

## Super Trains: Plans to Fix U.S. Rail Could End Road & Sky Gridlock

With airports and highways more congested than ever, new steel-wheel and maglev lines that move millions in Europe and Japan have the potential to resurrect the age of American railroads.



Unlike conventional diesel- and electric-powered trains, the motor for maglev trains is essentially embedded in the track. The track creates a traveling magnetic field beneath the train, which lifts the cars and propels them at 300-plus mph. The train's on-board systems are powered by induction from the track. And only the section of track under the train is energized. (Diagram by Hello-Napalm)

By John Quain

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**Nestled between the seaside bluffs** of Southern California's Torrey Pines and the concrete arteries of Interstate 5 is the low-profile campus of General Atomics, home to the only magnetic levitation, or maglev, train in the United States. The company's Electromagnetic Systems Division built the test track here three years ago, basing it in part on a design for a maglev rocket launch system developed by Lawrence Livermore National Laboratory.

General Atomics' director of maglev systems, Sam Gurol, has promised me a rare ride on this prototype train, which is not really a train at all, but rather a single, open chassis with no seats. The track looks a little like the guideway to the Walt Disney World monorail in miniature—just 400 ft. long and raised 2 ft. to 5 ft. off the ground.

As I climb aboard the chassis, a researcher waves enthusiastically from a nearby control room like a parent sending his child on a first roller coaster ride. Gurol stands next to me. "Hold on," he warns, and directs me to a single bar at the front of the vehicle. There's a subwaylike jolt, a quiet rumble, and we're off.

For a few moments I feel nothing but the soft La Jolla breeze as we accelerate. It feels as if we're floating, and we are: Between the car and the track is a 1-in. gap that allows the train to operate with zero mechanical friction. And almost no sound. One of the most surprising things about maglev propulsion is that it is whisper quiet. Suddenly, we're decelerating. There's another vibration, and we stop. The whole trip took 22 seconds, and our top speed was 20 mph, but the technology used on this modest test track may power a new generation of ground transportation in the United States.

Watch our video test drive [here](#); cover story continues below...

As a proof of concept, the General Atomics maglev is impressive, but to fully grasp the potential of high-speed trains in this country, you still have to use your imagination. Here's how it could work: You board a train in downtown Anaheim, Calif., at 5:30 on a Friday evening, destined for Las Vegas.

Instead of inching out of the traffic-choked Los Angeles metro area on what is typically a 4- to 6-hour drive, or gambling that the 1-hour, 15-minute flight will depart on time, you glide out of the city, accelerating toward Barstow. As the train fires through the Mojave Desert, it hits a top speed of more than 300 mph, and then pulls into Vegas just 90 minutes after departure—in time for dinner before an 8:00 show.

That scenario won't come to pass for years, but commercial high-speed train travel is no mere fantasy. In other countries, "steel-wheel" bullet trains have been in operation since the 1960s. Japan's Shinkansen sails along the 645-mile route between Tokyo and Fukuoka at up to 186 mph. In France, the high-speed TGV tops out at 199 mph on the 480-mile run between Paris and Marseille, which takes 3 hours. Within the U.S., Amtrak's seven-year-old Acela Express can reach speeds of up to 150 mph, although the tight curves and dangerous roadway crossings of the Northeast Corridor route curtail its average speed to 86 mph. Magnetic levitation, the technology floating the test train at General Atomics, has a smaller commercial footprint, but it has the most impressive capabilities in the world of superspeedy trains. A maglev train that began service four years ago in Shanghai runs 20 miles between Pudong International Airport and the city's business district in just 8 minutes at speeds of up to 267 mph. And this past September, the city of Munich, Germany, announced plans to build a new maglev line that will cover the 25-mile route between Franz Joseph Strauss International Airport and downtown in 10 minutes.

## Proposed North American High Speed Train Projects

There are plenty of plans in the works for next-gen passenger rail, from upgrading existing lines to building super-high tech tracks. Given the expense, the technical challenges and the political complexity of these projects, it'll be at least a decade before the first trains go into service—if they ever do.



