U.S. Department of Transportation
Federal Railroad Administration
OFFICE OF RESEARCH & DEVELOPMENT

TRANSPORTATION TECHNOLOGY CENTER

FEDERAL LABORATORY CONSORTIUM
FLC
FOR TECHNOLOGY TRANSFER

The Transportation Technology Center's Positive Train Control Test Bed

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Transportation Technology Center, Inc.

Outline

- Positive Train Control – Why?
- What Positive Train Control Is
- How Positive Train Control Works
- Transportation Technology Center & Its Relationship to the FRA
- TTC's Positive Train Control Test Bed

Why Positive Train Control?
(continued)

- **Need for capability to override human error in train operations highlighted by several tragic, high profile train collisions**
  - 1987 Amtrak train & Conrail locomotives collide in Chase, Maryland
  - 2005 NS wreck & chemical spill at Graniteville, South Carolina
  - 2008 Metrolink commuter train & UP freight train collision at Chatsworth, California
- **Rail Safety Improvement Act of 2008**
  - Established specific requirements
  - Provided mandated implementation date

Why Positive Train Control?
(continued)

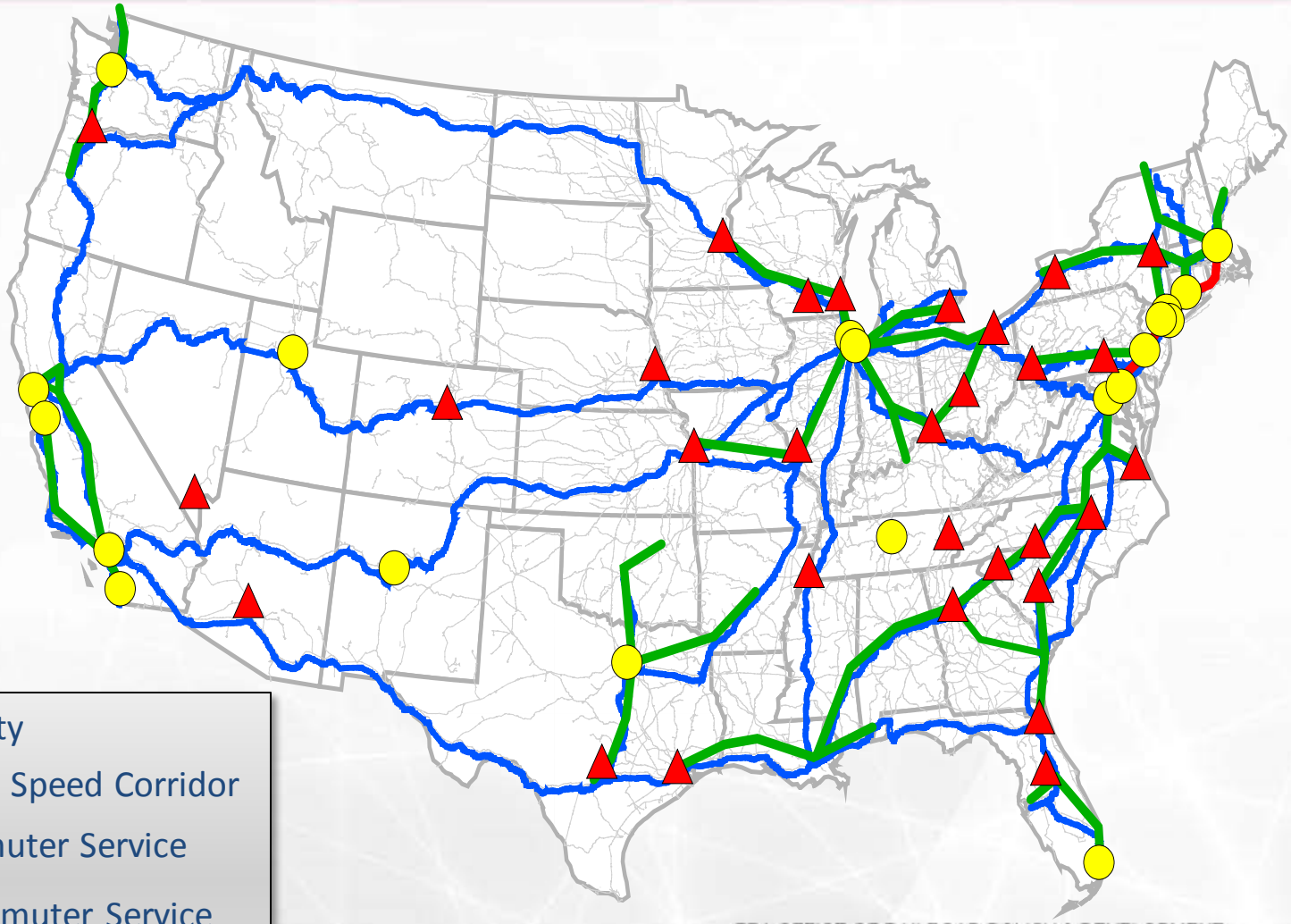
"Rail Safety Improvement Act" of 2008

"Each Class I railroad carrier and each entity providing regularly scheduled intercity or commuter rail passenger transportation shall develop … a plan for <u>implementing a positive train control system by December 31, 2015</u>, governing operations on—

- **"(A) its main line over which intercity rail passenger transportation or commuter rail passenger transportation …;**
- **"(B) its main line over which poison- or toxic-by-inhalation hazardous materials … are transported; and**
- **"(C) such other tracks as the Secretary may prescribe by regulation or order ...**

The railroad carrier <u>shall implement a positive train control system</u> in accordance with the plan."

Sharing the Track With Passenger Trains



- Amtrak Intercity
- Proposed High Speed Corridor
- Existing Commuter Service
- Proposed Commuter Service

What Positive Train Control Is

PTC means 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.
   (as defined in the Rail Safety Improvement Act)

1 is achieved by enforcing* authority limits.
2 is achieved by enforcing civil and temporary speed limits.
3 is achieved by enforcing* work zone limits.
4 is achieved by monitoring switch positions and enforcement.

* Warnings generally precede enforcement braking.

PTC provides Protection against Human Error

How Positive Train Control Works

PTC Office System

- Tracks Trains Closely
- Monitors Field Systems
- Verifies Authority Requests
- Transmits Authorities & Restrictions to Trains

More Precise and Timely Visibility of Operations in Office

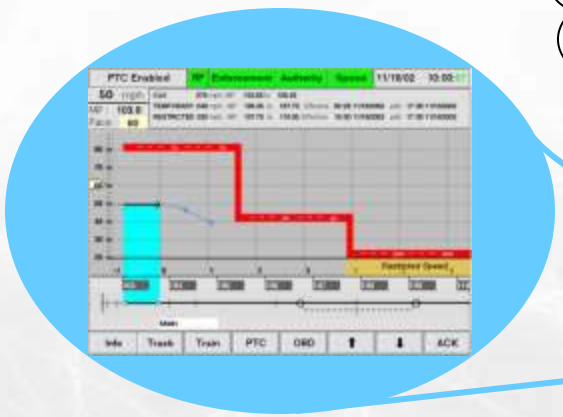
Onboard Equipment

- Determines Location
- Reports Location to Server
- Displays Authorities & Restrictions
- Warns of & Enforces Authorities & Restrictions

