Analysis and Modeling of Grade Crossing Accidents

Presented At:

2017 Grade Crossing Research Needs Workshop

August 15, 2017

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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

Technology

- *What new equipment works best to reduce accident frequency at grade crossings?*
- *Results of In-field testing*

Education & Enforcement

- *Are education programs effective?*
- *How can police officers help enforce safety?*

Demographics & Causes

- *Common risk factors*
- *Demographics of people involved in grade crossing accidents*

Human Behavior

- *In-vehicle monitoring of drivers*
- *How often are accidents caused by poor decision making or distractions?*

Trespassing Incidents

- *Common risk factors*
- *Demographics of trespassers*
- *Mitigation strategies*

Recommended Practices

- *Procedures for grade crossing closure*
- *Locomotive warning lights*

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

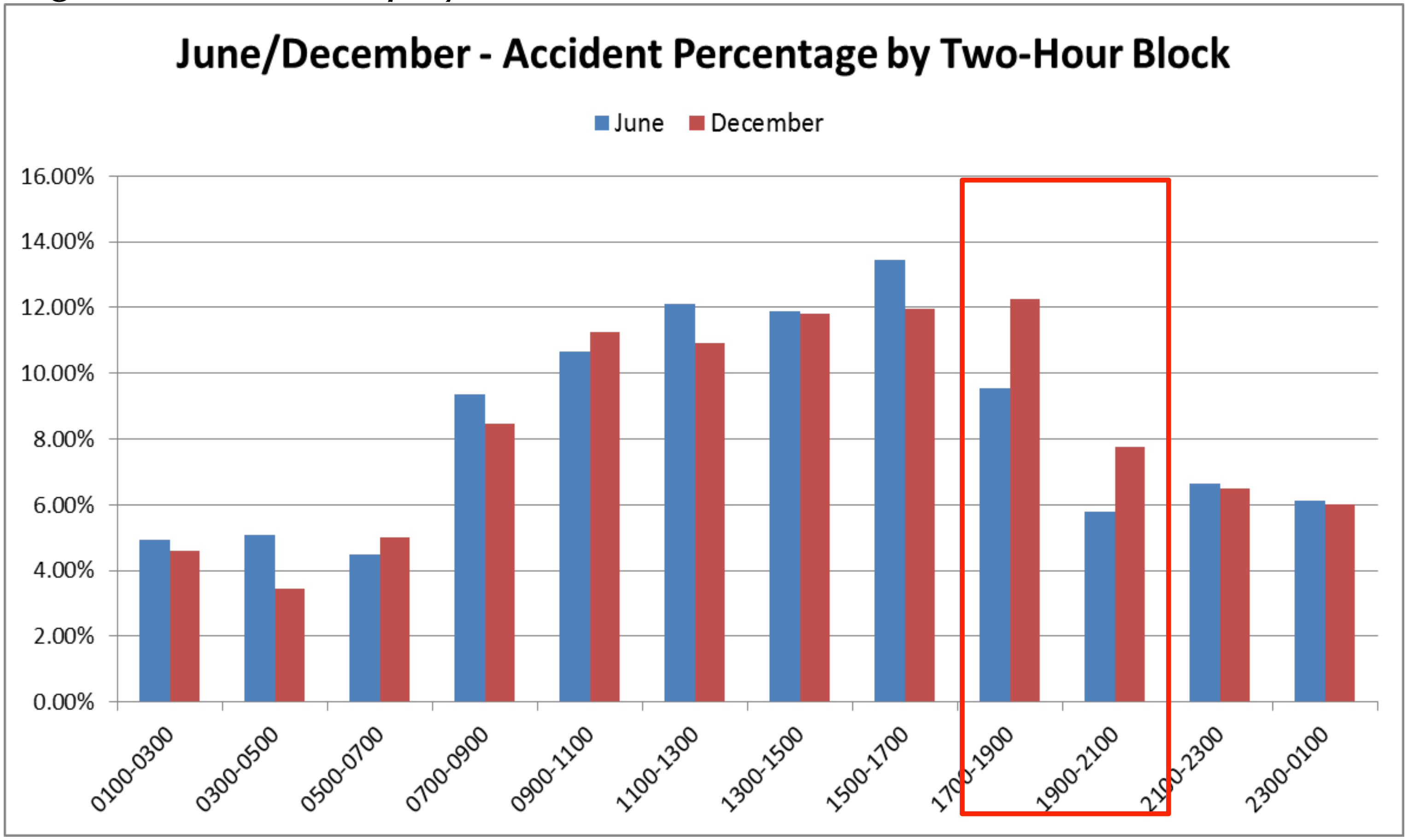
- Confirmed several demographic elements that had already been identified by FRA's data analysis team
  - Distribution of ages
  - Males being more likely to be involved in an accident
- Identified that males were more likely to be involved in a grade crossing accident even after correcting for exposure, 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

