Positive Train Control Overview

IV Encontro de Ferrovias *ANTF*

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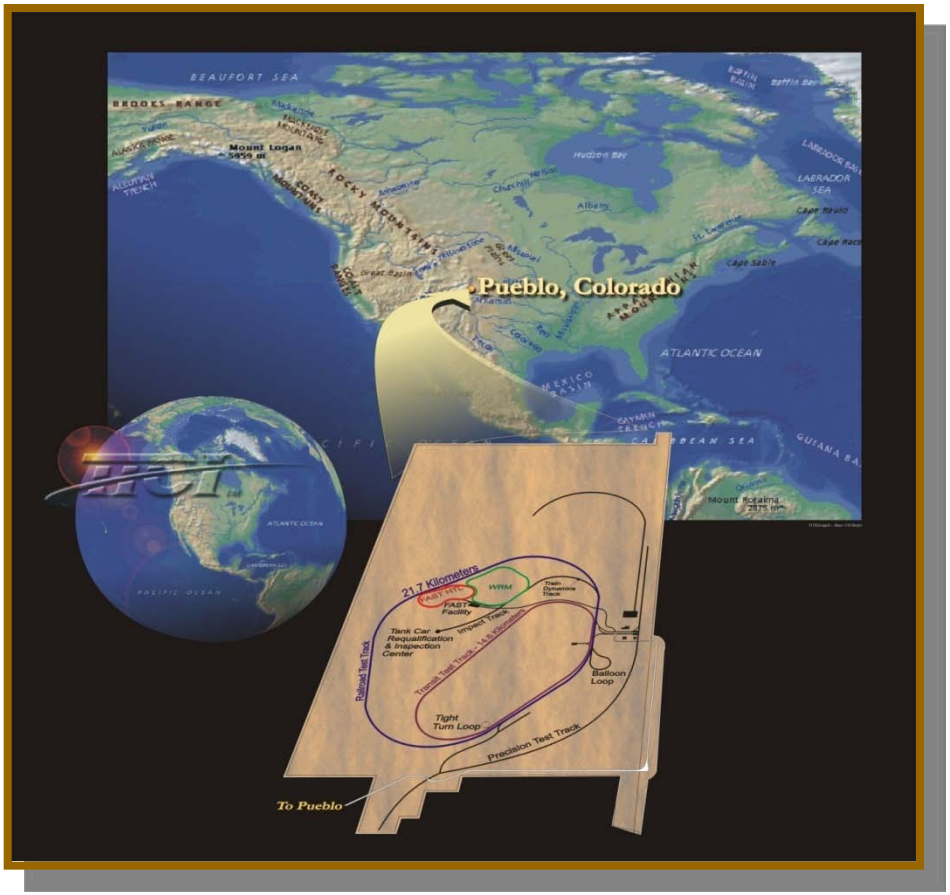
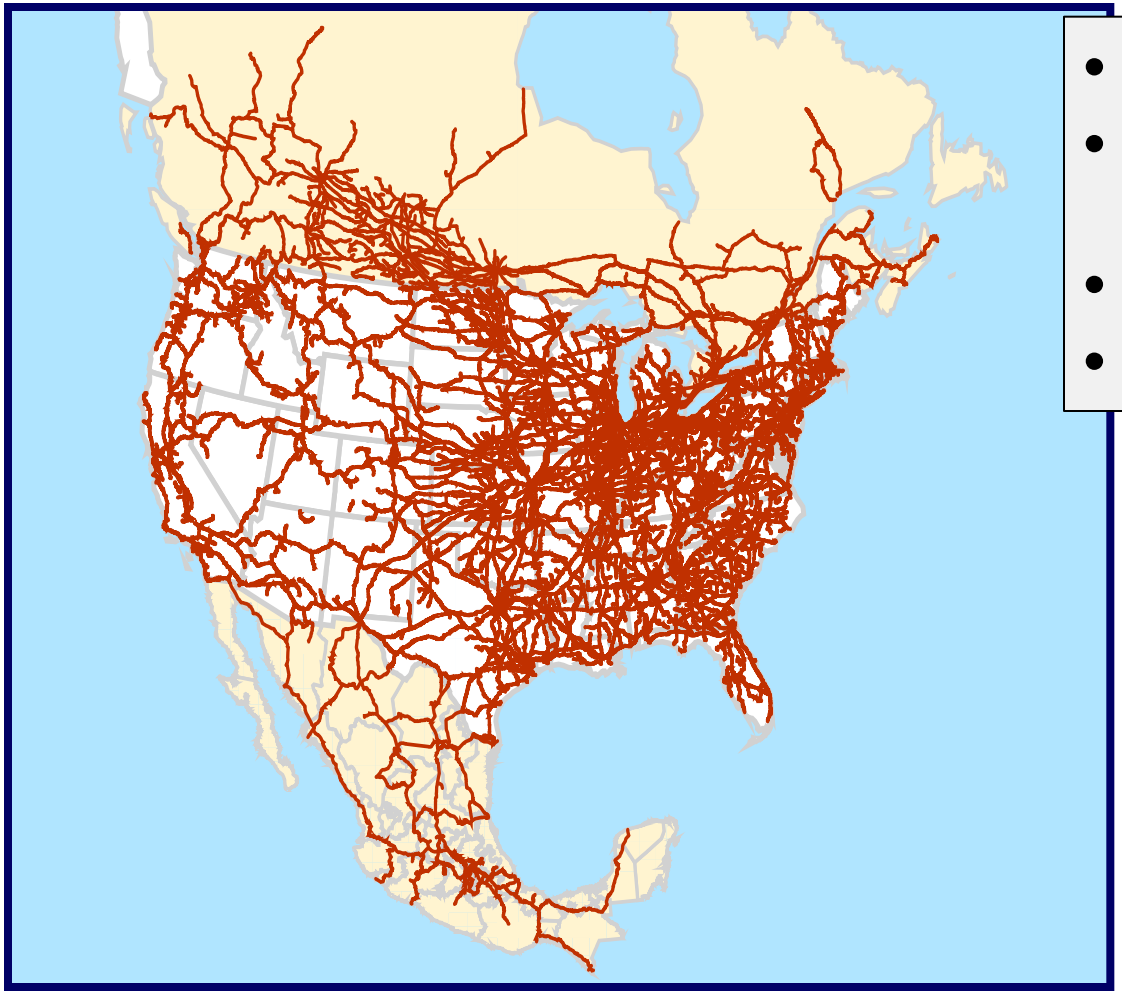
Transportation Technology Center, Inc.

