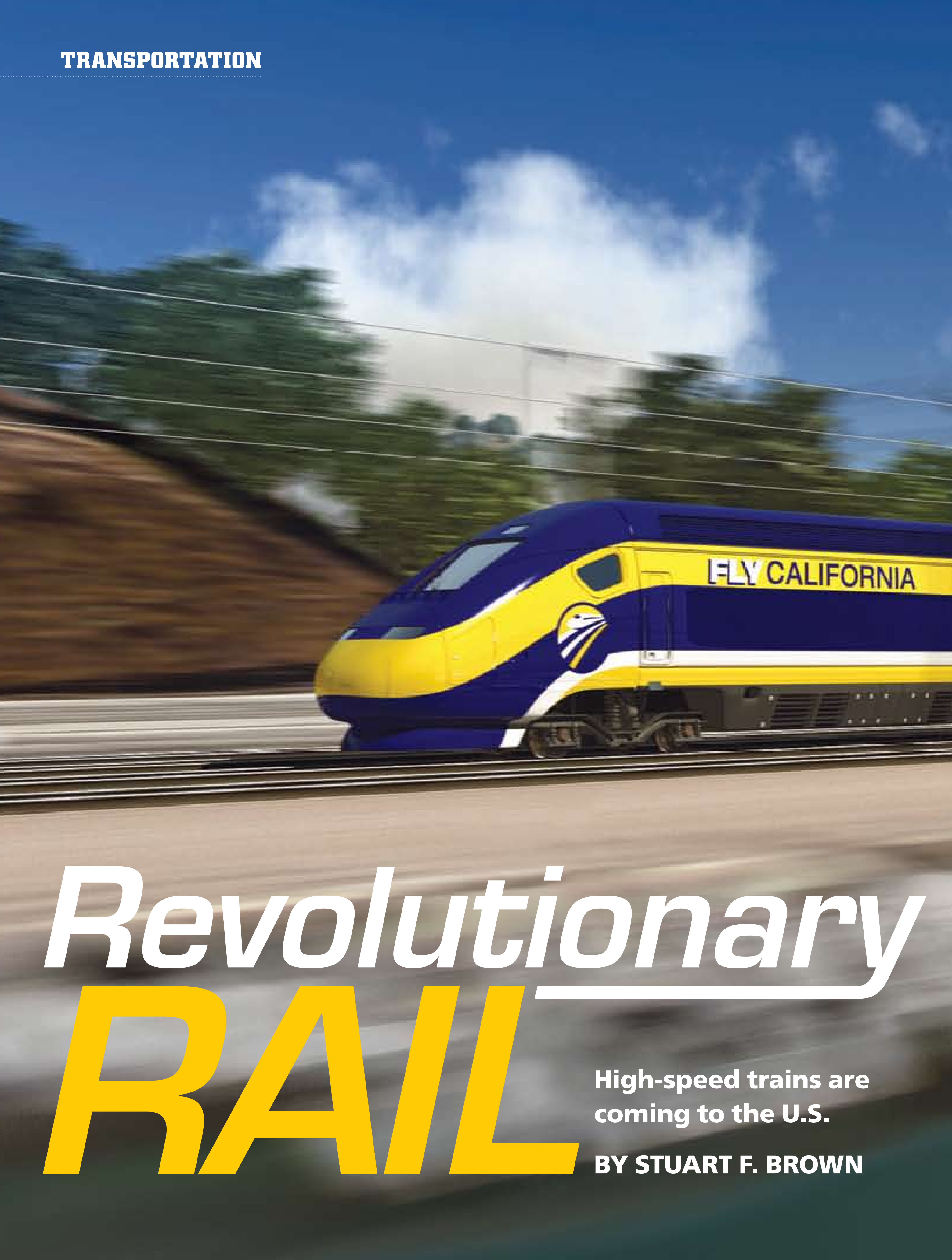


Revolutionary RAIL

High-speed trains are coming to the U.S.

