Reprinted from ISSUES IN SCIENCE AND TECHNOLOGY,
Volume VI, Number 3, © 1990 National Academy of Sciences

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Putting Maglev on Track

Magnetically levitated trains, currently an orphan technology in the United States, could help unclog the nation's air traffic system.

As even the infrequent flyer knows, air travel has degraded from an enjoyable experience into an often grueling one. Chicago's O'Hare airport alone tallies more than 12 million hours of passenger delay annually, the equivalent of 1,400 passengers standing idle around the clock. And delays in the largest cities affect other places; the Federal Aviation Administration (FAA) calculated that the cost of delays in 1986 for passengers and the airlines nationwide totaled $5 billion—$2 billion of which (or some 7 percent of the airlines' operating costs) were in wasted fuel and extra labor charges. Our air traffic system is choking on its own success.

And things will get worse. By 1996, the FAA predicts that unless the air traffic system adds significant capacity, the number of severely congested airports will grow from today's 18 to 32. Such expansion appears unlikely; citizens' groups around the country are resisting the construction of new airports, citing noise and emissions. The last major airport built was Dallas-Ft. Worth, in 1974. The planned Denver airport has taken over 10 years just to get site approval. Local officials vetoed a new airport for Miami, which has the twelfth most congested facility in the country.

The most sensible solution to this mounting problem lies in the seemingly sci-fi technology of magnetically levitated, or maglev, trains. In a maglev system, magnetic fields lift, guide, and propel vehicles along a guideway at speeds of 250 to 300 mph. The magnetic forces can come either from conventional electromagnets or, in a design that many researchers regard as superior, by coils of superconducting wire. Although maglev technology was of intense interest in the United States as early as 20 years ago, only Japan and West Germany now operate full-scale prototypes.

Maglev is an elegant technology, with many advantages over conventional means of transit. Because the maglev vehicles never touch the guideway, they make little noise and incur low maintenance costs. Maglev trains are virtually immune to adverse

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weather, which is the single largest cause of airline delays. According to a report issued last summer by the Maglev Technology Advisory Committee—a group organized by Senator Daniel Patrick Moynihan with members from industry, national laboratories, universities, and government agencies—the use of maglev would reduce emissions of air pollutants such as hydrocarbons, carbon monoxide, nitrogen oxides, and particulates. And it would even help retard the trend toward global warming, putting out one-fourth as much carbon dioxide as airplanes while consuming only a fourth as much energy per passenger-mile.

A maglev system would not waste land resources, either. According to Senator Moynihan's committee, a two-way maglev system would require only 50 feet of space and could be elevated to clear existing bridges and overpasses. Thus guideways could be built within the existing rights-of-way along the Interstate Highway System, avoiding the need for costly and disruptive land purchases.

A single maglev line would have a capacity equal to 6 lanes of interstate highway; a maglev network radiating from a city would have the passenger capacity of a major airport.

Working within the system

There is no reason to propose that maglev entirely replace air travel. Aircraft should be reserved for the job they do best—carrying large numbers of people long distances. But half of all flights are less than 500 miles; these trips are costly and fuel-inefficient, and they clog the airports' limited takeoff and landing slots. Maglev could, by taking over for these short trips, complement airline operations. Several U.S. airlines are actually beginning to examine maglev technology. USAir president Edwin Colodny, for example, has spoken highly of its potential for relieving airport congestion.

Airlines use hub-and-spoke systems to collect passengers from the many shorter routes and transport them in larger numbers over the longer-distance portions of their trips. Thus, many more airline passengers pass through major cities such as Chicago and Atlanta than travel to them as final destinations. To maximize ridership, a maglev train should, as one of its functions, serve as a substitute feeder into the existing hub-and-spoke airline networks. To provide flexibility, the maglev system should consist not of long, multiple-car trains but rather individual vehicles, each carrying about as many people as a mid-size aircraft.

Where the Action Is

There are two principal variations on maglev technology. In one, the levitating force comes from an attractive pull between a laminated iron rail in the guideway and a conventional electromagnet in the vehicle. This technique is now used in West Germany's 20-mile Transrapid prototype system.