- 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.

> half of US Rail Lines

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.

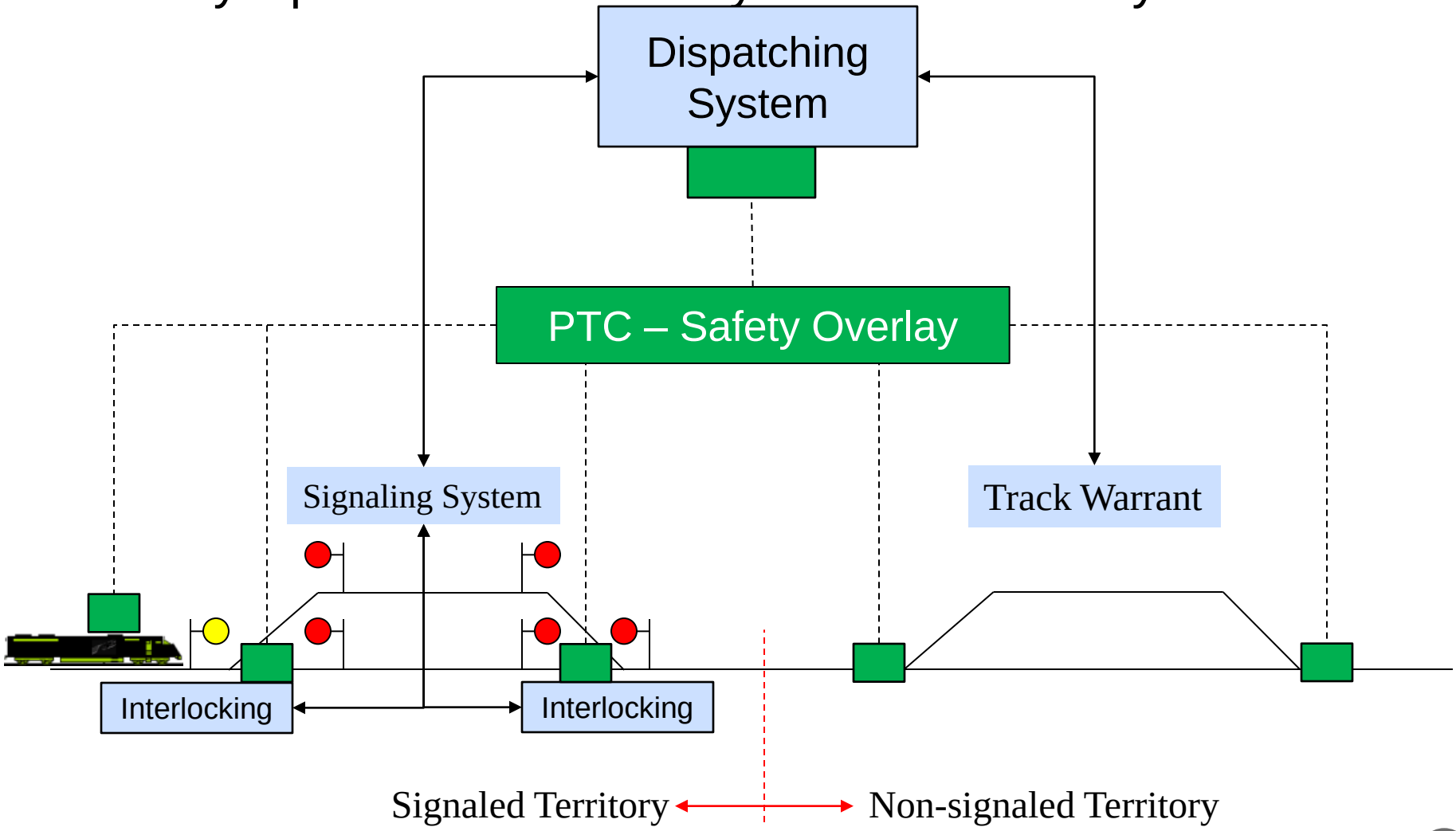
PTC provides Protection against Human Error

