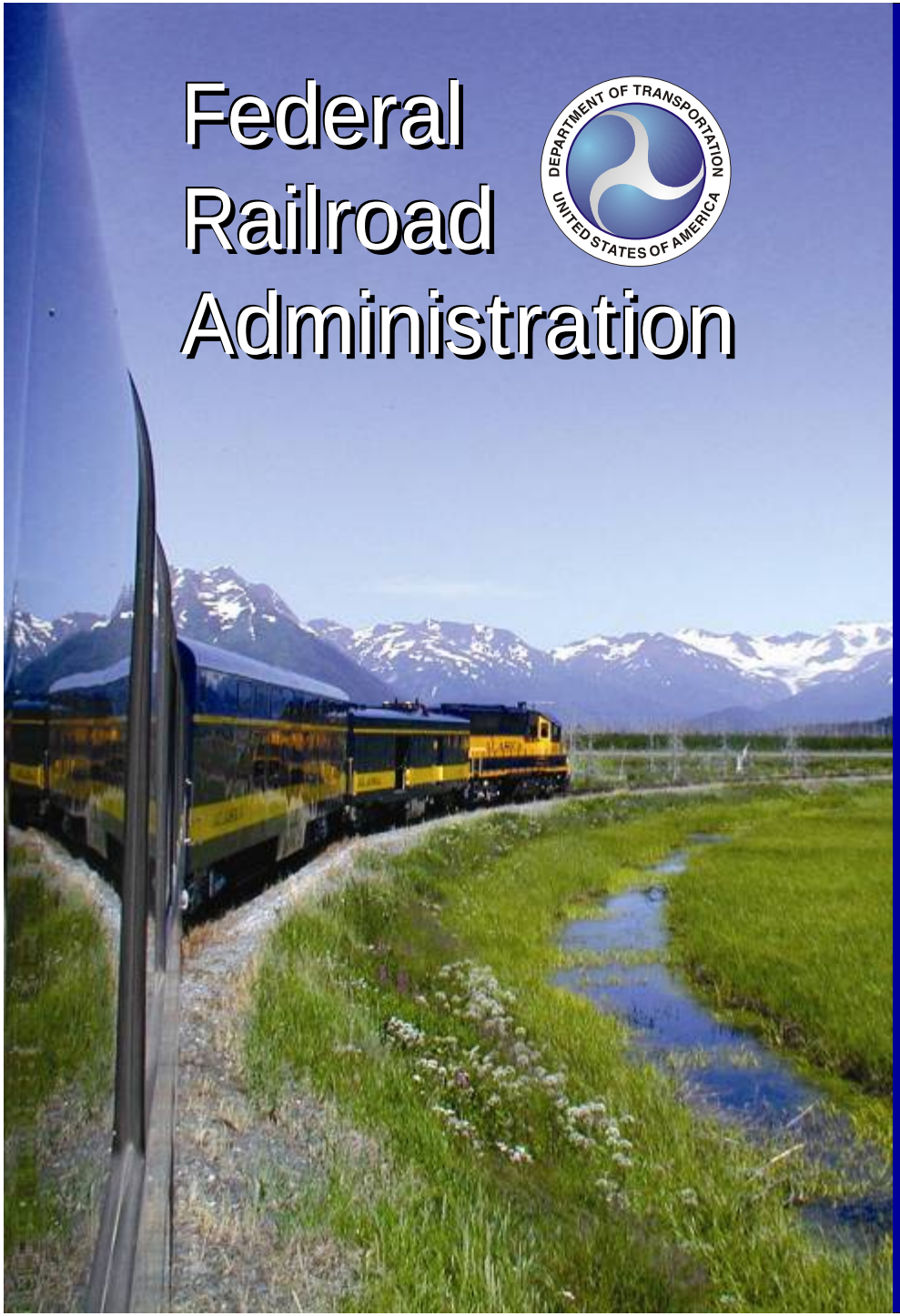
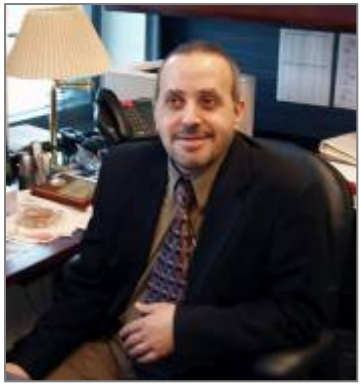


Overview: Office of Research and Development

Dr. Magdy El-Sibaie
Office of Research and Development

Federal Railroad Administration

Office of Railroad Development Organization



Office of Research and Development
Dr. Magdy El-Sibaie
Director

Equipment and Operating Practices Div.
Kevin Kesler
Chief

Signals, Train Control Communications Division
Sam Alibrahim, P.E.
Chief

Track Research Division
Gary Carr
Chief

Enacted 2009 R&D Budget

Program	FY 2008	FY 2009
• Railroad System Issues	3,168	3,155
• Human Factors	3,616	3,075
• Rolling Stock and Components	2,871	3,500
• Track and Structures	3,861	4,450
• Track and Train Interaction	3,168	3,100
• Train Control	5,600	7,120
• Grade Crossings	2,178	1,850
• Hazardous Materials Transportation	1,287	1,550
• Train Occupant Protection	5,120	3,600
• R&D Facilities and Test Equipment (F)	1,881	2,550
• Advanced Freight Locomotive Safety	980	0
• Dem and Deploy PTC in Alaska	735	0
• Center for Commercial Deployment of Transp Tech CA	245	0
• WVU Constructed Facility Center, WV	191	237
• Marshall Univ – Univ of Nebraska, WV	573	475
• PEERS Grade Crossings Safety Program, IL	490	475
• Ohio Hub Cleveland-Columbus Rail, OH	0	475
	$34.524M	$33.950M

Industry Overview
Freight and Passenger Railroads

Class I Freight Railroads	7
Intercity Passenger [Amtrak, Alaska Railroad]	2
Locomotives (Amtrak)	419
Passenger coaches (Amtrak)	1,505
High-speed train sets (Amtrak)	19
Commuter Railroads/Agencies	22
Passenger Locomotive/Coaches	6,392
Regional Railroads	33
Short-Line Railroads	523
Tourist, excursion, historical, etc.	102
At-Grade Crossings (total)	229,103
Public Grade Crossings	139,534
Private Grade Crossings	87,587
Pedestrian Grade Crossings	1,982
Freight Cars (total)	1,385,709
Freight railroad	580,630
Car Company & Shipper	747,955
Freight Locomotives (Class I railroads)	24,143
Major Classification Yards	88
Total Track Miles	201,920

Sources: FRA Safety Data Base & AAR Railroad Facts – 2008 Edition.

