of speeds in excess of 250 mph. The West German system is being tested under conditions and at performance levels that the West Germans believe are necessary to prove revenue service application. The Japanese also are conducting further test and development; their systems employ more new technology than the West German system. The United States terminated its maglev research program in the mid-1970’s.

Propulsion Systems.—The propulsion system options include *diesel power, electric power (including linear synchronous motors),* and *gas turbinepower.* Gas turbine power has been virtually abandoned due to poor fuel efficiency. Linear synchronous motors are being developed for high-speed maglev systems. Only electric and diesel power are suitable for state-of-the-art high-speed rail systems. Diesel power is cheaper and more flexible than electric power for low-volume operations; however, electric power can provide improved acceleration, higher speeds, and better braking. It is less expensive than diesel for high-density operations, and in the long term maybe preferred over dependence on liquid fuel.

Comparison of Options.-The cheapest capital costs for high-speed service result from diesel-powered conventional equipment on existing track at a maximum speed of 125 mph. A high-density operation is required before the economies offered by electric power can overcome the high fixed-capital costs associated with electric catenary and transformers. The most expensive option is to use electrically powered high-speed trains on completely new track at speeds well in excess of

125 mph. The costs of building new track, although always higher than upgrading existing track, can vary significantly from one place to another. The costs of the system depend on such factors as location, terrain, length of route, right-of-way issues, the high-speed technology selected, and the service levels to be provided. The construction cost of the French TGV line, for example, was reported to be $4 million per mile. The two latest sections of the Japanese Shinkansen are estimated to have cost about $35 million to *$40* million per mile, principally because of the extensive tunneling and viaducts required in Japan. The earlier Shinkansen lines cost approximately *$20* million per mile in 1979 dollars. The upgrading costs for the NEC have ranged between $4.5 million and $5 million per mile with an additional $2.5 million per mile for electrification. *

Minimum Characteristics of High-Speed Corridors

High-speed passenger rail systems require high ridership to generate enough revenue to cover most or all of operating costs, let alone capital costs. Thus, all existing foreign high-speed rail services have been introduced on corridors serving major population centers.

Analysis of the factors that influence the passenger's choice of travel mode, and of the experience of foreign high-speed systems, suggests that before a corridor is considered for high-speed passenger rail service, it should have some or all of the following minimum characteristics:

- cities grouped along a route giving major passenger travel flows in the 100- to 300-mile trip range;
- cities with high population and high population densities;
- cities with developed local transit systems to feed the high-speed rail line; and
- a strong "travel affinity" (reason to travel) between cities, generally because one city is a dominant center of commercial, cultural, financial, governmental, or other activity.

High population and high population densities are probably the most important characteristics of a potential high-speed rail corridor because they make possible the ridership levels and the support for the local transit infrastructure required for successful high-speed service.

Methods of measurement vary slightly, but, with few exceptions, U.S. cities have lower population densities than cities in either Europe or Japan with high-speed rail service. Table 1 shows 1980 population and population densities for selected European, Japanese, and U.S. cities. The data used in the table is for center city populations and excludes outlying suburban areas.

Based on foreign experience and current U.S. market factors, it appears that any U.S. corridor with totally new high-speed rail service would have difficulty generating sufficient revenues to pay entirely for operating and capital costs. Introduction of high-speed rail service, therefore, well may depend on whether the public benefits are judged sufficient to justify public support.

Maglev: Status and Outlook

Two different maglev technologies capable of speeds 250 mph and above are being developed abroad for high-speed intercity passenger service.

Table 1.—Population and Population Densities in Europe, Japan, and the United States

City pairs	Population (000s)	Square miles	Density (population per square mile)
Paris	8,548	827	10,300
Lyon	1,171	279	4,200
Tokyo	11,649	357	32,800
Osaka	2,648	98	27,100
London	6,900	621	11,100
Glasgow	763	61	12,447
New York	7,072	302	23,500
Washington	638	63	10,200
Chicago	3,005	228	13,174
Detroit	1,203	136	8,874
Los Angeles	2,967	468	6,400
San Diego	876	320	2,700

SOURCE: "Far East and Australia Statistics," 19S182, Europa Publications; "U.K. Statistical Yearbook, 19S1, by HMSO (Her Majesty's Statistics Office); "Whittaker's Almanac," 1963; "19S0 Census of Population," U.S. Department of Commerce, PC80 Series, February 1982.

