EIR Science & Technology

U.S. could leapfrog Europe, Japan in maglev technology

Although a foolish decision cost the U.S. its early lead, a policy shift now could revolutionize our crippled transportation by the 21st century. Marsha Freeman reports.

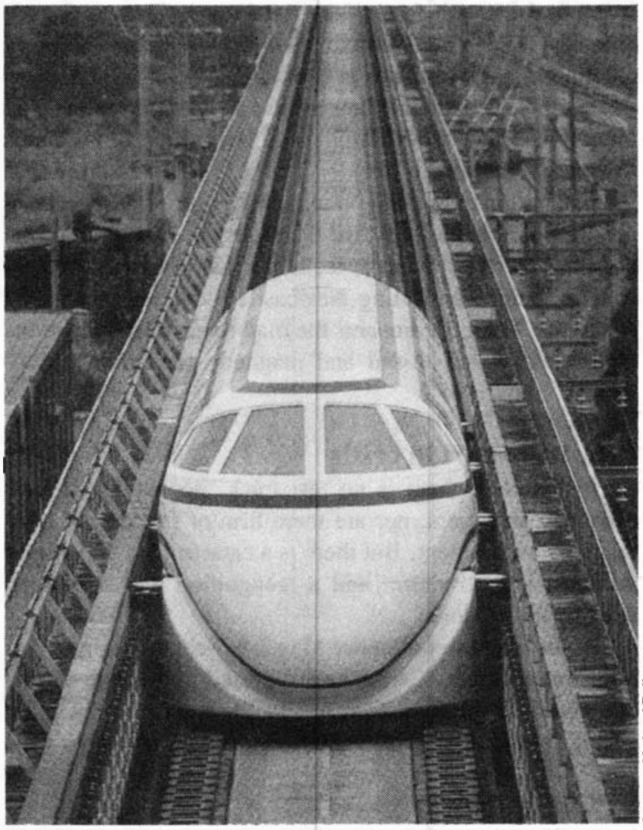
Over the next five years, U.S. scientists, engineers and transport designers could be putting on line a demonstration prototype of America's first advanced magnetically levitated transport system. The science and engineering has been under development for 20 years, but in the United States it has been under a funding embargo since 1975. In that year, the High-Speed Ground Transportation Act, passed a decade earlier, expired. The federal government decided that the cost of refurbishing the collapsed conventional rail lines, such as the bankrupt Penn Central, would soak up all the resources it could put into surface transportation. A foolish, short-sighted decision was made, which cost the U.S. its early lead in advanced magnetic levitation technology.

Over the same decade, Japanese and West German government and industry interests spent about $1 billion each in developing this transport technology. A handful of different approaches to maglev has been under active development: attractive maglev systems with conventional copper coil magnets in both Germany and Japan, and an experimental superconducting system in Japan. The West German Transrapid technology has been offered for sale to the U.S. by the German industry consortium which developed it, and in Pittsburgh, Florida, and Las Vegas, government and industry consortia are considering the offer. The Japanese have expressed interest in funding such a proposal, though they would not be exporting their own maglev system, which is less developed than the German.

Helping to finance the export to the U.S. of the German technology, however, would create a market for this future transport system, which the Japanese also plan to have ready for export around the turn of the century. The Japanese have already conducted market studies, indicating the potential for maglev studies in South America, and developing nations, such as Indonesia.

It may seem, at first glance, that the only way to have maglev in the U.S. in the near future, is to take up the German offer to export their Transrapid system. But importing maglev systems would mean the U.S. would create neither this advanced transport industry, nor the technologies, such as superconductivity, that will have multiple applications throughout the rest of industry. Moreover, the engineering and economic considerations used in the European and Japanese designs do not necessarily apply to the transport requirements in the United States. Both Europe and Japan have, for example, much higher primary energy prices and greater population-density than the United States. Their systems are optimized based on criteria which may not be as important here. Both nations also have functioning conventional and high-speed wheel-on-rail networks, which do not exist in the United States. Similarly, the distance between major population centers is much less, making short-distance air travel less important, and governments have preserved good, functioning rail systems that are economically attractive to passengers.

Finally, the West German Transrapid technology, which uses less technologically advanced attractive maglev, does not use superconducting magnets and has less operating flexibility and higher capital cost. The use of maglev technology will not be commercially introduced into the German transport system on an operational basis until the end of this



The Japanese MLU-001 is equipped with superconducting magnets on the vehicle and on-board cooling units. On the sides of the guideway are coils for propulsion and guidance.

decade. There is, therefore, still a window of opportunity for the U.S. to "leapfrog" ahead into the second or third generation of maglev systems, using the most advanced superconducting, power-handling and -conditioning, and other technologies.

