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The case for U.S. high speed rail

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ABSTRACT

High-speed rail is a form of self-guided ground transportation, which utilizes steel-wheels or magnetic levitation (i.e., Maglev) and can travel in excess of 200 miles per hour. High-speed ground transportation (i.e., HSGT) has been widely used in Europe and Asia, but the debate continues over the usefulness of high-speed rail in the United States. Several metropolitan areas in the United States have been identified as corridors that would benefit from HSGT. High speed rail can offer an alternative or a compliment to over-the-road and air transportation. Initial investment cost for this mode of transportation are high, but other factors such as fewer emissions from trains help to balance these costs. This manuscript examines the feasibility of bringing high-speed rail to clusters of cities throughout the United States (i.e., corridors) for passenger and commercial freight transportation.

BACKGROUND

High-speed rail has been proposed both as an alternative and as a compliment to existing transportation modes in the United States for both passenger and freight traffic. While high-speed rail is prominent in parts of Asia and Europe, the feasibility of such a system, especially on the freight side, is relatively unknown in this country. This manuscript examines the feasibility of bringing high-speed rail to corridors and cities throughout the U.S. for both passenger and freight transportation.

High-speed rail has been used extensively throughout Europe and Japan for decades because of pressing transportation needs. As travel demands grew in these countries, transportation by air and auto suffered from congestion and delays, particularly in the metropolitan areas. The introduction of high-speed rail was one solution to the growing traffic problems and the concomitant decreasing quality of service provided by other modes of transportation.

The passage of the High Speed Ground Transportation Act in 1965 stimulated interest in the use of high-speed rail in the United States. This legislation authorized $90 million to start a federal initiative to develop and demonstrate high-speed ground transportation (HSGT) technologies such as tracked air-cushion vehicles, linear electric motors, and magnetic levitation systems. The HSGT program also included a comprehensive multi-modal transportation planning effort that focused on the long-term needs in the Northeast Corridor of the U.S.

Because carrying freight has proved for decades to be more profitable than carrying passengers, in 1970 Congress stepped in to create and fund passenger service. The Rail Passenger Service Act of 1970 led to the creation of the National Railroad Passenger Corporation (Amtrak), which took over the inter-city rail passenger network from the freight railroads. Unfortunately, Amtrak has required federal capital and operating subsidies totaling over $23 billion since its inception (Belsie, 2001). Federal HSGT emphasis in the 1980's shifted to studies of potential HSGT corridors. In 1984, grants of $4 million were set aside for HSGT corridor studies on the state level under the Passenger Railroad Rebuilding Act of 1980. Unfortunately, none of the proposals was ever implemented. Interest in corridor planning and technology improvements resurged in 1994 with the appropriation of $184 million for studies in fiscal years 1995, 1996, and 1997 through the enactment of the Swift Rail Development Act of 1994. Renewed interest in high-speed rail has emerged as fuel prices continued to escalate (Albanese, 2000). In 2001, Senator Russ Feingold, along with Senators Joseph Biden and Kay Bailey Hutchinson, announced the introduction of the High-Speed Rail Investment Act of 2001. This bill authorizes Amtrak to sell bonds for the purpose of developing eight high-speed rail corridors throughout the country.

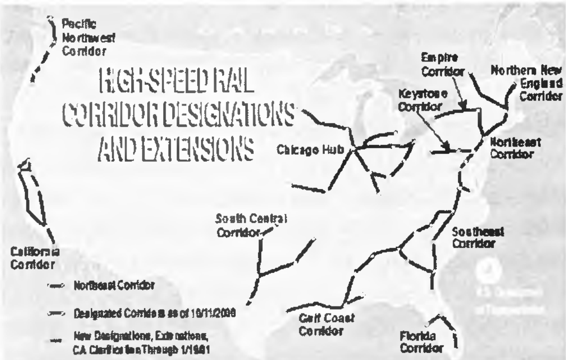
CORRIDORS

While much governmental debate has transpired and legislation has been passed regarding the use of HSGT, it has not yet been fully implemented at the national level. Currently, Amtrak's Northeast Corridor, which links Boston, New York City, Philadelphia, and Washington D.C., is the "only mature high-speed rail system" (www.fra.dot.gov) in the U.S. (see Figure 1). Extensions of the Northeast Corridor that are in various planning stages include: New York State's Empire Corridor, Pennsylvania's Keystone Corridor, and the Northern New England Corridor that extends into Vermont, New Hampshire, Maine, and north into Canada. The Southeast Corridor connects with the Northeast Corridor in Washington, DC, and reaches from Virginia to Jacksonville, Florida.

