CHAPTER 2

Introduction and Background

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Introduction and Background

Each year more people and goods travel between major cities throughout the world. Fueled by growing and shifting populations, economic development, and changing industry operating practices, this travel demand is straining the capabilities of transportation infrastructure at more and more locations for longer periods of time. Meeting this demand by paving more highways and runways, however, inevitably brings increased petroleum consumption, air pollution, noise, and real estate development, and is heatedly opposed by most communities. Public officials and the transportation industry are taking a close look at new technologies, including magnetically levitated (maglev) vehicles and tiltrotor aircraft, as they consider various investment and management options to address future transport needs.

maglev vehicles resemble either monorail cars or sleek trains and are lifted and propelled above special guideways by magnetic forces, unlike steel-wheel trains that are mechanically driven along rails. Commercial maglev systems could attain speeds in excess of 300 miles per hour (mph). Several foreign countries have invested substantially in maglev technology development, and low-speed maglevs now regularly carry passengers in transit service in Berlin, Germany, and Birmingham, England.

tiltrotors, developed and tested by the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD), can fly like both a helicopter and an airplane. Pivoting engine/rotor assemblies, mounted on each wingtip, permit a tiltrotor to takeoff and land like a helicopter at sites as small as a rooftop when the rotors are vertical, and let it cruise as fast as a propeller-driven commuter airplane when the rotors are tilted forward 90 degrees.

High-speed maglev and military tiltrotor vehicles may be operating regularly in the United States in the next few years. The German Transrapid 250-mph maglev is slated to operate on a 13.5-mile Orlando Airport-to-International Drive route in Orlando, Florida, as early as 1995. The V-22 Osprey tiltrotor could be delivered to U.S. Marine Corps squadrons by 1995 if the Federal Government decides to proceed beyond the present full-scale development testing.

Proponents claim that for roughly the same price as an airline ticket, commercial tiltrotors and maglev vehicles could help get travelers to destinations 100 to 500 miles away quicker and more reliably than can existing transportation systems. But even if hundreds of commercial tiltrotors can be sold, tiltrotors will still cost roughly 40 to 45 percent more to build than similarly sized aircraft.[1] And, since 75 to 90 percent of total maglev costs come from the guideway, a maglev route will need millions of riders per year if its capital costs are to be recovered through fares.[2] Thus, each technology will need substantial market demand if it is to provide alternative service at equivalent trip costs to airlines. Understanding future travel patterns is important for assessing the potential of these technologies.

The Federal Government is conducting some modest research and development and operational feasibility studies of maglev and civilian tiltrotor technologies. The Department of Transportation (DOT), the Department of Energy, and the Army Corps of Engineers recently began the National maglev Initiative to assess the engineering, economic, and environmental aspects of maglev. A major program report, planned for fall 1992, will consider whether to pursue future development of U.S. maglev capability. Additional studies of conventional and high-speed rail systems are under way by the Transportation Research Board, the Federal Railroad Administration, and the Volpe National Transportation Systems Center.

Since 1988, the Federal Aviation Administration (FAA) has awarded grants for 17 tiltrotor airport or

1 See ch. 3 for details.
2 See ch. 4 for details.

"vertiport" planning and feasibility studies, and most should be completed by the end of this year. NASA DOD, and FAA have jointly funded studies[3] examining civil applications and promising markets for tiltrotor technology. Vertical flight research and technology programs are established at FAA and NASA.

Common Issues for maglev and Tiltrotor

In DOT's National Transportation Policy, articulated in 1990, the United States is urged to ". . . take full advantage of new and emerging transportation technologies."[4] maglev and tiltrotor aircraft are identified as options for advancing U.S. transportation technology and expertise and for meeting high-density intercity transportation needs. Although maglev and tiltrotor systems are distinctly different from each other, a number of Federal policy issues and potential markets overlap for these technologies.

Financing

The commercial viability of each transportation mode in the United States—aviation, railroads, motor carriers, marine—has depended heavily on Federal support, primarily for infrastructure or right-of-way. Additionally, the Federal Government has developed (directly and indirectly) various vehicle technologies. A prime example is aviation, where virtually every key commercial technology originated in the military, and where NASA has an explicit mission to investigate technologies with potential commercial application.

Programs such as maglev and tiltrotor development require large cash outlays over long periods while the work is underway, and in some cases, amortization of infrastructure investment takes several decades, far exceeding the patience of private investors. Public financing seems essential if extensive tiltrotor or maglev systems are to be developed in the United States. Moreover, use of public resources, such as some air rights over interstate highways, may also be necessary.

Regulatory Framework

tiltrotors and maglevs have significantly different design and performance characteristics than conventional aircraft and rail systems, and neither are fully addressed by current Federal safety regulations. Executive branch agencies will have to establish appropriate safety, environmental, and economic oversight responsibilities if maglev, tiltrotor, or other comparable systems are placed in service, and some agencies have this process under way.

