Positive train control:
How does it work? How much will it cost?
What progress is being made in implementation?
What are the current critical issues?

HNTB’s high-speed read:
A series of white papers on what it will take to develop a high-speed rail program in the United States. This is the second installment on positive train control.
**Congress mandates positive train control by 2015**

Like air traffic control for trains, only better, positive train control is a means to improve the safety of train operations by automatically ensuring stops and speed restrictions. At any one time, there are tens of thousands of freight and U.S. passenger trains in operation in the United States. They share nearly 25,000 route miles of rail line. Now, add to that mix high-speed trains traveling at 110 mph to 187 mph, and you can see why we need a predictive system that limits incidents caused by human error. With PTC, the operator doesn't have to slow a train if it is in danger of collision. The train slows itself.

Citing increasing passenger and freight rail traffic, Congress passed the Rail Safety Improvement Act of 2008, which requires railroads to implement PTC systems on specific rail lines by the end of 2015. The mandate is intended to:

- Prevent train-to-train collisions
- Enforce speed restrictions
- Prevent movements over a switch in the wrong position
- Protect roadway workers and their equipment

To be clear, this is real change and a noble charge. Congress has tasked the industry with advancing the safety of rail travel beyond anything we’ve ever seen. Once implemented, PTC will be to rail passenger safety what the seat belt is to automobile passenger safety.

In fact, recent safety reviews of the September 2008 accident in Los Angeles’ Chatsworth District have led to speculation that if PTC had been in place, it could have minimized – if not prevented – the freight train and commuter train collision that killed 25 people.

Railroads are midway through programs to implement PTC by 2015. While the pace of progress on PTC has been astounding and the level of cooperation in the industry unprecedented, significant challenges remain. While the safety goals for PTC are noble, the costs continue to increase resulting in questions regarding the overall economic impact, unless the technology can be leveraged for future improvements.

While PTC is primarily about safety, the cost is significant and the overall effect on the efficiency of train movement has yet to be fully measured.

The U.S. high-speed rail development is closely tied to the overall move toward a more balanced, multimodal transportation system for the nation.

As a representative of the American Public Transportation Association, HNTB is an active member of the Railroad Safety Advisory Committee (RSAC) established by the Federal Railroad Administration to develop new regulatory standards. It is the committee’s job to provide recommendations on specific tasks assigned to it by the FRA, including PTC. The FRA, in turn, uses the committee’s consensus recommendations as the basis of proposed and final agency action.

As an RSAC member, HNTB has an insider’s understanding of PTC and the coming regulations. Through our work in supporting several of our client’s PTC programs we are pushing for completion by difficult deadlines and have been engaged in getting FRA approval of documentation for our clients.

**How does PTC work?**

PTC improves safety as it is a predictive system when dealing with human errors, where prior train control systems were only reactive to human errors. With PTC, the system determines when braking should start so that a red signal (or other movement authority) is not overrun and will enforce this braking if the operator does not act. Moreover, PTC assumes that a train should stop at the next control point, unless it explicitly receives a “release” stating that it is safe for the train to move beyond the control point. Many previous train control systems would only act after a red signal had already been passed, potentially unsafely.

With PTC, trains receive information from GPS or transponders about their locations and where they are allowed to travel safely, also known as movement authorities. The predictive technology monitors a train’s current conditions against its speed and end-of-authority limits. The speed and authority limits are monitored by the train’s speed curve and a distance-to-target (counter down) or the train’s breaking curve of the onboard PTC segment. PTC is activated when the train is no longer operating at an allowed speed (track speed or civil limit) or is not slowing or braking sufficiently to stop short of the end of authority.

The three main elements of a PTC system are: the onboard system, the wayside system and the back office servers. These elements are tied together by a wireless communications system (communications to the train) and a Ground-Based Network supporting BOS-to-wayside and BOS-to-BOS communications.
• The onboard equipment is aware of the train's position and speed and the profile of the track. It receives speed restrictions and limits of movement authority via the wireless data system. The onboard equipment provides an operator display and activates braking as necessary to enforce speed restrictions and limits of movement authority.

• The wayside equipment monitors selected elements of the signal system so that the proper movement authority can be communicated to the onboard equipment.

• The BOS is responsible for managing movement authorities and speed restrictions. Temporary speed restrictions are entered by dispatchers at the control center. The onboard equipment requests frequent updates of speed restrictions via the wireless data system and the GBN to the BOS. Where trains may transition from the territory controlled by one BOS to another, the two BOS work together so that each train gets all relevant speed restriction data prior to entering the new territory.

