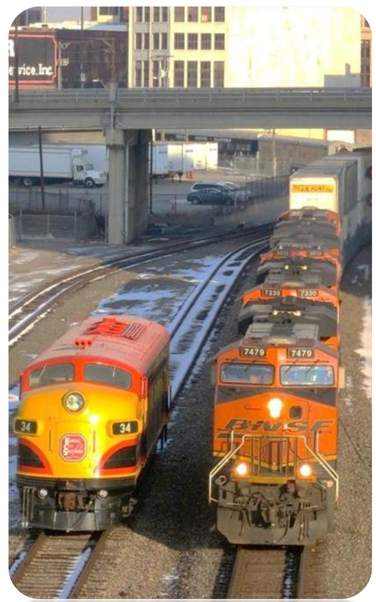
# NCHRP Report 755
# Cost of Crossing Collisions

## UNECE Group of Experts on Safety at Level Crossings – 4th Session

## Geneva, Switzerland

# Who We Are

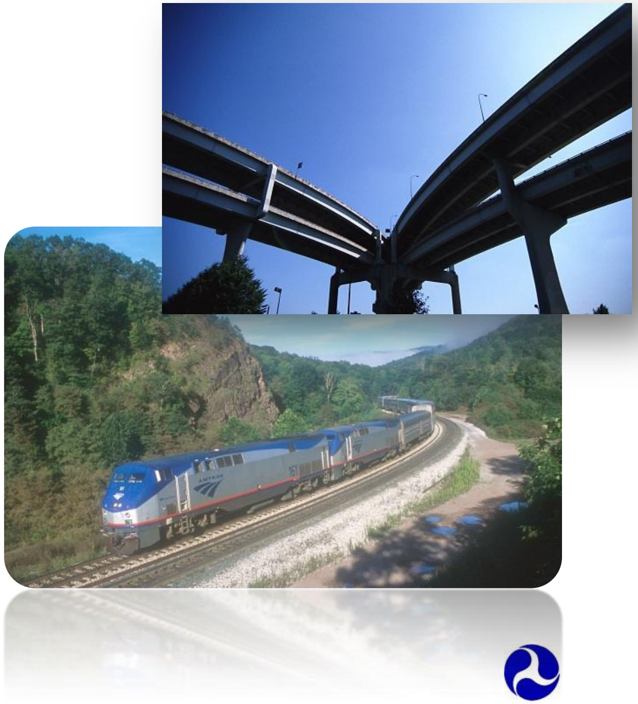




# RAIL– *Moving America Forward*

## Who We Are

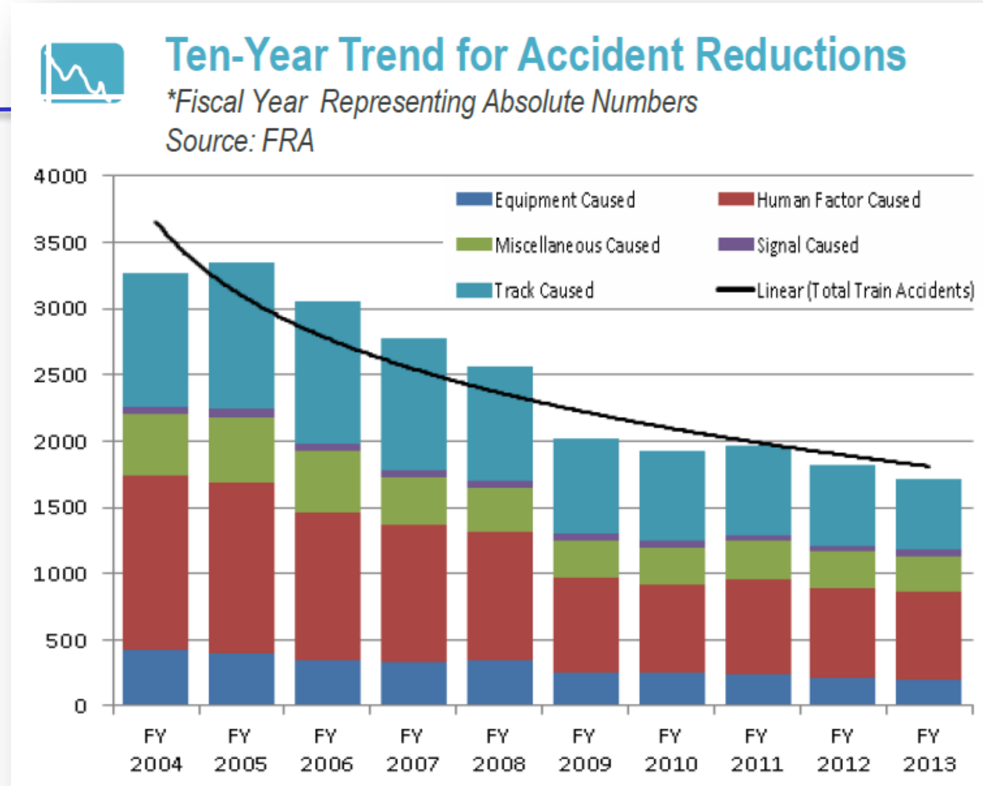
**The Federal Railroad Administration (FRA)** enables the safe, reliable, and efficient movement of people and goods for a strong America, now and in the future.

- Safety is our number one priority
- Continuing a rigorous oversight and inspection program based on strategic use of data
- Advancing proactive approaches for early identification and mitigation of risk
- Predictable dedicated funding to improve infrastructure through capital investments and robust research and development
- Laying a foundation for higher performing rail



