Technical Memorandum

SOUTHERN CALIFORNIA REGIONAL ITS ARCHITECTURE
2011 UPDATE

Positive Train Control History and Plans for Deployment

Prepared for:

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

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1. INTRODUCTION

The Southern California Regional ITS Architecture leverages long standing investments in Intelligent Transportation Systems (ITS) by fostering coordination and cooperation among public agency stakeholders. A Regional ITS Architecture provides a framework for ITS planning that promotes interoperability and communication across jurisdictional boundaries. Projects developed under a regional framework extend the usefulness of any single project by making information easily accessible for operators and users of the system.

In Southern California, there are several ITS architectures that may be applicable to an ITS project, depending on how far reaching the project is. Each County has developed a Regional ITS Architecture. In addition, as the Metropolitan Planning Organization (MPO), SCAG has developed a Southern California Regional ITS Architecture that addresses multi-county issues: those projects, programs, and services that require connectivity across county boundaries or are deployed at a multi-county level. A third "layer" is also in place at the state level: the California ITS Architecture and System Plan addresses those services that are rolled out or managed at a state level or are interregional in nature. Project sponsors are responsible for ensuring that their projects maintain consistency with the regional architectures, regardless of which architecture applies, as a requirement for federally funded projects.

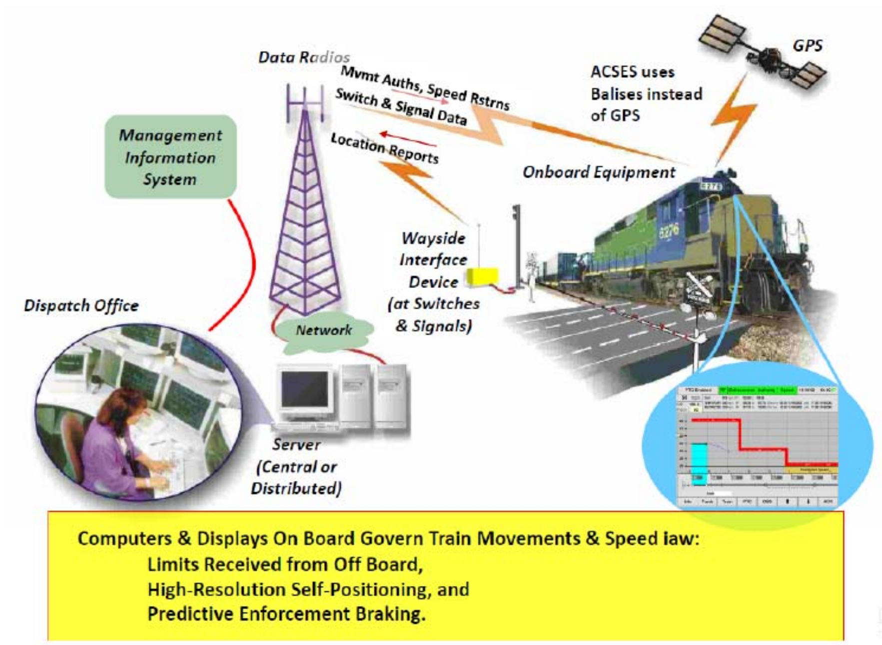
In the time between 2005, when the Southern California Regional ITS Architecture was developed, and 2011, as it is being updated, there have been several changes. The National ITS Architecture has been updated to reflect new user services, Southern California has continued as a national leader in ITS deployment with extensive ITS investments, and new technology applications have emerged. The 2011 update to the Southern California Regional ITS Architecture will reflect changes since 2005 and position the architecture to guide future ITS deployments as new technologies emerge. Topics covered in this 2011 update include express lanes, Positive Train Control, technologies in support of non-motorized transport, and goods movement in addition to the updates for other cross-county services such as to address traveler information, regional data exchange and archiving of regional data. Additionally, recommendations are made to subregional (county-level) ITS Architecture champions for their consideration in the event that changes are desired to be made at the county level for the associated topic.

1.1 Background and Purpose

The Southern California Regional Railroad Agency (SCRRA) that operates the Metrolink regional commuter rail plans to implement a positive train control (PTC) system by 2012, ahead of the deadline set for the end of 2015. Implementation of the PTC system is required by the Rail Safety Improvement Act (RSIA) of 2008. The RSIA requires all Class I railroads, intercity passenger and commuter railroads to implement a PTC system on all main-line tracks where intercity passenger railroads and commuter railroads operate and where toxic-by-inhalation hazardous materials are transported.

