Analysis and Modeling of Grade Crossing Accidents

Presented At:
2017 Grade Crossing Research Needs Workshop

August 15, 2017
Background

- Grade Crossing Casualties are a significant part of the total railroad accident casualties.
  - Human Behavior being the principal cause
- Decreasing trend of grade crossing cases from 1975 to 2014:
  - Incidents down from 10,979 to 2,282
  - Fatalities down from 916 to 293
  - Injuries down from 3,778 to 786
- However, these numbers are still a high proportion of the total number of all rail incidents in each year
- Review of causes shows that Engineering, Education and Enforcement can help
# Overview of FRA Research Efforts

<table>
<thead>
<tr>
<th>Technology</th>
<th>Education &amp; Enforcement</th>
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<tbody>
<tr>
<td>• What new equipment works best to reduce accident frequency at grade crossings?</td>
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<td>• Results of In-field testing</td>
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<td>• Are education programs effective?</td>
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<td>• How can police officers help enforce safety?</td>
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<table>
<thead>
<tr>
<th>Demographics &amp; Causes</th>
<th>Human Behavior</th>
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<tbody>
<tr>
<td>• Common risk factors</td>
<td>• In-vehicle monitoring of drivers</td>
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<tr>
<td>• Demographics of people involved in grade crossing accidents</td>
<td>• How often are accidents caused by poor decision making or distractions?</td>
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<table>
<thead>
<tr>
<th>Trespassing Incidents</th>
<th>Recommended Practices</th>
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<tr>
<td>• Common risk factors</td>
<td>• Procedures for grade crossing closure</td>
</tr>
<tr>
<td>• Demographics of trespassers</td>
<td>• Locomotive warning lights</td>
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<td>• Mitigation strategies</td>
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Research Needs

- A better understanding of passenger vehicle behavior
  - Overall trends and demographics from FRA data
  - Studying human behavior using non-railroad data sources for grade crossing incidents
  - Predictive models for grade crossing safety that include human factors considerations
KEY FINDINGS
Demographics

- Confirmed several demographic elements that had already been identified by FRA’s data analysis team
  - Distribution of ages
  - Males being more likely to be involved in an accident

- Identified that males were more likely to be involved in a grade crossing accident even after correcting for exposure, i.e., highway miles driven by males
Temporal Issues – Daylight Effects

➢ There appears to be a notable link between the amount of daylight hours and accident likelihood

➢ December, January, and February are the top three most dangerous months
  – This appears to be the result longer hours of darkness relative to the summer months
  – For example, December has a higher percentage of accidents from 5pm – 9pm, when it is dark in December but lit in June.
  – Also seen through a comparison of DST accident rates to non-DST accident rates
What is the effect of driving at night?

Compared accident rates for June and December to see if driving in darkness vs. driving in lit conditions plays a role.

**December has a higher accident percentage from 5pm – 9pm times when it is dark in December but lit in June**
Effect of Daylight Saving Time?

Across the years, the shorter daylight hours have higher accident rates.
Temporal Issues – Weekend Nights

➢ Weekend nights experience a lot more late night accidents, especially from 1am to 3am
  – A review of driver demographics associated with these late night accidents indicates that driver age is 7 - 8 years lower than the overall average.
  – There does not appear to be a gender differential.
Weekdays have most of their accidents (69%) during the workday from 7am to 7pm.
Time of Day Analysis – Weekends

Weekends experience a lot more late night accidents than weekdays do, especially from 1am to 3am.
### Average Age of Drivers in Grade Crossing Accidents

<table>
<thead>
<tr>
<th>Hour</th>
<th>From</th>
<th>To</th>
<th>All Days Avg. Age</th>
<th>Monday Avg. Age</th>
<th>Tuesday Avg. Age</th>
<th>Wednesday Avg. Age</th>
<th>Thursday Avg. Age</th>
<th>Friday Avg. Age</th>
<th>Saturday Avg. Age</th>
<th>Sunday Avg. Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>0100-0300</td>
<td>1AM</td>
<td>3AM</td>
<td>34.40</td>
<td>36.69</td>
<td>35.84</td>
<td>38.37</td>
<td>33.23</td>
<td>33.68</td>
<td>33.54</td>
<td>32.63</td>
</tr>
<tr>
<td>0300-0500</td>
<td>3AM</td>
<td>5AM</td>
<td>34.67</td>
<td>41.03</td>
<td>37.00</td>
<td>36.54</td>
<td>36.65</td>
<td>37.75</td>
<td>31.37</td>
<td>29.95</td>
</tr>
<tr>
<td>0500-0700</td>
<td>5AM</td>
<td>7AM</td>
<td>40.62</td>
<td>41.15</td>
<td>42.37</td>
<td>40.69</td>
<td>40.63</td>
<td>41.70</td>
<td>40.14</td>
<td>35.38</td>
</tr>
<tr>
<td>0700-0900</td>
<td>7AM</td>
<td>9AM</td>
<td>43.25</td>
<td>43.95</td>
<td>42.18</td>
<td>42.05</td>
<td>42.67</td>
<td>45.03</td>
<td>44.94</td>
<td>41.79</td>
</tr>
<tr>
<td>0900-1100</td>
<td>9AM</td>
<td>11AM</td>
<td>45.59</td>
<td>45.96</td>
<td>45.80</td>
<td>46.68</td>
<td>46.89</td>
<td>44.86</td>
<td>43.30</td>
<td>43.37</td>
</tr>
<tr>
<td>1100-1300</td>
<td>11AM</td>
<td>1PM</td>
<td>45.36</td>
<td>47.65</td>
<td>46.09</td>
<td>46.28</td>
<td>46.06</td>
<td>43.56</td>
<td>43.80</td>
<td>42.68</td>
</tr>
<tr>
<td>1300-1500</td>
<td>1PM</td>
<td>3PM</td>
<td>42.62</td>
<td>42.30</td>
<td>43.31</td>
<td>43.65</td>
<td>41.94</td>
<td>41.74</td>
<td>42.36</td>
<td>43.22</td>
</tr>
<tr>
<td>1500-1700</td>
<td>3PM</td>
<td>5PM</td>
<td>41.99</td>
<td>41.53</td>
<td>42.53</td>
<td>42.53</td>
<td>41.70</td>
<td>42.77</td>
<td>40.95</td>
<td>41.17</td>
</tr>
<tr>
<td>1700-1900</td>
<td>5PM</td>
<td>7PM</td>
<td>41.12</td>
<td>41.72</td>
<td>41.35</td>
<td>41.61</td>
<td>39.95</td>
<td>39.72</td>
<td>43.17</td>
<td>40.70</td>
</tr>
<tr>
<td>1900-2100</td>
<td>7PM</td>
<td>9PM</td>
<td>38.92</td>
<td>39.30</td>
<td>40.27</td>
<td>38.52</td>
<td>40.15</td>
<td>38.29</td>
<td>37.75</td>
<td>37.97</td>
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<tr>
<td>2100-2300</td>
<td>9PM</td>
<td>11PM</td>
<td>36.25</td>
<td>35.46</td>
<td>37.77</td>
<td>36.84</td>
<td>38.29</td>
<td>34.97</td>
<td>35.57</td>
<td>34.92</td>
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42 is the overall average age of drivers involved in grade crossing accidents. Average driver ages under 35 are highlighted.
TIME SERIES ANALYSIS
Decomposition