January 2009

Current Research Priorities

1. Positive Train Control (PTC) implementations and related technologies
2. Crashworthiness for passenger rail vehicles
3. Improved track inspection technologies - ATGMS, Joint Bar, VTI
4. Human Factors – fatigue (hours of service), CCC Reporting, RRP
5. Vehicle/track interaction (modeling and simulation)
6. Grade crossing safety and trespasser casualty mitigation
7. Risk-based analysis of tank car safety
8. Network capacity analysis
9. Energy efficiency and environmental issues (Bio-Diesel / Fuel Cells / Hydrogen Fuels))

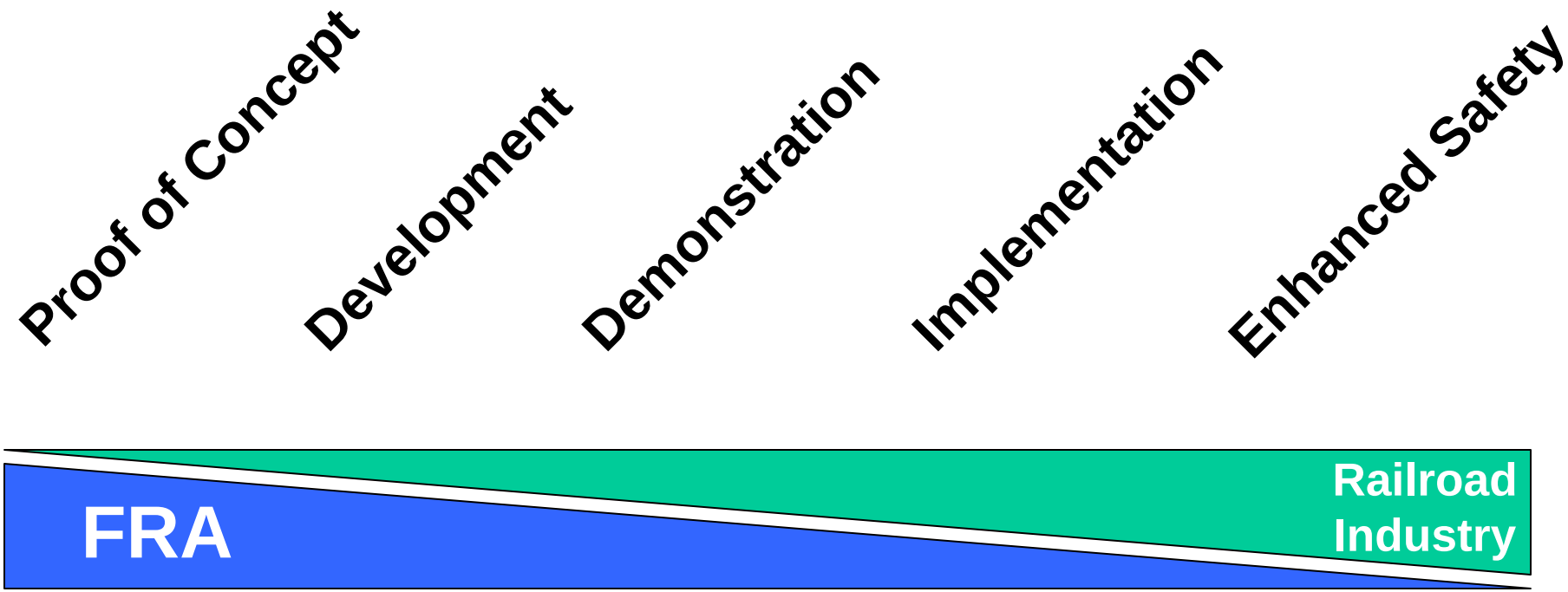
FRA R&D Mission

FRA R&D Provides:

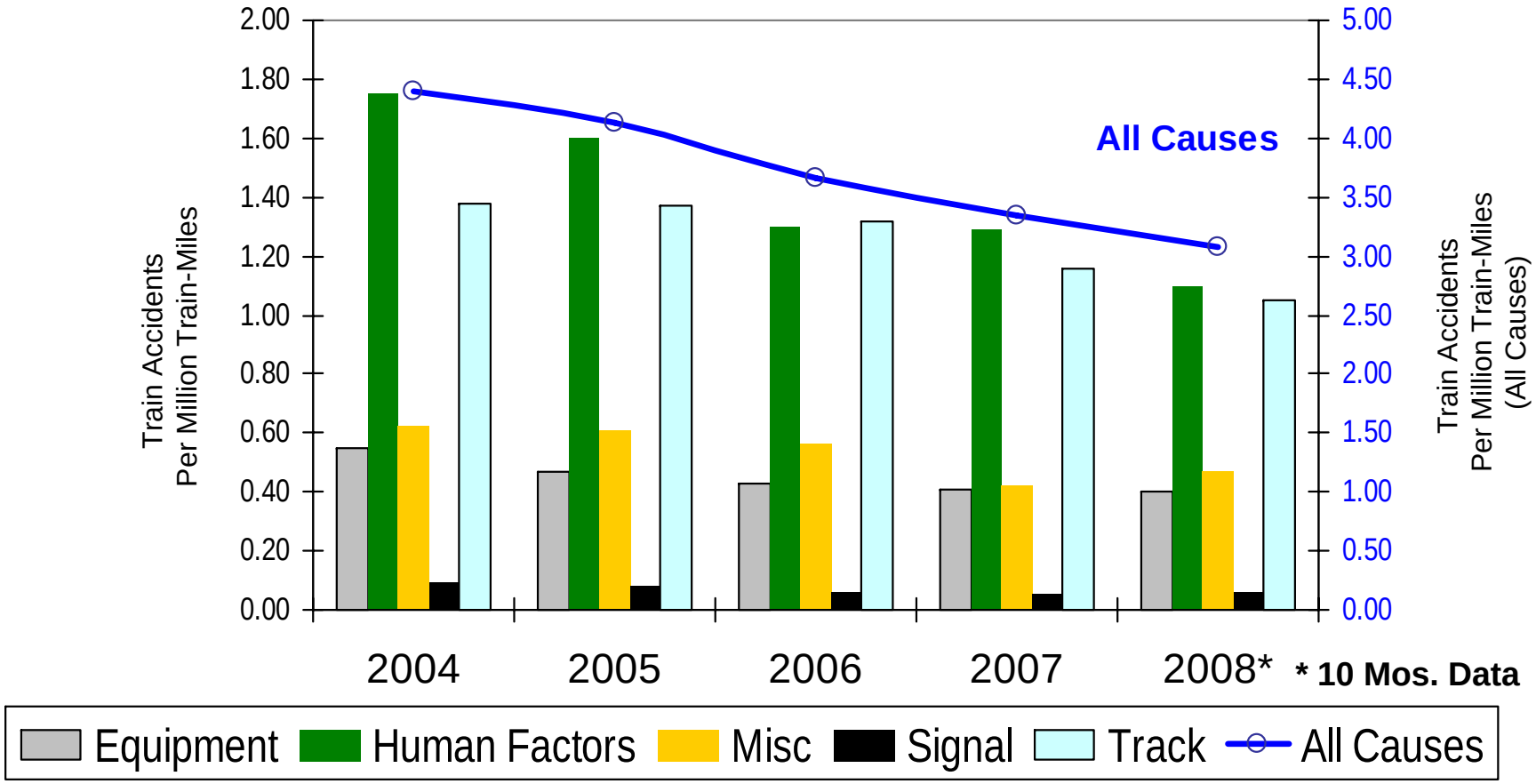
- Technical foundation for FRA safety regulations and industry recommended practice.
- Technical support to the Office of Safety including quick response for critical safety issues
- Leadership in the development and deployment of technology to enhance safety and performance
- Technical answers to inquires from stakeholders and constituents.

FRA's Role in Development

FRA and industry must work together develop long-term strategic plan for implementation and usage.



