U.S. Department of Transportation
Federal Railroad Administration

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POSITIVE TRAIN CONTROL

STIDS–2015

Outline

1. Positive Train Control (PTC) Introduction and Background
2. Issues to Implementation
3. Certifcation
4. Status

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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

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Impetus

Graniteville, SC January 6, 2005

9 Dead, 250 Injured
5400 Evacuated 2 weeks

Chatsworth, CA September 12, 2008

26 Dead, 131 Injured

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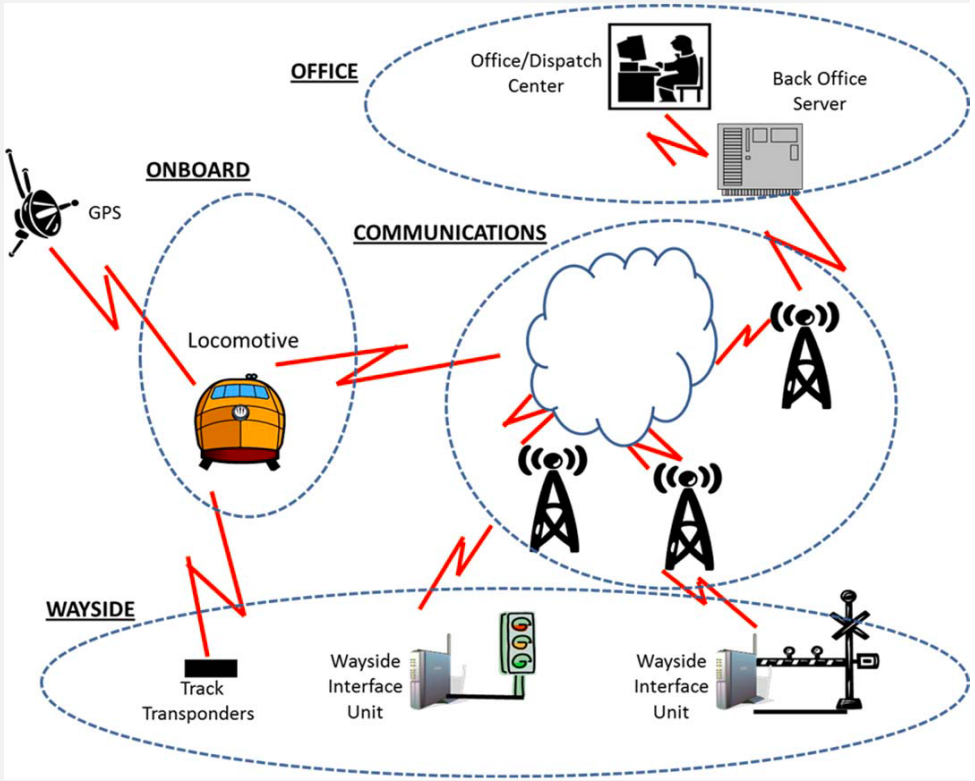
What are the typical components of a PTC system?

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



Example diagram of a PTC system architecture.

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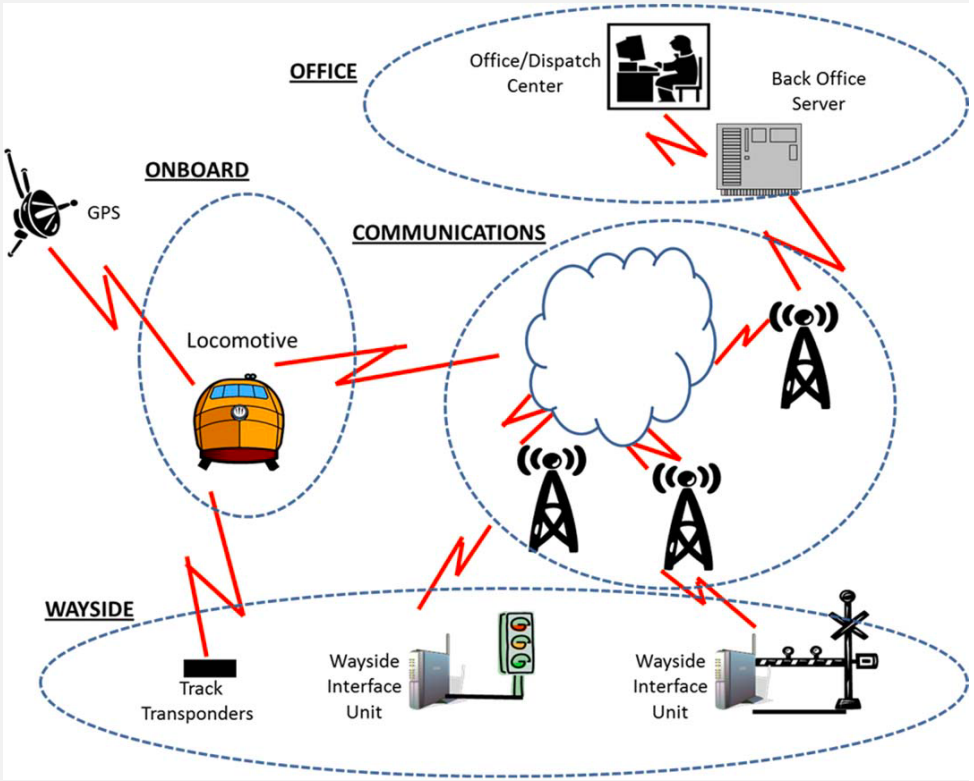
What are the typical components of a PTC system?