If the projects mapped above come on line, just how fast, efficient and enviro-friendly will next-gen rail be compared to other options? We gathered numbers from federal and private sources for a 400-mile trip (the equivalent of traveling from Boston to Baltimore).

High-Speed Rail	Amtrak (Diesel)
<b>Travel time:</b> 2 hours, 54 minutes (maglev); 4 hours, 35 minutes (steel-wheel) <b>Energy used per passenger mile:</b> 1180 Btu* (maglev); 1200 Btu (steel-wheel) <b>CO2 emissions per passenger mile:</b> 0.47 pounds (maglev); 0.48 pounds (steel-wheel)	<b>Travel time:</b> 7 hours, 5 minutes <b>Energy used per passenger mile:</b> 2709 Btu <b>CO2 emissions per passenger mile:</b> 0.46 pounds
Airplane	Car
<b>Travel time:</b> 2 hours, 20 minutes (including 1-hour check-in time) <b>Energy used per passenger mile:</b> 3264 Btu <b>CO2 emissions per passenger mile:</b> 1.06 pounds	<b>Travel time:</b> 7 hours, 6 minutes <b>Energy used per passenger mile:</b> 3445 Btu <b>CO2 emissions per passenger mile:</b> 0.77 pounds

\*Btu stands for British thermal unit. One gal. of gasoline yields about 114,000 Btu.

**Acela notwithstanding,** high-speed rail has been a difficult sell in this country because of high startup costs and the traditional reliability of our air and highway transportation systems. But it's increasingly apparent that, in many areas, those systems are reaching capacity. The average commuter spends 38 hours per year stuck in traffic. And [air travelers are spending more time in security lines and waiting on the runway](#) before they ever get into the air. According to the Department of Transportation, 2007 is on track to be the worst year in the past decade for airport delays, with 25 percent of flights arriving late.

Furthermore, all that waiting costs money—and fuel. The Texas Transportation Institute estimates that last year U.S. drivers wasted 2.9 billion gal. of fuel sitting in traffic. That kind of inefficiency is becoming increasingly worrisome, with oil cracking \$80 a barrel and all those idling engines generating significant greenhouse gas emissions. By contrast, high-speed trains draw power from the electrical grid, which is fueled primarily by domestically produced energy sources, such as coal. Plus, trains require about a third as much energy per passenger mile as automobiles (see above). Although nothing powered through the grid is entirely carbon-neutral, high-speed trains produce no direct emissions. "In the United States, some people are commuting to and from work over 200 miles a day using expensive fuel on dangerous highways," says Rod Diridon, chair emeritus of the California

High-Speed Rail Authority. "We're going to have a tough time meeting any reasonable standards of pollution control if we continue to rely upon automobiles and short-hop airlines for our transportation needs."

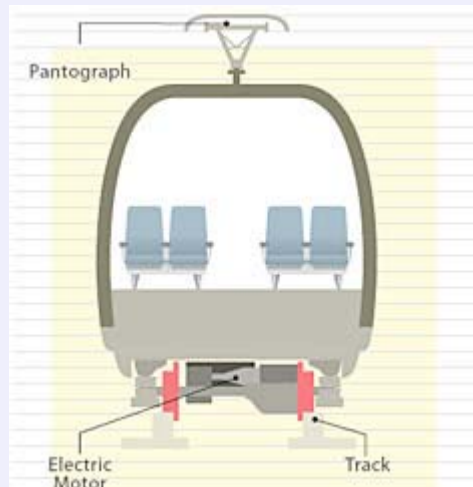
Building high-speed train routes in the U.S. would not be easy or cheap. Almost every proposed route faces some sort of political fight, and, depending on who you ask and what technology you're considering, the cost per mile of high-speed rail is anywhere from \$5 million to \$100 million. However, more and more transportation engineers and city planners are starting to see high-speed rail as the only rational way to ease the strain that booming populations are placing on their already overwhelmed infrastructure. "By 2035, the six counties in the Los Angeles region will add roughly 6 million people—that's the size of two Chicagos—to the 18 million residents already living here," says Richard J. Marcus of the Southern California Association of Governments. "How are all those people going to get around?"