The Chicago Hub is a sprawling network that will link many major U.S. Midwest cities, including the Twin Cities (i.e., St. Paul and Minneapolis, Minnesota), Milwaukee, Chicago, Detroit, Indianapolis, and St. Louis (Pierce, 2000). Extensions are anticipated to further encompass Kansas City, Louisville, Columbus, Cleveland, and Toledo (www.fra.dot.gov).

Additional corridors in the preparations phase are: the Pacific Northwest Corridor that would link Seattle, WA, and Portland, OR; the California Corridor, which would expand service that is currently available from San Diego to Los Angeles to add San Francisco/Oakland Bay area; the South Central Corridor that would connect major Texas communities with Oklahoma and Arkansas; the Gulf Coast Corridor of Louisiana, Mississippi, and Alabama, which is contemplating the possibility of an extension to Jacksonville, FL; and the Florida Corridor that was initially terminated by Governor Jeb Bush in 1999, but was resurrected by a Florida businessman and was approved by the citizens of Florida less than a year later (Pierce, 2000).

FIGURE 1



(Source: www.fra.dot.gov, 2001)

IMPLICATIONS OF OTHER MODES OF TRANSPORTATION

Air Transportation

The Federal Aviation Administration (FAA) projected that domestic air carrier revenue passenger miles (RPM) and passenger enplanements would increase at an average annual rate of 3.7 and 3.5 percent, respectively, between 1993 and 2005. Over the same period, RPM and passenger enplanements for inter-national air carriers are forecasted to grow annually by 6.3 and 6.5 percent, respectively. For regional/commuter airlines, RPM and passenger enplanements were expected to rise at 8.5 and 6.9 percent annually (FAA, Aviation Forecasts, 1994).

Because of the consistent growth in the airline industry, problems associated with congestion and delays are reaching high levels. Congestion-related delays not only increase airlines' operating costs, they also extend the overall travel time of passengers. These delays may consist of deviations from scheduled flight departures and arrivals and added time on the ground or en route. However, various capacity studies at highly congested airports have found that significant savings can be achieved by reducing those delays that occur because of the capacity-straining growth in operations such as takeoffs and landings (U.S. Department of Transportation, 1997).

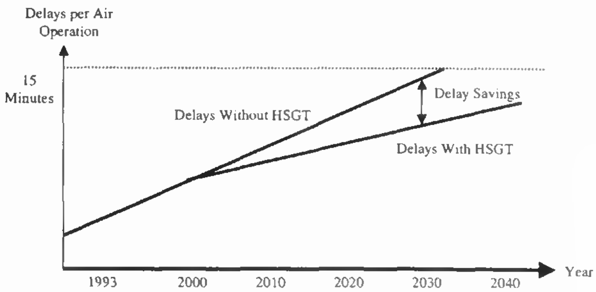
The HSGT option. The FAA realizes that the construction of new airports and new or extended runways at existing airports in the metropolitan areas on the U.S. East and West Coasts would not adequately meet the projected growth in demand. The FAA considers HSGT to be a potential means of relieving the pressure on short-haul traffic by diverting air trips of 500 miles or less to rail travel. The FAA also points out that intercity high speed rail systems could be designed for immediate access to airports and could provide connections between multiple airports in metropolitan areas (FAA, Capacity Plan, 1994). For example, the proposed addition of a rail station to service AMTRAK at Milwaukee's Mitchell Field Airport would essentially make Mitchell Chicago's "third airport." As the HSGT corridors divert some traffic from the airlines, they reduce the need to make capacity-related improvements at the more congested commercial airports.