BY STUART F. BROWN

FAST LANE: CALIFORNIA'S **planned high-speed line, shown here in an artist's impression, will likely be the first true high-speed rail line to be built in the U.S. With more than $11 billion in financing secured, construction could begin as early as next year.**

America is an absurdly backward country when it comes to passenger trains. As anyone who has visited Europe, Japan or Shanghai knows, trains that travel at nearly 200 miles per hour have become integral to the economies of many countries. With its celebrated Tokaido Shinkansen bullet trains, Central Japan Railway has for the past five decades carried billions of passengers between Tokyo and Osaka in half the time it would take to fly [*see box on next page*]. A new Madrid-to-Barcelona express train runs at an average speed of 150 miles per

KEY CONCEPTS

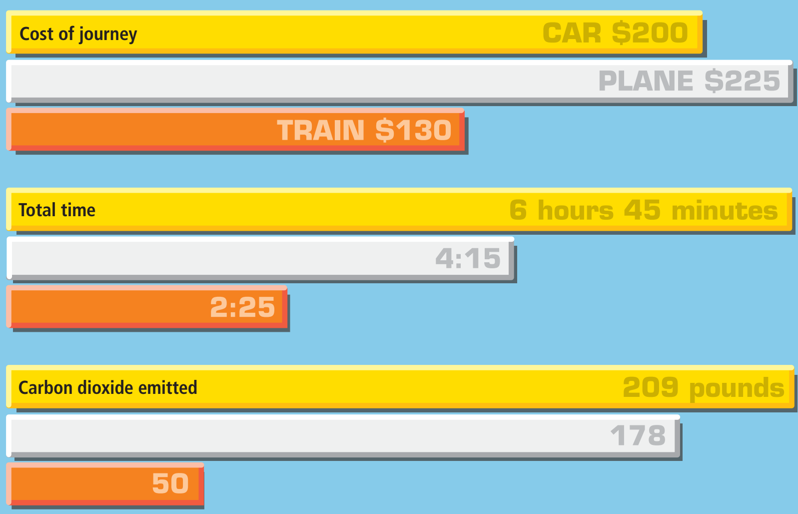
- Unlike Japan, France and other countries, the U.S. has no true high-speed train lines.
- A recent influx of federal money is spurring hope that long-planned projects could finally be built.
- Such projects include both steel-wheels-on-rails and magnetic levitation technology.

—The Editors

[HEAD-TO-HEAD]

The Benefits of Rail

The rail line that stretches the 320 miles between Tokyo and Osaka in Japan demonstrates a few of the benefits of high-speed trains. The figures below all refer to a one-way trip between the central business districts of each city.



SOURCES: U.S. Government Accountability Office, Reuters, Bureau of Transportation Statistics, Japan Central Railway.

▲ ALTERNATE ROUTE: **Japan's Tokaido Shinkansen bullet trains carry 150 million passengers every year.**

hour; since its inception two years ago, airline traffic between the two cities has dropped by 40 percent. In contrast, Amtrak's showcase Acela train connecting Boston to Washington, D.C., averages just 70 mph. That figure is so low because many sections of the Acela's tracks cannot safely support high speeds, even though the train itself is capable of sprints above 150 mph. Think of it as a Ferrari sputtering down a rutted country lane.

There has been a recent push to change all this. Earlier this year the Department of Transportation announced the recipients of $8 billion in stimulus funding designed to spread high-speed rail across the U.S. The 2010 federal budget requests an additional $1 billion in rail construction funds in each of the next five years. And in 2008 California voters approved a $9-billion bond measure to initiate an ambitious high-speed rail network that would connect Los Angeles to San Francisco and, eventually, Sacramento and San Diego.

Questions remain, however, about exactly what kind of passenger system will be built. In the decades since the federal government last pursued rail as a viable way to transport passengers—not just freight—train technology has advanced significantly, with advanced high-speed lines spreading through Europe and, more recently, across mainland China.

And what exactly qualifies as "high speed" by the guidelines of the stimulus funding is open to interpretation. Federal authorities, eager to spread the wealth to as many congressional districts as possible, are financing a bevy of incremental improvements to existing lines. In many cases, these projects will only marginally increase passenger rail speeds.

On the other end of the technological spectrum, some efforts aim to bypass wheels-on-rail systems by using magnetic levitation, or maglev technology, in which passenger cars float above a concrete guideway. Momentum for the technology comes in a number of forms. Although maglev trains have been in development for decades, the first (and, thus far, only) commercial system entered service in 2004. For mountainous regions of the U.S., the technology represents the only viable solution to the problem of steep gradients that would otherwise cripple standard rail lines. And perhaps most important, the technology has received a stunning vote of confidence from the world's foremost experts in building and operating commercial high-speed passenger rail lines.