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.

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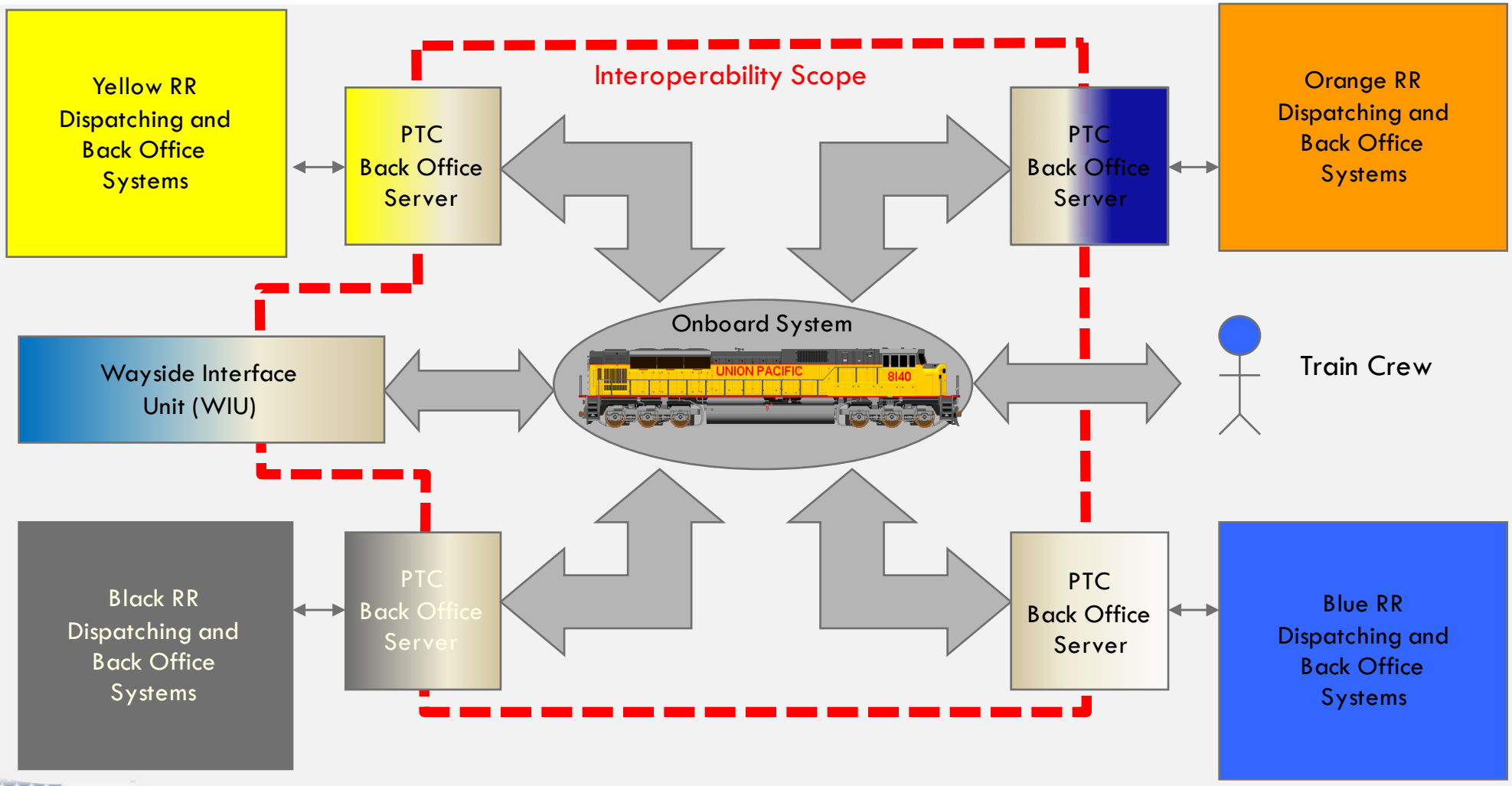
Architecture and Interoperability Paradigm