Strategic actions made to achieve PTC

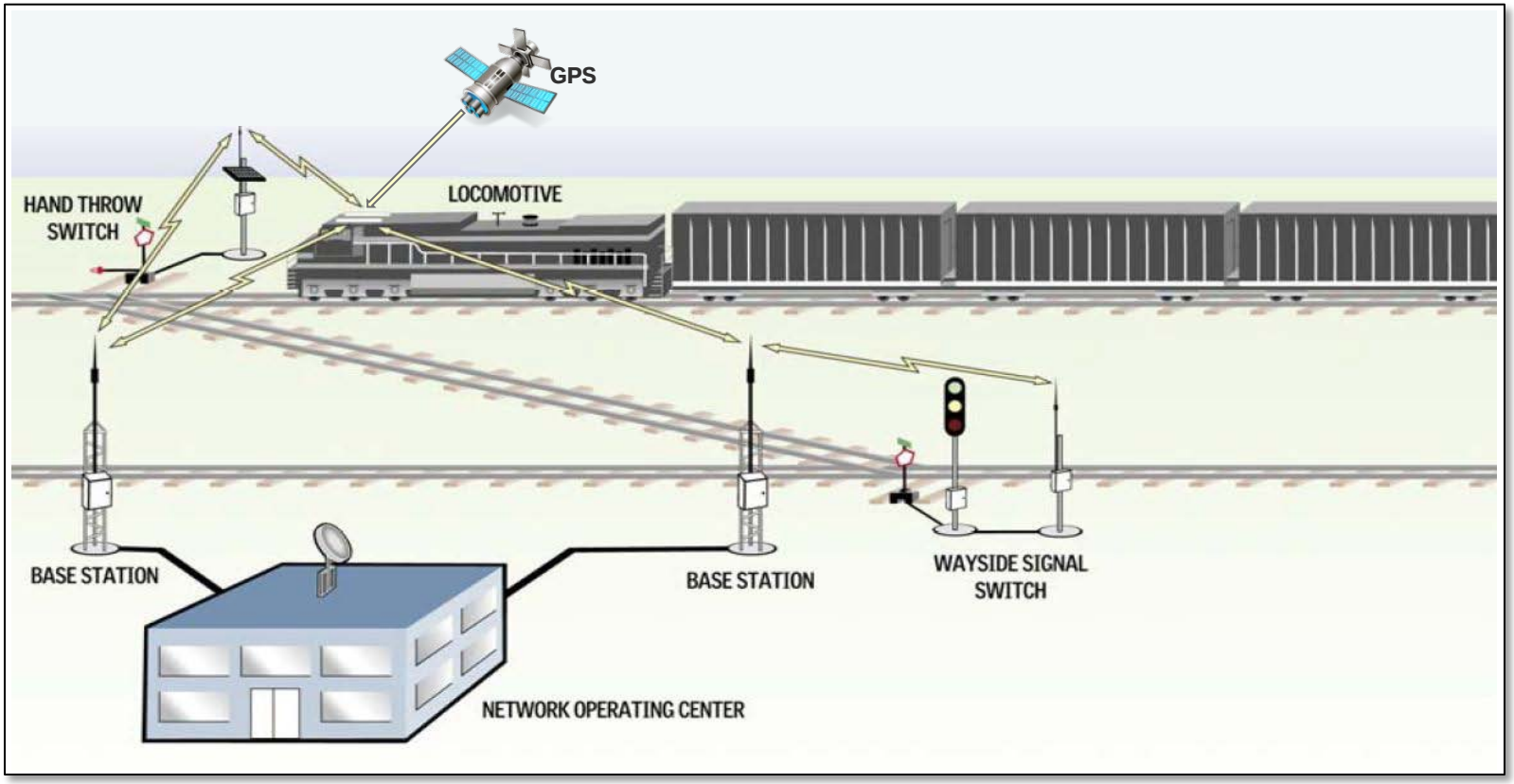
- Soon after RSIA08 was enacted, the Class I railroads started a joint effort to define common standards and requirements.
- Interoperable Train Control Committee (ITC) was created
  - Design of the Concept of Operations.
  - Application level requirements.
  - Requirements for the communication system.
  - 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



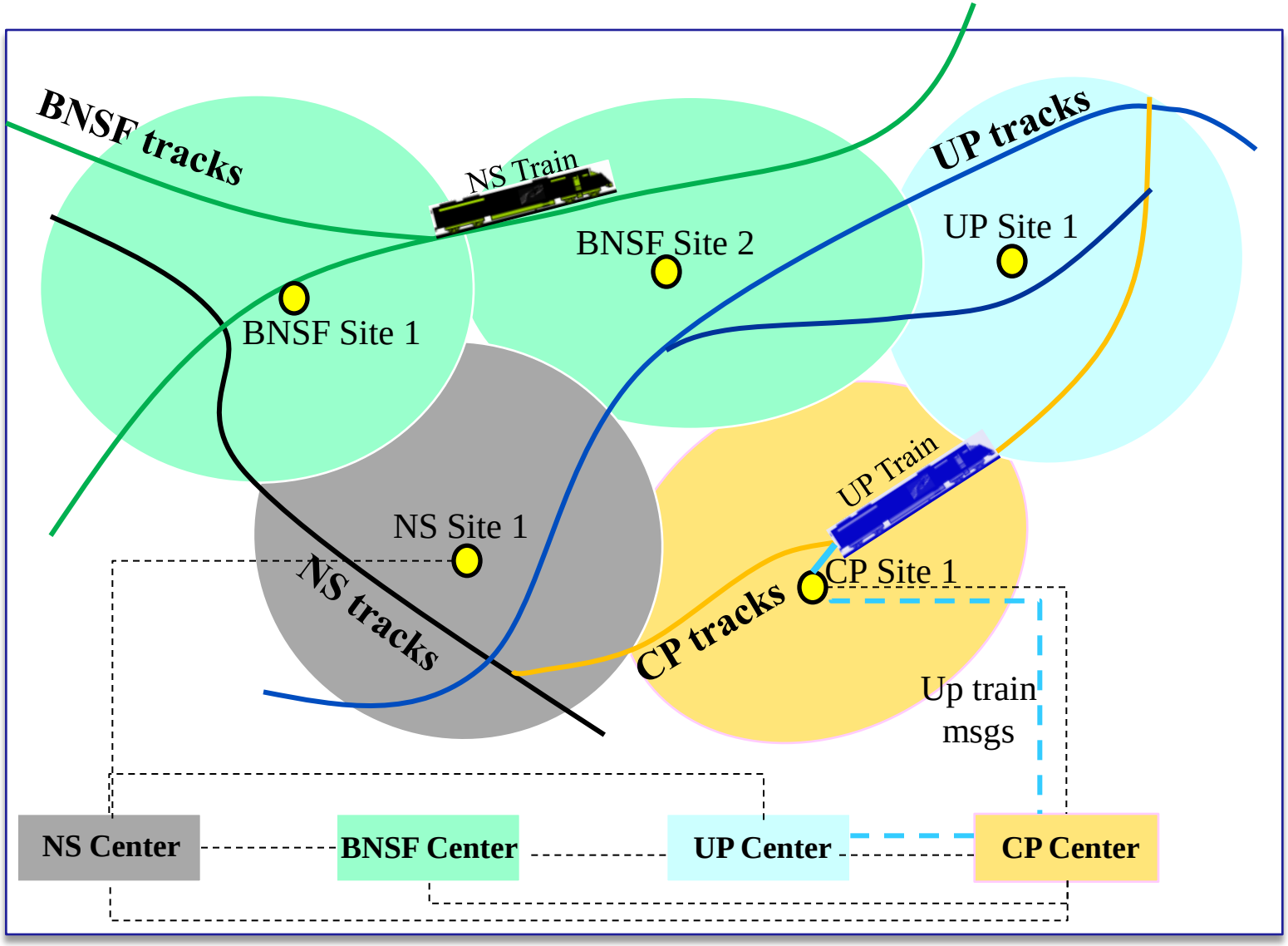
PTC System Overview – Current System Design