The alternative approach, used by the Japanese, relies on coils of superconducting wire to produce the vehicle's magnetic field. These superconducting magnets produce a field of the same polarity as that induced in the coils located at the bottom of the guideway; the resulting magnetic repulsion keeps the vehicle aloft.

The superconducting system, which was first proposed by scientists at Brookhaven National Laboratory in 1966, has two principal advantages: Because superconducting magnets, unlike conventional electromagnets, do not require an iron core to concentrate the field, the vehicles can be much lighter; and the repulsive technique allows a far larger gap between the guideway and vehicle—4 to 8 inches, as opposed to the 3/8-inch gap in an attractive maglev system. The larger gap reduces the precision required for aligning the track; it also adds a cushion of safety, which is particularly important to the earthquake-conscious Japanese.

In both designs, the guideway's array of electromagnets—when energized—not only lifts the vehicle but also propels it. The coils rapidly alternate polarity, alternately pulling the vehicle magnets from ahead and then pushing it from behind in a "linear synchronous motor."

Both Japan and West Germany have produced several full-scale, passenger-carrying maglev prototypes that operate in excess of 250 mph. The Japanese system, which holds the unmanned maglev speed *record of 321 mph, borrows heavily from the original Brookhaven design. The Japanese have used a small, 4-mile track for their work to date, but have received approval for a new 30-mile test track that will eventually become a part of an operational, 300-mile link connecting Tokyo and Osaka. Meanwhile, they reportedly plan to begin building their first revenue-generating maglev line in Hokkaido, from Sapporo to the airport, with an opening date possibly as early as 1994. The Japanese vision of the future includes superconducting maglev trains traveling at ultrahigh speeds in evacuated tubes to link continents.*

The German Transrapid maglev system has been operating on a 20-mile test track for several years; final certification testing for the commercial prototype is being conducted this year. Looking to the future, West German officials recently approved the first domestic route for the Transrapid—a corridor of about 100 kilometers between Essen and Bonn. Its first link, between Düsseldorf and Cologne airports, should be open in 1997.

Meanwhile, the Germans are marketing Transrapid technology abroad; in the United States, maglev systems of this type have been proposed in Florida, California-Nevada, and Pennsylvania. Maglev technology development or experimentation has also been conducted in Canada, the Soviet Union, and Romania.

The United States maintained a vigorous maglev research effort during the early 1970s. The Federal Railroad Administration supported feasibility studies and prototype development at Stanford Research Institute and Ford Motor Company; the National Science Foundation and several industrial firms funded work at MIT. But despite the promise of the technology, U.S. maglev research stopped in 1975. The work ended not for a lack of technical progress but because our air traffic and highway systems were deemed adequate—a conclusion that may have been true then but is now open to question.

Coupling the maglev to the air transportation network would also permit maglev fares to be high enough to support the system. If set up to compete with airlines, a maglev train would have to entice passengers by charging lower fares, which, combined with the inability to access the through traffic of the airlines, would result in substantially less revenue than is possible with an integrated airline-maglev system.

The precedent has already been set. Lufthansa's airline passengers can fly into Frankfurt and continue to their final destination either by air or the Lufthansa-owned Airport Express—a conventional train with terminals in Bonn, Cologne, and Düsseldorf. About half the passengers choose the train—even though it is slower than the plane—because it is less subject to delay and brings them closer to their destinations.

Having recently received government approval, Lufthansa hopes to eventually connect the Düsseldorf and Cologne airports with a maglev line, in essence making the two medium-size airports into one super-airport. The takeoff and landing slots made available by substituting maglev will be used for their more efficient, and profitable, long-distance airline flights.

In the United States, a maglev network should begin in regions where the distances between major cities are not too great—for example, in the Northeast, the Midwest, California, Florida, and Texas (see map). These are the areas in which maglev can effectively substitute for short-haul airline flights and significantly reduce air traffic congestion and delays. The system could extend to other metropolitan areas as increasing travel demands warrant the investment.

Several states and regions are already pursuing maglev technology. Florida, concerned with rapid growth and heavy demands on transportation, has passed a Magnetic Levitation Demonstration Act to help create a 15-mile maglev link between Orlando Airport and major tourist attractions. An application has been made to build that system using German maglev technology; private financing would come largely from the Japanese. This demonstration line could be operating as early as 1994, introducing millions of Americans annually to maglev technology.

