

# Implementation of Interoperable Positive Train Control on the Union Pacific



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Union Pacific

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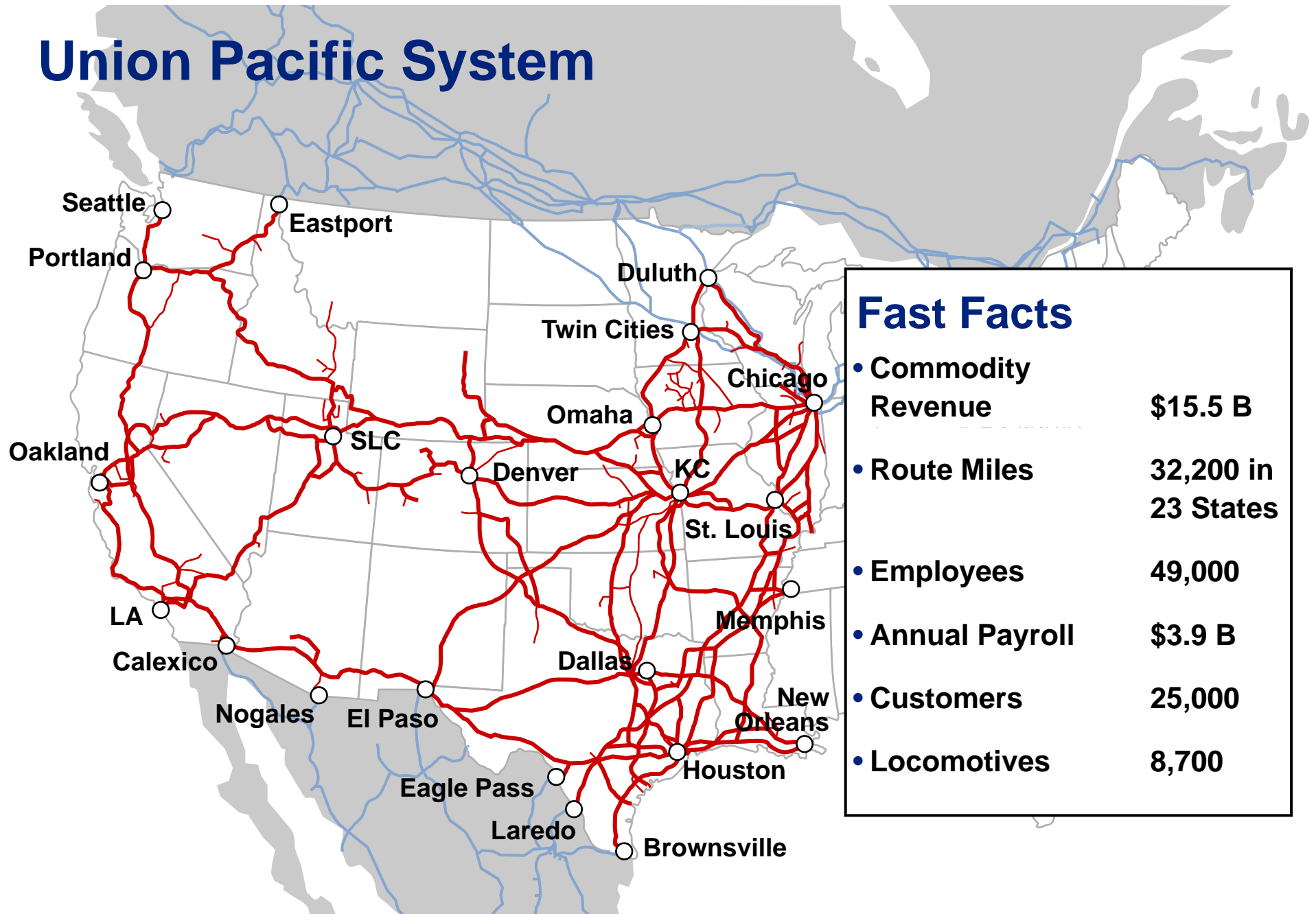


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# Agenda

- **Scope of Union Pacific PTC Implementation**
- **Factors Driving Implementation**
  - Background on Interoperability
- **PTC System Functional Highlights Related to Signaling**
- **Implementation Schedule**

# Union Pacific System



## Fast Facts

• Commodity Revenue	\$15.5 B
• Route Miles	32,200 in 23 States
• Employees	49,000
• Annual Payroll	\$3.9 B
• Customers	25,000
• Locomotives	8,700

# Union Pacific's PTC Implementation By the Numbers

- Scope of UP implementation driven by statutory requirements of the public law and regulatory requirements of 49 CFR 236 Subpart I
- PTC Route Miles
  - Between 19,500 and 21,500 of lines over which Union Pacific exercises effective operating control, subject to FRA's disposition of request for exclusion of certain lines
    - Between 75% and 82% of route miles
- PTC Locomotives
  - 6000 (of 8700) locomotives affected
    - ~5300 6-axle
    - ~700 4-axle
- PTC Wayside Locations
  - 12,425 wayside locations affected (not including radio base stations)
    - 3881 Control Point locations
    - 7589 Intermediate Signal locations
    - 955 Monitored Hand-Operated Switch locations
- ~90% of all employees may require some sort of training
- More may be found in UP's PTC Implementation Plan in Federal Regulations Docket *FRA-2010-0061*.

