Federal Railroad Administration
Research & Development
Program Review

Signal and Train Control

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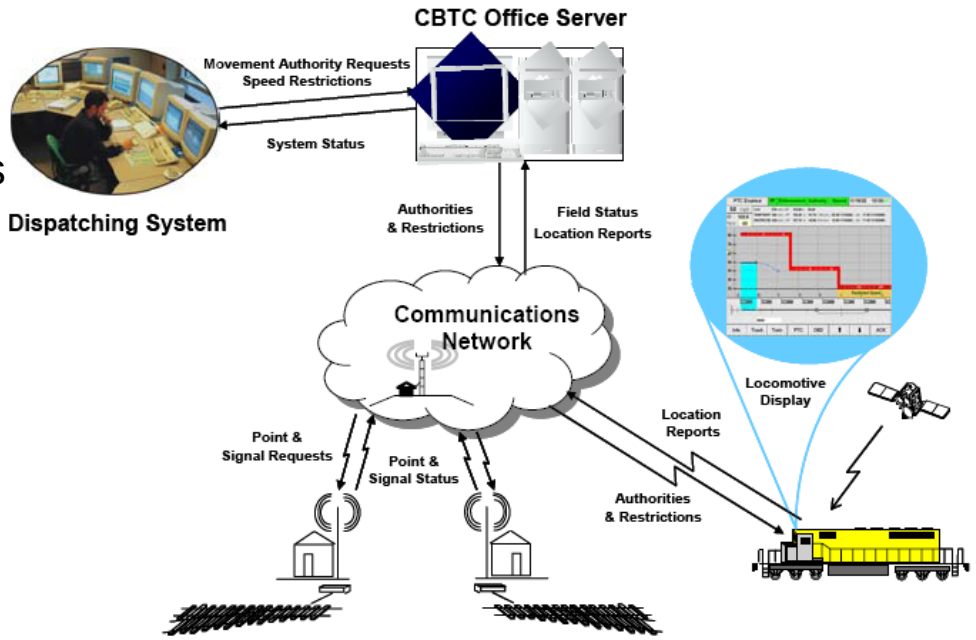
November 13-14
Washington, D.C.

Signaling and Train Control recent developments

- Head on Collision – Metorlink and UPRR trains, Chatsworth, CA, 09/12/2008. Fatalities – 25; Injuries – 135; Damage - $7.5 millions
- The President has signed the “Rail Safety Improvement Act of 2008” requiring certain freight and passenger railroads, by 2015, to implement PTC on their main lines (defined as 5 MGT traffic annually) over which,
  - ❑Intercity rail passenger transportation or commuter rail passenger transportation is regularly provided
  - ❑Poison or toxic-by-inhalation hazardous materials are transported
  - ❑Such other tracks as the Secretary may prescribe by regulation or order