# *Safety is our number one priority*

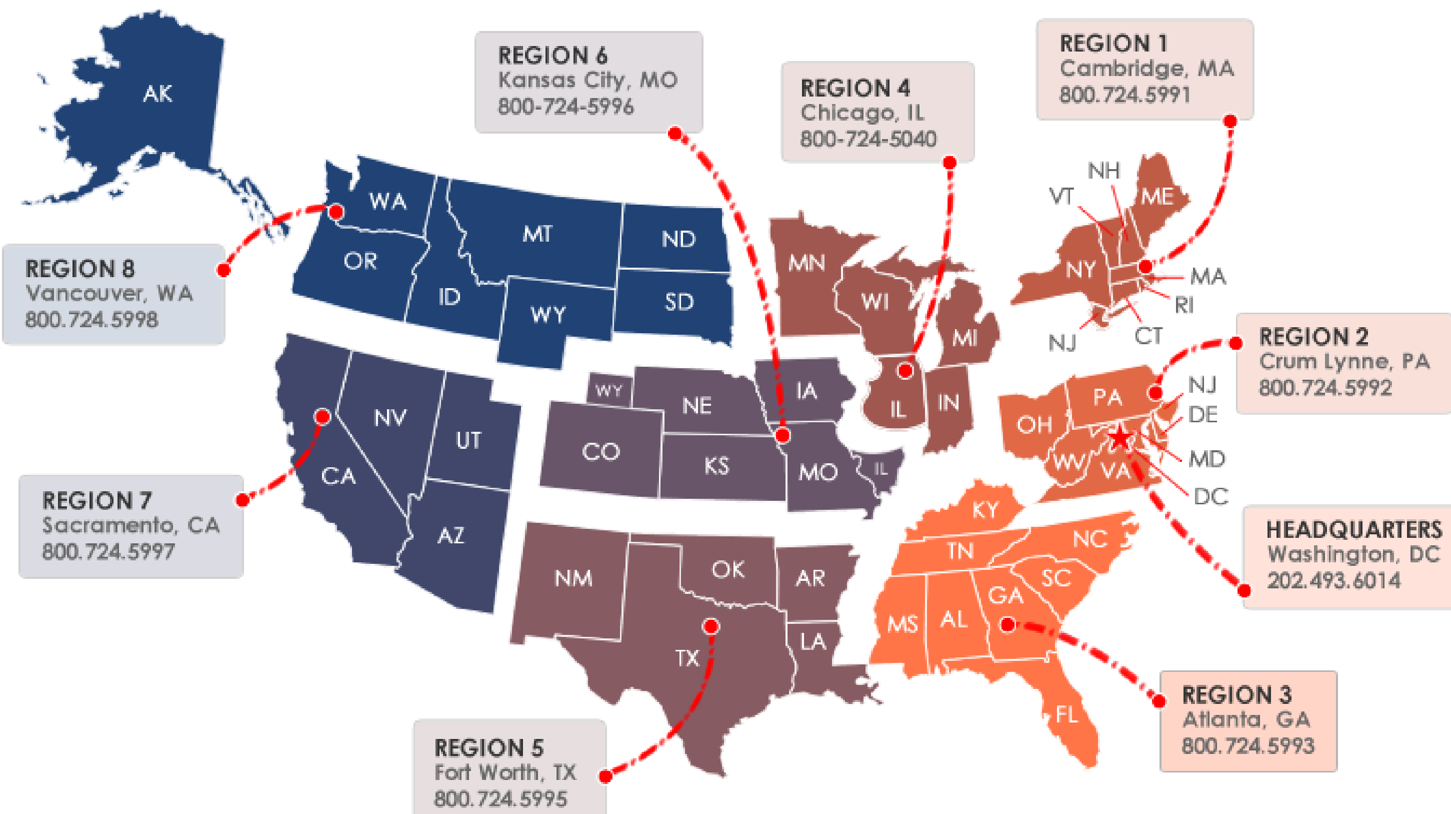
## Rail Has Never Been Safer




Every regulation and enforcement action we issue is based on facts and sound research. New records in safety have been achieved four of the past five years.

- Over the past decade, train accidents have declined 47 percent
- Highway-rail grade crossing accidents are down 35 percent
- And employee fatalities have been reduced by 59 percent

# *Safety is our number one priority*



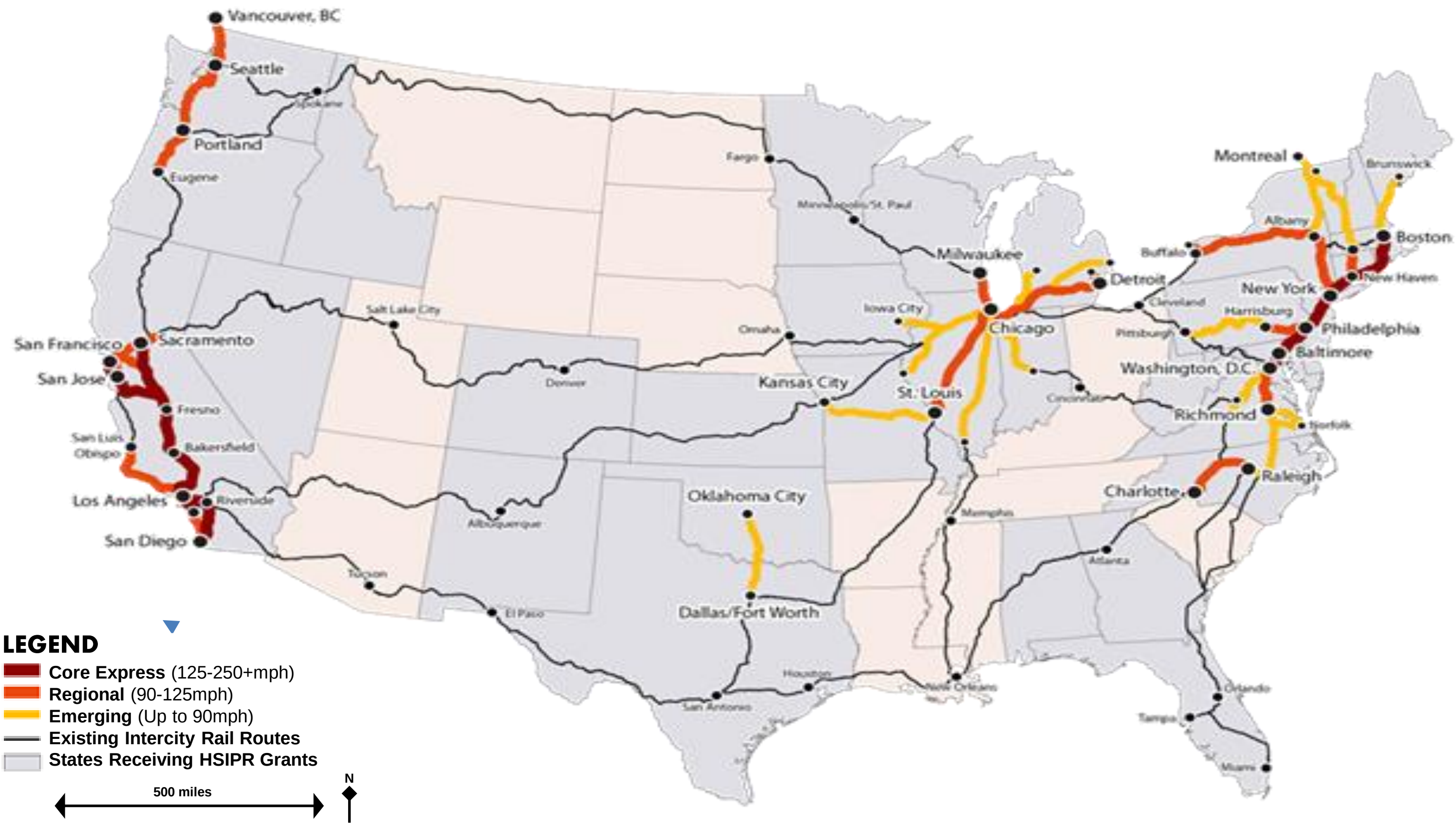
# *Laying a foundation for higher performing rail*

Our Multi-Billion Dollars Portfolio Includes:

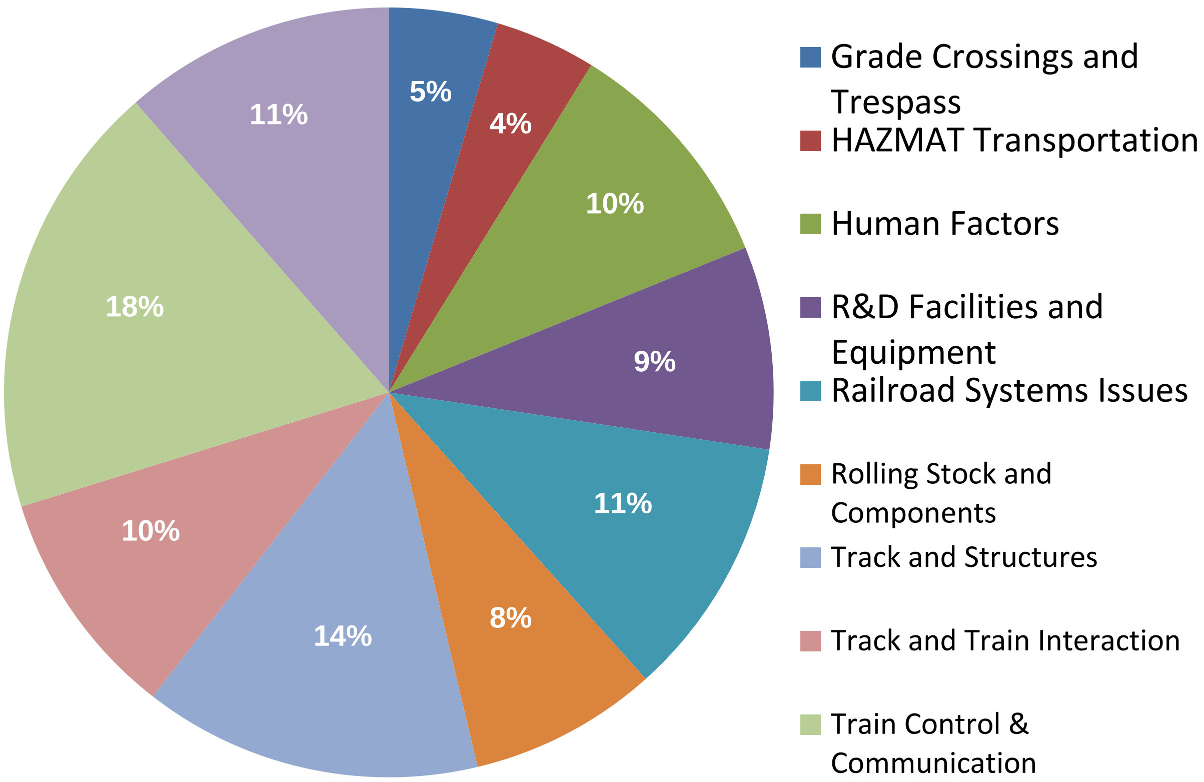
- Amtrak Operating and Capital Programs - $7 billion
- High Speed and Intercity Passenger Rail (HSIPR) Grants - $10.1 billion
- Research and Development - $30 million
- Railroad Rehabilitation and Improvement Financing (RRIF) Program – $1.7 billion
- Transportation Investment Generating Economic Recovery (TIGER) Programs - $423 million
- Rail Line Relocation Grants - $86 million
- Disaster Assistance Grants -$18 million

## *Laying a foundation for higher performing rail*

The High Speed and Intercity Passenger Rail Program

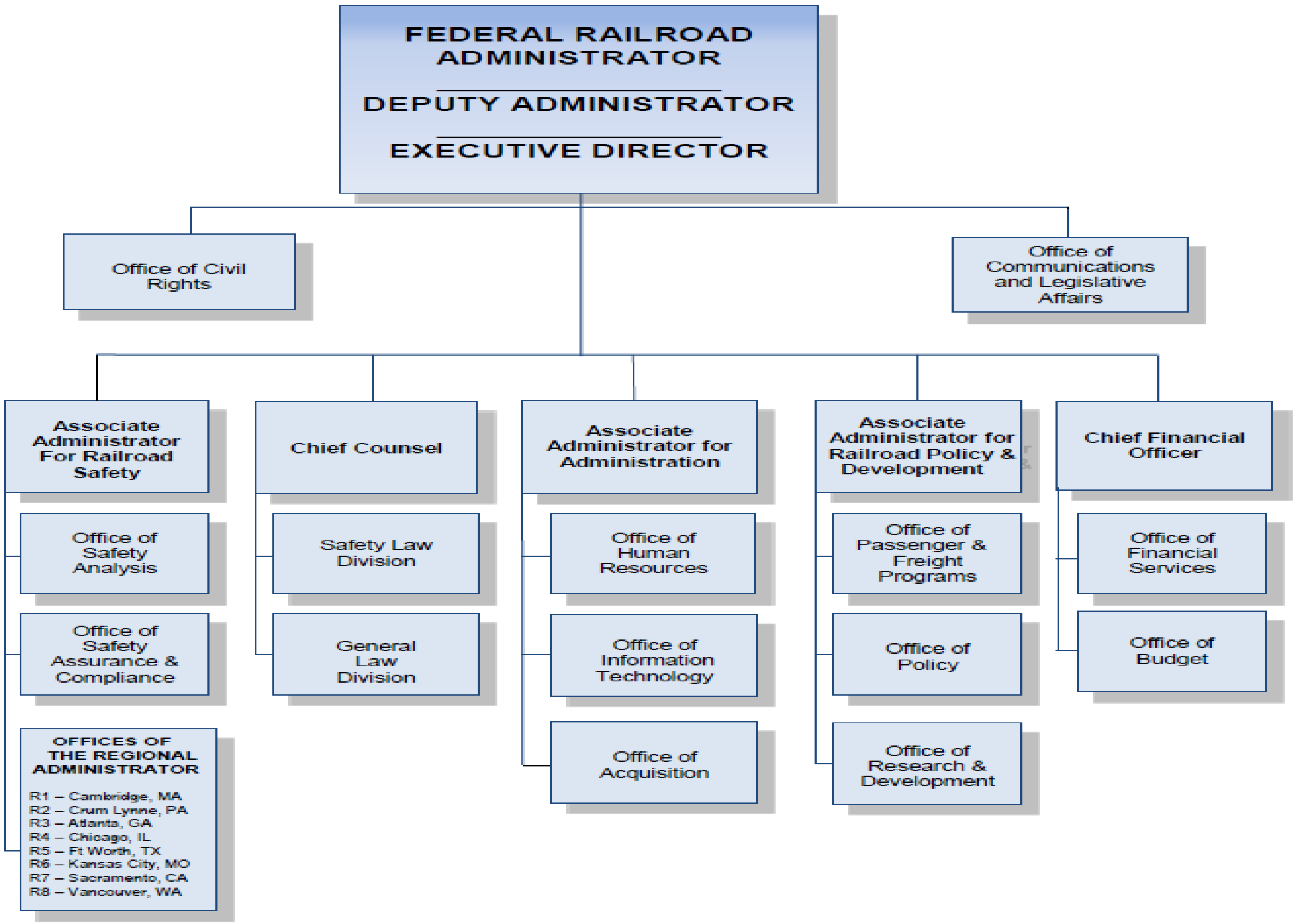


# Investments in Research and Development




Since 2006, we have steadily invested nearly $35 million in research and development annually.

# F E D E R A L   R A I L R O A D   A D M I N I S T R A T I O N



# *Guiding Principles*

- **Integrity**; the highest standards of ethical conduct guide our stewardship of the public's trust and resources.
- **Excellence**; we will empower employees to focus time and resources on data-driven, cost-effective solutions that promote FRA mission accomplishments. We seek ongoing development of our knowledge base and skills. We exhibit professional behavior at all times.
- **Transparency and Accountability**; senior leadership will engage employees in robust dialogue and constructive communication. We will embrace open decision-making. Our reward and recognition system will hold each of us responsible for our performance.
- **Innovation**; we will become an enterprising, resilient organization that invests in the future, as it streamlines and improves current operations.
- **Engagement**; we will engage our stakeholders for creative problem solving and development of effective policies, programs, technology, and investments.
- **Safety**; we will strive to ensure the safety of our employees, the public, and the rail industry workforce.