The five county members of the SCRRA are jointly funding the development of an interoperable PTC system to improve safety for freight and commuter railroads in the region. PTC is designed to prevent train collisions using GPS tracking to remotely monitor train movements. In a typical PTC system, onboard equipment on the train uses GPS satellites to transmit speed and location data over wireless or hard line communications links to an operations center. A back office system at the operations center analyzes the data using software that determine the likelihood of a collision or derailment. An advance alert is sent by the dispatch center to the locomotive and brakes are automatically engaged if the warnings are not acted on by the train engineer. Federal regulations does not prescribe the type of technology a PTC system uses as long as it can accomplish the following functions: preventing train-to-train collisions, derailment from over speeding, incursions into designated work zone areas and train movements caused by switches left in the wrong position.

Figure 1 illustrates the typical components and functions in a PTC system.



Source: PTC presentation by Alan Polivka TTCI , March 2010, Progressive Railroading Webinar.

Figure 1 – Typical PTC System Illustration

This Technical Memorandum summarizes current efforts to implement an interoperable PTC system in the SCAG region. A customized market package will be developed to address PTC activities in the Southern California Regional ITS Architecture.

2. History of Positive Train Control

The section discusses the background and history of PTC, including current European standards and activities.

2.1 PTC Deployment in the European Union

The formation of the European Union (EU) in the 1990s dissolved most economic boundaries for its 27 member states. European railways saw a growth in cross border freight and passenger traffic as trade and economic activity became more integrated. However, one major impediment to seamless train movement continued to be the separate train control systems in each country. The demand for interregional train service resulted in a 10 year development effort to establish a national train control system in the EU, leading to the development of the European Rail Traffic Management System (ERTMS). Implementation efforts are overseen by the European Railway Agency which coordinates the development of the technical specifications for ERTMS.

The following is a brief timeline summarizing the development of PTC[1] in the EU:

- A framework for achieving interoperability for high-speed train networks was issued in EU Council Directive 96/48/EC by the European Commission in 1996[2].
- Characteristics of the ERTMS describing command-control and signaling subsystems for conventional railways in Europe were issued in a 2001 directive by the European Commission.
- In 2005, a memorandum of understanding (MOU) between the European Commission and the rail industry identified six freight corridors for ERTMS deployment.
- Between 2005 and 2008, the technical specifications for interoperability were developed which guaranteed that any locomotive equipped with ERTMS control systems can travel on any railway outfitted with ERTMS.
- A second MOU was signed that expanded the number of participants from the European railway industry. It established the timeline for developing the next version of ERTMS system specifications in 2012 and allowing backward compatibility with previous versions.
- In 2009, the European Commission adopted the European Deployment Plan, which laid out how the European rail network will transition to an interoperable system under ERTMS. Progress of the deployment plan will be evaluated in 2015.

ERTMS consists of two primary components: GSM-R and ETCS (European Train Control System). GSM-R is a radio system based on GSM mobile communications standards. GSM-R uses a specific frequency for voice and data communications between the train and the control center. ETCS is the signaling and train protection system used to monitor train speed and movements[3]. The safety functionalities for ETCS are divided into three application levels[4]:

- **ETCS Level 1**: This application works with existing signaling equipment. Information is transmitted to the train as it passes over beacons located between the rails. The train's onboard computer uses the information to determine the track location and the appropriate speed profile. The information on maximum allowable speed and braking distance is displayed to the train

[1] European Commission, "ERTMS – European Rail Traffic Management", 30 October 2010, available from http://ec.europa.eu/transport/; accessed 12 April 2011.
[2] The European Commission is the executive body of the EU.
[3] European Commission, "ERTMS – Delivering Flexible and Reliable Rail Traffic", 2006.
[4] European Railway Agency, "ERTMS in 10 Questions", available from http://ec.europa.eu/transport/; accessed 12 April 2011.

operator. The onboard computer will automatically apply the brakes if the maximum speed is exceeded under the movement authority.

