Outline

1. Positive Train Control (PTC) Introduction and Background
2. Issues to Implementation
3. Certification
4. Status
What is PTC?

A type of train control required on most passenger and certain freight routes – with limited exceptions.

It is required by law by under the Rail Safety Improvement Act of 2008 (RSIA).

By statute a compliant PTC system must:

- Prevent train-to-train collisions
- Prevent over-speed derailments
- Prevent incursions into established work zones
- Prevent movement of a train through a switch left in the wrong position
- Be Interoperable
Impetus

Graniteville, SC   January 6, 2005
9 Dead, 250 Injured
5400 Evacuated 2 weeks

Chatsworth, CA   September 12, 2008
26 Dead, 131 Injured
What are the typical components of a PTC system?

On-board (locomotive):
- On-board computer
- displays
- event recorder
- antennas/transponder readers
- radios, and GPS

Infrastructure (track):
- Wayside interface units (WIU)
- Transponders
- Switch monitoring systems
What are the typical components of a PTC system?

Communications Infrastructure:
- Radio/cellular towers
- GPS antennas
- Fiber (or copper) backbone

Back Office:
- Back Office Servers (BOS)
- Dispatch center

Example diagram of a PTC system architecture.
Traditional Train Control

- **Basic Cab Signals**
  - Repeats Wayside Signal Aspect

- **Automatic Train Stop (ATS)**
  - Repeats Wayside Signal Aspect
  - Applies Brakes if
    - Train Passes Stop Signal
    - Engineer Fails To Acknowledge Alert

- **Automatic Train Control (ATC)**
  - Repeats Wayside Signal Aspect
  - Applies Brakes if
    - Train Exceeds Speed Indicated By Signal Aspect
    - Engineer Fails To Acknowledge Alert
  - No Enforcement under 15/20 MPH
PTC and Traditional Train Control

• Similarities
  Ø Both Display Authority
  Ø Both Provide Speed Control
  Ø Both Provide Warning And Automatic Enforcement

• Differences
  Ø PTC Is Predictive And Reactive, ATC Is Reactive Only
  Ø PTC Works In Signaled And Dark Territory, ATC In Signaled Territory Only
  Ø PTC Has Multiple Options For Position Determination, ATC Relies On Track Circuits
  Ø PTC Enforces Civil And Temporary Speed Restrictions, ATC Does Not
  Ø PTC Provides Direct Positive Control of train to EIC, ATC Does Not
PTC Strengths & Limitations

**Strengths**

- Enforcement Of Civil And Temporary Speed
  - Full Enforcement To Zero Speed Before A Stop Signal Vice After Stop Signal
  - Full Enforcement To Zero Speed Before A Misaligned Switch Vice Reduced Speed Through Switch.
- EIC Has Positive Control Of Train And Work Zone
- Does Not Require Track Circuits/ Flexibility To Support Changes In Operations

**Limitations**

- Will Not Prevent All Possible Train Accidents
  - Low Speed Collisions From Permissive Block Operation
  - Shoving Accidents In Reverse
  - Track Or Train Defect Derailments
  - Grade Crossing Collisions
  - Track Incursion Collisions
- Only Work Where Installed
  - All Trains Equipped (PTC)
  - Not Cutout
### What types of systems are currently under development?

<table>
<thead>
<tr>
<th>Railroad</th>
<th>System</th>
<th>Type</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNSF</td>
<td>IETMS</td>
<td>Non-Vital Overlay</td>
<td>Certified for Use</td>
</tr>
<tr>
<td>UP, CSX, NS, CN, CP, KCS &amp; Most non-NEC Passenger/Commuter</td>
<td>IETMS</td>
<td>Vital Overlay</td>
<td>Type Approved (In Development)</td>
</tr>
<tr>
<td>NEC Carriers</td>
<td>ACSES/Cab Signals</td>
<td>Vital Overlay</td>
<td>Certified for Use</td>
</tr>
<tr>
<td>AMTRAK (Michigan)</td>
<td>ITCS</td>
<td>Vital Overlay</td>
<td>Approved for Use</td>
</tr>
<tr>
<td>PATH</td>
<td>CBTC</td>
<td>Vital Stand Alone</td>
<td>Development</td>
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<tr>
<td>CALTRAIN</td>
<td>I-ITCS</td>
<td>Vital Overlay</td>
<td>Development</td>
</tr>
<tr>
<td>Tri-Met, SMART, AAF</td>
<td>EATC</td>
<td>Vital Overlay</td>
<td>Type Approved</td>
</tr>
</tbody>
</table>

GPS antenna (top), ACSES transponder (bottom)
Issues to Implementation

✓ Architectural Complexity
  ■ 4 Major Subsystems (Wayside, Office, Onboard, Communications)
  ■ 20+ Sub-subsystems
  ■ Not Commercial Off-the-Shelf

✓ Scale and Component Installation
  ■ ~22,000+ Locomotives – Multiple Classes
  ■ ~ 47,000 Switches
  ■ ~17,000 Signal Install/Upgrade – Unique Designs
  ■ ~ 22,000 Radio Towers

- Miles: ERTMS ~ 22,000 U.S. ~ 64,000 miles
- Vehicles: ERTMS ~ 5,700 U.S. ~ 22,000 vehicles
- Project Start: ERTMS ~ 1993/Public funding U.S. 2009/Private funding
Component Installation

Real estate is limited – component installation requires careful planning and functionality verification.

