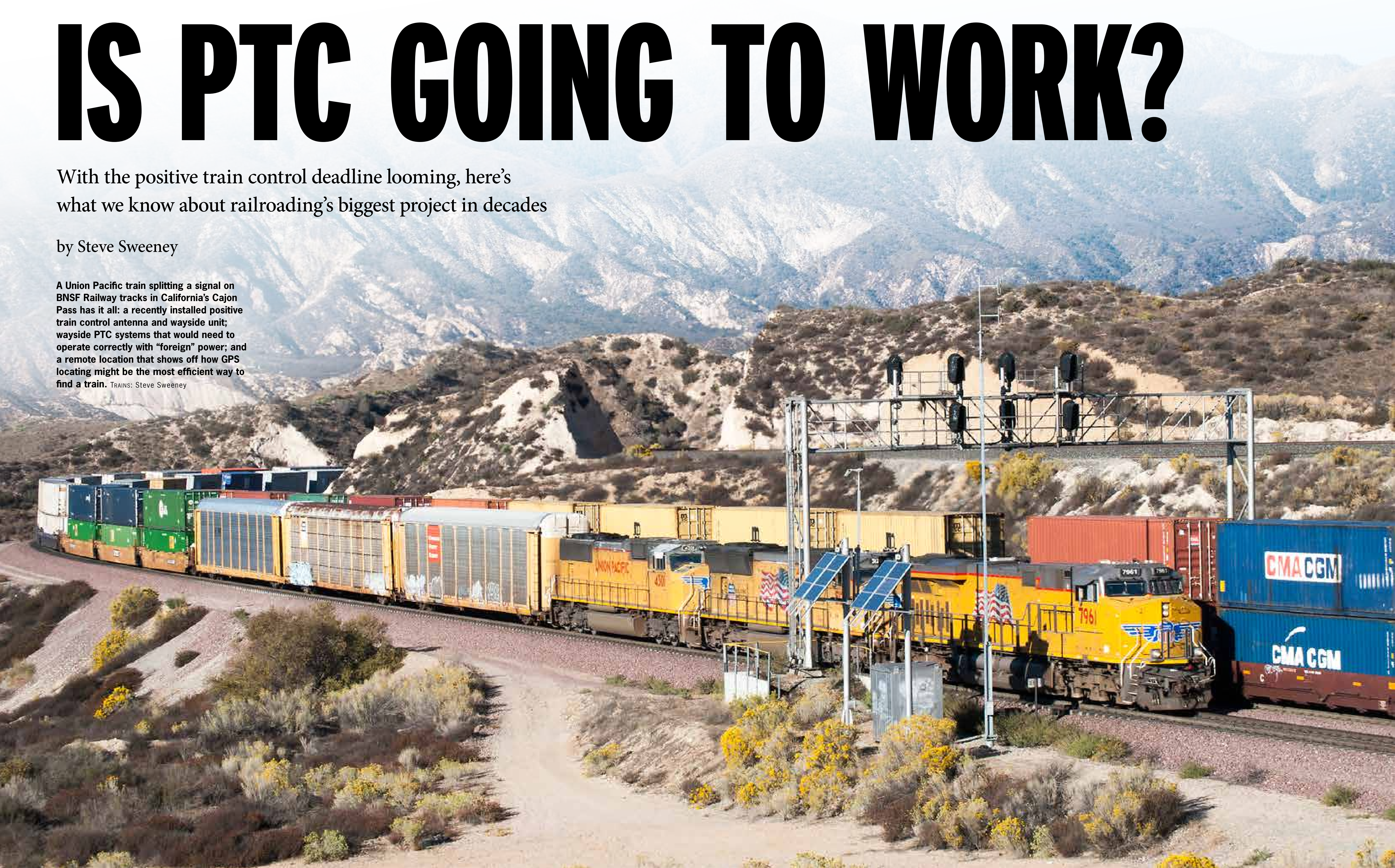
IS PTC GOING TO WORK?

