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Positive Train Control (PTC): Overview and Policy Issues

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Summary

The Rail Safety Improvement Act of 2008 (RSIA08) requires implementation of positive train control (PTC) on railroads which carry passengers or have high-volume freight traffic with toxic- or poisonous-by-inhalation hazardous materials. PTC is a communications and signaling system that has been identified by the National Transportation Safety Board (NTSB) as a technology capable of preventing incidents caused by train operator or dispatcher error. PTC is expected to reduce the number of incidents due to excessive speed, conflicting train movements, and engineer failure to obey wayside signals. It would not prevent incidents due to trespassing on railroads' right-of-way or at highway-rail grade crossings, where the vast majority of rail-related fatalities occur.

Under RSIA08, PTC is required on about 60,000 miles of railroad track by December 31, 2015. Many railroad companies are uncertain of their ability to fully implement PTC by this deadline. The Federal Railroad Administration (FRA) estimates full PTC implementation will cost approximately \$14 billion. Although the larger freight railroads are well along in planning for PTC, some smaller railroads and commuter lines have more difficulty funding implementation.

PTC uses signals and sensors along the track to communicate train location, speed restrictions, and moving authority. If the locomotive is violating a speed restriction or moving authority, on-board equipment will automatically slow or stop the train. A more expansive version of PTC, called communications-based train control (CBTC), would bring additional safety benefits plus business benefits for railroad operators, such as increased capacity and reduced fuel consumption. However, CBTC is not currently being installed by any U.S. railroad, due to the additional cost and to uncertainty about implementation of PTC before the 2015 deadline.

PTC is an issue in the reauthorization of RSIA08, which expired at the end of FY2013. Two bills introduced in the 112th Congress, S. 1813 as approved by the Senate and H.R. 7 as approved by the House Transportation and Infrastructure Committee, would have extended the deadline and made other policy changes. No language relating to PTC was included in the final surface transportation bill (P.L. 112-141) enacted on July 6, 2012. In the 113th Congress, bills were introduced to extend the deadline (S. 1462) and provide federal financial assistance for implementing PTC (H.R. 3634). Neither bill was enacted. If it wishes to reexamine the PTC mandate, possible options for Congress include

- postponing the implementation deadline;
- considering whether to make dedicated radio spectrum available to the railroads for PTC implementation and, if so, how to compensate current license holders of that spectrum;
- examining possible alternatives to PTC and their potential to create barriers to competition in the rail freight market; and
- providing federal financial support for PTC implementation by making PTC projects eligible for funding under the Railroad Rehabilitation and Improvement Funding Program or by appropriating other funding to FRA, as authorized in RSIA08.

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Introduction

Following several high-profile train incidents, Congress passed the Rail Safety Improvement Act of 2008 (RSIA08; P.L. 110-432), which mandated positive train control (PTC) on many passenger and freight railroads by December 31, 2015. The law does not describe PTC in technical terms, but defines it as a risk mitigation system that could prevent train incidents by automatically stopping trains when a collision or derailment is imminent.

While PTC promises benefits in terms of safety, its implementation entails substantial costs and presents a variety of other policy-related issues. These include the interoperability of individual railroads' systems, access to sufficient radio spectrum to support PTC, and the possibility that PTC could be a barrier to market entry.

Freight and commuter railroads have raised concerns about their ability to meet the deadline imposed by Congress. In the 112th Congress, measures to relax the deadline were approved by the Senate and by the House Transportation and Infrastructure Committee, but were not included in the Moving Ahead for Progress in the 21st Century Act (MAP-21; P.L. 112-141), the surface transportation bill signed by President Obama on July 6, 2012. The issue was reexamined in the 113th Congress in conjunction with the reauthorization of RSIA08. The December 1, 2013, derailment of a train operated by Metro-North Railroad in New York City, which resulted in four passenger fatalities, led to additional legislative proposals related to PTC.

Rail Safety and PTC

The United States railroad network comprises both freight and passenger operations. The seven largest operators by revenue, known as the Class I freight railroads, own about two-thirds of the nation's 140,810 miles of trackage (see **Figure 1**).¹ These companies include BNSF, Union Pacific (UP), Norfolk Southern (NS), Kansas City Southern (KCS), Canadian Pacific (CP), Canadian National (CN), and CSX Transportation (CSXT). The remaining trackage is controlled by Class II or regional freight railroads; Class III or short-line railroads; state and local government agencies; and Amtrak, the federally owned passenger operator.

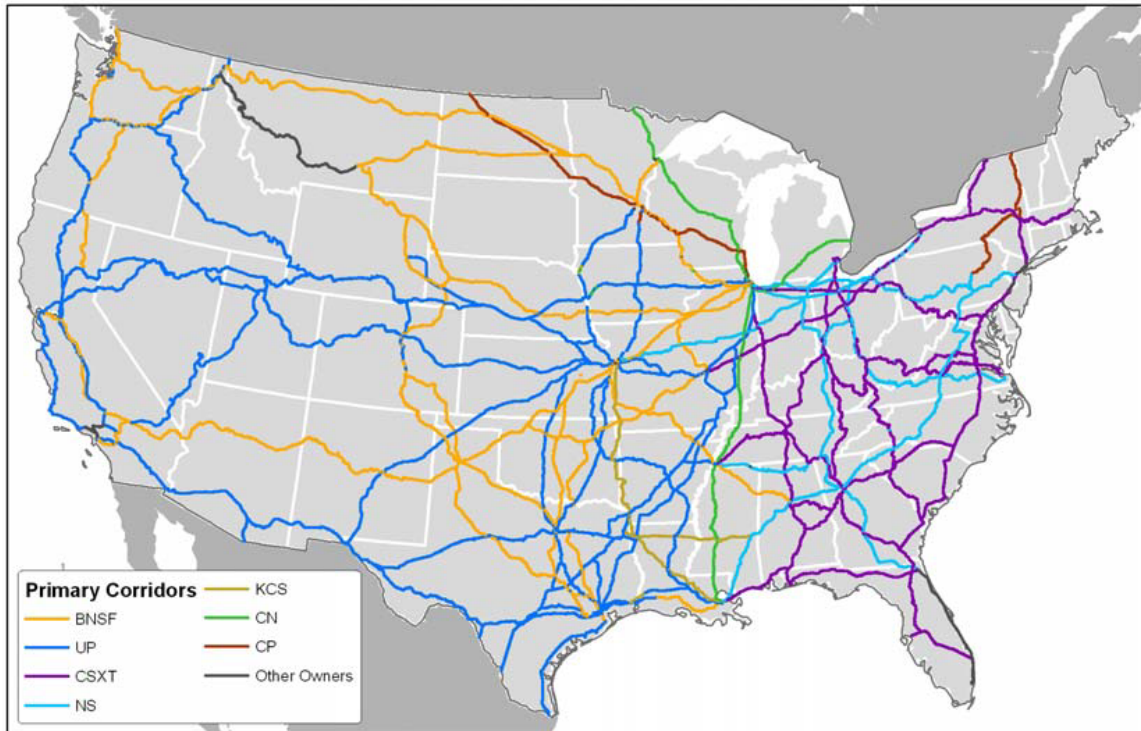
In many situations, both passenger and freight railroad companies operate over track owned by other railroads. This may occur under orders issued by the federal Surface Transportation Board or under voluntary agreements between carriers. Amtrak also has the right to operate trains using its own equipment over freight lines.²

The majority of freight railroad lines have a single track with passing sidings at various locations to allow trains to pass. Trains may operate in either direction along a track. High-volume corridors may have multiple tracks that typically operate in a single direction to increase both operating capacity and safety.³

¹ U.S. Department of Transportation, "National Transportation Statistics," http://www.bts.gov/publications/national_transportation_statistics/html/table_01_01.html.