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 Characteristics – Interoperability

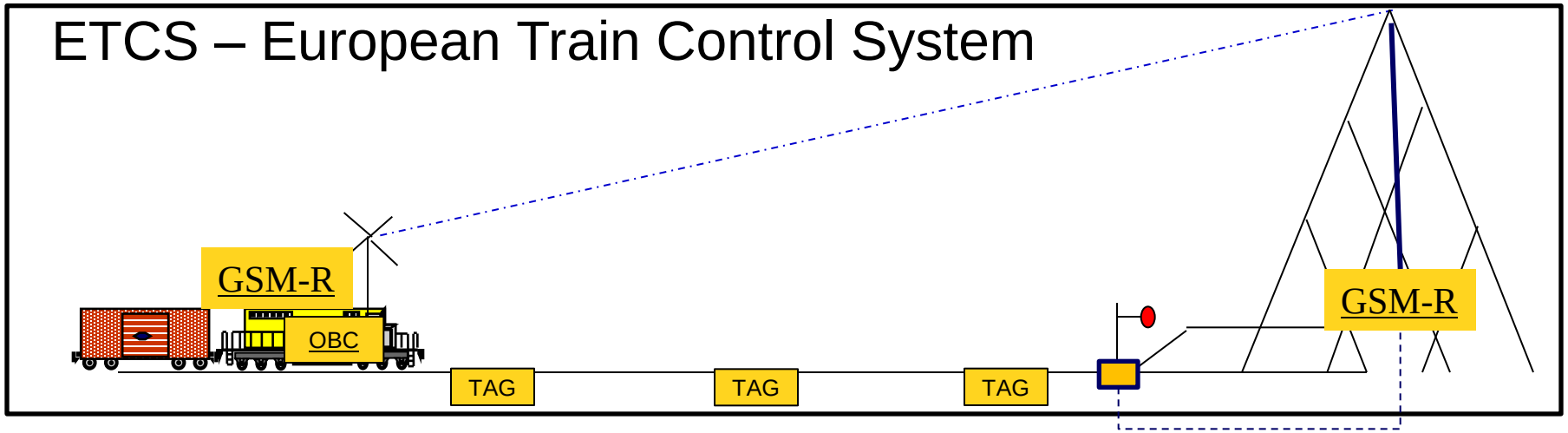


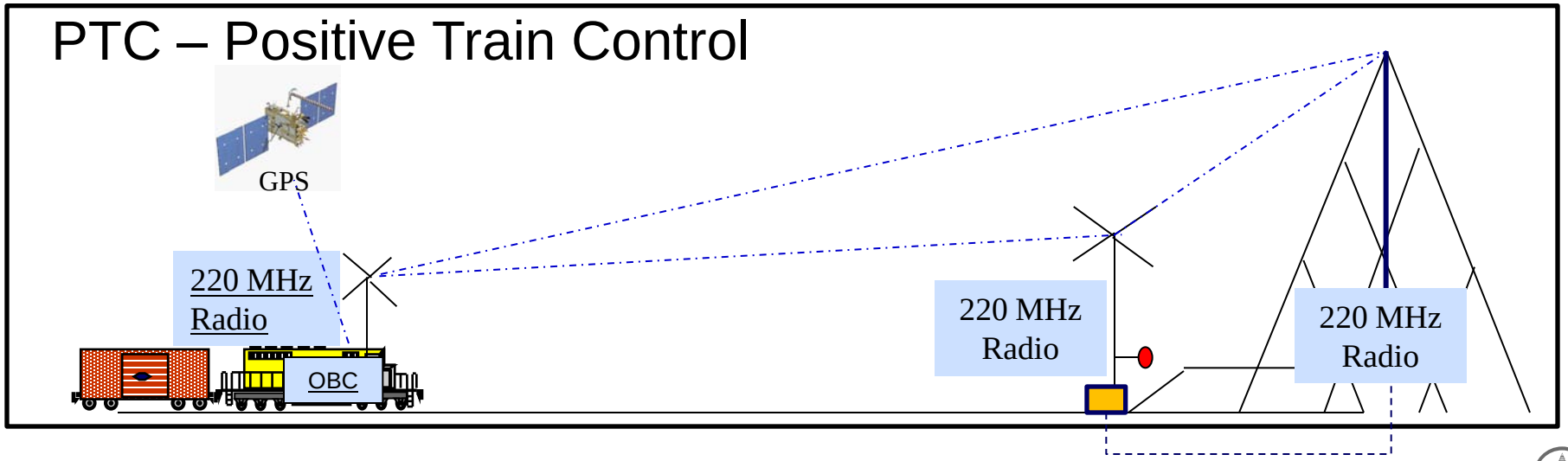
Main differences between European Train Control System (ETCS) and PTC