Fleet type – unique equipment may require special solutions and incur higher lifecycle costs.

Example of retrofit components potentially blocking brake valve.

Example PTC antenna array arrangement.
Issues to Implementation

✓ 220 MHz Spectrum Availability (217.6 to 222 MHz)
  - PTC 220 Limited Liability Corporation (LLC) NS, CSX, UP, BNSF
    - 4x 25 KHz Channels
    - Sufficient for Low Density
    - Sufficient Support for High Density Freight - Near Term
    - Insufficient to Support High Density Passenger and Freight Operations

■ Commuter/Passenger Secondary Market
  - 218–220 MHz Interactive Video Data Service (IVDS)
  - 217–218 MHz Automated Maritime Telecommunications System (AMTS)
  - Increased/Unreasonable Cost
  - Uncertainty in Ability to Procure (Bids/Incumbents/FCC Inventory)
  - Legal Encumbrances on Spectrum
  - Indemnification
Issues to Implementation

✓ Reliability
  ▪ Performance Issue (Throughput vice Safety Issue)
  ▪ Multiplicative Effect of Elements (100 components @ 99.99% in series yields 90.01% System)

✓ Radios
  ▪ Build on Demand, Small Supplier Base
  ▪ ~100,000 required
  ▪ Large Number for RR Industry, Small Number Compared to Entire Industry

✓ Back Office Server (BOS) and Dispatch
  ▪ Still in Design
  ▪ Complex Functionality – Message Routing and Integrity
Issues to Implementation

- Interoperable Train Control (ITC) Specification
  - All but Systems Management Specifications in ITC/AAR Review Process
  - Non ITC Members Need to Complete Contracting
  - ITC Establish Non Disclosure Agreement (NDA) for Access before Issuing as AAR Recommended Practice

- Track Database Verification
  - 60,000–70,000 Route Miles11 Different Critical Attributes (i.e. mile posts, clearance points, signals, etc.)
  - Real Time Configuration Management
Issues to Implementation

✓ Wayside Radio Antenna Installation
  • 22,000 wayside poles nationwide requiring State/Tribal Historical Preservation Officer approval
    ➢ Wayside poles will be installed within the disturbed railway bed about 1 to 2 miles apart and at switch points and other operational sites
    ➢ Wayside poles are expected to be 65 feet or less in height, including the antenna
  • Roughly 14-month hold on installation while new tower review process worked with FCC and Historical Preservation Officers
  • New review process in place and working

✓ Radio Desensitization
  • Desensitization occurs when a radio receiver is unable to receive a weak radio signal that it might otherwise be able to receive when there is no interference.
  • Observed with ITCS and I-ETMS, will become issue between I-ETMS and ACSES, also with PTC and non-PTC radios in the 218 to 222 MHz spectrum
Issues to Implementation

- **Qualified Personnel**
  - Small Pool of PTC Experienced Personnel
  - Competition between RR, FRA, Suppliers
  - 2–3 years to bring up to speed

- **Contracting**
  - Primarily Affects Public Agencies
  - PTC Costs Not in Current Budget
  - Like Federal Government work on 3-year cycle
    - 2012 Executing
    - 2013 Budgeting
    - 2014 Planning
  - Must have $$ in hand (Authorization and Appropriation)
Issues to Implementation

Performance based rules/requirements leaves the burden of specifications on the entities actually implementing the technology

- Railroads/agencies must have sufficient technical staff or contract support (there is no “off-the-shelf plug & play” technology)

Freight needs and requirements do not always align with passenger operation needs

- “Vital” systems are more complex and require a higher level of effort to be validated and certified.
- Regulations require “Vital” systems only to support high speed operations

Technology changes frequently – it takes much longer to implement that technology into a safe and reliable PTC system.
PTC System Certification Process

Phase 1 – Implementation Planning
• Establish how a system will comply with the applicable regulations, or provide justification for exemption
• Submittals: Implementation Plan (PTCIP)

Phase 2 – System Development
• Details technology to be used and how it will work
• Submittals: Development Plan (PTCDP), Notice of Product Intent (NPI), or Type Approval Identification & Variance

Phase 3 – System Deployment & Testing
• Designs finalized, installation & testing begin
• Submittals: Test Plans

Phase 4 – Certification & Full Deployment
• System functionality is verified and deployment continues until fully implemented
• Submittals: Safety Plan (PTCSP)
Basic Activities to Full Implementation

- Lab Functional & Integration Testing
- Functional Qualification Testing (FQT)
- Single Unit End to End Testing
- RSD Testing
- Certification
- PTC Safety Plan
- Full Network Design & Implementation
- Employee Training
- Training Program Design
- Locomotive Installation