Potential Markets and Service Capability

The busiest air travel routes are the primary target markets cited by both maglev and tiltrotor proponents. If terminals can be located close to population and industrial centers, maglevs and tiltrotors might offer quicker point-to-point travel for trips under 500 miles than comparable service via major airports.

maglevs and tiltrotors might help relieve environmental and congestion problems in other transportation modes. maglevs are not dependent on petroleum for power, do not degrade air quality where the vehicles operate, and are expected to be more energy efficient than the current and future jetliners with which they would compete in many travel corridors. tiltrotors could expand the capacity of busy airports by replacing some commuter flights, thereby making runway slots available for larger airliners. Both modes might improve mobility by offering alternatives if ground and air congestion in conventional transportation becomes too severe. However, to reduce overall congestion or energy consumption, favorable market conditions and possibly transportation and energy policies that encourage efficient use of resources might have to be in place to induce enough passengers and operators to switch from conventional modes to maglevs and tiltrotors. Moreover, there is no consensus about the accuracy of transportation congestion and delay forecasts, and about whether and when short-haul transportation alternatives might be warranted or could be effective.

3 *Boeing Commercial* Airplane Co. *et* al., *Civil tiltrotor Missions and* Applications: *A Research Study,* prepared for Federal Aviation Administration, National Aeronautics and Space Administration, and Department of Defense, NASA CR 177452 (Seattle, WA: Boeing Commercial Airplane Co., July 1987); and Boeing Commercial Airplane Group et al., *Civil tiltrotor Missions and Application Phase* II: The Commercial *Passenger Market,* prepared for National Aeronautics and Space Administration and Federal Aviation Administration, NASA CR 177576 (Seattle, WA: Boeing Commercial Airplane Group, February 1991).

4 U.S. Department of Transportation, *Moving America: New Directions, New Opportunities* (Washington, DC: February 1990), p. vii.

Community Acceptance

Community concerns about transportation noise and land use will be major factors in determining whether tiltrotor or maglev systems can be established. Noise is a problem for transport operators across all modes but is especially serious for airports and airlines, restricting present operations and blocking further growth in some instances. Community groups fighting to curb the noise of airport operations have limited airport development across the country.

If tiltrotors and maglevs are able to provide suitable alternatives to conventional air travel, both technologies could reduce the demand for new airports. Proponents claim that maglev and tiltrotor operations will be quieter in urban areas than conventional trains and aircraft, respectively, but whether such noise levels are acceptable has yet to be determined.

tiltrotors and maglevs will require new infrastructure. Changes in traffic patterns, aesthetics, and property values that could stem from these facilities and operations will be closely scrutinized by local zoning boards.

International Competition and U.S. Technological Leadership

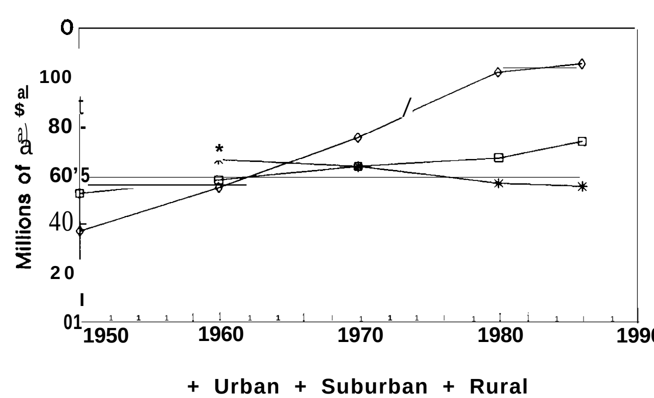
The United States was closely involved in early practical maglevs and tiltrotor research but developed only tiltrotor to the point of full-scale testing. U.S. aerospace still maintains a favorable balance of trade, and Europe, the Far East, and developing countries are potential markets for tiltrotors. However, the administration tried, unsuccessfully, to eliminate military tiltrotor funds in fiscal years 1990 and 1991. A Western European consortium is developing commercial tiltrotor technology and a Japanese company plans to produce a similar vertical flight vehicle based on tiltwing technology. Some contend that if the military V-22 program is terminated, foreign-produced aircraft could win control of any potential U.S. (and world) advanced vertical flight market.[6]

Federal funding for maglev ended in the United States in 1975. A decade later, German and Japanese companies were marketing maglev technologies in this country.

Intercity Passenger Travel in the United States

The migration of people from rural locations and inner cities (see figure 2-1) to suburbs has drastically altered traffic patterns and volumes in metropolitan areas.[7] Business activity has become more decentralized as employers followed workers.[8] Automobile use, virtually required for living or working in the suburbs, has grown steadily, regularly passing expected levels (see figure 2-2). For the intercity commercial traveler, these trends have resulted in longer and more congested trips to get to an airport or rail terminal. During the past decade, airline deregulation spurred rapid growth in passenger travel and encouraged air carriers to concentrate flights at hub airports, leading to considerable delays when using the busiest airports.

Figure 2-l—Population Trends in the United States



SOURCE: Office of Technology Assessment, based on U.S. Bureau of the Census data, 1991.

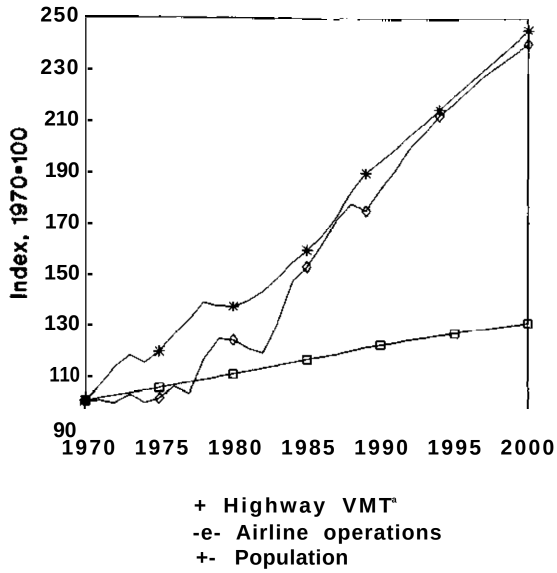
5 Seminal magnetic levitation research (for electromagnetic suspension) began in Germany in 1922.