Authorities & Restrictions

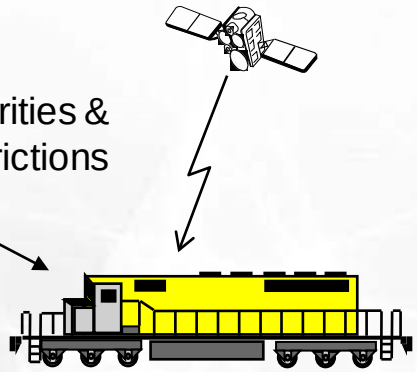
Location Reports

Communications Network



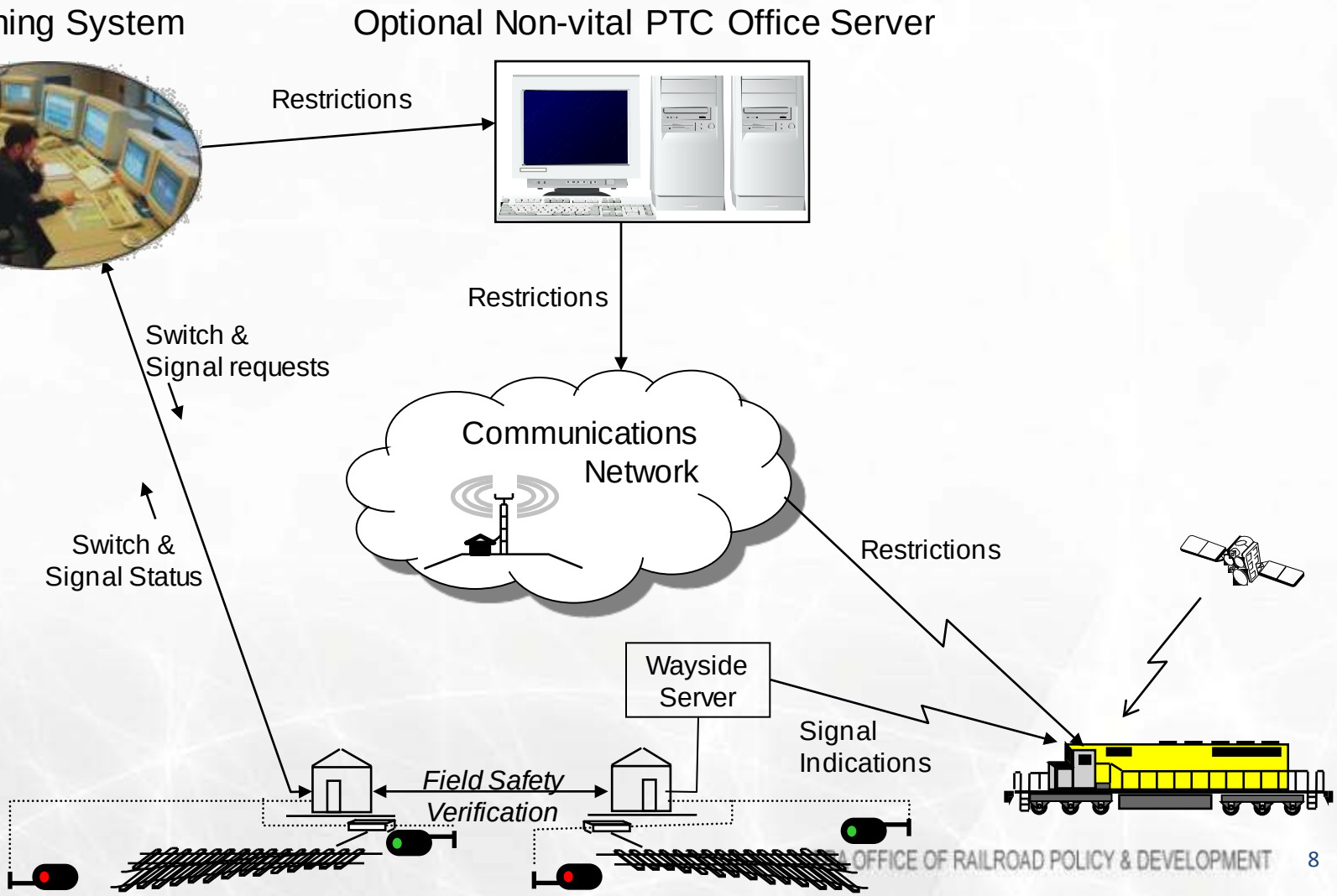
Authorities & Restrictions

Location Reports



Locomotive knows where it is, how far it is allowed to go and how fast, and train braking characteristics. It enforces limits to prevent violations cannot be overridden

Most Common Architecture of Distributed PTC System



TTC — FRA Relationship

- **Transportation Technology Center (TTC) - The Facility**
  - Land owned by Colorado
  - Leased to USDOT (FRA)
  - Facility Managed for FRA by TTCI

- **TTC Inc. (TTCI) - The Company**
  - Wholly owned subsidiary of Association of American Railroads (AAR)
  - Headquartered at TTC, Pueblo, Colorado, USA
  - Guided by Board of Directors – Chief Operating Officers of major RRs
  - Charged with developing TTC to become the world's leading railway research testing and training facility

Engineered Facilities for Dynamic Testing

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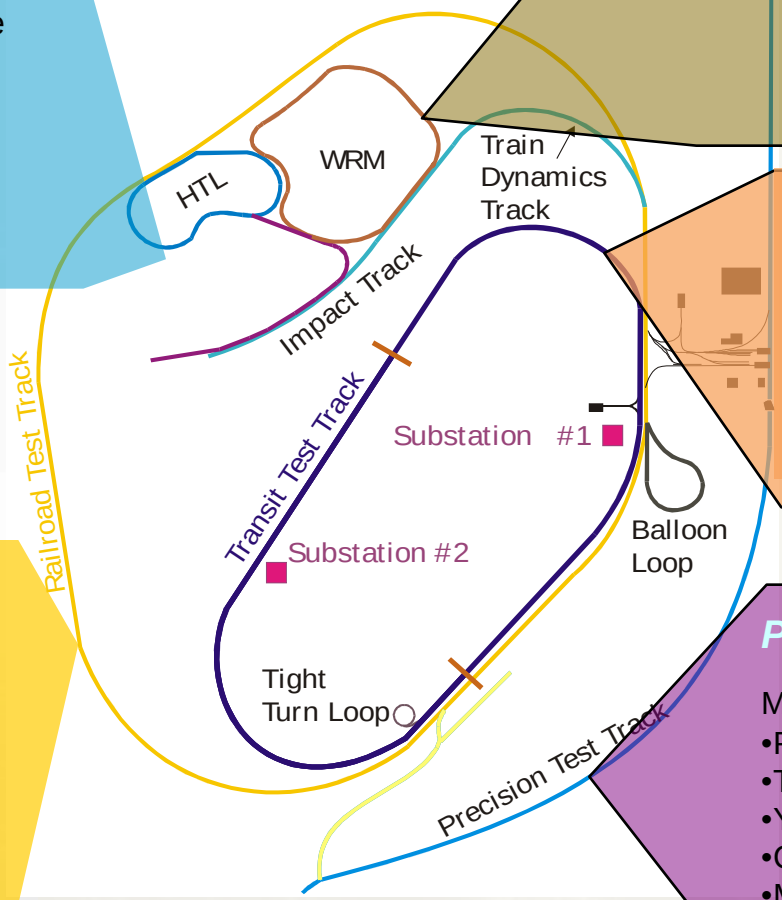
High Tonnage Loop (HTL)