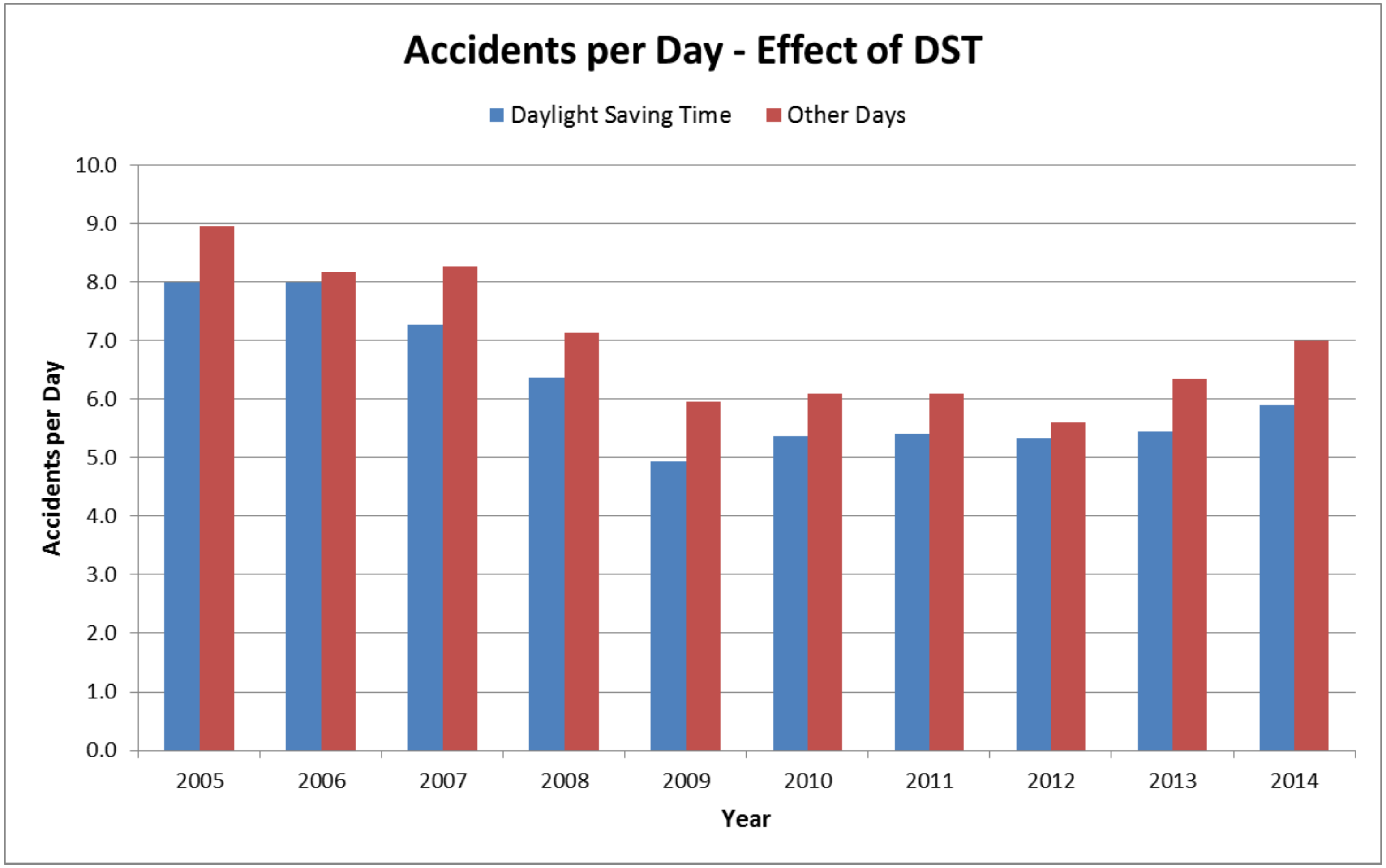
What is the effect of driving at night?

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?