6 Federal Aviation Administration, Research, Engineering, and Development A&&q Committee, tiltrotor Technology Subcommittee; *Report* (Washington, DC: June 26, 1990), p. 15.

7 US. Department of Transportation, *National Transportation Strategic Planning Study* (Washington, DC: U.S. Government Printing Office, March 1990), p. 5-1.

8 Ibid., p. 5-10.

Figure 2-2-Forecast and Trends in Population, Automobile Use, and Airline Operations



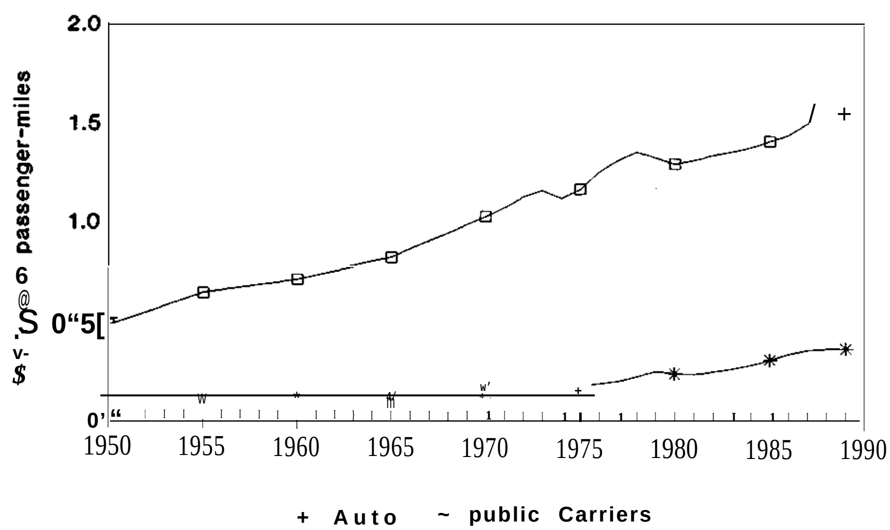
[a]VMT = vehicle-miles traveled. [b]Takeoffs and landings.

SOURCE: Office of Technology Assessment, 1991, based on information from the Federal Highway Administration, the Federal Aviation Administration, and the U.S. Bureau of the Census.

In the United States, the automobile has been the mode of choice for domestic intercity travel since the 1930s (see figure 2-3), although commercial aviation passenger travel grew at a faster rate until the past few years (see figure 2-4). The growth of both modes was encouraged by public policies and funding. Trips by automobile can be significantly cheaper, especially for group travel, and more convenient than by other modes. For distances under 100 miles, cars generally provide the quickest way of getting from door to door. However, as trip distance increases, travel time by auto falls further and further behind rail and air modes. People for whom trip time is the deciding factor, such as business travelers, depend heavily on airlines for intercity trips.

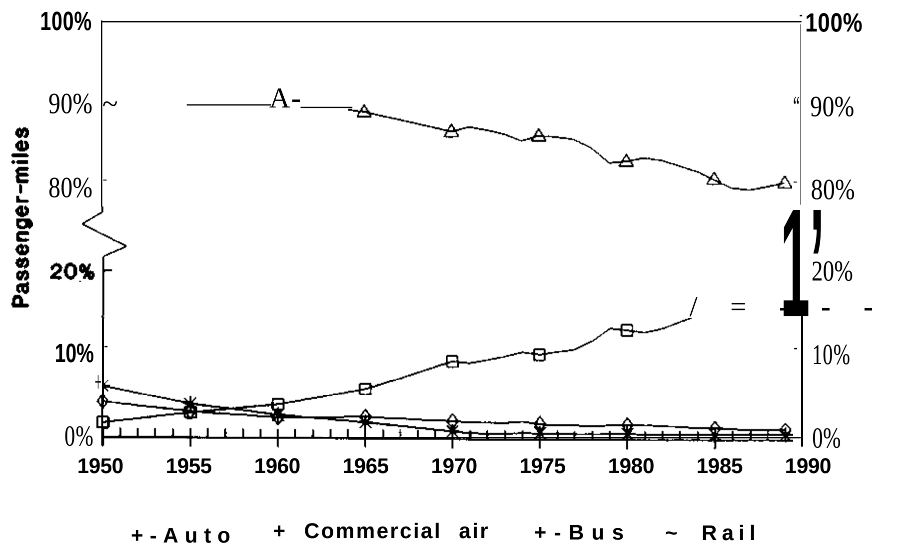
Airlines carry most commercial intercity passengers, although rail service is significant in the Northeast and California. Air travel began to dominate the common carrier market in the mid-1960s, and has steadily increased its share despite the creation of Amtrak in the 1970s. These trends suggest that any new high-speed transport system will have to focus, initially at least, on strong air travel markets. However, the volume of highway traffic to draw on is so large that if a tiny fraction of automobile users were to switch to maglev or tiltrotor, it would be significant for the

Figure 2-3-U.S. intercity Passenger Travel by Public Carriers and Private Automobile



SOURCE: Office of Technology Assessment, 1991, based on data in Eno Foundation for Transportation, *Transportation in America* (Washington, DC: 1990).

