Positive Train Control Overview

IV Encontro de Ferrovias

ANTF

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PTC Overview

Transportation Technology Center, Inc.

- Operates FRA’s Transportation Technology Center (TTC) - the world’s leading and largest railroad technology development and test center
- The largest concentration of railroad research and test engineers in the Western Hemisphere
- It was the AAR Research & Test Department until 1998
- Now, a for-profit subsidiary of AAR
North American Rail Network

- > 300,000 kms of tracks
- > 600 separate RRs
  - Mostly private
- > 1.5 million cars
- > US$ 50 billion revenue
Class I Railroads Network of North-America

- > 265,000 Kms of track
- > 70% of operation
- > 90% of revenue
- Almost 90% of employees
Why so much Interest in PTC?

HIGH PROFILE ACCIDENTS

RAIL SAFETY IMPROVEMENT ACT OF 2008 (RSIA’08)

Each Class I railroad carrier and each entity providing regularly scheduled intercity or commuter rail passenger transportation shall implement a Positive Train Control system by Dec 31, 2015, governing operations on:

- its main line over which intercity rail passenger transportation or commuter rail passenger transportation,
- its main line over which poison- or toxic-by-inhalation hazardous materials are transported, and
- such other tracks as the Secretary may prescribe by regulation or order.

RSIA’08 has been codified & Detailed as 49CFR236 Subpart I
PTC Requirements

PTC = a system designed to prevent:
1. train-to-train collisions,
2. over-speed derailments,
3. incursions into established work zone limits,
4. movement of a train through a switch left in the wrong position.

PTC provides Protection against Human Error
Strategic actions made to achieve PTC

• Soon after RSIA08 was enacted, the Class I railroads started a joint effort to define common standards and requirements.

• Interoperable Train Control Committee (ITC) was created
  o Design of the Concept of Operations.
  o Application level requirements.
  o Requirements for the communication system.
  o Ensure interoperability and open architecture design.

• FRA has been funding strategic research projects for PTC
PTC System Overview

• Today’s predominant PTC systems are overlay
PTC is Communications-Based Train Control (CBTC) with Computers & Displays On Board that Govern Train Movements & Speed iaw:

- Limits Received from Off Board,
- High-Resolution Self-Positioning, and
- Predictive Enforcement Braking.
PTC Overview

PTC Characteristics – Interoperability

- BNSF Site 1
- BNSF Site 2
- NS Site 1
- NS Site 2
- UP Site 1
- CP Site 1

- BNSF tracks
- NS tracks
- CP tracks
- UP tracks

- NS Center
- BNSF Center
- UP Center
- CP Center

- Up train
- Up train msgs
PTC Overview

Main differences between European Train Control System (ETCS) and PTC

<table>
<thead>
<tr>
<th>ITEM</th>
<th>PTC</th>
<th>ETCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio System</td>
<td>• Developing its own 220 MHz data radio</td>
<td>• Uses GSM-R - Global Systems for Mobile Communications Railway</td>
</tr>
<tr>
<td></td>
<td>• Allows direct communication between train and wayside devices</td>
<td></td>
</tr>
<tr>
<td>Locomotive positioning</td>
<td>• Uses GPS - Global Positioning System</td>
<td>• Based on tags placed along the tracks</td>
</tr>
<tr>
<td>Locomotive onboard components</td>
<td>• Distinct hardware and software components</td>
<td></td>
</tr>
</tbody>
</table>

Current PTC implementation is equivalent to ETCS Level 2
PTC Overview

Main differences between European Train Control System (ETCS) and PTC

ETCS – European Train Control System

PTC – Positive Train Control

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Key PTC Projects where TTCI plays a main role:

- Train Enforcement Braking Algorithm
- RF Network Planning and Design
- PTC Radio and System Testing
PTC Overview

Train Enforcement Braking Issue

- Challenge:
  1. Response of the braking system of rolling stock (locomotives, cars) is not uniform
  2. Variation can be considerable for freight trains
  3. Braking system must guarantee train stop before target.
  4. If the braking curve is too conservative, it would cause a significant impact in train operation

