Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WSDOT staff. Online and print sources may include newspaper and periodical articles, NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs and related academic and industry research. Internet hyperlinks in the TSRs are active at the time of publication, but host server changes can make them obsolete.

Request for Synthesis:
Scott Witt, Freight Systems Division Co-Director and State Rail and Marine Director, requested a synthesis of positive train control (PTC), including a general overview of how the system works, major role players (equipment manufacturers, railroads and other governing bodies already using such systems, etc.), and implementation costs.

Databases Searched:
- TRIS
- Google

Synthesis Summary:
- System Overview
- Projects
- Manufacturers
- Costs
- Safety
- Security
- Other Search Results

SYSTEM OVERVIEW
Positive Train Control, Wikipedia
This website provides an informal overview, lists of current PTC projects, and manufacturers. Manufacturers not noted elsewhere in this synthesis are PHW, Inc. and Quantum Engineering.
http://en.wikipedia.org/wiki/Positive_train_control

Positive Train Control, Federal Railroad Administration
Positive Train Control (PTC) systems are integrated command, control, communications, and information systems for controlling train movements with safety, security, precision, and efficiency. PTC systems will improve railroad safety by significantly reducing the probability of collisions between trains, casualties to roadway workers and damage to their equipment, and over speed accidents. The National Transportation Safety Board (NTSB) has named PTC as one of its "most-wanted" initiatives for national transportation safety. PTC systems are comprised of digital data link communications networks, continuous and accurate positioning systems such as NDGPs, on-board computers with digitized maps on locomotives and maintenance-of-way equipment, in-cab displays, throttle-brake interfaces on locomotives, wayside interface units at switches and wayside detectors, and control center computers and displays. PTC systems may also interface with tactical and strategic traffic planners, work order reporting systems, and locomotive health reporting systems. PTC systems issue movement authorities to train and
maintenance-of-way crews, track the location of the trains and maintenance-of-way vehicles, have the ability to automatically enforce movement authorities, and continually update operating data systems with information on the location of trains, locomotives, cars, and crews. The remote intervention capability of PTC will permit the control center to stop a train should the locomotive crew be incapacitated. In addition to providing a greater level of safety and security, PTC systems also enable a railroad to run scheduled operations and provide improved running time, greater running time reliability, higher asset utilization, and greater track capacity. They will assist railroads in measuring and managing costs and in improving energy efficiency. Pilot versions of PTC were successfully tested a decade ago, but the systems were never deployed on a wide scale. Other demonstration projects are currently in the planning and testing stages. Deployment of PTC on railroads is expected to begin in earnest later this decade.

http://www.fra.dot.gov/us/content/784
See also http://www.fra.dot.gov/us/content/1265

The North American Joint Positive Train Control (NAJPTC) Project
Federal Railroad Administration, April 2009, Research Results RR09-05

Background:
Positive train control (PTC) is a form of communication-based train control (CBTC). To satisfy the three basic safety characteristics specified by the Federal Railroad Administration’s (FRA) Railroad Safety Advisory Committee’s (RSAC) PTC Working Group, a PTC system must:

- Prevent train-to-train collisions;
- Enforce speed restrictions and temporary slow orders; and
- Provide protection for workers and their equipment operating under specific authorities.

Figure 2 illustrates the communications-based PTC architecture, with key subsystems and their main functions indicated.

Figure 2. PTC System Architecture

Communications Based Positive Train Control Systems Architecture in the USA

Positive Train Control
From abstract: This paper summarizes the recent regulatory change that supports the implementation of PTC in the United States. This paper describes basic PTC architectures and functionality being adopted in the railroad environment, and closes by highlighting two different implementations of the same basic PTC architecture.

PROJECTS
Two New Technologies Ready to Roll

Abstract: Positive train control (PTC) and electronically-controlled pneumatic (ECP) braking are two technologies that, after almost two decades of development, are finally poised to change North American heavy-haul freight railroading’s character dramatically. Existing brake cylinders and rigging are used in ECP-actuated braking, but the brake pipe functions only as a reservoir charging pipe. PTC is designed to protect track workers, enforce permanent and temporary speed restrictions, and prevent train collisions. The two technologies allow the opportunity for “intelligent” trains with intelligent control centers to be created, and pave the way for virtually unlimited opportunities for North American railways. Implementation challenges are discussed.

This article lists current projects:

- Advanced Civil Speed Enforcement System (ACSES) used by Amtrak
- Collision Avoidance System (CAS) used by Alaska Railroad, supplied by Union Switch & Signal
- Communications-Based Train Management (CBTM) used on CSXT track under Direct Traffic Control rules, supplied by Wabtec Railway Electronics. Received FRA extension approval to adapt to signalled territory.
- Electronic Train Management System (ETMS) used by BNSF, a CBTM-based system supplied by Wabtec. Received FRA deployment approval.
- Incremental Train Control System (ITCS) used on Amtrak’s Chicago-Detroit line, supplied by GE
- Vital Train Management System (V-TMS) being tested in the Powder River Basin and Washington state, an ETMS derivative supplied by Wabtec
- Optimised Train Control (OTC) used by Norfolk Southern, an ETMS derivative supplied by Wabtec
- Train Sentinel used on Panama Canal Railroad and being installed on Ohio Central Railroad, supplied by Quantum Engineering
- North American Joint Positive Train Control Project (NAJPTC) developed by AAR, FRA, Amtrak, Union Pacific, and Illinois DOT to produce an interoperable industry standard, tested by the Transportation Technology Center


