Spanish high-speed transportation technology is setting the pace for innovation on a global scale.
Innovation in Motion

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SPAIN ON THE FAST TRACK
HIGH-SPEED TRAIN AND TRANSIT INNOVATION

HIGH-SPEED TRANSPORTATION
The Madrid to Barcelona high-speed rail line opened in early 2008, and traverses 390 miles in only two hours and 38 minutes. In its first year, the line captured more than 50 percent of the travel between the country’s two major economic centers, and significantly reduced the number of daily flights between the cities. Since then, Spain’s rail authority has continued expanding the network, in 2010 completing the connection between Madrid and the coastal city of Valencia.

Joaquin Jiménez, the director of international relations for Spain’s rail administration (the Spanish acronym is ADIF), highlights the fact that Spain has more than 900 miles of high-speed rail under construction or in the planning process. “Developing high-speed rail remains a main objective in Spain,” says Jiménez.

According to Michael Clausecker, director of UNIFE, Spain has the most modern fleet of high-speed trains in Europe. The country has also been the first to have its high-speed network fully equipped with the latest signaling system, ERTMS, which will eventually become the unique signaling system for the entire European high-speed system and its international rail corridors, facilitating greater interoperability among different countries.

Spain and France are linking their two countries with a new high-speed line between Perpignan and Barcelona, which will dramatically reduce cross-border travel time. The engineering company Sener was involved in designing this line; despite the relatively short distance, the firm encountered a number of complications, among which were reconciling the two different control systems and two different electrification standards.

“We are living in a very important moment in the development of railways,” says Ignacio Barron, director of the high-speed department of the International Union of Railways. He compares today’s high-speed expansion to the original expansion of rail in the second half of the 1800s: “These developments are being prepared not only for us today; in fact we are preparing transportation for our children.”

As high-speed trains become more common around the world, the companies that sell those trains continue to do research to improve them, says Barron: They’re focusing on minimizing noise, lowering the cost of maintenance, and reducing the maximum load to make trains lighter, more aerodynamic, and more energy efficient.

These goals also motivate Spain’s train manufacturing company CAF, where engineers at its three-story R&D center devote them-
selves to rail innovations. CAF has developed trains that include a number of technological advances. They can switch between Spain’s wider track width and the usual European width; they’re increasingly light, contributing to energy savings; and they operate with reduced vibrations and noise, reducing the impact on the people and ecosystems that the trains pass.

CAF’s experience with trains of all kinds has translated into international success. CAF is supplying metro, tram, light rail, commuter, and regional trains to cities and countries that include Edinburgh, Stockholm, Belgrade, Turkey, Houston, and Sao Paolo. CAF has focused particularly on developing electric trains for tramways that can run without overhead power lines, or catenaries. Instead, they created an onboard energy-storage system, with high-speed recharging and a method for capturing the energy generated during the braking process.

CAF’s new high-speed train, called Oaris, was designed collaboratively by CAF’s research center and Spanish universities and technology centers, who labored to create an advanced train body that is fast, light, energy efficient, comfortable, and customizable for client needs. It is fully interoperable across borders, bridging differences of voltage, signaling systems, and track gauges.

President Obama’s 2011 State of the Union speech depicted a vision where 80 percent of Americans would have access to high-speed rail within 25 years; and his 2012 budget includes $8 billion for high-speed rail. Soon after President Obama’s address, Vice President Biden announced a $53 billion six-year project to continue construction of high speed and intercity passenger rail.

The railway vehicle manufacturer Talgo, capitalizing on more than 70 years of experience in the rail sector, has supplied high-speed trains to Oregon and Wisconsin. These can operate on existing rail lines at a significant improvement in speed. As Talgo’s market development director Mario Oriol explains, the company sees this as a way to reinforce Talgo’s presence in the United States market and prepare for improvements in rail that could lead to high-speed lines.

“These trains use advanced technology with lightweight construction, independent wheels, and an independent tilting system—which means that the trains adapt well to existing infrastructure,” says Oriol. “If you can use such a train to improve travel time by 20 percent, this can give planners the justification to invest in future infrastructure.” In addition to supplying trains throughout the Spanish high-speed system, Talgo is also currently providing tilting passenger coaches to the governments of Bosnia-Herzegovina and Kazakhstan and high-speed trains to the Republic of Uzbekistan.

Talgo’s trains leverage advances in materials and engineering, which make the trains lighter and more energy efficient, more stable, and more comfortable. These advances will continue in the new Avril train, currently under development. Avril will be comfortable and energy efficient and will run at some of the highest speeds possible, and its wider body will accommodate an additional seat in each row. “It’s a natural evolution based on Talgo’s high-speed technology,” points out Oriol, adding that the company will build mock-ups and should have a prototype by about 2013.