With the positive train control deadline looming, here's what we know about railroading's biggest project in decades

by Steve Sweeney



A Union Pacific train splitting a signal on BNSF Railway tracks in California's Cajon Pass has it all: a recently installed positive train control antenna and wayside unit; wayside PTC systems that would need to operate correctly with "foreign" power; and a remote location that shows off how GPS locating might be the most efficient way to find a train. Trains: Steve Sweeney

Chicago is a sprawling railroad hub where passenger trains and toxic chemicals passing near millions of people warrant PTC installation. TRAINS: Steve Sweeney

>> Surprise! PTC already works

Tick, tock.

U.S. railroads have collectively spent decades and billions of dollars on positive train control research.

Tick.

Public outcry after a 2008 commuter crash that killed 25 people — a crash that a Federal safety panel says PTC could have prevented — pushed Congress to act.

Tock.

With a Congressional deadline on their heels, railroads now have just 14 months to make PTC work nationwide.

Tick.

And they say it can't be done in time.

Tock.

With that kind of time pressure you might think that U.S. railroads would have adopted technologies created for Amtrak's Northeast Corridor or in the Midwest to fulfill their obligations.

And you might be wrong.

America's Class I railroads instead are quickening the pace of technology they've been working on since the 1980s. Rail executives say their chosen system is cheaper and has the best chance of helping their companies better manage trains, while reducing fuel and labor costs and meeting Congress' safety mandate from the 2008 Rail Safety Improvement Act.

14
years PTC has worked on the Northeast Corridor

But to understand why Class I railroad leaders chose what they did, you first need to understand that PTC is a group of concepts, and little more.

"The PTC law is not a technical standard. There is no PTC system as such," says Pierre-Damien Jourdain, solutions director for Alstom Signaling. In fact, several systems do qualify under the safety law, including Siemens' CBTC, GE Transportation's Incremental Train Control System in operation on high speed Amtrak lines in Michigan and Illinois, and Alstom's Advanced Civil Speed Enforcement System. Alstom and Amtrak collaborated to create the system that has helped the passenger railroad successfully avoid crashes on the Northeast Corridor since 2000.

Among the alphabet soup of options, all PTC is, says Jourdain, is another phrase for automatic train protection, which has been in use in railroading for decades. According to the safety act, any of these systems must do four things: prevent train-to-train crashes, enforce speed limits, protect track workers, and keep trains from running through a misaligned switch.

Inside these broad guides, railroads can be as high (or low) tech as they wish. In practice, the rail industry leans toward using modern radios, computers, and transponders. Using technology, locomotives are able to communicate with other locomotives, wayside equipment, and centralized dispatching systems. In certain forms, PTC systems cooperating with train management computer programs may make engine crews, as well as wayside and cab signals, redundant or obsolete.

In the face of several expensive options on how to communicate with trains and comply with the law, railroad officials chose to act conservatively.

This is why Class Is didn't consider the system Alstom developed for Amtrak. It uses fixed-location transponders embedded in the tracks to locate trains. In dense urban areas with hundreds of commuter trains a day and set track alignments, predictably spaced, hard-wired beacons could stay in place for years of service.

But in mountainous or remote areas of the country where trains are few and the population is sparse, the costs for frequently placed transponders, wiring, and corresponding maintenance would be great. Instead, railroads chose to anchor their system on the widely available global positioning system to locate engines.

Conservatism is also the likely reason railroads didn't adopt systems with cab signals. Officials say cab signals (used in both Alstom's and GE's systems) are absent from most freight locomotives and add another layer of complication and cost.

And then there is the conservative catch-phrase: "Go with what you know."

BNSF Railway and Pittsburgh-based Wabtec Corp. introduced an immediate forerunner of current GPS-based PTC systems known as the Electronic Train Management System in the 1990s. By the time of the 2008 safety act, the two companies were furthest along in the U.S. rail industry in deploying a PTC system on a freight railroad. Other Class I railroads had already joined BNSF and Wabtec to make nationwide implementation faster and less expensive.