# Union Pacific's PTC Implementation

## Driving Factors

- The requirement to maintain and enhance safety
- The requirement to support and minimize the negative impact on all rail operations
- The requirement for reliability
- The statutory and regulatory requirements for (effectively) industry-wide seamless interoperability
- The statutory and regulatory requirements to “...*implement the system in a manner that addresses areas of greater risk before areas of lesser risk...*”
- The statutory requirement to have completed “...*implementing a positive train control system by December 31, 2015...*”
- The Statutory and Regulatory requirements have had a profound effect on UP's project execution

# Driving Factors Safety

- **Union Pacific's PTC system is being developed as a vital overlay**
  - All existing methods of operation are overlayed by PTC functions
  - PTC system relies on and is stimulated by the existing underlying field and office infrastructures
  - As a vital overlay, the system required to be developed in accordance with Appendix C to 49 CFR 236, *Safety Assurance Processes and Criteria*
  - Focus on meeting the functional requirements of 49 CFR 236.1005 while not introducing new hazards

# Driving Factors

## Support for and Impact on Operations

- **PTC will support all existing Union Pacific methods of operation**
  - Traffic Control
  - Current of Traffic (GCOR 9.14 )
  - Track Warrant Control
  - Yard Limits
  - Other Than Main Track (GCOR 6.28)
- **No significant changes to existing underlying wayside architecture standards planned at this time, other than the addition of Wayside Interface Units (WIU) and communications infrastructure**
  - One possible exception: Cab Signals
- **Very few changes to existing operating rules**
  - Primarily the addition of rules for departure test, cut-in, cut-out, and failure enroute
- **System designed to remain cut-in during all operations**
- **Potential negative impact on operations caused by conservative predictive braking calculations, performance, and reliability remains UP's #1 operational concern**

# Driving Factors Reliability

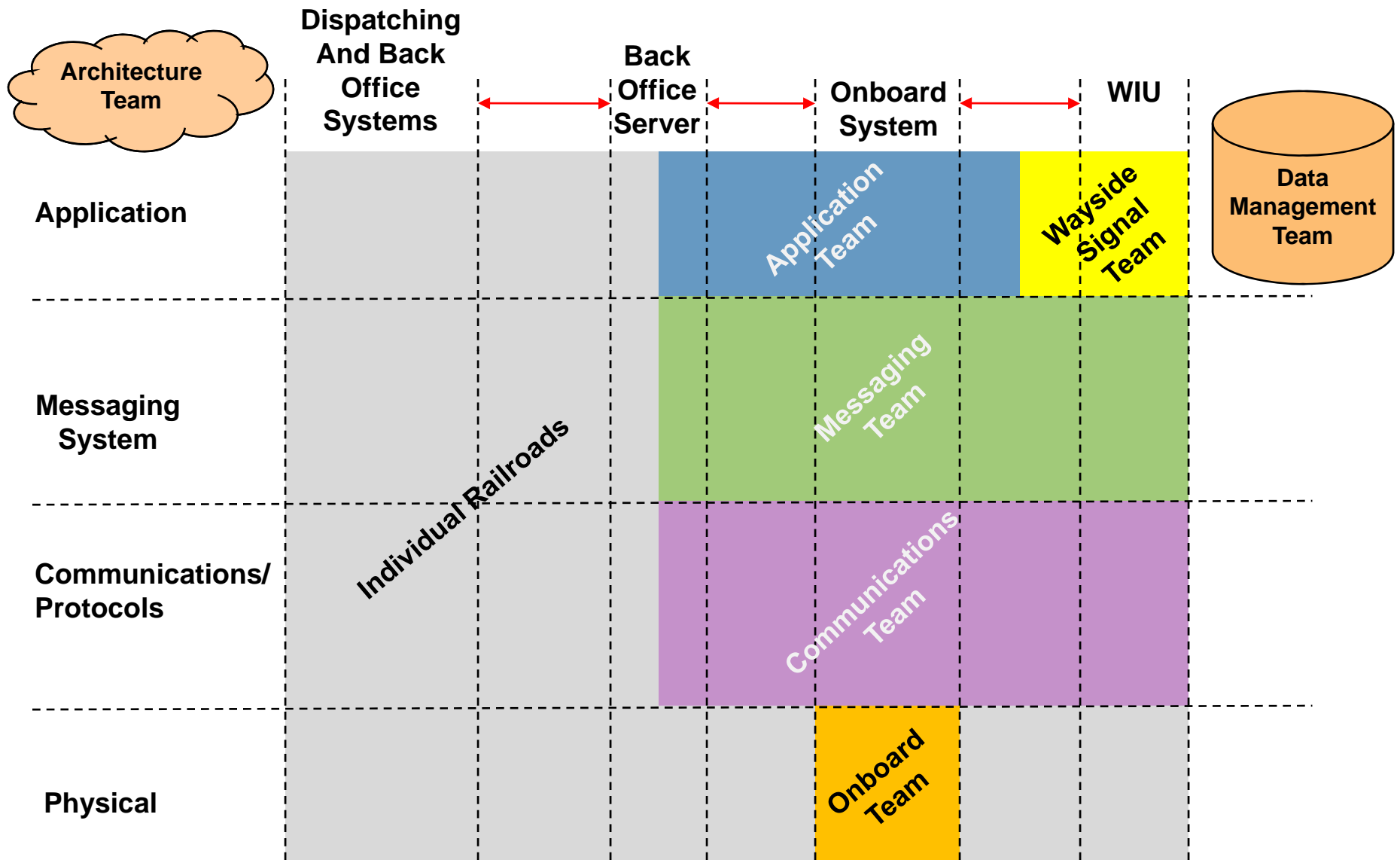
Component	Component Reliability	Component Reliability	Component Reliability
PTC Management Computer	99.90%	99.50%	99.00%
PTC Display Unit	99.90%	99.50%	99.00%
Locomotive Control System (OEMs)	99.90%	99.50%	99.00%
Locomotive Interface Gateway	99.90%	99.50%	99.00%
Communications Management Unit	99.90%	99.50%	99.00%
Mobile Access Router	99.90%	99.50%	99.00%
<b>PTC Reliability</b>	<b>99.40%</b>	<b>97.04%</b>	<b>94.15%</b>