- 2.7-mile loop, three 5 curves, one 6 curve
- Main use – HAL studies
- Test bed for various premium track components
- 25 MGT/month in controlled environment

Wheel Rail Mechanism Track (WRM)

- 7.5 , 10 , and 12 curving performance tests
- Dynamic curving tests
- Lubrication studies



Transit Test Track (TTT)

- 9.1-mile loop
- 80 mph max speed
- DC electrified third rail
  - Up to 1150 volts
  - Up to 12,000 amps

Railroad Test Track (RTT)

- 13.5-mile loop
- 1 -15' curve and four 50' curves
- Main use – HAL studies
- Maximum speed 165 mph
- 12.5-, 25-, and 50-kV overhead catenary

Precision Test Track (PTT)

Multi-use track for railcar testing

- Pitch and bounce
- Twist and roll
- Yaw and sway
- Car impact
- Miscellaneous studies

- Qualification Testing
- Conformance / Specification Testing
- Endurance Testing

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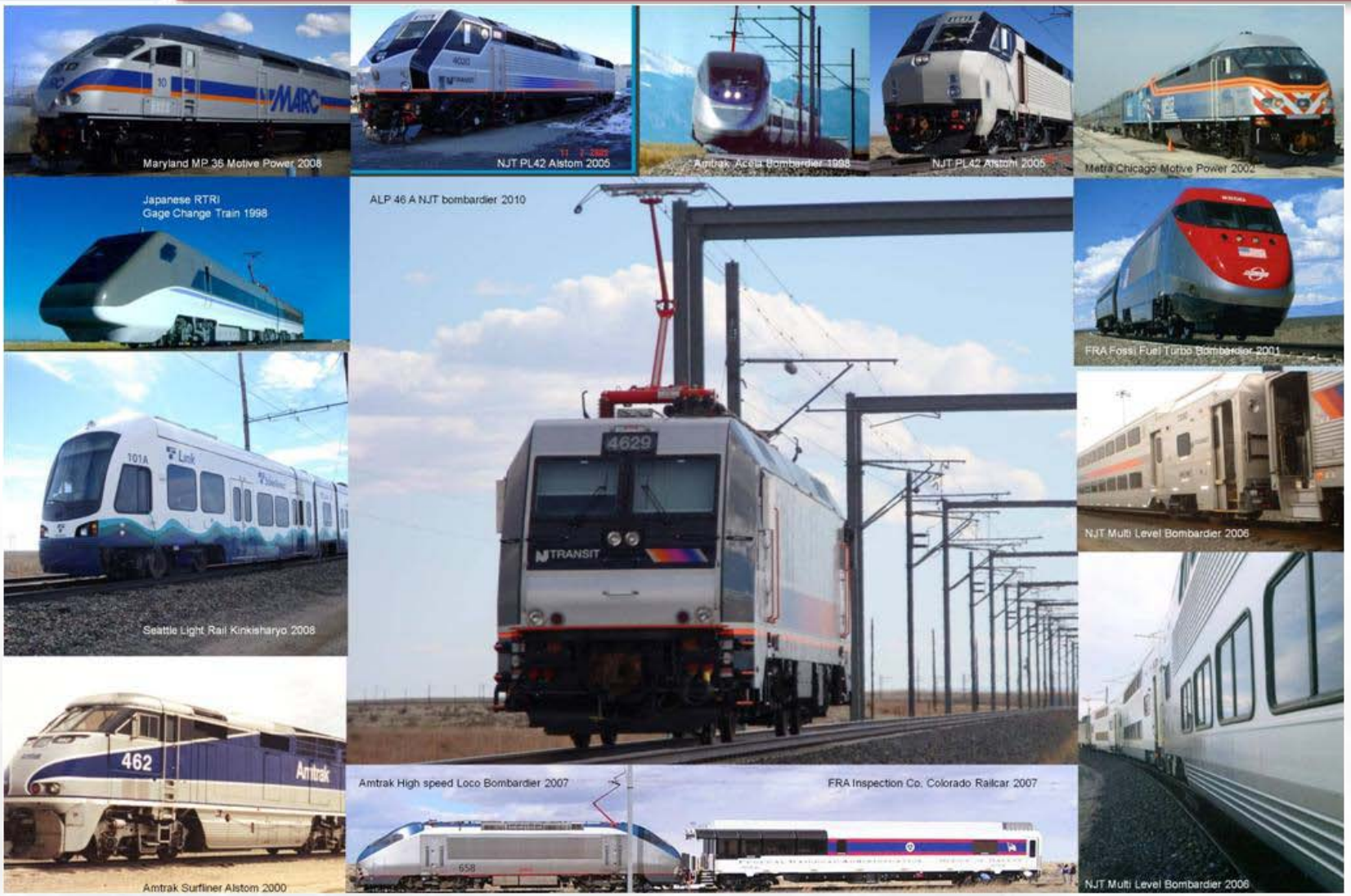
Passenger Equipment Performance Testing



Full-Scale Laboratory Testing

- Vibration testing
- Used for characterizing rail vehicle suspensions and components
- Vibration Test Unit (VTU) is also used to improve lading restraint systems

Boxcar on VTU

Auto Rack on VTU

TTC – RR Strategic Research

Vehicle-Track System

- Wheel / rail asset life extension
- Vehicle track performance
- Train condition monitoring
- New technology implementation

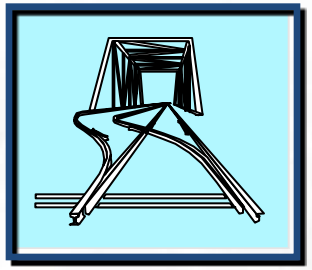
Mechanical

- Advanced freight train equipment
- Advanced freight car truck
- HAL axle design
- Improved car components
- Improved car performance

Heavy Axle Loads

- FAST/HAL operations
- HAL revenue service monitoring
- Automated train operation
- 150 MGT

Engineering



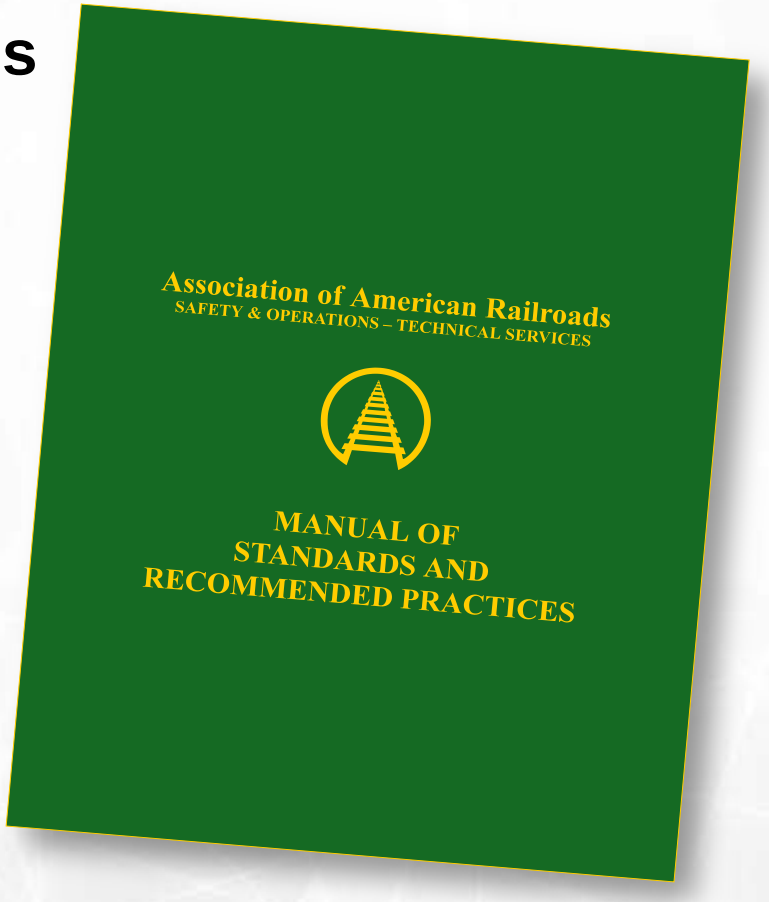
- Track integrity
- Special track work
- Bridge asset life extension
- Improved track components
- Improved performance track