WHAT I-ETMS WILL DO

Today, Wabtec offers I-ETMS, or Interoperable ETMS. Union Pacific, BNSF, CSX Transportation, and Norfolk Southern have all said in interviews with TRAINS that they intend to use Wabtec's system to comply with the safety act.

The system shares features and is designed to be interoperable with other companies' PTC applications but functions on Wabtec's own software.

"One of the other benefits we hope to achieve in leveraging this investment in PTC is integration with our other energy management systems to further improve

An *Amtrak Cascades* train heads north through a BNSF yard. In the latest Federal rules, yard locomotives would be exempt from installing PTC systems. Robert Scott

our fuel efficiency," says Chris Matthews, BNSF's assistant vice president for network control systems. "As this give us more precise location information for our trains, [we're] incorporating that into our movement planning with the goal of increasing velocity."

Through a spokesman, Wabtec confirmed that U.S. railroads will have "slightly different system configurations" but declined to elaborate on what options railroads will have available.

Based on the 2008 safety act's definition of PTC, and previously published informational materials, Wabtec systems will use GPS to locate a leading locomotive, and by extension, a whole train, along the track on the rail network.

Using that position information and local conditions reported by wayside units and dispatchers, computers built into locomotives will constantly recalculate when a train must slow down and stop relative to wayside signals and digitized track warrants. The system will automatically apply the train's brakes and cut engine power if the engineer fails to do so.

Train and back-office computers, meanwhile, maintain speed restriction information for curves, speed limits for operating through switches and crossovers, as well as variable information from train consists and track conditions, and local notices from maintenance-of-way crews. The capability prevents trains from running too fast for a given area, even if a train is operating at less than a local speed limit. And for misaligned turnouts, the system detects what position a switch is in, governing train movements more effectively than older track-circuit technology.

Wabtec's system will comply with required event recording rules so every engine control, signal aspect, and piece of data used by the train crew and locomotive are stored in case of an accident.

After Chicago, the high speed lines in the Northeast Corridor are the most prominent traffic concern. However, since the late 1990s, Amtrak *Acela* trains and Norfolk Southern freights have coexisted using a PTC system from Alstom. Michael S. Murray

PTC systems are designed to prevent head-on collisions like this one in Hoxie, Ark., in August 2014. NTSB

>> Getting PTC right is hard

But what's hardest to get right isn't making trains safe or even making locomotive computers talk to other railroads' networks. No, the hardest thing, rail industry experts say, is to just keep trains running.

Tom Schnautz, Norfolk Southern's assistant vice president for research and advanced technology, helps explain why railroads are focused on reliability when he says that a positive train control system is designed to "fail safe." In other words, a PTC system will stop a train by default when the outputs from multiple processors disagree. If that happens too often, train efficiency could suffer and give railroaders working with the system a reason to pause and ask questions such as, "'How good could it be, if it is always putting the brakes on?'" Schnautz says.

40+
railroads required to have PTC

He says the systems NS is testing are "immature" but improving.

"I think it's important to remember that railroads have been working on positive train control for decades. They are working to deploy a system that has safety benefits but that is reliable enough not to shut down the rail network," Schnautz says. "Something that will work flawlessly day in and day out."

Then there is the widely discussed "interoperability" component of the rail safety act. It requires railroads to install systems that enable trains to continue interchanging with other railroads without delay. It is a complication that makes reliability even more difficult to achieve.

In Europe, where national boundaries defined the limits of older PTC systems, locomotives have traditionally been equipped with all the components they will need to navigate the various train control systems on their routes.

Rather than installing multiple systems in locomotives, Schnautz says NS is looking to "dual-equip" wayside units along the Northeast Corridor where NS freight and Amtrak passenger trains share the right-of-way for short stretches.

In much of the rest of the country, where GPS-based PTC systems are expected to dominate, the focus is on how systems will automatically work together without extra equipment. CSX Transportation's PTC director, Kenneth Lewis, calls those tasks "communications" and "functional" interoperability. They are difficult to accomplish, Lewis says, because when PTC systems first came on the market, they weren't interoperable at all. Rather than trying to squeeze the PTC systems to meet a new requirement, they were redesigned from scratch to accommodate the 2008 mandate.