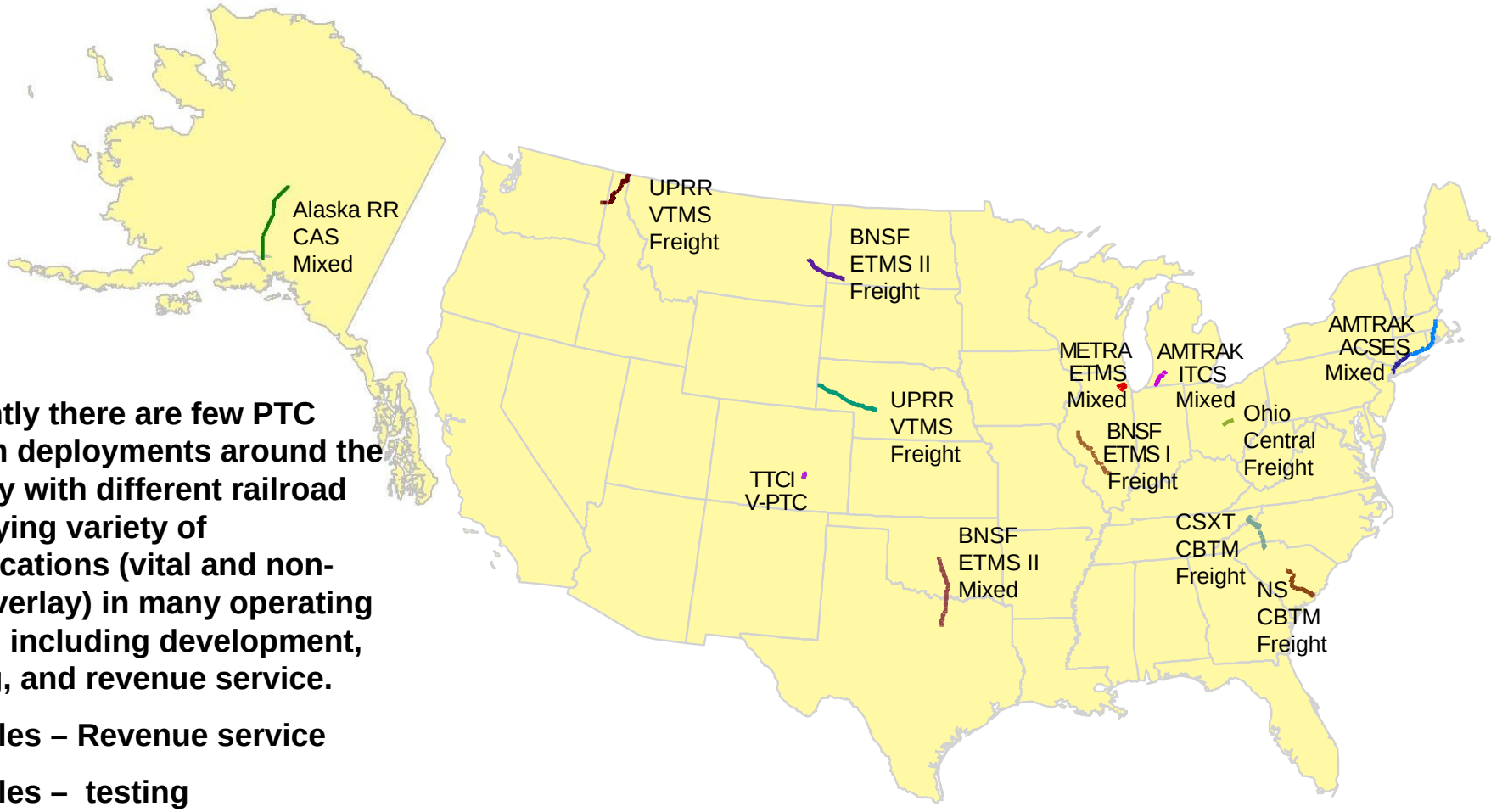
- Estimated 20,000 locomotives and 100,000 miles of track would need to be equipped with PTC

Signaling and Train Control recent developments

Additional Development

- ✓ On October 9, UPRR, BNSF, NS and CSXT announced that they will jointly developed a PTC interoperability standard
- ✓ All four railroads agreed to use 220 MHz frequency for wireless communication network
- ✓ FRA R&D met with the railroads on November 12 to establish R&D directions towards 2015 deployment deadline

Signaling and Train Control PTC corridors



Currently there are few PTC system deployments around the country with different railroad employing variety of specifications (vital and non-vital overlay) in many operating modes including development, testing, and revenue service.

469 miles – Revenue service

450 miles – testing

1374 miles – Development

FRA funded PTC system integration

- **Vital PTC (VPTC)** – IDOT 53M; VPTC 3.9M
  - Cooperate with Railroad Research Foundation (an AAR subsidiary), Transportation Technology Center, Inc (TTCI) and Lockheed Martin
  - A follow on effort of NAJPTC System in Illinois to develop a true vital PTC system
  - Jointly funded by Lockheed Martin and FRA
- **Incremental Train Control System (ITCS)** - $19M
  - Cooperate with Michigan Department of Transportation, Amtrak and Norfolk Southern
  - General Electric Global Signaling System is the contractor for the installation on Amtrak Michigan Line
- **Electronic Train Management System (ETMS)** - $3.7M
  - Cooperate with Burlington Northern Santa Fe
  - Wabtec Electronics is the supplier for the systems in Illinois, Texas and Oklahoma
- **Collision Avoidance System (CAS)** - $735,000
  - Cooperate with Alaska Railroad
  - Union Switch and Signal is the developer of the system in Alaska