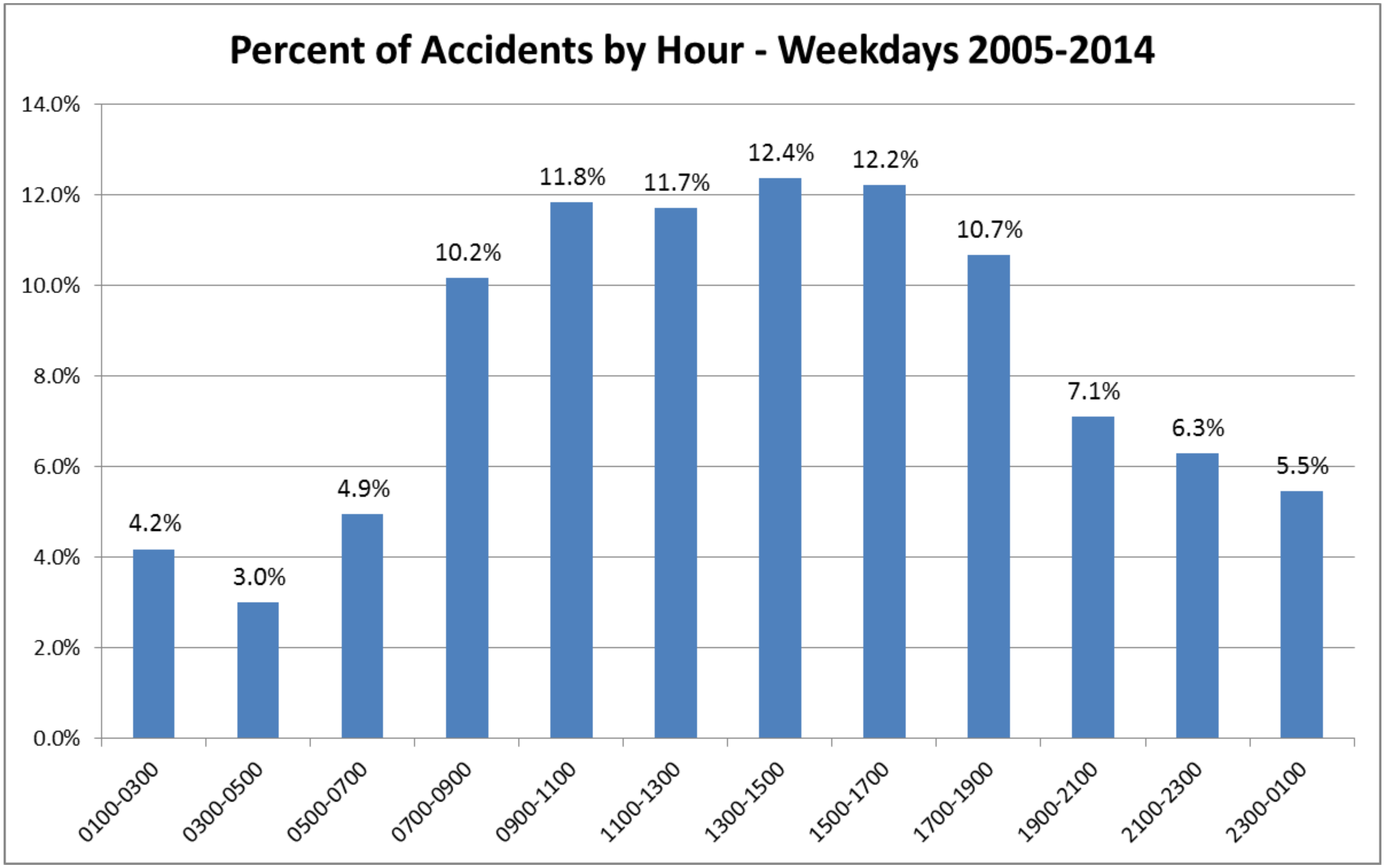


Across the years, the shorter daylight hours have higher accident rates.

Temporal Issues – Weekend Nights

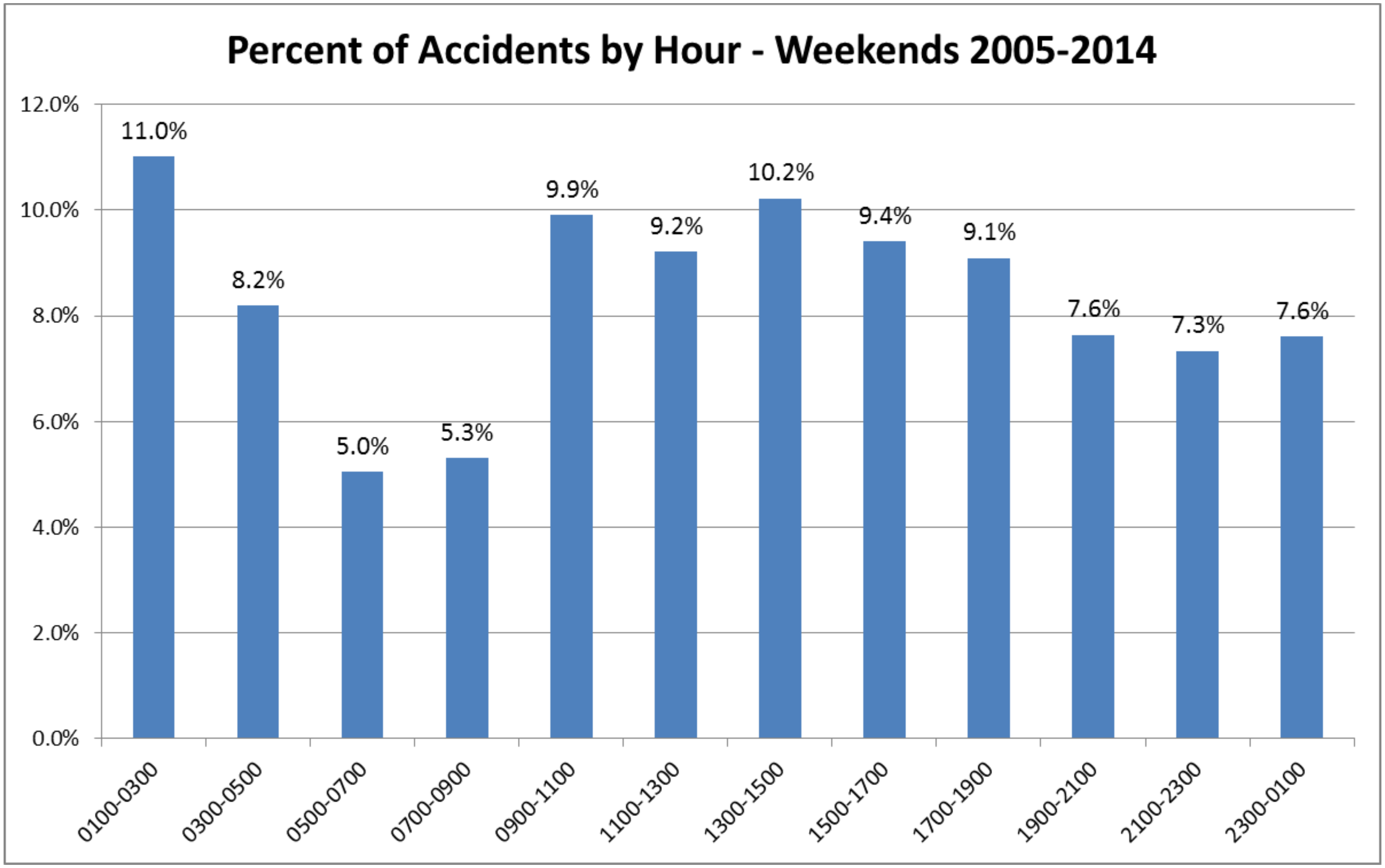
- Weekend nights experience a lot more late night accidents, especially from 1am to 3am
  - A review of driver demographics associated with these late night accidents indicates that driver age is 7 - 8 years lower than the overall average.
  - There does not appear to be a gender differential.