"A CSX locomotive has to behave like an NS locomotive when it's on NS property and vice-versa," Lewis says. "We all need to talk in the same message formats and use the same communications language and the same [radio] frequencies."

Standards for the railroads' systems to speak with one another are set by the Interoperable Train Control Committee, with the Association of American Railroads as a facilitator. Specific protocols are available from the AAR, for a fee, to the public and to potential vendors.

A railroad executive says it was the committee that was able to overcome the challenge posed by "technical details" such as whether to put a computer function on a locomotive or in a wayside device, or elsewhere. It was also the committee that set standards for the medium of train-to-system communication:

>> Follow Trains' continuing coverage of PTC: www.TrainsMag.com

>> Trains can be hacked, too

Trains using the latest technology can be hacked. And it's happened before.

Polish police arrested a 14-year-old boy in Lodz, Poland, in 2008 for modifying a television remote control and changing switches on the city's streetcar system. Duminda Wijesekera, a computer science professor at Virginia's George Mason University tells Trains that the streetcar system used a version of the standard European radio technology that governs rail operations.

Both the streetcar control system and the TV remote's transmitter have roots in GSM, the global system for mobile communications that's used by European and some U.S. cellphone networks. With enough of his own field testing, the teenager exploited the common elements to cause several derailments, including one that injured 12 people. Although positive train control systems in the United States use different technology, trains will be vulnerable because locomotives depend on the radio signals for up-to-date location and track information. Right now, train crews — not computers — interpret information received on radios, from dispatchers, and from wayside signals.

Hackers in the future could tap into computer-controlled trains directly with a radio transmitter equipped to send properly coded instructions or nonsense signals and interfere with trains in localized areas.

To be fair, Wijesekera says U.S. railroads and vendors are aware of the issues and are building computer software protocols that will be secure once installed in locomotives, along the right-of-way, and in railroad back offices.

Wijesekera, who says he has been studying railroad information security since 2003, says he is more concerned that railroads will have enough radio bandwidth for the time when rail traffic grows, especially with high speed passenger trains.

"If you don't have enough bandwidth, and too many [radio] signals, signalling in the same bandwidth would result in the different radios corrupting each other, and the [train instructions] would look like noise," Wijesekera says.

He says U.S. freight railroads appear to have enough radio bandwidth in the 220 MHz spectrum to afford to re-transmit instructions to freight trains that may not receive them the first time. There will be a problem, he says, when high speed passenger trains using the 220 radio band begin operating nationwide, because their higher track speeds will require radioed instructions to be received the first time.

"And you need to ensure that it is the actual radio of the railroad company that generated the signal and not some hacker," he says. "That's the security issue." — *Steve Sweeney*

220-MHz-band radios manufactured by Meteorcomm, a Renton, Wash.-based company jointly controlled by four Class I railroads. Those railroads are BNSF, CSX, NS, and Union Pacific.

But just how do railroads know PTC will work? Well, they test it.

Wabtec is a primary Class I supplier for locomotive consoles and wayside units. The products have been tested in laboratories and at the Transportation Technology Center Inc. in Pueblo, Colo. Wabtec and railroads are doing more lab tests and field trials on railroads' home territories. CSX, for example, studies PTC over six operating territory types. As work progresses, results from CSX and all other railroads are forwarded to the Federal Railroad Administration for review.

Trains usually operate on separate tracks, but occasionally something goes wrong. PTC systems must "know" when a track is aligned properly for a train movement. Marshall Beecher

AN AUDIT APPROACH, SOMEDAY

When FRA receives railroad test data, the federal agency trusts railroads and suppliers to tell the truth and be honest about their progress. It is a different position for FRA than the one Congress charged it with.

In the 2008 rail safety law, Congress required FRA to approve or reject railroads' development and safety plans and certify the results of field tests. Citing inadequate staff to observe tests, FRA told Congress in an August 2012 report that it intended to audit selected railroads' field tests (ones that railroads submit) for accuracy and compliance with the safety law.