● Costs include system design, program management, and construction, according to Department of Transportation officials.

The attraction maglev technology, which employs conventional iron-core electromagnets, is being developed by the Federal Republic of Germany. The repulsion maglev technology, which employs superconducting magnets, is being developed by Japan.

Both systems rely on electromagnetic forces to provide support (levitation), lateral guidance, propulsion, and braking without direct physical contact between the vehicle and the guideway. To date, neither system has been tested and operated at speeds and conditions necessary to determine if it can perform to desired standards at costs that will justify actual revenue service. The West German system is now in the final developmental testing stage. The results of the tests are expected in late 1985. The Japanese system is still in the experimental stage, and plans for a new test track are being considered.

Although capital costs can be estimated, the reliability of current guideway cost projections has been questioned by some because of the extremely close guideway/vehicle tolerances required in constructing a maglev system. Operating costs cannot be determined accurately until testing has occurred, though theoretical operating estimates are available.

West German and Japanese developers and other potential suppliers of maglev technologies are discussing with a few U.S. State and local governments the possibility of testing or eventually introducing maglev systems. According to a feasibility study prepared by technology suppliers for a Las Vegas-Los Angeles route, Federal support is not required to build a maglev route, although the feasibility study assumes that right-of-way would be made available at little or no cost by the Federal and State Governments. The feasibility study provides a joint public-private sector financing plan, in recognition of the risk involved in implementing the new technology. Additional feasibility studies for this corridor are being conducted by the Department of Transportation.

U.S. Passenger Rail Manufacturing Industry

Status and Outlook

There is currently no U.S.-owned passenger railcar manufacturer. * U.S. manufacturers are not likely to decide to reenter the market and manufacture railcars unless the U.S. Government (like other major Western countries and Japan) assures a stable, predictable, and planned rail equipment market that spreads orders out more or less evenly and in manageable sizes. Other factors likely to influence U.S. industry reentry into the railcar market are continued standardization of railcar requirements for the various passenger rail systems in this country, and continued improvements in some local procurement requirements.

Few U.S. passenger car orders are expected for the rest of this decade. For the 1990's, the total average annual railcar construction orders in the United States are estimated to be between 450 and 550 cars—possibly large enough, under the right conditions, to support a few small U.S. manufacturers. The addition of a new high-speed rail corridor would not significantly alter the overall market picture for railcar manufacturing.

Today, purchases by New York City and Chicago together represent about 77 percent of the total U.S. transit market and more than 40 percent of the total U.S. railcar market with six different railcar designs. Their plans for fleet replacement or expansion are the most important factors in determining the size and nature of the railcar market in this country. Amtrak now has a largely new fleet, and replacement needs for the next decade are likely to be small.

● The Budd Co., though located in the United States and employing U.S. labor, was purchased by Thyssen, a West German corporation, in 1978. U.S. passenger rail manufacturing refers to intercity, commuter, and transit cars.

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Questions for Public Policy

Interest in high-speed rail development in the United States dates to the early 1960's when Congress began examining passenger rail along the Northeast Corridor (NEC) and when the Government began exploring ways of retaining intercity passenger rail service. The basic policy questions considered at that time—including economic viability, corridor suitability, and technology options—still apply. However, today the available technologies (particularly equipment) are more advanced and typically are provided by foreign suppliers. The demographic characteristics of some U.S. corridors also have undergone some change during the last two decades.