Pushing Forward PTC: Railroads and Suppliers Have Picked Up the Pace in Deploying Next-Generation Train Control
William C. Vantuono, November 2006, Railway Age 207(11): 30-31, Accession No. 01037681

Abstract: This article looks at next-generation train control systems and how their deployment is being pushed forward as a result of recent rulemaking by the Federal Railroad Administration (FRA). It is anticipated that by the end of 2007, a number of railroads will have initiated fully functional Positive Train Control (PTC) systems. The article relates that while these systems are...
varied both in approach and scope, the focus will be on train control, safety enforcement, and the human machine interaction. An overview is given of the some of the different systems being considered by the railroads. These include: Norfolk Southern’s Optimized Train Control (OTC) and Unified Traffic Control System (UTCS), Alaska Railroad’s Collision Avoidance System (CAS), Amtrak’s Incremental Train Control System (ITCS), and BNSF’s Electronic Train Management System (ETMS).

http://findarticles.com/p/articles/mi_m1215/is_11_207/ai_n27080042/

Positive Train Control Systems
Jana Price and James A. Southworth, 2006, J. of Accident Investigation 2(1): 75-79, Accession No. 01036505

This overview of a 2005 symposium on PTC describes several current projects, including New Jersey Transit’s Advanced Speed Enforcement System (ASES), the NAJPTC project, Amtrak’s ITCS and ACSES, Alaska Railroad’s CAS, CSX’s CBTM, and BNSF’s ETMS.

http://www.ntsb.gov/publictn/2006/JRN0601.pdf [Full issue]

PTC Starts to Roll Out Across the USA

Abstract: This article relates how Positive Train Control (PTC) has gained significant momentum in the U.S. Four Class I railroads (BNSF, CSX, Norfolk Southern, and Union Pacific), as well as Amtrak, are pursuing PTC systems. The advantages in using PTC include improved safety, lower operational costs, improved service, and increased network capacity. The various systems perform functions such as enforcing authority limits and speed restrictions, monitoring point position, interfacing with rail detection systems, and providing train location tracking. PTC systems also deliver safety critical information to the locomotive cab, and this information, when merged with the train’s GPS-provided location, enables automatic braking to be initiated if necessary. The use of GPS in determining a train’s location also eliminates the need for track transponders. The article details and compares the capabilities of the different PTC systems being used. They include Union Pacific’s Communications Based Train Control (CBTC), CSX’s Communications Based Train Management (CBTM); BNSF’s Electronic Train Management System (ETMS), Amtrak’s Incremental Train Control System (ITCS) and Norfolk Southern’s Optimized Train Control (OTC).

[Check WSDOT Library for availability]

Creating Capacity: Growth Capital is a Priority at UP, and the Payoff is Impressive
William C. Vantuono, August 2008, Railway Age 209(8): 21-29, Accession No. 01111613

From abstract: This article explains why Union Pacific railroad is spending $3.1 billion in capital improvements in 2008 . . . [One] way UP expects to create capacity is through its Positive Train Control (PTC) system known as Vital Train Management System (V-TMS). UP will be evaluating interoperability with BNSF’s PTC system, as interoperability remains one of the biggest hurdles to deploying PTC across North America.

[Check WSDOT Library for availability]

Practical Positive Train Control in the Northeast Corridor and in an Emerging Corridors

Abstract: The purpose of this paper is to review some practical principles emerging from Amtrak’s successful development of new train control systems over the past fifteen years. The paper will note the importance of keeping the functionality as simple as possible, the advantage of modular architecture utilizing well-proven technologies when available, and the importance of early involvement of all disciplines affected by the new system to ensure timely acceptance for revenue service. Amtrak’s experience has come out of the search for enhanced safety while reducing Positive Train Control
passenger trip times in the Northeast Corridor and in the emerging corridors. In the Northeast Corridor, the Acela Express required full Positive Train Control (PTC) to raise speeds from 110 and 125 MPH to 150 MPH in December 2000. This system is now in operation on 430 track miles of the Northeast Corridor. In the “emerging” Chicago-Detroit Corridor, a 45-mile “new start” PTC system has achieved sufficient maturity to support revenue service speed increases from 79 MPH to 95 MPH, with the design speed of 110 MPH expected in 2007. This system will also be extended another 20 miles in 2007. The paper will walk through the development of these two vital failsafe train control systems. Both systems meet the basic requirements of PTC as defined by the Federal Railroad Administration. These systems, though different technologies in different service environments, have some common elements worth reviewing.