- Availability of a locomotive to lead in PTC territory will be a function of the reliability of both onboard PTC hardware/software and underlying mechanical and control systems, which will further reduce locomotive reliability from existing levels, without mitigation.
- The reliability of office, wayside, and communications systems is being engineered based on their respective impact on operations.
  - Example: Back Office Server at .99999 availability because of large impact of failure
  - Wayside and communications at lower levels because of more limited impact of failure

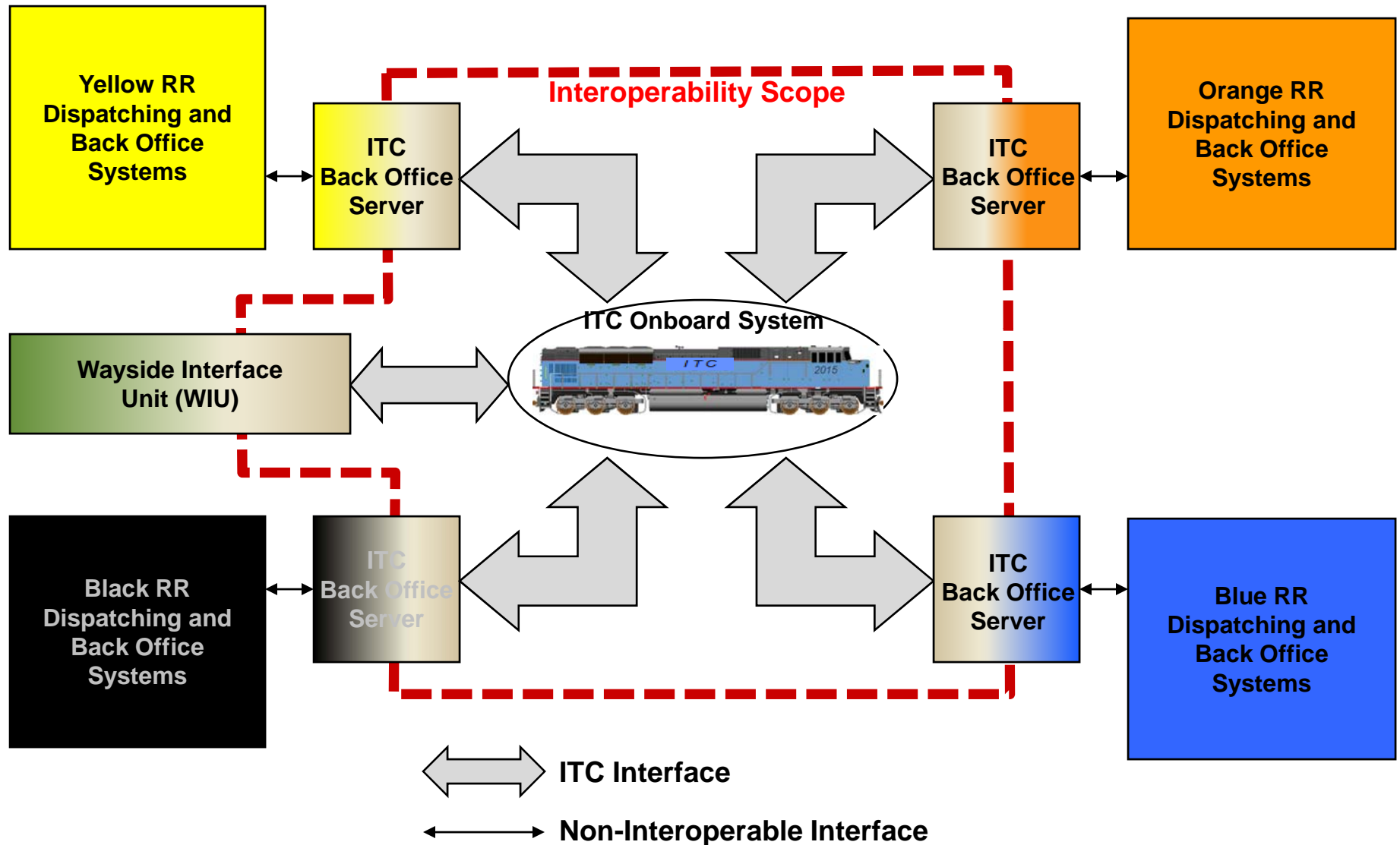
# Driving Factors Interoperability

- **Addressed at the industry level through the activities of the Interoperable Train Control (ITC) consortium**
  - **Formed December 2008, to address unprecedented scope of statutory and regulatory requirements for interoperability**
  - **Seven technical teams, each addressing some aspect of required interoperability**
  - **Each technical team is developing one or more specification drafts, to be delivered to and promulgated by the AAR**
    - **Catalog and timeline of proposed specifications to be refreshed in June 2010**
  - **Railroads may be party or participatory on any team**