For the first time since the mid 1970s, the fiscal year 1990 budget includes a small amount of funding for a look at national maglev requirements. The Army Corps of Engineers is spending $1 million this year, to begin to evaluate system designs, and the Federal Railroad Administration's (FRA) $500,000 is being used for initial safety studies.

For FY91, the Department of Transportation has requested $6.2 million for the FRA maglev effort, and $3.5 million has been sought for the Army Corps of Engineers, but only to study maglev requirements and technology status, and to begin safety and other institutional examinations of all maglev technology. Interestingly, the current renewed interest in maglev led to the requirement in the Senate amendments to the Clean Air Act, that within six months of passage of the law, an environmental assessment of maglev be done.

At a Government/Industry Maglev Forum in Washington on May 2-3, it was clear from the presentations, and discussions with the scientists and engineers who created and developed the idea for advanced superconducting repulsive maglev, that the only thing stopping the full-scale demonstration of the technology is the political and financial will to do it.

Dr. Gordon Danby, who, with Dr. James Powell, holds the original advanced maglev patent granted in the 1960s, stated at congressional hearings on March 21, "The technology has been in hand for years. There are no technical barriers to building maglev. . . . What is required is a third generation design, and leaderhip to pull this together."

Worldwide status of maglev

The Japanese government and industry have pursued the development of both attractive, or electromagnetic system (EMS), maglev, using conventional magnets for levitation and propulsion, and the more advanced repulsive, or electrodynamic system (EDS) designs, which use superconducting magnets. The less advanced attractive system, called the HSST, has been under development by Japan Airlines. It is considered an intermediate-speed system, limited to about 180 miles per hour because it picks up propulsion power from the guideway. It will be superseded by the more advanced technology.

The goal of Japanese maglev deployment is to bring all of the major cities within a one-day roundtrip of each other. Routes are being designed which are even geographically difficult in order to open up interior regions of the country that have limited surface transport access to economic development. For example, the Tokyo to Osaka system, which is projected to begin testing in 1995 for full commercial operation by the year 2001, could have been built along the shore, near the right-of-way established for the Bullet train. Instead, an expensive, mountainous route was chosen, which will require that 60% of the 300 miles of maglev guideway go through tunnels.

The system is expected to cost more than $21 billion, one-third of which will be paid for by the government largely through long-term debt. It is projected to carry 100,000 people per day. The Japanese would like to avoid the burgeoning of inefficient and petroleum-wasteful, short-haul air traffic the U.S. experienced, as their transport needs grow. A number of years before that 300-mile system is completed, however, a smaller 30-mile advanced maglev commercial demonstration project will be put into operation from the airport near the city of Sapporo, which is the capital of Hokkaido. The system is projected to cost about $3 billion. In 1994, this will become the world's first commercial superconducting maglev system.

The Japanese work in maglev started in the 1960s, soon after Drs. Powell and Danby patented their concept. In 1977, the four-mile-long Miyazaki test track opened to test the ML series of vehicles. Two years later, the ML-500 set the world's speed record for maglev at 321 miles per hour. In 1980, the MLU-001 began tests, with a new and improved design for the guideway. Future testing must include testing prototype vehicles at full speed, the passage of vehicles through tunnels to study aerodynamic effects, the wind effects of two vehicles passing each other at high speeds, and the development and testing of track-switching devices.

It has been pointed out that the fact that electricity costs are in Japan are three times those in the United States has led to design choices that minimize power requirements, but increase capital costs. For instance, shorter block lengths for the electrical activation of the guideway for propulsion; using discrete coils in the guideway rather than continuous conductors strips; and using non-magnetic, low-conductivity steel alloy reinforcing rods, all reduce electricity consumption, but increase the construction and materials costs of the guideway.

In West Germany, the major effort has gone into the operational development of the less advanced, and nearer-term, attractive, non-superconducting maglev technology, though repulsive maglev research was initially also done in the 1970s. The attractive system produces only a small, ⅜ inch gap between the vehicle and the guideway, which requires that it be maintained in nearly perfect condition, and thereby eliminates the inherent low-maintenance advantage of non-wheel-on-rail surface transport. In 1974, Transrapid was formed by Krauss-Maffei and the aerospace giant Messerschmitt-Bölkow-Blöhm. Two years later, the 10-ton Komet vehicle was tested on a one-mile guideway, and soon after, the steel firm Thyssen joined the consortium. The major test facility, which has carried passengers in demonstration runs since 1982, is the Emsland Test Track. The vehicle under development is the Magnetbahn Transrapid.

The limits of the attractive technology have confined the system to speeds of about 250 miles per hour, and it is seen as suited to lower speed applications than the superconducting technology, and therefore, not competitive with air transport.