[Check WSDOT Library for availability]

North American Joint Positive Train Control System Four-Quadrant Gate Reliability Assessment
Federal Railroad Administration, October 2008, Research Results RR08-10, Accession No. 01115334

Abstract: The implementation of high-speed rail (HSR) technology, at speeds of 80 to 110 miles per hour (mph) on corridors with pre-existing conventional rail service (up to 80 mph), requires upgrading the crossing activation technology with additional emphasis on safety by adding four-quadrant gates. Frequently, these crossings cannot be closed or grade-separated, and they are equipped with insufficient warning devices to support HSR operations. One solution, four-quadrant gates with inductive loop vehicle detection, was installed at 69 grade crossings on a 120.7-mile segment of the future 280-mile HSR corridor between Chicago and St. Louis. This segment will carry passenger trains at speeds up to 110 mph, including at many of the highway-rail grade crossings. These and other infrastructure improvements were completed to reduce the Chicago to St. Louis travel time from 5.5 hours to 3.5 hours and increase the number of daily round trips in each direction from three to five. The project conducted a reliability analysis of the four-quadrant gate/vehicle detection equipment based on maintenance records obtained from the Union Pacific Railroad, the owner and operator of the grade crossings. The results of this analysis were used to assess the impact of the equipment reliability on the proposed HSR timetable. The study showed that the total average delay to the five scheduled daily high-speed passenger roundtrips was an estimated 10.5 minutes, or approximately one minute per train. Overall, extensive analysis of the trouble ticket data showed that the four-quadrant gate and vehicle detection equipment are as reliable as the conventional crossing gate while providing additional protection.


Positive Train Control in Transition

Abstract: A jointly developed positive-train control (PTC) system, which is interoperable among competing suppliers’ communications systems, is the first significant step toward larger deployment of the technology since the early 1980s. Developed by suppliers GE-Transportation, Safetran Systems Corp. and Union Switch & Signal, the system is known as Communications-Based Signaling (CBS). Using radio and signal-based communications, it provides continuous overspeed protection, governs the safe movement of trains through a territory and allows secure communications between different substations. Key elements of this new generation of PTC are given, including the technique of replacing physical blocks as determined by track circuits with virtual blocks. Testing is scheduled for a number of carriers, including Alaska Railroad Corp., which would be the first installation of a PTC in dark territory. Other plans for PTGs at grade crossings are being made, and train management is being proposed for markets outside North America.

http://www.progressiverailroading.com/pr/article.asp?id=13239

Positive Train Control
Control Group: More Railroads Will Join Positive Train-Control Adopters Club Once They're Convinced the Benefits Outweigh the Upfront Costs
Jeff Stagl, December 2006, Progressive Railroading 49(12): 38-43, Accession No. 01041910

Abstract: This article examines positive train control (PTC) and why more North American railroad officials are beginning to deploy PTC. The author explains the role of the Federal Railroad Administration’s requirements for new PTC standards, and includes an interview with an executive from a firm which markets an Electronic Train Management System (ETMS). Union Pacific Railroad is testing an ETMS-related system, as is the Northeast Illinois Regional Commuter Railroad Corp. Some have raised doubts about positive train control for the passenger-rail segment, however. Amtrak, however, has been using GE’s Transportation’s Train Control System for operating passenger trains between 90 and 95 mph along its Chicago-to-Detroit corridor for several years and has not found problems.

[Check WSDOT Library for availability]

BNSF Starts Positive Train Control Trial

From abstract: This article focuses on BNSF’s involvement with positive train control (PTC), the mainline railway application of communications-based train control (CBTC). Although CBTC has not yet developed a strong business case with U.S. railways, the pilot project begun at BNSF could help. Additionally, BNSF has begun installation of an overlay PTC system, Electronic Train Management System (ETMS) that will enforce train speed and temporary speed restrictions, it will provide automatic train roll-up, and will also be able to determine the location of unprotected grade crossings and provide automated horn sounding.

http://findarticles.com/p/articles/mi_m0BQQ/is_3_44/ai_114629906/

Control Techniques: After Clearing Viability and Interoperability Hurdles, North American Railroads Prepare to Implement New Train/Traffic Control Technologies

Abstract: This article describes the current state of implementation of new train control technologies by North American railroads. Alaska Railroad Corp. is installing a collision-avoidance positive train control system, using what is described as the first commercially viable technology of its type. It was be installed on about 70 locomotives and will tie in to existing computer-aided dispatching systems. The article describes demonstration projects and other systems, many of which are intended to permit higher-speed operations, which save money, measured by one gauge as $100 million a year for every 2-3 mph gained. Transit agencies are also using new technologies for cab controls, as are maintenance of way trains.

[Check WSDOT Library for availability]

New Train Control Paves Way for High-Speed Rail

The first test using satellite-based global-positioning technology in a positive-train-control (PTC) installation on a stretch of Union Pacific track north of Bloomington, Illinois is a significant step toward deploying more high-speed trains on the U.S. rail network. PTC is one way to comply with rules issued by the Federal Railroad Administration that mandate automatic speed enforcement for trains traveling faster than 79 mph. The old way was expensive to maintain and outmoded. With public support, Lockheed-Martin has developed the system which was installed on the Union Pacific track section. This sits in the federally designated Chicago-St. Louis high-speed rail corridor. The system queries crossings to make sure the gates are operating properly and presents the engineer with a video screen that shows operating authority track warrants and instructions from the dispatcher, block authority, how far ahead the train is permitted to travel at
its present speed, and a track diagram showing the train’s location in the track network and in relation to other trains. By next fall, all Amtrak and Union Pacific locomotives in the test area should be equipped with the satellite system and the video screens, permitting full speed travel on the track.

[Check WSDOT Library for availability]

**NJ Transit Board Advances Final Phase of Rail Safety System**

News Release, February 13, 2002

The NJ TRANSIT Board of Directors awarded Phase III of a contract with Union Switch & Signal, Inc. of Pittsburgh, PA to complete installation work on the Corporation's Positive Train Stop (PTS) advanced rail safety system.