# ITC Technical Team Scope

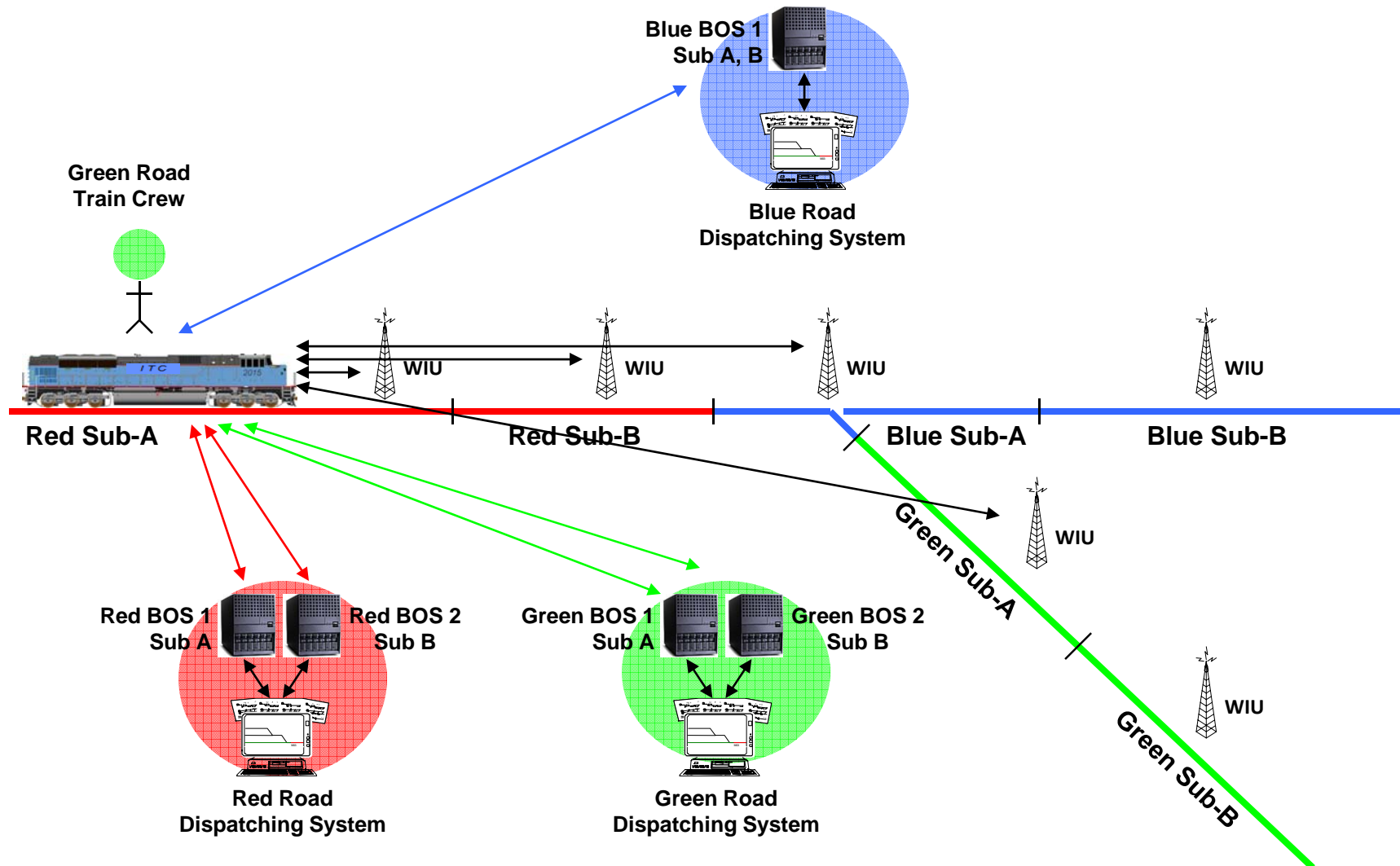


# ITC Interoperability Paradigm



# ITC Interoperability Scenario

ITC Onboard System maintains unique conversation with each governing Back Office Server and applicable WIU along track segments on its route.