Time of Day Analysis – Weekdays



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

			All Days	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Hour	From	To	Avg. Age	Avg. Age	Avg. Age	Avg. Age	Avg. Age	Avg. Age	Avg. Age	Avg. Age
0100-0300	1AM	3AM	34.40	36.69	35.84	38.37	33.23	33.68	33.54	32.63
0300-0500	3AM	5AM	34.67	41.03	37.00	36.54	36.65	37.75	31.37	29.95
0500-0700	5AM	7AM	40.62	41.15	42.37	40.69	40.63	41.70	40.14	35.38
0700-0900	7AM	9AM	43.25	43.95	42.18	42.05	42.67	45.03	44.94	41.79
0900-1100	9AM	11AM	46.45	46.51	46.56	47.15	47.40	45.49	45.68	46.31
1100-1300	11AM	1PM	45.59	45.96	45.80	46.68	46.89	44.86	43.30	43.37
1300-1500	1PM	3PM	45.36	47.65	46.09	46.28	46.06	43.56	43.80	42.68
1500-1700	3PM	5PM	42.62	42.30	43.31	43.65	41.94	41.74	42.36	43.22
1700-1900	5PM	7PM	41.99	41.53	42.53	42.53	41.70	42.77	40.95	41.17
1900-2100	7PM	9PM	41.12	41.72	41.35	41.61	39.95	39.72	43.17	40.70
2100-2300	9PM	11PM	38.92	39.30	40.27	38.52	40.15	38.29	37.75	37.97
2300-0100	11PM	1AM	36.25	35.46	37.77	36.84	38.29	34.97	35.57	34.92

42 is the overall average age of drivers involved in grade crossing accidents

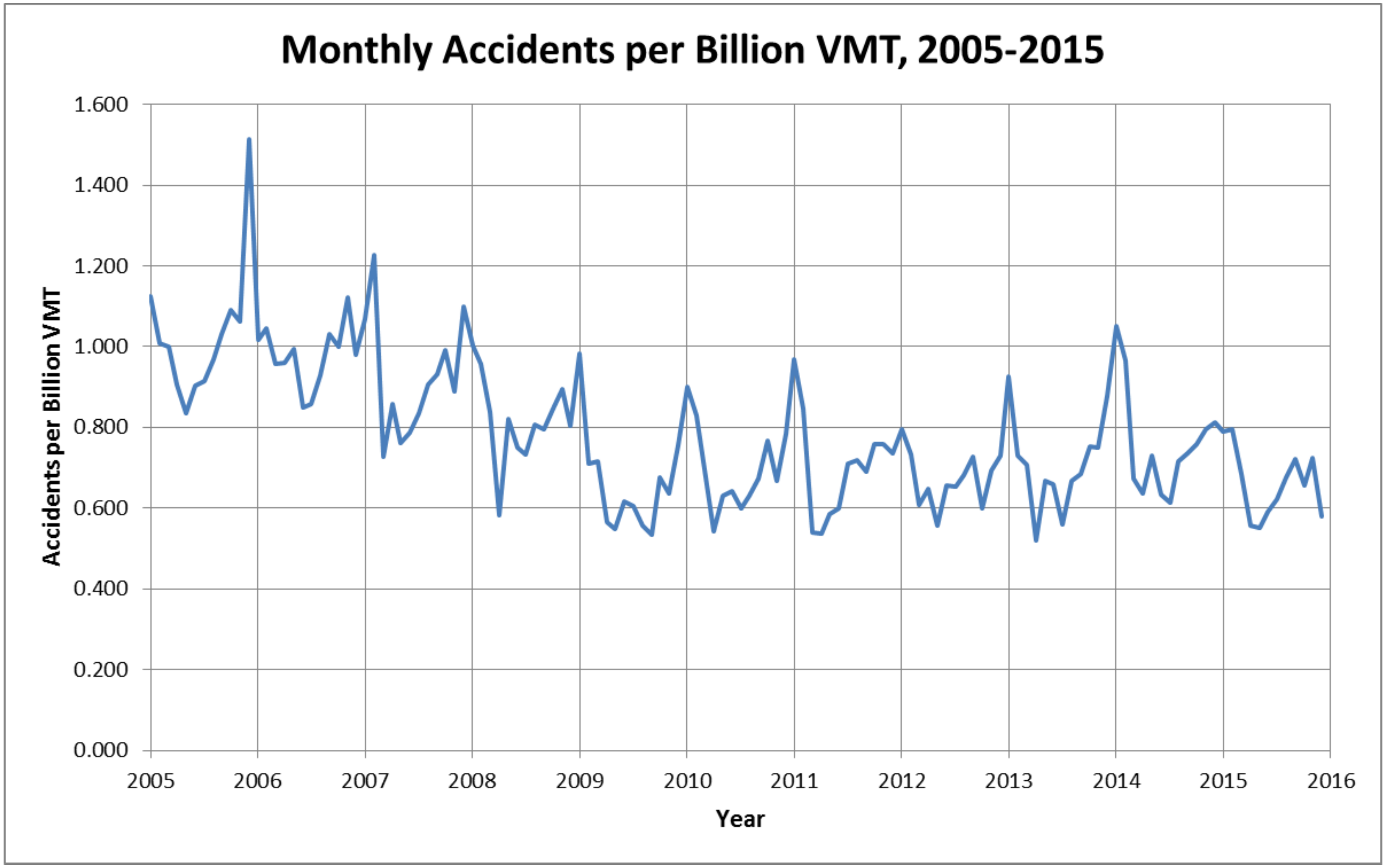
Average driver ages under 35 are highlighted

