Technical Meeting of the Institution

held at

1 Birdcage Walk, London
Thursday 13th November 2014

The Senior-Vice President, Mr Andrew Simmons, in the chair.

53 members and visitors were in attendance. The Chairman welcomed all to the second technical meeting of the session in London and tendered apologies from the President, Christian Sevestre, who was attending the Scottish Section meeting in Glasgow the same evening, and also for the late start due to an earlier meeting overrun, not unlike some railway possessions. He invited any new members present for the first time since their election to come forward to be introduced to the meeting, and Nigel Wilcox from Interfleet did so and was welcomed with the customary applause.

He then introduced Joe Noffsinger from GE Transportation, USA who had spent most of his career with railroads and suppliers in the USA but who had also spent nearly three years working for GE in the UK in the late 1990s, and invited him to present his paper 'The Challenge of Positive Train Control Implementation'.

Mr Noffsinger started by describing the PTC concept and listed the main features of the system. He reviewed the history of the evolution of train control on the main line railways of the USA and the major accidents which led to legislation being passed by the Congress to mandate the fitting of PTC by December 2015. He gave the scale of the project by saying that there were some 20,000 locos and 60,000+ miles of track to be fitted at a capital cost of around US$8bn. He went on to describe the approval process, and then the principles of operation of the system for the different types of signalled railway. He highlighted the important implications of braking considerations and showed some examples of cab layouts to highlight the potential amount of equipment to be installed, and some illustrations of the display graphics being implemented. He also showed an example of how an integrated driver's display screen could look, with potentially a large amount or even too much information being displayed.

He described the wayside equipment being provided and explained the philosophy being followed of non-intrusion to limit the volume of re-testing needed on existing installations. He also described in some detail the locomotive-based parts of the system. He finished by giving an update on the present implementation status of the project with different railroads being at a different state of progress, and at least one saying that they would not be able to meet the deadline. This had led to the Federal Railroad Administration providing a potential easing of the deadline to allow time for system fine tuning after December 2015.

Following the presentation Messrs Ian Mitchell (Delta Rail), Martin Beard (Network Rail), Andrew Simmons (Vice President), Simon Errington (Independent), Colin Porter (Past President), Denis Bowlby (retired), Brian Needle (Network Rail) and Yuji Hirao (Japan) took part in the discussion.

The Chairman then proposed a vote of thanks and presented the speaker with a commemorative plaque customarily awarded to the author of a London paper. He announced that the next technical meeting in London would be on 9 December 2014 when Nicolas Laurelut from RFF in France would present a paper titled 'Telecoms - Key Things Happening in Europe : IP Networks '.

The meeting closed at 19:45.

The Challenge of Positive Train Control Implementation

Joseph F Noffsinger, EurIng CEng FIET FIRSE PE[1]

INTRODUCTION

The Positive Train Control (PTC) initiative underway in the United States is one of the most comprehensive signalling and communications projects ever undertaken. The scope of the deployment alone is a significant challenge, with more than 60,000 miles of track and 20,000 locomotives and cab cars to be fitted with new appliances. When you add challenges such as novel technology developments, new safety approval processes, radio spectrum availability constraints, minimum public funding support and a statutory deadline, the program could be a signal engineer's dream, or possibly a nightmare. This paper will provide an overview of PTC, including brief historical perspective, the regulatory and approval framework, and a brief discussion of technologies being deployed. It will highlight some extraordinary hurdles in technology, cost, schedule, and risk reduction. It should be recognized that the PTC initiative involves complex technologies and processes, and high technical detail is beyond the scope of this discussion.

1 The author is with GE Transportation, an operating component of General Electric Company.

KEY DEFINITIONS & ABREVIATIONS

AAR	Association of American Railroads - trade association and standards body
ACSES	Advanced Civil Speed Enforcement System - a PTC system
AREMA	American Railway Engineering & Maintenance-of-Way Association - professional & standards organization
Class 1 Railroad	A freight railway with minimum annual operating revenue of $250 million. There are currently seven companies in operation that meet this definition.

FRA	Federal Railroad Administration - the regulator
IEEE	Institute of Electrical & Electronic Engineers
IETMS	Interoperable Electronic Train Management System - a PTC overlay system
ITC	Interoperable Train Control committee
ITCS	Incremental Train Control System - a PTC system
NTSB	National Transportation Safety Board - major accident investigation authority that makes safety recommendations

BACKGROUND

In October 2008 Public Law 110-432 passed both houses of the US Congress and was signed into law by then President Bush. This event ended 18 years of debate in the rail industry over whether the implementation of signal enforcement was warranted for normal speed traffic.

Collision prevention for the railways had been on the NTSB 'Most Wanted' list since 1990. The debate centered on the balance of cost versus risk avoided, as well as the readiness of technologies to provide protection without disrupting the capacity of the rail network. The need for an intervention was also questioned by the industry, as analysis of accident data reported to FRA showed a continuously improving trend from 1980 to 2008.