- **ETCS Level 2**: This application features continuous communications between the train and the control center using GSM-R. The train transmits its location using the track beacons to the control center and receives movement authority and signaling information in return. The Level 2 configuration eliminates the need for wayside signals.
- **ETCS Level 3**: For this application, the train sends its exact location without the use of beacons, supporting moving block operations, or continuous safe zones around the train at all times. Level 3 applications are under development.

2.2 PTC Deployment in the U.S.

The Federal Railroad Administration has been working on developing PTC technology for the past three decades, with the National Transportation Safety Board (NTSB) identifying it as the most wanted transportation safety improvement for many years[5]. The recent history of PTC dates back to the 1980s with the advent of computer microprocessors and digital communications technologies. What emerged was the development of two systems that predated PTC – the specifications for an advanced train control system (ATCS) and the Advanced Railroad Electronics System (ARES)[6]. ATCS featured the use of radio communications to transmit data between the train control center and the wayside devices. ARES used radio communications similar to ATCS except that GPS was used to locate locomotives. The technologies were deployed on some railroads in the U.S. and Canada, followed by the concept of PTC in the 1990s.

The following is a brief timeline summarizing the development of PTC[7]:

- The term positive train control was first introduced in a 1994 FRA report to Congress, *Railroad Communications and Train control*.
- The Railroad Safety Advisory Committee of the FRA created a PTC Working Group to specify safety objectives in 1997.
- In 1999, the Railroad Safety Advisory Committee published a report, *Implementation of Positive Train Control Systems* that specified how the government and the railroad industry would facilitate PTC development. That year, FRA and other formed the North American Joint PTC project to test signal and train control systems with PTC capabilities.
- The FRA initiated a study in 2004 to determine the cost and safety benefits of PTC, which estimated that costs will exceed $2.3 billion to implement a system on 100,000 miles of track.
- The FRA published a final rule in 2005 on the functional requirements and operational parameters to achieve PTC safety objectives. These regulations are performance based rather than prescriptive, meaning that PTC systems could be technology neutral, as long as safety and functional equivalencies were met.
- In 2008, the RSIA was signed into law.
- In 2010, the final rule for the implementation of PTC was issued by the FRA.

Prior to the passage of the RSIA in 2008, implementation of PTC systems was done voluntarily by railroad companies. The FRA and various railroad companies have developed and implemented several technologies that accomplish PTC functions. Two major PTC architectures have been

[5] FRA, "Final Rule – Positive Train Control", FRA presentation, January 2010.
[6] Grady C. Cothen, Jr., et al., "Positive Train Control – Ready to Go?", *MassTransit,* 12 January 2011, available from http://www.masstransitmag.com/; accessed 1 March 2011.
[7] USDOT, "Signals and Train Control Fact Sheet", October 2008.

developed – systems deployed by Amtrak on the Northeast Corridor (NEC) and others on railroads outside the NEC using technologies based on the Electronic Train Management System (ETMS). Currently, PTC systems have undergone testing and development in 16 different states on over 4,000 miles of track. Existing PTC systems that predate the RSIA are grandfathered by the performance based regulations issued by the FRA in 2005.

The following summarizes the major PTC systems developed in the U.S. through 2009[8]:

- **Advanced Civil Speed Enforcement System (ACSES)**. Implemented by Amtrak on the NEC between Boston and Washington D.C. ACSES supplements the existing cab signal/automatic train control system. The current transponder based system to determine train location will be replaced with a radio based system.
- **Collision Avoidance System (CAS)**. The Alaskan railroad is implementing a statewide train control system using a radio based communications infrastructure, GPS to track train movements and computer aided dispatch system.
- **Electronic Train Management System (ETMS)**. ETMS is an overlay system that functions on top of existing technology to enforce enforces movement authorization and speed restrictions for trains. BNSF will deploy version 1 of the ETMS on 35 BNSF subdivisions. A second enhanced version of ETMS will be deployed on an additional 300 miles of shared freight and passenger service in Texas and Oklahoma. Chicago METRA is implementing a PTC system based on ETMS in suburban Chicago.
- **Communications-based Train Management (CBTM)**. The system has been implemented on CSX tracks between South Carolina and Georgia. CSXT will modify the CBTM architecture to implement an ETMS-based architecture. The Port Authority Trans-Hudson (PATH) is developing a PTC system based on CBTM on the Trans-Hudson River Commuter Rail Line between New Jersey and New York City.
- **Incremental Train Control System (ITCS)**. ITCS is installed on Amtrak's Michigan line between Chicago and Detroit. The system features a highway-rail grade crossing warning system using radio communications between the trains and the crossing.
- **Optimized Train Control (OTC)**. The Norfolk Southern Railway (NS) is implementing a separate, stand alone safety system (non-overlay) in South Carolina.
- **Train Sentinel**. The Ohio Central Railroad System (OCRS) is developing a PTC system that was previously implemented in the Republic of Panama. Train Sentinel is an overlay system on existing non-signaled methods of operations.
- **Vital Train Management System (V-TMS)**. UP is developing a non-overlay system that is similar in functionality to the BNSF ETMS. V-TMS is being implemented in Wyoming and Washington.