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 <u>time series decomposition</u>, this data can be broken down into: linear trend, cyclical trend, seasonal trend, and randomness factor

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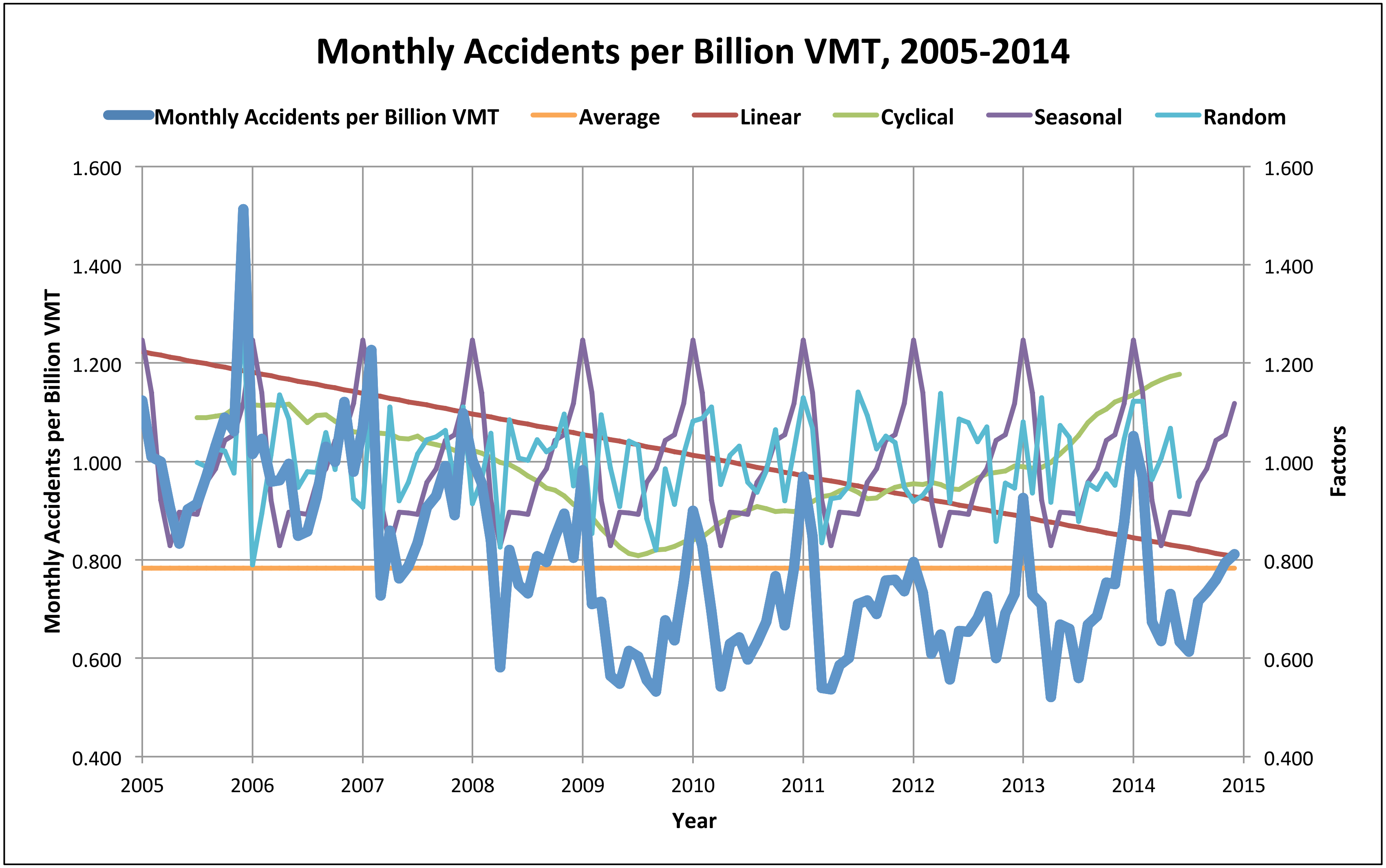
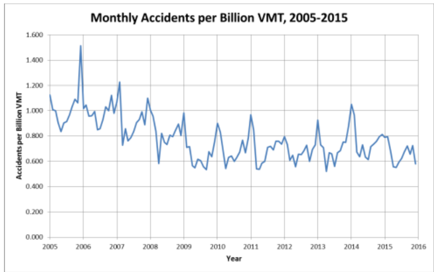
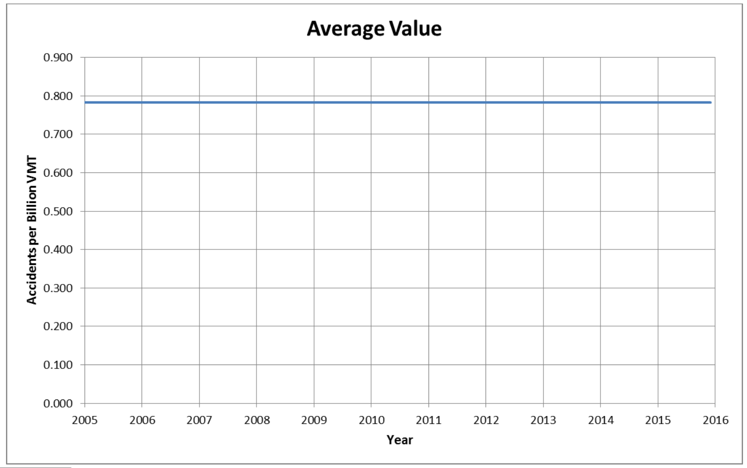
OFFICE OF RESEARCH & DEVELOPMENT