² See CRS Report R42512, *Passenger Train Access to Freight Railroad Track*, by (name redacted).

³ Cambridge Systematics, *National Rail Freight Infrastructure Capacity and Investment Study*, Final Report, September 2007, p. 25, http://www.aar.org/~media/aar/Files/natl_freight_capacity_study.ashx.

Figure I. National Network of Class I Railroads

Source: Cambridge Systematics, Inc., National Rail Freight Infrastructure Capacity and Investment Study, September 2007.

Note: This map shows the Class I railroads in the United States. Not all lines shown are subject to the PTC implementation mandate.

For safety purposes, train dispatchers and signals along the track provide the engineer with the authority to travel on a certain track segment to prevent collision with other trains. Some long stretches of track in remote areas use only one main line without any signalization. This is called “dark territory,” comprising about 40% of the North American rail network.⁴ In this case, railroads rely on communications with dispatchers to provide authority. Dispatchers are also responsible for assigning priority when more than one train requires use of a particular segment of track.

On signaled track, track is separated into blocks by trackside or overhead signals that indicate to an engineer whether the train can proceed (and at what speed) or must stop before it enters the next block. Given the long stopping distance required by trains, a prior signal actually informs the engineer about the indication on the next signal. This system is called automatic block signal (ABS), and is generally the most sophisticated signal system used by freight railroads. Since 1947, it has been required for freight trains traveling 50 or more miles per hour (mph) and passenger trains traveling 60 mph or more.⁵ Railroads have different operating rules regarding how and under what circumstances the conductor must call out signals to the engineer.

⁴ Institution of Railway Signal Engineers, *Introduction to North American Railway Signaling* (Omaha: Simmons-Boardman, 2008), p. vii.

⁵ Codified today at 49 C.F.R. 236.

Intercity and commuter passenger trains often incorporate additional features in their signal systems. A “cab signal” system relays external signal information to control displays inside the engineer’s cab via an electric current that travels along the rails and is picked up by a receiver on the locomotive. The cab signal is helpful when fog, sun, or track curvature hinders or delays visual sighting of wayside signals. It also increases track utilization, as the engineer can adjust train speed in between signals. An “automatic train stop” (ATS) or an “automatic train control” (ATC) system can override the engineer’s control of a train if a wayside signal indication is not acknowledged by the engineer. These devices are installed along the tracks, and trip a train’s brakes when an engineer fails to respond to a wayside signal. Cab signals, ATS, and ATC were developed beginning in the early 1900s, and have been required by federal regulations since 1947 for passenger trains traveling over 79 mph (see text box).

A Brief History of Major Legislative and Regulatory Developments

Congress has been interested in automatic train control for over a century. In 1906, Congress directed the Interstate Commerce Commission (I.C.C.)—the Federal Railroad Administration’s (FRA’s) predecessor in federal regulation of rail safety—to investigate and report on the use of and necessity of devices for the automatic control of railway trains, and to recommend such legislation as the agency deemed advisable (H.J.R. 153, 34 Stat. 838). In the Transportation Act of 1920 (41 Stat. 498), Congress authorized the I.C.C. to mandate the installation of ATS or ATC devices. In 1922, the I.C.C. ordered the installation of these devices on 49 railroads on segments of track totaling about 5,000 miles.⁶ In 1937, Congress enacted the Signal Inspection Act (50 Stat. 835), which required railroads to obtain I.C.C. permission for any modification to their signal systems. In 1947, the I.C.C. ordered any railroad operating at a speed of 80 or more mph (i.e., passenger trains) to install ATS, ATC, or cab signal systems on its lines.⁷ In its 1947 report, the I.C.C. noted that ATS or ATC was then in use on over 14,100 miles of track, while cab signals were in use on over 8,100 miles.⁸ The report estimated that its order would require such devices on an additional 27,156 miles of track.⁹

The National Transportation Safety Board’s (NTSB’s) first recommendation regarding automatic train control was issued to the FRA in 1970 after its investigation of a collision of a commuter train with a work crew train in Darien, CT, in 1969.¹⁰ It recommended that the FRA “study the feasibility of requiring a form of automatic train control at points where passenger trains are required to meet other trains.”¹¹ In 1976, the congressional Office of Technology Assessment issued a report requested by Congress on the use of automatic train control devices in rail transit systems.¹² In 1983, the FRA proposed a number of changes to signal and train control requirements, but in issuing its final rule, citing the 1947 I.C.C. threshold of 80 mph for installation of ATS, ATC, or cab signal devices, it determined that there was no compelling argument to either lower or raise the 80 mph speed threshold.¹³ In 1990, the NTSB placed automatic train control on its initial “Most Wanted List of Transportation Safety Improvements.”¹⁴ Congress directed the FRA to issue a progress report on positive train control in The High-Speed Rail Development Act of 1994 (P.L. 103-440). In 1997, after investigation of an accident between a commuter train and an Amtrak train in Silver Spring, MD, that killed eight commuter passengers, the NTSB recommended that the FRA require the installation of a positive train separation control system for all tracks where commuter and intercity passenger railroads operate.¹⁵ The FRA responded in 1998 to the NTSB’s recommendation by stating, in part,¹⁶

Current regulations create incentives for installation of these systems by authorizing higher train speeds. However, signal-based technology is expensive, and passenger operators cannot achieve significant increases in safety on the lines that they utilize absent parallel investments by freight operators (which are often the owners and/or dominant users of the line on which passenger trains operate). The answer to this problem is more affordable technology and commitments for joint action by freight and passenger service providers. It is important that we avoid any burden on passenger service providers that would result in service cutbacks and diversion of passengers to less safe forms of transportation.

In 2004, the FRA submitted a cost-benefit analysis of PTC at the request of Congress.¹⁷ That study showed that as of 2004, the costs of PTC outweighed the direct safety benefits, but the agency’s letter to Congress stated, “we believe PTC will be more affordable in the future.”¹⁸

⁶ 69 I.C.C. 258 (Order No. 13413), “In the Matter of Automatic Train-Control Devices,” decided June 13, 1922.

⁷ 268 I.C.C. 547 (Order No. 29543), “Appliances, Methods, and Systems Intended to Promote Safety of Railroad Operation,” decided June 17, 1947; 12 *Federal Register* 4683, July 15, 1947.

⁸ 268 I.C.C. 552.

⁹ 268 I.C.C. 559.

¹⁰ Railroad Accident Report, *Head-on Collision between Penn Central Trains N-48 and N-49 at Darien, CT, August 20, 1969* (NTSB/RAR-70/03).