“High-speed has become fashionable in [the] U.S. Many projects and studies have been carried out in order to develop rail in several corridors,” says Barron. High-speed rail has grown in Japan and in Korea and has exploded in China, he continues. Poland is developing a new high-speed railway connecting four major cities. The Spanish engineering company Idom is part of a joint venture to analyze a potential layout for the railway, develop a proposal for the system, and plan its construction.

**LINES UNDER CONTROL**

Controlling a complex and rapidly changing transportation network demands total integration, which a program called DaVinci, designed by the information company Indra, supplies for Spain’s network. DaVinci incorporates data that includes trains, signaling, energy inputs, timetables, and so on, and, with added algorithms to predict future delays or changes to the trains, allows the control room to easily manage the entire system in real time.

Indra first took its control experience overseas to the metro of Medellin, Colombia. The metro had been in operation for 15 years, running off what at the time was advanced metro technology. But the existing system was expensive to maintain, could not be scaled up to meet the needs of a growing...
“One of the great advantages of DaVinci is that it can meet all those needs,” says Antonio García, Indra’s business development manager. “It can use any physical technology, or any information technology—IBM, HP, Oracle, whichever—that’s available in the market.”

Indra worked with the Colombian metro authority to design a system that would integrate all existing information available for the Medellín metro (including traffic, communication, energy, and related systems), and process it to allow for more automated control. This allowed Medellín to add trains to existing lines and build additional stops, all at a significantly reduced cost. Indra is now working with London’s transportation system to expand and improve the management of its infrastructure as well.

Indra is also bringing DaVinci to Lithuania. The government of Lithuania wanted to upgrade its system and expand the number of trains running along its routes. They too turned to Indra because the DaVinci system can integrate the information from the existing technology and process it automatically, without the need to buy additional hardware.

“From now on, they will be able to grow as much as they need to grow, wherever they want, and they can choose whichever technology they’d like,” says Desirée Meza, a senior engineer in Indra’s railway infrastructures division. “They will not need to change an entire system” to achieve significant improvements.

MADRID’S INNOVATIONS

In 1919, at the opening of Madrid’s new subway system, the entire track covered only two miles. Less than a hundred years later, the tracks have expanded to more than 175 miles in total, covering 12 nearby towns. These advances have garnered the Madrid Metro Authority a number of awards, including one for innovative use of technology awarded in 2009 at the international Metro Rail Forum.

Madrid Metro underwent a complete overhaul, implementing the most advanced technology, such as automated trains, and more than doubling the length of its tracks. After two major periods of renovation and expansion, more than 75 percent of citizens in the region live within easy access of a station, and half of all trips in the city are taken on public transportation.

Madrid Metro developed its own in-house research program, and it cooperates with Spanish and Latin American universities and companies to create technologies both for its own system and for export to other metros. They worked with the Polytechnic University of Madrid and Indra to create a new driver-training simulator that significantly cuts down on track-based driving practice while ensuring that new drivers achieve equal or greater competency. Madrid Metro has also developed advanced fixed overhead electric lines that allow trains to increase their maximum speed by 25 percent.

These new power lines have also been implemented in the Dominican Republic, on Santo Domingo’s new metro line, for which Madrid Metro was a primary consultant. Madrid Metro has taken its expertise to a number of other cities around the world; in addition to Santo Domingo, the authority has consulted or provided services to cities that include Buenos Aires, London, Quito, and Tunis.

After the bombing at its Atocha station in 2004, Madrid’s local transportation authorities invested heavily in state-of-the-art security and surveillance systems for its updated metro systems. As a result, says director Aurelio Rojo, the Madrid Metro network has 100 percent video surveillance coverage, and the system includes the most advanced security technologies in the world.

The engineering company Sener, which partially oversaw project development and management for both the Madrid and Barcelona metros, has also expanded throughout Europe, works in Qatar and in Mexico, and is now participating in a study for the new subway system of Bogotá, Colombia.

AN AUTOMATED RIDE

In the first car of Barcelona’s new driverless subway lines, passengers perch by the window and watch as the train rushes along the tracks and dips into tunnels. Far from inspiring fear of a lack of safety (a common concern for planners of driver-free lines), the conductor-free trains have become something of a tourist attraction.

Barcelona’s system attracted more than 1,200,000 riders a day in 2010, for a total of more than 381 million passengers over the year. Its five percent growth over 2009 was sparked
by both improvements to existing lines and the implementation of new ones—in particular three automated lines put in place during 2009 and 2010. (Two lines were entirely new; the third was an existing line that was transformed into an automatic one.)