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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

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PTC and Traditional Train Control

- Similarities
  - Both Display Authority
  - Both Provide Speed Control
  - Both Provide Warning And Automatic Enforcement

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

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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

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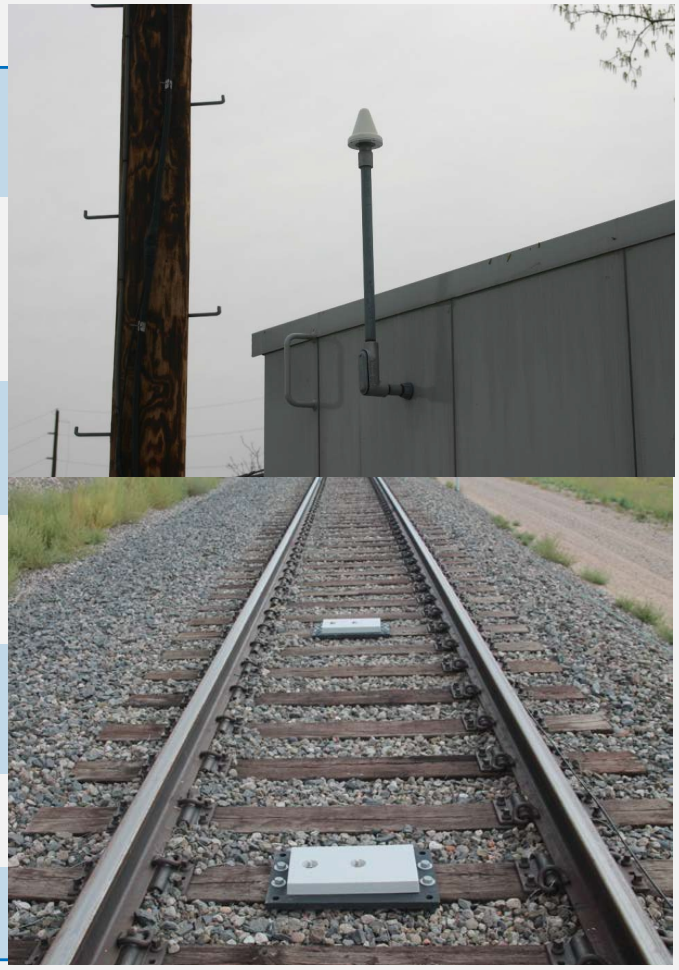
What types of systems are currently under development?

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



GPS antenna (top), ACSES transponder (bottom)

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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

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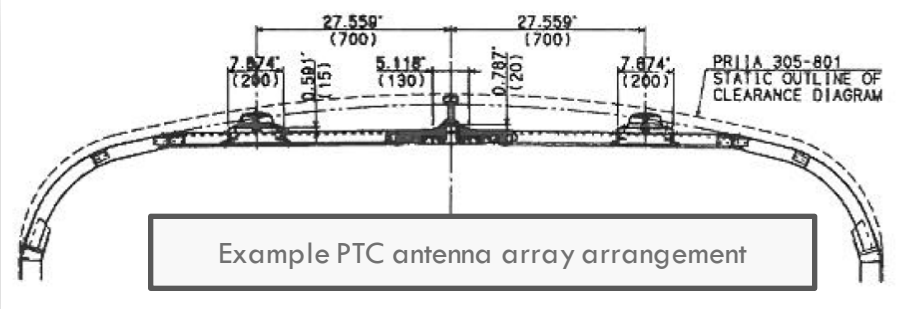
Component Installation

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



Example PTC antenna array arrangement

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

Example of retrofit components potentially blocking brake valve

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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

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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

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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

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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

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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)

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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.