PTS is part of a rail safety initiative launched by the NJ TRANSIT Board of Directors in August 1997. NJ TRANSIT is the first passenger railroad in North America to merge two railroad safety technologies -- Automatic Train Control (ATC) and Positive Train Stop (PTS). The combined technology is now known as the Advanced Speed Enforcement System (ASES).


**Interoperable Communications-Based Signaling Project**

Federal Railroad Administration, June 2009, Report No. DOT/FRA/ORD-09/12

Abstract: Interoperable Communication-Based Signaling (ICBS) refers to an implementation of a train control system based on signaling principles whose system architecture and interface are documented as Recommended Practices (from the AREMA Manual of Recommended Practices for Communications and Signaling) by the Association of Railroad Engineering and Maintenance-of-Way Association (AREMA). This project demonstrated that existing suppliers of vital (fail-safe) train control equipment can modify their products to support the system architecture and interfaces as specified. ICBS is capable of satisfying the requirements of a positive train control system.


**Wired For Progress: ECP Braking is Just One of Norfolk Southern's Ground-Breaking Technology Initiatives**


Abstract: This article describes some of the various technological advancements adopted and planned by Norfolk Southern Railway, as well as the positive financial results of these advancements. Focus is on the electronically controlled pneumatic brakes (ECP) adopted by the company. ECP braking provide the engineers with more control while loading and going downhill, while also reducing fuel consumption and wear on the train and rails. In addition to ECP, the railway is incorporating advanced technologies such as Unified Traffic Control System (UTCS) dispatching and Optimized Train Control (OCS), which will allow trains to go faster and more safely. The author indicates that these technological enhancements will increase capacity, which in turn increases profits for the company.

[Check WSDOT Library for availability]

**Communications-Based Signaling (CBS) – Vital PTC**


Abstract: This paper describes a Positive Train Control system based on using new technologies to evolve proven signaling principles and safety-critical architectures to achieve the safety, cost and performance benefits of positive train control systems. In addition, it describes the process for developing interoperability manual parts through AREMA Committee 37.

Positive Train Control
Using ITS to Improve Safety at the Highway Rail Interface - The Results
N. Wallach, October 2001, 8th World Congress on ITS, Sydney, Australia, Accession No. 00978977

From abstract: ALSTOM Transport Information Solutions has been engaged in a Research and Development project to marry ITS technologies with advances in train control technologies such as Positive Train Control (PTC) to make grade crossings even safer. There are eight main functions of ALSTOM's project to achieve this goal: 1. Establishment of Uniform Time Warning at the crossing; 2. Reductions in the amount of time that grade crossings are closed to automobile traffic due to station stops; 3. Recognition and reactions to stalled automobiles on the railroad tracks; 4. Emergency Medical Services (EMS) vehicle preemption of railroad crossings; 5. Queue detection and amelioration; 6. Use of Variable Message Signs to convey information to automobile drivers; 7. Allow for releasing gates should the train stop in the vicinity of a crossing; and 8. Reduction in "Transient Gate" phenomenon. The ultimate goal is to develop a system that will employ all the technologies available to substantially reduce or eliminate accidents at grade crossings. In this paper, the authors will report on the reasons and benefits of each of these functions to the driving public, as well as to the railroad operator. This development effort addresses the anticipated safety benefits provided by the system. The authors will present the system's architecture and its conformance with the national ITS architecture. The system was deployed between April and June of 2001 at the New Hyde Park Road crossing on the Long Island Railroad.

Positive train control initiatives in North America: technological and institutional issues

From abstract: The paper presents an overview of recent and current Positive Train Control (PTC) initiatives in North America, addressing the technologies deployed, along with concerns from economic, safety, user acceptability and regulatory perspectives.

The seemingly slow progress in utilization and acceptance of PTC systems in the North American rail environment is explained in light of both technological and institutional barriers. The role of standards making bodies and the impact of regulatory agencies can not be overstated.

Focusing on current PTC initiatives, this treatise explores the changing perspectives of the participants in these ventures - the suppliers, end users, industry organizations, and the regulatory bodies.

It's Now or Never for ERTMS Roll-Out

Abstract: This article focuses on efforts directed at revitalizing the rail transportation sector in Europe. With more than 20 signaling and train control systems in use across the continent, competitiveness, cost savings, and safety improvements are hampered. The article describes how deployment of the European Rail Traffic Management System (ERTMS), designed to provide a single signaling and train control system across Europe and focused on interoperability, is expected to bring about the necessary changes. The European Commission, along with a number of railway associations, is working on the implementation of ERTMS on 20,000 km of routes over the next decade. Six ERTMS priority corridors have been established where the European Train Control System (ETCS) will be implemented. The article details the various strategies involved as well as the financial support that is needed for facilitating deployment.
MANUFACTURERS

Alaska Vital Positive Train Control, Ansaldo STS

Project Overview
Union Switch & Signal Inc. was awarded in June 2004 a contract to deploy the next generation dispatch and Vital Positive Train Control (VPTC) for signalled and dark territory for the Alaska Railroad Corporation (ARRC), in the USA.

The contract has a two-phase approach in which US&S will provide a complete VPTC system, including US&S’s latest Computer-Aided Dispatching (CAD) system, vital Office Safety Server (OSS), and vital Onboard Computer (OBC). The project will be the first vital dark territory implementation of positive train control in the industry.