Reportable Train Accidents



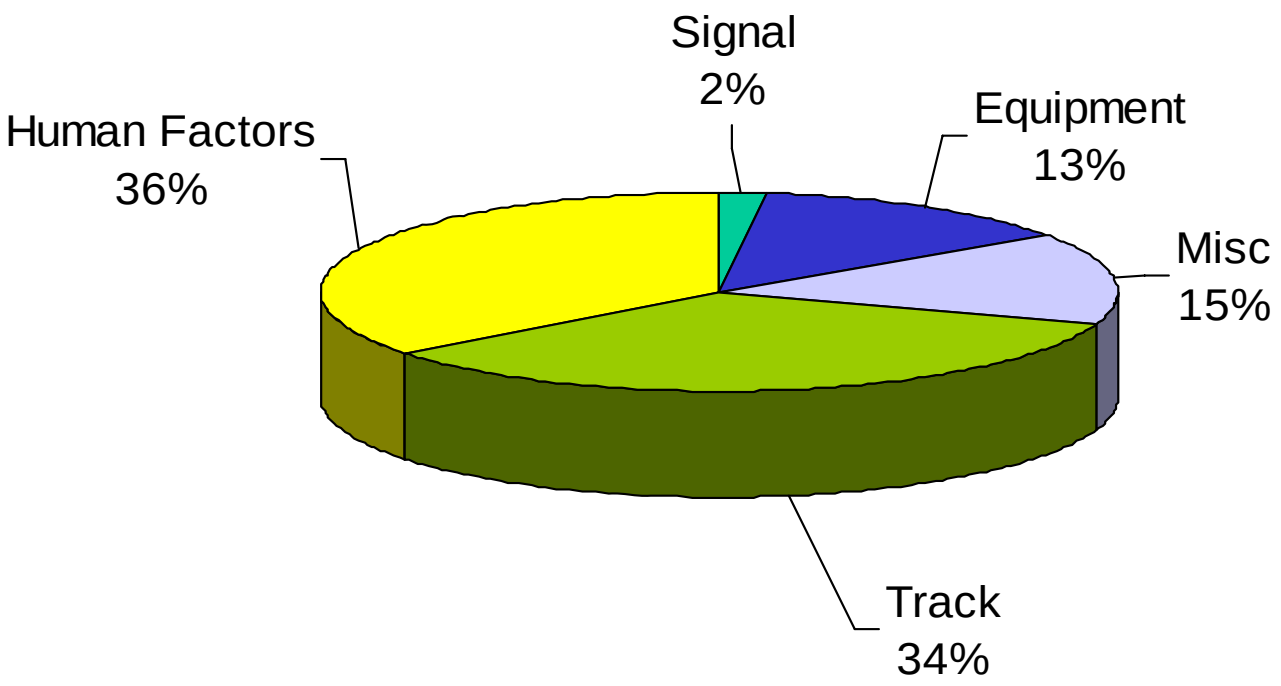
Source: FRA Safety Database

January 2009

Industry Overview
Train Accident Cause Categories

Accident Cause Categories – 2008 (Jan-Oct)

*Does not include Grade Crossing Accidents



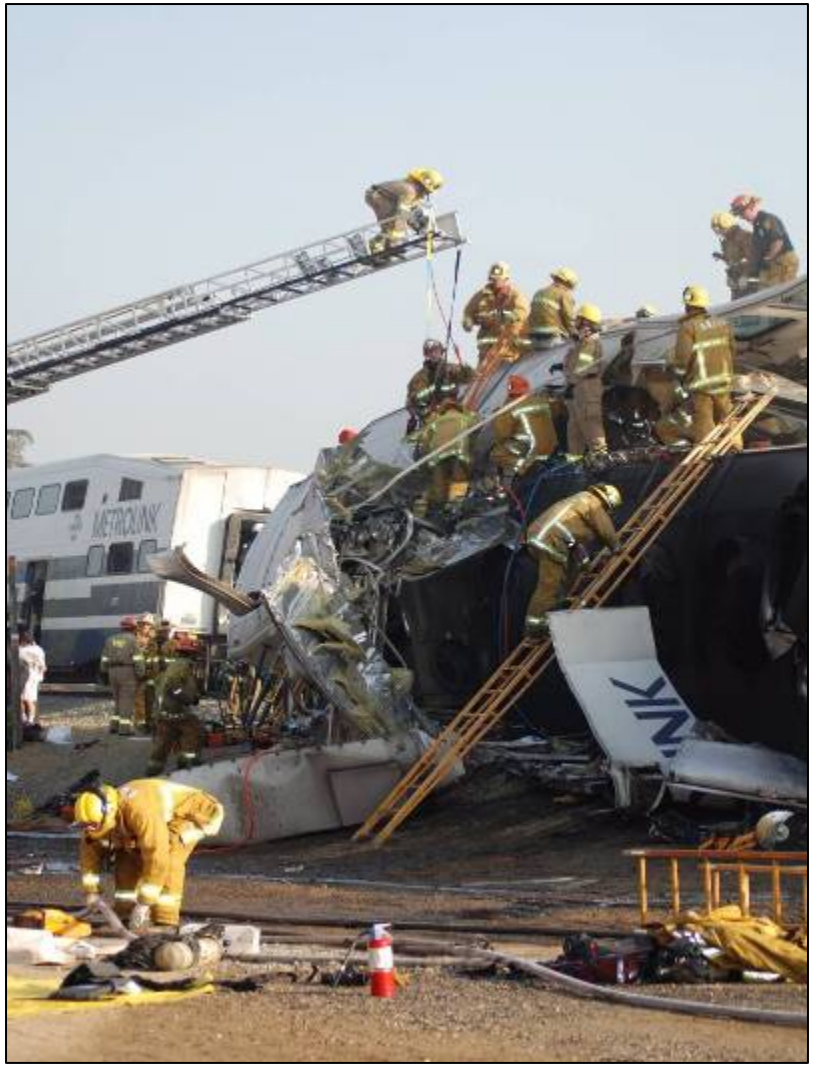
Source: FRA Safety Database

January 2009

PTC Implementation Is Now Mandatory

Head on Collision – Metrolink 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



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FRA Response To Congressional Mandate

Design and Build a New system that is at least As Safe As the Old

Familiar Task

Part 236, Subpart H

(existing rule)

Design and Build a New system that reduces risk by 80% for non-vital PTC

or

Design and Build a vital PTC system (vital overlay or stand alone PTC)

