Analysis of Risk as a Function of Driving-Hours 1 Through 11

Richard Hanowski, Ph.D.
Director, Center for Truck & Bus Safety
Virginia Tech Transportation Institute (VTTI)

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- Report was completed in January and is currently in peer review (Hanowski, Olson, Bocanegra, and Hickman, 2008)

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Federal Motor Carrier Safety Administration

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Our Mission: Save lives, prevent injuries, reduce vehicle-related crashes

Project Overview

- The revised Hours-of-Service (HOS) regulations were published on April 28, 2003
- One central component of the revised regulations was an increase in off-duty time from 8 to 10 hr
- Hanowski, Dingus, Sudweeks, Olson and Fumero (2005) found that this increase in off-duty time lead to drivers getting more sleep; approximately 1 hr more than under the old HOS regulations

Time-on-Task

- A second key component of the revised regulations was an increase in allowable driving time from 10 to 11 hr
- An important question associated with this change was does the additional 1 hr of allowable driving time increase crash risk?
- That is, does an increase in *time-on-task* (from 10 to 11 hr) increase crash risk?

Previous Findings

- Findings from previous research to answer this question are mixed
- For example, Hanowski et al. (2005) found no difference in critical incident occurrence between the 10th and 11th hours (i.e., no time-on-task effect)
- Also, the Driver Fatigue and Alertness Study (Wylie et al., 1996), a naturalistic study, found a strong time-of-day effect but not a time-on-task effect

More Related Findings

- However, Park, Mukherjee, Gross, and Jovanis (2005), using crash reports, did find an increase in crash risk associated with increasing driving-hours; increasing slightly between driving-hours 1 through 4 and then increasing significantly in the 5th hour

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Current Study

- Analysis of data collected in a naturalistic driving study to investigate:
  1. Critical incidents as a function of driving-hours 1 through 11
  2. For drivers that drove into the 11th hour, assess critical incidents for driving-hours 1 through 11
  3. Modeling the data to look for significant differences across driving-hour (logistic regression)
  4. Critical incidents as a function of shift within the driver's work week or "tour-of-duty"
  5. Critical incidents as a function of time-of-day

Method

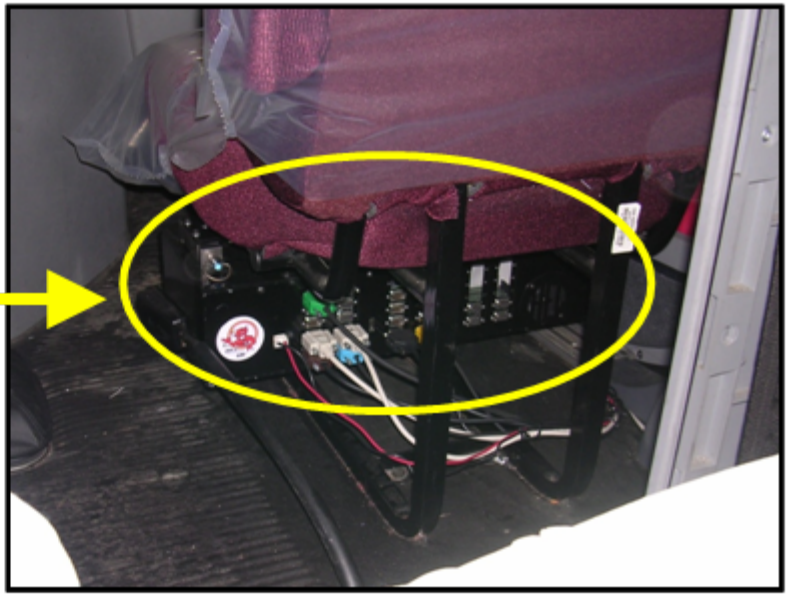
- Data collected during a Field Operational Test (FOT) of a Drowsy Driver Warning System (DDWS)
- Data collection began in May 2004 and ended in September 2005 (after the implementation of the revised HOS regulations)
- Naturalistic data collection approach is when data are collected as study participants drove company trucks during their normal, revenue-producing runs