# Interoperable Communications

- **Meteorcomm, LLC**

- Responsible for design of interoperable 220Mhz RF communications system
- Business processes for access to interoperable PTC radio technology forthcoming
- Joint venture of UP, BNSF, CSX, NS

- **PTC 220, LLC**

- Holds and manages a pool of 220Mhz spectrum to be utilized for interoperable PTC communications
- Business processes for access to interoperable PTC radio spectrum forthcoming
- Joint venture of UP, BNSF, CSX, NS

# Union Pacific's PTC Implementation Overview

- **PTC will display and enforce**
  - **All UP forms of movement authority, provided either by signal indication or mandatory directive**
    - Track and Time
    - Track Permit
    - Track Warrant
    - Foul Time
    - Authority to Pass Signal Displaying STOP Indication
    - Authority to Enter the Main Track Between Signals
  - **All restrictions imposed by UP track bulletin**
    - Form A – Temporary Speed Restrictions
    - Form B – Work Zones
    - Form C – Advisories
    - Crossing warning system failures
  - **All permanent speed limits**
    - Timetable maximum authorized speeds
    - Turnout speeds
    - Train Type
  - **All restrictions generated by UP Critical Alert system**
    - Weather, Equipment Defect Detector Reports, etc.
  - **All equipment- and consist-related restrictions**
  - **Conditions detectable by wayside hazard detectors**
    - Slide fences, high water, bridge alignment, etc.

# Union Pacific's PTC Implementation

## Sources of PTC Operating Data

- **Sourced from the UP dispatching system**
  - Authorities provided by mandatory directive
  - Track Bulletins
  - Train Sheet Information
- **Sourced from Other Office Systems**
  - Critical Alerts
  - Detailed Train Consist (required for Energy Management)
- **Sourced from the Wayside**
  - Signal indications
  - Switch position
  - Wayside hazard detector status
- **Sourced from Surveyed Data**
  - Track geometry
  - Feature location
  - Timetable information

# Union Pacific's PTC Implementation

## Wayside Implementation

- **Traffic Control Territory**
  - WIU at each control point and intermediate signal location
  - Position of switches on main track at locations other than control points monitored through signal system – no separate WIU deployed
- **Current of Traffic Territory**
  - WIU at each control point and intermediate signal location
  - WIUs required at main track switch locations required if movement against the current of traffic is to be made without a stop at each switch
- **Track Warrant Territory**
  - Non-Signaled: WIU at each main track switch
  - Signaled: WIU at each signal location
- **Other wayside detectors**
  - May be monitored through signal system or by stand-alone WIU
- **A single WIU may serve multiple wayside locations**
- **A single location may be served by multiple WIUs, e.g. complex interlocking**

# Union Pacific's PTC System WIU Implementation

- **Communications infrastructure**
  - PTC 220 Mhz Radio, Antenna, pole; or
  - Network link to interoperable RF communications system
- **Control Points, Interlockings, and Other Signal Locations**
  - Addition of PTC processor to existing processor-based locations
  - Upgrade of relay locations to PTC-capable processor as part of pole line elimination program
  - Addition of stand-alone WIU to complex relay-based locations that are not otherwise upgraded to processor
- **Monitored Switch Locations**
  - Switch circuit controller to sense NORMAL position
    - Addition of front rod to sense REVERSE position to be installed only at meet/pass locations
  - Stand-alone WIU
- **Other wayside detectors**
  - Monitored through signal system or stand-alone WIU