Train accidents per million train miles

Year	Collisions	Derailments	Total All Types
1980	1.67	8.98	11.43
2008	0.25	2.31	3.21

The FRA began rulemaking proceedings in the late 1990s to set technical standards for electronic systems and assess the case for requiring PTC. Much was made of the 'other business benefits' that could result from implementing the data communications network required for a CBTC solution, but the countering argument was that those debatable benefits could be otherwise achieved at a fraction of the cost of the complete safety system. After much debate between FRA, rail trade associations, rail labour organizations, and other interested parties about the costs and benefits of PTC, FRA economists eventually concluded that the PTC implementation did not meet the Department of Transportation thresholds for safety cost / benefit ratio. If FRA as a regulatory agency promulgated requirements for PTC, they likely would not successfully pass the review by the federal Office of Management and Budget.

This debate became moot after the high profile collision in Chatsworth, California in July 2008 with 25 fatalities and 100 injured. Despite the continuously improving performance on collision avoidance and reduction of derailments by the rail industry, any major rail accident generates a disproportionate amount of press coverage and regulatory attention as compared with other transportation modes. Congress quickly reacted to the Chatsworth incident with passage of Public Law 110-432 (Rail Safety Improvement Act of 2008) which directed FRA to mandate PTC and also set out the high level definition, requirements, and subject railways in statute.

Directed by Congress to override the cost/benefit test, FRA set about to develop and issue regulations requiring railways to implement and commission PTC by the statutory deadline of 31 December 2015.

Neither the framework legislation nor the regulations from FRA set aside any significant funding mechanism for PTC other than some development grants. The current estimated cost for capital installation and commissioning is an investment of $8 billion. If one includes the estimated net present value of future maintenance, the total system cost impact is expected to be about $15 billion. The costs will be borne by each railroad in its own budget. While a significant burden to all entities, it is especially difficult for passenger and transit agencies where the fare box cannot support programs of this magnitude. Federal, state, and local government programs may need to raise an unprecedented amount of subsidies in support of the passenger railways.

TOP LEVEL REQUIREMENTS OF PTC

By regulation, PTC has four core requirements, to:

1. prevent train-to-train collisions;
2. prevent over-speed derailments;
3. prevent incursions into established work zone limits;
4. prevent movement of a train through a switch (points) left in the wrong position.

Requirements 2 to 4 go beyond the original NTSB recommendation from 1990. Each is the result of one or more associated high profile accidents in recent years.

Of particular relevance to the discussion that follows, requirement 4 derived from an accident that had direct impact on identifying operations that would require PTC. The accident occurred in January 2005, on non-signalled track (manual block operation) near Graniteville, South Carolina. A freight train with two locomotives and 42 wagons moving at 47 miles per hour traversed hand operated facing points that had been left in the reverse position. The resulting collision with cars standing in the industrial track derailed the locomotives and 16 cars, including a tank car of chlorine, which breached. There were nine fatalities including the train driver. 5,400 residents were evacuated from an area within a one mile radius of the site.

In the final rule, the application requirement for PTC includes main track where there is intercity passenger traffic or commuter passenger operation, and also Class 1 freight main track with annual traffic levels of 5 million gross tons (MGT) or more including any quantity of toxic inhalation hazard

(TIH) hazardous material. There is an exemption process for lines with freight traffic below 15 MGT and less than 100 TIH wagon loads annually, if appropriate risk analysis can be demonstrated.

SCOPE

After each railway performed an analysis of their responsibility under the rule, the result is that all seven Class 1 freight railroads and thirty passenger agencies must implement and fit PTC. Approximately 60,000 miles of track is being enabled for PTC operation, involving:

- 38,000 Wayside Interface Units (WIU);
- 12,000 complete replacements of existing signal installations;
- 4,900 modifications to signal installations;
- 4,119 base station radios;
- 36,544 wayside signal radios.

Each train that will transit PTC equipped territory must have the controlling cab fitted with functioning PTC. The initial population to be fitted is a minimum of 20,000 locomotives and cab cars.

Since the rules require that mandatory directives from the train dispatcher must be enforced by PTC (temporary speed restrictions, track warrants for dark territory, work zone authorities), 30 installations of safety critical back office servers and CAD system modifications are required.

According to AAR's latest fact sheet:

- $4 billion has been spent to date;
- $8 billion capital will be spent by full deployment;
- 2,250 new signal personnel have been hired;
- 50% of rolling stock is fully or partially equipped;
- 33% of wayside interface units have been deployed;
- 33% of wayside antennas have been installed;
- 20% of PTC radios have been installed (Base, onboard, wayside).

The estimated net present value of the incremental future maintenance requirements is $6 billion. These numbers do not consider the potential cost of impact to train operations due to early stage system failures, with resulting impact to fuel, crew, and carriage contract penalty costs.

INTEROPERABILITY

Interoperability is a regulatory requirement, and of course desirable for business reasons. It is described as the ability for a train to pass from one railway to another at speed. This is equivalent to not having to change locomotives at Bruxelles Midi any more. This is important because the Class 1 freight railroads, intercity passenger carrier Amtrak, and many of the commuter agencies share track. For Class 1 freight operations, the railroads loan locomotives to each other, and keep an account of horsepower-hours for settlement. This improves efficiency of operations on trains that pass through multiple railroads, and improves industry wide asset utilization. Fielding incompatible systems would effectively partition operations over the general railway network. The good news for interoperability is that unlike the 21 or so different ATP antennas on the Trans European Network lines that drove ETCS, most of the PTC implementation is 'greenfield build' for the enforcement layer. However there are complications at boundaries, as commuter railways, higher speed intercity passenger, and freight railways have chosen different systems, yet share some trackage.