As our current transportation infrastructure groans under the stress, the idea of high-speed trains is starting to catch on. Eleven existing railway corridors in the U.S. are undergoing improvements for an upgrade to high-speed steel-wheel rail. Some of the most advanced, such as those in California, may be running trains as fast as 170 mph within 11 years. In addition, there are several maglev projects in development—one connecting the Pittsburgh airport and city center; another between Atlanta and Chattanooga, Tenn.; and a third that would link Baltimore and Washington, D.C. While some maglev proposals have mini-mal support, others are being promoted by well-organized, politically connected operations. The most ambitious is the California-Nevada Interstate Maglev Project described earlier.

## Reinventing Rail

There's more than one way to make a train go fast. High-speed steel-wheel rail technologies are already in service in 13 countries, with several more projects in development. As for maglev, electromagnetic suspension (EMS) tech is just beginning to enter the marketplace. Electrodynamic suspension (EDS) is still experimental. (Diagrams by Dogo)

### Steel-Wheel

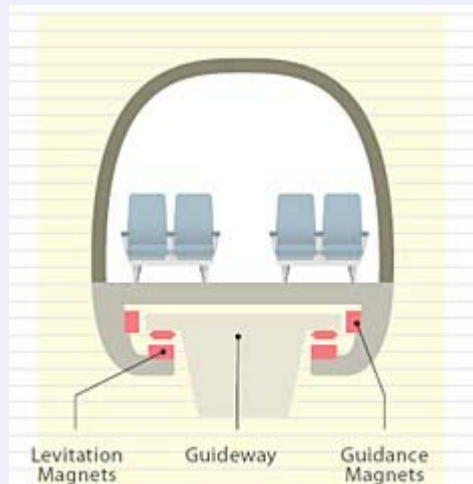


**Electric Power:** Overhead lines supply steel-wheel trains with 12 to 25 kilovolts of power, which is transmitted via an articulated arm known as a pantograph.

**Motor:** High-speed trains use AC traction motors and mechanical transmissions similar to those found in most electric trains.

**Track:** Wheel flanges lock trains to the rails. High-speed trains must run on tracks with wide curves or employ a hydraulic tilting mechanism.

### Electromagnetic Suspension

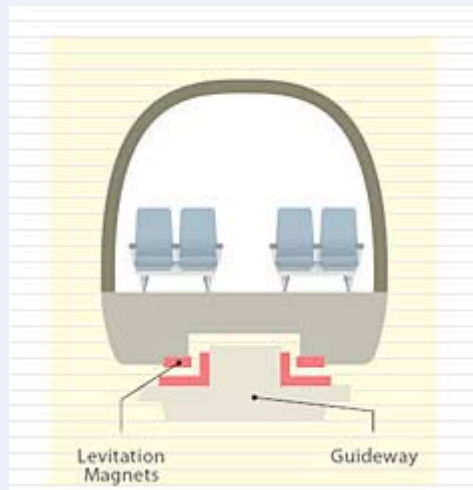


**Levitation:** The EMS train chassis wraps around the guideway. Upward-facing levitation magnets pull the train upward toward the track.

**On-Board Magnets:** Complex electronics constantly monitor the amount of current in the train's guidance magnets to maintain a gap of just 38 in.

**Propulsion:** The underside of the guideway acts as a long, electromagnetic stator, which creates a traveling field to pull the train forward.

## Electrodynamic Suspension



**Levitation:** EDS trains are suspended above the guideway by repulsive forces that build up as the train's magnets move past levitation coils in the track.

**On-Board Magnets:** Older systems use on-board cryogenically cooled superconducting magnets, while the General Atomics system uses permanent magnets in what's known as a Halbach array.