Figure 2 illustrates the conceptual basis for the airport congestion delay savings. In the absence of HSGT, the study projected traffic growth, assumed a small degree of capacity additions, and developed average delay estimates per aircraft operation for each major airport in a corridor. Average delays were capped at 15 minutes per operation because such crisis-level delays would likely be viewed as intolerable.

Highway Transportation

More than 40 years ago America began develpment of the interstate highway system. More than 46,000 miles of multilane routes were built without stoplights or grade crossings. However, the interstate system was not designed for high-speed travel. The interstate system had dramatic impacts upon mobility, economic growth, and transportation efficiency (Car-

FIGURE 2
DELAY SAVINGS



Source: U.S. Department of Transportation, *High Speed Ground Transportation for America*

michael, 2000). Total highway travel continued to increase at an annual rate of 3.5% from 1983 to 1991 (Report to the Secretary of Transportation, 1993), while the population during this same period expanded by only 1 percent (U.S. Census, 1990). Growth in rural travel for this time period was 2.9%, and urban travel increased by 3.9 percent. This growth reflects an upsurge in vehicle trip length and population, a reduction in vehicle occupancy, and a shift to single occupant vehicles. The Federal Highway Administration's (FHWA) forecast for the 20-year period from 1992 to 2011 anticipates that overall highway travel will swell at approximately 2.5 percent per year. This translates into a total increase of 65% (Report to the Secretary of Transportation, 1993), which will create considerable congestion problems unless an alternative mode of transportation is applied, potentially relieving some of the anticipated surge.

The costs of highway congestion are many, including delays, longer travel time, skyrocketing fuel costs, heightened environmental problems due to increased emissions and reduced air quality, and the rising cost of transporting goods. These problems ultimately translate into consumers shouldering a greater burden. A report conducted by the Texas Transportation Institute states that in 1991, the total cost of congestion for 50 urban areas was approximately $42.3 billion; delays accounted for 89% of this amount, and additional fuel costs represented the remaining 11 percent (Texas Transportation Institute, 1994).

The HSGT option. Conceptually similar to airport delay savings, highway congestion delay savings measure the value derived from a reduction in congestion and traffic delays on highways; this can be achieved by redirecting auto travelers from driving to HSGT. The value of HSGT experienced by the remaining highway users can be quantified as travel time saved when traffic volumes on major highways decrease and travel speeds improve. The impact of HSGT's effects on highway delays depends upon the relative prominence of intercity travel in a particular road's traffic mix and the share of HSGT markets in that intercity travel, as well as that highway's traffic, capacity, and delay conditions (U.S. Department of Transportation, 1997). The diversion of automobile traffic to HSGT would suspend the need for highway expansion, measured in terms of lane-miles that would otherwise be dedicated to carrying the diverted trips. The costs saved or deferred by not having to expand roadways could not be included in total benefits, since they measure the same phenomenon as the highway congestion delay savings.

BENEFITS OF HSGT TO COMMUNITIES

Transportation

By enhancing the railroad passenger infrastructure in major metropolitan areas, HSGT could theoretically lead to faster and more reliable commuter schedules, with significant time savings for existing riders. The better timings would likely attract new riders, thus reducing highway congestion. HSGT might also reduce the number of accidents, as well as bring about a decline in the fatalities, injuries, property damage, and the human and monetary costs that often accompany such accidents. However, significant methodological and data issues stand in the way of a straightforward, broadly acceptable projection of the safety benefits of HSGT (U.S. Department of Transportation, 1997).

Economic Development

For one industry to function, its production process requires, as inputs, the outputs (i.e., goods or services) of other industries. Each dollar spent on transportation stimulates additional spending, which affects other industries in the economy. Therefore, expenditures to build and maintain infrastructure and operate transportation services, such as HSGT, could provide a much-needed boost to local or regional economies. To the extent that HSGT expands in the United States as a consistent and predictable market for transportation equipment, the private sector may be willing to consider long-term investments that would increase the American involvement in HSGT vehicle design and manufacture (U.S. Department of Transportation, 1997).