The FRA regulations implemented a performance standard in lieu of prescriptive rules, but left technology choices up to each railway. In the required document filings with FRA each host railway must describe how it will achieve interoperability with railways with which it has operating agreements or trackage rights. The four largest Class 1 railroads necessarily took a lead position and formed the Interoperable Train Control (ITC) committee, setting common technical standards, having chosen the same core platform architecture to be developed. That committee later took other railways 'into the tent' and has issued draft standards for the IETMS system that have since been approved through the Association of American Railroads standards committees. Alternative PTC technologies (ITCS and ACSES) have made, or are making, modifications to utilize a common CBTC message set with the ITC standards or to add ITC compatible wayside subsystems.

APPROVAL PROCESS

Each railway is required to file a PTC Implementation Plan (PTCIP) with the regulator. The content of this comprehensive document includes listing rail lines and locomotives that are subject to the PTC requirements, the intended deployment schedule prioritized by risk, and the plan for how interoperability will be achieved. The PTCIP must reference a concurrent or previously filed PTC Development Plan (PTCDP).

The PTCDP describes the technology in detail. It must address in detail:

- system components and their relationship;
- railroad operations including traffic, speed, terrain, rules;
- operational concepts and how safety is enhanced or preserved;
- how system architecture satisfies requirements;
- human factors analysis;
- analysis of relevance and compliance with traditional signalling rules;
- system restoration plan and security measures;
- targets for mean time to hazardous event, system availability, and backup methods;
- how movement authorities and signal indications are enforced;
- necessary deviations from operating rules during service failures.

If the FRA agrees that the system described in the PTCDP is reasonably capable of meeting the PTC requirements, a Type Approval will be granted for 5 years. With a Type Approval in hand, the railway can build and perform system testing, creating documented evidence necessary for the next step, the PTC Safety Plan (PTCSP). The PTCSP is the comprehensive safety case, building on the PTCDP content with additional elements such as risk assessment, hazard log, hazard mitigations, safety principles chosen, verification and validation (V & V) process chosen, evidence of compliance, training programs, product warnings, configuration management scheme, and emergency measures. Acceptance of the PTCSP with documented test evidence by FRA will yield a PTC System Certification and the system can be commissioned for revenue service. While railroads may be assisted by the signal suppliers in preparation of the PTC safety case documents, the regulated party is the railway, and they are ultimately responsible for the content.

One option available for a railway is to classify the system in the PTCSP submission as a 'Non-Vital Overlay System'. This allows exemption from certain safety assurance principles normally in the PTCSP, but has the new requirement for a compelling quantified risk assessment (QRA) proving that at least 80% of the outstanding accident risk has been mitigated.

FRA also leaves the standards selection open to the railway, requiring disclosure of which standards are chosen, and then demonstration of how those standards are met. The railway might select CENELEC Norms, AREMA Recommended Practices, IEEE Standards, or any other provided there is a compelling argument that compliance with the standards will meet the desired safety objectives.