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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)*

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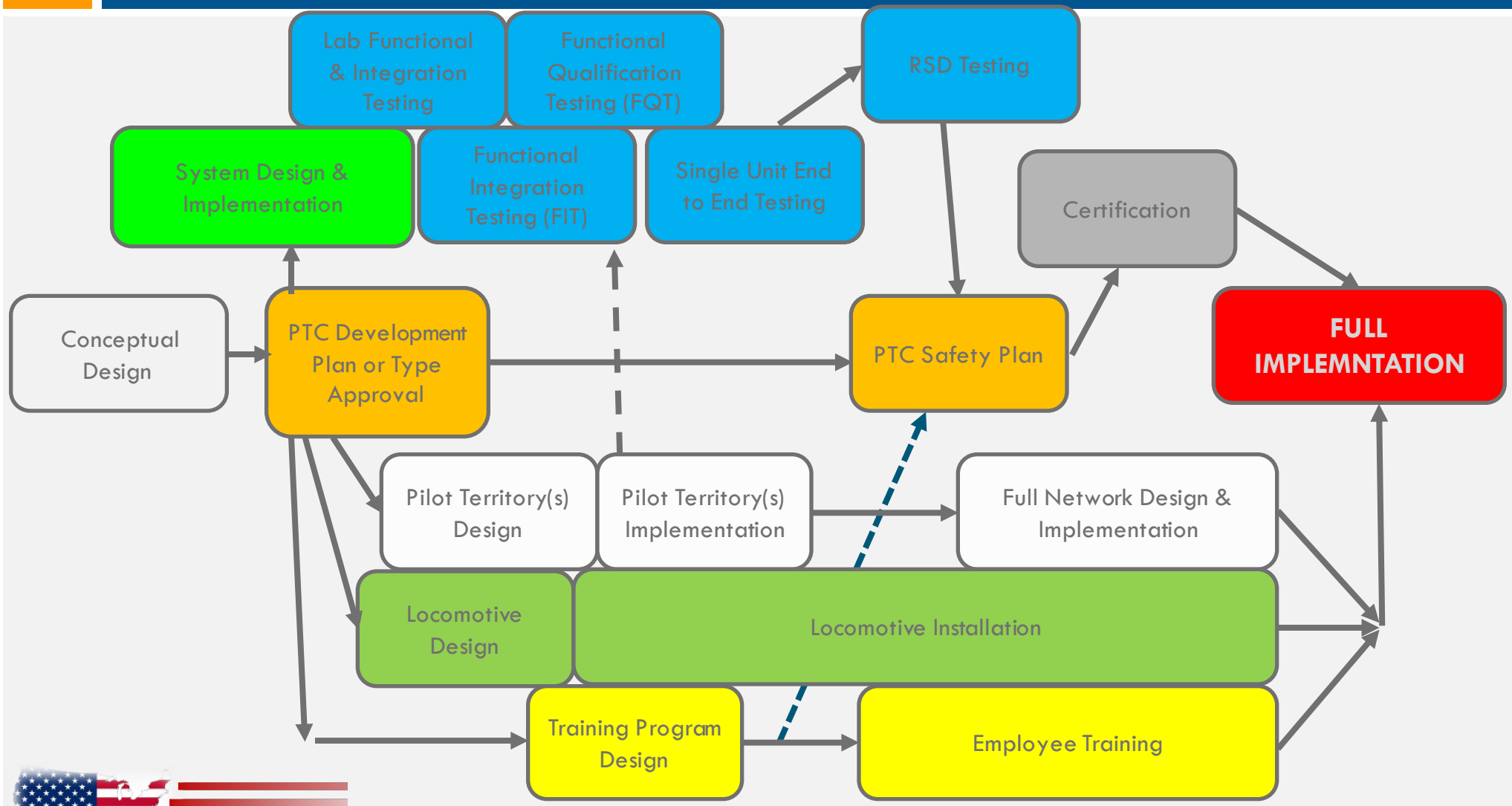
Basic Activities to Full Implementation



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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

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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

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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

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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

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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

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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.

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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, SCRRA, UP
- ✓ Revenue Operations Amtrak (NEC/ Michigan), BNSF

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Implementation Status

Locomotives 13,000 Out of 23,000 Complete	~56%
Wayside Interface Units	
➢ Integrated 17,530 Out of 30,550 Complete	~56%
➢ Standalone 1,715 Out of 3,810 Complete	~45%
Signal Replacements 8,335 Out of 14,730 Complete	~57%
Switch Installation	
➢ Power and WIU Required 588 Out of 3,329 Complete	~17%
➢ Switch Point Monitors Only 402 Out of 2,930 Complete	~14%
Radios	
➢ Base Stations 1,504 Out of 4,089 Complete	~37%
➢ Waysides 11,768 Out of 31,273 Complete	~38%
➢ Locomotives 5,529 Out of 23,057 Complete	~24%
Track Database Miles 23,308 Out of 75,877 Complete	~31%

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