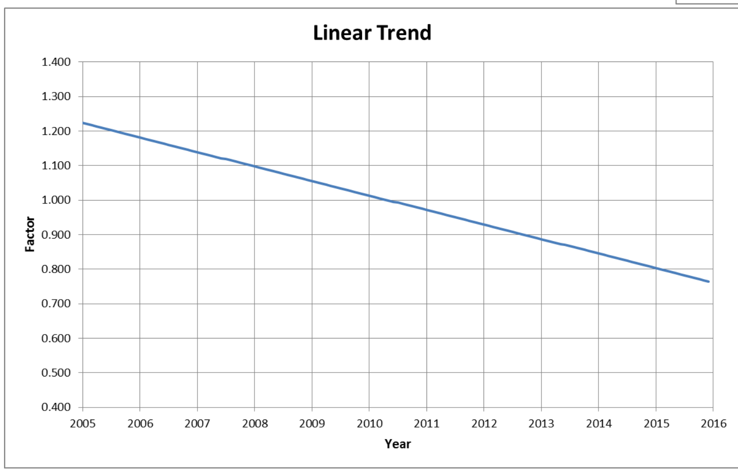
The lines for Cyclical and Random are cut off at the ends due to the way they are calculated

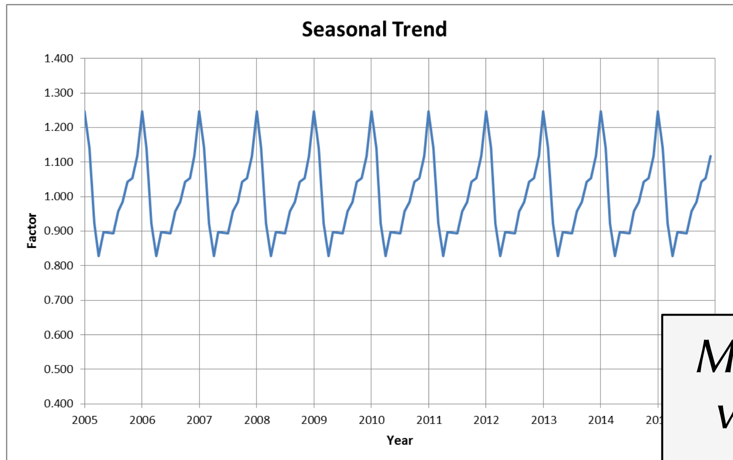
GRADE CROSSING DATA ANALYSIS



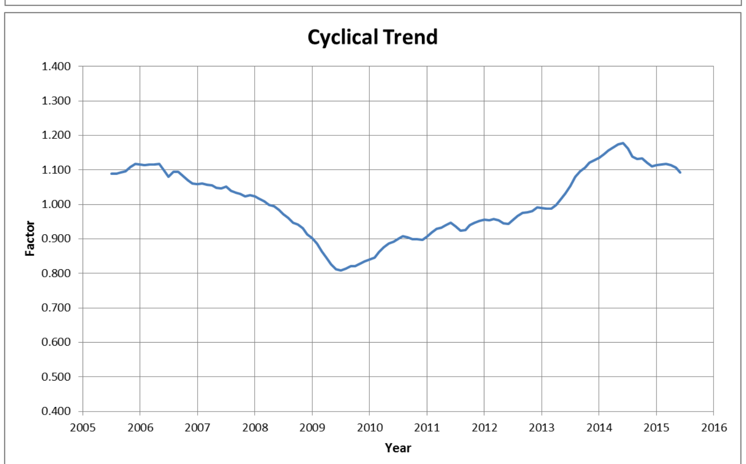


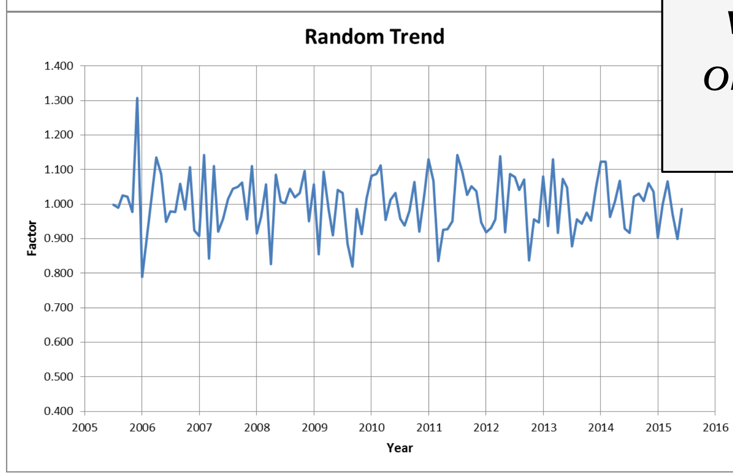
Time series analyses of <u>Normalized</u> accident data