New directions

- ✓ Will not initiate any new PTC system integration/development demonstration (besides the low cost collision avoidance system)
- ✓ Focus on research areas to promote wide deployment of PTC
- ✓ Assist the industry in enabling interoperability
- ✓ Develop expedient risk assessment methods and tools
- ✓ Develop better communication network and train tracking methods for continuous improvement process of PTC development
- ✓ Focus on enabler technologies such as vital consist determination, automatic track discrimination, and on-board braking algorithm
- ✓ Develop technologies to eliminate or existing shortcomings of PTC systems
- ✓ Continue to use Broad Agency Announcement to solicit innovative approaches and proposals for PTC technology improvements
- ✓ Assist the industry and guide the Agency in requirements and standards

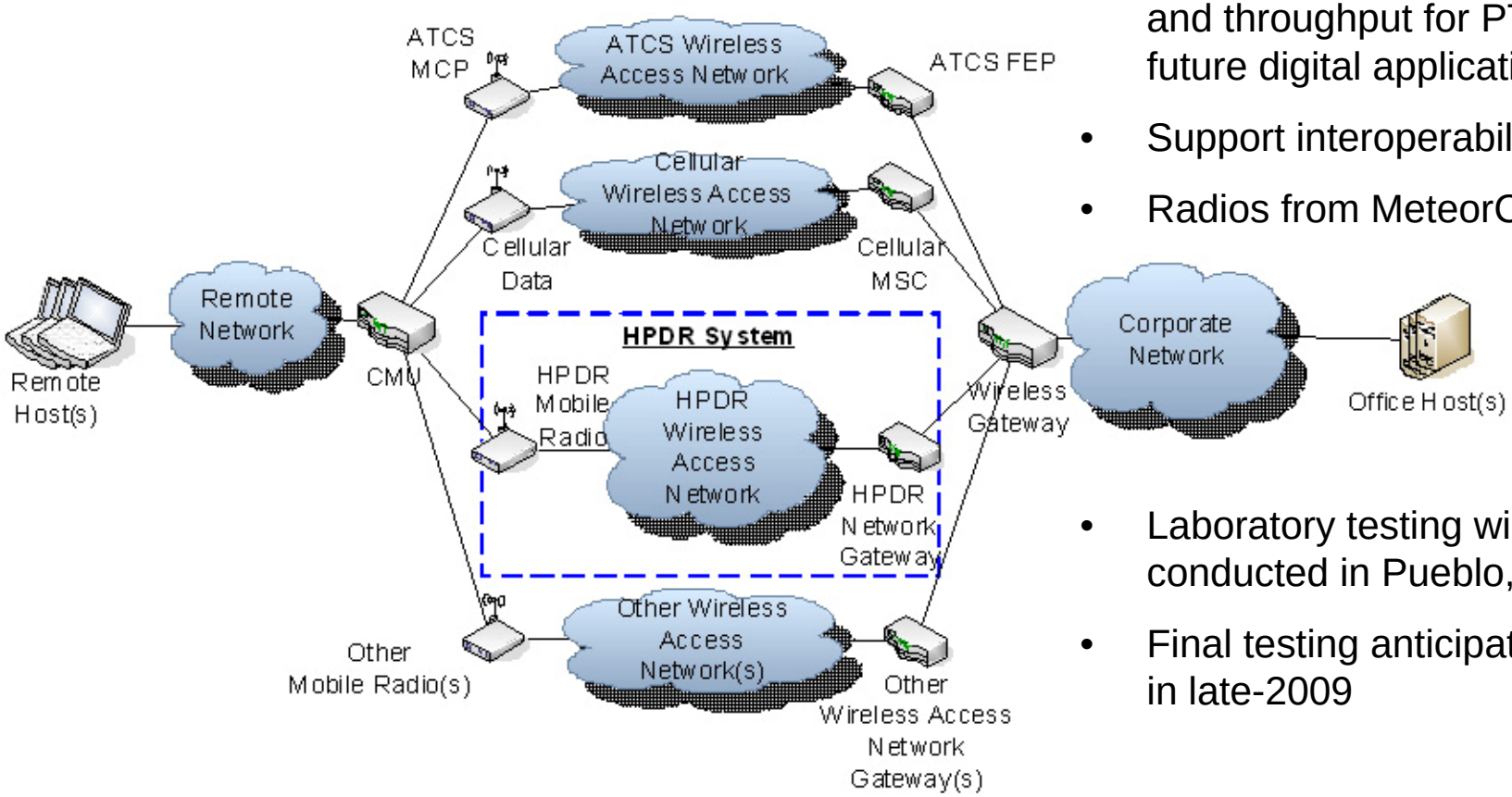
Enabler projects for better PTC

- **Need radio spectrum and adequate digital radio performance**
  - Higher Performance Digital Radio
  - Cooperate with AAR Wireless Communication Committee in identifying alternative solutions including utilizing new narrow band 160 MHz radios
  - WiFi and WiMax Testbeds
- **Need interoperability capability**
  - Completed development of Communication Management Units and Software Defined Radios
  - Interoperable Communication-based Signaling testing