Figure 2-4-U.S. Intercity Passenger Travel by Modal Share



SOURCE: Office of Technology Assessment 1991, based on data in Eno Foundation for Transportation, *Transportation in America* (Washington, DC: 1990).

ridership of these new modes. Moreover, the first two high-speed maglev routes proposed for the United States are primarily automobile markets.[9]

Inter-city Travel Markets

Population and distance strongly influence the volume of passengers traveling between two areas. In general, passenger traffic increases as population grows, and, other things being equal, travel between two cities will be greater the closer they are.[10] The busiest travel corridors are centered on the largest cities, but cultural, political, industrial, and geographical factors also affect intercity travel.

What constitutes an intercity travel market, or city pair, depends on how travel origins and destinations are defined. One way to define each end of a city pair is to use the Department of Commerce's metropolitan statistical areas-losely linked urbanized regions that extend across jurisdictional boundaries. A key characteristic of a market suitable for maglev or high-speed rail may be the potential for connecting the city pair with a single guideway (with branches or closely spaced stops in the metropolitan areas). For example, both the Los Angeles basin and the San Francisco Bay area cover a large region and are served by multiple airports, but theoretically only one double-track guideway would be necessary for the 250 miles or so between the outskirts of these broad locales. Guideways, of course, are not a factor for tiltrotor, and these market boundaries are not precisely applicable to tiltrotor market analyses. Commercial tiltrotor operators might serve routes with too few passengers for rail or maglev, since tiltrotors have relatively modest ground infrastructure requirements.

The largest travel corridors in the United States with trip distances suitable for maglev or tiltrotor are along the east and west coasts. DOT statistics on origin-to-destination airline travel indicate that the busiest corridor lies between San Francisco and Los

9 The two routes are Orlando Airport to International Drive in Orlando, FL, and Anaheim, CA to Las Vegas, NV.

10 To estimate traffic volumes, transportation planners sometimes use the gravity model, so named because it is similar to the formula for calculating the gravitational force between two objects.

Table 2-l—Domestic U.S. Air Travel for 1988 Between Major Urban Areas Separated by Less Than 600 Miles

City pair	One-way passenger trips (millions)	Distance between city pairs (miles)
Los Angeles . . . San Francisco	6.6	347
New York . . . . . Boston	3.4	191
New York . . . . . Washington	3.3	214
Los Angeles . . . Phoenix	2.6	348
Dallas . . . . Houston	2.0	222
San Diego . . . . San Francisco	1.8	447
Los Angeles . . . Las Vegas	1.6	221
Chicago . . . . . . Detroit	1.4	238
Las Vegas . . . . San Francisco	1.3	408
Los Angeles . . . Sacramento	1.1	383
Boston . . . . Washington	1.1	400
Chicago . . . . . . Minneapolis	1.0	344
Detroit . . . . New York	0.9	489
Chicago . . . . . . St. Louis	0.9	256
Buffalo . . . . New York	0.9	293
Phoenix . . . . . . San Diego	0.8	304
Dallas . . . . San Antonio	0.8	253
New York . . . . . Pittsburgh	0.8	329
Chicago . . . . . . Washington	0.8	596
Dallas . . . . Austin	0.7	187
Las Vegas . . . . Phoenix	0.7	255

SOURCE: Volpe National Transportation Systems Center, 1991.

Table 2-2—Projected U.S. Domestic Air Travel for Year 2000 Between Major Urban Areas Separated by Less Than 600 Miles

City pair	One-way passenger trips (millions]	Distance between city pairs (miles)
Los Angeles . . . San Francisco	12.8	347
Los Angeles . . . Phoenix	6.5	348
New York . . . . . Washington	5.2	214
New York . . . . . Boston	4.7	191
Dallas . . . . Houston	4.5	222
Los Angeles . . . Las Vegas	4.1	221
San Diego . . . . San Francisco	3.7	447
Las Vegas . . . . San Francisco	3.1	408
Los Angeles . . . Sacramento	2.6	383
Phoenix . . . . . . San Diego	2.3	304
Las Vegas . . . . Phoenix	2.0	255
Dallas . . . . San Antonio	2.0	253
Dallas . . . . Austin	1.9	187
Chicago . . . . . . Detroit	1.8	238
Boston . . . . Washington	1.7	400
Chicago . . . . . . Minneapolis	1.5	344
Detroit . . . . New York	1.2	489

SOURCE: Volpe National Transportation Systems Center, 1991.

Angeles,[11] with the Northeast Corridor city pairs of New York-Boston and Washington-New York in second and third places, respectively (see table 2-l). When travel only between specific airports is examined, Boston Logan-New York LaGuardia and Washington National-LaGuardia are the leading routes. If the trend of migration to the Sunbelt continues, one DOT report estimates that by the year 2000 the only eastern or Midwestern city pairs in the top 10 markets will be Washington-New York and Boston-New York, and they will be third and fourth, respectively (see table 2-2). However, when highway traffic is included, the Northeast Corridor is more traveled than anywhere in Europe or North America.