- System Design & Implementation
- Conceptual Design
- PTC Development Plan or Type Approval
- Pilot Territory(s) Design
- Pilot Territory(s) Implementation
- Locomotive Design

FULL IMPLEMENTATION
PTC Implementation Plan

Contents

• Interoperability Agreements
• Subdivision / Line Segment Risk Based Deployment Schedule
• Locomotive Equipage Schedule
• Describes Proposed Technology to be Deployed
  • Development Plan (Potentially Compliant - Not Previously Described by Another Railroad)
  • Type Approval (Potentially Compliant – Previously Described by Another Railroad)
PTC Development Plan
Contents

- Common Product Information for Proposed Technology
  - Proposed Architecture
  - Proposed Concept of Operations
  - Proposed Target Safety Goals
  - Proposed Performance Objectives
  - Proposed Human Machine Interface

- Type Approval –
  - Formalized Description of an FRA Approved Development Plan
  - Eliminates Repetitive Paperwork, & Simplify Process for Other Railroads wanting to use the same technology
  - Filed in Lieu of Development Plan
  - Validity Period
    - 5 years if Technology Not Implemented
    - Indefinite if Technology Implemented
PTC Safety Plan Contents

• Railroad Specific Variations From Type Approval Or Development Plan

• Safety Case For As Built System
  - Demonstrate Reliable Operations
  - Demonstrate Meet Target Safety Goals
  - Non Vital Overlay
    ✓ Demonstrate 80% Reduction In PTC-relevant Risk
    ✓ Demonstrate No Changes In Method Of Operations
PTC Safety Plan Contents

- Safety Case For As Built System
  - Vital Overlay:
    - Demonstrate Fail Safe Build
    - Abbreviated Risk Assessment
    - Demonstrate No Change In Method Of Operations
  - Standalone
    - Demonstrate Fail Safe Build
    - Demonstrate Changes In Method Of Operations
    - Full Risk Assessment;
    - Demonstrate Introduce No New Hazards That Have Not Been Mitigated
  - Mixed = FRA Case By Case Basis
PTC Safety Plan Contents

• Final HMI Analysis
• Security Measures
• Operations and Maintenance Manual
• Training and Qualification Program
• Record Retention Program
• Cutover and Life Cycle Change (Regression) Testing
• Configuration Management
• Hazard Log and Hazards Frequency
• As Built Safety Assurance Concepts
• Failure Modes, Notification, and Recovery Plan
HSR-125 Contents

- Description Of Track Fouling And Intrusion (Rollout) Detection And Protection Technology

- Description Of Row Perimeter Intrusion And Detection And Protection Technology

- Above 125 Mph
  - Demonstration Of Safety Performance Equivalent To High Speed Rail System Of Same Class Internationally

- Above 150 Mph
  - Demonstration Of Safety Performance Equivalent To High Speed Rail Of Same Class Internationally
  - Must Be Integrated Into Comprehensive Railroad (Not Just PTC) System Safety Plan Approved By Fra.
Implementation Status

- 40 Railroads (400+ Tenant)

- 1 PTCSP Received for Approval (BNSF) I-ETMS
  - >5,300 Pages Highly Technical Safety Case Documentation
  - FRA Review
    - 7 Months
    - 13 Government Reviewer Team
    - Independent Contractor Review for “Sanity”
    - Does Not Support the Case for Certification as a Vital System
    - >1,500 Major Issues Requiring Resolution
    - Unable to Support Detailed Review of Multiple Plans
    - Certify to Lesser Standard
    - Audit and Return for Correction

- Revenue Service Demonstration  CSX, NS, SEPTA, SCRRRA, UP
- Revenue Operations Amtrak (NEC/ Michigan), BNSF
## Implementation Status

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
<th>Completed</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Locomotives</td>
<td>13,000</td>
<td>23,000</td>
<td>~56%</td>
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<tr>
<td>Wayside Interface Units</td>
<td></td>
<td></td>
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<tr>
<td>Integrated</td>
<td>17,530</td>
<td>30,550</td>
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<tr>
<td>Standalone</td>
<td>1,715</td>
<td>3,810</td>
<td>~45%</td>
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<tr>
<td>Signal Replacements</td>
<td>8,335</td>
<td>14,730</td>
<td>~57%</td>
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<td>Switch Installation</td>
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<tr>
<td>Power and WIU Required</td>
<td>588</td>
<td>3,329</td>
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<tr>
<td>Switch Point Monitors Only</td>
<td>402</td>
<td>2,930</td>
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<td>Radios</td>
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<tr>
<td>Base Stations</td>
<td>1,504</td>
<td>4,089</td>
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<td>Waysides</td>
<td>11,768</td>
<td>31,273</td>
<td>~38%</td>
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<tr>
<td>Locomotives</td>
<td>5,529</td>
<td>23,057</td>
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<tr>
<td>Track Database Miles</td>
<td>23,308</td>
<td>75,877</td>
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