Another possibility to consider is the addition of development investments. The building of offices, retail stores, hotels, and some housing may gravitate to the vicinity of HSGT stations from less attractive locations on the corridor because of HSGT-induced changes in spatial/temporal relationships, as well as the market potential represented by HSGT riders.

Environment/Energy Considerations

According to the Environmental Law & Policy Center's website (www.elpc.org), "high-speed trains would be three times as energy efficient as cars and six times as energy efficient as planes." The dollar value of energy savings can not be considered in the total benefits because fuel and power costs already directly affect the operating expenses of the HSGT options, the perceived cost of auto travel, and the economics of the airline industry. It would be double counting to include, within total benefits, the savings incurred as a result of a reduction in the use of this material of transport production. Beyond the value of the energy savings per se, lower petroleum consumption due to HSGT use might help to wean the U.S. from its dependence on foreign oil sources (U.S. Department for Transportation, 1997).

Federal regulators have deemed several Midwest urban regions as areas that have "severe" smog problems (www.elpc.org). To be sure, smog is even more of an issue in densely populated areas, such as those found on both the West and East Coasts of the United States. Because of the decreased pollution that trains produce, air quality in these sectors might have the opportunity to recover somewhat as high-speed rail would become increasingly popular. High-speed rail also has the ability to cause a decline in the nation's dependence on auto traffic, which arguably might facilitate the drop in ozone emissions. The differences in emissions among modes of transportation relate to the nature of their respective fuel sources and to the specific power necessary to overcome inertia and to counteract three classes of force: air resistance, which affects all modes of travel; gravity; and contact/rolling resistance, which is experienced by all wheeled modes (U.S. Department for Transportation, 1997).

COST OF IMPLEMENTATION

The initial investment in HSGT, combined with the continuing investment in vehicles, track replacement, and operating expenses, can be quite substantial. These initial costs differ considerably among corridors, in part due to the discrepancies among technological alternatives. The more advanced options represent significantly higher prices and greater variations in cost. For example, the Accelerail 90 is estimated to require an initial investment of $1,000,000-$3,500,000 per route-mile, while the Maglev can cost from $20,000,000-$50,000,000 per route-mile (www.fra.dot.gov). Table 1 details the initial investment costs specific to each HGST choice.

TABLE 1
INITIAL INVESTMENT COST RANGES FOR ILLUSTRATIVE CORRIDORS

Technology	Typical Range of Total Initial Investment per Route-Mile (Millions of Dollars)
Accelerail 90	$1 to $3.5
Accelerail 110	$2 to $5
Accelerail 125F	$3 to $5.5
Accelerail 125E	$5 to $7.5
Accelerail 150F	$4.5 to $7
Accelerail 150E	$6.5 to $9
New HSR	$10 to $45
Maglev	$20 to $50

Factors affecting initial investment. The layout of a corridor can influence costs both because of the length needed and the area that is to be crossed, including potential appeasments. Shorter corridors absorb a greater share of the fixed cost (e.g., equipment shops, etc.) per route-mile than longer corridors. A short corridor such as the San Diego-Los Angeles route, which is 128 miles, has higher costs compared to the 425-mile route from Los Angeles to the Bay Area. Further, a corridor that involves laying track through difficult mountain crossings requires major tunneling, and one that passes through urbanized landscapes incurs comparatively high initial costs. The initial vehicle purchase also differs with route mileage, HSGT ridership, and associated frequency. The cost of vehicles is typically between 20 - 40 percent of the initial cost of Accelerail 90 and 110. However, vehicles encompass a much smaller portion of total costs in the more technological alternatives.

One other factor that determines the initial investment is the projected use. As potential traffic densities increase with Accelerail alternatives, the need arises to plan for more double track and passing sidings. Figure 3 summarizes the effects of these factors as they shaped the initial investment needed for each corridor.