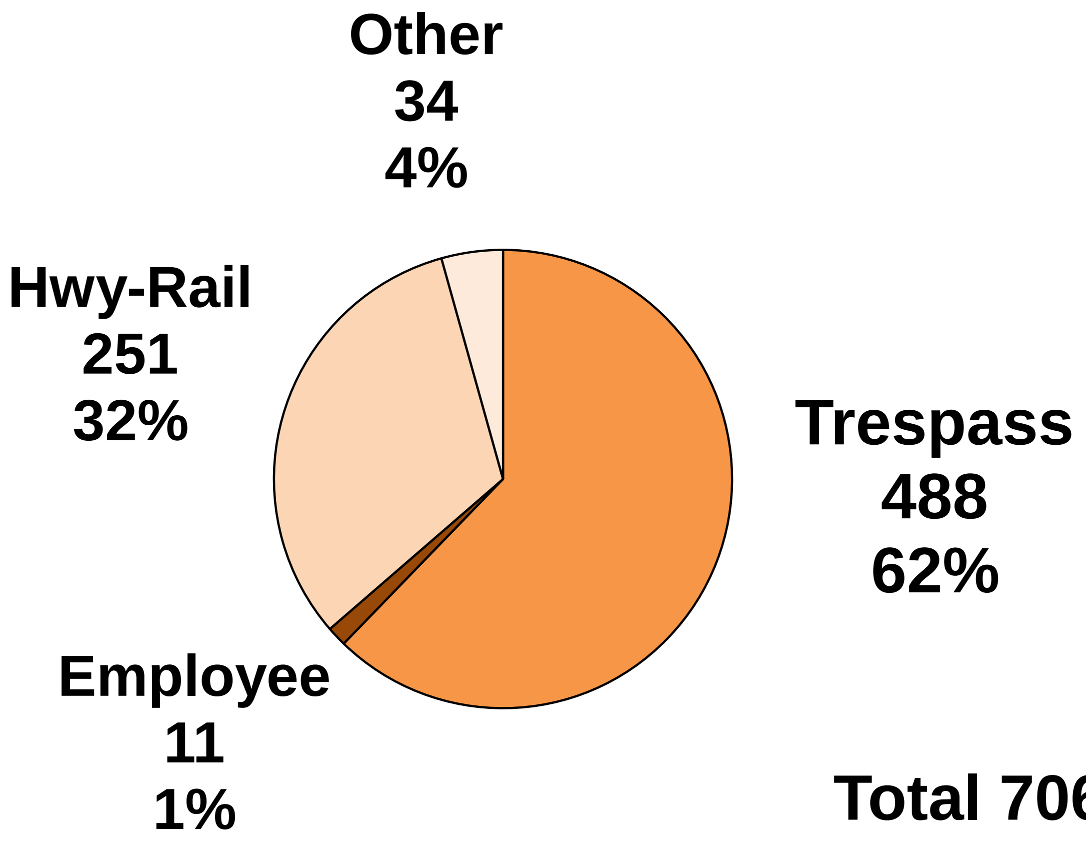
# FRA Strategic Goals

- **Unify FRA:** Increase awareness and leverage cross-agency networks to execute FRA's single, unifying mission and vision.
- **The Future:** Advance rail's vital role in moving people and goods by making continuous safety improvements and promoting state of good repair, economic competitiveness, and environmental sustainability.
- **Communication:** Enhance opportunities and mechanisms to improve communication with and among employees, stakeholders, media, and the public.
- **Operational Efficiency:** Pursue a performance-oriented approach to advancing the mission and to make the best use of FRA's limited resources.
- **Workforce:** Recruit, develop, and retain an increasingly diverse, engaged, knowledgeable, empowered, and collaborative workforce.

# U.S. Rail Facts

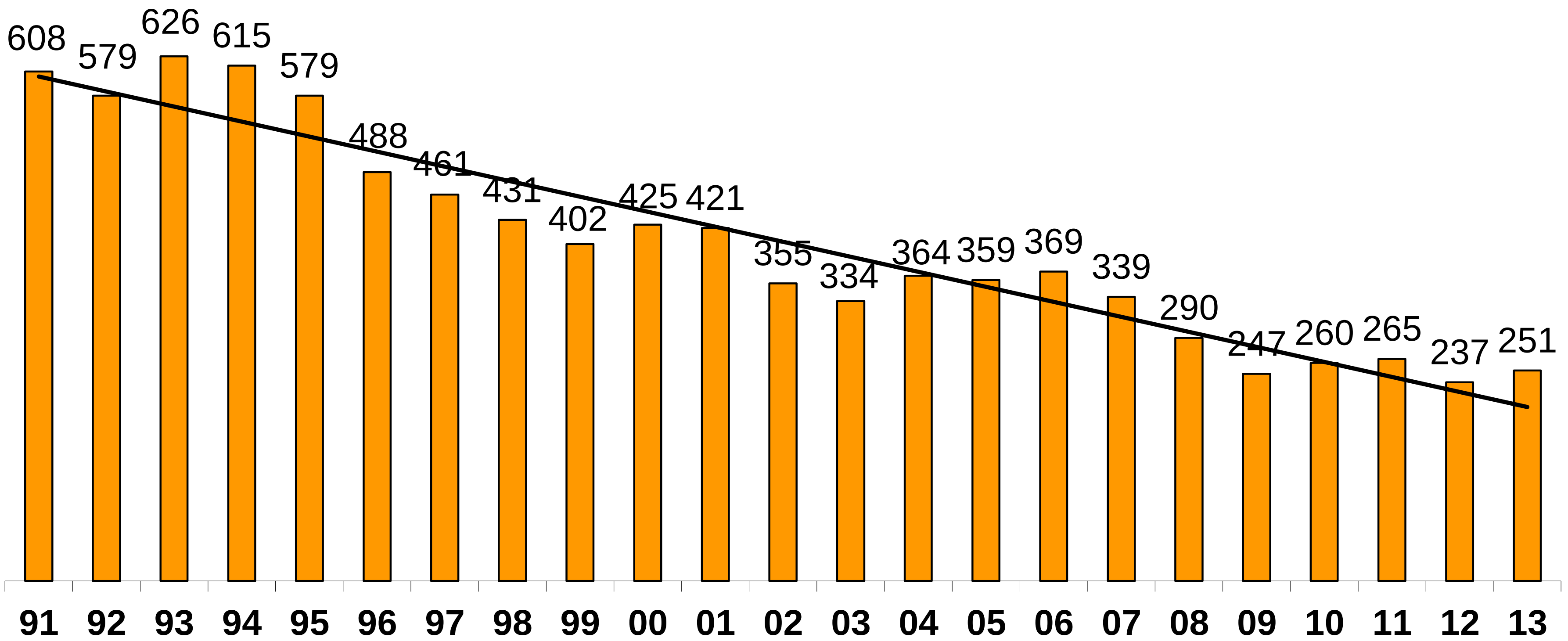
- Approximately 140,000 miles (226,097 km) of rail corridors
- 129,584 public level crossings
- 80,120 private level crossings
- 2,189 pathway level crossings
- 38,818 grade-separated crossings