Since that 2012 report, Trains has learned that the agency will not begin auditing PTC systems until after they are rolled out and ready for revenue service throughout a railroad's network. To complement this audit effort, FRA has a technical team working with PTC experts at the railroads to see how components and systems function in the field.

An FRA official spoke only on background for this article.

Insufficient staffing at FRA was also a concern for Class I railroad employees who spoke with the U.S. Government Accountability Office for an August 2013 report to the U.S. Senate Commerce Committee. In that report, anonymous officials said their companies' timetables for PTC deployment depended on quick responses and approvals from FRA.

Amid manpower shortages, FRA approved BNSF's application to test I-ETMS on its San Bernardino subdivision in January. BNSF shares that line with Los Angeles Metrolink commuter trains.

In February, they were the first railroads to operate Wabtec's Interoperable ETMS in revenue service. As part of the authorization, BNSF is supervising the tests until other subdivisions on BNSF and Union Pacific receive approval for PTC operation.

BNSF's Matthews says the Ft. Worth, Texas-based Class I submitted its "safety plan" for the Wabtec system to the FRA in July. If approved, BNSF would be the first Class I to operate Wabtec's PTC system in regular revenue freight service in a network that spans Chicago to Los Angeles and Seattle to New Orleans.

It is no mistake: PTC will not be required (yet) on heavy-haul coal lines into Wyoming's Powder River Basin. David Honan

>> How many billion dollars?

Time is money. So for a moment, think of the time it will take for railroad laborers or outside contractors to install brackets for radios and visual displays in 22,000 locomotives; the time it will take to install 38,000 new wayside interface units throughout the country; or the time to install 12,000 signals — all things FRA says railroads will have to update. Oh, and don't forget the time to test the new PTC components and systems to make sure they work.

Certain components have also only recently become available in any quantity. New 220 MHz radios approved for railroad use are among these. Several railroads told the Government Accountability Office that their workers have had to "touch" locomotives twice: first installing hardware and wiring to connect a system, and a second "touch" to install the transmitters, displays, and radios. "There are over 1,000 people at CSX working on [PTC]," says CSX's Lewis. "We are upgrading about 7,500 miles of our signal system from relay-based to solid state. It's a huge undertaking for the company. There's a lot of people working hard to install this."

It is easier then, to understand why U.S. railroads say they've spent $3.4 billion on positive train control as of the end of 2013, according to annual filings with the U.S. Surface Transportation Board. The dollar figure excludes Amtrak and the dozens of regionals, short lines, and commuter systems that are required to have a PTC system. The figure, an aggregate of the seven Class I railroads' reported right-of-way and equipment investments in PTC, lacks detail to pick out individual items or groupings. But, dividing out the total spent through 2013 by the Class I railroads' total operating mileage for 2013, the railroads spent an average of $17,452 per mile on PTC. UP spent the most, at more than $22,000 per mile, while CN's Grand Trunk subsidiary spent more than $5,000 per mile.

And here's the kicker: Railroads are spending all of this time and money on PTC and complementary systems in the hope that they will see some benefit out of it. The FRA once estimated that the railroad industry will spend $22 in infrastructure investments for every $1 of safety benefit gained. Other estimates available say different PTC configurations offer greater benefits, but no estimate so far shows railroads getting more benefits than dollars spent.

>> U.S. Class I railroad spending on PTC (Totals as of December 2013, in thousands of dollars)

	BNSF	Canadian National	Canadian Pacific	CSX	Kansas City Southern	Norfolk Southern	Union Pacific	TOTAL
RIGHT-OF-WAY	$575,938	$2,194	$0	$80,718	$0	$242,348	$791,451	$1,692,649
EQUIPMENT	$96,043	$49,879	$0	$59,240	$0	$108,616	$314,660	$628,438
IN PROGRESS	$230,292	$0	$112,925	$522,167	$56,313	$183,367	$15,473	$1,120,537
TOTAL	$902,273	$52,073	$119,310*	$662,125	$56,313	$534,331	$1,121,584	$3,448,009

Source: Surface Transportation Board annual R-1 reports for 2013. U.S. operations only. *Total includes "Interest during construction" costs not reported by other railroads.