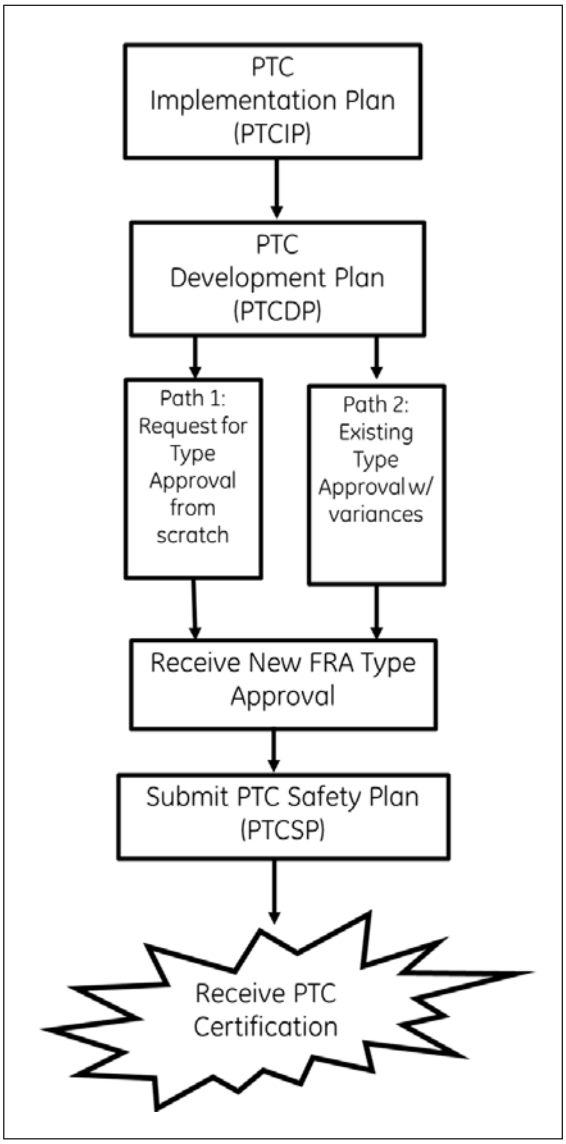


Diagram 1 Simplified PTC Approval Process Diagram

TECHNOLOGY AND CONTROL FLOW

There are various technical approaches to solve the four core requirements of PTC. Three different technologies are being deployed and are associated with different types of operation. Freight railroads have chosen IETMS, along with a comprehensive wireless mobile IP network, standardized message sets for interoperability, and a mix of options for distributed versus centralized logic. On the Detroit to Chicago corridor, for example, the national intercity passenger carrier Amtrak is expanding ITCS mileage to support more 'higher speed' 110 mile/hr operations and wireless level crossing activation. In the high speed Northeast Corridor, Amtrak's ACSES continuous current dual carrier cab signal plus balise system is evolving and being adopted by connecting commuter rail agencies from Boston to Washington. The contents and operation of the systems core are summarized below.

1) INTEROPERABLE TRAIN MANAGEMENT SYSTEM (IETMS)

IETMS will have the widest deployment and has been adopted by all seven Class 1 railroads in their PTCDPs. It is being deployed on the majority of the route miles and locomotives subject to the PTC mandate. It is proposed as capable of meeting the requirements of a vital PTC system, but can also be the framework for the non-vital approach to address the 80% minimum risk mitigation target. IETMS is a communications based overlay enforcement system, and is not being applied to replace the primary method of operation, at least not in the near term.

At the initial terminal departure test, the system is initialized. An IETMS HMI display with 'soft keys' provides the initialization dialog. Objects on the locomotive Ethernet are identified, CRCs are confirmed and peripherals initialize. The controlling locomotive number is read into the system, and the driver logs in for security. The system contains a track database of grade, curvature, and signal system objects. Any track database updates are downloaded from the PTC Back Office Server (BOS). The manifest of the train is downloaded through the BOS link to the railway IT transportation management system. This includes all other locomotives and all wagons in the train, yielding train length and weight. A brake pipe test is automatically performed, checking for leaks and verifying propagation of a pressure reduction through the length of the train as measured at the end-of-train (rear) telemetry device. When the system successfully passes the initialization test the train can legally depart for a route that requires PTC.

A location determination system (LDS) is part of the system, and tracks the train position in the track database. The LDS utilizes GPS with correction services along with axle tachometers for dead reckoning. Optionally it may be augmented by an inertial navigation unit. The train is graphically displayed on the HMI screen on a scrolling map showing the train length superimposed over the track grade profile. Signals and level crossings are shown on the map, as well as the forecast braking profile of the train.

The train proceeds into PTC territory and enforcement is enabled. If the line is signalled, each wayside signal location will transmit the signal aspect to the approaching train over the wireless network. The onboard computer updates the target list as aspects are received. Permanent speeds and any temporary speed restrictions are included in the target list, and also displayed on the scrolling track map. The back office server sends a periodic 'heartbeat' with a checksum of the current authorities and speed restrictions. If the on-train data does not match and is not updated within a pre-determined interval, movement authority is withdrawn.

If the driver attempts to violate the authority limit, authorized speed, or braking profile, the traditional warning is given, with a countdown of time to enforcement displayed. If the driver is able to manage the train to trend to a speed under the warning curve, time to penalty increases and then clears. A full service penalty brake application is triggered if corrective action was not sufficient.

On non-signalled track (also known as 'dark territory', having manual block operation and/or track warrant operation) the process is similar. A movement authority is issued from the CAD system, through the PTC back office server, for the train to proceed to a virtual block station ahead. The end of the authority is set as a zero speed target, and enforced in a like manner to a stop signal. Points to sidings are in the onboard track map, interrogated by the approaching train for status, and enforced as a zero speed target if not correctly lined.

The normal braking process for freight trains differs from what most UK members are familiar with. Freight trains equipped with PTC may be up to two miles in length, and weigh 10,000 to 15,000 tons (9100 to 13,600 tonnes). The placement of loaded wagons and empties is not stringently managed, to save time in building trains. Due to the propagation time for brake pipe reductions made at the head end to be effected at the rear of the train, bringing the train to smooth stop may involve multiple incremental reductions of air pressure, with wait times for propagation so slack action run-in does not derail the train. This helps if the train was 'stretched' at the time braking is initiated. The resulting braking distance required from 50 mph to full stop may require 2 miles or longer, depending on terrain.

Freight PTC systems have to manage the trade-offs between smooth train handling, high assurance of compliance with the target speed and location, and not surrendering line capacity by stopping far short of target.

IETMS uses an adaptive braking algorithm that considers:

- current train speed;
- length, weight, and braking capability;
- proximity to target;
- track profile from train to target;
- locomotive control settings;
- current state of the braking system using brake pipe & reservoir sensors.

To assure compliance with a stop target, the deceleration rate is monitored after a penalty application is initiated. If the train is not predicted to stop with high confidence, an emergency brake actuation is initiated. This only occurs when the train is at a low speed to de-risk the probability of a run-in derailment.