Data Collection Approach

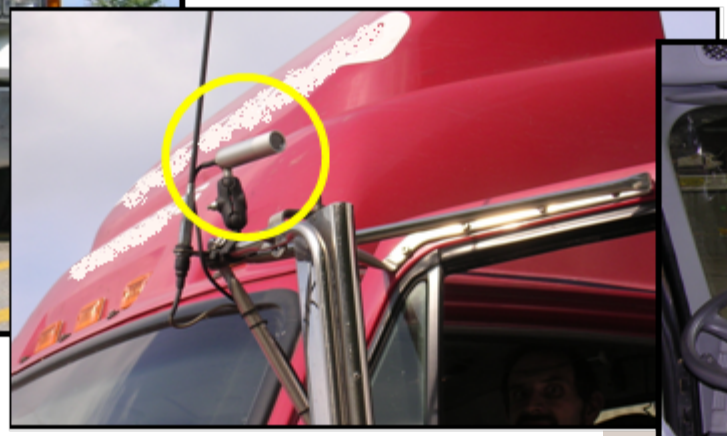
- 46 trucks were instrumented with the DDWS and a Data Acquisition System (DAS)
- 103 drivers participated, driving for, on average, 12.4 weeks
- 3 trucking companies; line-haul and long-haul represented
- Continuous data collection approach used
- Over 100 data measures collected on driving performance (e.g., lane position), actigraphy, questionnaires and 4 video cameras

Data collection system box

Data collection system box under passenger's seat



Front VORAD



Rearward Camera

Face & Forward Cameras

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Data Collection Statistics

- ~ 2.3 million miles of driving data
- ~ 190,000 hours of actigraphy data
- ~ 12 terabytes of data
- In terms of data collected, largest and most complete on-road study ever conducted
- Provides opportunity to look at various commercial motor vehicle issues, beyond the effectiveness of the DDWS

Critical Incidents

- Critical Incidents = crashes, near-crashes, and crash-relevant conflicts
- Crash = Contact with an object, either moving or fixed, at any speed
- Near-Crash = Any circumstance that requires a rapid, evasive maneuver (e.g., hard braking, steering) by the subject vehicle or any other vehicle, pedestrian, cyclist, or animal, in order to avoid a crash
- Crash-Relevant Conflict = …less severe evasive maneuver as compared to Near-Crash

Datasets

- Number of critical incidents varied based on the analysis conducted
- Reason is the data were parsed in different ways to help ensure no significant findings were being overlooked
- For example, Analysis 1 had:
  - 819 Critical Incidents
    - 12 Crashes (6 V1 at-fault; 3 deer hits)
    - 12 Tire-Strikes
    - 85 Near-Crashes
    - 710 Crash-relevant Conflicts

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Key Results

- *Driving Hours 1 through 11*
- Conducted 8 sub-analyses, parsing the data in different ways to help ensure no significant findings were overlooked
- For each driving hour, frequency of critical incidents and opportunities (exposure) was determined

Relative Frequency Calculation

- A rate was calculated:

  $$\frac{\text{Critical Incidents per Driving-Hour}}{\text{Total Opportunities per Driving-Hour}}$$