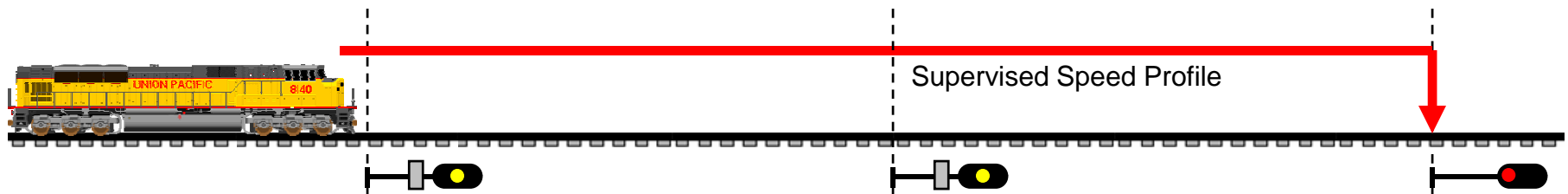
# Union Pacific's PTC System

## Signal Enforcement Principles

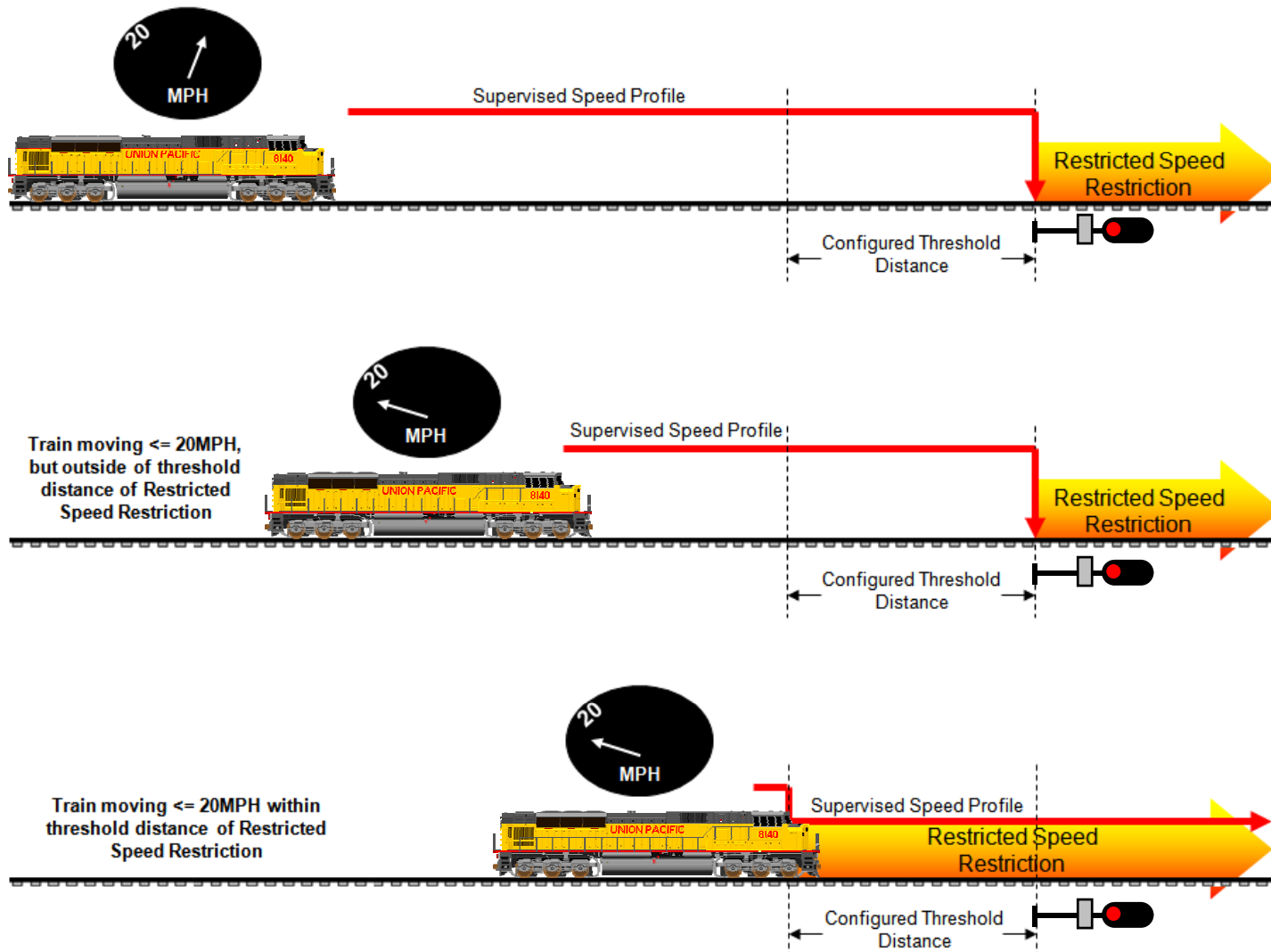
- All signal codes provided by WIU are mapped by the onboard system into one of five general indications, each identifying if and where a STOP might be required under the most restrictive conditions where that signal is displayed
  - No Stop Enforced
    - UP Examples: *CLEAR, DIVERGING CLEAR, APPROACH CLEAR SIXTY*
  - Enforce Stop at 2<sup>nd</sup> signal in advance of signal
    - UP Examples: *ADVANCE APPROACH, DIVERGING ADVANCE APPROACH*
  - Enforce Stop at next signal in advance of signal
    - UP Examples: *APPROACH, DIVERGING APPROACH*
  - Enforce Restricted Speed at Next signal in advance of train
    - UP Examples: *RESTRICTING, RESTRICTED PROCEED*
    - Restricted Speed enforcement described subsequently
  - Enforce Stop at next signal in advance of train
    - UP Example: *STOP*

# Union Pacific's PTC System Signal Enforcement Principles

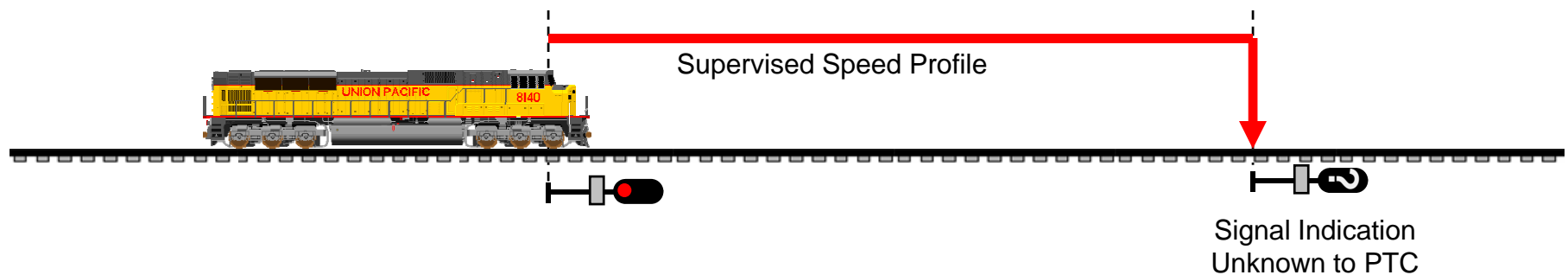
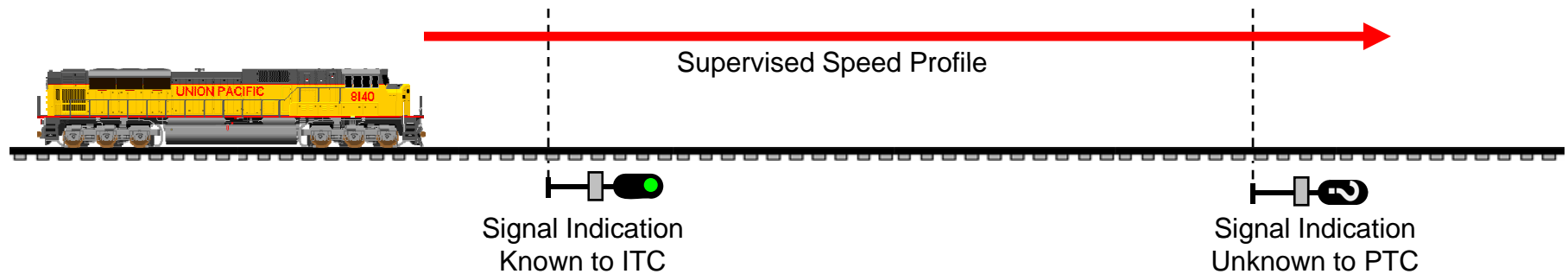
- Other speeds conveyed as part of existing signal indications are handled by other ITC functions
  - Turnout speeds via switch position monitoring
  - Reducing speeds for stop by Predictive enforcement
- The indications of signals in advance of a particular signal may preempt the enforcement of a stop conveyed by the general indication for that signal when such indications are known to PTC.
  - Example: Double Approach to a STOP.