¹¹ NTSB Recommendation R-70-20.

¹² Office of Technology Assessment, *Automatic Train Control in Rail Rapid Transit*, May 1976.

¹³ NPRM, 48 *Federal Register* 11882, March 21, 1983; Final rule, 49 *Federal Register* 3374, January 26, 1984.

¹⁴ National Transportation Safety Board, Office of Public Affairs, “NTSB unveils new ‘Most Wanted List,’” press release, June 23, 2011, p. 1, <http://www.nts.gov/news/2011/110623.html>.

¹⁵ NTSB, Safety Recommendation R-97-9 through -21, August 28, 1997; see also Safety Recommendation R-97-013.

¹⁶ Safety Recommendation History, NTSB Safety Recommendation R-97-013.

¹⁷ U.S. Congress, House Committee on Appropriations, *Conference Report on the Consolidated Appropriations* (continued...)

According to the FRA, an average of 1,983 derailments and 203 train collisions, resulting in 420 injuries and 12 fatalities, occurred annually from 1999 to 2010, excluding incidents at highway-rail crossings.¹⁹ The number of incidents may increase as operations in both freight and passenger rail expand, despite a reduction in total track length. However, the majority of train-related fatalities are due to interactions with vehicular traffic at highway-grade crossings or trespassing on railroad property rather than train collisions or derailments. In 2010, 8 fatalities occurred from train collisions or derailments, 257 fatalities occurred at highway-rail grade crossings, and 434 fatalities resulted from trespassing on railroad property or right-of-way.²⁰

While most incidents are minor, several high-profile incidents led Congress to mandate PTC. In 2005, a train carrying chlorine gas was improperly diverted onto a side track by a manual switch left in the wrong position. Another train was parked on the side track. As a result of the collision, chlorine gas was released from one derailed car, killing nine people and forcing the evacuation of 5,400 people within a mile radius of the incident for two weeks. This incident occurred in dark territory. The Federal Railroad Safety Improvement Act of 2007 (H.R. 2095, S. 1889), introduced in the 110th Congress, mandated implementation of PTC in specific circumstances.

In 2008, the head-on collision of a Metrolink commuter train and a Union Pacific freight train in Chatsworth, CA, led to 25 fatalities and over 100 injuries. That crash occurred on a section of track on which no cab signal, ATS, or ATC system was installed, leaving the commuter train engineer completely dependent on his sightings of the wayside signals. Reportedly, the cost of also equipping freight locomotives with automatic signaling technology was one reason a new system had not been installed.²¹ The cause of the accident was determined to be negligence by the commuter train engineer—it is believed he missed a red signal while texting. PTC was specifically identified by the NTSB as a technology that could have prevented Chatsworth and other similar incidents by providing a safeguard against human error.²²

The Chatsworth accident on September 12, 2008, expedited the legislative process, and the bill mandating PTC was signed into law October 16, 2008, as the Railroad Safety Improvement Act of 2008 (RSIA08). RSIA08 requires “each Class I railroad carrier and each entity providing regularly scheduled intercity or commuter rail passenger transportation” to implement PTC on all segments or routes of railroad tracks that (a) carry frequent passenger or commuter service, or (b) carry more than 5 million gross tons of freight per year and also are used for transporting toxic-by-inhalation hazardous materials (TIH).²³ At the time the law was signed, this mandate covered approximately 70,000 miles of railroad track.

(...continued)

Resolution, to accompany H.J.Res. 2, 108th Cong., 1st sess., 2003, H.Rept. 108-10 (Washington: GPO, 2003), pp. 1286-1287.

¹⁸ Letter from Betty Monro, Federal Railroad Administration Acting Administrator, to Senator Robert Byrd, August 17, 2004, http://www.fra.dot.gov/downloads/safety/ptc_ben_cost_report.pdf.

¹⁹ Federal Railroad Administration, Office of Safety, *Railroad Safety Statistics*, 2010 Annual Report (latest available), April 4, 2012, pp. 4-20.

²⁰ *Ibid.*, pp. 4-5.

²¹ “Train Crash’s Roots Run Deep; Decades-old Decisions by Metrolink Gambled on Passenger Safety, According to Experts and Documents,” *Los Angeles Times*, December 12, 2008.

²² National Transportation Safety Board, *Collision of Metrolink Train 111 With Union Pacific Train LOF65-12 Chatsworth, California*, RAR 10/01, September 12, 2008.

²³ P.L. 110-432, §104.

During the FRA rulemaking process, it became apparent that rail companies could change the routes of trains carrying TIH to avoid the PTC requirement on some track segments. A Senate bill was introduced to forgo mandatory PTC implementation on lines that will not be transporting passengers or hazardous materials by the end of 2015.²⁴ This was estimated to eliminate the PTC mandate on 10,000 of the 70,000 track-miles initially covered. The bill was not enacted, but FRA approved such a change in its amended final rule, effective July 13, 2012.²⁵ The American Short Line and Regional Railroad Association proposed several changes to the FRA final rule, including eliminating the PTC requirement for trains traveling less than 20 miles on PTC-required track and extending the deadline for Class II and III railroads to employ PTC-equipped locomotives until 2020. FRA approved these changes in an amended final rule.²⁶

In the 112th Congress, bills to delay the PTC implementation deadline were considered in both houses of Congress. As approved by the Senate, the Moving Ahead for Progress in the 21st Century Act (MAP-21; S. 1813) would have allowed the U.S. Department of Transportation (DOT) to extend the December 31, 2015, deadline for any railroad in one-year increments until December 31, 2018, if it deemed full implementation infeasible and if the railroad had made a good-faith effort to comply. The bill would have allowed use of Railroad Rehabilitation and Improvement Financing (RRIF)²⁷ for PTC implementation. The American Energy and Infrastructure Jobs Act of 2012 (H.R. 7), which was adopted by the House Transportation and Infrastructure Committee but was not approved by the House of Representatives, would have extended the deadline for PTC implementation to December 31, 2020, and would have allowed railroads to adjust TIH routes until 2020 to reduce the extent of track affected by the PTC mandate. The bill also would have allowed railroads to implement alternative strategies on track that does not transport passengers where the “alternative risk reduction strategy that would reduce the risk of release of poison- or toxic-by-inhalation hazardous materials to the same extent the risk of a release of poison- or toxic-by-inhalation hazardous materials would be reduced if positive train control were installed on those tracks.”²⁸ While the provision would have allowed flexibility on the part of the railroads, alternative safety measures might interfere with the goal of interoperability and could raise costs for smaller railroads that might need to conform to multiple safety systems. The final version of the 2012 surface transportation bill, signed by President Obama on July 6, 2012, as P.L. 112-141, did not change existing law concerning PTC.

The derailment of a Metro-North commuter train in the Bronx, NY, on December 1, 2013, renewed calls for PTC implementation. Four passengers died and 60 to 70 passengers were injured in this derailment. The train traveled at 82 mph over a straight section of track with a 70-mph speed limit, but then derailed as it entered a curve with a 30-mph speed limit. According to one report, although this section of Metro-North’s network was equipped with a cab signal/ATS/ATC system, Metro-North’s version of this system was designed to prevent collisions with other trains, and did not restrict speeds when no other trains posed a danger (as was the case with the derailed train). In other words, the backup safety signal system was designed strictly to

²⁴ S. 301, 112th Congress.