TABLE 1
Alternative rail technologies (operational above 125 mph)

	Cruising speed	Cost ($/mi)	Applicability
High-speed steel wheel on steel rail			
Japan—Shinkansen Bullet train	150	$21 mn	Intercity
France—Train à Grande Vitesse	185	$10 mn	Intercity
Sweden—(Asea Brown Boveri)	150	$10 mn	Intercity
Maglev: attractive force (electromagnetic system (EMS)			
Germany—Maneto-Bahn	40	N/A	Commuters
Germany—Transrapid	250	$12 mn	Intercity
Japan—HSST	30	N/A	Commuters
Maglev: repulsive force—electrodynamic system (EDS)			
Japan—Railway Technical Research Inst.	250	$16 mn	Intercity

It is not too much faster than the French Train à Grande Vitesse (TGV), the German Inter-City Express (ICE), or other high-speed rail lines in operation.

In 1999, Transrapid plans to have an operational line over the 90-mile route from Hamburg to Hanover. The system is to cost $1.7 billion.

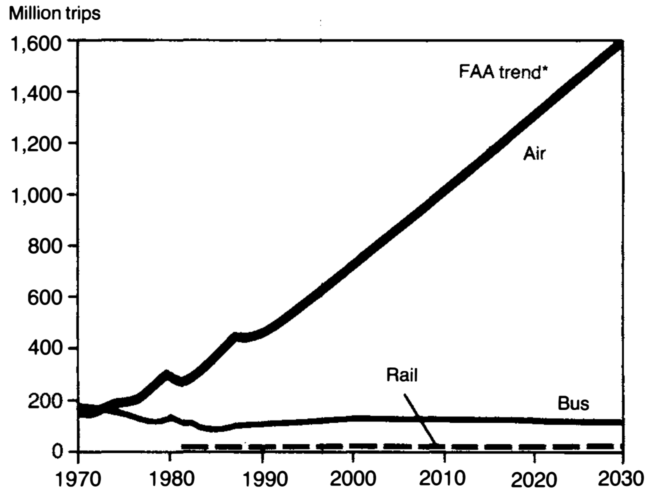
In addition to bidding on regional maglev transport projects proposed in the U.S., the Germans have also studied the potential for this transport technology in Saudi Arabia, as well as a line connecting Newcastle-Sydney-Canberra, in Australia. **Table 1** compares the major characteristics of the high-speed wheel-on-rail and magnetic levitation technologies.

U.S. transport in crisis

In the U.S. there is no test track, no maglev vehicle carrying passengers, nor are there firm or funded plans for maglev development. But there is a catastrophic collapse of transport infrastructure, and a recognition that something must finally be done.

At the maglev conference May 2-3, Federal Railway Administrator Gilbert Carmichael reported that in the 1920s, one could travel from Chicago to St. Louis by rail at an average speed of 120 miles per hour. Today, no matter what

FIGURE 1
Intercity commercial passenger travel is projected to grow annually 4.1% to 2000