A cab display in service on Metrolink, which started using PTC in February.

MAINTENANCE, AND ...

In decades to come, PTC systems will cost billions more to maintain and to update, just as signals, radios, and track do.

In fact sheets, the Association of American Railroads says the projected cost to install first-generation PTC systems will be $8 billion.

The accountability office report to the Senate says the total costs for the industry will be $9.6 to $13.2 billion during 20 years. These numbers are based on FRA estimates and include non-AAR member shortline and regional railroads.

But those are the costs railroads expect. One railroad official told Trains that as PTC development has progressed, his company now expects PTC-equipped locomotives to be in shops for train control-related functionality or integration repairs 10 to 20 percent of the remainder of their working lives. That railroad is considering whether it needs to buy more freight locomotives to fill the downtime needs at more than $2 million a copy from U.S. locomotive builders.

Industry suppliers, meanwhile, see estimated costs as the potential for sales. Siemens AG, a relatively smaller player in the U.S. PTC market, announced in early August that it will hire 129 workers and triple its workforce in Pittsburgh to keep pace with a PTC contract for New York's Metropolitan Transportation Authority.

Siemens, like Wabtec, Alstom, and other companies, is courting railroads and transit systems for future PTC-spending dollars. Perversely, the amount spent will depend, in part, on the state of technology and Congress' desire for more train-safety regulation.

3.4
billion dollars spent on PTC through 2013

>> Commuters spend on PTC, too

A recent study by the Federal Transit Administration estimated that, by the time positive train control is installed and certified by America's 25 commuter rail agencies, total expenses will likely exceed $2 billion. Unlike their freight rail brethren, commuter rail agencies depend, to a large extent, on public money for both operating funds and large-scale capital projects.

Funds for PTC must be diverted from other pressing needs, such as new or refurbished locomotives and cars, welded rail, and station improvements, to name but a few. Until recently, FTA and other federal agencies contributed little or no money to assist commuter rail with the cost of PTC. Even now, federal funding remains miniscule, even though the PTC requirement began as an unfunded federal mandate. In the case of Southern California's Metrolink, federal funding is only about 9 percent of the total cost.

Metrolink operates on 388 route-miles, equipped with about 52 locomotives and 90 cab cars, all of which must be equipped with PTC gear and be totally interoperable with freight partners Union Pacific and BNSF, along with other area commuter rail agencies. In other parts of the country, the situation is similar.

The Metropolitan Transportation Authority, which operates the Long Island and Metro-North railroads, is expected to spend $428 million. In Chicago, Metra's PTC costs are expected to come in at between $235 and $400 million, while Metrolink, the first commuter railroad to operate an approved PTC system after the 2008 Rail Safety Improvement Act, will spend $216 million, of which 50 percent will be paid by the five-county Southern California Regional Rail Authority, 41 percent by the state of California and only 9 percent by FTA. Seattle's Sound Transit is expected to spend $53 million, including a cost-sharing split of about $3 million with BNSF Railway. — *Forrest Van Schwartz, a Madison, Wis.-based rail consultant*

An Amtrak train passes a nearly empty Metrolink car at the scene of a 2008 wreck in Chatsworth, Calif., that kicked the PTC debate into high gear. Two photos: David Lustig

Railroads are safe now and PTC would make them safer. The problem is that officials estimate the amount spent versus the safety value gained at 22:1. Michael D. Harding

>> Politics & professionalism

Criticisms abound on how railroads are developing PTC. In turns, Class I companies are accused of spending too much or too little money, of making systems overly complex, or of including too few safety features. The list goes on.

Few critics have been as scathing as former National Transportation Safety Board Chair Deborah Hersman, who said in 2013 that it's taken less time for NASA to find a way to land astronauts on the moon than for railroads to develop and deploy PTC.