²⁵ Federal Railroad Administration, “Positive Train Control Systems Amendments (RRR),” 76 *Federal Register* 52918, August 24, 2011. See also 78 *Federal Register* 5767, January 28, 2013, and 79 *Federal Register* 49693, August 22, 2014.

²⁶ Federal Railroad Administration, “Positive Train Control Systems,” 75 *Federal Register* 2704, January 15, 2010.

²⁷ Railroad Reinvestment and Improvement Funding (RRIF) provides direct loans and loan guarantees up to a total of \$35 billion to improve or develop new rail equipment and facilities, and refinance outstanding debt.

²⁸ H.R. 7, §8401, p. 805.

ensure train separation and did not include a speed control element. Other commuter railroads (New Jersey Transit and Southeastern Pennsylvania Transportation Authority, for example), as well as Amtrak on the Northeast Corridor, had a system that would have restricted train speed in this instance.²⁹ FRA ordered Metro-North to add speed control to its signal system and to station a second crew member with train control duties at certain locations until it did so.³⁰

The Basics of PTC

PTC is defined in federal law as a “system designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and the movement of a train through a switch left in the wrong position.”³¹ The federal government has imposed no specific technical requirements, allowing railroads to adopt whatever PTC systems seem best suited to their particular needs. However, all PTC systems share certain characteristics, including use of radio communication to provide in-cab signals to the train engineer and the ability for the dispatcher to stop a train in an emergency.³²

Most U.S. railroads currently plan to implement what is referred to as an “overlay-type” system, in which the sensors, signals, and transponders are installed over existing track.³³ The network operating center sends one-way communication in the form of speed restrictions and moving authorities to a train as it passes over a transponder embedded in the track. This information requires integration with existing signals, switches, sensors, and other wayside infrastructure. The network operating office does not track real-time train location, but rather receives notice whenever a train passes the wayside infrastructure. **Figure 2** illustrates PTC hardware and communication pathways in an overlay-type system architecture.

²⁹ “Spuyten Duyvil: Why? A Safety Expert Weighs In,” *Railway Age*, December 5, 2013.

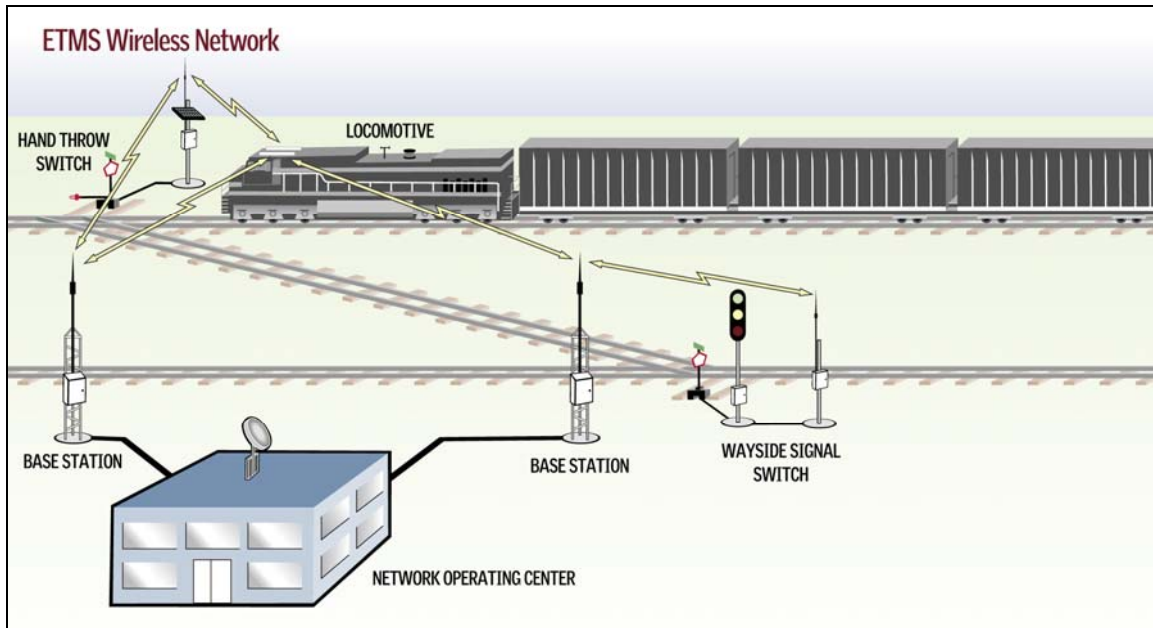
³⁰ FRA, Emergency Order 29, Notice No. 1, December 6, 2013.

³¹ 49 C.F.R. §236.

³² Federal Railroad Administration, *The North American Joint Positive Train Control (NAJPTC) Project*, Research Results, April 2009, p. 2.

³³ Jeff D. Young, Lisa C. Wilson, and Denise E. Lyle, *Interoperable Electronic Train Management System (I-ETMS) Positive Train Control Development Plan (PTCDP)*, Union Pacific Railroad, Norfolk Southern Railway, and CSX Transportation, Inc., FRA-2010-0060-0002, June 1, 2011.

Figure 2. Example PTC System Architecture



Source: Meteorcomm LLC, ETMS Wireless Network, 2011.

Note: Meteorcomm supplies communication equipment for the Electronic Train Management System (ETMS), which several large freight companies are planning to implement. This diagram shows a two-way communications-based PTC system, although most railroads are installing one-way systems that comply with the law.

Communication between wayside infrastructure, transponders, and trains is delivered through analog radio signal. Wireless communication options that provide greater data transfer capability, such as Wi-Fi, are not currently practical. Equipment on the train receives information from transponders to alert the train operator to current and upcoming signals, movements, and work zones. The train has equipment capable of superseding train engineer authority, so that the PTC system can slow or stop the train to prevent incident in the event of human error.

A more expansive variant of an overlay-type system is communications-based train control (CBTC). CBTC is a more sophisticated computer-aided dispatching framework which requires train information to be sent to a central location, which then disseminates the information to all entities in the network.³⁴ In this architecture, Global Positioning System (GPS) is used to track train location and speed, with other instrumentation providing location and speed coverage when the GPS cannot locate a signal. These additional components provide greater precision as well as system redundancy in the event of failure. Similarly, GPS and radio communication similar to cell phone technology can be used to identify work zone locations along specific lengths of track. CBTC is based on digital rather than analog technology, facilitating interoperability among systems used by different railroads.

With CBTC, central control automatically tracks the movements of all the trains in the network, sends speed restrictions and movement authorities to individual trains, and checks for potential

³⁴ There are many ways of designing the system architecture to support PTC communication. In the context of railroad operations with dispatchers, a system architecture with central control is the most plausible design.

derailment and collisions (see **Figure 3**). The system uses location and speed information to determine headway distance and the necessary braking distance required to prevent potential incidents. Braking distance can be several miles for large freight trains and is dependent on factors such as train speed, reaction time, wheel-rail friction, brakes wear, track conditions, track grading, mass, and mass distribution of the train.³⁵ All these variables are processed with a complex braking algorithm to ensure an emergency stop prior to a collision without excessive speed restriction leading to inefficient operation.