Recent proposals for high-speed rail and maglev corridor development have tended to focus on private sector development or some form of public-private sector cooperative enterprise. However undertaken, any high-speed corridor developed will affect substantially a region's structure, environment, and total transportation system as well as pose fundamental questions of public policy at all levels of government. These include:

- what anticipated public benefits are to be derived from introducing high-speed or maglev service?
- what are the anticipated public costs?
- if the benefits of implementing such a system are judged sufficient, what funding will be necessary, and who should pay for implementation of the service?

Some benefits of high-speed systems are quantifiable. Others are a matter of societal and political judgment. Similarly, some costs, particularly those associated with economic efficiency of the system, can be projected; others are more difficult to estimate. As discussed in the following section, some claimed benefits, when taken individually, appear small. However, when all benefits, tangible and intangible, are taken into account, a given region or locality may well wish to implement a high-speed system. Benefits and costs, however, must be examined for the near-term as well as long-term impacts.

PUBLIC BENEFITS AND COSTS

The public benefits often cited for high-speed rail service include:

- increased transport system capacity and mobility;
- reduced congestion in highway and airport ground traffic and other environmental gains;
- energy efficiency, economic development, and employment; and
- safety.

In addition to these explicit reasons, national pride and a desire for continued and modern rail service are also reasons that appear to influence public opinion in favor of high-speed services. "If other countries can provide such service successfully, then why can't the United States?" is a question frequently raised.

Possible public costs of a high-speed passenger rail system include near- and long-term subsidy of the system if ridership and revenues are insufficient; environmental concerns; adverse effects on competing travel modes, services, and employment; and questions of regional equity.

Following is a discussion of the potential benefits, costs, and tradeoffs that may influence decisionmaking regarding high-speed rail.

Benefits

Several types of benefits potentially occur from introduction of high-speed transport systems: some result from long-term improved transport system capacity (high ridership) and mobility; others from system implementation irrespective of improved capacity and the resulting ridership. The latter benefits typically have more near-term impacts, whereas the benefits resulting from improved capacity have longer term implications for the region involved.

The large ridership capacity inherent in a high-speed system allows for new travel demand, for accommodation of population growth of a region, and provides for a competitive alternative to divert some travelers from other modes. To illustrate the ridership levels that can be achieved by frequent high-speed service, the original Tokyo-Osaka line attracted 85 million riders in 1970. Five years later, the total line, extending from Tokyo to Hakata, attracted a high ridership of 157 million passengers. Assuming that high ridership volumes result, other potential benefits that could stem from the improved transport system capacity include reduced energy consumption, regional economic development (including tourism) and resulting employment, reduced air traffic and highway congestion, and improved transportation safety.

Analysis of available data suggests that rail is an energy-efficient mode only in high-volume corridors. Like other individual means of conserving energy, it should not be overlooked, but, by itself, it will make only a small contribution on high density routes. One proposal for a high-speed passenger rail corridor in Florida views the advantage of the system not as a means of saving energy, but as a means of shifting some transportation to a reliance on electricity, thus backing up Florida's ability to attract and care for tourists in the event of another oil shortage and to provide mobility for the State's citizens. Changes in the future availability and cost of transportation energy may alter the perspective on transportation needs and high-speed rail applications in the United States.

Regional economic growth, including tourism and real estate development and the resulting employment, also are benefits that may result from the improved capacity offered by implementation of high-speed rail. The newness of maglev technologies in particular is thought by its advocates to be a major stimulus of new travel demand in corridors where it is being proposed.

More transportation options would result from the introduction of high-speed rail. There is little evidence provided to indicate that it will significantly affect highway and airport congestion. The former generally is caused by commuter and other urban area access traffic rather than intercity traffic. Hence, those benefits of a high-speed rail system inferred from its ability to relieve highway congestion need careful analysis, as does the relationship of commuter services and fares to the overall system design. Whether a high-speed system will relieve airport ground congestion depends, again, on the individual corridor. With the possible exception of NEC and southern California, it does not appear that high-speed rail service would have an appreciable effect on airport ground congestion. Much of the activity for other large airports that now have or are soon to have severe congestion results from passenger flight transfers. High-speed rail would not alleviate this.