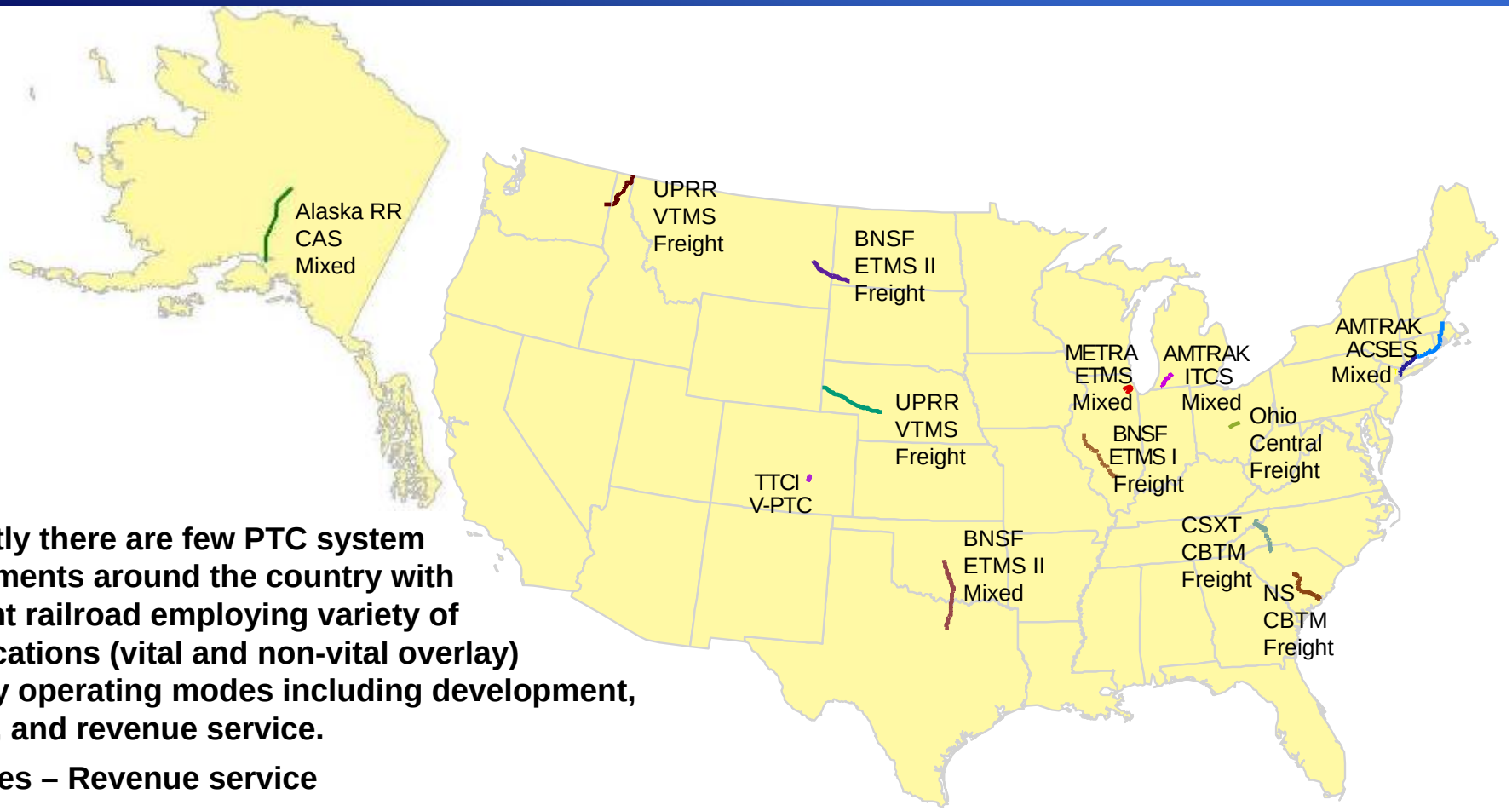
New Task

Part 236, Subpart I

(new rule)

Federal Railroad Administration

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

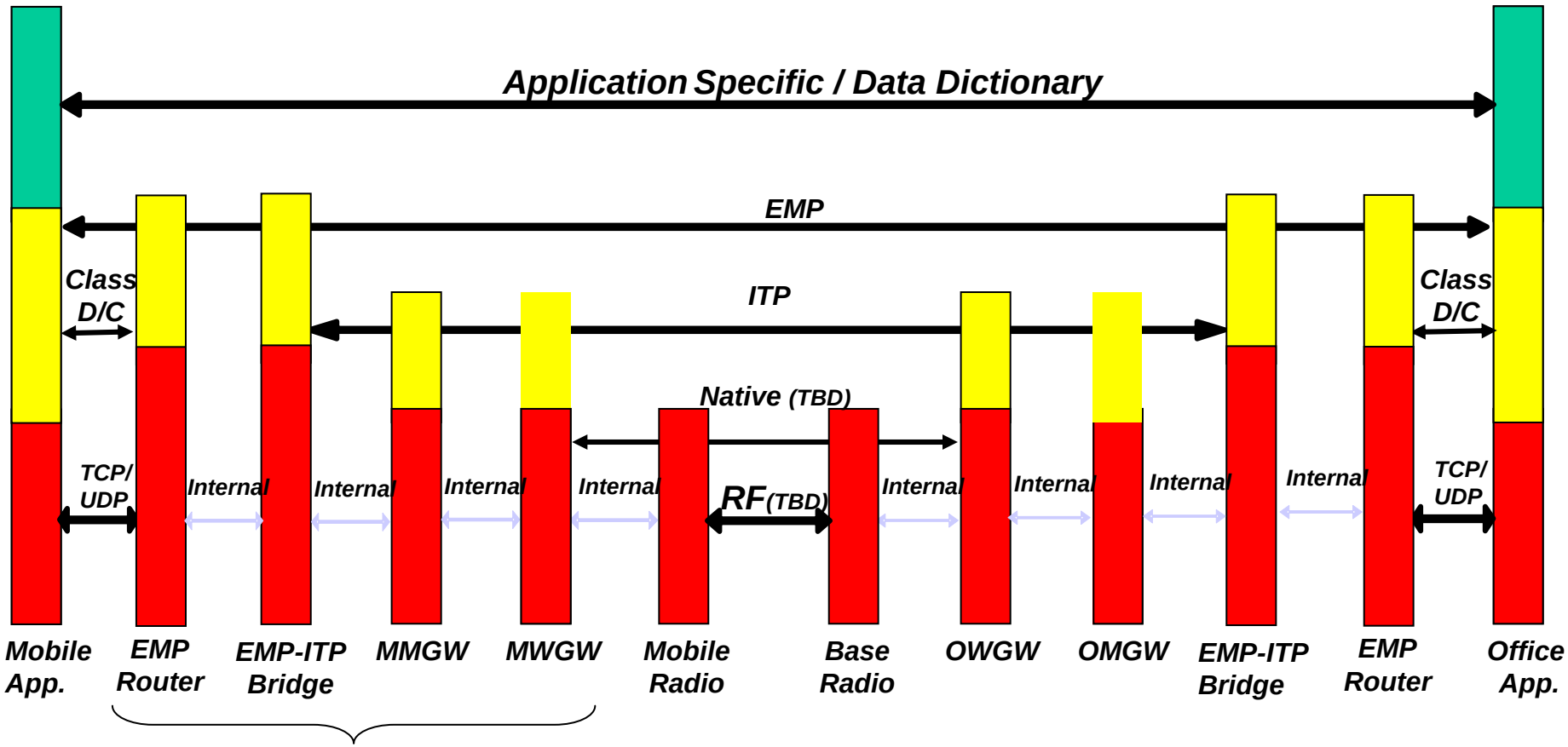
1374 miles – Development

(FRA funded and supported majority of these pilot projects)