But California's U.S. Sen. Dianne Feinstein goes further and pins bad motives on railroads in an Aug. 6 opinion piece on the San Francisco Chronicle's website: "Key segments of the railroad industry ... are resisting a system that uses digital technology to prevent deadly accidents caused by human error."

Back-and-forth mudslinging between government officials and private enterprise has become something of a high-stakes public game in recent decades, and could be easily ignored — if it weren't for industry voices who say there are still problems with PTC's rollout.

"They way over-designed it. They put in additional functionality that isn't required in the FRA regulations," Ron Lindsey says. Lindsey is an independent railroad consultant and the architect of an early PTC system who says PTC wiring for intermediate signals is pointless since the signals will become redundant. According to Lindsey, locating locomotives with GPS will be more accurate and likely more expensive than necessary and that railroads could have more wisely used their existing radio channels in the 160 MHz spectrum with "trunking" technologies, or 44 MHz bands. Instead they bought space in the 220 MHz range for voice and data communications.

Steve Ditmeyer, an adjunct professor of railway management at Michigan State University, agrees with Lindsey on wiring intermediate signals, saying it drives up costs and doesn't produce a benefit. Ditmeyer is best known for his work on early PTC applications on the Burlington Northern in the 1980s and was the one asked by railroad executives to start looking into GPS technology. He and Lindsey also fault railroads for not including end-of-train detection in the systems.

Robert Gallamore, an elder statesman of the industry and author of a recent book on railroad innovations of the 20th century (see pages 42-49), says he doesn't fully understand certain decisions railroads have made. Although he's been away from detailed discussions on PTC implementation since the mid-2000s, Gallamore says greater openness from the standards-setting committee would go a long way to reduce criticism and distrust from the public. He also thinks there should be matching fund programs from the federal government to develop and install PTC systems and a more "reasonable" implementation path than the current 2015 deadline.

Rail executives say they are proud of their efforts on PTC and, in spite of challenges, find the results of their work useful. They also tend to dismiss criticisms from people not directly involved in recent PTC development efforts.

Railroads and the FRA are also working through a controversy with the Federal Communications Commission, which announced in 2013 that railroads installing new PTC radio towers would need to submit applications verifying that they would not interfere with historic American or Native American sites.

Although FCC has participated in PTC discussions since the 2000s and the rules on radio antennas have been on the books for years, it is unclear why enforcement became an issue in 2013. Earlier this year, the federal agencies and the rail industry agreed on a fast-tracking process for PTC radio applications, though railroads say they will not receive all the radio tower licenses required by the end of next year. FRA also ended another regulatory uncertainty by issuing a third round of final regulations regarding train control. These were issued in late August and refine rules on PTC in rail yards, en route PTC failures, and technical requirements for grade crossings. Still, without any changes to the 2008 safety act, FRA inspectors could start issuing fines to non-compliant railroads in 2016. That could amount to fining an entire railroad every day. To avoid this and other complicated problems, South Dakota's U.S. Sen. John Thune introduced a bill in August 2013 that would push out the deadline for PTC until Dec. 31, 2020. The same day Thune introduced the bill, it was referred to the Senate Commerce Committee where it will likely die when the congressional term ends this year.

1970
the year the NTSB first asked for PTC

For its part, FRA recommended to Congress in an August 2012 report that legislators should grant FRA authority to hand out provisional certifications and case-by-case deadline extensions to railroads that show "due diligence" in implementing PTC.

President Barack Obama's recently introduced Grow America Act includes language to grant FRA those powers, while otherwise leaving the Dec. 31, 2015, deadline intact.

AAR has yet to take a public stance on this portion of the Grow America Act, but anonymous railroad officials told the Government Accountability Office for its 2013 report that piecemeal extensions amount to unfair penalties for railroads that met the deadline without extensions or waivers.

Though, in speaking about the deadline generally, the AAR says, "Our industry has been clear in stating that PTC will be done, but complete, nationwide interoperability cannot be accomplished by Dec. 31, 2015. Extending the deadline will allow railroads and other stakeholders, to make sure PTC is done right."