Security & Emergency Response Training Center (SERTC)

- RR security, HazMat, & first responder training for derailments & RR industry accidents
- Trainees from many countries
- Well trained responders benefit RR industry & nation

Standards Development & Certification

- **Elements of Technical Standards**
  - AAR technical committees
  - Industry quality programs
  - Rules and standards policing
  - Certification testing



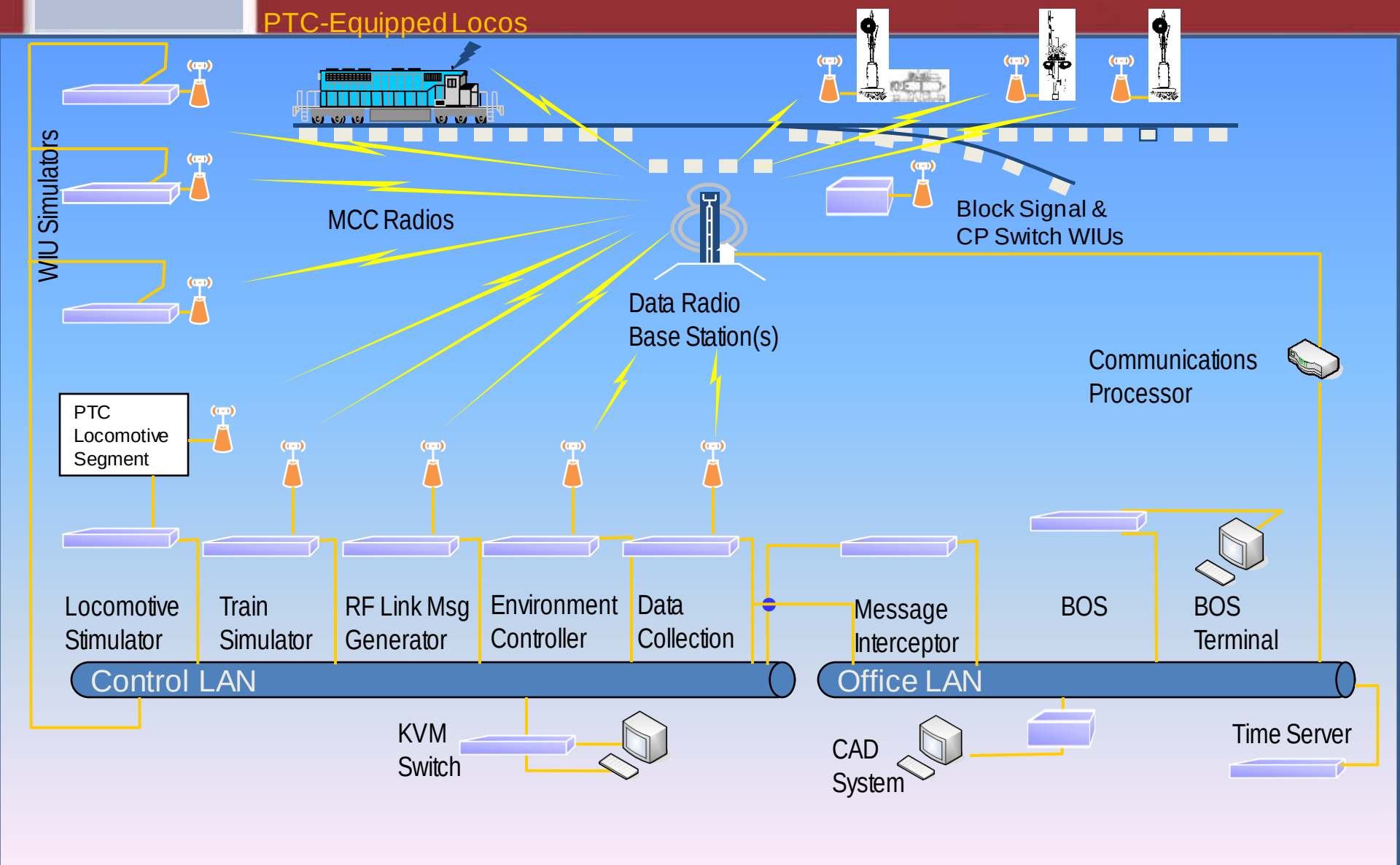
Why a PTC Test Bed?

- **PTC system testing of new functionality in live, RR revenue service environment is very difficult**
  - Must accommodate revenue traffic
  - Must obey all RR Operating Rules or obtain Waivers from FRA
  - Difficult or impossible to conduct stress testing
  - Scheduling test team & test resources is a significant challenge
  - Results are often not repeatable
  - Changes to vital equipment require lengthy V&V and significantly extends “test-fix-retest” cycle
- **On-track PTC Test Bed without revenue traffic and RR regulations alleviates these problems**