- Examples:
  - Driving Hour 1: Rate = 0.026

    $$\frac{\text{122 Critical Incidents}}{\text{4748 Opportunities}}$$

  - Driving Hour 11: Rate = 0.015

    $$\frac{\text{23 Critical Incidents}}{\text{1535 Opportunities}}$$

- Odds ratios on the rates were evaluated

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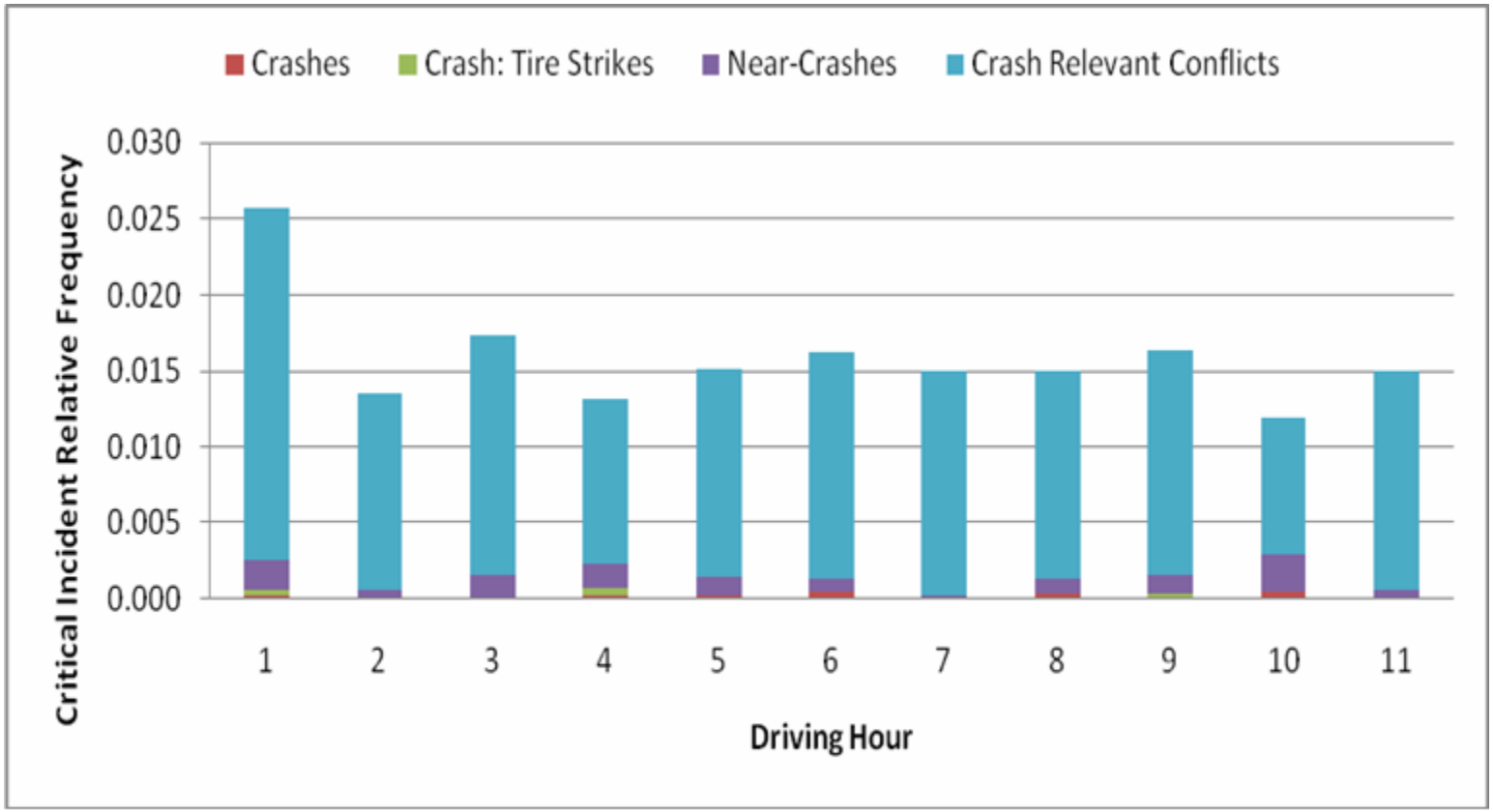
Time-on-Task Results: At-fault



Critical Incident Relative Frequency as a Function of Driving-Hour where the Subject Driver was At Fault