The different investment levels share the single purpose of reducing the line-haul travel times. Figure 4 shows a sharp decrease in existing Amtrak running times with the institution of tilt-train Accelerail 90 service and dramatic trip time benefits from New HSR and, especially, Maglev.

Investment requirements grow disproportionately to trip time savings, as the alternatives become more ambitious. Figure 5 shows the dollars of initial investment per timetable-hour that can be saved over Amtrak's 1993 performance in the Chicago-Detroit corridor. The cost per hour saved grows exponentially once technology beyond the Accelerail 110 is analyzed.

Even after allowing for all operating costs, including long-term maintenance and rehabilitation, the system is projected to generate surplus operating revenue. While the projected operating surplus generated by the system will contribute significantly to the capital-financing plan, it is not sufficient to fully fund construction of the system or attract adequate private investment. Thus, a substantial source of public funds will need to be raised for construction (Pierce, 2000).

Travel times, fares, and frequencies are three factors that affect ridership.

Travel times. The ability to redirect customers from existing modes depends on comparative total travel times, which includes access to and exit from the stations, as well as the time spent there. The percentages that comprise these total travel times depend upon the mode of transportation. Figure 6, taken from statistics on the Chicago-Detroit corridor, demonstrates that automotive travel has a natural advantage in the fact that it can offer door-to-door convenience, and air gains an advantage because of its greater speeds.

FIGURE 3
INITIAL INVESTMENT PER ROUTE-MILE: MAGLEV EXAMPLES
(http://www.fra.dot.gov)

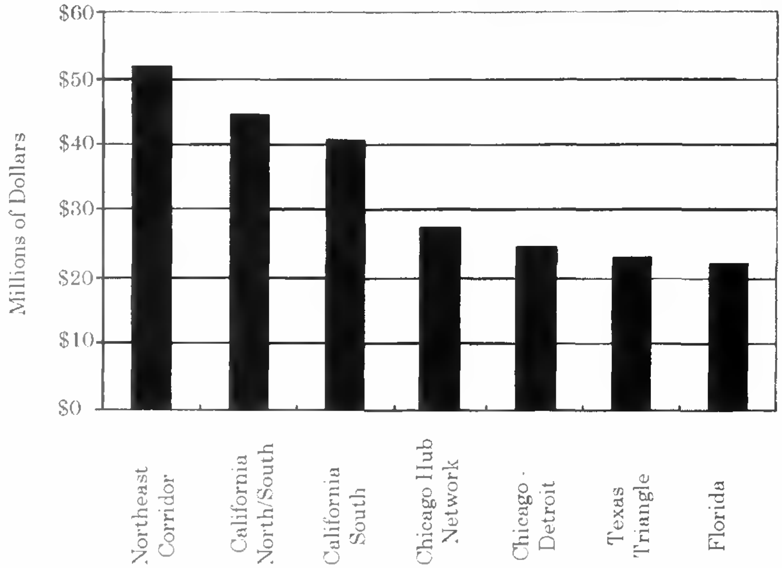


FIGURE 4
LINE-HAUL RUNNING TIMES, CHICAGO—ST. LOUIS
(www.fra.dot.gov)