ACSES, ALSTOM Signaling

ACSES is an expansion overlay for the cab signaling system. Current installations include AMTRAK's North East Corridor which runs from Boston, MA to Washington, D.C.

ACSES is a modular on-board and wayside PTC system that delivers incremental safety functions while allowing speeds up to 150 mph.

ACSES uses passive transponders to enforce permanent civil speed restrictions. Features include:

- Positive train stops at interlocking signals
- Positive train stop release via radio
- Temporary slow orders through a data radio network

Key Safety Benefits include:

- Prevent train-to-train collisions (PTS)
- Protection from overspeed incidents
- Protects work crews with Temporary Speed

GE’s Positive Train Control Technology is Full Speed Ahead on Amtrak’s Michigan Line
October 2005 Press Release

The trip for Amtrak passengers in Michigan will be faster after an historic Federal Railroad Administration approval to increase passenger train speed to 95 mph on Amtrak’s service in Michigan.

This marks the first time in the U.S. in 20 years that revenue passenger trains outside the Northeast Corridor are operating at speeds of 95 mph. The milestone is made possible by GE’s wireless train control technology called Incremental Train Control System. ITCS offers the rail industry the same freedoms that cellular technology provided the telecommunications industry. Rather than purchasing and using traditional signaling infrastructure, customers using ITCS can increase speed, line capacity and safety using satellite positioning technology and wireless communication to transmit signaling and crossing information to trains.

ETMS, Wabtec

Positive Train Control
Wabtec's Electronic Train Management System (ETMS) integrates new technology with existing train control and operating systems to enhance train operation safety. ETMS helps prevent track authority violations, speed limit violations and unauthorized entry into work zones – all of which reduce the potential for train accidents. With ETMS, the crew remains in control of the train. The system monitors and ensures the crew's compliance with all operating instructions, while the ETMS screen-based display provides the train crew with a wealth of operating information. As the train moves down the track, the ETMS computer – with the aid of an onboard geographic database and global positioning system – continuously calculates warning and braking curves based on all relevant train and track information, including speed, location, movement authority, speed restrictions, work zones and consist restrictions. ETMS also queries wayside devices for broken rails, proper switch alignment and signal aspects. All of this information is combined and analyzed in real time to provide a "safety net" for improved train operation.

Communications-Based Train Management (CBTM)
Electronically Controlled Pneumatic (ECP) Braking

Positive Train Control, ARINC
Since 1985, ARINC has been the systems engineering contractor for the rail industry in the development of PTC technology and related rail systems-integration solutions. Currently, ARINC leads the systems engineering team for the North American Joint Positive Train Control (NAJPTC) program, a joint project of freight railroads, Amtrak, the Federal Railroad Administration, the Illinois Department of Transportation, and the Association of American Railroads’ Transportation Technology Center Inc. ARINC also provides technical support to NAJPTC's program to implement PTC on a high-speed rail corridor in Illinois.

http://www.arinc.com/products/intel_trans_sys/positive_train_ctr.html
http://www.arinc.com/products/rail_control_ctr/train_control.html (Communications-Based Train Control description)

Positive Train Control, Lockheed Martin
http://www.lockheedmartin.com/products/PositiveTrainControl/

Are you implementing a Positive Train Control (PTC) system?
Transportation Technical Center, Inc.

If the Railway Safety Improvement Act of 2008 affects you and you would like help from the organization with the greatest number of staff members with direct PTC experience with the most PTC projects (who's not a PTC supplier), you may want to contact TTCI.

Here's a brief summary of TTCI's staff experience with PTC . . .
http://www.aar.com/products_services/pdfs/are_you_implementing_a_positive_train_control.pdf

Argenia's Positive Train Control (PTC) & Hybrid Vital Wheel Sensor Technology
Argenia Systems Inc. has submitted patent applications for new hybrid PTC technology which confirms to this mandate and to the emerging interoperability standards. The technology itself is unique, fool-proof and literally costs a fraction of the costs proposed by the major suppliers to date. This system vastly improves train tracking and positioning using real-time train control and enhanced monitoring; this leads to improved track utilization, higher train speeds and improved safety. This is the only technology on the market which removes the need for insulated joints/rail & buried cables saving railway operators millions of dollars in installation and maintenance costs.

Argenia has developed relationships with The National Research Council, Transport Canada and The Railway Association of Canada. We are seeking additonal alliances who can bring this technology to the market on a worldwide scale.
From Window Shoppers to Adopters: Four Suppliers Post Progress in Enticing Railroads to Deploy Train-Control Technologies

Abstract: While improving safety is the primary objective of train control systems, the technologies that are involved can offer railroads a wide range of applications. This article focuses on four different train control suppliers, how their train control systems work, and which railways are testing and purchasing the products. It relates how train control technologies can be used to monitor and enforce train speed limits, provide positive train control (PTC), automate dispatching through computer-aided dispatching (CAD) systems, generate electronic authorities, or issue track warrants in dark or non-signaled territories.