Figure 3. Communication-based Train Control (CBTC)



Source: Federal Railroad Administration, Research Results, North American Joint Train Control (NAJTC) Project, April 2009.

Note: Two-way data communication and computer-aided dispatch are the primary subsystems that distinguish full CBTC from PTC.

The greater capability of CBTC makes it suitable for very high speed passenger lines, and CBTC is being instituted on some European rail lines for that reason. However, the system requires seamless communication coverage along the entirety of PTC-equipped track, as temporary communication loss can pose safety risks. The need for constant communication also requires significant investment in either radio towers or fixed transponders. These requirements raise the capital cost, making CBTC more expensive than an overlay-type system.

³⁵ David Barney, David Haley, and George Nikandros, "Calculating Train Braking Distance," This paper appeared at the 6th Australian Workshop on Safety Critical Systems and Software (SCS '01), Brisbane, 2001, pp. 23-29, <http://129.96.12.107/confpapers/CRPITV3Barney.pdf>.

The CBTC system potentially offers greater business benefits to railroad operators than an overlay-type system. For example, the real-time, two-way communication of train locations combined with speed restrictions and moving authorities can lead to more efficient scheduling, increased capacity, and fuel savings. Nonetheless, U.S. railroads appear to have concluded that the advantages of communication-based train control are not worth the additional cost of installing it at the present time.

It is important to note that both overlay-type systems and CBTC systems are designed principally to reduce collisions between trains. The systems do not address intrusion into railroad right-of-way. Currently, there is no requirement that they be capable of detecting and notifying trains about crossing-gate failures, vehicles blocking tracks, or trespassers. However, such capabilities could be incorporated into PTC systems in the future.

Implementation

Motivated by the December 31, 2015, deadline, the large railroad companies are currently testing and implementing PTC on selected track segments across the United States. There are also several small-scale projects underway designed to meet specific local needs. Most of the current PTC projects rely on fixed transponders in conjunction with GPS with one-way information communication to the trains to fulfill the baseline PTC requirements. Only a few systems involve two-way communication with real-time information and computer-aided dispatch. The smaller railroad companies and commuter lines, in most cases, are relying on the Class I railroads to implement PTC before investing in their own systems due to the high risk and the cost of developing their own systems.

In the United States, precursors to full PTC capability were developed voluntarily prior to the 2008 mandate. Development of radio-based CBTC systems and coordinated wayside systems used to locate and communicate with trains began in 1983. Although systems developed by the Association of American Railroads and Burlington Northern Railroad achieved technical success, both systems were functional only in fully signalized territory and were deemed not economically viable to deploy on a nationwide scale.

In 1991, Amtrak adopted an automatic train control (ATC) system along the tracks it owns in the Northeast Corridor. That system, as discussed above, repeated signalization in the cab and required the train engineer to acknowledge and enforce the speed limit given by the signals to reduce human error. That system was later upgraded with the Advanced Civil Speed Enforcement System, using transponders to send signals to trains and to enforce speed restrictions and stop orders.³⁶ Amtrak began transitioning to radio-based communication in 2009 to incorporate work zone safety measures required by RSIA08.³⁷

In 1999, CSX Transportation began development of a PTC system that uses GPS combined with fixed infrastructure at switching points to provide exact track location information, specifically on

³⁶ James Hoelscher and Larry Light, "Full PTC Today with Off the Shelf Technology: Amtrak's ACSES Overlay on Expanded ATC," Proceedings of the 2001 AREMA Conference, Chicago, IL, 2001, http://www.arena.org/files/library/2001_Conference_Proceedings/00022.pdf.

³⁷ Federal Railroad Administration, "Positive Train Control Overview," press release, February 2, 2009, p. 1, http://www.fra.dot.gov/frrs/pages/fp_1265.shtml.

parallel lines. This method is particularly useful to improve safety on long stretches of non-signalized track. CSXT is now modifying this architecture to meet the full requirements of PTC. BNSF, Union Pacific, Norfolk Southern, and Chicago's Metra commuter line are planning implementation of similar systems. Norfolk Southern's system is expected to provide for computer-aided dispatch over small segments of track.³⁸

Prior to certification and revenue service, each rail company is required to submit to FRA a PTC Implementation Plan (PTCIP), Development Plan (PTCDP), and Safety Plan (PTCSP) and receive approval for each plan in that order.³⁹ Companies can also receive "type" approvals when using an identical PTC system that has already received approval. This process and implementation of the plans must be completed prior to the deadline of December 31, 2015.

At an NTSB forum on PTC held February 27, 2013, BNSF Railroad, Amtrak, the Alaska Railroad, and Metrolink Commuter Railroad were identified by an FRA official as the only railroads that were perhaps on schedule to meet the December 31, 2015, deadline.⁴⁰ One topic of discussion at the forum regarded the allowances FRA was making in implementing PTC because of the deadline.⁴¹ The complexity of testing the numerous subsystems, spectrum availability in urban areas, and "back office" software interoperability were some of the difficulties that the railroads identified.

Cost and Benefits

In 2009, the FRA estimated the total capital cost of wayside, on-board, radio, and office equipment necessary for full PTC deployment on all affected railroads to be in excess of \$10 billion. It projects annual maintenance costs of \$850 million.⁴² In 2011, fixed-capital investment by U.S. railroads was \$11.6 billion, of which \$7.9 billion went for structures and \$3.7 billion for equipment.⁴³ The estimated capital cost of meeting the PTC mandate is thus roughly almost equal to the railroads' total capital spending in a single year.

The four largest railroad companies account for almost all of the estimated 60,000 miles of Class I track that fall under the PTC mandate. In August 2010, two railroads (CSXT and NS) estimated costs of PTC alone to be over \$1.2 billion each.⁴⁴

³⁸ William Vantuono, "Two new technologies ready to roll," *International Railway Journal*, vol. 48, no. 4 (April 2008), pp. 26-28.

³⁹ For an example, see 79 *Federal Register* 62705, October 20, 2014.

⁴⁰ NTSB, *Forum—Positive Train Control: Is It on Track?*, February 27, 2013. Witness presentations and a webcast of the forum are available at <http://www.nts.gov/news/events/2013/ptc/presentations.html>.

⁴¹ Described as "shortcuts" by a former FRA official, see testimony of Grady C. Cothen, Jr., NTSB, *Forum—Positive Train Control: Is It on Track?*, February 27, 2013; available at <http://www.nts.gov/news/events/2013/ptc/presentations.html>.

⁴² Frank D. Roskind, *Positive Train Control Systems Economic Analysis*, Federal Railroad Administration, FRA-2006-0132, Notice No. 1, July 10, 2009, p. 120.

⁴³ Association of American Railroads, *Railroad Facts*, 2012 edition (latest available), p. 44.