Many factors in potential markets will have to be examined closely to determine if maglev or tiltrotor service is feasible. How many terminals are needed and where to locate them in a metropolitan area are aspects critical to the total trip-time advantage of these technologies. Additionally, local opposition to new infrastructure development and transportation operations may put some markets out of reach.

Passenger Travel Data

Public data on passenger transportation in the United States is sparse (see box 2-A). Commercial carriers gauge intercity passenger volumes from ticket receipts, and the major airlines, with reporting requirements stemming from the days of the Civil Aeronautics Board, provide what public detail there is on air passenger travel. Automobile travel statistics, when compiled, usually focus on local transportation or are based on gross assumptions. For example, passenger-miles traveled by automobile in the United States are calculated from Federal fuel tax revenues. For common carriers and automobiles alike, only city-to-city or terminal-to-terminal passenger travel estimates can be made—precise origin-to-destination patterns are not well understood. All together, passenger data are sufficient for identifying the largest transportation markets and for estimating traffic volumes, but a better picture of how people travel door-to-door and how factors other than price affect travel demand is necessary for predicting with much certainty the ridership potential of new high-speed transportation systems. In support of the National maglev Initiative and FAA civil tiltrotor studies, DOT's Volpe National Trans-

[11] This corridor includes four airports in the Los Angeles metropolitan area (Los Angeles, Burbank, Orange County, and Ontario) and three airports in the Bay Area (San Francisco, Oakland, and San Jose).

Box 2-A—Passenger Travel Databases

Public data on intercity passenger travel are limited primarily to statistics reported by commercial carriers and to occasional surveys of automobile users. This information is sufficient for identifying the largest intercity travel corridors but provides little insight into the specific trip origins and destinations and passenger decision factors that will be critical in planning maglev or tiltrotor routes. Door-to-door travel time and cost are important factors in passenger choice of transportation modes, and little public data exist on total trip times and expenses.[1] The Federal Railroad Administration (FRA) found that intercity rail and air passenger data were adequate for analyzing a possible high-speed rail system but that highway data were deficient.[2] Moreover, data on transportation congestion and delays, crucial factors for maglev and tiltrotor viability, are generally crude.

Airline passenger statistics, a legacy of the era when U.S. airlines were closely regulated, are superior to those of other modes. In 1985, the Department of Transportation (DOT) assumed the former Civil Aeronautics Board's responsibility for collecting data on airline operations, traffic, and finances, and the primary source of airline passenger data is the Uniformed System of Accounts and Reports for Large Certificated Air Carriers.[3] Large airlines, those that operate aircraft with more than 60 seats, are obligated to report operating, financial, and passenger data by airport and aircraft type and in total. Since these reports do not identify specific passenger travel patterns, DOT requires certain air carriers to collect a statistically valid sample of passenger tickets for each route and to report trip origins and destinations, connecting or stopover points, and the dollar value of each ticket.[4] Demographic information, which often underscores changes in travel patterns, is not contained in these reports. Travel agents and airlines with extensive computer reservation systems keep more detailed, but proprietary, databases of passenger characteristics important for market forecasting.

Because Amtrak and Greyhound bus lines have a virtual monopoly on intercity passenger rail and bus transport, respectively, ticket information available in the companies' annual reports gives some indication of traffic volume. The Nationwide Personal Transportation Study (NPTS) administered by the Federal Highway Administration (FHWA) gives information on daily household travel patterns, offering some insight on dentographic and household trends. However, because trips over 100 miles account for only 0.7 percent of all trips, the NPTS is of little value in determining intercity volume.[5] Another drawback is the infrequency of the study. A 12-month study recently begun in 1990 is the first one conducted in 7 years.

The U.S. Travel Data Center, a private organization, also surveys Americans on their travel patterns. Each month the center conducts a National Travel Survey (NTS) of 1,500 adults, collecting data on trips longer than 100 miles taken during the previous month. The NTS is primarily a data source for the travel industry, but DOT has used NTS results in compiling intercity trip information.

Unlike public carriers, automobile use does not entail a ticket purchase. Consequently, gathering highway passenger data is problematic. Local transportation authorities usually understand commuting patterns in their own communities, but a nationwide picture of automobile travel is lacking.

There are two major sources of highway data managed by FHWA: the Highway Performance Monitoring System (HPMS) and the NPTS, neither of which is very helpful in determining intercity travel patterns. States report to HPMS on pavement condition, miles, and use for a sample of 102,000 miles of collector and arterial

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[1] John P. O'Donnell, Volpe National Transportation Systems Center, personal communication, June 28, 1991.

[2] Because of government operation of Amtrak, passenger rail data are much easier to obtain. Arthur B. Sosslau, "Surface Transportation Data Needs, Resources, and Issues," *Transportation Research Record, No. 1253,* January 1990, p. 43.

[3] 14 CFR 241.

[4] At least 1 percent of the total tickets for large domestic markets and 10 percent for other markets are included ‘n ‘ach sample.