[Check WSDOT Library for availability]

Low Cost Multiple Sensor Inertial Measurement Sensor for Locomotive Navigation: High-Speed Rail Program
F. Riewe, December 2001, Report No. TRB-IDEA-HSR-14, Accession No. 00921357

Abstract: This project was to investigate the use of microelectromechanical (MEM) arrays, combined with GPS, to provide the location of locomotives with sufficient accuracy for communications based train control systems. A laboratory prototype system was designed, fabricated, and tested, navigation and Kalman filter algorithms developed and tested, and the code for these algorithms developed. Field testing of the prototype system was conducted on Amtrak and the rest data analyzed. Final revisions to the system, including debugging the navigation and Kalman filter software, were completed. The prototype system proved to be sufficiently successful that a follow-on contract was awarded to design, build, and test a production prototype of this system suitable for use with Positive Train Control systems.

[Check WSDOT Library for availability]

COSTS

Positive Train Control—Ready to Go?

This article discusses PTC technologies and technical and financial hurdles to implementation in the U.S., including an overview of costs (beginning on webpage 5). An FRA cost-benefit study concluded that safety benefits provide less than 1 percent of the overall benefits of PTC. It is estimated that railroads would receive only 2.33 to 11.76 percent of the net societal benefits (ranging from $3.3-7.1 billion per year), with the bulk of benefits going to shippers and the general public. It’s also estimated that implementation and deployment costs greatly outweigh safety benefits. One hundred thousand miles of track would require upfront capital outlays in excess of $2.3 billion.

http://www.masstransitmag.com/print/Mass-Transit/Positive-Train-Control--Ready-to-Go/1$4990

Benefits and Costs of Positive Train Control
Federal Railroad Administration, August 2004

From abstract: This report endeavors to describe safety benefits, and business benefits of positive train control (PTC) and allied business systems, which might utilize a PTC communications platform or draw information from PTC functions and utilize it to support business applications, together with the costs of those systems and applications . . . At this time no in-service PTC system achieves the business benefits which may be possible.

Positive Train Control (PTC): Calculating Benefits and Costs of a New Railroad Control Technology

Abstract: This study attempts to quantify the business benefits of positive train control (PTC) for the Class I freight railroad industry. Examples of potential business benefits include: line capacity enhancement, improved service reliability, faster over-the-road running times, more efficient use of cars and locomotives, reduction in locomotive failures, larger "windows" for track maintenance, and fuel savings. Benefits were estimated in these areas and the cost of deploying PTC on the Class I network was calculated. Findings suggest that deployment of PTC on the Class I railroad network would cost between $2.3 billion and $4.4 billion over five years. Once the system was fully implemented, annual benefits were estimated at $2.2 billion to $3.8 billion, suggesting a rapid payback period. The internal rate of return was estimated to be between 44% and 160% depending on timing and cost.

[Check WSDOT Library for availability]

Tracking PTC's Benefits

Subtitle: Government study indicates rail industry could get billions from positive train control; AAR doubts it.

[Check WSDOT Library for availability]

SAFETY

U.S. Railroad History Relating to Fatigue, Safety Culture, and Technology
Frederick C. Gamst, January 2006, Railroad Operational Safety: Status and Research Needs, Midyear Meeting of the TRB Railroad Operational Safety Subcommittee, Transportation Research E-Circular E-C085: 13-49

Abstract: The author, with 49 years of experience with the railroad industry, reviews the railroad industry, beginning with the U.S. government's historical interaction with railroads and the two eras of federal railroad regulation (1893 through the 1920s and 1965 through the 1990s). He then addresses the topics of the current meeting, including the following: Human Fatigue and Vigilance - fatigue, sleepiness, and scheduled work; Impact of Advanced Technologies on Railroad Operational Safety - early fixed signals and communications, early safety appliances, air brakes, dynamic brakes, later signaling and communications, retarder yards, wayside detectors, journal bearings, rail, electronic computation and communications, locomotives, distributed power, remote control locomotives, positive train control, and end-of-train devices; and Safety Culture - conceiving of and using the phrase "safety culture," military roots of U.S. railroad culture, the basis of railroad safety, and organizational and regulatory errors.

http://onlinepubs.trb.org/onlinepubs/circulars/ec085.pdf [Discussion of PTC begins of page 44 of the PDF]

Intelligent Transportation System/Positive Train Control at Highway-Rail Intersections
Federal Railroad Administration, June 2007, Research Results RR 07-20

From abstract: Since the mid-1990s, the U.S. Department of Transportation (U.S. DOT) Federal Railroad Administration (FRA) has sponsored research, conducted by the John A. Volpe National Transportation Systems Center of the U.S. DOT Research and Innovative Technology Administration (RITA), aimed at integrating Positive Train Control (PTC) and Intelligent Transportation System (ITS) technologies. The objective of this research is to improve safety and efficiency at highway-rail intersections (HRIs) by finding affordable, standardized systems that can be installed at HRIs to provide immediate safety benefits.

Human Factors Considerations in the Evaluation of Processor-Based Signal and Train Control Systems: Human Factors in Railroad Operations

From abstract: In August 2001, the Federal Railroad Administration issued the notice of proposed rulemaking: Standards for Development and Use of Processor-Based Signal and Train Control Systems (49 Code of Federal Regulations Part 236 . . . Under the proposed rule, a railroad wishing to implement a positive train control (PTC) system in revenue service must develop and submit a product safety plan (PSP) and assess the risk associated with the new system. This report attempts to fill the gap provided by the lack of knowledge about the kinds of human performance challenges and safety risks that will occur with these proposed systems. To fill this gap, the authors identified human factors issues that arose in other industries where similar kinds of technology and human-machine interfaces were used. This literature review, along with an analysis of PTC-preventable accidents, served as the basis for structuring interviews with employees at several railroads that had experience with train control technology containing elements of PTC. The answers to these questions provide the reader with a roadmap of human performance issues to consider in preparing or evaluating a PSP, along with the implications for risk.