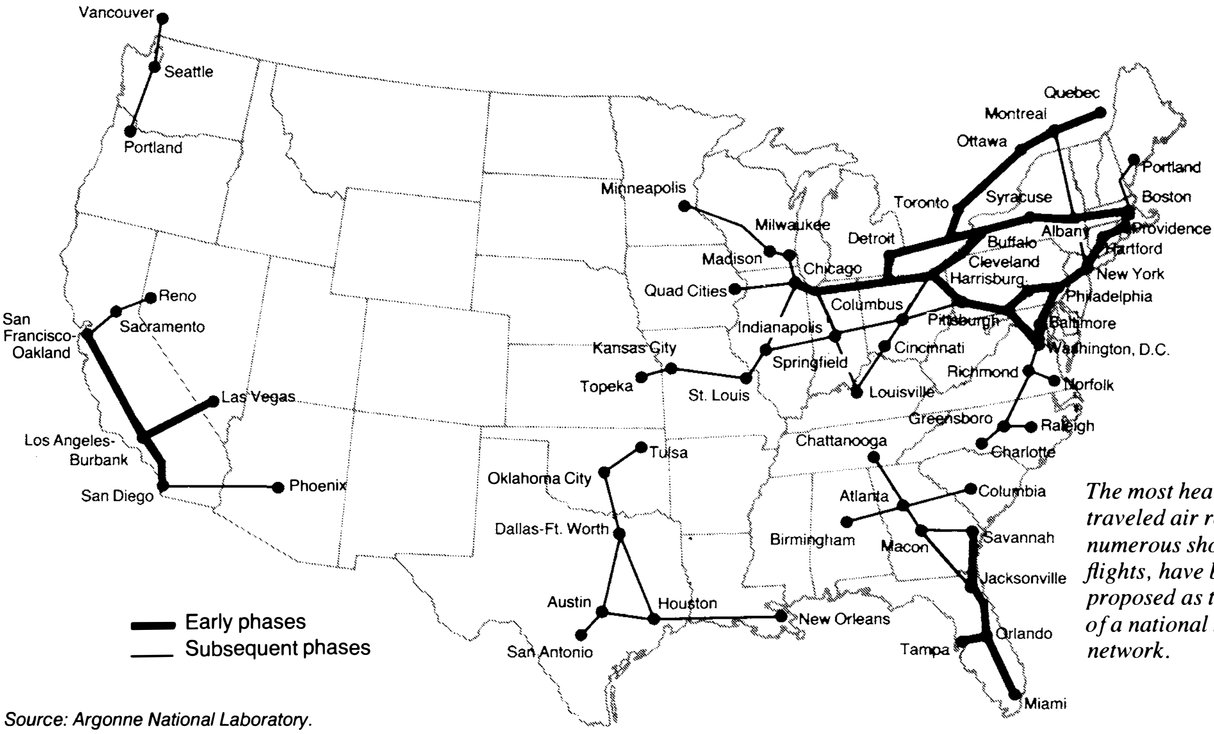


Source: Argonne National Laboratory
**The percentage of adults who have flown increased from 49% in 1972, to 72% in 1986.*

Since the mid-1970s, the growth of passenger transport has been overwhelmingly in the air mode. Without a new transport technology to relieve some of that burden, the nation's air transport system will become increasingly congested.

FIGURE 2

Conceptual plan for connecting hub airports with maglev systems



The most heavily traveled air routes, with numerous short-distance flights, have been proposed as the first leg of a national maglev network.

Source: Argonne National Laboratory.

mode of transport you use, the average speed is 45 miles per hour along the same corridor. The federal government may just be awakening to the crisis in American transportation, but states and localities have known it was coming since the 1960s. It is currently expected that by the year 2020, I-95 in Florida would have to have *44 lanes,* to accommodate the projected automobile traffic between Miami and Ft. Lauderdale, if alternate transport is not provided.

Figure 1 illustrates the profile of American passenger transport. Since 1970, the millions of trip-miles by air has grown at a steady rate. Because no airports have been built for 15 years, this has led to the phenomenon that passengers spend more time in airports than in flight for their short-haul trips. Air delays cost carriers and passengers more than $5 billion annually. Because rail and bus service are not a major portion of passenger transport, auto transport, especially for trips up to 100 miles, and air transport primarily for distances over 100 miles are the projected areas of growth and aggravated congestion.

At the maglev conference, FRA Administrator Carmichael continually stressed that the U.S. must have a *safe* transport system. Over 1 million people have died on this nation's highways since 1970. Studies have shown that the frequency of highway collisions tends to go up as the square of the traffic density. Moreover, though it is not generally reported, according to interviews, one out of every five commercial airplane pilots has experienced a "near miss" midair collision, as a function of overloading in urban areas.

Although the federal government bowed out of any high-speed rail development 15 years ago, throughout the 1980s, cities, states, and regions started to consider options for their future transport needs. In 1983 the High-Speed Rail Association was established for the purpose of promoting new modes and new industries of high-speed rail passenger service, in excess of 125 miles per hour. It joined together manufacturing firms, engineering consultants, legal and financial firms, state officials, labor representatives, and academia for this goal. At the same time, many states and regions were examining their future options. Presently the most active planning is in Florida, Nevada, and Pennsylvania, with growing interest in the Northeast corridor between Boston and Washington, the industrial Midwest cities, and Texas.

In 1984 the Florida state legislature passed the High-Speed Rail Act, which authorized the study of a 300-mile high-speed rail system to connect Miami, Orlando, and Tampa, and conventional high-speed rail is under consideration. Four years later, the Magnetic Levitation Demonstration Project Act was passed, without any specific location indicated. Under consideration for the 17-mile route from the Orlando airport to the vicinity of Disney World is the German Transrapid system, with financial support from the Japanese, through a consortium called Maglev Transit, Inc.

In another indication of the turn of this nation's transport toward servicing entertainment centers, a second region actively planning to meet future transport needs is on the route between Los Angeles and Las Vegas. The plan is to operate a high-speed surface transport system in this corridor by about 1998. The approximately 250-mile system must be built at no expense to the state of California and bids are due in July. As of now, it is expected that there will be proposals representing the French TGV rail system, and also the German Transrapid maglev. Projections are that the TGV would cost about $2 billion, and the maglev about $3.5 billion. The project requires congressional authorization for dual use of the interstate right-of-way, which has been raised in Washington.