A FINAL THOUGHT

Positive train control, in its various forms, does work and will keep improving in the U.S., making railroading safer than ever. The question is whether railroads can move fast enough to satisfy Washington and the public while figuring out how PTC will "make sense" from a business viewpoint. I

David C. Lester, David Lustig, and Forrest Van Schwartz contributed to this article.

>> When a railroad almost built a PTC system

Since the early years of railroading, as soon as railroads started to run more than one train at the same time on the same segment of track, the industry has sought various means and technologies to prevent trains from running into each other. Various "control systems" evolved over the decades; most were good, some not so good.

In the early 1980s, one idea for increasing safety (and savings) came from Richard Bressler, Burlington Northern's chairman and chief executive. He had a long career in the oil industry and became fascinated with new technology developed by the U.S. military: the global positioning system. He approved a team to look for a project using GPS and the vastly improved computer systems available by the mid-1980s.

That team's efforts led to a project to replace the signal and communications pole line on a former Great Northern route extending west from the Lake Superior ports of Duluth, Minn., and Superior, Wis.

Originally, BN partnered with two other Class I railroads to advance the train-control project, but eventually shouldered the responsibility alone for what became known as the Advanced Railroad Electronics System, or ARES. Information was provided to train crews via radio links to in-cab displays as well as to train dispatchers at the central offices.

BN chose Rockwell International as the prime contractor for the radio system. ARES became one of the first applications of GPS technology in the railroad industry, used to survey and produce accurate terrain profiles of the track. Locomotive displays included current train location, track profile, switch positions, and signal locations. ARES was the first computerized attempt to calculate non-vital (advisory) braking time and distance along with on-board brake override, particularly important to safely handling heavy trains in extreme weather conditions.

Veteran locomotive engineers, who knew every inch of their territory, grew to trust and rely on the in-cab displays. Train dispatchers liked the greatly improved voice radio communications and the speed at which switch and signal instructions were sent to field locations.

In the end, ARES was not operated independently of existing control systems and it did not reach the point where wayside block signals could be removed. It was never "vitalized." In a 1991 observational study, Harvard Business School published the opinions and decisions of railroad leadership and why they didn't adopt ARES, saying that executives, "... were not fully comfortable with whether the assessment of ARES benefits was realistic or optimistic." The report said executives struggled to find out if they could get some of the same benefits promised by ARES with another technology, but came up short. In another follow-up brief in 1993, the business school said executives were still studying ARES, but had made no decisions. — *Forrest Van Schwartz*

>> Timeline

August 1985 - Burlington Northern executives approve testing a PTC prototype system, ARES, in Minnesota's Iron Range.

May 1, 2007 - U.S. Rep. James Oberstar introduces H.R. 2095 that will become the Rail Safety Improvement Act of 2008, requiring PTC implementation.

Sept. 12, 2008 - Crash between Metrolink commuter and Union Pacific freight trains kills 25 people. The engineer at fault was texting and missed a stop signal.

October 2008 - Pres. George W. Bush signs Oberstar's bill into law. Deadline for U.S. railroads to comply set for Dec. 31, 2015.

January 2010 - Federal Railroad Administration issues first set of "final" PTC implementation rules. Railroads oppose regulatory language and definitions.

July 2010 - Association of American Railroads challenges FRA rules in court. Class I railroads work to obtain more radio frequencies.

March 2011 - FRA and AAR reach settlement on differences.

May 2012 - FRA issues a second set of "final" PTC rules.

December 2012 - FRA issues a third set of proposed rules.

May 2013 - Federal Communications Commission tells AAR, FRA that railroads must apply for historic review of every PTC radio tower.

Aug. 1, 2013 - Senate Bill 1462 would extend deadline for railroads to implement positive train control systems until Dec. 31, 2020.

May 2014 - FCC, preservation committee, and railroads reach agreement on radio tower applications.

June 11, 2014 - "Grow America Act," H.R. 4834, includes language that would allow FRA to permit PTC in stages, effectively eliminating the 2015 deadline.

Aug. 22, 2014 - FRA issues a third set of "final" PTC rules.