⁴⁴ CSX Transportation, *CSX Corporation 2010 Annual Report*, Jacksonville, FL, 2010, p. 6; Thompson Reuters, *NSC - Q1 2010 Norfolk Southern Corp Earnings*, Conference Call Final Transcript, April 27, 2010, p. 19, <http://www.nscorp.com/nscorphtml/pdf/transcript042710.pdf>.

Smaller freight companies often share track with the Class I railroads. While this presents interoperability challenges, there is opportunity to use the PTC type approvals from the larger companies' development efforts to save cost. This is also the case with shared passenger rail in the Northeast Corridor. Despite this advantage, the infrastructure cost alone for just two of the five largest transit agencies operating on the corridor, Metro-North in the New York area and the Southeastern Pennsylvania Transportation Authority in the Philadelphia area, has been estimated at \$350 million and \$100 million, respectively.⁴⁵ As the FRA has stated (see text box), the expense of PTC could constrain commuter rail development, diverting commuters to less safe forms of transportation.

Commuter railroads' cost for installing PTC is likely to be borne primarily by state or local governments. FRA established a railroad safety technology grant fund to support railroads' development and implementation of PTC systems, with \$50 million budgeted for each FY2009-FY2013.⁴⁶ However, no funds have been appropriated for this program.

Some shippers believe that since the majority of the investment in PTC will come directly from the railroad companies, these costs will likely be passed to customers. They expect price increases due to the cost of PTC implementation, especially if the rail companies are unable to realize business benefits from the new systems. The Chlorine Institute, a trade organization representing the chlorine industry, expects the railroad companies to raise costs disproportionately for shipments of toxic-by-inhalation hazardous materials (TIH), as concern about the safety of TIH transport is perceived as a source of the PTC mandate.⁴⁷

Safety Benefits from PTC-Preventable Incidents

Based on analysis of past PTC-preventable incidents, FRA estimates \$90 million in annual safety benefits will be realized after full implementation of PTC.⁴⁸ Safety benefits are calculated by estimating the cost of incidents that are likely to be prevented by PTC, including fatalities and injuries, equipment damage, track damage, off-track damage, hazardous material cleanup, evacuations, wreck cleanup, loss of freight, and freight delay. According to a 1999 FRA estimate, between 1987 and 1997 an annual average of 7 fatalities, 22 injuries, \$20 million in property damages, and evacuations of 150 people due to potential hazardous material release could have been prevented by PTC.⁴⁹

Although many serious incidents due to error by train engineers or dispatchers could be prevented by PTC, PTC is expected to prevent less than 2% of the approximately 2,000 railroad collisions

⁴⁵ Jeff Stagl, "PTC: Railroads, suppliers still have a ways to go to meet the 2015 positive train control mandate," *Progressive Railroading*, August 2010.

⁴⁶ U.S. Department of Transportation, "FRA Announces \$50 Million Safety Technology Grant Program," press release, April 7, 2010, <http://www.fra.dot.gov/Pages/press-releases/201.shtml>.

⁴⁷ The Chlorine Institute, Inc., "Chlorine Institute Asks Federal Rail Administration to Reconsider Positive Train Control Rule Due to Faulty Cost-Benefit Analysis," press release, March 16, 2010, <http://www.chlorineinstitute.org/files/PDFs/2010-03-16%20-%20CI%20PTC%20petition.pdf>.

⁴⁸ Frank D. Roskind, *Positive Train Control Systems Economic Analysis*, Federal Railroad Administration, FRA-2006-0132, Notice No. 1, July 10, 2009, pp. 140-144.

⁴⁹ Railroad Safety Advisory Committee, Federal Railroad Administration, *Implementation of Positive Train Control Systems*, Report, August 1999, <https://rsac.fra.dot.gov/meetings/19990908.php>.

and derailments that occur annually. The majority of these 2,000 incidents occur in rail yards and are generally less severe than PTC-preventable incidents.

While the costs and safety benefits are projected with some confidence, there is disagreement regarding the potential business and social benefits of PTC. This makes a full cost-benefit analysis of PTC-related issues difficult. Business and social benefits are expected to come from increased railroad efficiency, reductions in logistical costs, and diversion of freight from truck to rail. However, these benefits are predicated on the functionality of full computer-based train control and not PTC alone. Computer-aided dispatch has the potential to increase capacity and reduce fuel consumption. This can reduce railroad operating costs, lead to faster, less-expensive delivery, and induce demand from truck freight. This then may lead to social benefits such as reductions in fuel consumption and truck accidents.

FRA projects \$4 billion in potential annual business benefits a decade after full PTC implementation. However, the overlay system without CBTC capability currently planned by the railroads is expected to offer little or no business benefit to the railroads. The social benefits of the overlay system are likely to come largely from the anticipated reduction in incidents.⁵⁰

Policy Issues

Interoperability

The freight rail transportation network has two primary components: the track and the freight service. In some cases, the service is provided by the same company that owns the track. However, since shippers' needs do not correspond to railroads' track ownership, freight operators trade trackage or haulage rights and share revenue from the shipper. FRA regulations require that railroads' PTC systems be interoperable so that any train operating on PTC-equipped track can communicate with the host railroad's PTC system.

Prior to RSIA08, several railroad companies were developing communication-based train control independently for their own business reasons, and were not concerned about interoperability. The federal mandate has required changes in these plans in the interest of interoperability. UP, CSXT, and NS have received FRA "type approvals" for Interoperable Electronic Train Management Systems (I-ETMS) in which the PTC system itself is approved for development.⁵¹ This makes it likely that the systems installed by these railroads will be highly compatible. BNSF, which has a precursor ETMS system in place, has type approval for that system, which is to be updated to I-ETMS when software becomes available.

Interoperability issues pertain to passenger service as well. In the Northeast Corridor, Amtrak operates on Amtrak-owned track and track owned by regional transit authorities and vice versa. Amtrak began PTC development prior to RSIA08 and has provided the PTC standard and type

⁵⁰ Frank D. Roskind, *Positive Train Control Systems Economic Analysis*, Federal Railroad Administration, FRA-2006-0132, Notice No. 1, July 10, 2009, pp. A-1-A-16.

⁵¹ Letter from Jo Strang, FRA Associate Administrator for Railroad Safety/Chief Safety Officer, to Jeff D. Young et al., Union Pacific Railroad Assistant Vice President, Transportation System, August 26, 2011, FRA Type Approval (FRA-TA-2011-02) for the Interoperable Electronic Train Management System (I-ETMS).

approval for transit authorities utilizing the corridor. The freight companies and Amtrak are now working to ensure interoperability between their respective systems.

Communication Spectrum

One aspect of interoperability involves the communications links between wayside equipment, locomotive, and the network office. Various types of equipment owned by many different railroads must be able to communicate on any track equipped with PTC. It would be most efficient to utilize a single radio frequency band across the entire PTC system to minimize the cost of radio receivers and network equipment, although a system with multiple frequencies is possible.

The radio frequency band to be used for communication must be known prior to equipment purchases. PTC-220 LLC, a consortium of the Union Pacific, Norfolk Southern, CSX, and BNSF railroads, has purchased licenses to some frequencies in the 220 MHz range,⁵² and is requesting the Federal Communications Commission (FCC) to reassign additional spectrum in the 220 MHz band to the railroads for the purpose of PTC. The FCC has designated spectrum in the 220 MHz range mainly for commercial uses and has auctioned licenses to various parties.