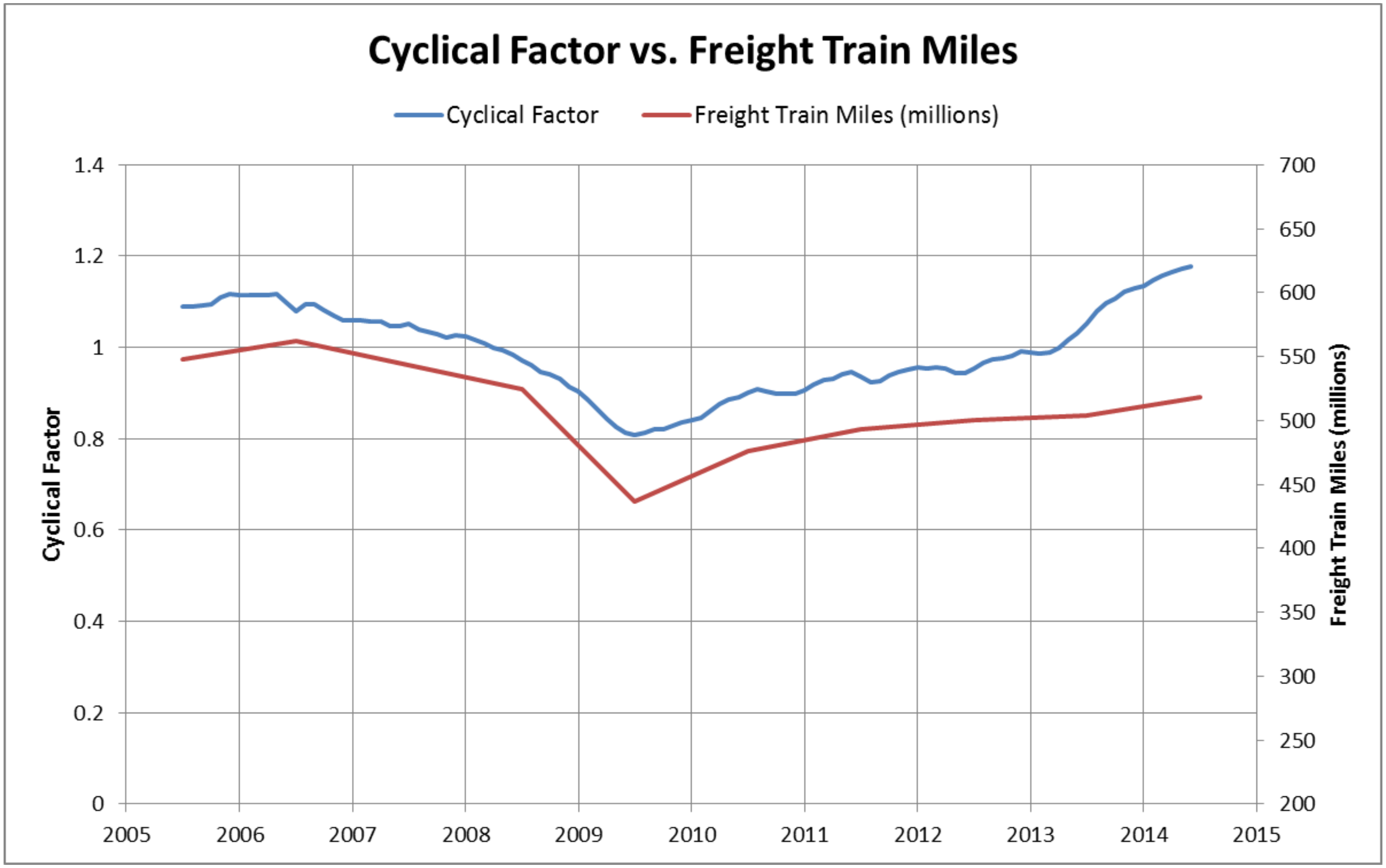


Multiplying these values together will return the original accident data



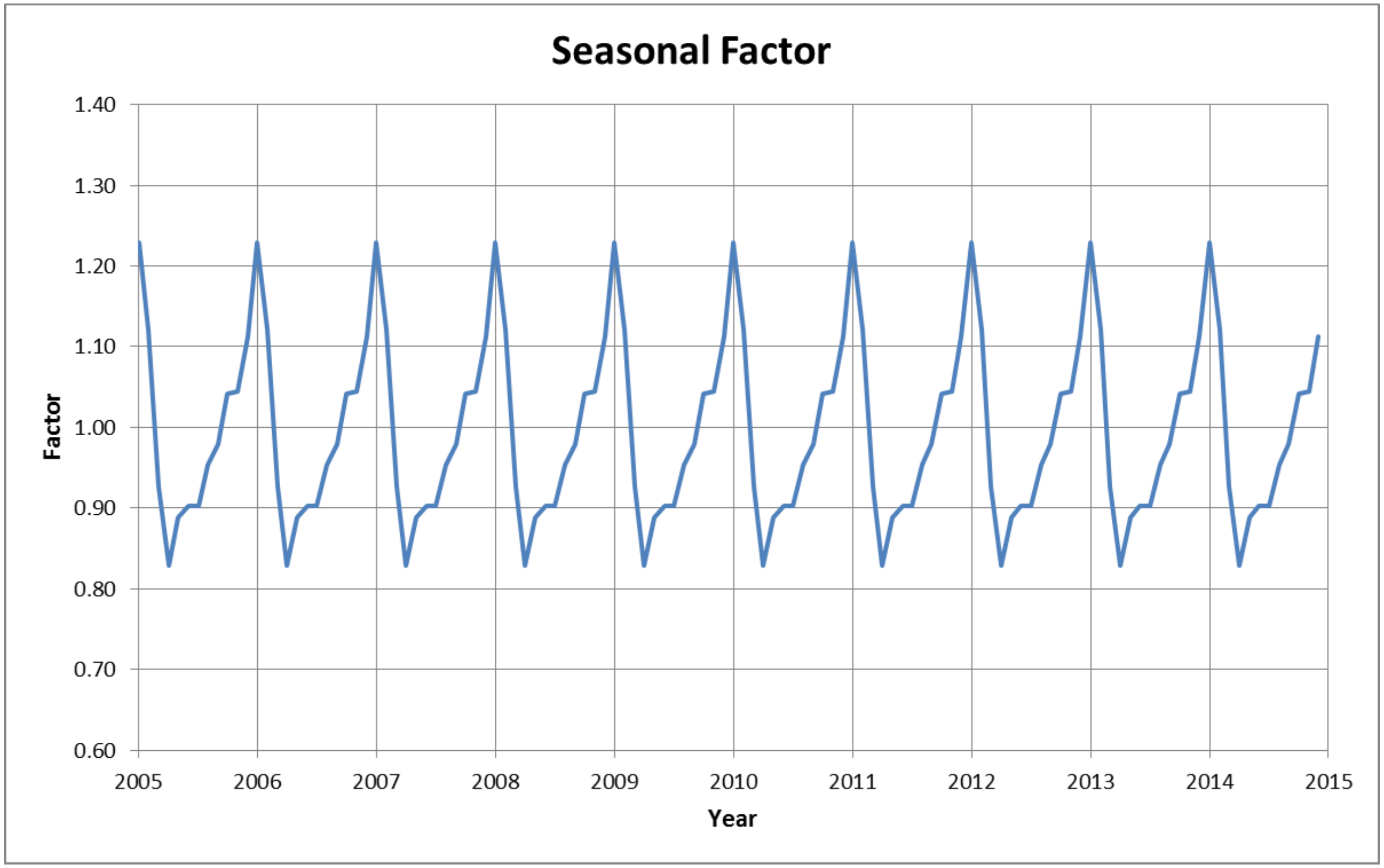


Closer Look at Cyclic Trends



Cyclical Factor taken from time series normalized by vehicle miles

Closer Look at Normalized Seasonal Factor



	Seasonal Factor
January	1.229
February	1.121
March	0.927
April	0.829
May	0.888
June	0.903
July	0.902
August	0.954
September	0.980
October	1.042
November	1.044
December	1.113

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

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

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