[5] Sosslau, op. cit., footnote2!p“44”

Continued on next page

Box 2-A, continued

roadways. Although these statistics include vehicle-miles traveled, HPMS data provide little information on intercity travel since they contain no origin-destination data,

Transportation congestion and delays are difficult to quantify reliably and consistently. For example, FHWA has yet to develop a surface congestion measurement system. Local authorities can usually monitor road congestion, but the information is often not incorporated at the Federal level where it can be used on a nationwide basis. And even if the data were included in Federal studies, lack of coordination between agencies that gather information makes a complete picture of travel patterns difficult.[6]

DOT maintains three aviation delay reporting systems. Air traffic controllers record the numberof flights delayed by 15 minutes or more and the cause of the delay. Separate delaying events, such as waiting for takeoff clearance or rerouting because of weather, go unreported if each event results in delays of less than 15 minutes, although the total delay for the flight might exceed 15 minutes.

The Federal Aviation Administration also collects data directly from certain airlines on all delays, regardless of length, and the phase of flight in which they occur. This Standardized Delay Reporting System (SDRS) once accounted for 25 percent of all air carrier flights. Due to industry financial difficulties, only one airline currently provides data to SDRS.[7] The third database, DOT's widely publicized compilation of airline on-time performance, indicates how well airline schedules anticipate delays.

To address data concerns, the DOT budget for fiscal year 1993 calls for the resumption of the NTS (different from the one conducted by the U.S. Travel Data Center), which was abandoned in 1977. This multimodal survey would help determine regional travel patterns more completely. The actual details of what would be included in the survey have yet to be ironed out.

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[6] U.S. Congress, Office of Technology Assessment, *Delivering the Goods: Public Works Technologies Management, and Financing OTA-SET-47* (Washington, DC: U.S. Government Printing Office, April 1991), p. 11.

[7] James McMahon, Office of System Capacity and Requirements, Federal Aviation Administration, personal communication, May 23,1991.

portation Systems Center is examining various local travel surveys and will try to project intercity travel by zones representing different parts of metropolitan areas.[12] Furthermore, high-speed rail planners have improved their methods for estimating ridership in recent high-speed rail system proposals.[13]

Air travel data offer less information on commercial travel potential between cities less than 150 miles apart, because conventional aircraft offer little time savings, if any, over surface modes on these routes. However, some of these markets, such as Houston-Austin, Los Angeles-San Diego, Phoenix-Tumon, and Portland-Seattle, have greater air travel than would be expected, and might be feasible for maglev or tiltrotor service.[14]

Transportation Forecasts

The consensus among Transportation forecasters is that intercity travel, and the demand for roads and airports, will continue to grow well into the next century. Population growth, economic strength, and past traffic patterns are the primary factors for travel forecast models. Population data and forecasts are detailed and generally reliable, but information on passenger travel by automobile, and measurements of highway and air traffic congestion, arc crude.

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[12] Arrigo P. Mongini, deputy associate administrator for Passenger and Freight Services, Federal Railroad Administration, personal communication, July 1, 1991.

[13] Joseph Vranich, High Speed Rail Association, personal communication, June 27, 1991.

[14] John B. Hopkins, "Overview of Intercity Passenger Travel," *Passenger Transportation in High-Density Corridors* (Cambridge, MA: U.S. Department of Transportation, Volpe National Transportation Systems Center, November 1990), p. 4.

The most prominent population trends include the shift from the Northeast and Midwest to the Sunbelt, the continuing migration to the Nation's metropolitan areas and the decentralization of these same cities, and the increasing number of households. A combination of economic and demographic factors have contributed to the steady increase in automobile traffic. In the 1960s, traffic trends directly reflected population growth. However, traffic continued to increase steadily, even though the U.S. population growth rate decreased during the past 20 years. The number of households and workers increased about one-third faster than the total population during this period, helping spur this demand for automobile travel.[15]

According to Texas Transportation Institute data, the past decade has already seen a significant increase in road congestion in major metropolitan areas (see table 2-3). Nationally, average urban congestion increased by 16 percent between 1982 and 1989, and congestion in cities such as Los Angeles, Washington, DC, San Francisco, and San Diego grew two or three times this rate during the same period. Congestion data on highways between cities are not as readily available.

FAA figures indicate that both the number of airline flights and the average time delayed per flight increased by about one-third during the past decade.[16] However, most of this growth was prior to 1987. Nevertheless, FAA predicts that the number of congested airports will nearly double, to 41, by 1998.[17]

Events such as energy crises or even macroeconomic cycles that are difficult to predict make forecasting the demand for new transportation projects and infrastructure precarious. Environmental, demographic, and cultural changes and transportation industry strategies will also affect future travel, but are difficult to quantify and predict using mathematical models. For instance, policymakers lost interest in Federal High Speed Ground Transportation Act programs over a decade ago, when the dire predictions of gridlock on the highways and airways of the Northeast Corridor failed to materialize. However, surface and air traffic did continue to grow, and public and private entities took steps to increase highway, aviation, and rail capacity.

Table 2-3-Roadway Congestion Changes in Major Urban Areas, 1982-89[a]

City	Percent change
San Diego	51
San Francisco-Oakland	35
Washington	27
Seattle-Everett	27
Los Angeles	26
Sacramento	26
Austin	25
Portland	23
Orlano	22
Dallas	21
Boston	21
San Antonio	21
Miami	19
Chicago	19
Baltimore	18
San Bernardino-Riverside	16
Fort Worth	14
San Jose	14
New York	11
Tampa	10
Pittsburgh	5
Philadelphia	5
Houston	-2
Detroit	-4
Phoenix	–lo

[a]Congestion level is based on the Roadway Congestion Index (RCI) developed by the Texas Transportation Institute. The RCI calculates roadway mobility by combining average traffic volume per lane-mile for freeways and principal arterial streets, accounting for total vehicle-miles traveled and the capacity of each type of road.