In normal operation of very long trains, the driver typically has more options for braking than IETMS can incorporate. Many long heavy trains utilize Locotrol(TM) distributed power systems where additional locomotives are placed in the center or rear of train and linked by data radio to the lead unit. In synchronous mode, when a brake application is made on the lead unit, the same brake pipe reduction will be initiated on the remote units, fractionalizing propagation time, reducing stopping distances by 30% or more, and eliminating slack run-in risk. Since there is a chance that the radio link may be disrupted, the system is not closed loop, and remote braking contributions cannot be considered in the PTC fail safe stopping estimation. While there are methodologies to make this configuration fail safe, they are not being pursued at this time. Also in normal driving many trains are managed to a planned smooth stop in a 'bunched' state by using dynamic braking on the two or three locomotives normally on the head end. Train air brakes are only used at low speed and to hold the train once stopped, and even that is not necessary for chopped AC traction motor locomotives. Since the dynamic brake resistor grids may fault, contributions of dynamic braking effort are also not counted on in calculations forecasting stopping ability.

IETMS functions through networks, both on board the locomotive and wayside. Wired & wireless Ethernet is the transport layer, using Edge Message Protocol (EMP) and two broad categories of message classes are used. Class C defines a broadcast message, and Class D a point to point message.

On board the locomotive, the typical configuration might be:

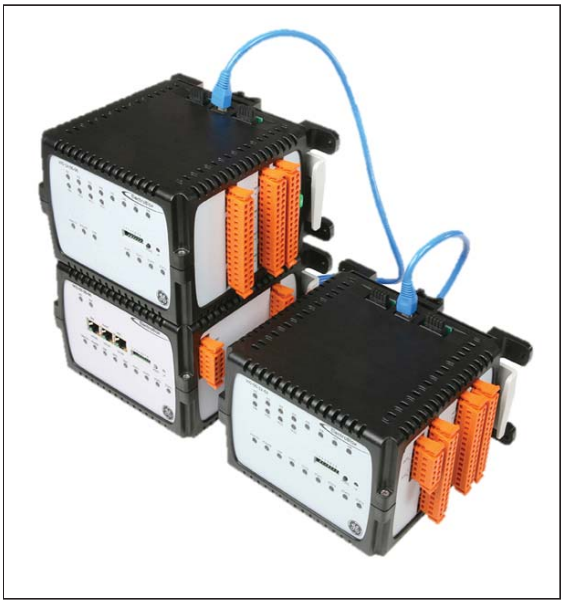
- driver's HMI screen;
- safety On Board Computer (OBC) 2oo2 or 2oo3 (freight railroads are using the Wabtec TMC);
- locomotive ID Module;

Picture 1 Onboard Wireless Communications Module, containing dual LTE modems, dual Wi-Fi modems, a GPS receiver, and Gigabit Ethernet backplane connectivity.

- direct wired sensors to control stand, brake pipe and brake reservoir;
- direct connection to penalty brake and emergency electro-valves or brake processors units;
- dedicated 220 MHz PTC Ethernet data radio (such as Meteorcomm radio);
- AAR S9101 Ancillary Card Cage (ACC) populated with:
- 9 port Ethernet managed switch and router;
- Wireless Communication Module (such as GE GoLinc with dual Wi-Fi and dual LTE cellular chips);
- antenna farm with antenna diversity on the roof for all five radios;
- multiple GPS receivers;
- crashworthy judicial event recorder (capturing key PTC parameters as well as traditional data);
- Locomotive Interface Gateway (LIG) – firewall and data arbitrator between the PTC network and the locomotive control system network.

A note on the LIG: it allows parameters from the locomotive systems to be published on the PTC onboard network without risking corruption to either system. It may be configured to publish throttle position, brake handle positions, tractive effort, speed, travel distance, acceleration, brake system pressures, etc. whether as a primary source or redundant source to sensors connected directly to the TMC.

Picture 1 shows an Onboard Wireless Communications Module containing dual LTE modems, dual Wi-Fi modems, a GPS receiver, and gigabit Ethernet backplane connectivity. All modems support antenna diversity.



Picture 2 GE ElectroBlox WIU – Stackable DIN rail modules for I/O expansion.

With the exception of the primary hard wired sensors and antennas, all the onboard systems are connected together by wired Ethernet or Ethernet backplanes in the TMC or ACC.

On signalled track, wayside equipment consists of the conventional signal system components, augmented by PTC system components.

At a wayside signal or switch, additions to the signal system include:

- a wayside interface unit (WIU) that monitors status of signal aspects, or position of points
- a wayside message server (WMS) that formats the PTC messages, and contains the standard ITCSM 'stack' that manages message flow.
- a local PTC 220 data radio, and/or an Ethernet link to a wayside PTC 220 base station radio.

Picture 2 shows a GE ElectroBlox WIU, with stackable DIN rail modules for I/O expansion. Lamp & relay currents are sensed with vital flux gates.