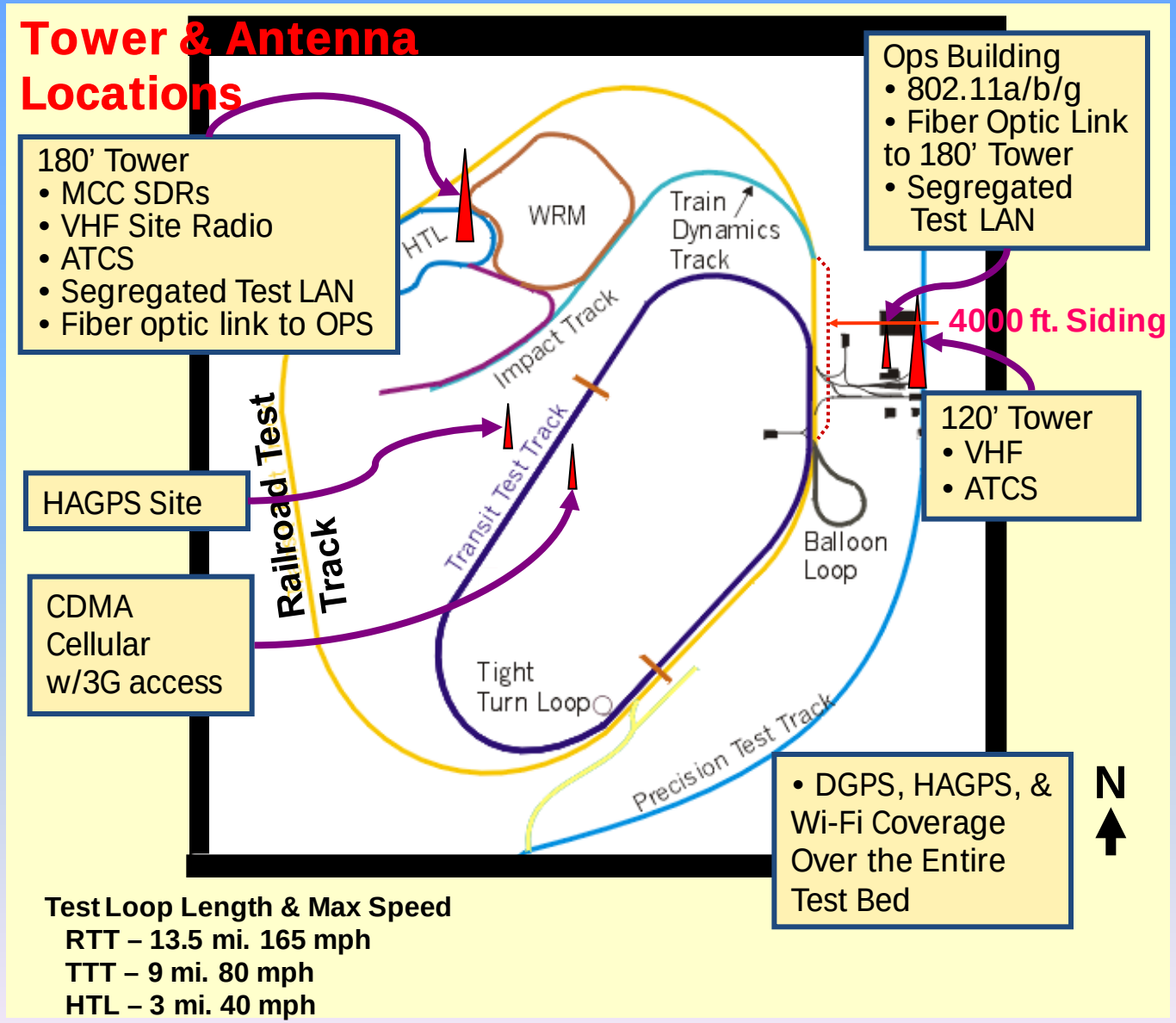
TTC - PTC Test Bed

- **Test Bed is Combination of Fixed & Configurable Elements**
  - Fixed Elements
    - RTT & TTT track infrastructure, including insulated joints, track circuits, switches, physical crossings, etc.
    - Major communication infrastructure, such as towers, base stations, & fiber optic cable runs (& H/W in Communications Test Lab)
    - Computer-Aided Dispatch (CAD) with Back Office Server (BOS) interface
    - PTC-configured locomotives
    - Programmable Wayside Interface Units (WIUs)
  - Configurable Elements
    - Train & WIU simulators
    - Environment Controller
    - Radio Frequency (RF) link traffic generators
    - Automated test script generators
    - Data collection system
    - Track database
  - Units Under Test (PTC equipment)