**Propulsion:** A second set of propulsion coils in the guideway pulls the train forward with alternating current.

The technology for conventional steel-wheel high-speed trains is well-established. All high-speed rail trains are electrically powered, drawing current from overhead power lines. They operate on tracks carved into the landscape with wide-radius turns and grades that max out at about 5 percent. Although high-speed rail trains can travel on standard tracks, the Federal Railroad Administration has ruled that trains traveling faster than 125 mph must operate on tracks with no grade crossings—meaning no intersections with public roadways.

There are two main “flavors” of maglev technology: electromagnetic suspension (EMS) and electrodynamic suspension (EDS). In EMS designs, the train chassis wraps around a guideway and, when current is applied to the rail, the train rises. With EDS technology, the train does most of the heavy lifting, as powerful magnets in the chassis generate an opposing force against conducting plates in a guideway. Each technology has its advantages and drawbacks: EMS trains can levitate at a standstill, but require a lot of sophisticated electronics to monitor and adjust the gap between train and track. EDS trains require less on-board intelligence—they’re “basically a dumb vehicle on a smart track,” explains General Atomics’ Guroi—but they need to build up speed on wheels before they can lift off the guideway.

Almost all of the maglev projects in the U.S. are based on the more established EMS technology by Transrapid International, the German company behind the Shanghai and the planned Munich maglev projects. EDS designs, on the other hand, are in the experimental stage. But the technology for both systems is still evolving. For example, the General Atomics test vehicle I rode on is an EDS design using magnets arranged in a pattern known as a Halbach array to achieve liftoff at walking speeds. MagneMotion, in Acton, Mass., is developing a hybrid EMS design that dispenses with much of that technology’s on-board electronic monitoring in favor of permanent magnets.

Maglev trains are capable of 300-plus-mph cruising speeds, but with current steel-wheel trains already passing 200 mph, is maglev really necessary? Maglev proponents argue that it is easier to maintain—most designs do not include wheels, transmissions, brakes or axles, thus reducing the need for repairs. “Engineers joke that the only moving parts are the doors,” says Richard Thornton, MagneMotion’s CEO. But maglev’s skeptics argue that lower maintenance costs are just speculation, since there aren’t enough commercially operating tracks to know what real-world performance would be. But mostly, critics of maglev point to its enormous expense. “Maglev routinely costs three to four times what is projected,” Diridon says.

In the end, the fate of high-speed trains in America will come down to money and politics. Federal funding comes and goes depending on the priorities of different branches of government. “We’re not really pushing high-speed rail,” says Steven Klum, of the Federal Railroad Administration. “This administration believes that money would be better spent on more immediate concerns, such as highways, transit and airports.” And Congressional appropriations for high-tech train projects often get labeled as pork. The proposed California-Nevada maglev line is a pet project of Senate Majority Leader Harry Reid—and an article last year in *BusinessWeek* painted a picture of the Nevada senator financing a popular local project with millions of federal dollars.

It does seem evident, however, that for trains to remain relevant in the U.S., they’ll have to go fast enough to release the pressure on short-haul air traffic in crowded corridors. Since the development timeline for high-speed trains is so long, many railway authorities are pursuing short-term technologies to make trains on existing tracks faster. Positive Train Control systems from companies such as General Electric use GPS positioning data to maintain distances between trains and to automatically stop trains in emergencies. These systems are already used in freight trains (PM covered cutting-edge freight-train tech in Jan. ’06) and could allow passenger trains to operate safely at speeds up to 150 mph—a far cry from the speeds of the world’s fastest trains, but at least a step in that direction.

A few hours after my ride on the experimental maglev track, I find myself back in the real world behind the wheel of a rental car, baking in bumper-to-bumper traffic on Interstate 5. As I fret about getting to the airport on time, I wonder how many other drivers around me are wishing there was a more efficient way to travel. There may be a better way—I just tried it.