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60 MPH

- Conservative Curve
- Effective Curve

Stop at target
Train Enforcement Braking Issue

Freight train stopping from 60 mph

*Predictive automatic enforcement algorithms based solely on car braking:*
- No dynamic braking
- No locomotive braking (except for short trains)
- Worst case braking parameters
  - Train weight
  - Braking efficiency
  - Type of brake valve

Large Safety Margin in PTC Braking Algorithms causes trains to Slow or Stop Sooner than Desired, which can Degrade Capacity

PTC Overview

PTC Overview

PTC Overview
Approach to resolve the issue:

- Intelligeint algorithm that adjusts the braking curve as the train moves:
  - Onboard computer knows where the train is and the topography of the track
  - Onboard computer learns for previous train brake application
  - Dynamic adjustments as train operates

60 MPH

Conservative Curve

Effective Curve

Adjusted Curve

Stop at target
PTC Overview

Enforcement Braking Solutions Evaluated by TTCI

Case 1: Start of Current PTC Enforcement

Case 4: Less conservative train parameters

During full service enforcement, PTC monitors EOT brake pipe pressure & applies emergency braking only after reduction has reached EOT (train is bunched).

Case 7: Emergency Only

Base Case: Adaptive Braking

Braking Distances – From 40 mph – 10 cars

Test Controller and Logger

Enforcement Algorithm

TOES™
RF Network Planning and Design

Main Issues to Resolve in Dense Urban Areas

- How much RF spectrum is needed?
- What additional resources are necessary (like new sites)?
- What is the plan for railroads to share communication resources in those areas?

Chicago Case

> 800 radio sites

<table>
<thead>
<tr>
<th>Railroad</th>
<th>Route Miles</th>
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<tr>
<td>UP</td>
<td>154</td>
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<tr>
<td>NS</td>
<td>82</td>
</tr>
<tr>
<td>BNSF</td>
<td>31</td>
</tr>
<tr>
<td>CN</td>
<td>269</td>
</tr>
<tr>
<td>NICTD</td>
<td>32</td>
</tr>
<tr>
<td>Metra</td>
<td>187</td>
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<tr>
<td>CSX</td>
<td>60</td>
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<tr>
<td>IHB</td>
<td>44</td>
</tr>
<tr>
<td>BRC</td>
<td>20</td>
</tr>
<tr>
<td>Amtrak</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>880</td>
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TTCI was hired to resolve the dense urban areas in the USA
PTC Overview

RF Network Planning and Design

- Train Traffic Simulation
- PTC Message Simulation
- RF Propagation Simulation and Loading Analysis
RF Network Planning and Design

❄ RF network projects developed for the following cities

<table>
<thead>
<tr>
<th>Urban Area</th>
<th>Track extension (Km)</th>
<th># of Radios</th>
<th># of Railroads</th>
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<tbody>
<tr>
<td>Los Angeles</td>
<td>1200</td>
<td>320</td>
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</tr>
<tr>
<td>Chicago</td>
<td>4500</td>
<td>900</td>
<td>11</td>
</tr>
<tr>
<td>St. Louis</td>
<td>1000</td>
<td>350</td>
<td>7</td>
</tr>
<tr>
<td>Kansas City</td>
<td>900</td>
<td>280</td>
<td>6</td>
</tr>
<tr>
<td>New Orleans</td>
<td>1200</td>
<td>340</td>
<td>7</td>
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<tr>
<td>Mn-St.Paul</td>
<td>750</td>
<td>260</td>
<td>5</td>
</tr>
<tr>
<td>Toledo</td>
<td>700</td>
<td>250</td>
<td>5</td>
</tr>
<tr>
<td>New York</td>
<td>1500</td>
<td>400</td>
<td>6</td>
</tr>
<tr>
<td>Dallas-Ft Worth</td>
<td>650</td>
<td>N/A</td>
<td>5</td>
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Chicago Model
PTC Radio and System Testing

- System testing of new functionality in live, operating environment is very difficult
  - Difficult or impossible to conduct Stress Testing
  - Often Not Repeatable
  - Must accommodate Revenue Traffic
  - Must obey all Operating Rules or obtain Waivers
  - Changes to Vital Equipment require Lengthy V&V

