Level Crossing Crash Taxonomy for Connected Vehicle Safety Research

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Introduction

Research sponsors

- US DOT Federal Railroad Administration Office of Research and Development
- US DOT Intelligent Transportation Systems Joint Program Office

Research Objective:

- Analyze FRA level crossing incident data from 2008-2012
- Estimate the economic and infrastructure costs associated with these incidents
Background

- Connected vehicle safety technology employs data radio transmission to reduce motor vehicle crashes
- These technologies potentially address up to 81% of crash scenarios involving unimpaired drivers
- This may result in the prevention of tens of thousands of automobile and truck crashes every year
Level Crossing Connected Vehicle Safety Applications

For Highway Rail Intersections

Concept of Operations

Version 1.0
August 2014

Prepared for:
FRA Office of Research and Development

Prepared by:
John A. Volpe National Transportation Systems Center
Infrastructure Systems and Engineering Directorate
Systems Safety and Engineering Division

The information in this document is based upon work supported by the Federal Railroad Administration (FRA). Any opinions, findings, and conclusions or recommendations expressed in this report are those of the author(s) and do not necessarily reflect the views of the FRA or U.S. Department of Transportation.

- Focus on level crossing-highway intersection
- Research products
  - Crash Taxonomy
  - Concept of Operations document
  - System requirements

Connected Vehicle Safety Applications
For
Highway Rail Intersections
System Requirements Specification

Draft Version 1.0
March 2013

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U.S. Department of Transportation
Federal Railroad Administration

Highway-Rail Intersection Crash Taxonomy
For Connected Vehicle Safety Research

Office of Research
and Development
Washington, DC 20590

Connected Vehicle Safety Applications
For
Highway Rail Intersections
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Crash Taxonomy Overview

- Taxonomy recommended by Connected Vehicle Advisory Team created in 2011
- Advisory Team composition
  - Rail
  - Transit
  - Highway
  - Motor Carrier
- Advisory Team recommended a 5-year data analysis
- Crash taxonomy is the foundation for the rest of the connected vehicle study
US Level Crossing Incident and Casualty Trends

1997-2012
- Incidents: – 50.4%
- Injuries: - 44.3%
- Fatalities: - 39%

2008-2012
- Incidents: – 20.7%
- Injuries: - 24.7%
- Fatalities: - 16.7%
# US Level Crossing Statistics 2008-2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Crossings</th>
<th>Incidents</th>
<th>Injuries</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>219,758</td>
<td>2298</td>
<td>938</td>
<td>227</td>
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<tr>
<td>2009</td>
<td>217,479</td>
<td>1822</td>
<td>706</td>
<td>189</td>
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<tr>
<td>2010</td>
<td>211,708</td>
<td>1908</td>
<td>835</td>
<td>181</td>
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<tr>
<td>2011</td>
<td>209,991</td>
<td>1928</td>
<td>986</td>
<td>186</td>
</tr>
<tr>
<td>2012</td>
<td>210,315</td>
<td>1819</td>
<td>871</td>
<td>186</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td><strong>9775</strong></td>
<td><strong>4336</strong></td>
<td><strong>969</strong></td>
</tr>
</tbody>
</table>
Crash Circumstances

- Train struck highway user
  - 80% of all incidents
  - 88% of all fatalities

- Train struck highway user was 80% more likely to result in a fatality as train struck by highway user
Motor Vehicle Accident Costs

- From FRA level crossing accident database
- Zero fatalities
  - 91.67% of all incidents
  - 89.2% of all injuries
  - 89.3% of all vehicle damage costs
- Average vehicle damage costs, on a per accident basis, was $7,276