The onboard 'local' network devices communicate to the off board wayside signals, and back office server through wireless messaging. The baseline transport is over the PTC 220 MHz data radio, which is being fielded to provide universal coverage across all of the freight railroads. Existing 160 MHz voice radio towers have PTC radios added, and additional towers are being fielded to provide redundant coverage. This baseline frequency group guarantees connectivity for any railroad's locomotives operating offline on any other railroad, complying with the interoperability requirement. Wi-Fi and mobile cellular modems are also included onboard, with LTE being the preferred service level. Each railroad may choose their own wireless carriers (such as T-Mobile, Sprint, AT&T, etc.) based on coverage and preferences. The Wi-Fi and mobile cellular connections provide redundant networking for PTC, wide bandwidth for database updates,

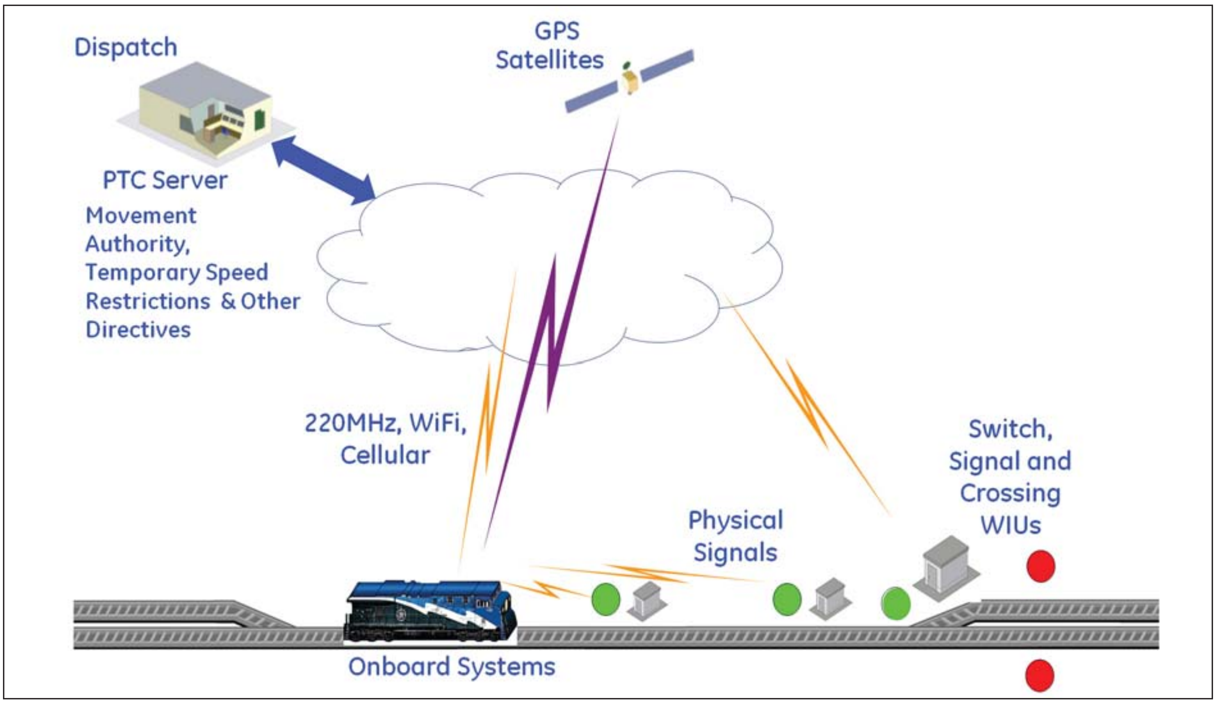


Diagram 2 IETMS simplified architecture diagram.

event recorder and video downloading, as well as other business functions, remote monitoring, and diagnostics.

Every locomotive and every wayside location is interfaced to the wireless network through a PTC Message Server. This device arbitrates communications, and guarantees interoperability. No matter who builds the hardware device, it must contain the ITCSM software 'stack', which also provides message prioritization as well as diagnostic & support functions. System management specifications are being finalized to provide capability for remote software updates, as well as log and diagnostics data retrieval.

There is some debate ongoing with IRSE members and the International Technical Committee about the appropriateness of IP communications for signalling. Suffice it to say that the North American freight railroads are committed to mobile IP as the backbone for operations. Network security will not be debated in detail here, but a few brief points may be made.

- FRA Rule 236.1033, 'Communications and security requirements' sets out the high level guidelines for security. Those interested in more detail may search that rule on the web.
- Communications require cryptographic message integrity and authentication.
- Cryptographic keys must use an algorithm approved by the National Institute of Standards (NIST) or a similarly recognized and FRA approved standards body
- To pass PTC system certification, FRA expects the railways to have programs of continuously improving security methods as technology and security capabilities evolve.
- While the railroads' regulatory document filings such as PTCIP, PTCDP, and PTCSP may be available on www.regulations.gov as public documents, one will find security information redacted.

The complexity of the system, i.e. large number of new components, gives rise to great concern over reliability forecasting and the potential negative impact to operations. Many system components must function correctly for a train to complete its mission with working PTC. Rather than add redundant equipment on each locomotive, a different path is implemented. Since most freight trains have a head end consist of two or three locomotives, the onboard network can be bridged to the trailing unit(s) networks. This allows sparing or redundancy online with PTC kit on the trailing units. The most benefit will likely be from the trailing 220 MHz radios and mobile cellular modems, since radios often have a disproportionate failure rate. Even without failed equipment on the lead unit, adding trailing units to the network provides antenna spatial diversity as well as hardware diversity, improving probability of message delivery.