What PTC Systems are being implemented?
There are two PTC systems that are being deployed by most railroads in the United States:

1. **Electronic Train Management System**, to be used by most Class I freight carriers, is an enhanced safety overlay system. It enforces the operating railroad's current train control procedures and is applicable to medium-density train tracks with speeds of 70 mph or less. BNSF Railway deploys this type of system. A second version of ETMS is being developed, originally dubbed V-ETMS (vital) it is now being called I-ETMS (interoperable).

2. **Advanced Civil Speed Enforcement System** is a safety-critical system that overlays an existing cab signal system. It has been in operation on Amtrak’s Northeast Corridor between Boston and Washington, D.C., for about 10 years. Because of the large amount of interoperability between Amtrak and commuter rail trains along the Northeast Corridor, many of the commuter rail operators are electing to deploy ACSES-compatible systems.

There are some systems being implemented on lines where interoperability is not a primary concern. Two of these are:

1. **Incremental Train Control System** is a safety-critical, wayside-centric system that overlays an existing centralized traffic control system, using a network of vital processors along the route. It communicates with trains by data radio on Amtrak's Michigan line.

2. **The Collision Avoidance System** is used by the Alaska Railroad. CAS has been a multi-year, multi-phase development program that includes integration with the computer-aided dispatch system.

Because railroads can choose between more than one type of PTC system, interoperability will be a requirement for PTC in two ways:

1. Host railroads must document in their implementation plans how they are interoperable with their tenant railroads or visa versa.

2. Support for interoperability must be proved for the PTC system to be certified by the FRA.

How much will PTC cost?
Current industry estimates are that PTC will cost between $9.5 billion and $13.2 billion over the next 20 years. This is an average of about $130,000 per mile. Estimates of the initial deployment costs are between $2.0 billion and $3.7 billion.

While the federal government has made an authorization of $50 million per year for 2009-2013 in funding to help support PTC with the Rail Safety Act of 2008, funding was not included in the Administration’s budget requests for Fiscal Year 2009, 2010, or 2011 and is absent in the 2012 budget as well.

As the typical commuter railroad operates at a deficit, the cost of PTC will pass to the taxpayers. As most commuter railroads have a backlog of maintenance and capital improvements it is likely that some will be deferred so that PTC can be implemented by the 2015 deadline.

What do we know about the FRA regulations?
On April 4, 2009, the RSAC submitted to the FRA its recommendations, that is, those functions that the committee felt related directly to the mandate. They are listed by category below.

Function:
- To prevent train-to-train collisions, restricted speed operation must be enforced stringently. Rail-to-rail connections, such as diamonds, also require additional protection, especially when one of the rail lines is non-PTC.
- To prevent overspeed derailments, temporary speed restrictions must become part of the protection afforded by PTC. Highway-rail grade crossing malfunctions, workers on or near the track and speed restrictions based on class of train should all be part of PTC.
- To prevent incursions into roadway work zones, the employee in charge on the ground must maintain control over the releasing of trains into work zones.
To prevent train movement through a switch left in the wrong position, switches must have their positions detected and secured prior to train movements over them in unsignaled territory. In signaled territory, route integrity, as required today, will be integrated into the PTC system.

The committee also recommended that high-speed rail have a subset of PTC regulations due to the nature of the service.

PTC-required rail lines: Class I railroads with five million gross tons and poisonous/toxic inhalable hazardous chemical traffic will be required to implement PTC, as well as regularly scheduled intercity and commuter passenger railroads. The committee recommended exceptions for yards and passenger terminals where speeds are restricted to 20 mph or less. More recently, a change to the date where rail lines are determined to carry poisonous/toxic materials has been supported, resulting in a decrease in the amount of territory that must be equipped due to this provision.

PTC-equipped locomotives: All trains in PTC territory must be equipped. Latitude during implementation will be granted because not all locomotives can be equipped overnight. However, new starts after Dec. 31, 2015, will not have such a grace period. Class II, Class III and short line trains operating on Class I track also must be equipped.

PTC plans and processes: Implementation plans, submitted by all railroads and reviewed by the FRA in 2010:
- Defined interoperability with tenant railroads
- Explained railroad operation
- Described the type of PTC system to be used
- Included development plans for any new type of PTC system

No railroad carrier will be permitted to begin the implementation of its plan before securing approval from the FRA and the secretary of transportation. Following shortly after the submission of the PTC Implementation Plan, is the submission of the PTC Development Plan. The PTCDP provides a more technical description of how the system is designed and will operate.