[8] FRA, "Positive Train Control Overview", 20 February 2009, available from http://www.fra.dot.gov ; accessed 1 March 2011.

3. Current Plans for Positive Train Control

The section discusses the current status of PTC plans in the US and Southern California.

3.1 Nationwide Plans for PTC Implementation

As mentioned in Section 2.2, the FRA regulations are not prescriptive on the type of technology to be deployed for PTC. The regulations promote technology neutrality and require only that the PTC systems accomplish core safety functionalities. In contrast, the railroad industry in the EU is deploying systems based on the adopted GSM-R and ETCS technologies. To meet the RSIA mandate set for 2015, the Class I railroads (UP, NS, BNSF and CSXT) are working with various vendors to design systems based on the different PTC technologies listed in the previous section.

The railroad industry is coordinating interoperability efforts through the American Association of Railroads (AAR). The Class I railroads have formed the Interoperable Train Control (ITC) Committee to develop technical standards to support PTC interoperability. The PTC systems being developed are based on standards published by the AAR.

The Class I railroads have agreed to use the 220 MHz spectrum for radio communications[9]. The radios will provide the locomotives with a communications link to the operations center and wayside devices. The PTC systems will be interoperable to allow different types of onboard equipment to communicate with the PTC infrastructure in any railroad territory. To support interoperability, the ITC is developing a communications messaging standard using the Advanced Message Queuing Protocol (AMQP). The AMQP standard will enable the locomotive of a railroad company to exchange information seamlessly with the back office system of another railroad company.

3.2 Regional Plans for PTC Implementation

Metrolink is developing a PTC system that supports the functionalities of a “Rung 1”, ITC compliant PTC system[10]. The Metrolink Rung 1 system is based on the V-ETMS being developed by UP, CSX and NS. The PTC system will cover Metrolink train service on 512 miles of trackage, including those shared with BNSF, UP, Amtrak and a portion of the Northern County Transit District (NCTD) subdivision in San Diego County.

The following are the primary components of the Metrolink PTC system:

- On-board computers, display screens, GPS tracking and radios on 57 cab cars and 52 locomotives;
- Back office system to store track geometry, wayside signal configuration and speed restriction databases;
- Stop enforcement system at 476 wayside signals;
- Six county specialized communication system operating on the 220 MHz spectrum to link the wayside signals, trains and the centralized dispatched office; and
- Replacement of the current dispatch system with a new CAD system;

[9] Sam Alibrahim and Terry Tse, “FRA Research and Development Review, Signal and Train Control”, presentation given at the November 2008 TRB conference.
[10] Phone interview with SCRRA, 30 March 2011.

4. NEXT STEPS

The development of a PTC system is well underway in the SCAG region, with a target completion of 2012. A regional PTC system will provide safety enhancements to a densely trafficked regional railway network with a mixture of freight and passenger rail service. The SCRRA is working closely with UP and BNSF to implement a system that conforms to interoperable standards and specifications for PTC. Interoperability is critical for allowing trains operated by any railroad to communicate with the PTC infrastructure throughout Southern California.

In anticipation of the regional 2012 deadline for deployment, the Regional ITS Architecture needs to be updated to support information flows and exchanges between the PTC system and regional ITS elements. The updated Southern California Regional ITS Architecture will feature a PTC module that addresses the following: stakeholders, inventory, services, interfaces, operational concepts, standards, functional requirements, projects and agreements.