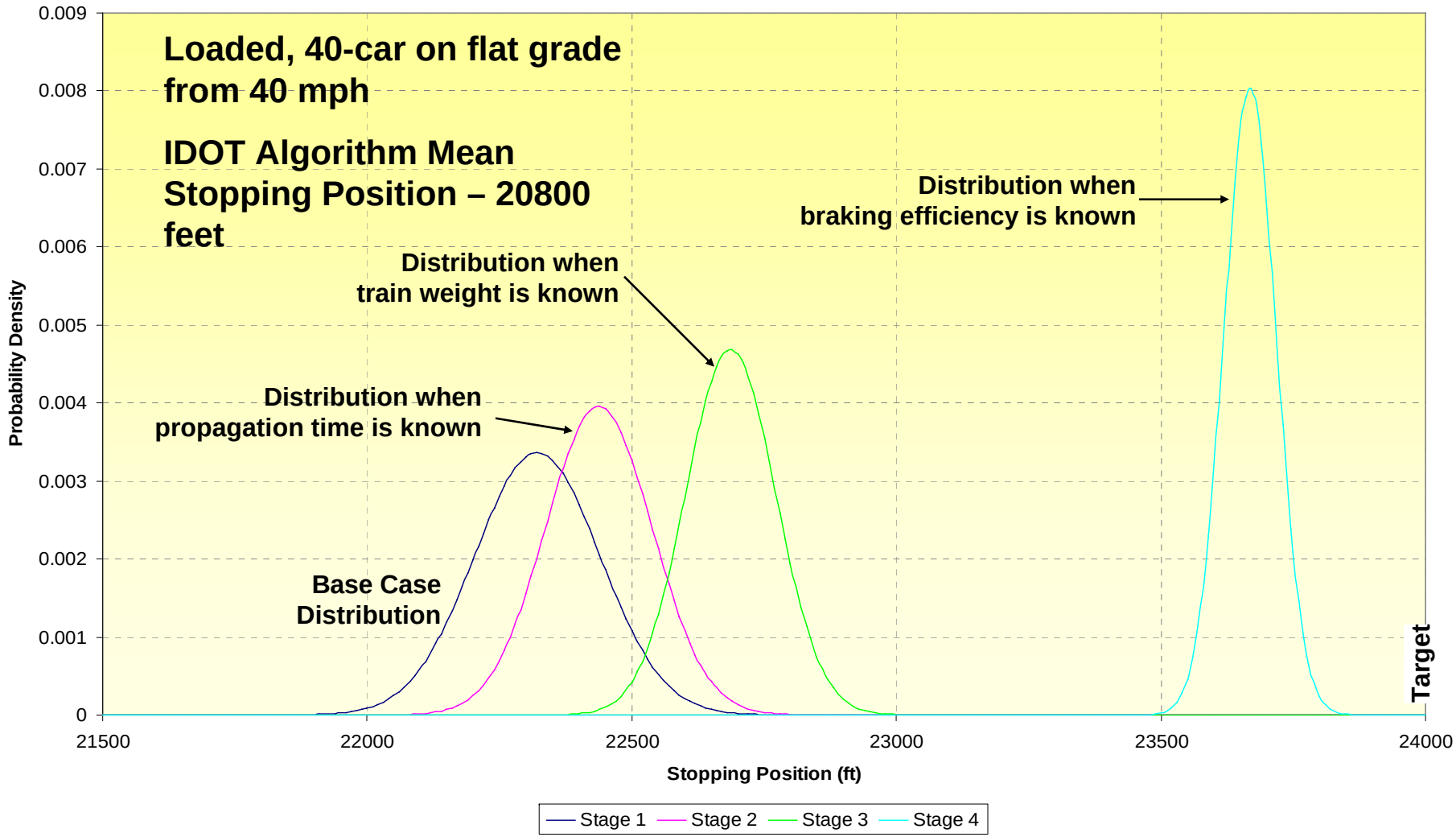
Communication Spectrum and Throughput

- Currently railroads use a variety of frequencies for data and voice including 900 MHz, 44 MHz, and 220 MHz with varying degrees of performance
- There is a general consensus to migrate to 220 MHz spectrum for better performance and throughput.
- Assist railroads in the migration to 220 MHz spectrum and petition FCC for waivers of “build or lose” provision for the 220 MHz spectrum. (UP and NS have acquired 5 channels of 25 KHz each)
- Conduct demand study using a basic territory model of a metropolitan area and based on the newly defined messages. (to be completed end of March)
- Develop other measures to improve throughputs and channel use: concatenate messages, use directional antennas, limit power etc
- Continue the development of HPDR (Higher Performance Digital Radio) with MeteorComm. (A prototype model is at TTCI for development testing)

Communication Protocol Testing



Adaptive Braking Algorithm

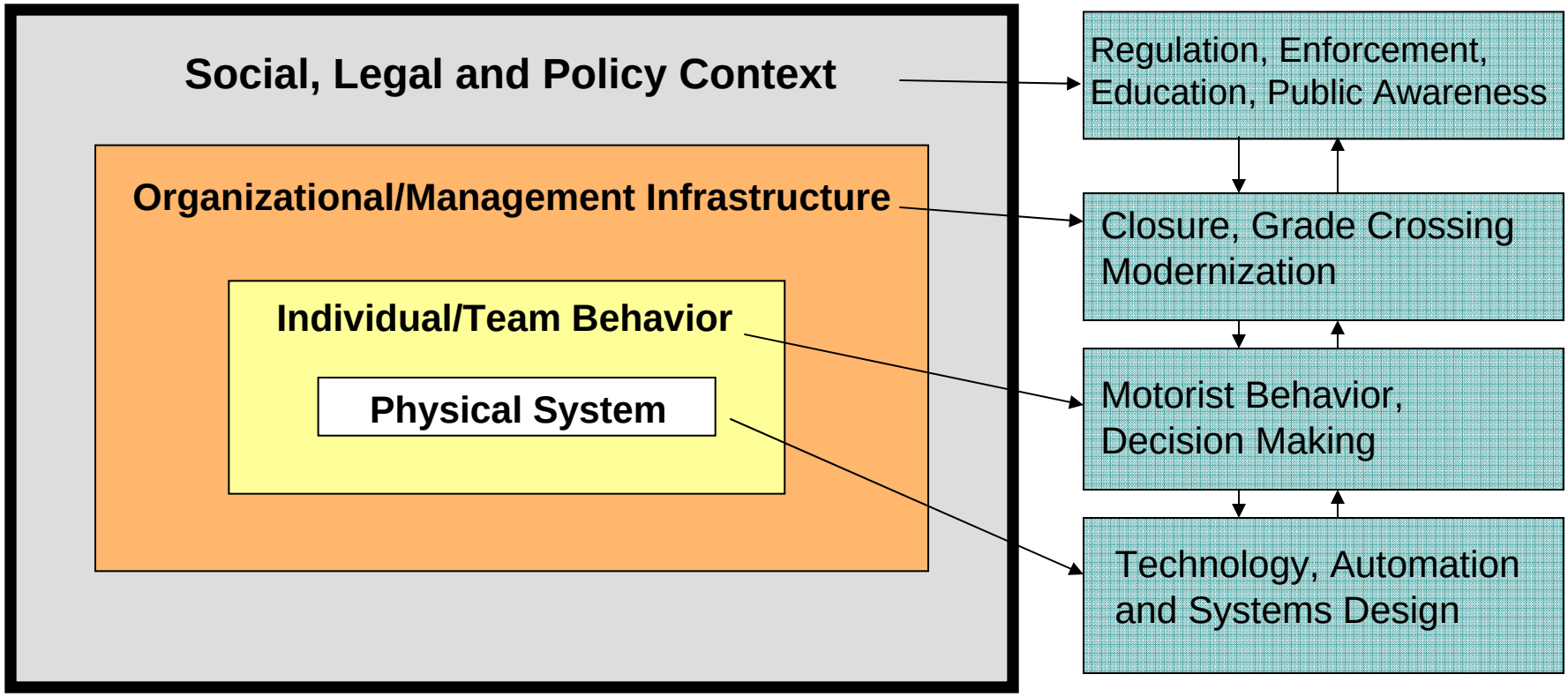


R&D Focus in PTC Development

- PTC interoperability standards
- Adaptive braking algorithms
- High performance digital radio
- Secure RF spectrum
- System reliability

Highway-Rail Grade Crossing R&D process

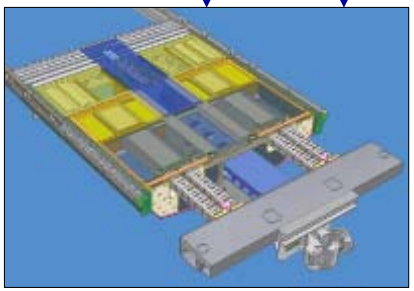
Grade Crossing R&D Strategic Focus



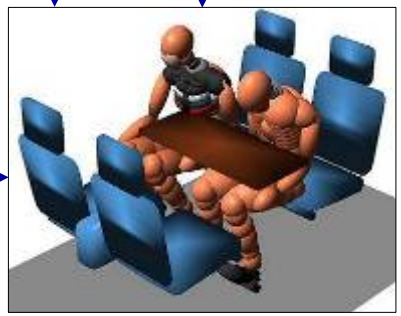
Train Occupant Protection – Passenger

Challenge- Equipment designed in Europe and Asia – do not meet U.S buff strength requirements