The Maglev Option

The Central Japan Railway (CJR) has by far the world's largest body of experience in operating high-speed trains, having run the sleek wheels-on-rail Shinkansen bullet trains connecting the population centers of Tokyo, Nagoya and Osaka since 1964. Yet the realities of running the bullet system are now spurring CJR's interest in maglev. Every night a marching army of 3,000 railway workers descends on a 12-mile section of Shinkansen track, scrutinizing the rights-of-way, replacing worn components and assuring precision alignment of the rails. The following night they labor on the next 12-mile section of track. The work never ends.

The company must invest all this costly effort because even small imperfections in the tracks can trigger serious vibrations in the speeding trains. These vibrations, in turn, increase wear and tear on the infrastructure. The deterioration of rails, train wheels and the overhead catenary wires supplying electricity to locomotives increases exponentially with the train's running speed. Truly high-speed rail turns out to be murder on the hardware. If the nighttime maintenance work on the Shinkansen line takes longer than expected, its 309-train daily schedule is thrown into chaos.

Hoping to avoid such difficulties, the company plans to construct a high-speed maglev line called the Tokaido Shinkansen Bypass, which it aims to complete by 2025. Although this would not be the world's first commercial maglev line—a 19-mile shot connecting Shanghai's airport with its financial center opened in 2004—at 180 miles, it will be by far the most ambitious. Yoshiyuki Kasai, CJR's chair, told a gathering of transportation officials in Washington, D.C., last June that maglev would be less expensive than traditional high-speed rail in the long run because of less costly upkeep demands over the life cycle of the system. CJR also says maglev promises to reduce trip times because the trains accelerate and slow down much more rapidly than wheel-on-rail trains can.

More significant for the prospects of maglev technology in the U.S., maglev propulsion allows trains to climb much steeper gradients than standard high-speed rail lines can. It is the only way fast trains could pass through much of the western U.S.'s jagged terrain.

The problem for classic technology is traction. Locomotives' steel wheels can maintain only so much adhesion to steel rails before they start to slip, and the train stalls. Common and unpredictable conditions such as rain, snow, ice and even wet leaves place a limit on the steepness of the grade a train can climb or safely de-

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[FUNDING]

THE FEDERAL EXPRESS

In January the government announced the recipients of $8 billion in stimulus funds for high-speed rail. The biggest individual slices went to true high-speed projects in California and Florida; the rest of the money will be used to incrementally improve passenger service on lines shared with freight trains. The colored lines below mark all projects awarded more than $25 million; the boxes highlight the five biggest winners.

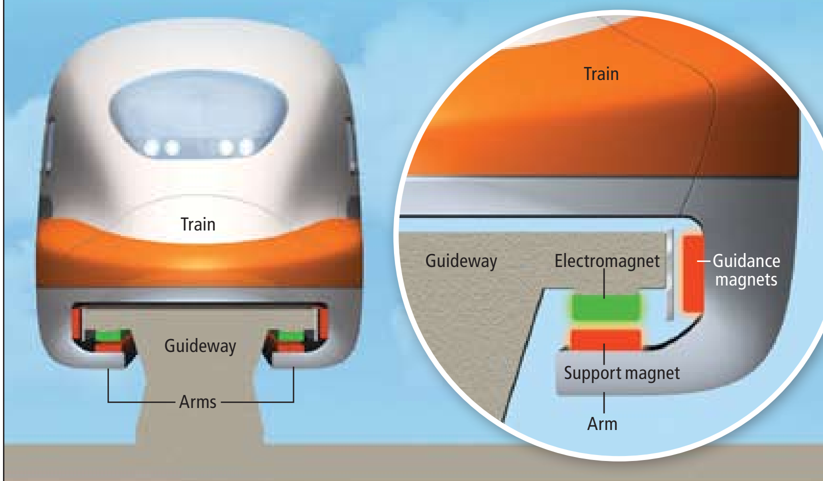
NILES A. JAEGER (Brown); JESSICA HUPPI (map)

[HOW IT WORKS]