  - Development of Universal On-board Platform
  - Testing of ITP/SIP protocol for interoperability message delivery

Enabler projects for better PTC

- **Need dependable braking algorithm**
  - Adaptive Braking Algorithm
  - Investigation of Modified Penalty Braking Scheme
- **Need reliable systems**
  - Higher Accuracy Nationwide Differential Global Positioning System
  - Practical Risk Assessment Methodology Development
  - Employee-in-charge Portable Terminal
  - Risk Assessment with Train Movement Simulator

Higher Performance Data Radio (HPDR)



- Provide sufficient bandwidth and throughput for PTC and future digital applications
- Support interoperability
- Radios from MeteorComm

- Laboratory testing will be conducted in Pueblo, CO
- Final testing anticipated to be in late-2009

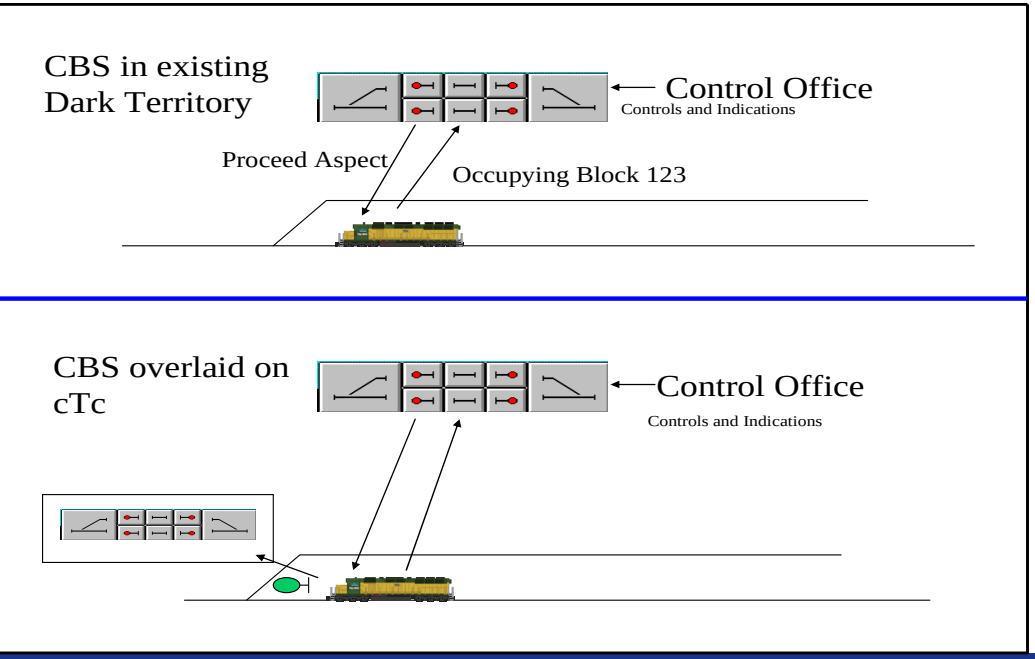
Wi-Fi and Wi-Max test beds

Typical Access Points

- ✓ Feasibility and performance study of Wi-Fi (802.11b/g) and WiMax (802.16e) wireless standard technologies
- ✓ Project is being led by University of Nebraska
- ✓ Evaluate the throughputs, mobility, reliability, security, and coverage range of these technologies
- ✓ Test bed in Hasting Subdivision of BNSF helps to quantify the throughputs for high speed moving trains up to 60 MPH
- ✓ Test bed also verifies the coverage range of the access points given the topology