In Pennsylvania, there has been an aggressive effort to revitalize transport and the economic viability of the region for more than a decade. Recently, a study led by Carnegie Mellon University has been completed, proposing that the German Transrapid system be imported, but be licensed for production in unused factories in the Pittsburgh area. Promoters of this plan hope that Japanese financing would be available. Eventually the system would connect the major urban centers of Pittsburgh, Philadelphia, and the state capital at Harrisburg, but would start with a smaller demonstration project. It has been projected that 4-12 million riders per year would be attracted to this novel system.

The route most in need of maglev technology, however, is the Northeast corridor, which is heavily congested. No new airline flights can be added in any of the major airports. Maglev USA, formed recently by General Electric, Westinghouse, the Grumman Corp., CSX, Rust International, and Sverdrup, is promoting the construction of a Baltimore-to-Washington maglev line.

Clearly, this should be the first leg of the full Boston-to-Washington system. Spokesmen for the project have used the example of the Washington-to-Baltimore telegraph line in the last century, which stimulated the development of telecommunications nationwide, as the role the corridor can play in maglev development.

Over the 1970s, as the situation in the Northeast corridor worsened, the federal government poured more than $1 billion into upgrading the deteriorated Amtrak rail line, explicitly as a tradeoff to simultaneously being able to use the corridor as a showcase of the most advanced U.S. transport technology.

It has been proposed by Maglev USA and the experts who have studied this region for Sen. Daniel Moynihan (D-N.Y.) and the Senate Committee on Environment and Public Works, that freight be included in the service provided by maglev, particularly along this corridor. It is an important freight route, unlike the entertainment orientation of many of the other proposed routes. Dr. Gordon Danby reports that multipurpose maglev vehicles can be designed to carry both passengers and freight. Containerized freight, which is carried by airplanes and trucks today, could be moved on maglev. A fully intermodal system would allow the quick transfer of freight from one transport system to another.

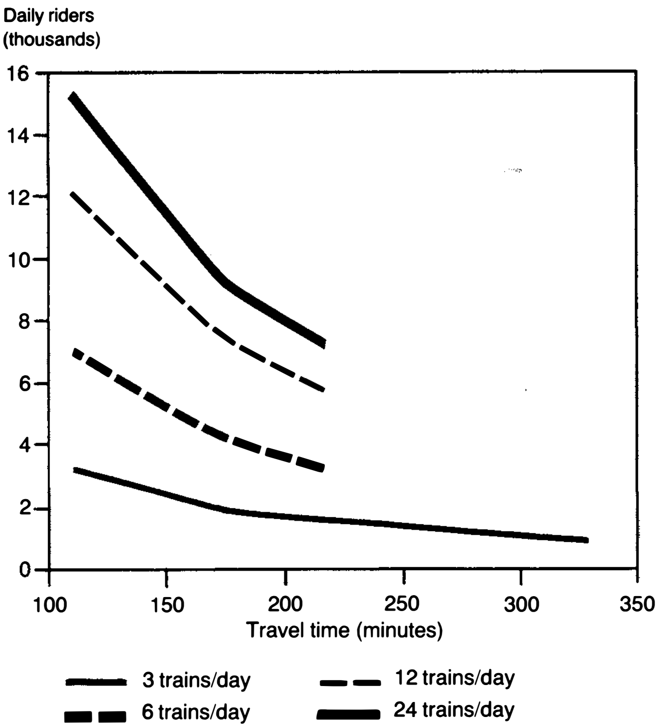
Because there has been no federal leadership in transportation, and particularly in high-speed ground transport, for 15 years, different systems are being considered in various parts of the country. If these projects go ahead, it will eventually be difficult to link them up to a national maglev grid. We can see that very problem in Europe, with the effort to integrate rail systems with different gauges.

Figure 2 is a conceptual plan for starting the national system by connecting hub airports to maglev networks. Architectural plans have also been drawn up for the interface between the air and surface modes, so passengers can deplane and enter the maglev terminal, rather than renting a car or taking an additional short flight to reach their final destination.

In passenger transport, and even more so for freight, intermodal operation with clean interfaces and added convenience can exponentially increase the productivity of the en-

FIGURE 3

Effect of travel time on ridership
Detroit-Chicago corridor



Source: Federal Reserve Bank study, 1984.

Travel time and the frequency of departures have been found to be the two major factors influencing how passengers choose among various transport modes.

tire system and make traveling safe, rapid, efficient, and environmentally pleasurable.

What makes maglev 'economical'?