PTC Test Bed Architecture



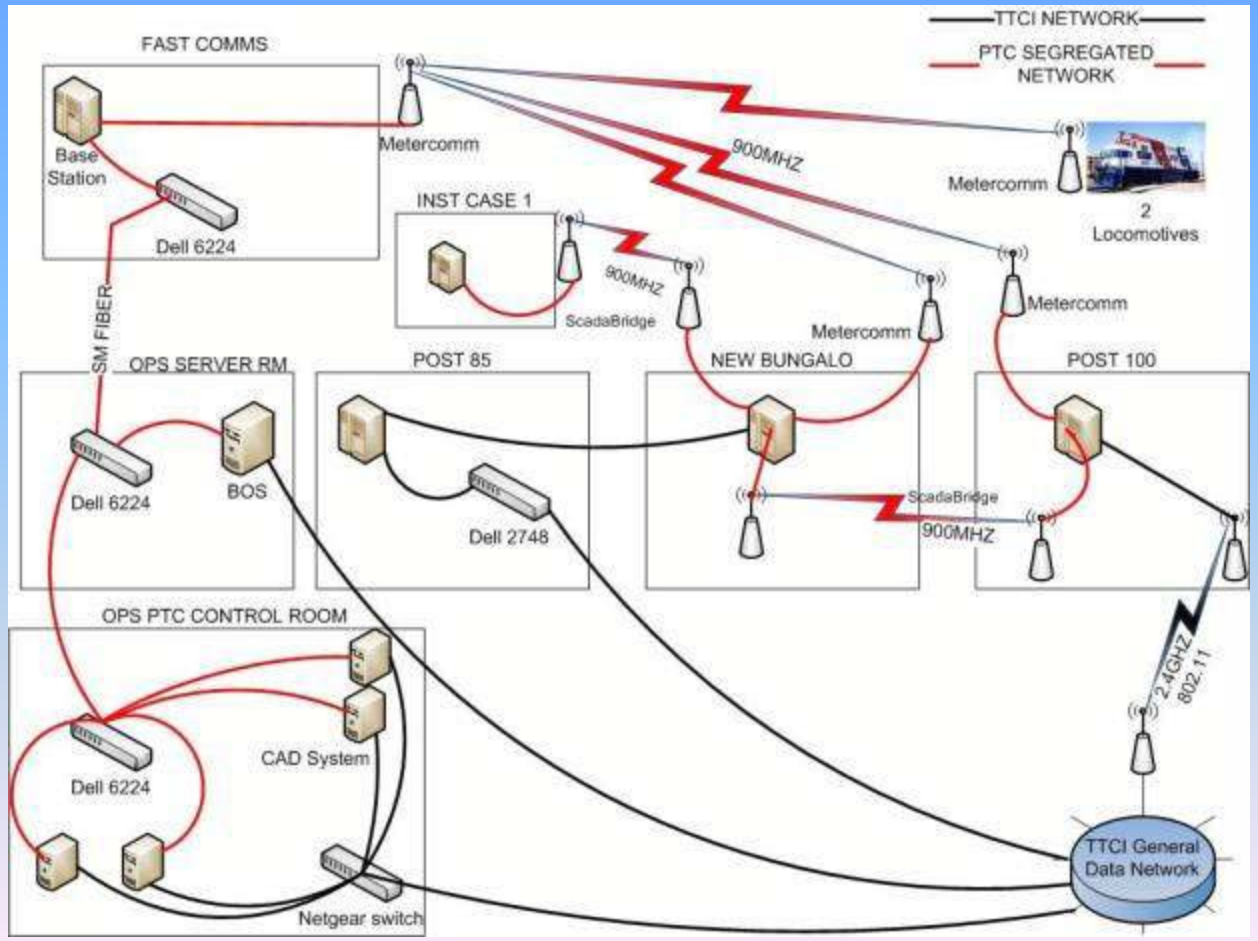
Test Bed – Infrastructure Overview



48 miles of Test Track on 52 mi² of land near Pueblo, CO

TTC - PTC Test Bed *(continued)*

Dedicated/Segregated PTC Test LAN



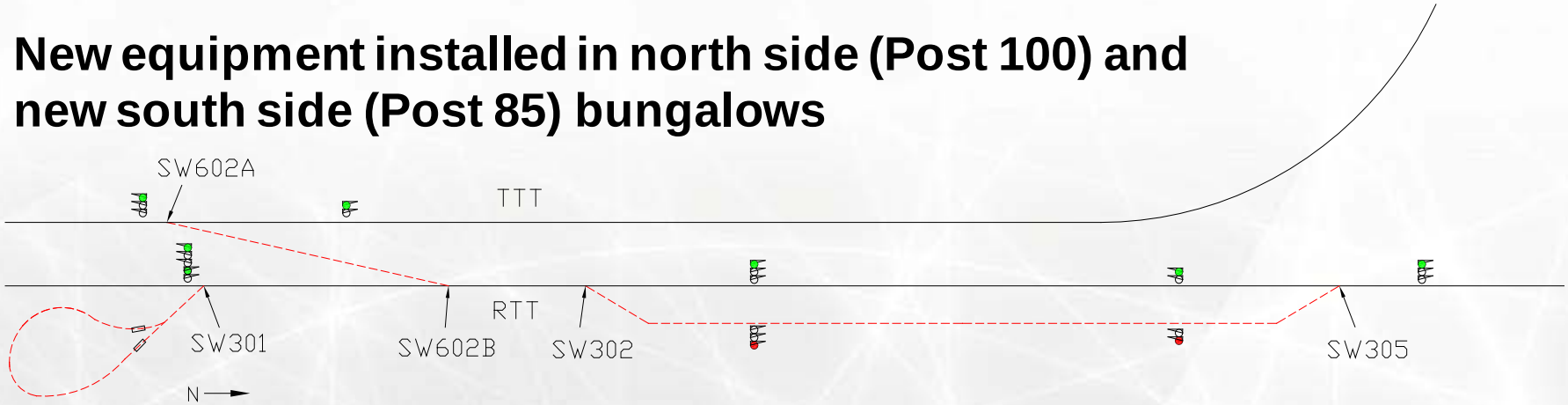
TTC - PTC Test Bed *(continued)*

Computer Aided Dispatch (CAD) System

Provides capability to monitor train location, monitors & controls power-operated switches, monitors other switches & route conditions, determines maximum authorized speed based on train and track information, and issues authority automatically through a data link.

TTC - PTC Test Bed *(continued)*

- **4000 ft siding on the RTT – track & switches installed**
- **Powered switch machines installed to replace four TTC core-area manual-throw track switches**
- **Switch Position Indicator Lights (SPIL), in-track occupied site (OS) circuits, and OS circuit electronic detectors installed**
- **New equipment installed in north side (Post 100) and new south side (Post 85) bungalows**

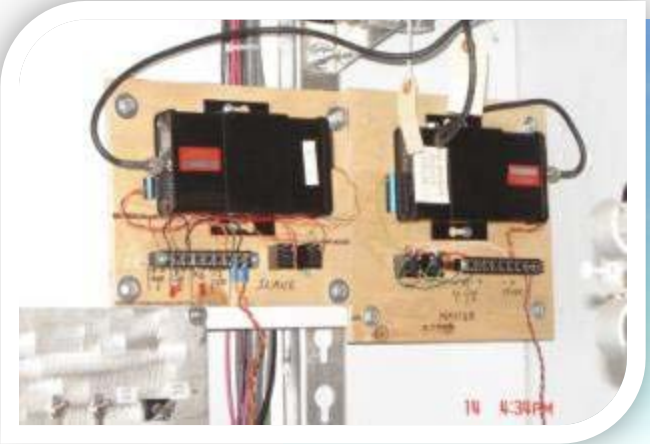


TTC - PTC Test Bed *(continued)*

New siding includes 4,000 ft of track, 4 new remotely operated switches, a new bungalow, island circuits, SPIL lights, radios, & segregated PTC LAN

TTC - PTC Test Bed *(continued)*

External communication links important part of new bungalow



TTC - PTC Test Bed *(continued)*

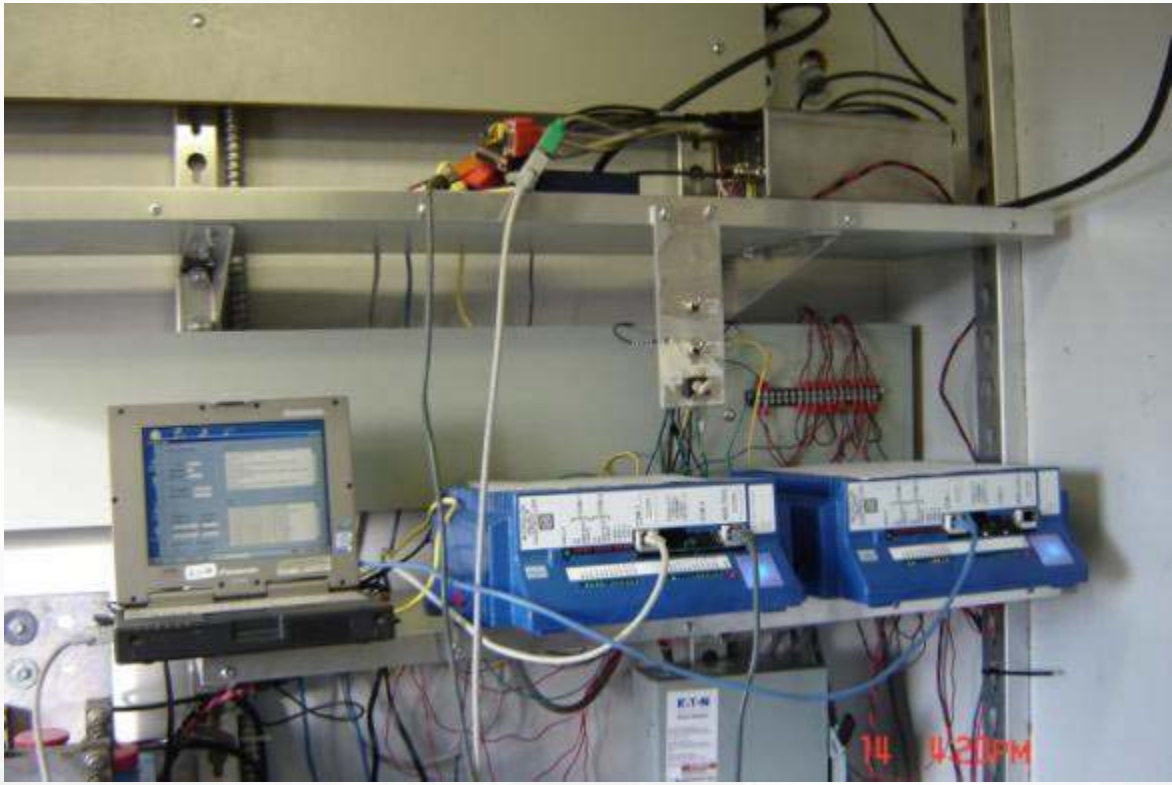
Twelve 2-volt batteries with a 24 VDC heavy duty battery charger. Batteries provide 12 or 24 VDC for operation of switches, SPIL lights, track circuits, relays, and radios.

TTC - PTC Test Bed *(continued)*

Equipment bungalow also houses Safetran track island circuits for track occupancy along with relays that control SPIL & switches.