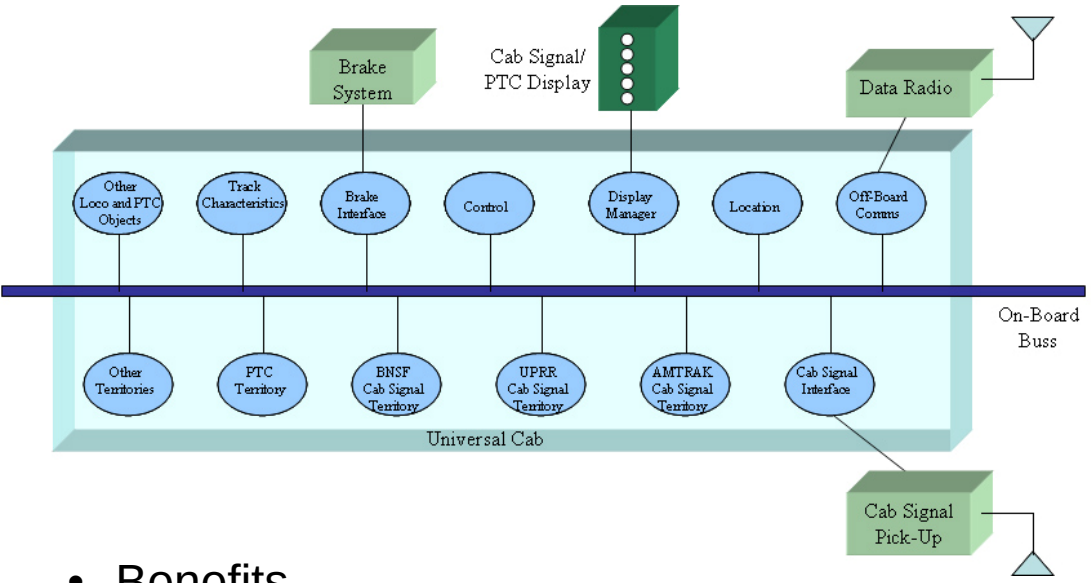
Interoperable communication-based signaling system

- AREMA standards will be used to test the communication-based in-cab system the laboratory environment for true interoperability capability
- AREMA standards may require revision based on these tests
- Interoperability will be demonstrated using each manufacturer's onboard equipment to interface with all other manufacturer's wayside infrastructure



- Manufacturers participants – GE, Safetran, Alstom and US&S
- Project initiated in late 2007 and projected to complete within a year
- Experience learned can be applied to future PTC interoperability testing

Universal On-board Platform (UOP)



To develop a single hardware platform which can support various cab signal and PTC operations with correct system behaviors, interfacing with infrastructure in various territories for these operations

- Benefits
  - Conform to industry interoperability objectives. Incorporate EMP, Class C and D messages into the platform for industry interoperability consideration.
  - Ensure backward compatibility with cab signal equipment
  - Cost effective solution to minimize capital investment for universal adaptability, in train control and other onboard applications
- Request for Proposal (RFP) resulted in selection of GE