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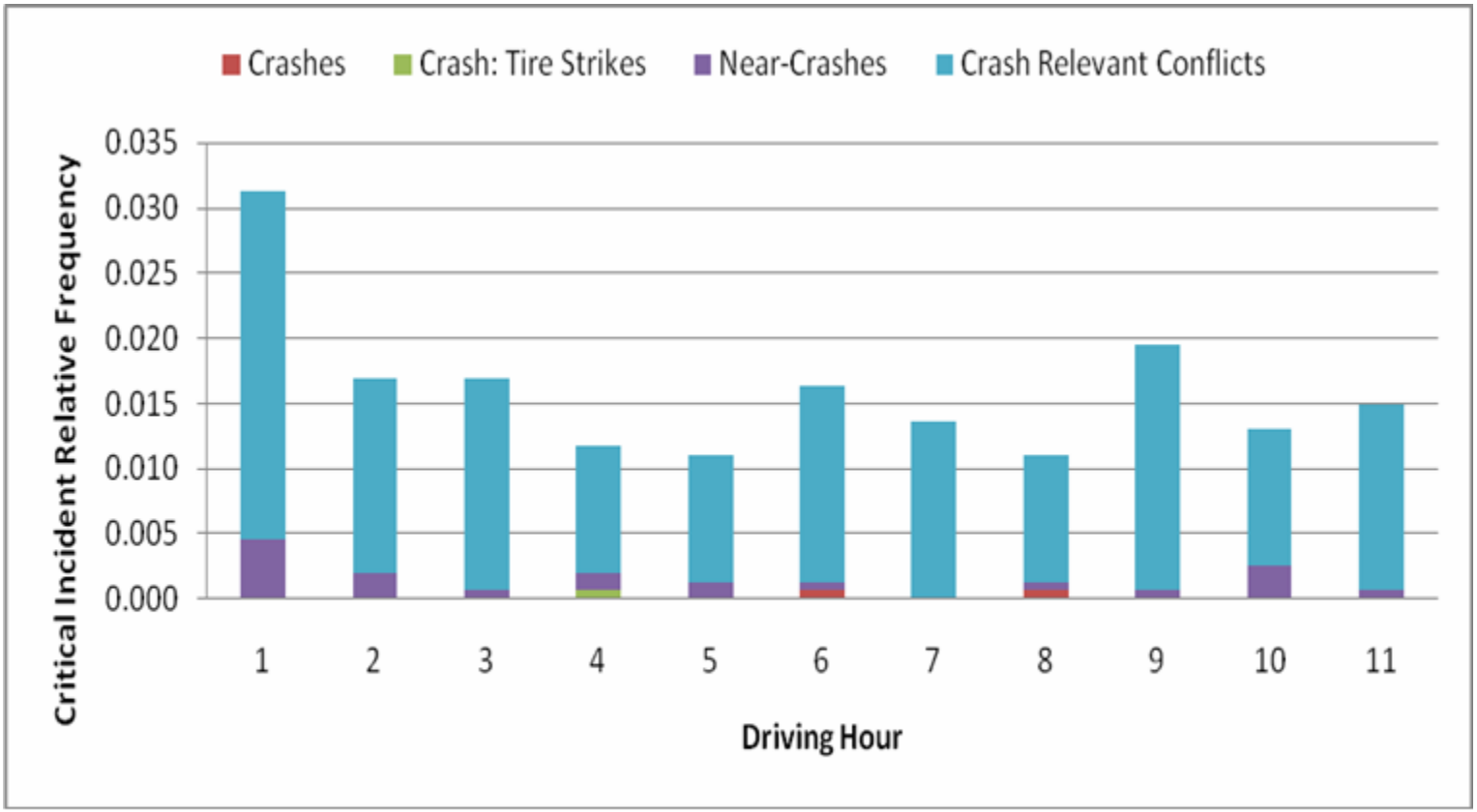
Time-on-Task Results: 11th Hour Drives (N=1535 trips), At-fault



Critical Incident Relative Frequency as a Function of Driving-Hour for Trips that went into the 11th Driving-Hour, and the Truck Driver was At-fault

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Logistic Regression Approach

- Analysis 3 computed odds ratios using logistic regression modeling
- Difference in approach from Analyses 1 and 2 is that assumption of independence is not made
- Approach uses Generalized Estimates Equations to account for correlations that might exist
  - Logit $(P(Y_t = SCE)) = \alpha_{SCE} + \beta_t$
- Where t is driving-hours 1 through 11, α_{SCE} is the intercept term, and β_t is the effect of driving in the tth driving-hour