2) ADVANCED CIVIL SPEED ENFORCEMENT SYSTEM (ACSES / ACSES II)

Amtrak's Northeast Corridor and adjoining commuter operations in Boston, New York City, Philadelphia, Baltimore, and Washington are upgrading their signal and ATP systems to ACSES II to meet the PTC mandate. The underlying signal system is based on dual carrier coded continuous cab signals to generate in-cab aspects. ACSES I active transponders are being upgraded in ACSES II with a combination of passive transponders for location and data radio (at 220 & 900 MHz) for dynamic data related to speed restrictions and work zones. Current maximum speed for the Northeast Corridor is 150 mile/hr (240 km/hr), the fastest in North America.

3) INCREMENTAL TRAIN CONTROL SYSTEM (ITCS)

ITCS architecture and control flow was addressed in an IRSE London paper in October 2003 by Messrs. J. K. Baker and W. J. Scheerer from GE Transportation, citing the first implementation on Amtrak. In addition to the ongoing Amtrak Chicago to Detroit line expansion, ITCS is the PTC platform for Caltrain commuter operations in California. The system was also commissioned in western China in 2006 on the Xining to Lhasa line as the primary method of operation, using in-cab targeting without any wayside signals. Additional implementations are underway on FMG in Australia, and Fenoco in Columbia.

4) ENHANCED CAB SIGNAL SYSTEMS

At least four commuter railways are using conventional cab signals to meet the PTC objectives, enforcing absolute stop indication with no code present. To command appropriate speed codes for temporary and civil speed restrictions, additional SCADA nodes are being installed in wayside code change points, with control functions added in the dispatch back office. For special PTC functions such as work zone protection, stop indications will be enforced at the code change points prior to the work zones. This is a trade-off of line capacity for system simplicity.

OTHER NOTEWORTHY POINTS

Many wayside signals are ‘approach lit’, to preserve lamp life and mitigate vandalism. When a signal lamp failure occurs, detection circuitry will downgrade the aspect on prior signals. To assure that signal enforcement targeting is consistent with the signal aspects observed by the driver, an approaching train may send a light up message to the WIU at signals two or more blocks ahead so that aspects are stable for creating the PTC messages from the WIUs.

Disarrangement of the wiring, or changes to application software may require extensive field re-testing. Special procedures were developed to expedite field installation of the WIU function with high efficiency where microprocessor based interlockings and automatic signals are used. To extract status information from legacy electronics, a new processor board was created for each product that was electrically identical to the old, except bus traces that carried signal state information had a connector added to support a daughter card. The daughter card contains a vital PTC processor that captures the signal state messages from the interlocking or automatic signal, maps the status bits to a PTC message, and connects by Ethernet port to the PTC message server in the location. To enable a location for PTC, the existing processor card is exchanged for the new card with the added PTC processor on board. The ROM containing the location specific application software is moved from the old card to the new one. For certain legacy products, the ROM containing generic executive software is replaced with a pretested version that publishes all signal statuses on the bus. If checksums match and the system reboots, the PTC upgrade to enable the location is safely completed in 5 to 10 minutes without disarrangement of the signal system.

This paper previously discussed the concept of using PTC kit on trailing locomotives as hot spares on an extended network. But adding intra-consist cables and connectors is always a reliability risk, and short haul wireless networking adds complexity. Locomotive consists are built by plugging the units together with an AAR standard multiple unit (MU) cable. Each locomotive has an MU socket on front and rear. Ethernet bridge and routing software is installed on each locomotive, and functions over existing control lines in the MU cable, similar to Ethernet over power lines. When two locomotives are connected as multiple units by a standard MU cable, the network extension between automatically configures. This Ethernet-over-MU bridge is known by the trade name ‘eMU’. AAR developed standards for interoperability of the network extension, so all equipped locomotives will be compatible to connect.

REMAINING CHALLENGES

Railways have expressed some disappointment in the less than perfect alignment between federal agencies.

The requirements of PTC steered the industry to communications based solutions. Yet neither Congress nor the Federal Communications Commission (FCC) made any special initiative to allocate spectrum for PTC. The FCC continues to auction open spectrum to the highest bidder to raise revenue. With significant effort and cost, the Class 1 railways had to create and fund an entity known as ‘PTC220’ to purchase spectrum on the open market from existing license holders.

The PTC Final Rule issued by FRA in 2010 required PTC to be implemented on rail lines that carried Toxic Inhalation Hazard traffic in test year 2008. At the time this rule was issued the Pipeline and Hazardous Material Safety Administration (PHMSA) was requiring railroads to re-route hazardous traffic to lowest risk corridors, away from major cities. In effect, many lines prioritized by FRA for PTC installation would have the hazardous traffic removed by the time PTC is installed. An amendment to the PTC Final Rule in August 2014 finally allowed some flexibility for railroads to revise applicable lines in their PTC Implementation Plan filings.

Railroads were aggressively installing poles and towers to support the 40, 000 wayside radio and base station antennas, when they were reminded by the FCC that they were not in compliance with a little known rule that required clearance for each site from representatives of Native American Indian tribes. All work came to a halt. The tribal councils were not readily prepared to perform the inspections, intended to assure that sacred burial grounds were not being disturbed. Work on wayside antennas was halted for approximately 1 year, pending agreement of expedited procedures.