With regard to safety, high-speed rail systems have fared well. The record of the Japanese Shinkansen system essentially is perfect. There have been no passenger fatalities on that system since it became operational in 1964. The British system, even though it operates shared facilities with commuter and freight rail, is considered to have a good record as well. The new French TGV reports no passenger fatalities for its operation to date. If new technology for high-speed passenger rail is introduced in this country, several issues associated with safety standards and practices will require consideration and review. In addition, operational and safety certification of these new technologies also will be required. Potential maglev developers already are beginning to investigate U.S. certification procedures.

One safety issue of concern for the United States will be that of protection for rail/highway grade crossings. While it is less costly to provide warning signals and gates at grade crossings (as is done in rural areas of Europe) than grade separation, grade crossing accidents in the United States account for the highest fatality category in rail safety. According to some State officials, rural populations probably will seek to ensure that grade separations are provided if a high-speed rail route is to be implemented in their area, and grade separation—an expensive step—could well be mandatory.

Regulatory standards for track currently included in the Federal Code also will have to be reexamined. U.S. practices for building railcar equipment could be inadequate as well. Countries that have high-speed services have found it necessary to modify vehicle construction methods in the interest of ride quality, weight reduction, and fuel economy. There appears to be no evidence that these changes have reduced the safety of the vehicles, and both the French and the British agree that features of the designs would make them safer in a collision than the conventional equipment. U.S. construction is such that a U.S. vehicle of a given capacity weighs more than those now built abroad, adversely affecting fuel consumption. If high-speed rail is introduced in the United States, equipment specifications may need to be reviewed and the issues of track shared with the heavier U.S. freight equipment will need to be addressed. U.S. track standards also would need revision to permit higher speed operations.

The potential benefits described above are based on near capacity ridership. OTA's review of foreign experience and U.S. market conditions suggests that if ridership sufficient to justify system implementation is to be attracted, the following characteristics of a corridor are necessary: cities with major passenger travel flows of 100- to 300-mile trip range; cities with high populations and high population densities; a strong travel affinity (reason to travel) between cities; and cities with developed transit systems to feed the rail link. *At these distances and with these conditions, assuming frequent service and effective fare policies, rail can compete with air and automobile transportation. For shorter distances, rail will only compete where special circumstances exist. For longer distances air is likely to dominate the market.* Predicting the level of travel resulting from the introduction of high-speed systems is difficult; and is the most uncertain factor in the decision-making process.

Other benefits will result from high-speed rail systems including employment during construction of the rail system itself. As discussed in chapter 7 of this report, foreign firms now have an exclusive hold on the U.S. railcar market, though one foreign-owned firm located in the United States employs U.S. labor. Rail system employment is dependent on service frequency, labor agreements, and degree of system automation. Construction employment would be corridor specific.

costs

There are likely to be public costs associated with the provision of any high-speed passenger rail system in the United States. The market for intercity passenger rail has been eroded steadily by air travel and automobiles. If rail is to attract the ridership necessary to help meet operating costs, it must compete with other transport modes both private and public. If it does not compete effectively, public assistance for operating expenses may become necessary. Some argue that the loss of ridership and consequent service losses from other modes, were high-speed rail to be successful, should be considered a public cost, particularly if the new rail service receives some Government support. A recent Congressional Budget Office study concludes that rail receives much higher Federal subsidies than any other intercity passenger mode, although rail proponents disagree with this analysis.

A second public cost maybe that of capital subsidy, whether directly for the construction, or indirectly, as the associated costs of building public facilities (e.g., parking) to support the rail system, or those required for relocation or redesign of existing public facilities. As indicated elsewhere in this report, every high-speed system in the world initially has received some form of Government support. If some rail corridors are undertaken as private sector, State and local ventures, Federal Government assistance may eventually be sought to complete such projects, if construction timetables and costs are not met as planned. Additional support may be required if original market and cost forecasts are inaccurate.