# Rail-Related Fatalities in 2013

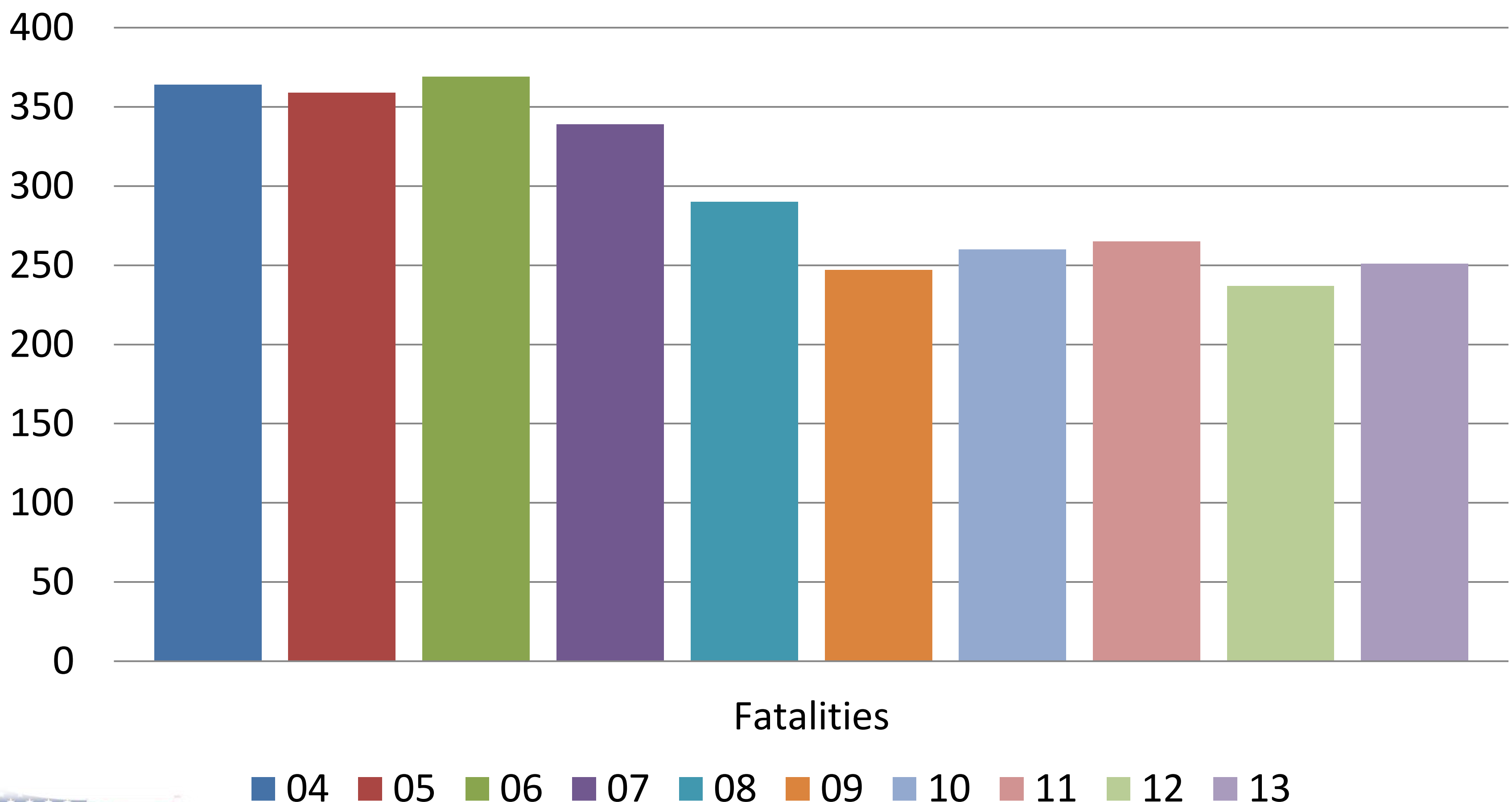



Total 706

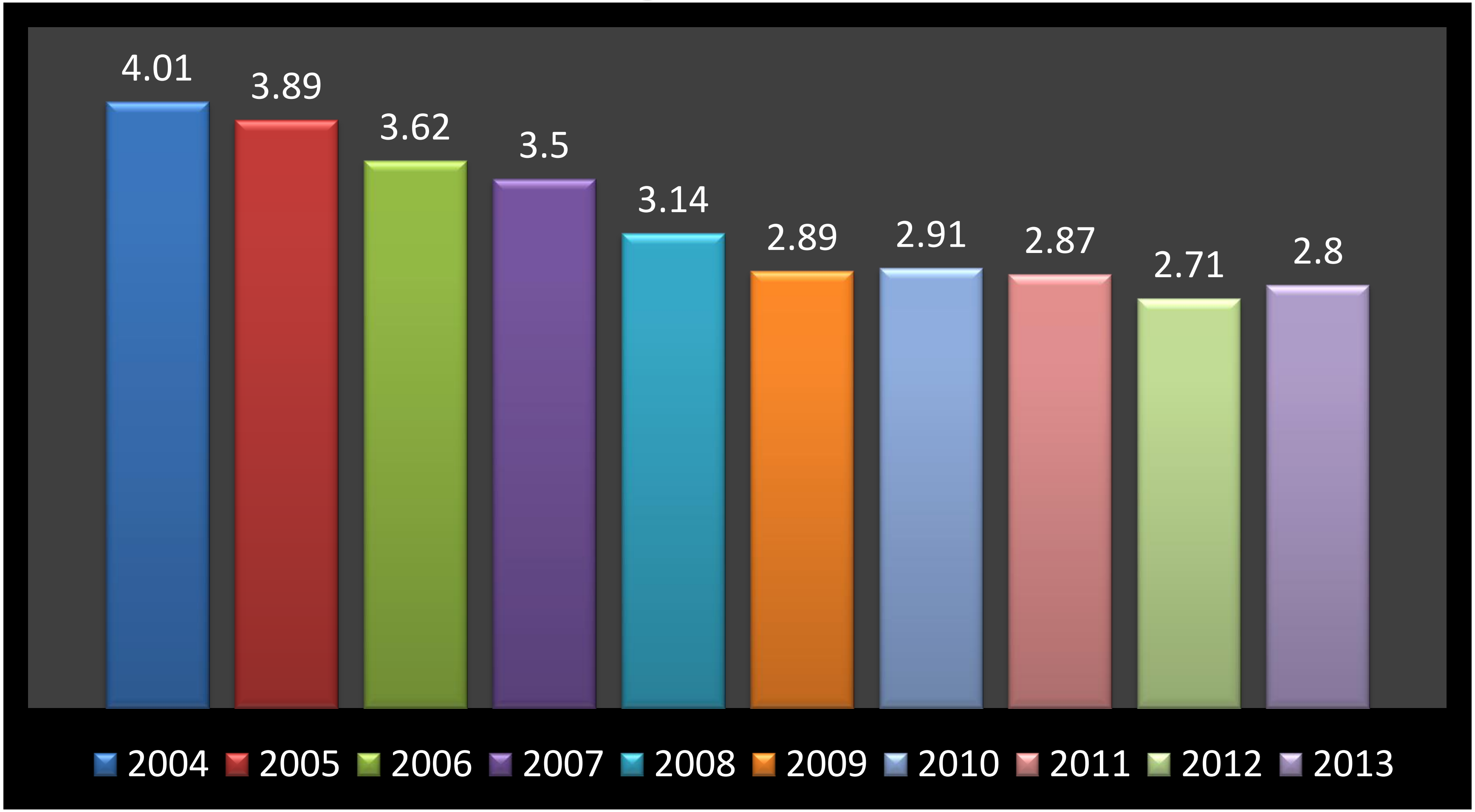
# Trends in Fatalities At Grade Crossings, 1991-2013