<table>
<thead>
<tr>
<th>Total Fatalities Per Incident</th>
<th>Incidents</th>
<th>Injuries</th>
<th>Fatalities</th>
<th>Vehicle Damage</th>
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<td>0</td>
<td>8961</td>
<td>3874</td>
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<td>$63,504,318</td>
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<td>1</td>
<td>695</td>
<td>268</td>
<td>695</td>
<td>$6,324,914</td>
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<td>2</td>
<td>92</td>
<td>46</td>
<td>184</td>
<td>$714,725</td>
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<td>3</td>
<td>20</td>
<td>30</td>
<td>60</td>
<td>$453,500</td>
</tr>
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<td>4</td>
<td>4</td>
<td>24</td>
<td>16</td>
<td>$25,000</td>
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<td>5</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>$16,000</td>
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<tr>
<td>6</td>
<td>1</td>
<td>101</td>
<td>6</td>
<td>$80,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>$71,118,457</td>
</tr>
</tbody>
</table>
Motor Vehicle Accident Costs

- Annual total motor vehicle accident costs are trending lower.
- Light and commercial vehicle accident costs are roughly equivalent.
- However per accident commercial vehicle accident costs are 3-4 times higher than those of light vehicles.
Rail Infrastructure Accident Costs

- Rail equipment accident costs are sensitive to low probability, high consequence events
- June 2010 accident = $3.3 million
- June 2011 accident = $8.5 million
- Losses to rail infrastructure have increased
- Motor vehicle damages have stabilized

[Graphs showing annual damage trends for equipment, track, and total from 2008 to 2012, with specific damages noted for each year.]
Accident Costs Related To Vehicle Violations: Light and Commercial Vehicles

- “Went Around/Thru Gates” violation type
  - $6.3 million (9.8%) of $64.3 million cost
  - Commercial vehicles: 121 (1.4%) of 8918 total incidents, but $13,785/incident
  - Light vehicles: 1040 (11.66%) of incidents, but $4,448/incident

- “Did not Stop” violation type
  - $28.2 million (43.7%) of $64.3 million cost
  - 3696 (41.4%) of 8918 total incidents
  - Commercial vehicles: 1134 (12.7%) of 8918 total incidents, but $14,935/incident
  - Light vehicles: 2562 (28.7%) of incidents, but $4,383/incident
Accident Costs Related To Vehicle Violations: Active and Passive Crossings

- **“Went Around/Thru Gates”** violation type
  - 1231 (12.6%) of 9775 total incidents
  - $6.5 million (9.4%) of $71 million cost
  - All active at a cost of $5,280/incident

- **“Did not Stop”** violation type
  - 4031 (41.2%) of 9775 total incidents
  - $31.2 million (44%) of $71 million cost
  - 2647 passive and 1144 active
  - Active: $7.4 million or $6,470/incident
  - Passive: $23.8 million or $9,000/incident
Direct Economic Cost Method

- FRA accident database does not account for injury severity or cost
- Direct Economic Cost Model
  - Used to estimate costs of Connected Vehicle preventable accidents*
  - Employs Maximum Abbreviate Injury Scale
  - Developed by the Association for the Advancement of Automotive Medicine