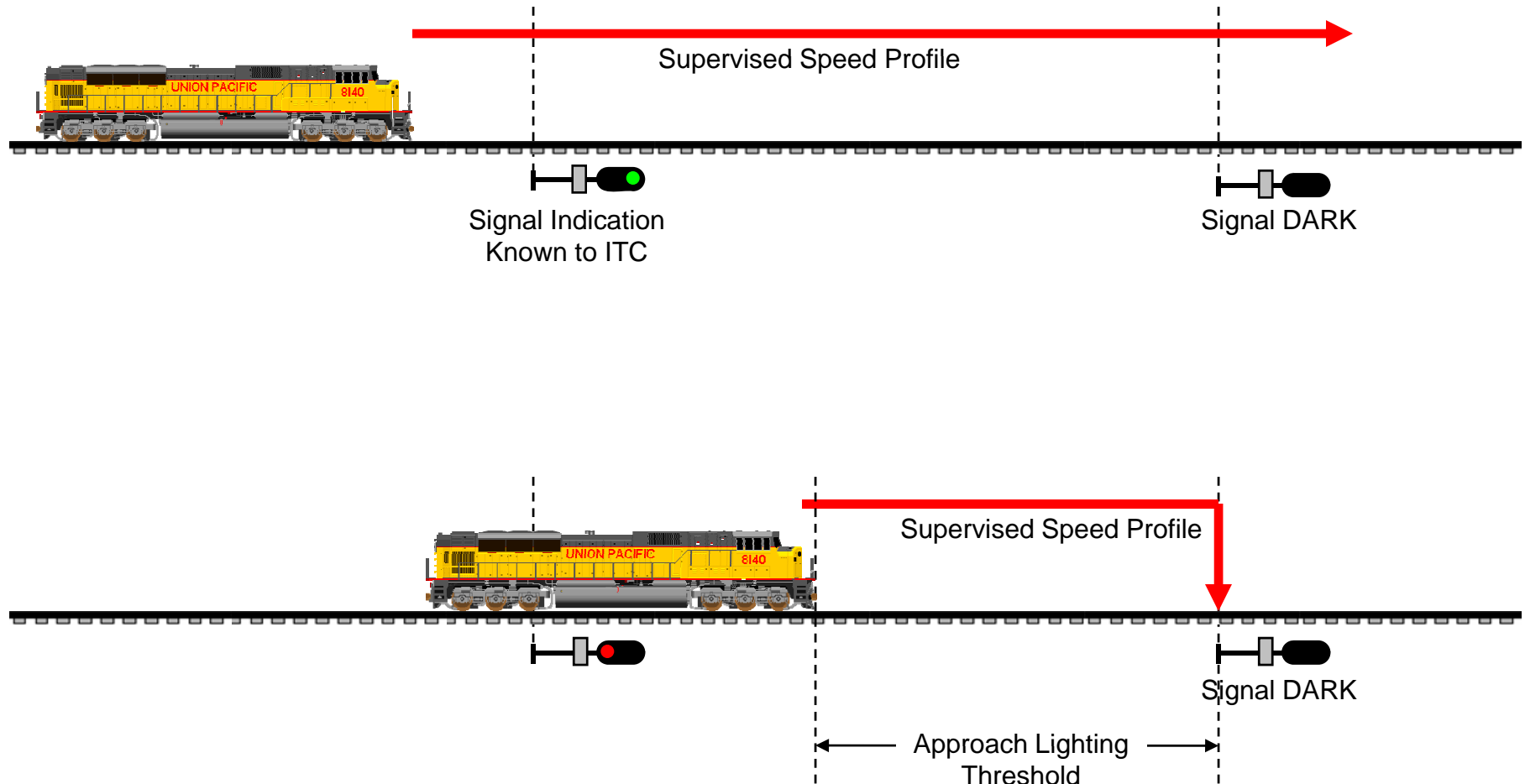
# Union Pacific's PTC System Restricted Speed Enforcement