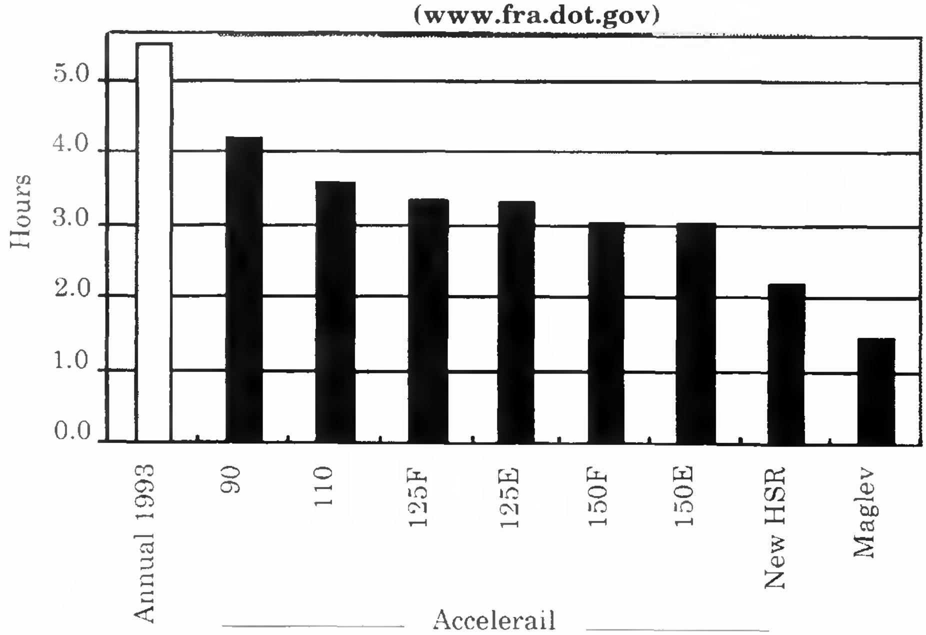


FIGURE 5
INITIAL INVESTMENT PER HOUR SAVED OVER AMTRAK 1993 BASE
(www.fra.dot.gov)
EXAMPLE: CHICAGO – DETROIT

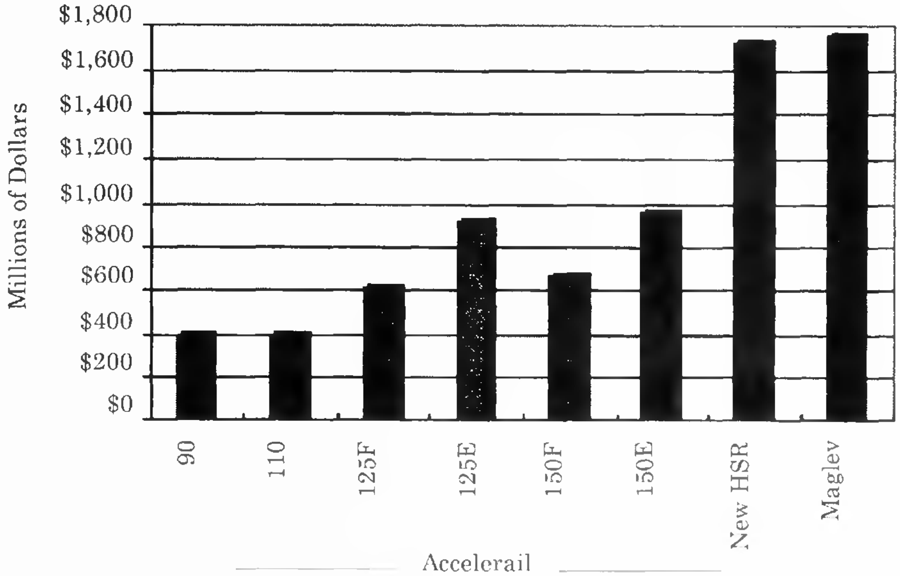


FIGURE 6
COMPOSITION OF EACH MODE'S TOTAL TRAVEL TIME
(http://www.fra.dot.gov)
EXAMPLE: CHICAGO-DETROIT