On-track Test Bed without Revenue Traffic and Regulations can Alleviate these Problems.
PTC Radio and System Integration Testing

Tower & Antenna Locations

- 180’ Tower
  - MCC SDRs
  - VHF Site Radio
  - ATCS
  - 452.465 MHz VTS
  - Microwave 6GHz T1

- 120’ Tower
  - VHF
  - ATCS

Operations Building (OPS)
- 802.11b/g
- Microwave 6GHz T1

CDMA Cellular w/1xEVDO

Test Loop Length & Max Speed
- RTT – 14 mi. 165 mph
- TTT – 9 mi. 80 mph
- HTL – 3 mi. 40 mph

DGPS Coverage over the Test Bed

80 km of Test Track on 160 km² of land near Pueblo, CO
# List of PTC Projects at TTCI

<table>
<thead>
<tr>
<th>Customer</th>
<th>Project</th>
<th>IR&amp;D Project</th>
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<tbody>
<tr>
<td>FRA</td>
<td>TO 219 Low Cost Adv Act Xing Dem</td>
<td>• Network Simulator</td>
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<tr>
<td>FRA</td>
<td>TO 234 HA-GPS Upgrade/Testing</td>
<td>• Test Controller/Logger</td>
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<tr>
<td>FRA</td>
<td>TO 242 Braking Algorithm, Freight</td>
<td>• Broken Rail Detection</td>
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<td>FRA</td>
<td>TO 256 FRA PTC Test Bed Upgrades</td>
<td>• C&amp;TC Test Bed</td>
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<td>FRA</td>
<td>TO 257 FRA EIC PRT Integration</td>
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<td>FRA</td>
<td>TO 267 Braking Performance Model, Passenger</td>
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<td>TO 269 Braking Performance Model, Passenger</td>
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<td>FRA</td>
<td>TO 270 PTC Test Bed Upgrade</td>
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<td>RRF CA - HPDR</td>
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<td>RRF ITP Proof of Concept Project</td>
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<td>EMD</td>
<td>EMD PTC Proof of Concept</td>
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<td></td>
<td><strong>PTC Overview</strong></td>
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Summary of what TTCI’s C&TC Team Does

TTCI applies System Engineering & State of the Art Tools to:

- Solve **Critical PTC Issues** (e.g., enforcement braking, data comms)
- Assess **PTC Performance Impacts**, e.g., on Network Capacity
- **Plan & Conduct Testing** – at TTC’s PTC Test Bed or Railroad
- Help RRs select the best suited **PTC Technologies & Configurations**
- Develop **Procurement Documents** (Rqmt Specs, ConOps, RVCCM)
- Provide **Train Control & Communications System Training**
- Provide **Radio Frequency Coordination & Design**

TTCI doesn’t supply PTC systems …
We help improve PTC System Safety, Performance & Cost Effectiveness.
PTC Overview

Main Challenges and Concerns for PTC Successful Deployment

• **Main challenges**
  - Finish all integration and interoperability tests
  - Be able to deploy components in the field and locomotives according to deadline

• **Concerns**
  - Cost of PTC implementation for track and locomotive
  - Unforeseen impact in production (train operation, interoperability, reliability)
Current Deployment Stage

• Intensive tests with PTC system and components
  o Radio and onboard components
  o Integration and interoperability

• Deployment at railroads
  o Field infrastructure (WIUs, base stations towers and antennas) at major cities and main railroad links are under way

• First PTC deployment => L.A. basin area (Metrolink)
  o RF network design in final stages
  o Field deployment in advanced stages
PTC Overview

The Future

• Explore communications infra-structure
  ➢ Improve train monitoring/control (efficiency)
  ➢ Improve communications with field operations
  ➢ Improve reliability/availability (real-time health monitor)

• Stand-alone System Operation
  ➢ Reduce field infra-structure (maintenance costs and reliability)
  ➢ Signaling system is currently the fall back

• Moving Block Concept
  ➢ Still not feasible for freight operation (need to resolve dependency on track circuit for broken rail detection and train integrity).
  ➢ Unless under extremely heavy traffic, production gains are unlikely to justify its use.
OBRIGADO !