# Trends in Fatalities At Grade Crossings, 2004-2013



# Highway-Rail Level Crossing Collision Incident Rates per Million Train Mile



# NCHRP 755 Report "The Comprehensive Costs of Highway-Rail At-Grade Crossings Crashes"

DecisionTek

Economic Development Research Group

Susan Jones Moses & Associates

http://www.trb.org/main/blurbs/169061.aspx

# Costs of Crashes

- Existing methods of grade crossing crash prediction (occurrence and severity) categorize crashes into casualty (fatal and non-fatal injury) and non-casualty (e.g., property damage only)
- Direct cost components of **general** highway crashes: medical, emergency services, market productivity, household productivity, insurance administration, workplace cost, legal cost, travel delay and property damage

# Indirect Costs

- The indirect costs include intangible consequences of casualties (i.e., pain and suffering)
- Measures of indirect costs lead to crash cost estimates that are larger than the direct costs by an order of magnitude
- The Value of Statistical Life (VSL), from which values of injury by severity are derived, is inclusive of all direct and indirect costs - correct measure for benefit-cost analysis
- VSL determined by U.S. DOT as $6.2 million in March 2011 (updated in March 2013 to $9.1 million)

# Implication for GX crashes

1. Given the VSL-derived costs for casualties, refined estimates for crash costs depend upon per crash casualty counts
2. GX crash costs includes damage to rail equipment and infrastructure, some of which is captured in FRA databases
3. GX crash hazmat releases from rail cars are extremely rare
4. Methods for predicting crashes and their severity indicate useful refinements to the DOT Accident Prediction Severity Model are necessary

# New Factors Used in Study

- Delay and Supply Chain Impacts
  - Re-routing costs
  - Lost sales
  - Prevention costs
  - Inventory spoilage
  - Freight and passenger delays
  - Freight and passenger reliability
- Total logistics cost model can be applied to estimate cost of supply chain effects due to crash
- Several approaches to account for costs of rare catastrophic crashes

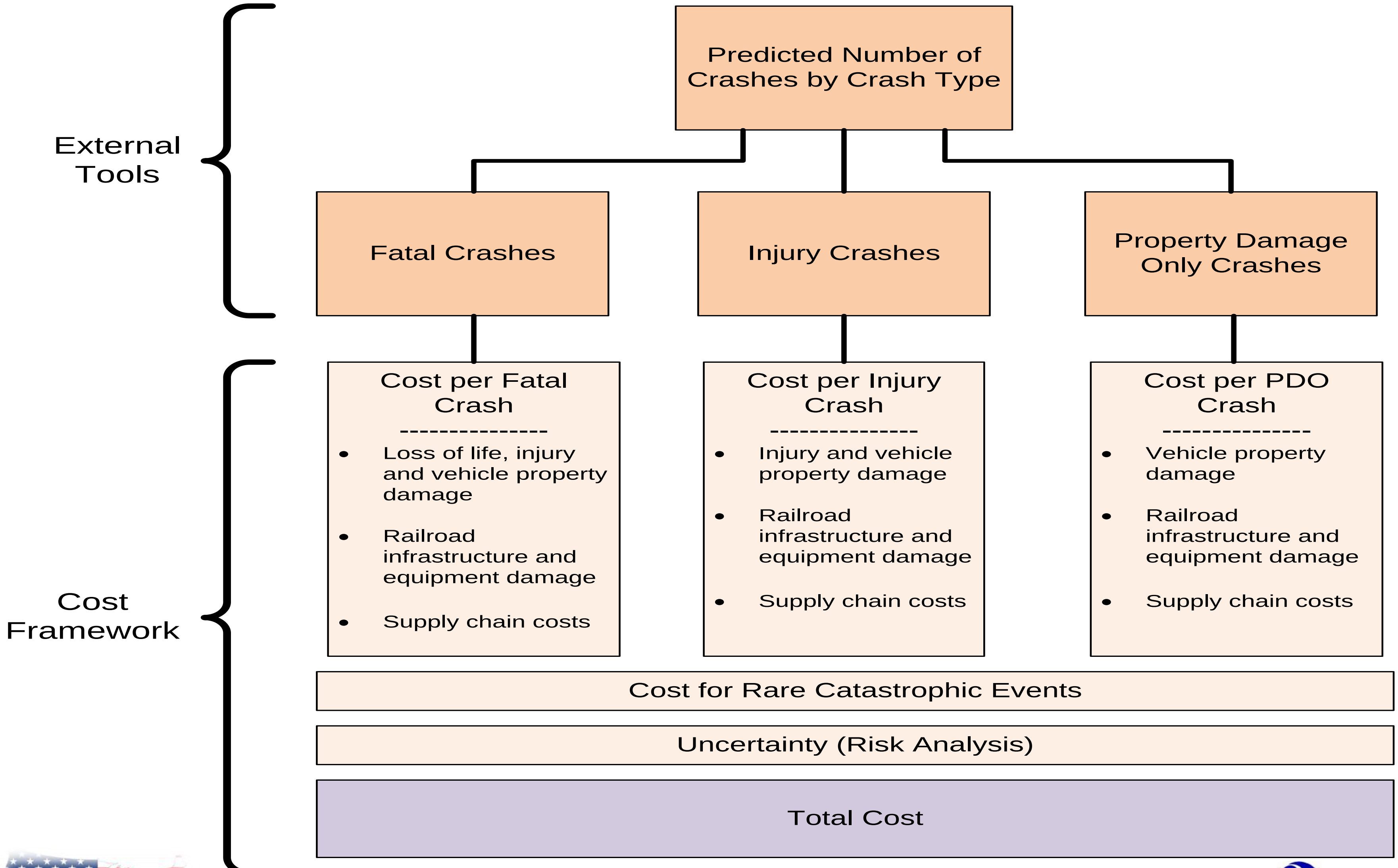
# GX Crash Cost Components

| Effect | Impact | Cost Component |
|---|---|---|
| Primary | Direct | Property damage (highway vehicles, railroad equipment and infrastructure)<br>Other direct costs (e.g., EMS, insurance) |
| | Indirect | Work-related productivity loss<br>Tax loss |
| | Intangible | Quality of life<br>Pain and suffering<br>Environmental cost |
| Secondary | Supply Chain and Business Disruption | Re-routing costs<br>Lost sales<br>Prevention costs<br>Inventory spoilage<br>Freight and passenger delays<br>Freight and passenger reliability<br>Increased inventory |

# Comprehensive GX Crash Cost Framework

- Use existing tools (i.e., WBAPS, GradeDec.Net) to derive predicted crashes by severity type
- Estimate cost per crash by severity type
  - Casualty count and apply costs per casualty by severity
  - Property damage highway vehicles
  - Property damage railroad equipment and infrastructure
  - Delay and supply chain effects
- Sum predicted crashes times cost per crash
- Add costs associated with rare, catastrophic events