PERIPHERAL SYSTEMS

An interface is defined between the IETMS system and energy management systems to hand off data. Many freight locomotives are equipped with systems like the GE Trip Optimizer system which drives the train to an optimized speed profile for fuel savings. Others are equipped with a driver prompting system to achieve similar goals. By sharing the same track database and operational parameters used on board for PTC, conflicts between the systems can be avoided, and efficiencies can be obtained in updating reference databases as well. The energy management systems will not challenge the enforcement curves of PTC, and can re-calculate more efficient profiles as signal aspects ahead are known.

BASE SYSTEM RENEWALS

Inherent in the PTC build out is a significant signal renewals program. AAR cites completed or planned replacements of 12,000 signal locations. These may be driven by dilapidation of relay based stations, additional housing space requirements, or desire for new technology. It is a unique opportunity for updating of the base signal systems.

FORECAST

Railroads are committed to implementation for compliance with the regulations where PTC is required. But concern continues about the constraints that may be imposed on their operations with newly developed technologies in such widespread application on a fast timetable. There is also growing concern with overall system reliability numbers that must be met so as to not disrupt service to customers.

It will be a challenge for any railways to meet the mandated date of 31 December 2015 to have PTC in full service. A recent statement by one Class 1 railroad on UTube reads, 'Norfolk Southern is committed to implementing a positive train control (PTC) system that will strengthen an already safe rail network. However, far too many technological and regulatory barriers exist today, and despite our best efforts, the 2015 deadline for full implementation of PTC will not be met.' Similar statements may be expected from other railways in the near future.

In an amendment to the PTC Final Rule in August 2014, FRA has added some leeway to address startup problems. If procedures are described (and approved) in the PTC Safety Plan, a railroad may temporarily disable PTC system service and operate under alternative rules until corrections can be made. This temporary relief provision expires on 31st December 2017, which provides some flexibility for a two-year period.

GENERAL REFERENCES

Note for IRSE members with further interest: rules, explanations, public comments, and PTC document filings are publicly available at www.regulations.gov (narrow search criteria to the agency 'FRA').

See also:

'Railroad Facts,' 2013 Edition, Association of American Railroads at www.aar.org

National Transportation Safety Board website at www.NTSB.gov/Safety/mwl8_2014

'Positive Train Control - Report to the Chairman, Committee on Commerce, Science, and Transportation, U.S. Senate,' United States Government Accountability Office, 2013.

'Federal Railroad Administration Positive Train Control Fact Sheet,' FRA Office of Public Affairs 2013

'Federal Railroad Administration Report to Congress - Positive Train Control Implementation Status, Issues, and Impacts,' August 2013

http://www.fra.dot.gov/eLib/ details/L03718

'American Railroads,' Robert E Gallamore and John R Meyer, Harvard University Press 2014

Discussion

Summary of discussion of paper by J Noffsinger entitled 'The Challenge of Positive Train Control Implementation' given on 13th November 2014.

The discussion was opened by I. Mitchell (DeltaRail) who thanked the speaker for his paper. He then asked how the required accuracy of the GPS had been tackled, especially for trains on adjacent lines.

J. Noffsinger confirmed that this was a real challenge and advised that the driver has to initiate the location of the train and from that point onward the equipment could determine the position. He thought that multiple GPS receivers might be able to give the required accuracy but there was no definitive solution yet.

M. Beard (Network Rail) questioned how a train was confirmed as being complete.

J. Noffsinger explained that there were various methods including 'End of Train' devices and brake pipe pressure monitoring; for consists where locomotives are distributed throughout the train, comparison between the speed of the front and back of the train is undertaken.

A. Simmons (Network Rail) asked about the security of the system, both in technology and manpower terms.

J. Noffsinger advised that security is enforced by the requirements in the rules together with cryptography and encryption techniques.

S. Errington (Consultant) wondered where the funding and human resource was coming from.

J. Noffsinger explained that whilst Congress had funded the Research and Development programme, the implementation costs are falling mainly on the railroad companies themselves although some grants had been made to commuter railways and exemptions to fitment have been granted under certain circumstances. The human resource is mainly being met by hiring skilled contractors to undertake the work.

C. Porter (IRSE) asked if the equipment was interoperable and interchangeable.

J. Noffsinger confirmed that provided the communication protocols and links were the same then the equipment was both interoperable and interchangeable between the (currently) three manufacturers involved.

D. Bowlby (retired) questioned what happened for US/Canadian cross-border trains and if the Canadian Railways also had to comply.

J. Noffsinger advised that this was less of a problem as a large proportion of Canadian National and Pacific trackwork was actually in America; he envisaged that Canada would eventually have to comply.

B. Needle (Network Rail) wondered what had been the impact on headways and operating capacity.

J. Noffsinger explained that there had been no detrimental effects on either headway or capacity mainly because of the improved braking capabilities. Additional benefits have been realised by utilising the communication network that has been installed.

Y. Hirao (University of Japan) noted that PTC took a bottom-up approach whereas ERTMS/ETCS took a top-down approach.

J. Noffsinger explained that it would have been impractical to install the trackside equipment on an un-fenced railway and also communications technology is different in the US compared to Europe. He also believed that using ETCS would have been far costlier.

A. Simmons (Vice President) thanked the speaker for his paper highlighting the work being undertaken in North America.

(Produced by Peter Grant)