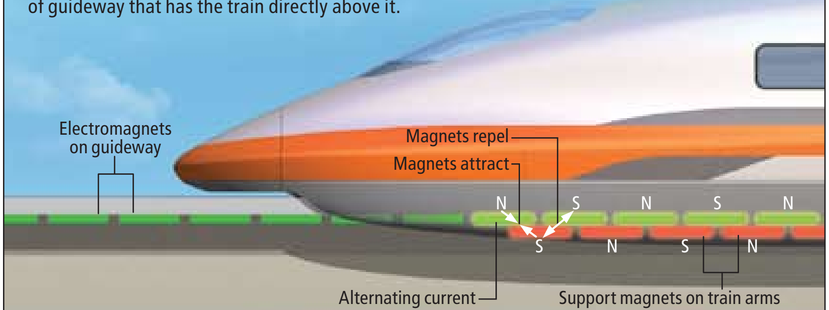
THE PULL OF MAGLEV

The Central Japan Railroad has announced that it will build a 200-mile-long line that will use magnetic levitation—or maglev—technology. Maglev systems employ magnetic fields to lift and propel trains above concrete guideways. Because it eliminates the friction between steel wheels and rails, the approach not only raises speeds, it significantly reduces wear on the system, leading to lower maintenance costs. Planners in Colorado, Nevada and California hope to bring similar systems to the U.S.

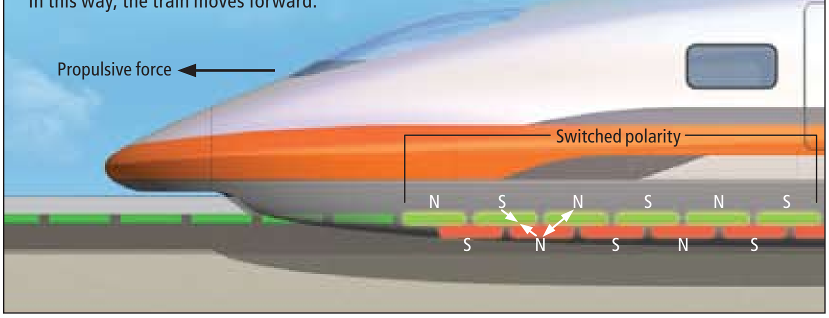
▼ **LEVITATION:** In a maglev system, arms on each side of the train reach around and below an elevated concrete guideway. Electromagnets on the underside of the guideway attract support magnets installed in the train's arms. Sophisticated control systems balance the weight of the train against the magnets' pull, keeping the train a constant distance from the track. In addition, guidance magnets on each side ensure that the train stays centered.



▼ **PROPULSION:** Old-fashioned trains have locomotives. In a maglev, the guideway does most of the work. Inside the guideway an alternating current creates a moving magnetic field that pulls the support magnets on the train's arms. By varying the frequency of the alternating current, the train can accelerate or decelerate as needed. The current goes through only the section of guideway that has the train directly above it.



A fraction of a second later, the alternating current in the guideway switches the polarity of the magnetic field. Magnets that pulled now push; magnets that pushed now pull. In this way, the train moves forward.



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scend. Because of this limitation, grades on railways in the U.S. are generally kept below 3 percent, and grade maximums of 2 percent or less are most common.

Maglev lines, in contrast, have no steel-on-steel contact, so traction does not pose the challenge it does on a wheels-on-rails line. Maglev lines can climb a 10 percent grade, which permits planners to select more expeditious routes when laying out new rights-of-way through hilly terrain.

The technology also allows for high-speed transport in areas that would otherwise remain impassable. The Rocky Mountain Rail Authority recently completed an 18-month study of building two intersecting high-speed train lines running along about 400 miles of Colorado's north-south and east-west interstate highways. It concluded that the trains need to be maglev, because some of the grades along the highways reach 7 percent. "You're going through the Rocky Mountains," says Harry Dale, the rail authority's chair. He also notes that because magnetic forces, not physical adhesion, propel and slow the train, Colorado's "snow and ice problem goes away."

Dale believes that the maglev trains built by Transrapid International, a joint venture of the German firms Siemens and ThyssenKrupp, could do the job. Transrapid is the manufacturer of the Shanghai airport system, which has whisked more than 17 million passengers from Shanghai to its airport at peak speeds of 267 mph. Transrapid's maglev trains use conventional electromagnets; the Japanese, on the other hand, have been researching technology that employs superconducting electromagnets not unlike those found inside the Large Hadron Collider. While the superconducting approach provides greater clearance between train and guideway as a precaution against earthquakes, the magnets must be cooled with liquid helium, an expensive and unwieldy proposition.