# Overview of Conceptual Framework



# Method for Comprehensive Cost of GX Incidents

**Overall Crash Cost Equation**
(by crash severity type: Fatal, Injury, Property Damage Only)

**Equation 1: General Formula**
Crash Cost = Predicted Crashes *( Primary Effect Costs per Crash +
Secondary Costs per Crash )

**PRIMARY COST EFFECT EQUATION**

**Equation 2: Primary Effects**
Primary Effect Costs per Crash =
S (Average Number of Casualties by Severity Level * Cost per Casualty)
+ Property Damage Estimate per Crash

**SECONDARY COST EFFECT EQUATIONS**

**Equation 3: Delay and Rerouting Cost**
Delay & Rerouting Cost = Traffic Volume *
[ (Closure Type * Delay Duration * Cost per Hour)
+ (Rerouting Rate * Rerouting Miles *
Travel Cost per Mile) ]

**Equation 4: Supply Chain Transport Cost**
Supply Chain Transport Cost = Traffic Volume *
[ ( Hours Delay * SC Delay cost per hour )
+ ( Diversion Rate * Transfer Cost per ton ) ]
*By shipment and commodity type*

**Equation 5: Supply Chain Inventory Cost**
Supply Chain Inventory Cost = Traffic Volume *
[ (Loss Rate * Shipment Size * Value per Ton)
+ (Reliability Risk * Shipment Size * Value per Ton ) ]
*By shipment and commodity type*

Note: S = ∑

# FRA's WBAPS (Web-based Accident Prediction System)

- Calculates predicted grade crossing crashes
- Three severity categories - fatality, injury, and property damage only
- Assigns a cost per crash to each crash severity category to estimate a total crash cost
- Contains crash incidence prediction models for three main grade crossing device types (passive, lights, and gates).
- Uses independent models for each grade crossing device type which can lead to insufficient sensitivity to variances in traffic volume, train speeds, and other factors for each type of grade crossing

# FRA's GradeDec.Net

- Integrates WBAPS models
- Enables segmentation of highway and rail traffic into categories.
  - Highway: cars, trucks, and buses;
  - Rail: freight, passenger, local movements (switch trains).
- Includes high speed rail model – severity based on kinetic energy and tracks casualties by mode
- Adds the risk assessment framework for grade crossing risks with high speed passenger rail

# FRA's GradeDec.net

- Adds real-world aggravating risk factors, proximity to hazards, geography, and track characteristics (e.g., curvature)
- Enables full benefit-cost analysis and risk analysis, and is able to compare alternative grade crossing improvements
- Adds methods to estimate direct delay costs of queued vehicles at blocked crossings (not from crashes)
- Adds methods for estimating environmental impact

# NCHRP 755

- Includes or improves on the above WBAPS and GradeDec.Net features, including:
  - Accommodates additional data granularity and setting densities
  - Adds explicit methods for calculating the average cost per crash by crash type
  - Adds methods to estimate supply chain costs and other secondary cost impacts
  - Adds methods to estimate costs of potential low probability catastrophic crashes in which multiple parties are injured or killed

# Direct Costs

- Collisions - Determined the numbers, types, fatalities and injuries
- Valuation of collision casualties – fatal, severe injury, moderate injury, light injury and property damage only
- Property cost
  - Vehicle property damage
  - Railroad damages – rail equipment and infrastructure

# Indirect Costs

- Delay and Rerouting Cost
- Supply Chain Effects
  - Transportation Cost
  - Inventory Cost

# Rare, Catastrophic Events

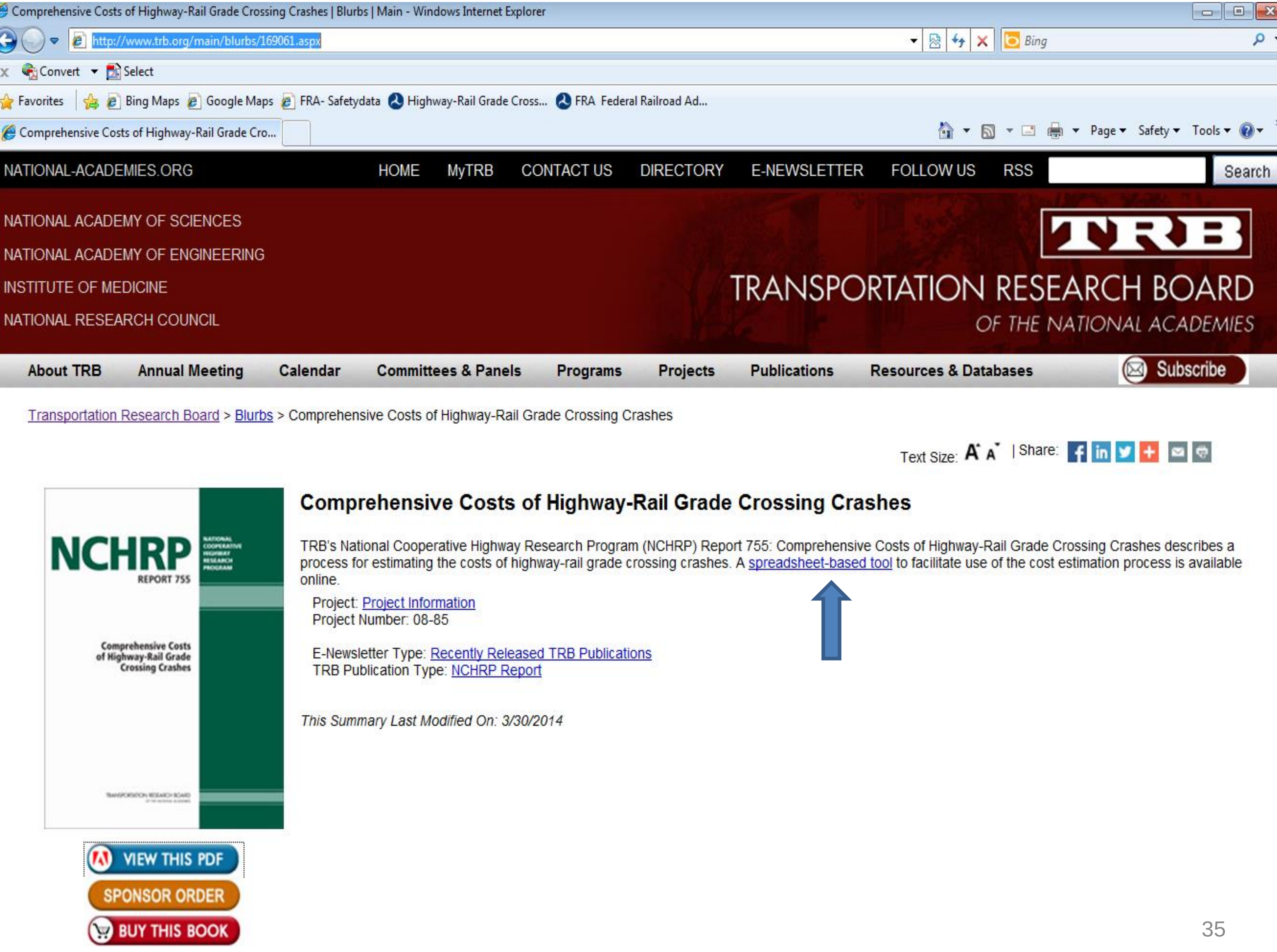
- Alternate approaches
  - “Best guess” – large number (estimate of damages) times small number (probability of occurrence)
  - “Disregard very small risks”
  - “Mitigation/Abatement approach” – Quantify costs of catastrophic crashes and consider measure to mitigate the relative risk of occurrence (say, by half). Count the cost of mitigation as the crash cost component.
  - “Weighted Best Guess Approach” – give greater weight to the catastrophic event in calculating cost

# Conclusions

- The research classified the types of primary and secondary costs imposed by grade crossing crashes.
- The research offered a clear method for calculating grade crossing crash costs and proposed data sources.
- The research demonstrated that secondary costs (delay and supply chain costs) can be significant for long closures due to crashes.
- The research prepared a software tool illustrating use of the method developed in the research.