The city of Las Vegas has had a strong interest in a high-speed ground transportation link with Southern California. After studying maglev as well as conventional options, the city endorsed maglev. A request for proposals, possibly leading to a 230-mile maglev system by 1998, was issued in January.

Where do we go from here?

The question is whether we purchase foreign maglev technology or finish developing what we started 20 years ago. For several reasons, we should follow the latter course.

We should be able to improve on the West German maglev design, depending as it does on heavy, conventional electromagnets rather than the far more powerful and efficient superconducting magnets. The superconducting designs, with greater guideway tolerance and lighter vehicles, offer the potential for a lower-cost system.

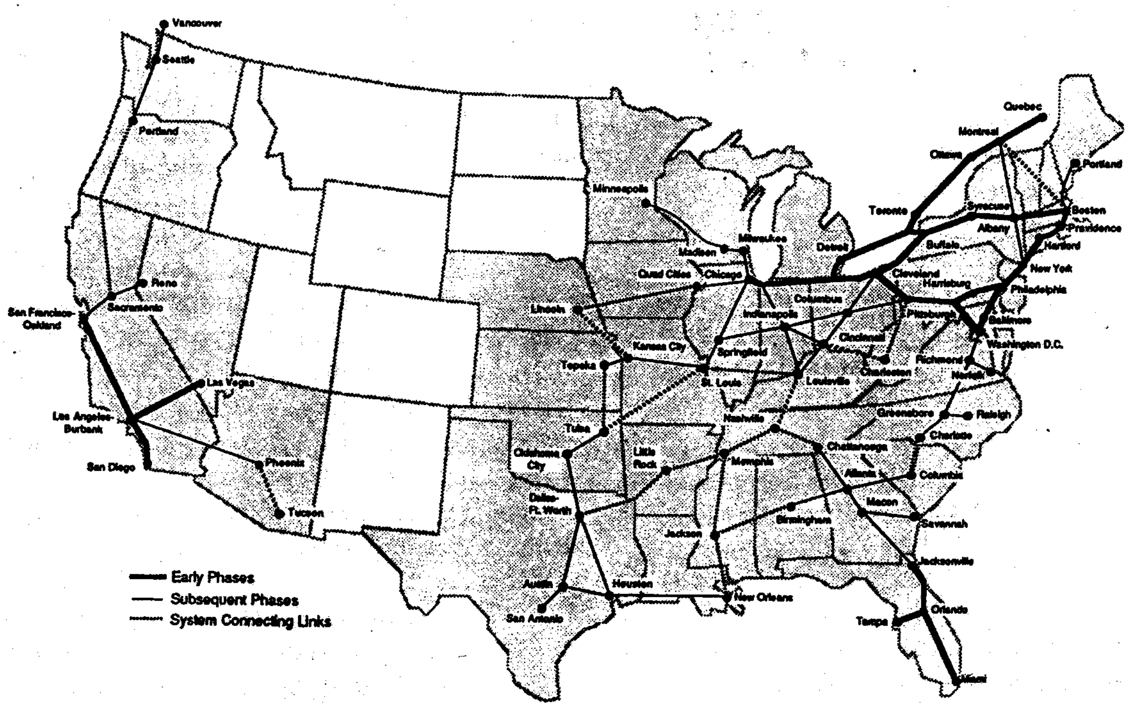
And the Japanese design has limitations in the U.S. market as well. In developing their superconducting maglev, the Japanese tended to choose designs that minimized operating expense even at high capital cost. This trade-off makes sense for the Japanese, whose energy costs are extremely high. A U.S. maglev, however, could follow less capital-intensive designs because we can better afford the energy that a cheaper design would consume. Moreover, a maglev of the sort proposed here—with individually traveling cars of modest size—would not need as expensive a guideway as the Japanese need to accommodate their heavy, 14-car trains.

Unfortunately, maglev is at present an orphan technology in the United States: Without a clear plan for integrating maglev into our current transportation system, manufacturers are unlikely to develop it; and without a demonstration of the high-speed maglev technology designed specifically for U.S. needs, the airlines, the railroads, and the government will be reluctant to plan for its use.