SOURCE: Office of Technology Assessment, based on Texas Transportation Institute, "1989 Roadway Congestion," Research *Report* 1131-4, 1991.

The extent of future intercity traffic jams is difficult to assess because congestion forecasts are based on inadequate databases (see box 2-A again) and the implicit assumption that automobile drivers and airlines will continue to try to squeeze more vehicles into saturated locations. Airline strategies rather than passenger demand sometimes govern congestion, especially at hub airports. For example, at the four airports expected to be the most severely congested by the turn of the century-Chicago O'Hare, Dallas-Fort Worth, At-

15 U.S. Department of Transportation, op. cit., footnote 7, pp. 1-7 and 5-8.

16 According to the Federal Aviation Administration's Standardized Delay Reporting System database, airline delays averaged 11.8 minutes per flight in 1980 and 15.6 minutes per flight in 1988.

17 U.S. Department of Transportation, Federal Aviation Administration, *1990-91* Aviation *System Capacity Plan*, DOT/FAA/SC-90-l (Washington, DC: September 1990), p. 1-13.

lanta, and Denver—the majority of passengers fly in just to change planes for another destination.[18] Changes in operating practices and vehicle occupancy rates in the air and on the ground could dramatically alter congestion levels. Additionally, changes in energy or environmental costs to vehicle operators and advances in telecommunication technologies could alter the demand for transportation.

National leadership is a crucial ingredient for efficient transportation, but local communities often establish land-use and development policies that lead directly to metropolitan gridlock. Local citizens and the airline industry have a strong say in airport development and have, for the most part, delayed or squelched airport expansion in urban areas. The only new major airport (the replacement for Denver Stapleton) now being built in the United States was opposed by the dominant hub airlines at Denver. Due in part to the reluctance of these airlines, the initial plans for the airport have been scaled back, and recent forecasts for passenger travel through the airport have fallen significantly from projections made in the mid-1980s.[19] Generally, there are fewer congestion problems on the intercity portions of the transportation infrastructure, such as airways and highways, than on local segments.

Passenger Travel Patterns in Other Countries

Public policies have created entirely different travel conditions overseas, and the largest commercial intercity transportation markets in the world are in Western Europe and Japan, regions with higher population densities and more closely spaced cities relative to the United States. Each of the countries depends strongly on conventional and high-speed rail for medium length trips, and some are developing or planning to develop maglev vehicles and tiltrotor-type aircraft. However, since public policies, economies, and social structures differ markedly overseas, transportation comparisons with the United States, including the market potential of maglev and tiltrotor systems, must be viewed with caution.

Key Differences Between U.S. and Foreign Markets

Japan and the countries in Western Europe have population densities from 4 to 13 times that of the United States (see figure 2-5) and more of their people live in urban areas. However, certain regions of the United States are densely populated. For example, the population density in the Northeast Corridor between Massachusetts and Washington, DC, is slightly higher than that of central Europe.

With low automobile and energy prices in effect since the 1920s and a widely spread populace, the United States focused its transportation policies, relative to those of other countries, more on aviation and private automobiles than on surface transit. The level of auto ownership attained by United States in the 1930s was not reached by war-torn Western Europe and Japan until the late 1960s and early 1980s, respectively (see figure 2-6). Consequently, these areas had to address mass transit modes such as rail. Now, the private automobile dominates local and intercity travel in every developed country.[20]

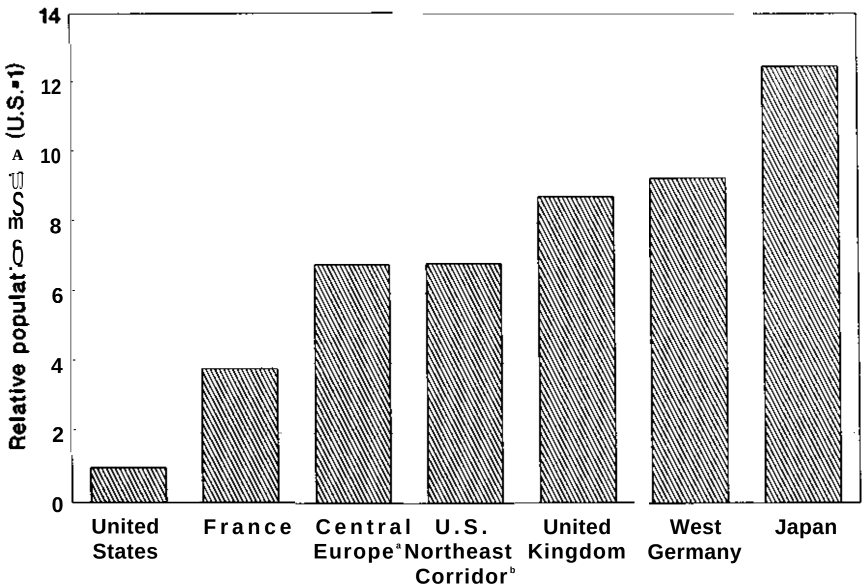
The major difference between travel in the United States and its overseas counterparts is in the role of public carrier modes. Geographic and political factors, such as having dominant transportation corridors, encouraged passenger rail development in Europe and Japan. For example, the Japanese corridor of Tokyo-Nagoya-Osaka contains one-half of Japan's people but only 10 percent of Japan's land area. Similar situations exist in European countries, with the capital cities of London and Paris dominating British and French lives, respectively. In the United States, no single region has the political strength to garner the lion's share of Federal transportation funds. In Europe and Japan, trains carry the majority of commercial passengers, whereas in the United States, almost all common carrier travel is by air. However, airlines have been increasing their market share in Europe and may continue to gain if bureaucratic barriers and prices fall as Europe deregulates its air carrier industries during the next decade.