Pre-requisites of Class 1 railroad interoperability

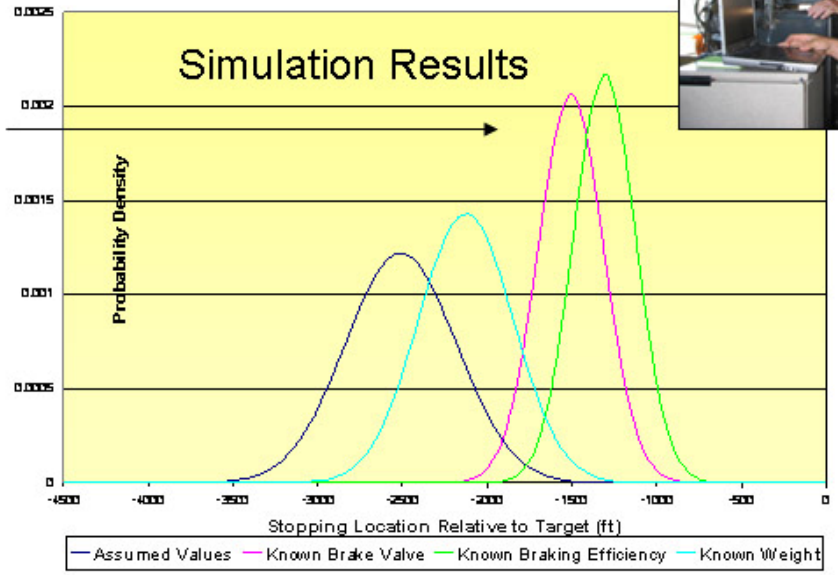
- **Message Set**
  - ETMS Common Office-Locomotive ICD
    - A message set which encompasses BNSF ETMS, UP VTMS and NS OTC system messages
- **Protocols**
  - EMP (Edge Message Protocol) as an upper layer message wrapper
  - Class C is an IP based multicast protocol
  - Class D is an IP based point to point protocol
  - ITP (Interoperability Transport Protocol) as a lower layer routable transport protocol
    - ITP is being tested for proof of concept using FRA funding
- **Communication Network**
  - UP, NS and BNSF will use 220 MHz radio network so interoperability is not a problem
  - CSXT is contemplating using 3 commercial cellular networks – not certain if they will convert
  - Industry with FRA support will continue HPDR development
- **Display/Screen/Control**
  - Technically this is not complex but need decision on whether one standard should be adopted

Adaptive Braking Algorithm

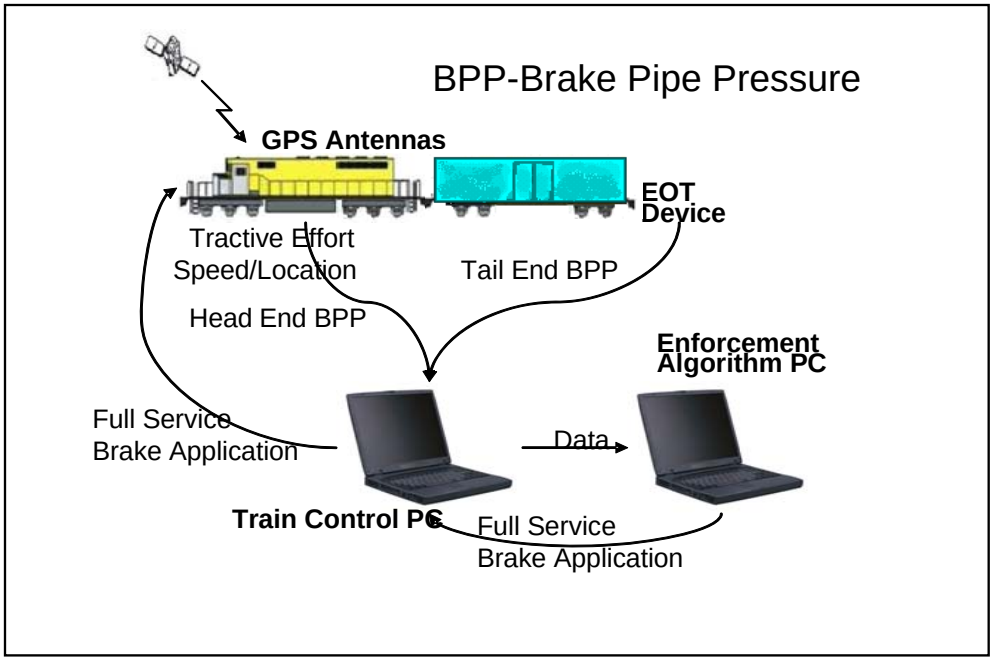
Field Test Results

Test	# of Cars	Load	Speed	Grade	Mean Stop Dist	Mean Dist to Trgt	Std Dev of Dist to Trgt	Prob of Overshoot	Prob of Undershoot
1	40	Loaded	40	Flat	3268	1294	30	0%	100%
2	40	Loaded	60	Flat	7275	1673	299	0%	100%
3	40	Loaded	40	Incline	2262	479	75	0%	0%
4	40	Loaded	40	Crest	2712	923	38	0%	0%
5	10	Loaded	40	Flat	2380	1397	40	0%	100%
6	75	Loaded	10	Flat	490	146	15	0%	0%
7	75	Loaded	40	Decline	4497	3895	140	0%	100%
8	40	Empty	40	Flat	N/A	N/A	N/A	N/A	N/A