What can we do to break this deadlock? I present here a broad strategy for getting us moving on maglev:

Government should lead the way. A national transportation system is, of course, a federal responsibility. The government should, with guidance from potential operators of the maglev system, provide the specifications necessary for maglev to meet U.S. travel needs. An important first step has recently been

CANDIDATES FOR MAGLEV



The first maglev systems would likely connect large cities separated by distances of a few hundred miles—corridors in which congestion and costs are the highest. As demand grows, other metropolitan areas would join the network.

Source: Argonne National Laboratory

taken with the president's proposed 1991 budget, in which maglev is included as one of ten major R&D initiatives. The proposed funding of $10 million would explore the potential of this emerging technology, but even this modest beginning would need congressional approval.

Thus a dialogue on maglev technology development is needed within Congress, and Concurrent Resolution No. 232, introduced by Representative Jimmy Hayes (D-La.), is a good way to start it. The resolution would commit Congress to examining—possibly through fact-finding hearings that involve U.S. manufacturers as well as state and local governments—what maglev systems could contribute to the country's transportation system and international competitiveness.

A single lead agency or a joint project office ought to have the responsibility for the development effort. Maglev technology now crosses many agency jurisdictions; within the Department of Transportation alone, safety concerns fall to the Federal Railroad Administration, airport connections to the FAA, and use of highway rights-of-way to the Federal Highway Administration. Development of superconducting technologies and the energy-conservation potential of maglev are missions of the Department of Energy. The Army Corps of Engineers is responsible for developing an overall plan for maglev implementation.

At the moment, a working group composed of the three agencies is functioning well, but a single development office would be preferable for accelerating maglev's progress. Decisions could be made faster, responses to changing events could be formulated more effectively, and industry participation could be made simpler.

Industry should develop the technology. We are already seeing the beginnings of industrial involvement. Several companies (including Grumman, General Dynamics, and Intermagnetics General) have devoted considerable effort to assessing maglev technology for Senator Moynihan's committee. Some of these companies, and others with a broader transportation interest, have formed a group called Maglev 2000 to enlist federal support for a national initiative leading to the introduction of maglev systems by the year 2000. Other major corporations, such as CSX, General Electric, and Grumman, have joined in another coalition, called Maglev USA, to further encourage federal policy toward commercializing maglev technology.

Traditional railroad companies have begun to show an interest in maglev as a technology that could serve them well into the next century. Midlands Railway has already taken steps to develop a maglev design, and Burlington Northern has been considering maglev for its commuter operations in the Chicago area. General Motors is also commiting resources at its locomotive facility toward advanced technology development of superconducting systems.

Tap the resources of the national laboratories and universities. The superconducting maglev was invented at Brookhaven National Laboratory by researchers who still work there. Argonne National Laboratory has a core of maglev researchers, including the head of a 1970s program that developed an 1,100-pound maglev vehicle, and the laboratory recently began a small-scale program to explore alternative vehicle and guideway designs.

Similarly, there is continuing interest at MIT, Cornell, Carnegie-Mellon, and other universities that have conducted maglev experiments. But both the national laboratories and the universities need clear direction from the government in order to focus their expertise more intensely and effectively.

Funding is needed for maglev R&D, but the needs are relatively modest. To develop maglev technology, we should expect to spend from $500 million to $1 billion over about seven years. To put that figure into perspective, the federal government subsidizes Amtrak at $600 million *per year*.

There are many possible ways to raise the development funding, including aircraft landing fees, a unified transportation trust fund, and public-private consortiums. One simple solution would be a minuscule transportation fuel tax dedicated to R&D on advanced transportation technology; a tenth of a cent per gallon would raise over $100 million per year. This source of funding would be particularly equitable because it would raise the most money from states with the largest populations and, hence, the largest transportation problems.

The time is not far off when we should be able to have fast, safe, convenient, and environmentally benign maglev transportation in a variety of U.S. metropolitan areas that at present are highly congested. But unless we act now to control our destiny, we will be holding congressional hearings in the year 2000, asking why we lost the lead in yet another major technology.

Recommended reading

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