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RESEARCH RESULTS

FRA OFFICE OF RAILROAD POLICY & DEVELOPMENT

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ANALYSIS OF GRADE CROSSING ACCIDENTS RESULTING IN INJURIES AND FATALITIES

SUMMARY

This report describes trends and correlations resulting from an in-depth analysis of highway-rail grade crossing accidents between 2005 and 2014. A future report will describe the incorporation of these analyses into a predictive model of grade crossing accidents.

BACKGROUND

Approximately 212,000 highway-rail grade crossings (or "grade crossings") exist in the approximately 140,000 miles of track that make up the United States' railroad system. By law, trains have the right-of-way at highway-rail grade crossings, since they cannot stop or change direction to avert collisions with motor vehicles or people. In 2015, 277 individuals died at railroad crossings. This figure is down from 294 in 2014 and 290 in 2013. Nearly all of these deaths are preventable, as 94 percent of train-vehicle collisions can be attributed to driver behavior or poor judgment.

The Federal Railroad Administration (FRA) issues and enforces regulations on grade crossing safety and sponsors research aimed at reducing grade crossing accidents and fatalities. A better understanding of human behavior in the highway vehicle during these incidents could significantly improve the strategies employed to reduce grade crossing incidents.

OBJECTIVES

FRA's Office of Research, Development & Technology provided funding to Sharma & Associates (Sharma) to conduct a two-phase study on the human factors issues related to grade crossing accidents.

In Phase 1, Sharma conducted descriptive analyses of FRA data on grade crossing accidents and identified additional data sources (e.g., State police accident reports, the National Highway Traffic Safety Administration's (NHTSA) vehicle accident reports) on human behavior at grade crossings. In Phase 2, Sharma will use Phase 1's descriptive data and the additional data sources to develop a predictive model of grade crossing accidents that accounts for both structural attributes and human factors elements of grade crossings.

METHODS

Sharma reviewed existing grade crossing research conducted by FRA and the Volpe National Transportation Systems Center and identified significant human factors variables associated with grade crossing accidents.

RESULTS

Driver Characteristics

On average, males are more likely to be involved in grade crossing accidents, even after correcting for exposure (i.e., vehicle miles traveled). When it comes to age as a driver characteristic, the results are more complex, as time of day and day of the week affect the relationship between age and grade crossing accidents.

Seasonal Factor

Grade crossing accidents show a systematic seasonal factor. Numbers of grade crossing accidents are below average in March through July and above average in August through February, according to analysis of grade crossing accident frequencies over ten years (2005-2014); January and December have the highest average over the ten-year span.

There is a link between the amount of daylight hours and number of grade crossing accidents. Even after normalizing for vehicle miles traveled, months associated with Daylight Savings Time (i.e., months with more daylight) have the lowest accident rates.

Thus, the seasonal effect associated with grade crossing accidents may be due to the amount of daylight, rather than factors such as weather. To illustrate this hypothesis, Sharma compared the number of grade crossing accidents between 5pm and 9pm for the months of June and December. During this block of time, when it is dark in December but light in June (due to daylight savings), December has a higher percentage of grade crossing accidents. The difference is less pronounced during other time blocks for the same two months (Figure 1).

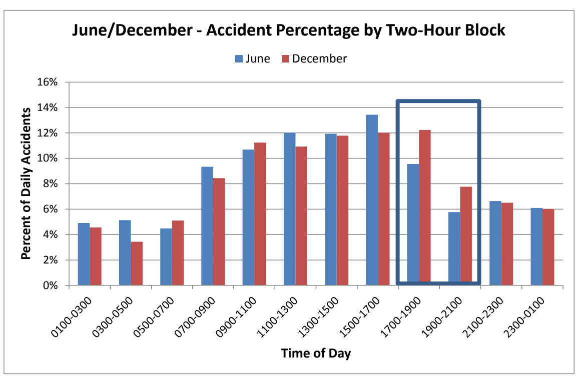

Figure 1. June and December accident percentages by time of day, 2005-2014.

Day of the Week and Time of Day

Grade crossing accidents show distinct temporal factors. Weekend nights (i.e., Friday 9pm-12am, Saturday 12am-3am and 9pm-12am, Sunday12am-3am) are associated with more late night accidents than weekdays.

Between 1am and 3am, there are 3 times as many grade crossing accidents on weekend nights as compared to the same times on weekday nights. Most weekday grade crossing accidents (69%) occur between 7am and 7pm (Figure 2).

Time of Day	Weekends	Weekdays
0100-0300	11.0%	4.2%
0300-0500	8.2%	3.0%
0500-0700	5.0%	5.0%
0700-0900	5.3%	10.2%
0900-1100	10.0%	11.8%
1100-1300	9.2%	11.7%
1300-1500	10.2%	12.4%
1500-1700	9.4%	12.2%
1700-1900	9.1%	10.7%
1900-2100	7.6%	7.1%
2100-2300	7.3%	6.3%
2300-0100	7.6%	5.5%

Figure 2. Percentage of accidents by time of day, 2005-2014.