# Spreadsheet Based Tool

- http://www.trb.org/main/blurbs/169061.aspx
- Allows user to input values to assess costs to fit specific situations


Comprehensive Costs of Highway-Rail Grade Crossing Crashes | Blurbs | Main - Windows Internet Explorer
http://www.trb.org/main/blurbs/169061.aspx
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Transportation Research Board > Blurbs > Comprehensive Costs of Highway-Rail Grade Crossing Crashes
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Comprehensive Costs of Highway-Rail Grade Crossing Crashes
TRB's National Cooperative Highway Research Program (NCHRP) Report 755: Comprehensive Costs of Highway-Rail Grade Crossing Crashes describes a process for estimating the costs of highway-rail grade crossing crashes. A spreadsheet-based tool to facilitate use of the cost estimation process is available online.
Project: Project Information
Project Number: 08-85
E-Newsletter Type: Recently Released TRB Publications
TRB Publication Type: NCHRP Report
This Summary Last Modified On: 3/30/2014
NCHRP
REPORT 755
Comprehensive Costs of Highway-Rail Grade Crossing Crashes
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TO PANEL REVIEWERS: THE YELLOW HIGHLIGHT INDICATES USER INPUTS. IN DETAIL WORKSHEETS COLUMN B GIVES VARIABLE NAMES FOR VALUES AND FORMULAS IN COLUMN C, AND THESE NAMES ARE USED IN THE FORMULAS. SOURCES LISTED AS "TABLE" ARE FROM DRAFT FINAL REPORT.

**NCHRP 8-85 HIGHWAY-RAIL COMPREHENSIVE CRASH COST ESTIMATION FRAMEWORK**

| | | | | | |
|---|---|---|---|---|---|
| **Grade crossing DOT ID** | 123456J | | | | FROM EXTERNAL TOOLS |
| **Device type** | Gated | | | | |
| | **Fatal Crash** | **Injury Crash** | **PDO Crash** | **TOTAL** | |
| **Annual Predicted Crashes** | 0.075 | 0.24 | 0.36 | 0.675 | FROM EXTERNAL TOOLS |
| **Primary Effect Crash Cost Components** | | | | | |
| Casualty cost | $ 7,673,246 | $ 412,772 | NA | $8,086,018 | |
| Hway veh damage | $ 8,483 | $ 11,707 | $ 7,598 | $ 27,788 | |
| RR eqip damage | $ 24,328 | $ 17,527 | $ 8,045 | $ 49,900 | |
| RR infra damage | $ 2,448 | $ 2,332 | $ 923 | $ 5,703 | |
| **Total Primary Effect Crash Costs** | **$ 7,708,505** | **$ 444,338** | **$ 16,566** | **$8,169,409** | |
| **Secondary Effect Crash Cost Components** | | | | | |
| Delay cost | $ 147,395 | $ 49,351 | $ 49,351 | $ 246,098 | |
| Rerouting cost | $ 2,815 | $ 1,564 | $ 938 | $ 5,318 | |
| Supply Chain Cost, Trans. - Delay | $ 39,934 | $ 24,606 | $ 8,858 | $ 73,399 | |
| Supply Chain Cost, Trans. - Diversion | $ 54,168 | $ 30,093 | $ 18,056 | $ 102,317 | |
| Supply Chain Cost, Logistics - Loss | $ 1,541 | $ 949 | $ 342 | $ 2,832 | |
| Supply Chain Cost, Logistics - Reliability | $ 7,663 | $ 5,768 | $ 2,077 | $ 15,508 | |
| **Total Secondary Effect Crash Costs** | **$ 253,517** | **$ 112,332** | **$ 79,622** | **$ 445,471** | |
| **Total cost per Crash** | **$ 7,962,021** | **$ 556,670** | **$ 96,188** | **$8,614,880** | |
| **Total annual crash costs at crossing** | **$ 597,152** | **$ 133,601** | **$ 34,628** | **$ 765,380** | |

D14 | $f_x$ | USDOT VSL, per OST policy memom

| | A | B | C | D |
|---|---|---|---|---|
| 1 | **Description** | **Variable Name** | **Value** | **Source** |
| 2 | Fatalities / Fatal crash | FATF | 1.126801153 | Based on 2009-2011 national data |
| 3 | Injuries / Fatal crash | INJF | 0.461095101 | Based on 2009-2011 national data |
| 4 | Injuries / Injury crash | INJI | 1.40323547 | Based on 2009-2011 national data |
| 5 | | | | |
| 6 | % Severity A of fatal crash injuries | PAINJF | 71.6% | Based on 2009-2011 national data and analysis of NHTSA sample |
| 7 | % Severity B of fatal crash injuries | PBINJF | 21.7% | Based on 2009-2011 national data and analysis of NHTSA sample |
| 8 | % Severity C of fatal crash injuries | PCINJF | 6.7% | |
| 9 | | | | |
| 10 | % Severity A of injury crash injuries | PAINJI | 11.4% | Based on 2009-2011 national data and analysis of NHTSA sample |
| 11 | % Severity B of injury crash injuries | PBINJI | 18.5% | Based on 2009-2011 national data and analysis of NHTSA sample |
| 12 | % Severity C of injury crash injuries | PCINJI | 70.1% | |
| 13 | | | | |
| 14 | Cost per fatality (VSL) | CFAT | 6200000 | USDOT VSL, per OST policy memom |
| 15 | Cost per A (Severe) injury | CINJA | 1992000 | From Blincoe (2002) estimate of relative severity |
| 16 | Cost per B (Moderate) Injury | CINJB | 291400 | From Blincoe (2002) estimate of relative severity |
| 17 | Cost per C (Light) injury | CINJC | 18600 | From Blincoe (2002) estimate of relative severity |
| 18 | | | | |
| 19 | Fatality cost / fatal crash | CFATFC | $ 6,986,167 | |
| 20 | Injury cost / fatal crash | CINJFC | $ 687,078 | |
| 21 | **Total casualty cost / fatal crash** | TCFC | **$ 7,673,246** | |
| 22 | | | | |
| 23 | Injury cost / injury crash | CINJIC | $ 412,772 | |
| 24 | **Total casualty cost / injury crash** | TCIC | **$ 412,772** | |

# Thank You

Paul Worley, Director Rail Division, North Carolina Department of Transportation, for providing much of the material in this presentation.

# Questions

Ron Ries, Staff Director

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