- Braking distance of current NAJPTC algorithm can be off by close to 50%, affecting PTC performance and operation efficiency
- Need an adaptive braking algorithm as a close loop prediction for acceptable accuracy



Adaptive Braking Algorithm testing at TTCI

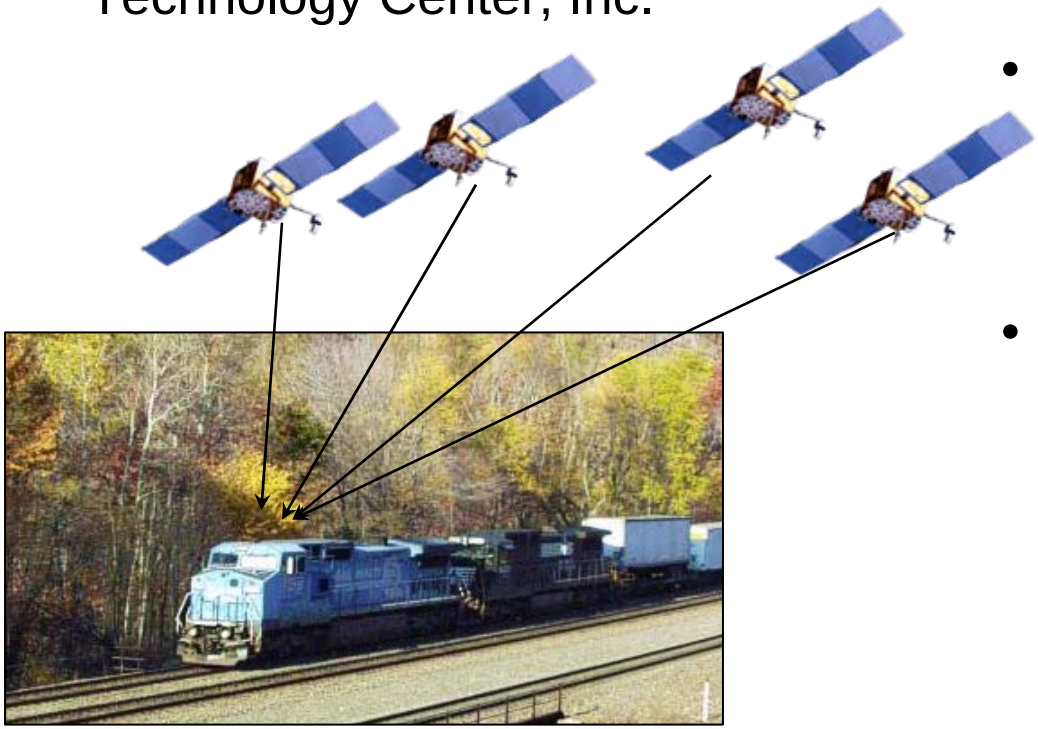


- Target completion date: end of 2008
- 40,000 simulated stops will be made with Train Operation and Energy Simulator prior to field tests

- Due to insufficient consist and brake equipment information, existing PTC braking algorithms are conservative, leading to inefficiency
- Feedback and close-loop algorithm to approximate actual values in brake propagation rate, train weight and brake efficiency
- Benefits are to enable a PTC train to stop as close to the target as possible within over-running it
- Also give leeway to the engineers in train operations instead of forcing them to apply braking early

