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Spanish High-Speed Train Crash Offers Safety-System Lessons

The tragic incident has brought a decades-old Spanish success story crashing to a halt

By Lucas Laursen | Friday, July 26, 2013 | 1 comments

The driver of the high-speed train that derailed July 25 at a sharp curve in Santiago de Compostela, Spain, killing at least 80 passengers and injuring 130 more, told controllers he took the curve at around 190 kilometers per hour, despite an 80 kph speed limit. He survived the crash and is now under investigation by local authorities. Even if the driver turns out to have been responsible for speeding, rail passengers might wonder what else had to fail in the safety system to allow one man's error to harm so many people.

Image: Flickr/Contando Estrelas

The crash is the first fatal accident of a high-speed train in Spain, which launched its high-speed network in 1992 and now serves around 100,000 passengers a day. Authorities have not yet assigned it a cause, but it may turn out to be an anomaly. "The most common [reasons for a derailment are] problems with the track or rail and equipment," says mechanical engineer George Bibel at the University of North Dakota, author of *Train Wreck: The Forensic of Rail Disasters*. Whereas train accidents from Connecticut to France have made news lately, derailments are a declining threat, at least in the U.S., where they dropped about 90 percent from 1976 to 2011.

The decline has resulted in part from improved monitoring of aging infrastructure such as rails, wheels and bearings, Bibel says. Spanish media reported that the tracks on which this train was running were not designed for the fastest class of high-speed trains. The implication is that the tracks may somehow have contributed to the accident. Lower-grade tracks do vibrate more and wear down faster. And using the same tracks for multiple types of trains, such as high-speed, longer local passenger trains, or even freight, may also promote uneven metal fatigue. Changing temperatures or wet tracks can combine with worn-down train wheels or uneven loading of a train to promote a derailment. Yet things as basic as regular inspections of hot spots with an infrared sensor or of metal fatigue with an ultrasound sensor can alert rail operators to aging infrastructure.

Higher-tech control systems are also emerging. Both the U.S. and Europe are adopting semi-automated braking systems designed to take over from speeding drivers. The track at the accident site, which was very close to the station, used older-generation signaling technology called ASFA, which alerts the driver to upcoming speed restrictions but cannot override his or her control. The Madrid-Barcelona high-speed train line, in contrast, uses the Level 2 European Rail Traffic Management System (ERTMS), which can override the driver. The train drivers union announced that the tragedy "could have been avoided" if ERTMS had been installed on that stretch of track. Even if that is true, Spain already has one of the highest ERTMS deployments in Europe. In the U.S., rail authorities have warned that they are unlikely to complete a legislated upgrade to similar technology in time for the 2015 deadline.

And Bibel points out that no automatic braking system can cover every scenario: "There's been technology to stop trains since the 1920s but one of the problems is you can't stop a speeding passenger train the same as a 150-car heavy freight train." That hasn't stopped researchers from trying. The U.S. Department of Transportation is conducting work on algorithms that would develop a dynamic custom braking profile for each individual train based on its load (pdf). That might improve automatic control systems, although the performance would still depend on local track conditions, which may be harder to account for.

The high rate of death and injury in the Santiago accident is also anomalous. Derailments tend to be less harmful than collisions, Bibel says, unless they occur on a mountainside, over water or near something into which the derailed train can collide. That is, unfortunately, what happened at the curve in Santiago. The 10-car train skipped the rails, the locomotive began rolling over, and then the train slammed into a concrete retaining wall (video).

Survivors, such as American Stephen Ward, called themselves lucky, and relative to the dead and injured, they are. Yet all the passengers were unlucky in that several systems failed. The train's still-unexplained speed, the lack of a sufficiently sophisticated braking system, and the derailment next to a concrete wall all contributed to the deaths and injuries.

But not all system failures—or solutions—are technological. “The problem is that you are setting up people to fail,” says railroad systems engineer Felix Schmid, of the University of Birmingham, in the England. “You have a very-high protected railway connected virtually straight into a less-protected railway.” The shift is similar to a car driver exiting smooth traffic on a highway for the less predictable gridlock of a city center. “It's the change from low demand to high demand which is sometimes quite difficult to manage,” he adds.

New York City's Metropolitan Transit Authority learned to cut open-door accidents (in which doors open mistakenly when trains are not safely parked at a platform) by adopting a Japanese human-factor innovation: requiring drivers to signal by hand when they reached the appropriate platform marker for opening the doors. The requirement ensured drivers were paying attention to the shift from low-demand cruising to the more demanding platform stop. Japan also claims to have carried 9.2 billion passengers on its high-speed trains between 1964 and 2009 without a single fatality. That's a standard to which Spain and all other high-speed rail operators can aspire.

Bibel is optimistic that derailments such as this week's shouldn't discourage future high-speed rail projects: "These kinds of accidents have been happening forever. Thankfully they're rare."