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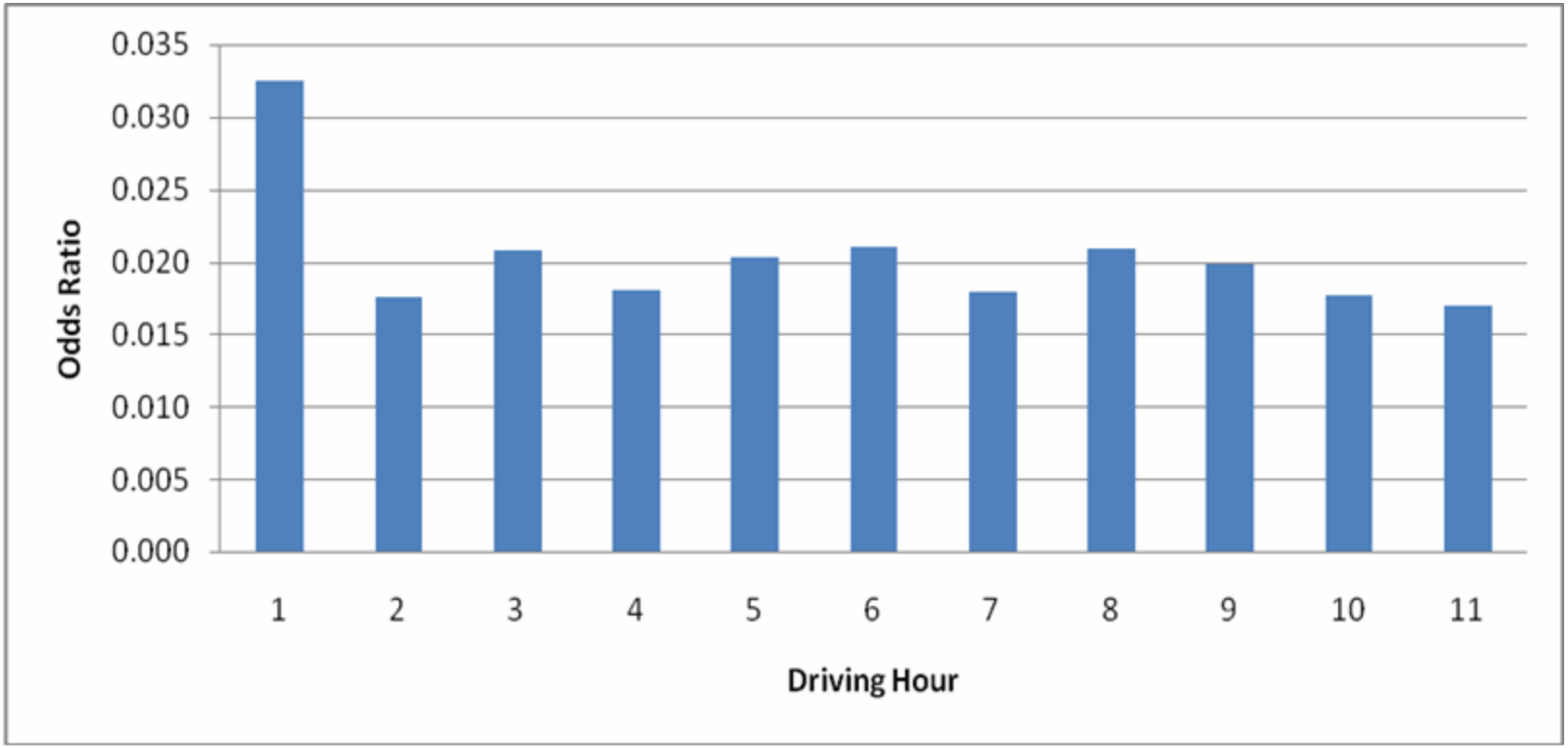
Logistic Regression Results: All Data