Full Scale Tests



Structural Crashworthiness



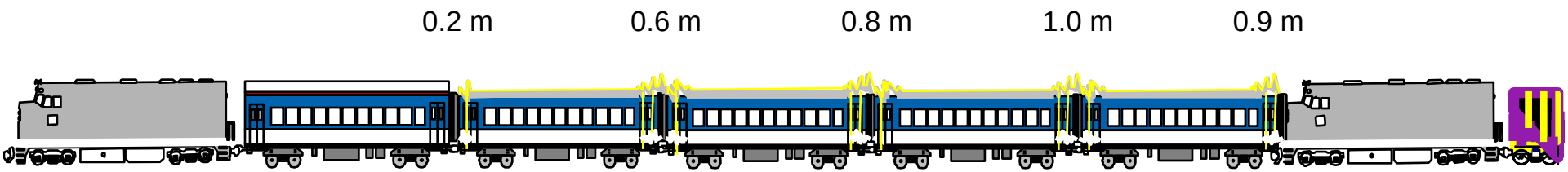
Occupant Protection

Train Occupant Protection - Passenger

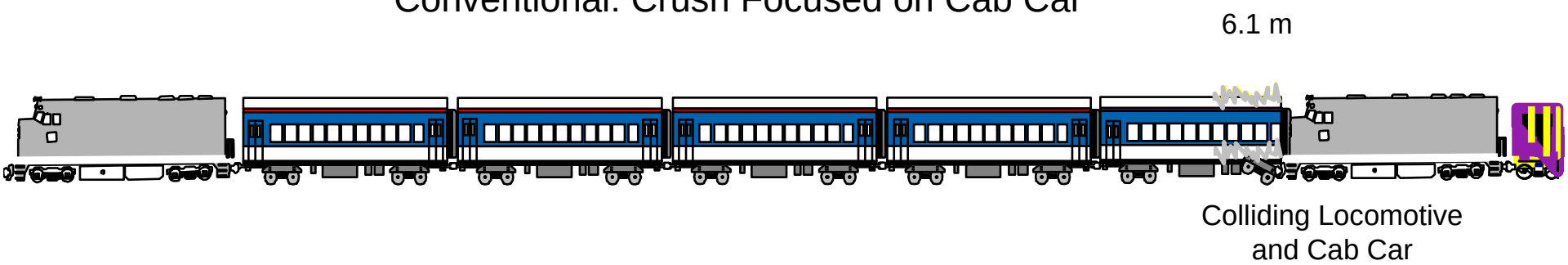
Crash Energy Management (CEM) Approach

Expected Crush Distribution for Train-to-Train Test with Conventional and CEM Equipment

Crash Energy Management: Crush Distributed Among Cab and Coach Cars

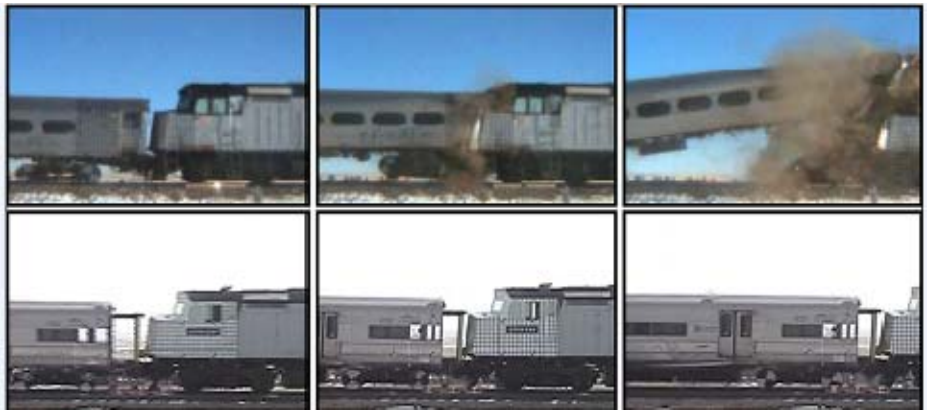


Conventional: Crush Focused on Cab Car



Train Occupant Protection – Compliance with Performance Standards

- Train collision dynamics
  - Motions of the cars during collision
  - Distribution of damage
- Car crush
  - Force required to collapse structure
  - Geometry of collapsing structure
- Occupant dynamics
  - Motions of occupants
  - Forces imparted to occupants



Note: Performance Standards for Crashworthiness are a More Recent Development in the Transit and Railroad Industries

Train Occupant Protection – Types of Standards

- Current FRA crashworthiness standards (prescriptive)
  - Prescribe characteristics of components
  - e.g., Collision post static load cases
  - Pro: performance verified with accepted techniques
  - Con: assumes design approach includes particular components

- Performance standards (as alternative or hybrid standards)
  - Prescribe performance in defined conditions
  - e.g., No loss of occupant volume for ***XX*** mph collision of a cab car led train with a locomotive led train
  - Pro: no assumptions on design approach
  - Con: can be difficult to verify performance

Train Occupant Protection – Alternative Standard Development Steps

- Step 1. Develop scenarios
  - Based on heuristic review of past accidents
- Step 2. Decide standard framework
  - Using hybrid of existing design/performance approaches similar to FRA/APTA/metrolink and EN12663/EN15227
  - Borrow from existing standards and use relevant research results
- Step 3. Develop evaluation/compliance procedures
  - Evaluate options for tests and analyses
  - Select criteria for evaluating results of tests and analyses
- Step 4. Determine compliance criteria values
  - Based on reasonably achievable level of performance
- Step 5. Produce standard(s)

Train Occupant Protection – Summary of Standards Goals

- Hybrid design/performance standards
  - Address features currently lacking in existing standards
    - **Compatibility** between different types of equipment potentially operating on the same corridor
    - Applicable to wide range of equipment – no assumption as to what structure looks like
  - Establish clear definition of equivalent safety
  - Provide clear guidance to car builders on allowable new/innovative designs
  - Application of CEM a potential means of achieving desired performance goals

Human Factors R&D

- Fatigue Risk Management
  - Required under Rail Safety Improvement Act of 2008
  - Focus on groups with highest risk
  - Use established baseline to evaluate effect
- Close Call - Voluntary and confidential safety reporting system
  - Federal Railroad Administration (FRA)
  - Bureau of Transportation Statistics (BTS)
  - Volpe Center
- Railroad Carriers
  - Union Pacific Railroad, Canadian Pacific Railway, New Jersey Transit (in process), Amtrak (in process), Association of American Railroads, American Short Line and Regional Railroad Association
- Railroad Labor Organizations
  - BLET, UTU, BRS

Hazmat Research - Goals

- Reduce risks associated with hazmat transportation by rail
- Understand structural performance of tank cars in current fleet during normal operations and during accidents
- Develop performance standards and technologies for maintaining tank integrity during all scenarios
- Assist FRA Office of Safety in promulgation of responsive rules to maintain safety of hazmat transportation by rail