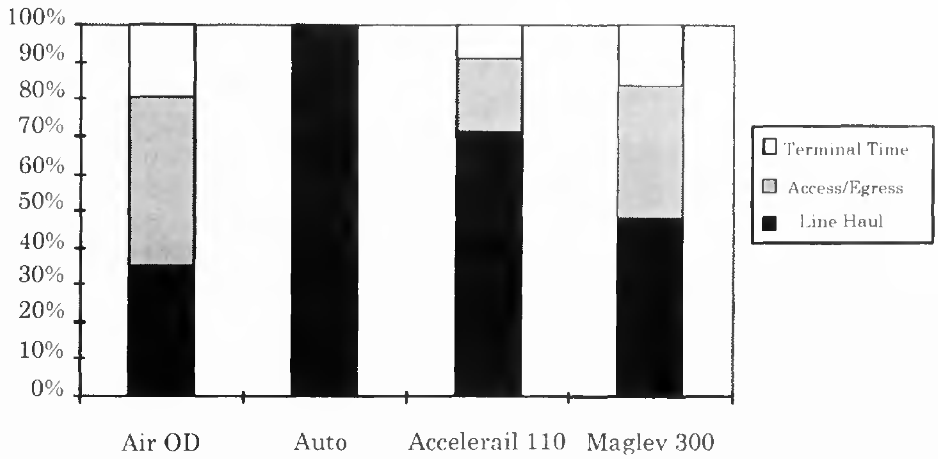
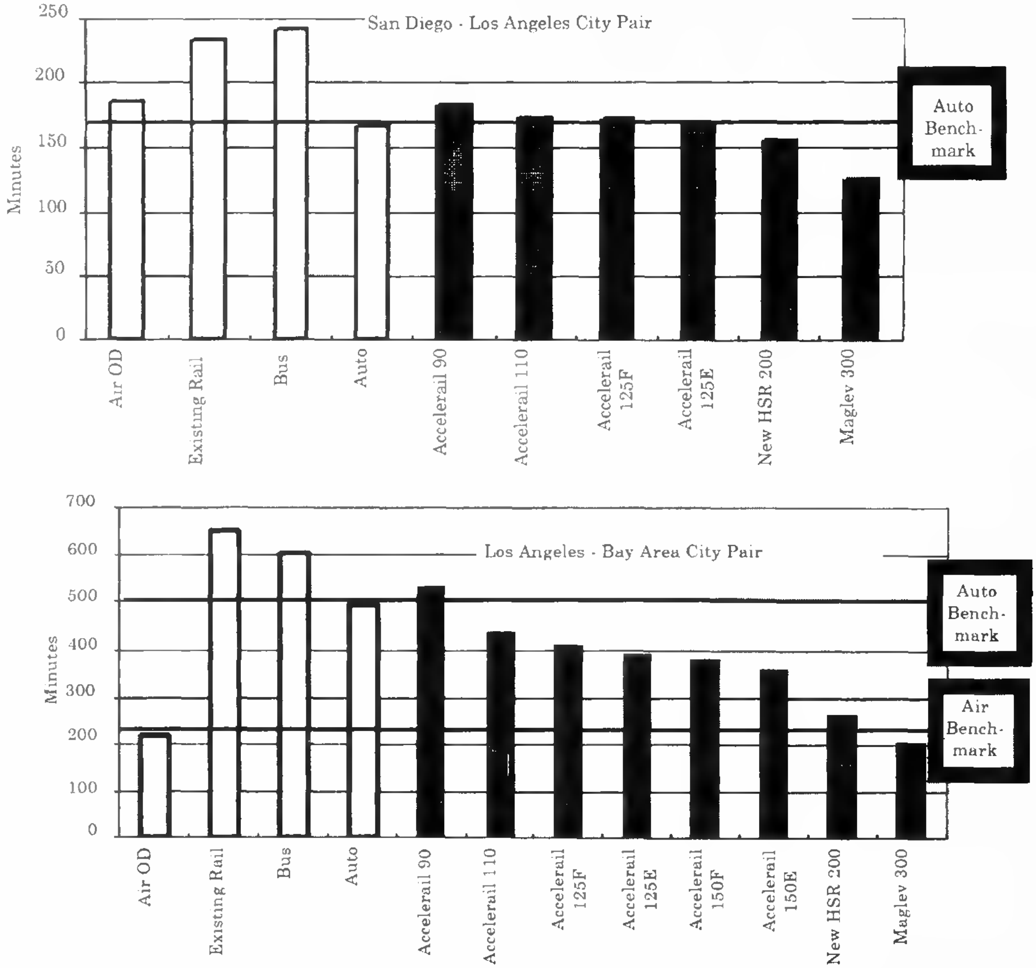


Figure 7 evaluates the total travel times by mode in two sample city-pairs: San Diego-Los Angeles (128 miles) and Los Angeles-Bay Area (425 miles). These graphs illustrate that an Accel-

FIGURE 7
COMPETITIVE POSITION OF HSBT IN TWO SAMPLE CITY PAIRS
(http://www.fra.dot.gov)



erail trip can take longer than the often-cheaper auto travel in shorter city pair markets, but Accelerail timings can outperform autos in medium and longer distance corridors. Maglev can do better than air on total travel times even in markets in the 400-mile range, whereas New HSR approaches (but does not reach) time comparability with air in longer markets.