Furthermore, along with Amtrak and other railroads, the consortium has requested additional 217-222 MHz spectrum and appropriate license and rule changes, claiming 220 MHz will be insufficient in congested areas.⁵³ Although frequencies may be available in various bands, the railroads prefer the 217-222 MHz range due to compatibility with current infrastructure and the radio communication technology they have chosen to employ (I-ETMS).⁵⁴ Because of uncertainty over spectrum needs, the FCC issued a public notice seeking comments from stakeholders on May 5, 2011, but has not instituted a formal rulemaking process regarding PTC radio spectrum issues.⁵⁵

The railroads' requests for dedicated spectrum for PTC raise a number of policy issues. Licenses to much of the spectrum requested by the railroads have been purchased by other entities in FCC auctions. While the FCC is empowered to reallocate spectrum if necessary for public safety, reassignment for PTC would effectively represent a forced transfer of licenses from some private parties to others. In comments submitted to the FCC, some current licensees of spectrum in the 218-219 MHz range asserted that it is unfair to reallocate spectrum to which they have purchased rights in a competitive bidding process. They also believe the railroads have identified 220 MHz as the core spectrum for PTC without sufficient investigation into their specific radio

⁵² Spectrum is segmented into bands of radio frequencies and typically measured in cycles per second, or hertz. Standard abbreviations for measuring frequencies include kHz—kilohertz or thousands of hertz; MHz—megahertz, or millions of hertz; and GHz—gigahertz, or billions of hertz.

⁵³ Association of American Railroads, *Comments of Association of American Railroads*, Federal Communications Commission, WT Docket No. 11-79, June 20, 2011, <http://apps.fcc.gov/ecfs/document/view?id=7021688770>.

⁵⁴ It should be noted that the radio communication supplier for ETMS is MeteorComm, a wholly owned subsidiary of BNSF, and BNSF is a member of PTC-220, LLC. MeteorComm, "MeteorComm™ Powers BNSF's Electronic Train Management Communications," press release, January 19, 2007, http://meteorcomm.com/downloads/MCC_PSPApproval.pdf.

⁵⁵ Federal Communications Commission, Wireless Telecommunications Bureau Seeks Comment on Spectrum Needs for the Implementation of the Positive Train Control Provisions of the Rail Safety Improvement Act of 2008, WT Docket No. 11-79, Washington, DC, May 5, 2011, http://fjallfoss.fcc.gov/edocs_public/attachmatch/DA-11-838A1.pdf.

communication needs or possible alternatives. They contend the railroads can lease spectrum from primary license holders without FCC action.⁵⁶

The railroads counter that leasing spectrum for PTC from existing license holders could raise their costs by creating captive demand for a limited amount of spectrum. A related problem stems from the fact that some of the railroads required to install PTC are commuter lines owned by state or local government agencies. These agencies may have difficulty raising the funds to obtain desirable frequencies in competitive auctions; indeed, the FCC normally assigns frequencies to government agencies at no cost.

An unexpected issue arose with the installation of PTC antennas on American Indian tribal lands. Tribal leaders are required to approve the installation under the Historic Preservation Act because digging is required for the antennas' foundations. Tens of thousands of antennas must be approved, more than the Indian tribes are capable of reviewing if PTC is to be installed as required by the end of 2015.⁵⁷ The FCC established an expedited procedure for these reviews in May 2014.⁵⁸

Avoiding Barriers to Market Entry

There are several ways the PTC mandate could be used as a barrier to market entry for the railroads. First, installing track will now be more expensive due to the need to incorporate PTC wayside equipment, which is expected to add approximately \$50,000 per mile to the \$1 million to \$3 million per mile cost of installing new rail lines. On-board PTC equipment is expected to cost around \$55,000 per locomotive, which represents only a minor increase in the cost of a new \$2 million locomotive but is substantial compared to the \$75,000 cost of used locomotives operated by some short line railroads.⁵⁹ In addition to capital costs, operating and maintenance costs will increase as well.⁶⁰ This could be a barrier to both railroad expansion and startup services.

Another barrier to market entry could arise from the need for interoperability and spectrum compatibility. Hypothetically, if two rail networks have different PTC systems because they do not currently share track or services, it may be cost prohibitive to implement a new service over these two lines. Similarly, one company could upgrade or modify its PTC system, forcing further investment by other companies using its track. Also, if the radio spectrum licenses are owned by certain railroads or a consortium of railroads, they could dictate leasing prices to operate necessary PTC systems on that spectrum for a new railroad or service which is not part of the consortium. Control of spectrum and interoperability issues with PTC could be used as tools to prevent new services on existing lines or even using an interoperable spectrum on new lines.

⁵⁶ The Coalition of 218-219 MHz Service Licensees, *Reply Comments of The Coalition of 218-219 MHz Licensees*, Federal Communications Commission, WT Docket No. 11-79, July 11, 2011, <http://apps.fcc.gov/ecfs/document/view.action?id=7021691731>.

⁵⁷ See 78 *Federal Register* 65308, October 31, 2013.

⁵⁸ FCC, WT Docket No. 13-240, May 19, 2014.

⁵⁹ Federal Railroad Administration, "Positive Train Control Systems Amendments (RRR)," 77 *Federal Register* 28285, May 14, 2012.

⁶⁰ Frank D. Roskind, *Positive Train Control Systems Economic Analysis*, Federal Railroad Administration, FRA-2006-0132, Notice No. 1, July 10, 2009, pp. 115-116.

The possibility that PTC could impede competition may be of particular concern for short line and regional railroads which operate on Class I track. Class I railroads have a legal obligation to accommodate short line railroads, but in some cases may be reluctant to allow short line trains on their networks.⁶¹ The president of the American Short Line and Regional Railroad Association issued the following testimony to the Surface Transportation Board:

Differential pricing of certain routes or products by class I carriers ... ha[s] eliminated marginal customers who may be a small railroad's only source of business on its line, effectively putting the small railroad out of business. Some small railroads who want to provide service to new customers meet resistance from connecting carriers whose marketing plans are inconsistent with the small railroad's proposed business.⁶²

At this point, concerns that PTC could create barriers to railroad competition are hypothetical, as no specific complaints are known to have been presented to FRA or to the Surface Transportation Board, which oversees certain rail competition issues.

2015 Implementation Deadline

It remains uncertain whether all affected railroads will be able to comply with the December 31, 2015, deadline for implementing PTC. Many railroads continue to argue that the large capital expenditures required over a small period will divert funding from other uses, including investment in improving the safety of highway-rail grade crossings, where most train-related incidents and fatalities occur.⁶³

The effect of the deadline on installation of more advanced systems is disputed. As discussed earlier, PTC and CBTC have different capabilities, but they share similar infrastructure and communication architectures. While CBTC would require additional cost, it might be cost-effective to develop both functionalities simultaneously. Railroads also argue the deadline for PTC has caused railroads to focus on that system rather than on the potential business advantages of a broader CBTC system.⁶⁴ Also, some commuter lines have stated interest in extending PTC capability through wireless technology capable of transmitting more data, but investment in these more complex emerging technologies may be deferred due to the approaching deadline.⁶⁵

On the other hand, the PTC mandate institutes a common infrastructure and communication architecture platform that could be used for future CBTC and additional safety feature integration in a coordinated way across disparate stakeholders. Without the PTC mandate it is likely that PTC/CBTC would not have been developed with such a coordinated effort, due to the multitude of stakeholders. FRA has concluded that incremental steps are the preferred way to develop a more complex train control system, such as CBTC.⁶⁶

⁶¹ CRS Report RL34117, *Railroad Access and Competition Issues*, by (name redacted).