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

Current PTC implementation is equivalent to ETCS Level 2

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





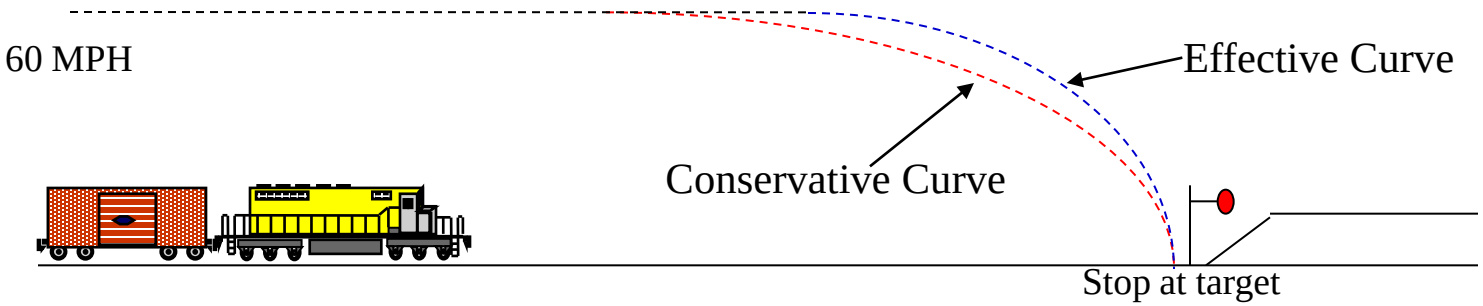
Key PTC Projects where TTCI plays a main role:

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

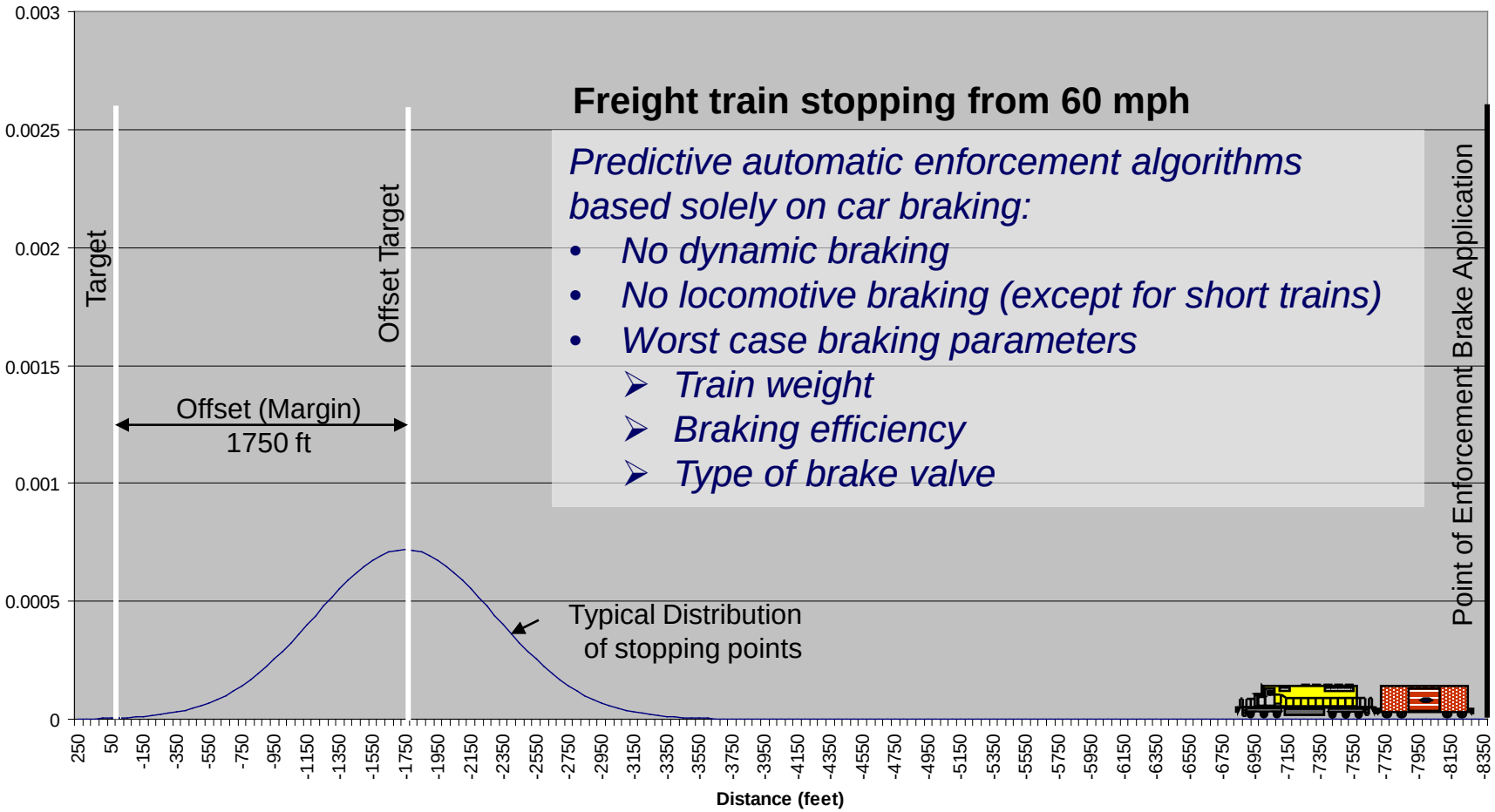
Train Enforcement Braking Issue

- 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**



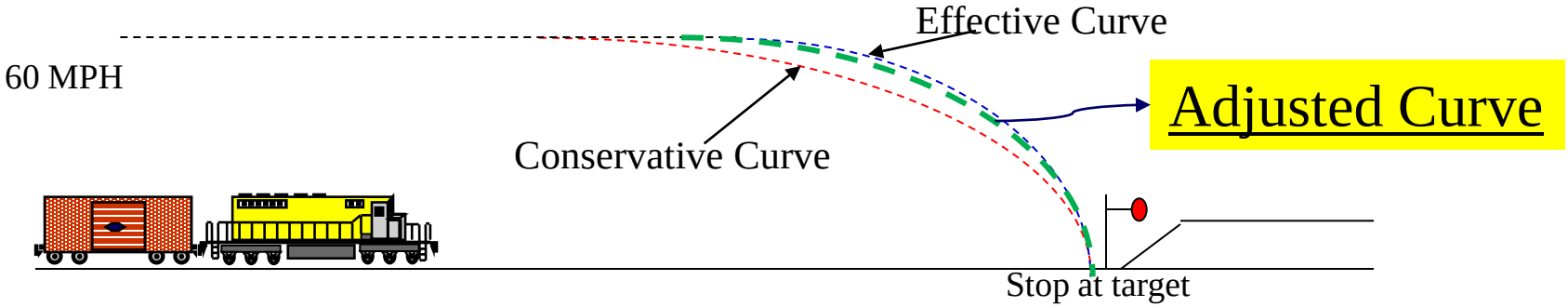
Train Enforcement Braking Issue



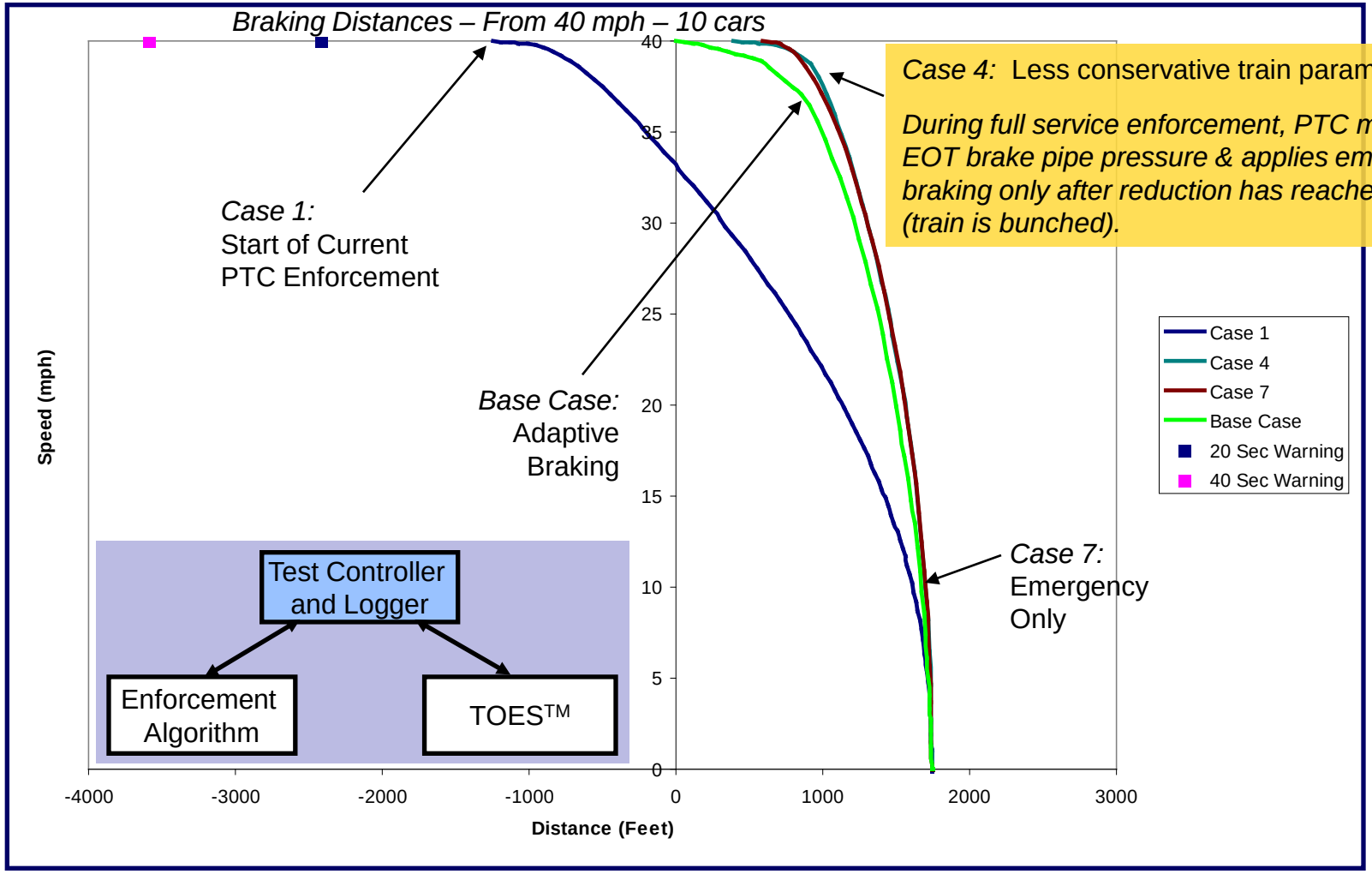
Large Safety Margin in PTC Braking Algorithms causes trains to Slow or Stop Sooner than Desired, which can Degrade Capacity