An interesting institutional question arises regarding Amtrak, the congressionally designated passenger rail carrier in the United States. Amtrak negotiates agreements with freight carriers for use of their rights-of-way in all but NEC and a few other segments. The fact that several high-speed passenger rail corridors may be developed as privately operated enterprises raises questions of the effect of such new service on existing Amtrak service and on the provisions of services Amtrak may offer to such an enterprise. Amtrak could compete with the new rail service on the same corridor, or it could drop service if it could not make an adequate percentage of its operating revenues from that line, In the latter instance it might also be reimbursed by private sector operators for lost revenues resulting from the new service, as is now planned in an agreement between Amtrak and the American High Speed Rail Corp. Legal questions have been raised about whether Amtrak's licensing authority extends to all passenger services in this country, or whether it is confined to routes and corridors on which Amtrak currently provides service.

Another issue related to costs is the question of regional equity. Since there are a number of corridors currently being reviewed for possible introduction of high-speed passenger rail or maglev service introduction, and from all indications some Government support appears necessary, then questions of the equity of Government support among regions of the country becomes an issue. Which, if any, corridors should receive support? What criteria should be used to evaluate such support?

Finally, the potential environmental impact of noise has tended to be a critical issue associated with high-speed rail introduction. The Japanese high-speed system encountered initial strong opposition due to the noise and vibrational effects generated by the passing trains. These effects later were mitigated by technical and social adjustments. Noise levels of foreign systems fall within U.S. Government standards. Maglev systems are reported to be environmentally preferable in terms of noise. Tests to verify this are included in the West German test plans.

Congressional Role

Independent of specific consideration of technology or corridor decisions on high-speed rail, it is important to rethink the fundamental role to be played by rail in a changing transportation network. The present rail infrastructure in the United States is essentially the remaining core of a past system. Other nations have developed the high-speed rail technologies as a means of transforming their rail systems. Accordingly, Congress may wish to encourage further research on transportation systems of the future and to formulate guidelines for the contributions that could be made to them by differing technologies.

There are a number of uncertainties associated with U.S. development of high-speed rail. The technologies themselves are the least uncertain; they can be made to work. Decisions on location, number of stops, and frequency of service will contribute strongly to the attractiveness of the system; these decisions, appropriately reflecting local political and social concerns, cannot be predicted. Costs of construction and operation, while likely to exceed initial projections, can probably be forecast to some acceptable certainty. By far the most uncertain factor is the issue of ridership over time. Realizing very large ridership projections now being made will require a major change in current U.S. transportation patterns.

If Federal assistance is required for development of U.S. high-speed corridors, questions of competing transportation priorities, regional equity among corridors, likely public benefit, and economic success, will confront policymakers. Most of the estimated long-term benefits and costs depend on the accuracy of ridership projections and the effect of such ridership on other transportation modes. The gains that occur irrespective of the ridership tend to be more near term, accruing to those involved in building the system.

In light of these facts, if Congress should decide to support the development of high-speed passenger rail, several activities warrant consideration:

- Detailed independent evaluations of those corridors with high-speed rail potential are needed to assess carefully the benefits and costs of introduction of a high-speed passenger rail system. The evaluations should include:
  - —range of potential ridership and factors affecting it;
  - —probable costs (including those due to mishaps or delays) and certainty of cost forecasts;
  - —magnitude of regional support;
  - —estimates of potential revenues and effects of possible shortfalls;
  - —availability and suitability of proposed technology; and,
  - —environmental, economic, and transportation impacts on the region, and on other transport modes.

- *Because* benefits and costs of a high-speed rail system are so dependent on the actual ridership achieved, it would be desirable to have better data from which to estimate future passenger demand. Experimental verification of the importance of individual factors that affect ridership would be particularly useful. Congress may wish to determine whether it is feasible for the Department of Transportation to support such experiments.
- The relationship between institutions, including Amtrak and possible private rail operators, as well as State and Federal agencies, should be further clarified.