MAIS costs in 2009 dollars

<table>
<thead>
<tr>
<th>Factor</th>
<th>PDO</th>
<th>MAIS 0</th>
<th>MAIS 1</th>
<th>MAIS 2</th>
<th>MAIS 3</th>
<th>MAIS 4</th>
<th>MAIS 5</th>
<th>Fatal</th>
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</thead>
<tbody>
<tr>
<td><strong>Severity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property Damage Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td>$0</td>
<td>$1</td>
<td>$3,427</td>
<td>$22,504</td>
<td>$66,964</td>
<td>$189,111</td>
<td>$478,816</td>
<td>$31,822</td>
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<tr>
<td>EMS</td>
<td>$39</td>
<td>$27</td>
<td>$121</td>
<td>$264</td>
<td>$458</td>
<td>$1,034</td>
<td>$1,061</td>
<td>$1,038</td>
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<tr>
<td>Market Productivity</td>
<td>$0</td>
<td>$0</td>
<td>$2,324</td>
<td>$33,246</td>
<td>$94,959</td>
<td>$141,452</td>
<td>$583,016</td>
<td>$791,199</td>
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<tr>
<td>Household Productivity</td>
<td>$62</td>
<td>$44</td>
<td>$760</td>
<td>$9,730</td>
<td>$28,007</td>
<td>$37,222</td>
<td>$198,423</td>
<td>$254,548</td>
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<td>Ins. Admin</td>
<td>$145</td>
<td>$100</td>
<td>$923</td>
<td>$8,607</td>
<td>$23,538</td>
<td>$40,285</td>
<td>$84,964</td>
<td>$46,246</td>
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<tr>
<td>Workplace</td>
<td>$68</td>
<td>$45</td>
<td>$335</td>
<td>$2,595</td>
<td>$5,670</td>
<td>$6,243</td>
<td>$10,886</td>
<td>$11,565</td>
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<tr>
<td>Legal</td>
<td>$0</td>
<td>$0</td>
<td>$187</td>
<td>$6,206</td>
<td>$19,695</td>
<td>$41,967</td>
<td>$99,490</td>
<td>$127,250</td>
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<tr>
<td>Travel Delay</td>
<td>$1,067</td>
<td>$1,027</td>
<td>$1,033</td>
<td>$1,124</td>
<td>$1,249</td>
<td>$1,327</td>
<td>$12,157</td>
<td>$12,157</td>
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<tr>
<td>Property Damage</td>
<td>$1,849</td>
<td>$1,269</td>
<td>$4,789</td>
<td>$4,926</td>
<td>$8,471</td>
<td>$12,250</td>
<td>$11,768</td>
<td>$12,798</td>
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<tr>
<td><strong>Total</strong></td>
<td>$3,230</td>
<td>$2,514</td>
<td>$13,899</td>
<td>$89,202</td>
<td>$470,891</td>
<td>$1,480,581</td>
<td>$1,288,623</td>
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</tr>
</tbody>
</table>

*US DOT National Highway Traffic Safety Administration
## Overall Harm To Society

<table>
<thead>
<tr>
<th>Year</th>
<th>Property Damage Only Accidents</th>
<th>No Vehicle Occupants Injured</th>
<th>Vehicle Occupant Injuries</th>
<th>Fatalities</th>
<th>Cost*</th>
<th>Functional Years Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>314</td>
<td>1595</td>
<td>935</td>
<td>227</td>
<td>$728,311,254</td>
<td>20,402</td>
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<tr>
<td>2009</td>
<td>252</td>
<td>1226</td>
<td>703</td>
<td>190</td>
<td>$572,618,073</td>
<td>16,165</td>
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<tr>
<td>2010</td>
<td>249</td>
<td>1248</td>
<td>802</td>
<td>178</td>
<td>$602,811,176</td>
<td>16,787</td>
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<tr>
<td>2011</td>
<td>244</td>
<td>1244</td>
<td>993</td>
<td>188</td>
<td>$703,668,112</td>
<td>19,401</td>
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<tr>
<td>2012</td>
<td>277</td>
<td>1050</td>
<td>871</td>
<td>186</td>
<td>$644,502,307</td>
<td>17,919</td>
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<tr>
<td>5-Year Average</td>
<td>268</td>
<td>1,273</td>
<td>861</td>
<td>194</td>
<td>$650,382,184</td>
<td>18,135</td>
</tr>
</tbody>
</table>

Cost* Calculated using MAIS Costs in 2009 Dollars

*Functional Years Lost is a non-monetary measure that sums the years of life lost to fatal injury and the years of functional capacity lost to nonfatal injury.
Comparison of Costs

- MAIS costs exceed combined motor vehicle and rail infrastructure damage costs by a factor of 20-25

![Graph showing comparison of costs over years]
Findings

- 2008 – 2012: level crossing incidents declined by around 20%
- Injuries and fatalities were relatively stable after 2009
- More than 50% of incidents occurred at active crossings
- Commercial vehicles
  - 20%-25% of the total
  - 45%-55% of the accident costs
- Societal harm costs
  - Average $650 million
  - Range between $250 million and $1.5 billion
  - Exceed combined motor vehicle and rail damage costs by a factor of 20-25
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