The Fast Route

Competing proposals for a passenger train line connecting Las Vegas to southern California further demonstrate just how important maglev technology can be. Urban planners have dreamed of linking Las Vegas to Los Angeles with fast trains for decades. "This is an ideal corridor for high-speed trains because you are connecting one of the biggest entertainment districts in America with southern California, one of the largest population centers," says engineer Thomas Bordeaux, senior transportation manager at Parsons Transportation, an engineering firm in Las Vegas. The cities are 270 miles apart—right in the sweet spot between 100 and 500 miles where train travel is more convenient than either driving or flying. And the land between those two cities is little more than sand and scrub, a blank canvas on which to paint the tracks.

Unfortunately, the Los Angeles basin is flanked to the east by the San Bernardino and San Jacinto mountain ranges. Any high-speed line penetrating these natural obstacles would have to scale grades of up to 7 percent, which is only feasible using maglev technology. The California-Nevada Super Speed Train project aims to do just that, connecting Las Vegas with Anaheim, a large city just south of Los Angeles.

The alternative to maglev technology is to avoid the L.A. basin area altogether. The DesertXpress, as the project is called, would build a traditional high-speed rail line that links Las Vegas to Victorville, a high desert outpost more than an hour and a half from downtown Los Angeles (this assumes no traffic, which is an anomaly in L.A.). While it would not require advanced technology, it also would not take passengers anywhere they would want to go.

The DesertXpress will also fail to connect to the planned California high-speed rail system that will link Los Angeles to San Francisco. The California project was one of the two big winners in this year's stimulus fund giveaway, along with an 84-mile route connecting Tampa and Orlando in Florida. When the stimulus money is combined with the $9 billion secured in the 2008 voter referendum, the California project will have in hand more than a quarter of its $40-billion projected total cost. Construction is likely to begin as early as 2011.

Exclusive Access

Regardless of whether maglev or conventional rail-on-wheels technology is used, an inviolable requirement for safe fast-train operation is having special tracks dedicated to the high-speed trains, no exceptions permitted. That is where Amtrak's pokey Acela line, which shares its route with freight and slower passenger trains, was born to fail.

Another necessity is laying out the track so that there are no grade-level crossings, which is where most crashes happen involving trains and road-going vehicles. Time and time again, people try to drive around a closed crossing gate to beat the train, or pedestrians who are unaware that oncoming locomotives project very little sound in front of them notice a train when it is too late to escape. Depending on a route's terrain, lots of overpasses, underpasses and tunnels may be needed to keep the rest of the world out of the exclusive path of the fast trains.

Why has it taken so long for the U.S. to get onboard with technologies that are already ripe? The short answer: passenger trains have not been a federal priority for quite some time. The nation spent decades building interstate highways and airports; investment in tracks suitable for fast trains dwindled to almost nothing. American railroads became almost exclusively low-speed haulers of heavy freight.

But the recent push for green transportation, along with the realization that the nation's highways and airports are already operating past capacity, could bring fast trains into vogue—at least in a few key regions of the country. ■

GEORGE RETSECK

[COST COMPARISON]

Maglev vs. Traditional High-Speed Rail

The existing and planned high-speed train projects listed below demonstrate that the cost of a project depends greatly on individual circumstances. The most important factors include the terrain the line must pass through (mountainous areas are more costly), how densely populated the area is, the cost of labor, and the technology being used.

Line	Estimated construction cost per mile (millions)	Status	Technology	Length (miles)
Yatsushiro to Kagoshima	$82	Completed 2004	Wheels on rail	79
Barcelona to Madrid (*pictured above*)	$39	Completed 2008	Wheels on rail	468
Los Angeles to San Francisco	$63	Proposed	Wheels on rail	520
Las Vegas to Victorville	$22	Proposed	Wheels on rail	183
Las Vegas to Anaheim	$48	Proposed	Maglev	269
Baltimore to Washington, D.C.	$132	Proposed	Maglev	40

➡ MORE TO EXPLORE

High Speed Passenger Rail. Report of the U.S. Government Accountability Office, GAO-09-317, March 19, 2009. **www.gao.gov/products/GAO-09-317**

The Third Way: Will a Boom in Government Investment Bring True High-Speed Rail to the U.S.? Michael Moyer in *Scientific American*, Vol. 301, No. 2, pages 15–16; August 2009.

California High-Speed Rail Authority Web site: **www.cahighspeedrail.ca.gov**

Transrapid maglev technology demonstration: **http://bit.ly/transrapid**