Barcelona Metro has hosted about 800 visits from governments of different cities and countries. The municipality has taken its experience overseas: the authority is serving as an advisor to the government of Panama, which is designing that country’s first subway line, and to the mass transit administrations in Santiago de Chile, Buenos Aires, Bogotá, and other South American cities.

Madrid Metro, which more than doubled its track mileage and capacity in recent years, also implemented a new automatic system on three of its lines, and today serves about 2.5 million passengers a day. The implementation of these advances allowed Madrid to significantly and safely increase the number of trains on each track, with less wait time between trains.

Automatic train-operating systems are attractive to transportation planners for a number of reasons: they demand fewer staff resources, they’re safer than traditional trains, and the trains can run more frequently, with greater accuracy and less wear on the equipment. Creating lines with the new signaling system has also allowed the transportation authority to keep lines running for extended hours during special events or festivals, without a significant increase in cost.

“Currently in the mass transit market, we are facing a high demand for an increase in capacity,” explains Beatriz Muñoz, product line manager for the rail control and signaling company Dimetronic, involved in the development of the Barcelona and Madrid lines.

In the past, driverless trains operated on tracks equipped with detectors to determine whether a train was on top of that particular segment. The latest system that Dimetronic and other companies have developed is called communication-based train control (CBTC) and involves constant radio communication between the track and the train. With this system, the control center is aware at all times of the exact location of every train, and can communicate directly with the train in real time to avoid dangerous situations. This technology also involves energy-saving algorithms, such as one that detects a downhill gradient and instructs a train not to accelerate, since the downhill slope will accelerate the train without any increase in power. CBTC-controlled trains can increase the capacity of a given line up to about 30 percent more passengers per day.

The first line in Madrid to be controlled by CBTC technology began running in October 2010. Dimetronic is also involved in creating a new line powered by CBTC in Sao Paolo, Brazil, which is slated to open by the end of 2011; another in Caracas, Venezuela; and a totally unmanned line in Singapore.

Not long ago, Sener was asked to evaluate the problems that were plaguing an overcrowded subway line in Santiago de Chile, in Chile. The government found itself having to temporarily close down stations, because there was simply no more room for passengers. One long-term solution may be to build a parallel line, but in the short term, Sener engineers have found that more trains can be added by introducing a driverless system and automating the line. This has increased the line’s capacity without the need for expensive new construction.

POWERING THE SYSTEM

A major concern for local transportation authorities and companies involved in rail is how to cut down on energy use, and how to recover available energy. Ingeteam, an electrical engineering company, has a division devoted to rail, from light rail and subways to high-speed trains. The company can supply a train’s entire power system, including the motor, its controls, power electronics, and onboard electrical solutions.

The company’s latest innovation offers a novel method to capture the energy expended by braking at the station. “Usually, that energy can be captured by the electrical lines and fed into another train that needs energy,” says Angel Laurrieta, CEO of Ingeteam’s traction division. “But that situation doesn’t always occur, because there isn’t always a match between a braking and accelerating train.”

So to avoid wasting braking energy—of particular interest to city-based metros and regional trains—Ingeteam engineers designed a system that directs the energy straight into the rail’s electrical system and allows it to be used by any other part of the same system. “This can supply about 10 percent of the total energy needs for the train,” says Laurrieta. The system works in parallel with any existing physical setup, extracting the energy and routing it to other uses within the network.

“This is incredibly important,” points out Laurrieta. “Rail administrations are quite conservative,” and are interested in new technologies that obviate the need to change existing hardware.

The system has thus far been in operation for a year in the metro system of Bilbao, in the north of Spain. Ingeteam has attracted interest from public transportation systems in the U.S. and in other cities in Europe and Latin America.

Spain’s rail expansion continues to attract visitors from around the world. Jiménez highlights ADIF’s collaboration with countries like Russia, Turkey, and Poland as they develop high-speed lines, noting that ADIF has also played an advisory role to the state of California’s rail planning efforts. Clausecker adds that UNIFE regularly brings representatives from Eastern European countries, such as Poland, Romania, and the Czech Republic, to Spain to learn from the Spanish system. As Clausecker concludes, “Spain is a role model for infrastructure investments.”
RESOURCES

ICEX (Spanish Institute for Foreign Trade)
www.spainbusiness.com
www.spaintechnology.com

ADIF (Spanish rail administration)
www.adif.es

Barcelona Metro
www.tmb.cat

CAF
www.caf.net

Dimetronic
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Idom
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www.mafex.es

Sener
www.sener.es

Talgo
www.talgo.com

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