➢ A statistical process that attempts to separate multiple elements of time-based data:
  – Linear trends that show long term changes, such as the drop in accident rates
  – Cyclic trends that capture medium term changes such as business cycles, economic downturns, etc.
  – Seasonal trends that capture month-to-month changes in activity that are annually cyclic
  – Randomness, accounts for changes that cannot be attributed to the above three elements
Normalized by vehicle miles traveled

Using time series decomposition, this data can be broken down into: linear trend, cyclical trend, seasonal trend, and randomness factor.
The lines for Cyclical and Random are cut off at the ends due to the way they are calculated.
Time series analyses of Normalized accident data

Multiplying these values together will return the original accident data
Cyclical Factor vs. Freight Train Miles

Cyclical Factor taken from time series normalized by vehicle miles
Closer Look at Normalized Seasonal Factor

<table>
<thead>
<tr>
<th>Month</th>
<th>Seasonal Factor</th>
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<tbody>
<tr>
<td>January</td>
<td>1.229</td>
</tr>
<tr>
<td>February</td>
<td>1.121</td>
</tr>
<tr>
<td>March</td>
<td>0.927</td>
</tr>
<tr>
<td>April</td>
<td>0.829</td>
</tr>
<tr>
<td>May</td>
<td>0.888</td>
</tr>
<tr>
<td>June</td>
<td>0.903</td>
</tr>
<tr>
<td>July</td>
<td>0.902</td>
</tr>
<tr>
<td>August</td>
<td>0.954</td>
</tr>
<tr>
<td>September</td>
<td>0.980</td>
</tr>
<tr>
<td>October</td>
<td>1.042</td>
</tr>
<tr>
<td>November</td>
<td>1.044</td>
</tr>
<tr>
<td>December</td>
<td>1.113</td>
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Decomposition Results

- The overall drop in accident rates is very clear by looking at the linear trends.
  - Reflects ‘structural’ improvements, whether they are physical or based on the 3Es.

- Cyclic data clearly points to periods of economic downturn and the subsequent uptick in economic growth.
  - This effect is captured in the data due to changes in train traffic.

- There is very distinct seasonality.
NON-RAILROAD DATA
Available Data

➢ Highway datasets contain several data elements that are of interest, including:
  – Occupant Demographics
  – Driver Impairment
  – Driver Distraction
  – Roadway Conditions
  – Attempted Avoidance Maneuver
  – Pre-Crash Operating Conditions
  – Damage Severity
GRADE CROSSING DATA ANALYSIS

MODEL DEVELOPMENT
Model and Variables

- Predictive model
  - Grade crossing attributes
  - Human factors
- Key to an effective model is the identification of ‘metrics’ or risk elements that need to be considered
‘Infrastructure’ Model Variables

These variables were shown to be highly correlated with the number of accidents:

- Total Trains
- Average Annual Daily Traffic (AADT)
- Number of Traffic Lanes
- Max Train Speed at Crossing
- Number of Main Tracks
- Highway Intersection Near?
Human Factors Variables

- Driver age and gender
- Time of day, day of the week, month, etc.
- Drug or alcohol use
- Fatigued driving
- Median income of county where crossing resides
- Type and condition of vehicle
Next Steps

- Detailed review of Non-Railroad Data
  - Human Factors Considerations
  - Experience/Impairment/Distraction

- Develop Predictive Model
  - Human Factors Elements
  - Grade Crossing Elements
Acknowledgements

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  - Program Manager, Human Factors, FRA Office of Research, Development, & Technology

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  - Director, FRA Office of Research, Development, & Technology