TTC - PTC Test Bed *(continued)*

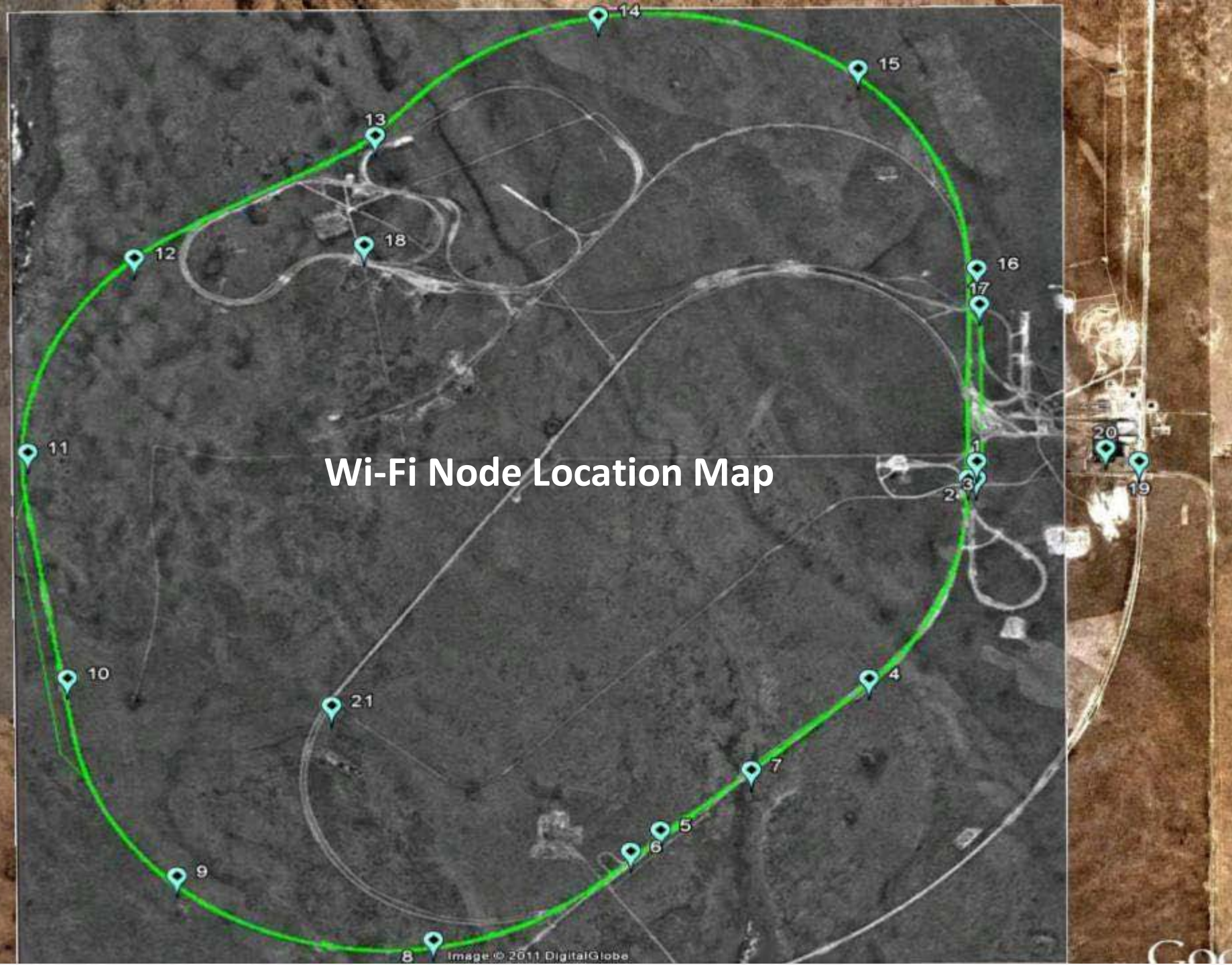
US&S object controllers monitor and control relays & switches. Above the object controllers is a MeteorComm radio sending data to the base station, locomotives, & PTC back office server

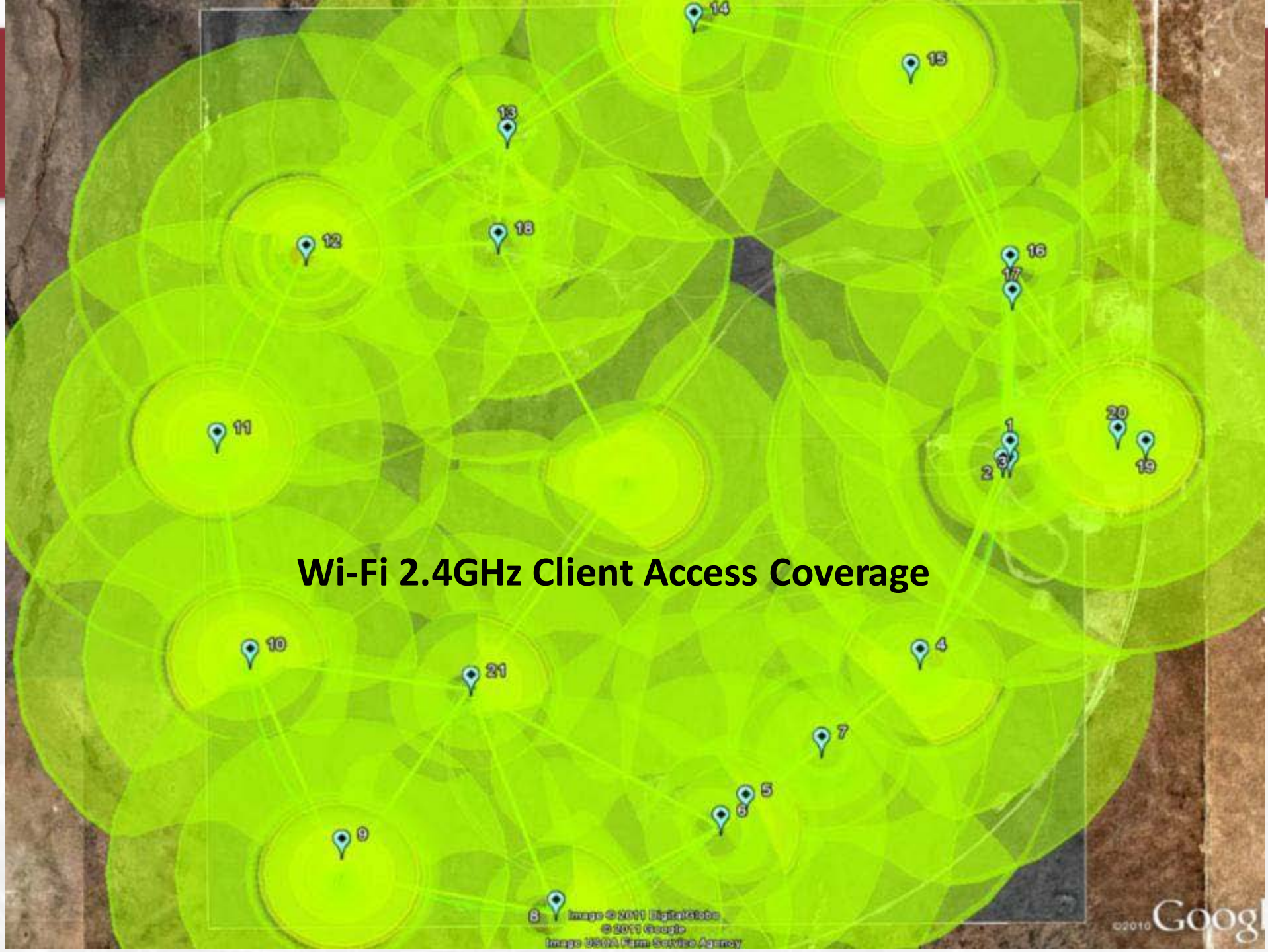


TTC - PTC Test Bed *(continued)*

All equipment within each bungalow is protected with Safetran equalizers, air gap arrestors and tunable narrow band shunts