Odds Ratio as a Function of Driving-Hour Using Logistic Regression Modeling

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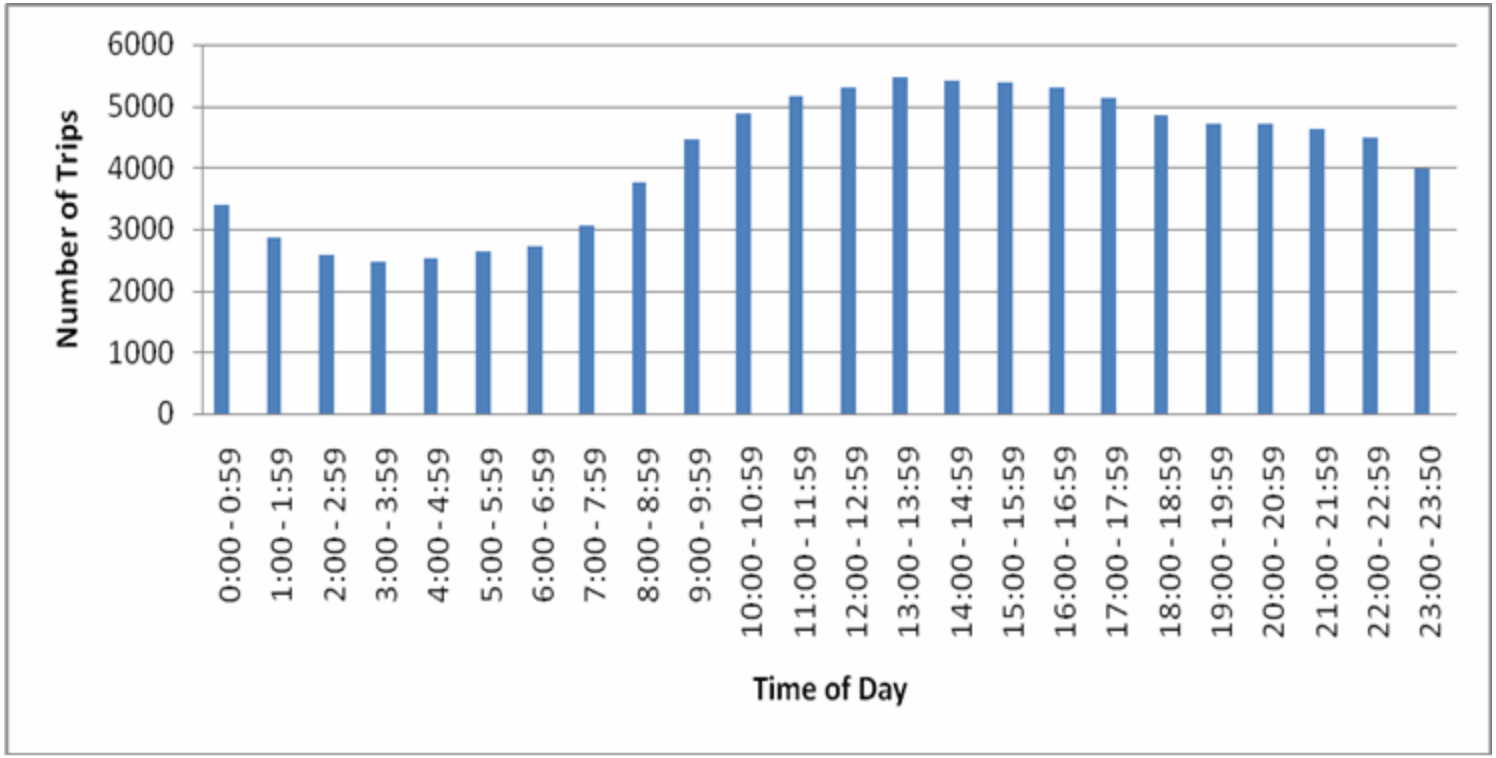
Time-of-Day Results