Relative Risk of Workload Transitions in Positive Train Control

From abstract: First, the research team performed a review and analysis of the fundamental human factors and systems performance issues associated with workload and workmode transitions involving technologies like positive train control (PTC) that can lead to safety and operational problems. These include concerns associated with over-reliance, fixation, skill loss, and shifts in authority between components in the system. Second, the team has examined proposed PTC systems and their intended roles in rail operations to provide an analysis of the risks of the different transitions as they relate to the use of PTC systems in railroading. The opportunities for the high risk failures is greater with PTC systems that provide only an overlay safety function, and are virtually out of sight during normal operations, because the primary risks are associated with the reduction of people’s awareness of the system operating state.


Communications-Based (Positive) Train Control -- Consistent Safety Assessment for Diverse Technical Approaches

From abstract: Communications-Based Train Control (CBTC) systems, also known as Positive Train Control (PTC), represent substantial advances in the flexible and efficient, yet safe, operation of rail transportation . . . . Several of the CBTC/PTC systems under development are being assessed for safety using methods that follow and build upon the Federal Railroad Administration Part 236H rule requirements [7], IEEE Standard 1483-2000 [3], and MIL-STD-882C [1]. These safety assessments have so much in common that, from them, a generalized quantitative assessment process has evolved. This paper describes such a risk assessment process which can be applied to diverse train control system designs while addressing the objectives, rules, regulations, standards, and requirements governing their operation. Such a structured assessment can minimize subjectivity and maximize confidence in the system’s safety integrity. The approach used builds on experience from train control safety assessments for such properties as SEPTA, WMATA, Los Angeles Metro, Baltimore MTA, Class I railroads, and rail suppliers.

[Check WSDOT Library for availability]
Next Stop, Safety

Subtitle: Positive train control benefits coming but some say not yet.

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Positive Train Control Promotes Track Safety
L. Davis, September 2001, Metro 97(7): 86-89, Accession No. 00817970

Abstract: A positive train control (PTC) project in Illinois along a track segment where high-speed passenger trains share space with freight is allowing higher speeds for both types of service. Trains can be located and monitored precisely, using digital technology, and controllers can easily trace their routes. In the future, industry-wide standards are hoped for, based on a common set of data elements.

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SECURITY

Trust-based secure Positive Train Control (PTC)

Abstract: Positive Train Control (PTC) is a wireless control system ensuring railroad safety by enforcing train separation, speed enforcement, roadway worker protection and other safety functions. Due to shared trackage rights over each other’s tracks in North America, company A’s trains must be safely operated by company B’s crew on company C’s tracks, requiring different PTC systems to securely interoperate with each other. We propose using a trust management system with certificates and over the air re-keying (OTAR) as a security framework to ensure secure interoperation. Preliminary estimates show that our solution meets timing needs of PTC.

http://www.springerlink.com/content/j23l31g0608912l2/fulltext.pdf

Key Management Requirements for PTC Operations
Mark W. Hartong et al, June 2007, IEEE Vehicular Tech. Mag. 2(2): 4-11, Accession No. 01089598

Abstract: Positive Train Control (PTC) electronic systems, also known as Communications Based Train Control, promote safe and efficient railroad operation. PTC systems exchange control information through wireless communications for roadway worker protection, and provide speed enforcement and positive train separation. Distributed real time traffic hazard and road condition communications among vehicles in radio line of sight are provided through vehicular ad-hoc networks (VANETS). Potential highway rail intersection collision reduction through train movement information communication to highway vehicles is offered by communicating PTC VANETS. There must be secure interoperation between different PTC systems for this to occur. The authors outline a PTC security framework which supports interoperation through over the air re-keying and certificate based trust management system use.

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Mapping Misuse Cases to Functional Fault Trees in order to Secure Positive Train Control Systems

Abstract: Use cases specify the higher-level functional requirements of a system under design and misuse cases specify its possible misuses. Analyzing them together prevents the latter from occurring while ensuring that the former are implemented. Independently, functional fault trees (FFT) hierarchically breakdown anticipated system failures with respect to its functional architecture. This work presents and algorithm that transforms higher-level use-misuse case to
FFTs, and thereby allows the application of the analytical methods available for the latter to the former. The utility of such a mechanism is illustrated by studying the security vulnerabilities that can be introduced to Positive Train Control (PTC) systems – wireless command and control systems for the safe operation of freight and passenger trains.