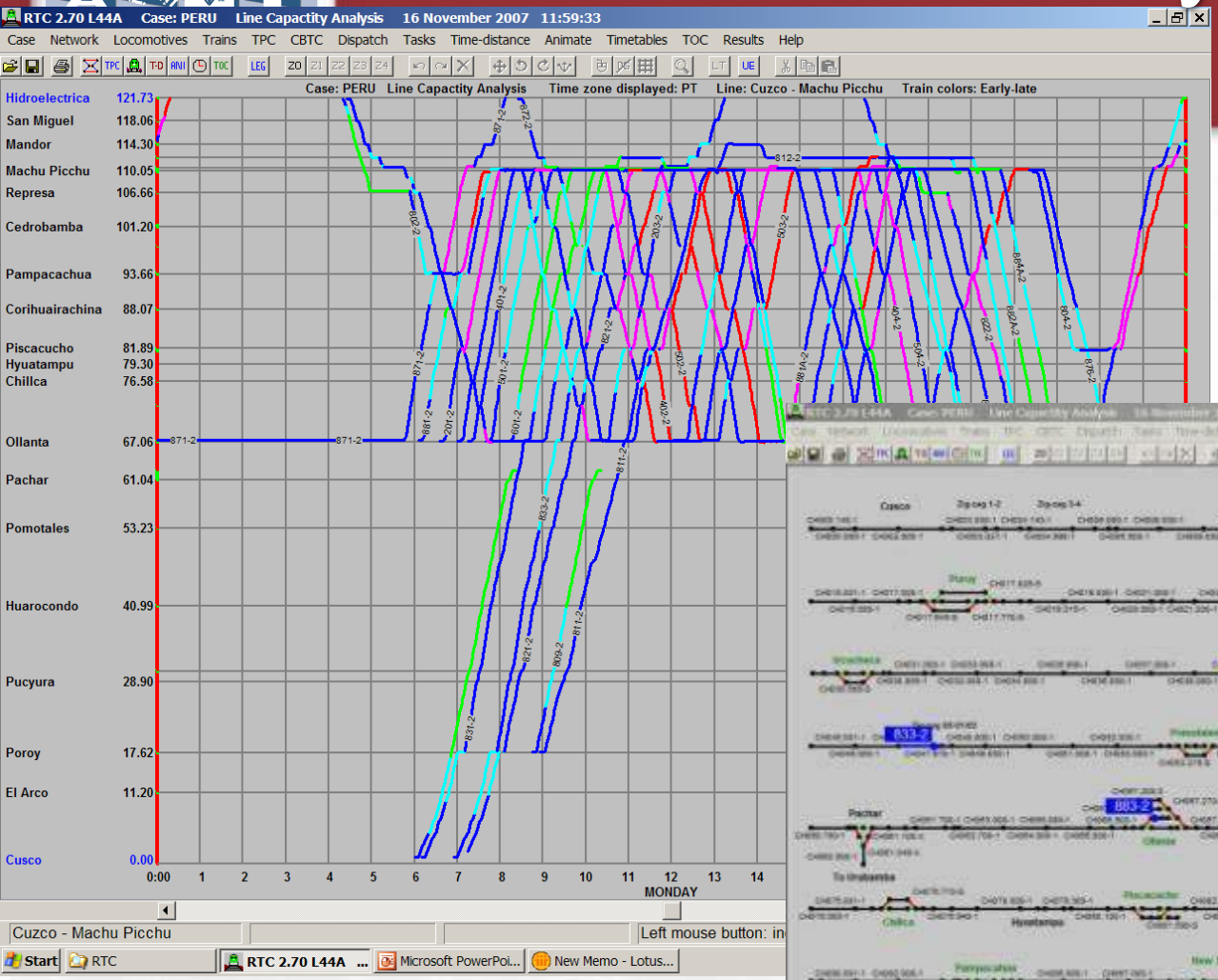
Wi-Fi Node Location Map



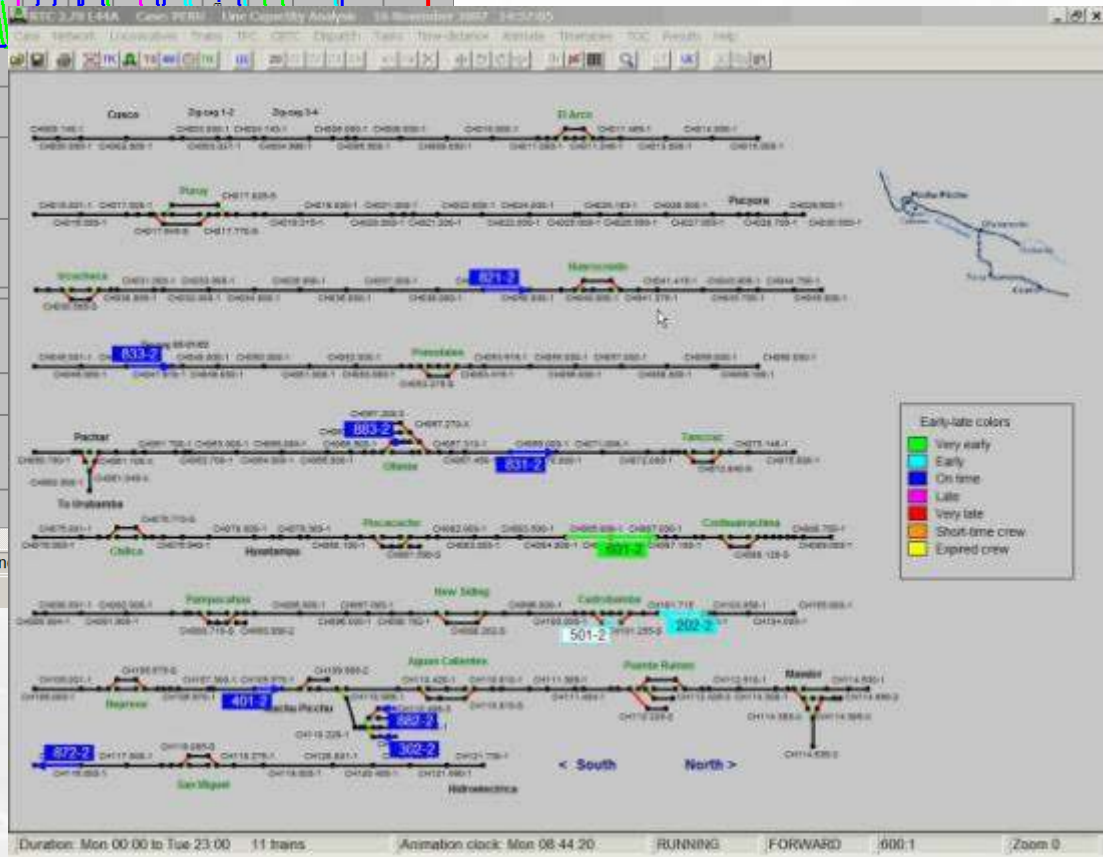


Wi-Fi 2.4GHz Client Access Coverage

PTC Test Bed - Railway Network Model



Determine operating characteristics of Railways under conventional and Positive Train Control as parameters are Varied



TTCI's Network Simulator models a variety of PTC environments as well as conventional signaling.

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PTC Test Bed - Radio Test Lab

TTC's PTC Test Bed

Questions?