⁶² Richard F. Timmons, *STB Ex Parte No. 677: Common Carrier Obligation Hearing*, American Short Line and Regional Railroad Association, Testimony of Richard F. Timmons, Washington, DC, April 25, 2008, p. 2.

⁶³ U.S. Government Accountability Office, *Rail Safety - Federal Railroad Administration Should Report on Risks to the Successful Implementation of Mandated Safety Technology*, GAO-11-133, December 2010, p. 25.

⁶⁴ *Ibid.*

⁶⁵ Jeff Stagl, "PTC: Railroads, suppliers still have a ways to go to meet the 2015 positive train control mandate," *Progressive Railroading*, August 2010.

⁶⁶ Federal Railroad Administration, *The North American Joint Positive Train Control (NAJPTC) Project*, Research (continued...)

Options for Congress

The Moving Ahead for Progress in the 21st Century Act (MAP-21; S. 1813) and the American Energy and Infrastructure Jobs Act (H.R. 7) from the 112th Congress both included provisions which amended RSIA08 with respect to PTC. The provisions in these bills were ultimately excluded from the final version of the transportation bill (H.R. 4348), but both provide insight into possible strategies to address some of the policy issues with PTC.

Table 1. PTC Provisions in Unenacted Senate and House Bills in 112th Congress

Bill	Deadline Extension	Safety	Interoperability	Communication Spectrum	Funding	Barrier to Entry
House-Reported H.R. 7	12/31/2020	Full PTC or equivalent alternative	No change	No change	No change	No change
Senate-Passed S. 1813	At FRA discretion for each railroad in one-year increments, not beyond 12/31/2018	Full PTC	No change	FCC/DOT joint report on spectrum needs and availability for PTC required	Eligible for Railroad Rehabilitation and Improvement (RRIF) financing	FCC/DOT joint report on spectrum needs and availability for PTC required

Source: CRS, based on texts of S. 1813 and H.R. 7.

In the aftermath of the Metro-North derailment, Representative Sean Maloney introduced H.R. 3634, 113th Congress, which would have made PTC an eligible use of RRIF loans and extend and increase the authorization of federal grants for railroad safety technology. S. 1462, 113th Congress, introduced by Senator Thune in August 2013, would have extended the deadline for implementing PTC from December 31, 2015, to December 31, 2020, and authorized further extension of the deadline on a case-by-case basis for individual railroads under certain circumstances.

Congress has already shown its concern about implementation risk, and the enacted version of MAP-21 required DOT to report on PTC implementation to Congress by December 31, 2012. The Government Accountability Office recommended that this report include “an analysis of (1) the likelihood that railroads will meet the PTC implementation deadline; (2) the risks to successful implementation of PTC; and (3) actions Congress, railroads, or other stakeholders can take to mitigate risks to successful PTC implementation.”⁶⁷ In August 2012, DOT reported that railroads would likely miss the deadline and listed criteria for extending the deadline on a case-by-case basis, and suggested the possibility of granting provisional certification, and allowing for alternative safety technology on line segments with lower safety risks.⁶⁸

(...continued)

Results, April 2009, p. 4.

⁶⁷ U.S. Government Accountability Office, *Rail Safety - Federal Railroad Administration Should Report on Risks to the Successful Implementation of Mandated Safety Technology*, GAO-11-133, December 2010, p. 47.

⁶⁸ FRA, *Positive Train Control: Implementation Status, Issues, and Impacts*, August 2012, http://www.fra.dot.gov/downloads/08.2012_FRA_Report_to%20Congress_on_Positive_Train_Control.pdf.

The most obvious way to mitigate implementation risk would be to extend the 2015 deadline, giving railroads and FRA additional time to make sure PTC will work as intended. However, extending the deadline would create a different sort of risk by leaving railroads exposed to PTC-preventable incidents for a longer period of time. The NTSB's 2015 "Most Wanted List" specifies 2015 as a date certain for implementing PTC.⁶⁹

One of the major concerns of railroad companies is the cost of PTC. This is especially true for short line railroads and local commuter services reliant on local and state government funds. RSIA08 authorizes federal grants to railroads to support PTC, but no funds have been appropriated for this purpose. Congress could address this issue by specifically making PTC projects eligible for funding under the Railroad Rehabilitation and Improvement Funding Program or by appropriating other funding to the FRA.

Issues related to spectrum allocation for PTC remain unresolved. While the FCC has solicited comments about the use of spectrum for PTC, it has not instituted a formal proceeding and is not required by law to do so. Congress could establish deadlines or direct FCC actions on the subject. Alternatively, by not acting, Congress could choose to leave the matter entirely to the FCC's discretion.

Although many more rail-related fatalities occur at highway-rail crossings than from train collisions, these are not specifically addressed in the PTC mandate of RSIA08. Congress could address this by extending the definition of PTC to require coverage of highway-rail crossings. This can be achieved technically within the PTC framework by installing sensors at crossings that would engage the brakes of an oncoming train if a crossing gate is not working properly or if a vehicle is detected on the tracks.⁷⁰ While this may require further investment on the part of the railroads and may not be implementable by the current deadline, it may offer more significant gains in terms of safety than train collision prevention alone.

In addition to routes serving passengers and moving TIH products, Congress authorized PTC installation on other tracks at FRA's discretion. In recent years, shipments of ethanol and crude oil have become a booming business for the railroads. These commodities are often hauled in unit trains of 70 to 120 tank cars, the first time hazardous materials have been hauled in unit trains. Several derailments of these trains have caused large fires, deaths (47 in one instance in Canada), injuries, and evacuation of nearby residents. While these derailments may not have been PTC-preventable, ethanol and crude oil represent a large and rapidly growing business of hazardous materials by rail.⁷¹

The commuter rail incidents at Chatsworth, CA, and the Bronx, NY, have revealed significant disparities among signal system capabilities deployed by commuter operators. These two incidents have intensified calls for PTC installation, even though neither railroad had fully deployed long-standing signal technology that could also reduce the risk of collisions and derailment. Congress may wish to gain a better understanding of the various available signal technologies and the obstacles to their use.

⁶⁹ http://www.nts.gov/safety/mwl/Documents/MWL_2015_Factsheet_04.pdf.

⁷⁰ Fred Coleman III, Ronald W. Eck, and Eugene R. Russell, "Railroad-Highway Grade Crossings," TRB Conference Publication, Washington, DC, January 2000.

⁷¹ CRS Report R43390, *U.S. Rail Transportation of Crude Oil: Background and Issues for Congress*, by (name redacted) et al.

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