Hazmat Research – Railroad Hazmat Rulemaking

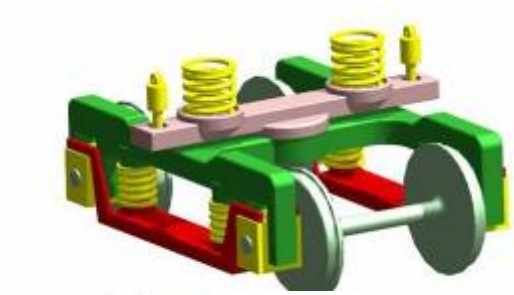
- NPRM issued April 1, 2008
- Comments from industry
  - Proposed standards are “technology-forcing”
  - Proposed eight-year implementation period is too aggressive
  - Proposed weight increase would result in light loading of tank cars or use of smaller cars
  - Proposed speed restrictions will cause congestion
  - Need for an interim standard for PIH tank cars

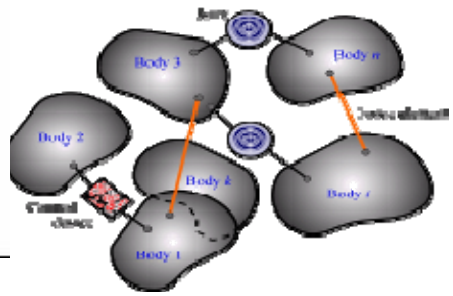
Hazmat Research – Summary of Final Rule (FR)

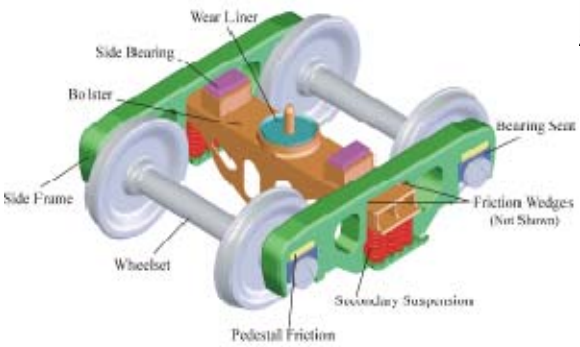
- Published Date: January 13, 2009
- Effective Date: March 18, 2009
- Responds to need for interim design standard for railroad tank cars
- Calls for enhanced commodity-specific design standards for PIH tank cars and scaled improvements based on existing DOT specification cars

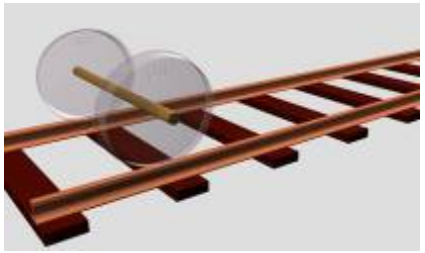
Track Research – Modeling and Simulation: Sams-rail

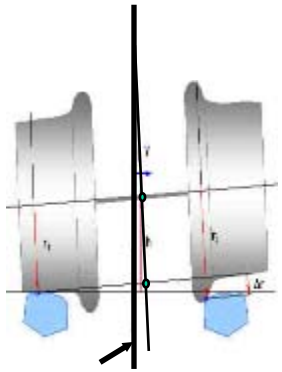
- Generalized multibody computer code
- Developed by the University of Illinois at Chicago
- Multibody formulation for railroad vehicle systems
- Method to study dynamics of railroad vehicles on tangent and curved tracks
- 3D wheel/Rail Contact
- Generalized Track Coordinates
- Being tested and validated by FRA/Volpe











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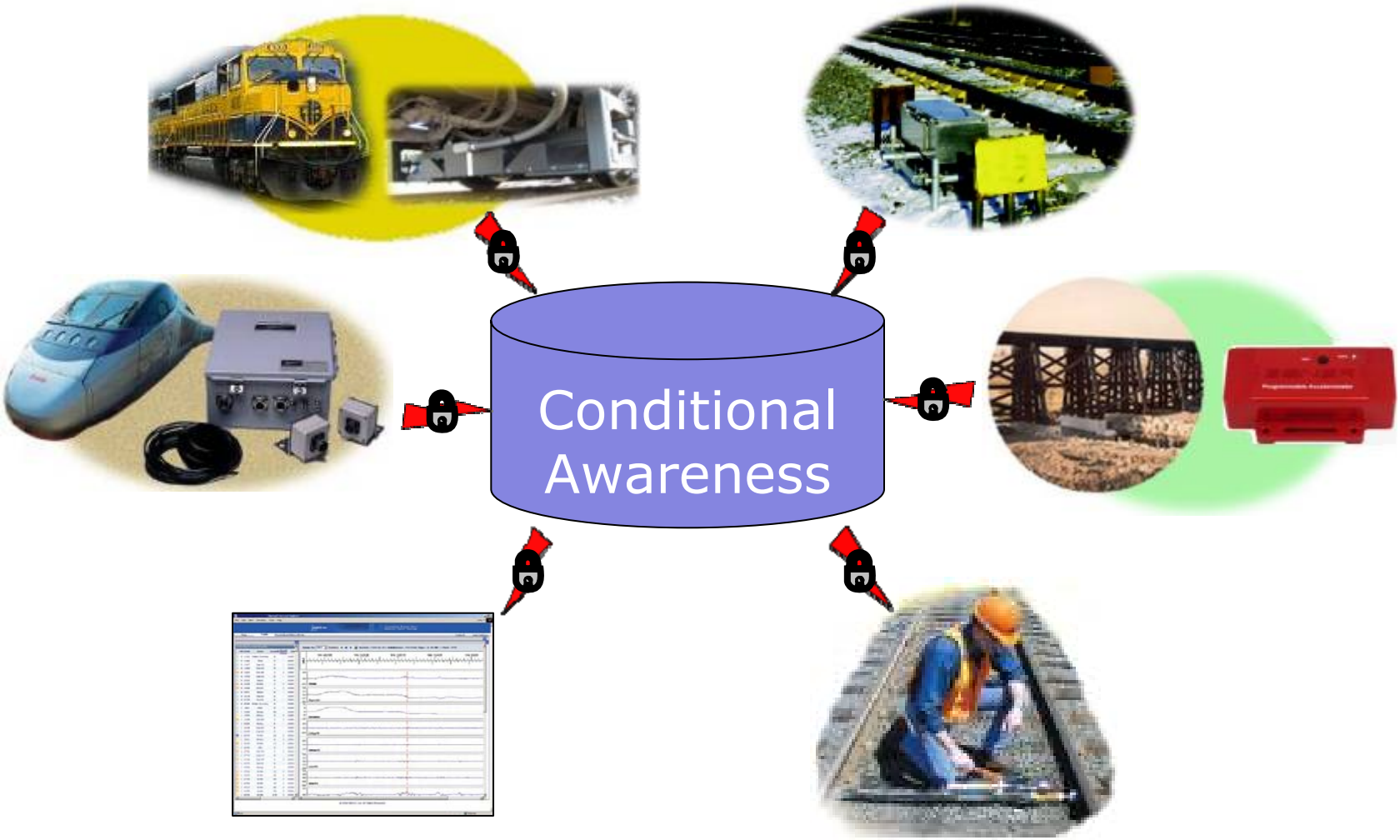
Track Research - Remote Sensing Technology Concept



Track Research – Vision Taking Shape

- Amtrak and most US Class 1 Freight Railroads have technology developed through industry/FRA initiatives to monitor vehicle and truck performance remotely;
- FRA is currently developing:
  - Autonomous track geometry inspection technology,
  - Rail neutral temperature monitoring devices and rail temperature prediction applications,
  - Rail defect detection systems,
  - Joint Bar inspection systems,
  - Bridge condition reporting systems.
- Many in-place monitoring systems being developed today could eventually be deployed autonomously.