Number of Trips as a Function of Time-of-Day

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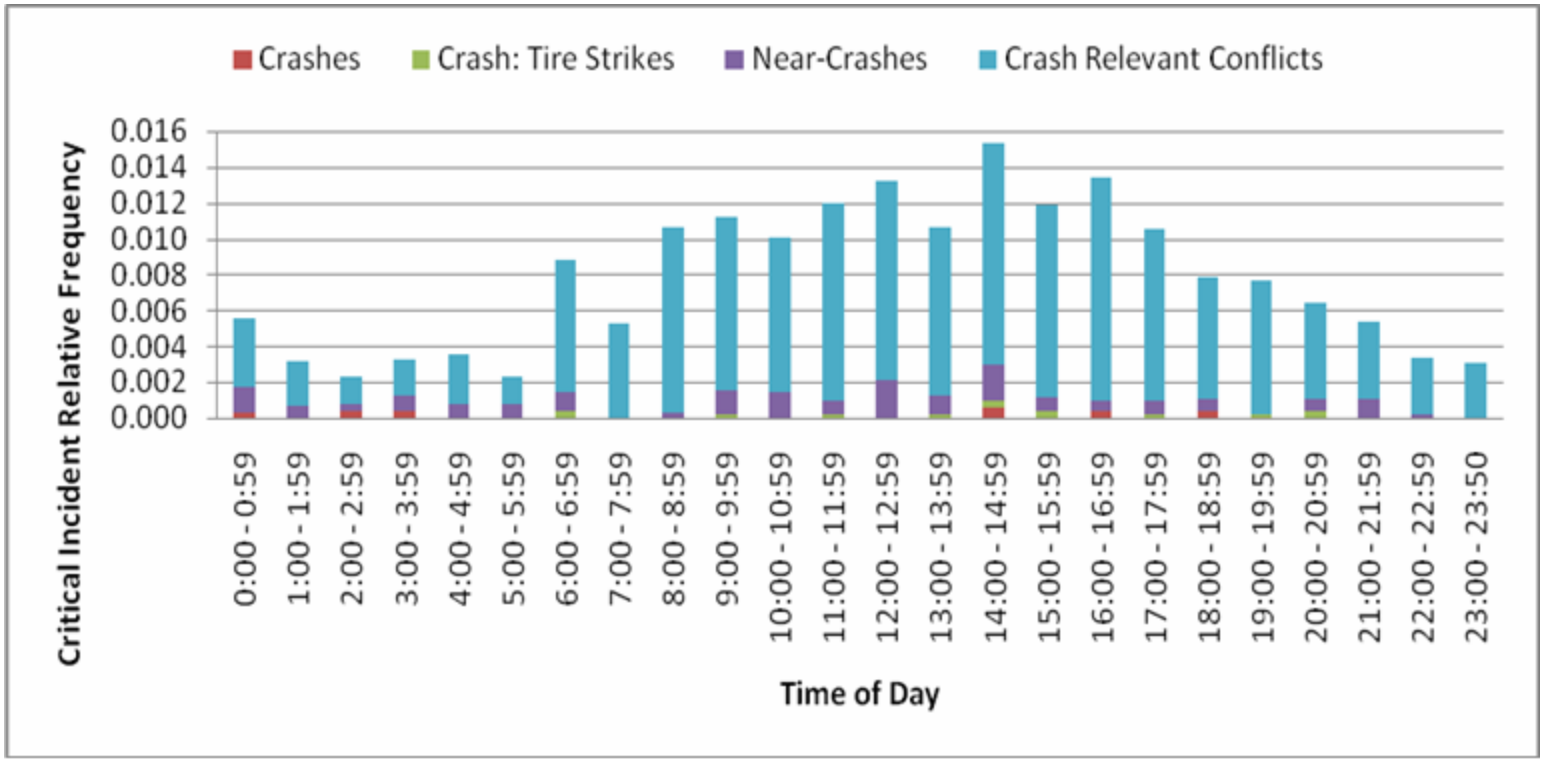
Time-of-Day Results



Critical Incident Relative Frequency as a Function of Time-of-Day

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Time-of-Day Follow-Up Analyses

- First, looked at circadian lows vs circadian highs (nothing significant); this analysis is outlined in the report
- Next, looked at traffic density
- Plotted data from Festin (1996) that was broken up by time-of-day…