In a article in the *New York Times* in September 1989, Eric W. Beshers insisted that high-speed rail cannot pay for itself. Unfortunately, Mr. Beshers is not just a misguided commentator, but the former deputy director of the office of economics of the Department of Transportation. It is no wonder we have had no investment in transportation. Aside from Beshers' insults that the French and Japanese high-speed trains are nothing but "boondoggles" and that the claims of cleaner air, energy efficiency, etc. are "nonexistent," it is interesting that he has no historical understanding of the role of transportation as the "enabling" capability to all economic activity. As most U.S. schoolchildren know, before there was large-scale development of industry and agriculture west of the Mississippi, there were the trains. Before that, the network of man-made and improved internal waterways allowed the East to develop.

There is no cost-benefit analysis that can be carried out which will show that infrastructure can "pay for itself." Do children "pay for themselves?" Their role is to be "enabling" for the future of society.

It is also disturbing that Mr. Beshers makes no attempt to reveal what parameters, particularly for financing, he is using. At the recently held maglev symposium in Washington, Dr. George Lodge from Harvard University referred to the difficulties that the government-supported Sematech consortium is facing in promoting U.S. commercial leadership in semiconductors.

Semiconductor industry leaders, who are developing a product which *is* supposed to be able to make a profit, have told the Congress that, unless credit at lower interest than currently exorbitant commercial rates is made available, they cannot compete with a Japanese semiconductor industry which can borrow capital at 5-6% interest. The United States has nearly succeeded in proving that it is actually possible to make *all* productive economic activity unprofitable!

At the maglev symposium, where the Bush administration fixated on partnerships between the public and private sectors to build new transport systems, aerospace industry representatives, whose companies would build the airplane-like maglev vehicles, readily admitted they had no capital for large-scale private investment. The week before, these same aerospace companies had announced more than 10,000 layoffs—their portion of the "peace dividend."

Fairly detailed analysis of the costs of maglev systems have been done, partly to discover how further advancements in the proposed component technologies and system designs can cheapen the cost of this revolutionary new transport. Dr. Richard Thornton has suggested that the technology be made more "elegant" and simpler, as the way to reduce the cost. At the maglev symposium, he remarked that the German Transrapid system could be used to serve vacationers and casino tourists, but the U.S. needs a national system, to serve the needs of the whole country.

Figure 3 describes two of the most important considerations, from the passengers' standpoint, in choosing a particular mode of transport. The longer a trip takes, the fewer riders will prefer that mode. Also, the higher frequency of departures, the more passengers. Maglev systems for the U.S. have been conceived of as consisting of one-car vehicles, which can have a headway, or time between departures, as short as one minute. This is possible because the sophisticated computer controls which are necessary for the levitation, propulsion, and guidance of the 300 mph vehicles already require the constant monitoring and control which would allow the vehicles to have relatively small distances between them.

As Table 1 shows, the per mile cost of building high-speed rail ranges from $21 million for the Japanese Bullet train, to perhaps $10 million for the French and Swedish versions. For maglev, it is estimated that 80-90% of the cost will be for the construction of the guideway. The vehicles are relatively inexpensive. While it is too early to estimate with any degree of confidence what the superconducting maglev system will cost, it is interesting to note that interstate highway construction can cost $15 million per mile in suburban areas, and as high as $30 million per mile in urban regions. Of course, included in these figures is the highly inflated cost of real estate. As Vice President Dan Quayle pointed out in a speech on May 1 before the annual meeting of the American Institute of Aeronautics and Astronautics,

TABLE 2

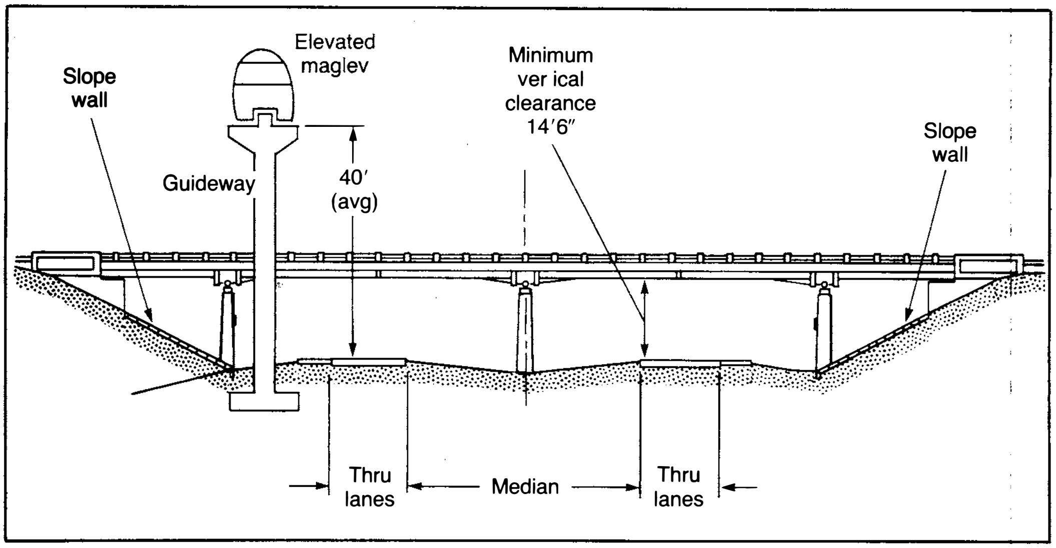
Energy-intensity comparison for a 300-mile trip with a load factor of 0.6*