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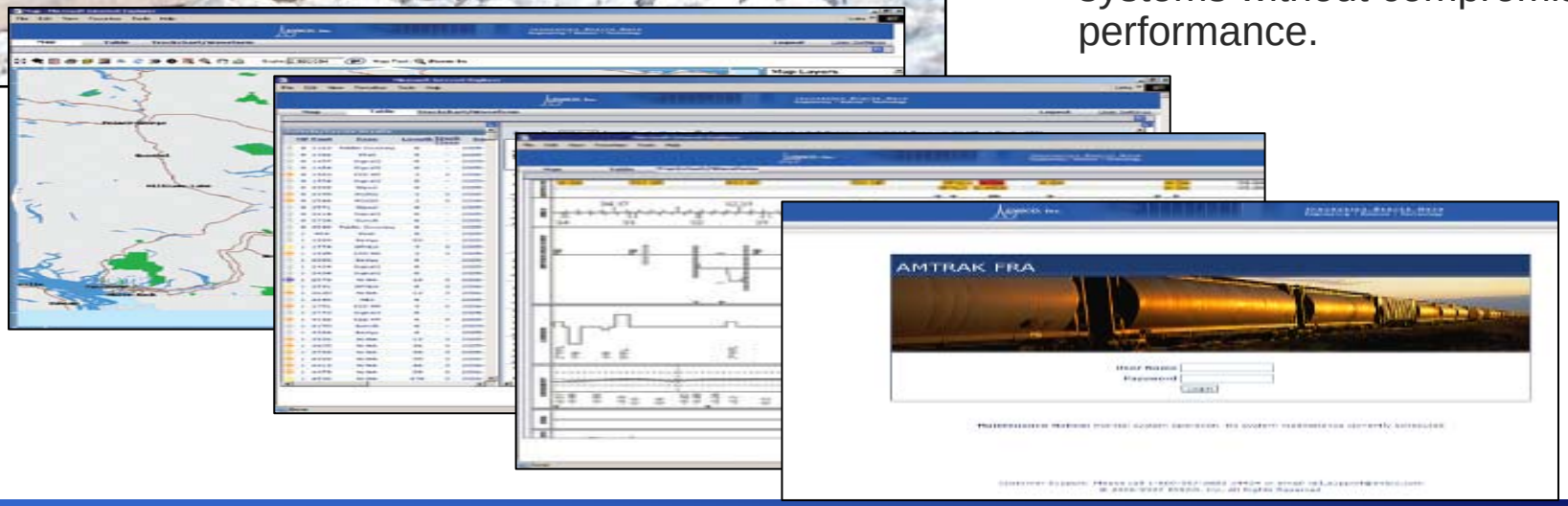
Autonomous Track Geometry Measurement System (ATGMS)



- Track conditions can be monitored every time the car with the ATGMS moves on track.
- Normal business and traffic will not be interrupted for testing by dedicated test cars.
- The system offers an effective reduction in complexity, size and cost of traditional geometry systems without compromising performance.

Federal Railroad Administration

Autonomous Track Geometry Measurement System (ATGMS)

- Remote continuous assessment of track geometry conditions
- Pinpoints location, time, and description of critical conditions for remediation
- Communicates critical conditions in realtime
- On-board system health monitoring
- Remote calibration of system sensors
- Forecasting and trending of track conditions is significantly enhanced
- Greatly enables condition-based maintenance
- Displays real-time vehicle location and data through the Web

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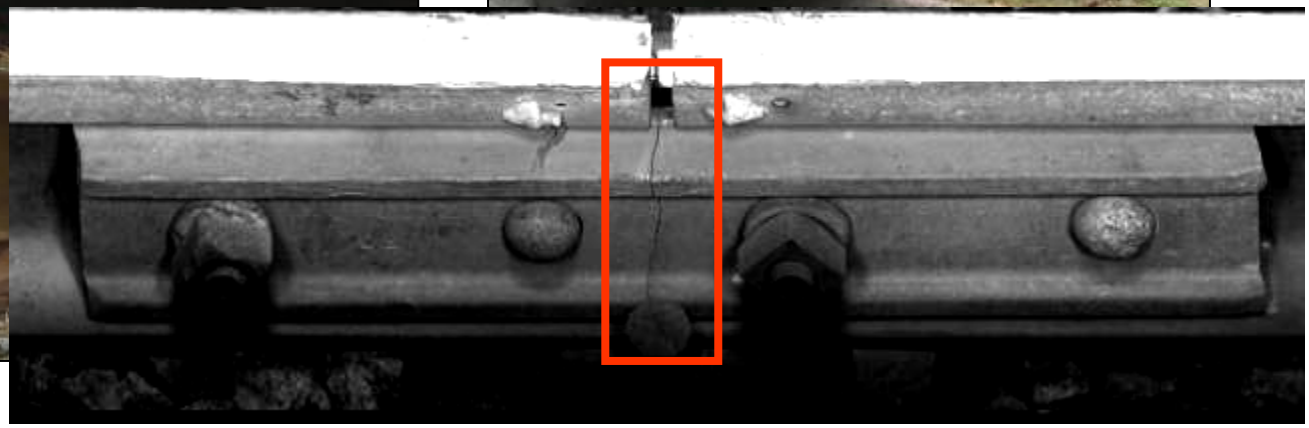
Joint Bar Inspection System



Joint Bar Inspection System Findings in the Field

- The systems have surveyed (August 2007-June 2008):
  - 3480 total number of defects found
  - 6630 miles of track
- Between Jan-Jun 2008, 379,150 Joints were inspected by all the deployed systems
  - 2555 miles tested (1425 miles Jointed track, 1130 Miles CWR)
  - 900 center cracks, 190 center breaks
  - 55 double center cracks (both bars center cracked on the same joint)
  - 15 double center breaks (both bars center broken on the same joint)
  - 850 quarter cracks and breaks
  - 300 stripped joints (all bolts missing on one side of the joint)

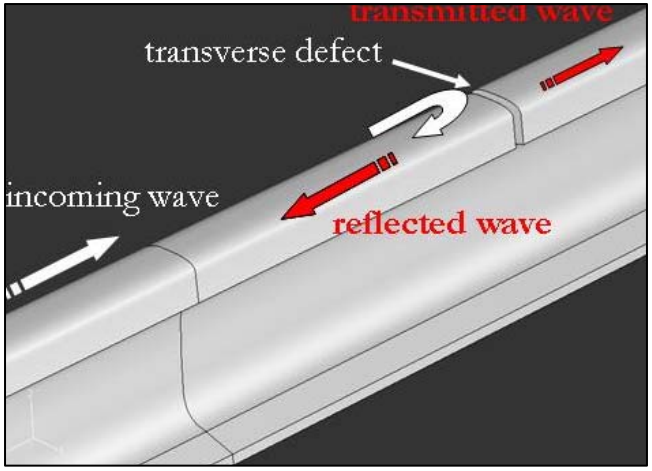
Joint Bar Inspection System Findings in the Field

- Technology was pioneered by FRA Office of R&D
- Rapid development and deployment in field testing that made an impact on safety
- Five commercial inspection systems have been produced and are in use.

Rail Defect Detection
Elements of Prototype

Elements include:

- A *pulsed laser* for exciting the ultrasonic guided waves, arrays of *air-coupled sensors* for detecting the ultrasonic guided waves and r*ail flaws detected* by comparing signals from the array through a statistical pattern recognition algorithm



Advantages Are:

- No contact with rail (>1.5” lift-off), potential for high speeds (current capability 40 mph, potentially increasable), reduced masking of internal defects under head checks/shelling and statistical algorithm provides classification between joints, surface defects and internal defects in real-time

Federal Railroad Administration

Research & Development Cars