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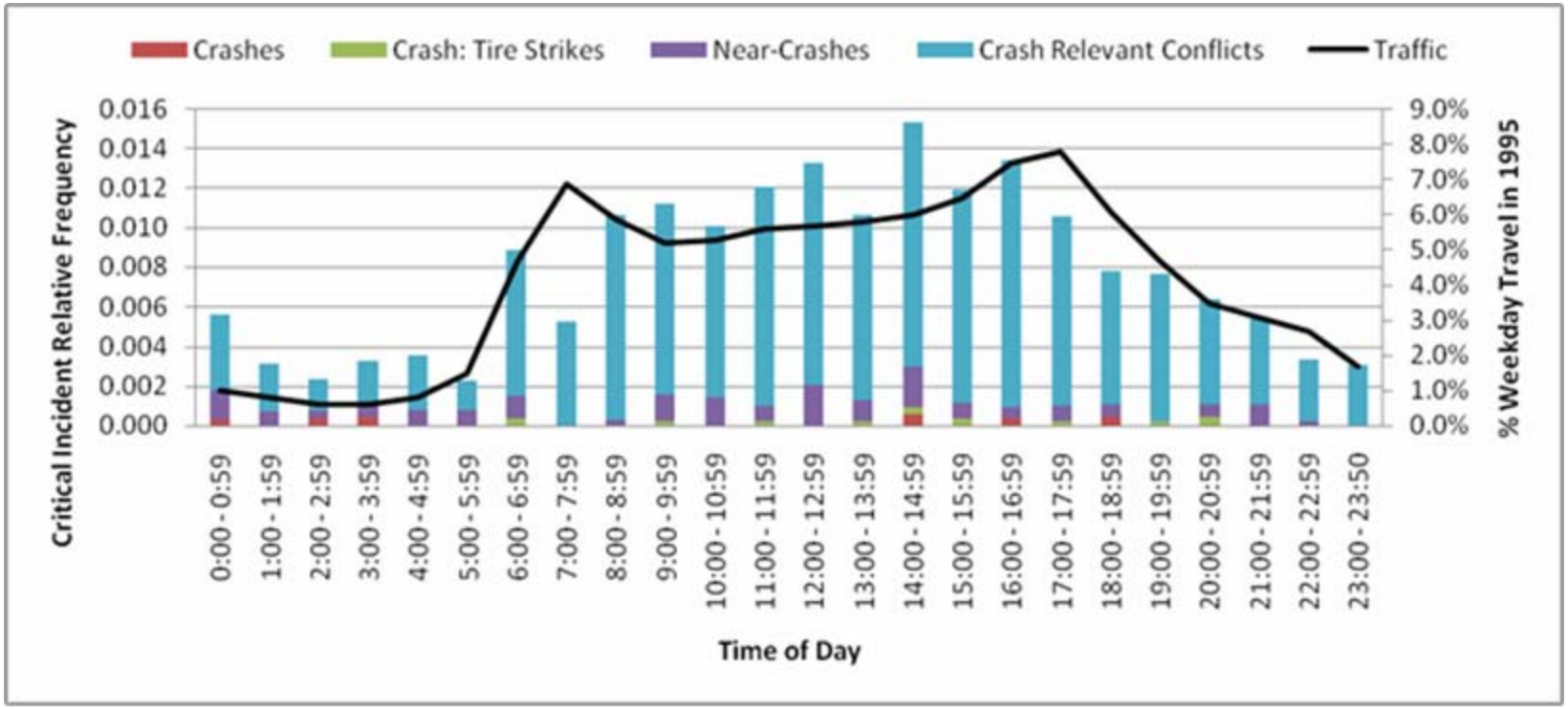
Time-of-Day/Traffic Density Results



Critical Incident Relative Frequency as a Function of Time-of-Day, with Traffic Density Plot Superimposed (R^2=0.69)

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Conclusions

- Study resulted in a major finding that is relevant to the assessment of the 2003 HOS regulations
- A statistically significant difference in critical incident relative frequencies between the 1st driving-hour and all other driving-hours
- However, there was generally no statistical difference between the 2nd through 11th driving-hours

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Consistent Results

- 1st hour "spike" was also seen in the LTCCS database
  - Of all hours, 1st driving-hour had the highest raw percentage of crashes (14.7%)
  - Note that the LTCCS database does not account for exposure, however the current study with naturalistic data did
- Findings from this study are consistent with Wylie et al. (1996) with regard to time-on-task; i.e., poor predictor of crashes…except for the first hour

No Difference in Hours 2-11

- Why the 1st hour spike?
  - Sleep Inertia?
  - "Take-off" and "Landing" effects?
  - Time-of-day?
- Study results do not support the hypothesis that there is an increased risk from CMV drivers driving in the 11th hour as compared to the 10th hour, or any driving-hour
- Caution: Though this dataset is perhaps the best of its kind, it represents a small fraction of CMV drivers, vehicles, miles driven, and there were very few crashes

hanowski@vtti.vt.edu