System or mode	Cruising speed (mph)	Energy-intensity (Btu/PM)
West Germany TR07 Maglev	310	1,150
Canadian second generation maglev	280	890
Japanese MLU002 maglev test vehicle	260	1,420
Japanese six-car maglev revenue train	310	890
Magneplane (MIT)	225	1,340
Ford Motor Co. Maglev		
Base case (80-pass)	300	5,540
Modified (140-pass)	300	4,190
Three-car train	300	3,380
Base case with LSM	300	1,390
Aircraft	400-500	9,170
Personal highway vehicle (at 32.3 mi/gal)	65	1,940

*Data are for cruising speed only, except for aircraft, which include all gate-to-gate operations.

FIGURE 4

Elevated guideway design for Northeast corridor



Source: Report of the Maglev Technology Advisory Committee, 1989.

To avoid slowing down for rises and dips in the road, as well as for increased safety and all-weather operations, it has been proposed that the Northeast corridor maglev system be elevated perhaps 40 feet.

since early in this century, the U.S. has spent about $2.5 *trillion* on its interstate highways. In earlier periods of history, national leaders clearly decided that infrastructure *was* "cost effective."

Designers have used the construction cost of $10-15 million per mile as target for maglev systems designs. **Table 2** clearly demonstrates why this technology should be fostered. Though even with the energy parameters in BTUs per passenger-mile, maglev consumes less than one-third as much energy as aircraft, and no more than automobiles and conventional rail; in addition, aircraft and autos use petroleum-based liquid fuels, of which, at the current time, 54% is imported. Here, the quality of the fuel is more important than simply the quantity. Maglev is an all-electric transport mode. While conventional and high-speed rail in Europe is almost entirely electric, in the United States, less than 10% of the total rail trackage is electric. The rest is serviced by liquid fuel-engined locomotives. For improved energy and transport security, as well to avoid environmental noise and air pollution, all-electric transport is required.

The proposal by the Maglev Technology Advisory Committee, contained in its report, "Benefits of Magnetically Levitated High-Speed Transportation for the United States," benefits from the years of research by Drs. Danby and Powell, as well as Drs. Henry Kolm and Richard Thornton, who developed and tested their superconducting Magneplane concept, in scale model, in the 1970s. The committee proposes to build the maglev guideway using the right-of-way of the existing interstate highway along the Northeast corridor. The center median is typically 50 feet wide, which is adequate for an elevated maglev system. The physical features of the road, the report points out, such as dips and rises, bridges, and interchanges, would limit vehicle speed at some locations if the guideway were at ground level. In addition, at 300 miles per hour, at ground level, the passengers would see nothing but a blur. To solve that problem, it is proposed that the maglev guideway be elevated to a height of approximately 40 feet, so it can pass over existing structures with adequate clearance, as **Figure 4** shows.

For abrupt angle curves, the guideway would depart from the interstate. Offline loading would allow the maglev vehicles to maintain higher speeds and only stop at selected stations. It is proposed that the guideway be constructed with prefabricated beams and piers, installed on concrete footings, and the beams have their aluminum conductors laid on top. The optimum distance between beams, according to the report, is in the range of 50-100 feet. While the system is under construction, one guideline must be minimum disruption of normal highway travel. A rough estimate made by the scientists, engineers, and industry advisers is that such a system could be built at a cost of $11-13 million per mile for a two-way guideway, including components and installation.

One important requirement for the U.S. system operating in the Northeast, is that it be operable in all weather conditions. The guideway must be designed so it does not accumulate ice or snow. According to Dr. Danby, this is a geometric problem, which is easier to solve on an elevated system, where there is no possibility of drifting. A porous design, for example, would prevent snow from sticking to the guideway. If the guideway is elevated, the weight of the vehicle becomes a constraining factor. Superconducting maglev vehicles are projected to be in the 40-ton range, whereas the attractive, non-superconducting maglev vehicle weighs typically 100 tons. Dr. Danby estimates that containerized freight in the range of the 80,000 pounds carried in trucks, could be hauled on an elevated maglev guideway.

It is estimated that for approximately the same $1 billion that has been spent by the Germans and Japanese over the past decade, a superconducting demonstration maglev project could be built in the United States. This could likely be completed over the next five years. From there, commercial systems could be designed, to be in operation at the turn of the century.