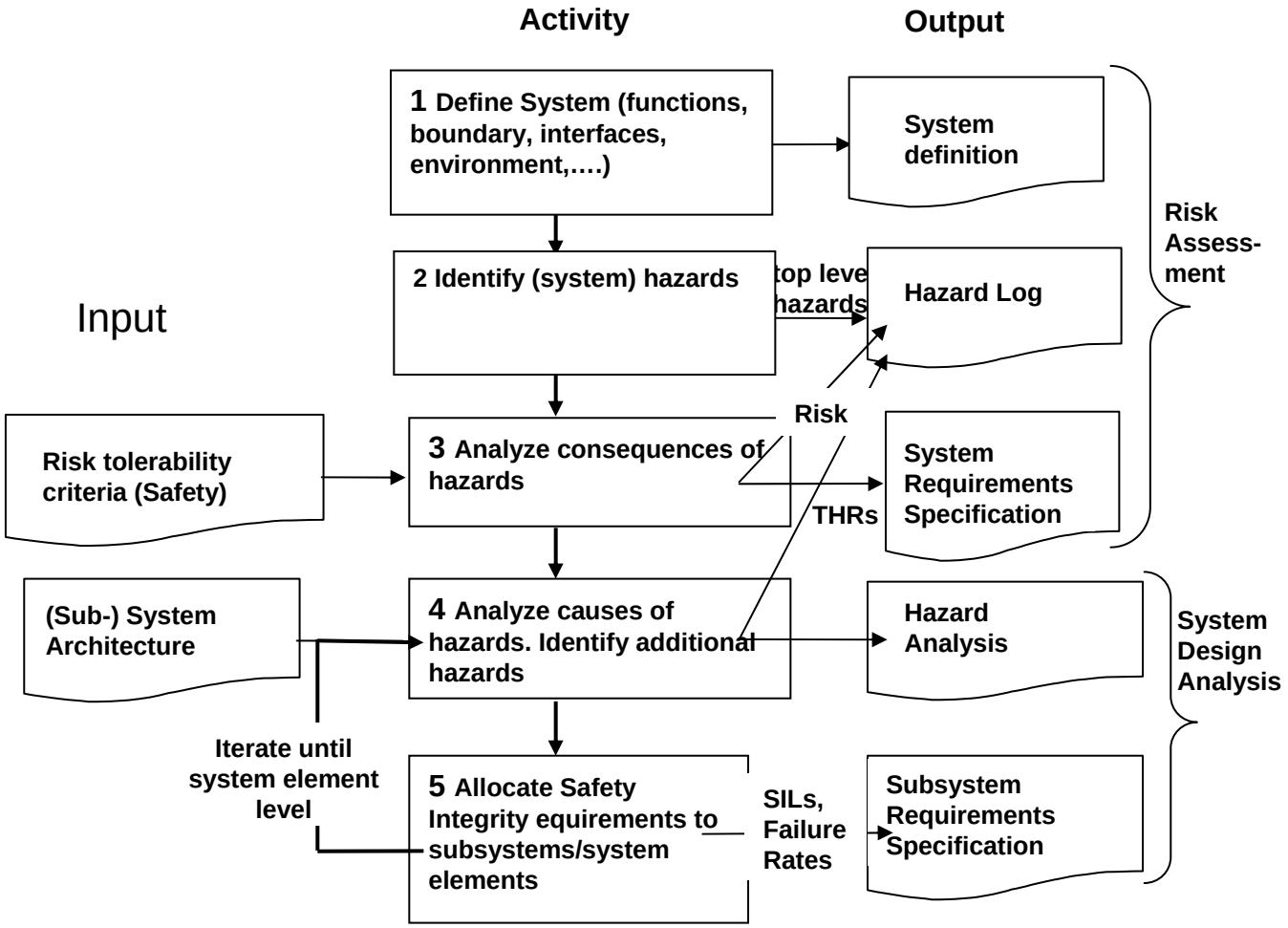
High Accuracy Nationwide Differential Global Positioning System

- High Accuracy Global Positioning System offers 10 cm to 20 cm resolution
- Provides a low cost but accurate positioning solution for PTC
- Tests scheduled for one year will be performed at Transportation Technology Center, Inc.



- Accuracy is sufficient to resolve which track the train occupies with a probability of success greater than 0.999999
- Tests will show the potential benefits and demonstrate the implementation for train control systems, track database maintenance, and other railroad applications

A Practical Risk Assessment Methodology (PRAM)



- US&S was contracted in late 2007
- A toolset will be developed, which includes database
- Methodology is to verify that the proposed system meets the tolerable hazard rate derived from the base system
- Target completion date: end of 2008

Employee-in-charge Portable Terminal (EIC PRT)

- Develop a vital, wireless, handheld device used by the employee-in-charge (EIC) of roadway workers to communicate with a CBTC system to:
  - Request and release work zones
  - Control entry and speed restrictions of trains allowed into the work zones
- Mitigate train/gang collisions within work zones (To be completed in September 2009)