Adaptive Train Enforcement Braking Algorithm

- Approach to resolve the issue:
  - Intellingent 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



Enforcement Braking Solutions Evaluated by TTCI



Case 4: Less conservative train parameters

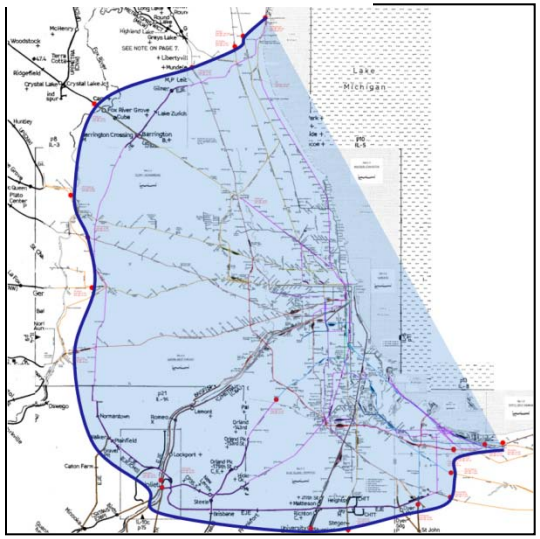
During full service enforcement, PTC monitors EOT brake pipe pressure & applies emergency braking only after reduction has reached EOT (train is bunched).

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

Railroad	Route Miles
UP	154
NS	82
BNSF	31
CN	269
NICTD	32
Metra	187
CSX	60
IHB	44
BRC	20
Amtrak	1
TOTAL	**880**

TTCI was hired to resolve the dense urban areas in the USA

RF Network Planning and Design

Train Traffic Simulation

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PTC Message Simulation

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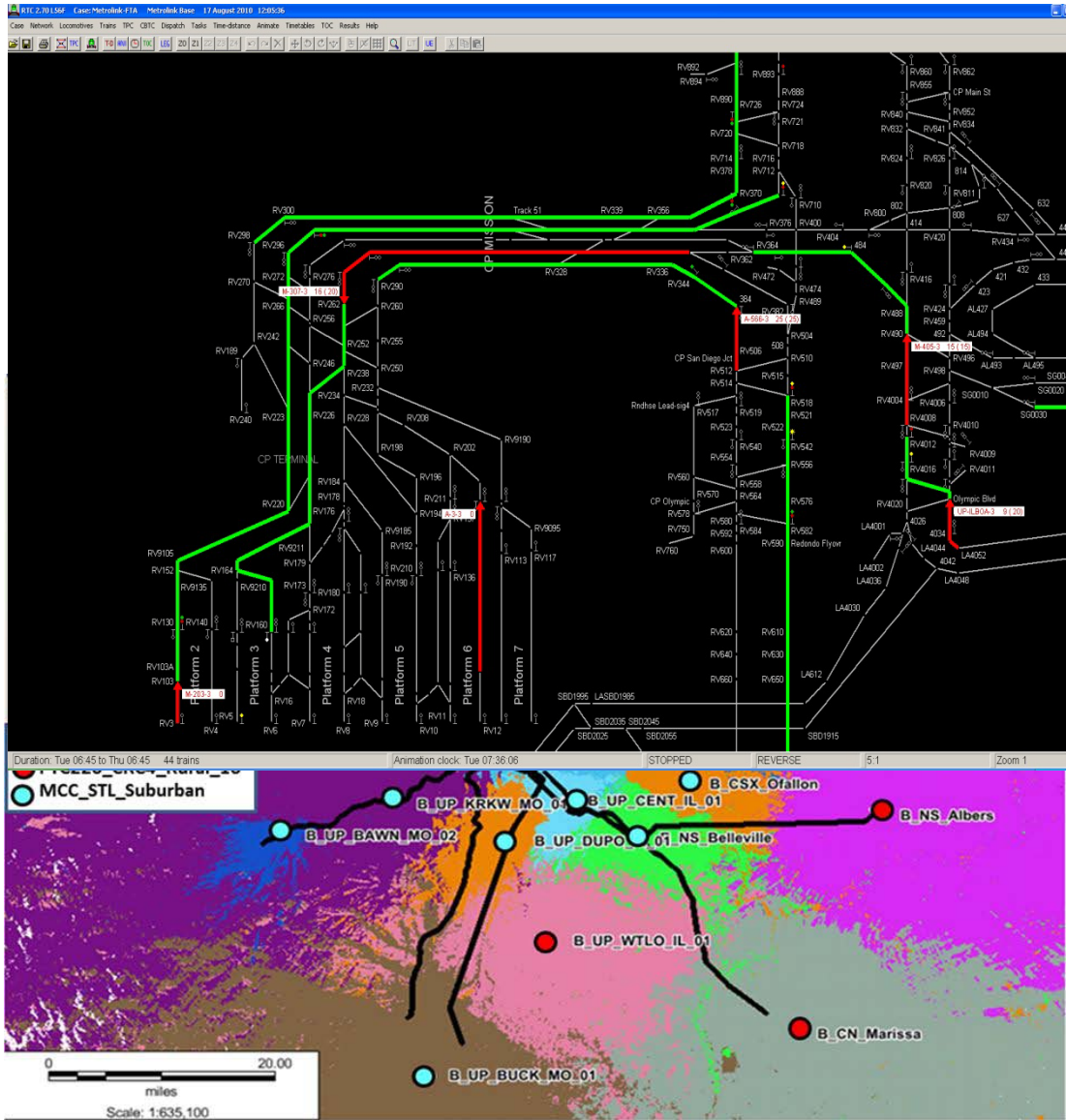
RF Propagation Simulation and Loading Analysis