There is little argument that the U.S. has the *capability* to leapfrog into second and third generation maglev technologies. How to fund moving from the research and study stage of maglev into the construction of full-scale systems is the subject of a number of pieces of legislation, as well as discussions in the scientific and industrial communities.

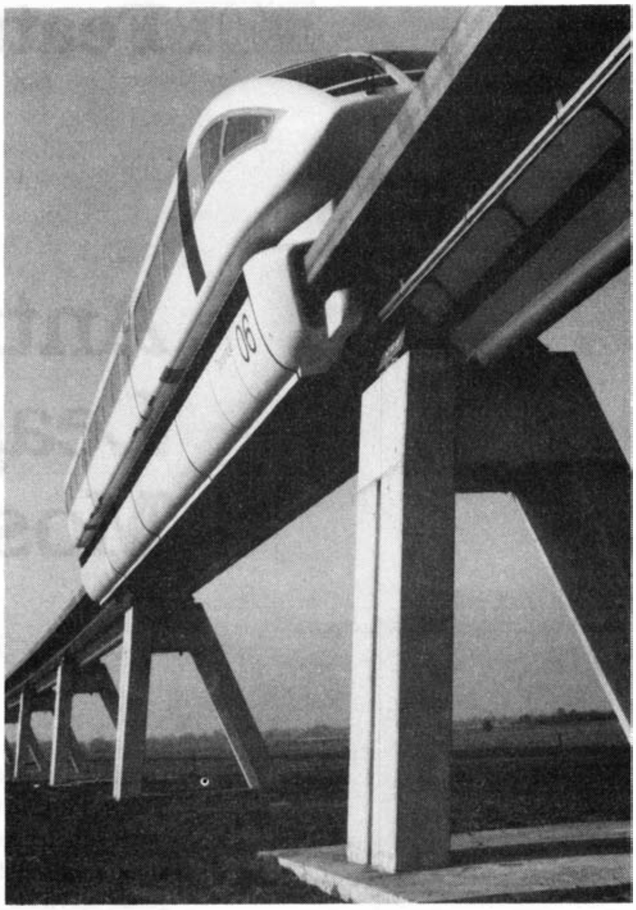
Moving maglev forward

Numerous bills have been introduced in the Senate by Senator Moynihan and others to try to get maglev off dead center. They vary in the amount of money which would be available, and the way the work is to be paid for. Proposals range from the use of government employees' pension funds to guarantee loans to industry, to direct appropriations through the budget, and there is even a propsal to return to a 1960s pro-growth policy of investment tax credits for industry. Though Moynihan has made great public fanfare of the scandal that the Social Security Trust Fund surplus is being ripped off to alleviate the budget deficit, the senator fell silent at the maglev symposium when this reporter suggested that the more than $60 billion fund be used to extend long-term, low-interest credit to an emerging maglev industry.

The collapsing aerospace industry, now following the unprotected "smokestack" industries of the past decade into economic oblivion, is in no position to "share costs" in maglev development. Recent reports indicate that the political defense policies being pushed by the Bush administration to take down defense production *and* defense research and development, could easily push the heavily indebted defense and industrial capability of this nation over the edge.

The billion dollars required to build a demonstration maglev system should be paid for from the federal research budget in transportation, as well as the bloated tax receipts already being collected through the Social Security payroll tax, and the surpluses in the highway, air, and other "user fee" trust funds. Credits at 1-2% interest over 10-15 years would allow industrial firms to participate in the rebuilding of American transport, using the technology of the 21st century.

According to FRA's Carmichael, there are people in the Bush administration discussing using the Highway Trust Fund, once again, for transportation. Carmichael stated that perhaps there should be a new intermodal trust fund for technologies such as maglev. Currently, the nation spends $600 billion per year on transportation. Surely, a small percentage of that should be put into future technology.



The German attractive maglev vehicle is the Transrapid. It is being developed for commercial operation between Hamburg and Hanover.

Next month, the FRA will present a report to the Department of Transportation evaluating the market potential, and interest in U.S. industry for maglev. According to Maj. Gen. Patrick Kelly of the Army Corps of Engineers, the goal of the U.S. R&D effort is the development of U.S. advanced maglev technology by the end of the century. In June, the Army Corps of Engineers will present an implementation plan for the government intergency effort in maglev. At the maglev symposium, General Kelly reminded the audience that the Corps had helped NASA put a man on the Moon.

Unless the decision is made to make that investment soon, the window of opportunity for U.S. maglev development will close. Then, 10 years from now, our Trade Representative will be making visits to Tokyo to convince the Japanese to implement trade barriers which prevent the export of Japanese maglev systems to the U.S., while the transport systems and economy here collapse into a heap of rusted metal.