# Union Pacific's PTC System Radio Coverage Tolerance



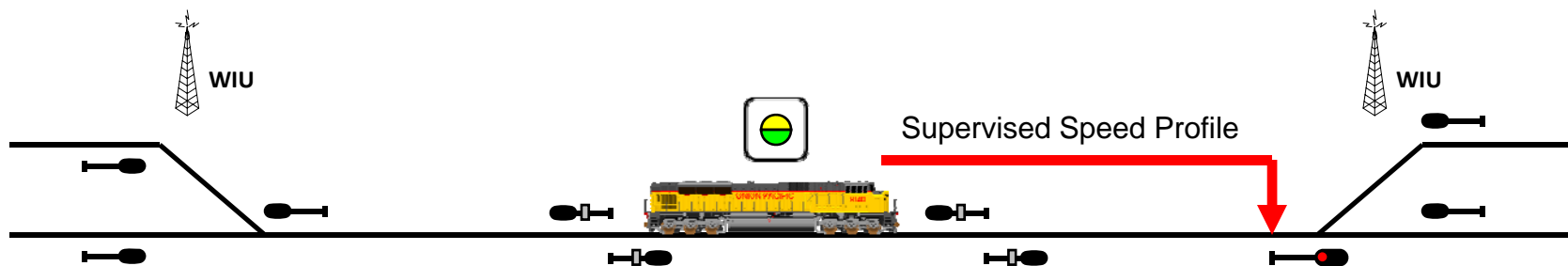
# Union Pacific's PTC System Approach Lighting Tolerance



Radio-Based approach lighting capability also exists.

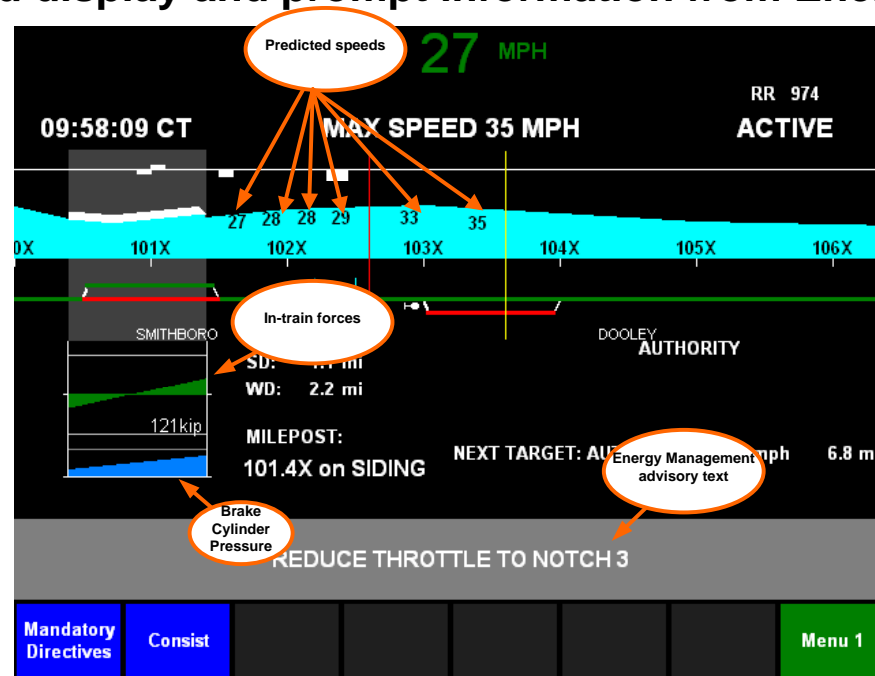
# Union Pacific's PTC System Cab Signal Integration

- PTC onboard system can integrate with and accept cab signal indications from an onboard 4-aspect cab signal system
- Cab signal indications utilized to stimulate the onboard system in lieu of WIU indications
- WIUs likely still required at control points, interlockings, or other absolute signal locations in order to disambiguate absolute signal indications and switch position
- Key advantage
  - Reduced WIU and communications installation costs in cab signal territory
- Key disadvantage
  - Reliability of and costs to maintain multiple, layered wayside and onboard systems
- Union Pacific currently plans to apply for discontinuance of its 2- and 4-aspect cab signal systems after PTC deployment due to concerns about the reliability and maintenance costs of layered systems



# Union Pacific's PTC Implementation Energy Management

- Energy Management functions are non-vital fuel conservation and in-train force management functions
  - New York Air Brake LEADER ®
  - GETS Trip Optimizer ®
- Energy Management systems traditionally limited by lack of visibility into on-track position, route preview, navigation, and real-time authorized operating profile
- PTC provides this information to energy management for inclusion in its calculations
- PTC accepts limited display and prompt information from Energy Management



# Union Pacific's PTC Implementation Schedule

- Pole line elimination projects underway
- Begin equipping locomotives in high-volume in 2012
- Testing begins in Pilot Territories 2Q 2011
- PTC Safety Plan submitted 4Q 2011
  - Approval anticipated by 3Q 2012
- First production cutovers
  - Lines on which Metrolink operates in LA Basin Q4 2012

# Questions ?