RF Network Planning and Design

- **RF network projects developed for the folowing cities**

Urban Area	Track extension (Km)	# of Radios	# of Railroads
Los Angeles	1200	320	5
Chicago	4500	900	11
St. Louis	1000	350	7
Kansas City	900	280	6
New Orleans	1200	340	7
Mn-St.Paul	750	260	5
Toledo	700	250	5
New York	1500	400	6
Dallas-Ft Worth	650	N/A	5

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

802.11b/g

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

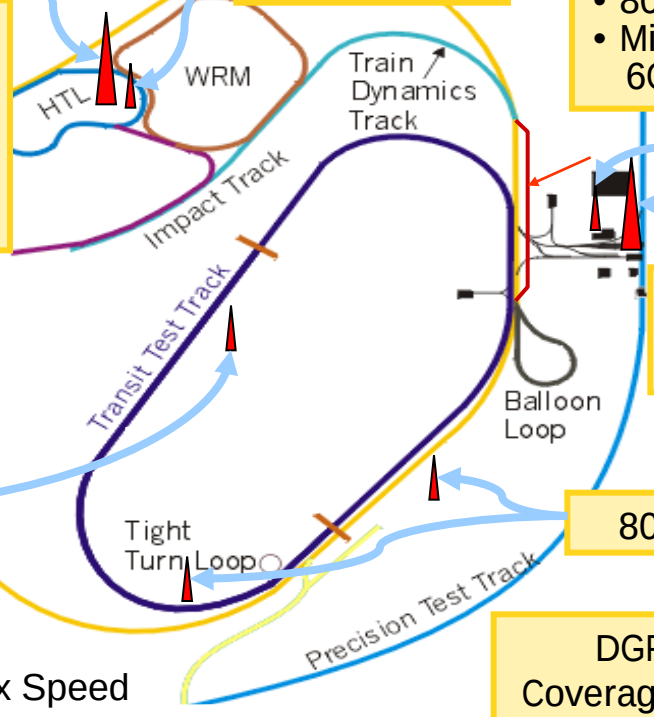
4000 ft. Siding

120' Tower
- VHF
- ATCS

CDMA Cellular w/1xEVDO

802.11b/g

DGPS Coverage over the Test Bed



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

- Infrastructure for Testing:
  - Communications Systems
  - PTC Systems & Components
  - Remote Control Locomotives (RCL)
  - Other Wireless Applications
- Test Capabilities for:
  - Interoperability & Standards Compliance
  - Performance Evaluation
  - Proof of Concept for New Applications
  - V&V
  - Handoff Schemes
- Related Systems:
  - DGPS – Beacon Site Nearby
  - HANDGPS

80 km of Test Track on 160 km^2 of land near Pueblo, CO

List of PTC Projects at TTCI

Customer	Project
•FRA	TO 219 Low Cost Adv Act Xing Dem
•FRA	TO 234 HA-GPS Upgrade/Testing
•FRA	TO 242 Braking Algorithm, Freight
•FRA	TO 256 FRA PTC Test Bed Upgrades
•FRA	TO 257 FRA EIC PRT Integration
•FRA	TO 267 Braking Performance Model, Passenger
•FRA	TO 269 Braking Performance Model, Passenger
•FRA	TO 270 PTC Test Bed Upgrade
•RRF	RRF CA - HPDR
•RRF	RRF ITP Proof of Concept Project
•RRF	RRF/FRA R&D Enhance PTC
•FTA	FTA Rail Capacity
•Alaska Railroad	ARRC TOES
•AAR	AAR PTC Enhance RTC Simulator
•PTC-220, LLC	PTC 220 RF Coordination
•Proprietary	220 PTC Radio Testing
•SYSTRA	Metrolink PTC Consulting
•SYSTRA	LIRR PTC Consulting
•SYSTRA	MNR PTC Consulting
•ARINC	CAD Consulting
•Invensys Rail	Invensys PTC Braking Algorithm Test
•EMD	EMD PTC Proof of Concept

IR&D Project
•Network Simulator
•Test Controller/Logger
•Broken Rail Detection
•C&TC Test Bed

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**

Simulators/Tools:
TEM, TOES, RTC,
TCL, RF, Test Bed

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

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**
  - Radio and onboard components
  - Integration and interoperability
- **Deployment at railroads**
  - 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)**
  - RF network design in final stages
  - Field deployment in advanced stages

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 !