Fares; frequency of service. The nature of the competitive market and the quality of the HSGT will affect the fares that a particular corridor can charge. When travel times improve as compared to the alternatives, fares can be higher since the public will endure a higher price for better service. Frequency of service will fluctuate among corridors based on demand. For the Accelerail alternatives, most corridors can sustain 10-20 daily round trips. However, the California Corridor provides an example of how heavier traffic justifies more frequent service.

CONCLUSION

High-speed rail systems have been operated in Europe and Japan for over thirty years. Over this period, it is estimated that over four billion passengers have been carried without major accidents. High-speed rail has been proven in other countries as a convenient and safe mode of transportation that could positively impact economic growth. A drawback of implementing new technologies is that there could be some resistance to change. The public has been voicing its opinion about the safety of a rail system that moves at speeds in excess of 200 mph. These concerns could be easily addressed by the years of data collected on the use of high-speed rail in other countries.

The Shinkasen was first introduced in Japan in the mid-1960's, and it was a 343-mile line connecting Tokyo and Osaka. Today, the Shinkasen is a high-speed rail network that connects Japan's major metropolitan areas and carries over 300 million passengers a year. While operating hundreds of high-speed trains a day, the Japanese have a perfect safety record as well as impressive on-time performance. High-speed trains are also used in France and Germany and recently high-speed rail networks have been set up throughout most of Western Europe (California High-Speed Rail Authority).

However, many critics of high-speed rail have been quick to point out that in Europe and Asia, high population densities restrict the number of airports, and this is why high-speed rail is needed in these areas. The critics argue that instead of putting money into a new mode of transportation, the U.S. government should just improve the existing transportation network. While it is true that the U.S. landscape and transportation network vary greatly from those found in Japan or Europe, there are many advantages in implementing a high-speed rail system in the U.S.

The first major advantage is that even though the U.S. transportation network is well developed, high-speed rail will only help future mobility and connectivity. That is, the corridors are in place, the track is laid, and appeasements are sunk. With only incremental improvements in the existing network, labor and commercial goods mobility could be negatively affected. High-speed networks could reduce the burden of increased travel demand and also act as means of connecting existing modes of transportation.

What is far more contentious is the ability of high-speed rail to effectively and efficiently carry freight over the proposed corridors, and is a necessary direction for future research consideration. In the 1970's, driven by efficiency pursuits of the maritime carriers, the stack train was introduced to the U.S. The operational advantages of the stack train include dedicated service, less sway, less coupling friction, and the ability to carry twice the containers with the same amount of labor and fuel. These operational advantages led to marketing advantages, including less pilferage, less damage to cargo, more accurate transit times, and greater predictability. Overall, the steamship lines increased return on investment by keeping their assets (i.e., containers) in motion with greater predictability and service ability. Can this revolutionary technology be applied to HGST? Can a double stacked rail car withstand 200 MPH stresses? European and Asian high speed trains transport dangerous chemicals (i.e., HazMat) on their runs. Will this be accepted socially in the U.S.? Will the perceived risk of carrying stacked freight outweigh the benefits of doing so? These questions should be answered in order to more fully answer the question of feasibility for freight of HGST in the U.S.

This analysis shows that high-speed rail is vital for sustaining economic growth. It offers a complementary mode to air and highway, which would positively affect intercity mobility. With organizations streamlining operations and an increased effort to move toward a just-in-time system, high-speed rail could be an effective solution for both passenger and freight transportation.

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