Key management requirements for Positive Train Control communications security

Abstract: Positive Train Control (PTC) is an electronic system that enforces train separation, speed enforcement, roadway worker protection and a host of other activities essential to operate railroads safety and efficiently that requires wireless communication to exchange control and sensory information between mobile locomotive and static control centers and wayside devices. This requires communication security ensuring the freshness, confidentiality, integrity, and authenticity of the information. For that purpose, we propose a cryptography based key management system (KMS). This paper outlines the requirements for a KMS, provides a proposed key distribution method, and highlights several significant implementation tradeoffs

OTHER SEARCH RESULTS

Why PTC Matters More Than Ever

Abstract: Railroads are pushing ahead with implementation of positive train control (PTC), in response to a number of influences. The Federal Railroad Administration (FRA) has issued a mandate that all shared-use lines, as well as those handling hazardous materials, must be equipped with PTC by 2015. Additionally, the industry now sees PTC as a tool for helping to fill the capacity gap with minimal capital investment. Thirdly, with President Obama's endorsement of high-speed rail, the prospect of conventional trains traveling at speeds on the order of 100-110 mph is more likely and will require some kind of PTC. The major railroads are using different systems, with a rulemaking due out soon in 2009 to set the requirements for core PTC. A key component is the 220-MHz licensed radio frequency over which all PTC train/wayside communications will take place, devised as part of an interoperability agreement, which is allowing the industry to come together with interoperable systems. For the affected track to meet the FRA mandate, some 75,000 wayside devices will have to be upgraded, at a rate of seven to 10 per day. Locomotives will have to be upgraded at a rate of two to three per day. Another aspect of PTC is the potential uses to which the wireless network can be put for other operational objectives, including tracking cargo, timing trips, and the like.

Cases for Common Ground: We Now Have Positive Train Control Systems That Work
William C. Vantuono, July 2007, Railway Age 208(7): 31-33, Accession No. 01054511

Abstract: This article reviews the current status of interoperability as it relates to Positive Train Control. The Association of American Railroads has completed work on a plan to build on and consolidate existing efforts for interoperable systems, which the author describes. So far 11 of 13 milestones are underway, but significant effort is required still to identify and develop communications standards, messaging standards, and an architecture standard and concept of operations. The author describes the work of the AREMA Committee 37, which is working on defining an interoperable, safety-critical “Communications-Based Signaling” system.

Traffic Control Gets Smarter

Positive Train Control
From abstract: This article looks at how CAD systems can help railroads improve capacity and service quality, while also helping dispatchers make better and more informed decisions. The article also looks at the issue of technology interoperability and how a national railroad network equipped with different forms of Positive Train Control and wayside fault detection equipment will require a high level of interoperability.


Where's PTC's benefit?

Subtitle: In safety, not capacity, railroads say; others claim long-term economic benefits for positive train control.

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The Network Effects of Railway Investments

Abstract: This paper describes how network effects occur when a change at one place in the railway network results in changes elsewhere in the network, and they may be far away from the original change. Railway investments have network effects, and therefore, this paper describes the network effects and how these network effects can be examined by queuing time. This paper gives examples of network effects and describes the importance of the size of the analysis area and the connections between trains in the railway network.

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Human Reliability Analysis in Support of Risk Assessment for Positive Train Control

Abstract: This report describes an approach to evaluating the reliability of human actions that are modeled in a probabilistic risk assessment (PRA) of train control operations. This approach to human reliability analysis (HRA) has been applied in the case of a safety evaluation of the Communications-Based Train Management (CBTM) System being tested by CSXT Transportation, Inc. This report describes the overall approach to the HRA and its trial application to the CBTM evaluation.


Risk and Train Control: A Framework for Analysis

Abstract: The effects of train control strategies on the risks of railroad operations are examined. Analysis of a hypothetical 1800-km (1,200-mi) corridor identified the main factors that increase risks. Passenger traffic is the most important factor because the addition of passenger trains creates the possibility of catastrophic accidents with dozens of fatalities. Increasing the number of trains per day leads to more than proportional increases in the risks of collisions. Single-track operations are much more susceptible to collisions, whereas higher train speeds increase both the likelihood and the severity of the consequences of accidents if there is a signal overrun or a failure to obey a slow order. Positive train control (PTC) systems can reduce most, but not all, of the collisions and overspeed derailments, as improper train handling or equipment failure could still lead to accidents. Establishment of a digital communications link to the train should also allow the possibility for improved grade-crossing protection. For the hypothetical corridor, the potential benefits from improved grade-crossing protection were on the same order of magnitude as the...
predicted benefits from PTC systems. If new technologies are developed to detect broken rails, the digital communications link could also be used to implement immediate braking, thereby preventing some additional derailments. The risk-based approach demonstrated may provide a more complete assessment of rail risks than a methodology that estimates safety benefits based on documentation of accidents that might have been prevented if more advanced train control techniques had been in place. Risks include the possibility of catastrophic accidents, whether or not such accidents occurred recently. A causality-based methodology also allows greater flexibility in sensitivity analysis and in assessment of trends in traffic volume, traffic mix, and other factors.

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**Systems Integration--The Key to Successful Implementation of Advanced Technology Train Control Systems**

Alan F. Rumsey, June 2002, 8th Intl. Conf. on Computers in Railways, Lemnos, Greece: 3-12, Accession No. 00934168

Abstract: Advanced technology train control systems are a cost-effective means of improving the level of service offered to transit passengers in terms of safety, dependability, and comfort while providing increased capacity and reduced travel times on existing transportation infrastructure. Many rail agencies around the world have or are in the process of implementing such systems. While a number of these projects have been highly successful, others have been less than successful with major schedule and budget overruns. This paper explores some lessons learned from these projects and provides an insight into why some advanced technology projects succeed while others fail. The importance to project success of systems integration techniques to manage the institutional, operational, technical, physical, schedule, and contractual interfaces is also described and discussed.

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