PTC safety plans also are required prior to FRA approval for service. It is expected that the PTC Safety Plan will be the critical document in allowing the FRA to judge the overall compliance with RSIA, leading to certification.

Training: The committee also recommended training for all railroad personnel, including contracted employees, who operate and/or maintain any part of a PTC system.

As of May 2011, only one major Commuter Rail Operator has its full PTC implementation program under contract. The freight railroads are continuing to move ahead with implementation. As discussed in the next section considerable development and risks remain.

Current Challenges
Although the Class I railroads have indicated intent to use ETMS (or I-ETMS), the PTCDP for ETMS has not yet been approved by the FRA. As the railroads are moving ahead with programs, in order to meet the 2015 deadline, this is a significant risk.

In order to support interoperability, there needs to be a common means of wireless data communications. Led by the Class 1 freight railroads, the use of 220 MHz radio channels is being adopted by the industry. However, there is no specific allocation of channels for PTC from the Federal Communications Commission. Each railroad has been left by itself to acquire channels and licenses that will cover its area of operations. Four of the Class 1 freight railroads have created a company, PTC-220, to acquire and manage spectrum. Other railroads are trying to acquire spectrum on the open market, while still pushing for an FCC allocation.

The wireless data technology for PTC is slowly evolving. Radios for support of ACSES at 220 MHz have only recently been released by a single manufacturer and are under test. The communications manager that will work with the radio to handle the ACSES protocol is under development. ETMS-compatible radios and communications managers are not yet available in production form.

While the costs for PTC are still being tallied, railroads are looking for ways to use PTC technology and equipment to realize a business benefit in addition to the safety benefit. Some of the potential areas to explore include: improved real-time diagnostics of locomotive and signal equipment and improved management of train operations through more precise knowledge of train location. Evolving PTC into a system that will safely support improved capacity on a rail line is thought to be the key in obtaining economic benefit. Once the reliability of PTC has been proven, it may be possible to implement PTC as a stand-alone system (vs. an overlay) so that there would be cost avoidance of some signal components.
HNTB is providing design-engineering services to the Massachusetts Bay Transportation Authority for its Green Line Positive Train Control Project, the first light rail adaptation of the safety system, and one that will likely be a model for transit systems across the country.

Boston's Green Line is the highest-capacity light rail system in the country, moving more than 200,000 people daily. Rapid transit systems are exempt from a 2008 federal law mandating that certain freight and commuter rail lines adopt PTC by 2015. However, accidents in 2008 and 2009, and a letter from the National Transportation Safety Board, prompted MBTA to consider its own PTC.

The system MBTA will implement is expected to be very different than that implemented by railroads, due to the MBTA's need to have trains operate very closely following each other therefore, finding a formula to maintain efficiency while implementing a speed-control, safety system is one of the significant challenges of the project.

By March 2012, an alternative analysis and recommendations study will be complete. The study will: define PTC as it relates to Green Line; identify candidate PTC systems; determine PTC’s effects on operations; and outline how the system will be implemented. HNTB will develop the scope for preliminary engineering based on the study’s recommendations.

One of the biggest risks is that the system technology needs to be implemented efficiently on a working transit line. Some attempts at similar advanced technology have resulted in 10-year-long pilot programs. To achieve more cohesion in the process, MBTA work with the American Public Transportation Association and other transit organizations to develop a unified solution in the same way major freight railroads have collaborated on PTC development.

HNTB has fundamental knowledge of PTC because of its participation on the Railroad Safety Advisory Committee, established by the Federal Railroad Administration to develop new regulatory standards. Additionally, HNTB will interview suppliers and collect best practices by visiting five properties with operational PTC systems.

The operational date will be determined by the type of system the MBTA chooses and the cost, which can range from $12 million to $20 million per mile.

Additional resources
For more information about PTC, consult the following:

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Association of American Railroads: PTC Key Facts
www.aar.org/Initiatives/PositiveTrainControl/PTC_Key_Facts.aspx

Federal Railroad Administration
- Positive Train Control: www.fra.dot.gov/us/content/784
- PTC Overview: www.fra.dot.gov/us/content/1265
- PTC Analyses: www.fra.dot.gov/us/content/602
- Signal and Train Control Compliance Manual: www.fra.dot.gov/us/content/1456

National Transportation Safety Board’s “Most Wanted” List:
Implement Positive Train Control Systems
www.ntsb.gov/Recs/mostwanted/FedMWL-TRAIN.pdf

U.S. Department of Transportation:
Federal Railroad Administration Railroad Safety Advisory Committee
http://rsac.fra.dot.gov/home.php

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