Additionally, the average age of drivers involved in late night accidents on Friday and Saturday nights is 7-8 years younger than the overall average of all drivers involved in grade crossing accidents. Overall, the average age of drivers involved in grade crossing accidents is 42.24; on Friday and Saturday nights the average age is 35.37. Males and females are equally likely to be involved in a weekend grade crossing accident.

Time Series Decomposition

Using time series analysis (a statistical procedure), Sharma extracted meaningful patterns from the grade crossing accident database (such as Figure 3). Specifically, Sharma parsed the cyclical, seasonal and linear trends and the randomness factor from the data.

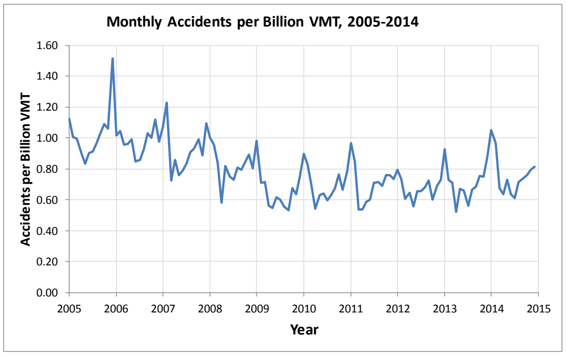

Figure 3. Accidents per billion vehicle miles traveled (VMT), 2005-2014

Cyclic trends capture medium term changes such as business cycles, economic downturns, etc. Cyclic trends in the grade crossing data reflect periods of economic downturn up until 2009 and then a subsequent uptick in economic growth. This effect is captured in the data due to changes in train traffic (i.e., increase in train traffic beginning in 2009).

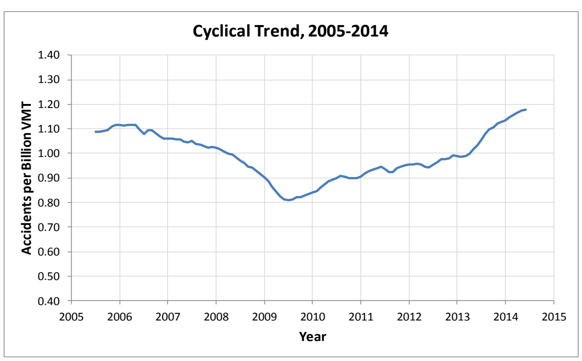

Figure 4. Cyclic trend accident estimates per billion VMT, 2005-2014.

Seasonal trends capture month-to-month changes in activity that are annually cyclic. Grade crossing accidents have very distinct seasonality, as winter months are associated with higher accident rates.

Linear trends show long term changes, such as the drop in accident rates. In the grade crossing data, the linear trend shows a clear decrease in accident rates between 2005 and 2016. Linear trends reflect "structural" improvements, whether they are physical or based on Engineering, Enforcement, and Education.

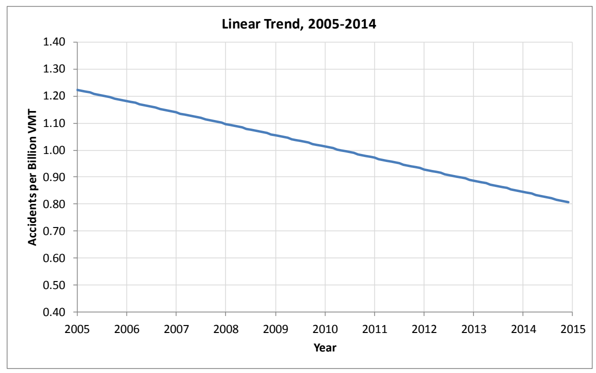

Figure 5. Linear trend accident estimates per billion VMT, 2005-2014.

Randomness accounts for changes that cannot be attributed to the above three elements.

CONCLUSION

In-depth analysis of ten years' worth of grade crossing accident data from the FRA Office of Safety Analysis Highway Rail Accidents database (6180.57; http://safetydata.fra.dot.gov/OfficeofSafety/default.aspx) provided descriptive information about the driver characteristics, seasonal factor, and temporal factors associated with grade crossing accidents.

FUTURE ACTION

In Phase 2, Sharma will review sources of non-railroad data, such as State police accident reports and NHTSA's Fatality Analysis Reporting System and National Automotive Sampling System databases. These data sources provide additional information about the motor vehicle operator in a grade crossing accident. Qualitative data captured in these reports will provide descriptive information about what happened during the accident—information that is not captured in the railroad data (e.g., intoxication and drug use).

Using the results from Phase 1 and qualitative information collected in Phase 2, Sharma will develop a mathematical model (i.e., predictive model) to predict the probability of accidents, injuries, and fatalities resulting from grade crossing collisions between railroads and motor vehicles. FRA's current predictive model is used to help scale the risk of a grade crossing based on its infrastructure. This model helps FRA compute cost effectiveness of grade crossing upgrades and identify grade crossing locations for on-site inspections.

The predictive model resulting from Phase 2 of the current project will identify both structural grade crossing attributes and human factors elements associated with high grade crossing accident rates.

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KEYWORDS

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