18 U.S. Congress, Office of Technology Assessment, *Safe Skies for Tomorrow: Aviation Safety in a Competitive Environment* OTA-SET-381 (Washington, DC: U.S. Government Printing Office, July 1988), p. 33.

19 John P. O'Donnell, Volpe National Transportation Systems Center, personal communication, June 28, 1991.

20 U.S. Department of Transportation, op. cit., footnote 7, p. 6-7.

Figure 2-5-Population Density of Selected Countries



aWest Germany, Italy, United Kingdom, France, the Netherlands, Belgium, and Switzerland.
bMassachusetts, Connecticut, Rhode Island, New Jersey, Delaware, Maryland, District of Columbia, one-half of Pennsylvania, and one-half of New York.
SOURCE: Office of Technology Assessment, 1991, based on data from Volpe National Transportation Systems Center, and Population Reference Bureau, World Population Data Sheet (Washington, DC: 1989).

Moreover, other countries find it much easier to cross-subsidize transportation operations. Because many foreign rail operations, and some air service, are traditionally government-owned monopolies, or near-monopolies, financial assistance for transportation industries is an expected part of national spending.[21] Automobile fuel taxes amounting to $3 per gallon in some countries (see figure 2-7) help raise general revenues and support the more energy-efficient and environmentally sound public transit systems. Most European countries reinvest into roads about one out of every three dollars they receive in highway fees and taxes. The comparable U.S. spending ratio is about one-to-one, but U.S. taxes and transportation-related fees are much lower than in Europe, so the U.S. total is less. In other parts of the world, such as Argentina and Australia, governments draw considerably on general revenues to finance highways.[22]

Although the infrastructure for each transportation mode in the United States was initially provided with public funds, new Federal financial support for transportation facilities that is not backed by user fee revenues draws fire from competing interests. Urban Mass Transit Administration grants for mass transit are supported by a 1.5-cent-per-gallon tax on gasoline, but in general, transportation trust fund dollars do not cross modal boundaries. Proposals to allow flexible and cross-modal use of highway funds by States have been introduced in recent surface transportation legislation in Congress.

21The Tokaido Shinkansen high-speed train in Japan and the TGV Paris-Lyon high-speed train in France are reportedly self-supporting.
22U.S. Department of Transportation, op. cit., footnote 7, p. 6-10.

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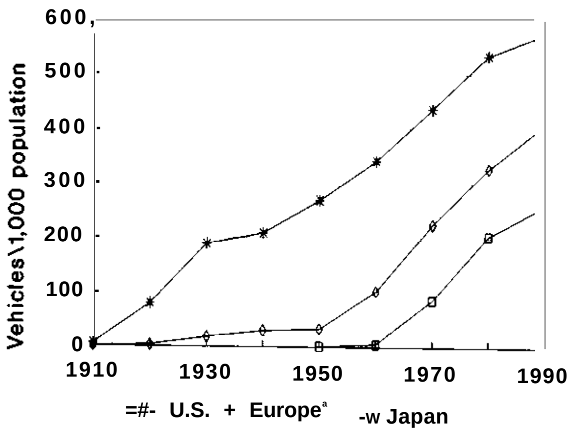
Figure 2-6-Private Passenger Vehicles per 1,000 Population, 1910-90

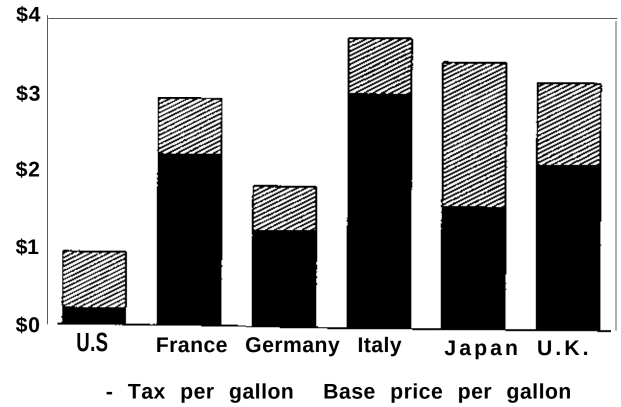


[a]Average for France, Germany, and the United Kingdom.

NOTE: 1990 values as estimated from 1987 data.

SOURCE: Volpe National Transportation Systems Center, 1990.

Figure 2-7--Gasoline Prices in Selected Countries[a]



[a]1988 dollars.

SOURCE: Office of Technology Assessment, 1991, based on data in Editors of the Economist, *The* Economist Book of Vital World *Statistics* (London, England: The Economist Books, Ltd., 1990).