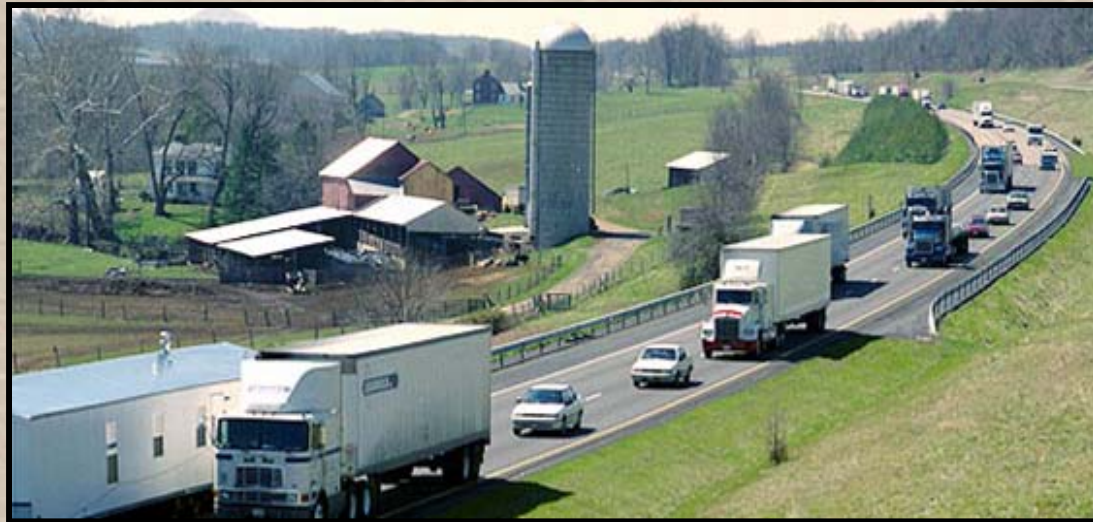


Evaluating Crash Causation in Commercial Vehicles using Naturalistic Data



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Presentation Overview

- Virginia Tech Transportation Institute (VTTI) overview
- What is naturalistic data collection?
- Commercial Vehicle Field Operational Test
- Key Results
- Hours-of-Service Analysis
- Summary



VTTI Safety Research

VTTI Safety Research Centers

- Center for Truck and Bus Safety
Rich Hanowski, Director
- Center for Automotive Safety Research
Jon Hankey, Director
- Center for Vehicle-Infrastructure Integration
Vicki Neale, Director
- Center for Product Development
Mike Mollenhauer, Director



Sample Capabilities

- Virginia Smart Road
- Car and truck fleet
- Truck Driving Simulator
- Naturalistic Driving
- Database Analyses



Safety Research Impact

- VTTI conducts research that has a measurable impact on National Transportation Policy
 - Driver distraction
 - Hours of Service
 - Truck driver fatigue
 - Night visibility enhancement
 - Indirect visibility for trucks
 - School bus safety
 - Intersection crash avoidance
 - Teen driving safety
 - Evaluate ITS technologies
 - Transportation policy effects



Naturalistic Data Collection

- “in the natural or original position or place”
- Collecting driver behavior and performance data in a naturalistic environment
- Examples:
 - as light vehicle drivers commute to/from work (e.g., 100-Car Study)
 - as truck drivers operate their vehicles on revenue-producing runs (e.g., Sleeper Berth Study, Local/Short Haul Study)
- High validity
- Low control



Naturalistic Method

- Study participants use an instrumented vehicle for an extended period (e.g., several months to one year)
- Able to get detailed pre-crash/crash information along with routine driving behaviors
- Highly capable data acquisition systems (well beyond EDRs)
- Able to collect crash pre-cursor data and driver performance/behavior data using sensors and video cameras



Drowsy Driver Warning System Field Operational Test

- Sponsor
 - US Department of Transportation
- Purpose
 - Collect data that can be used to evaluate the effectiveness and operational capabilities, limitations, and characteristics of a drowsiness monitor



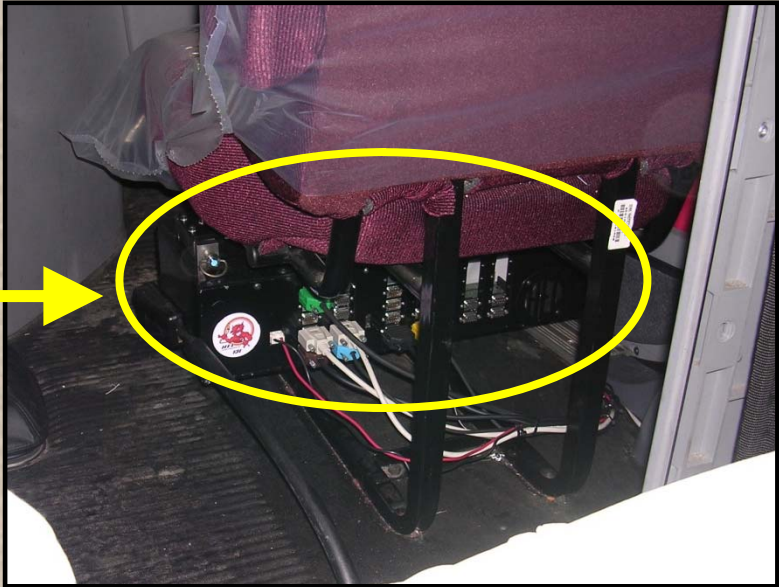
Approach

- 46 trucks were instrumented with the DDWS and a Data Acquisition System (DAS)
- 103 drivers participated
- Continuous data collection approach used
- Over 100 data measures collected on driving performance (e.g., lane position), actigraphy, questionnaires
- 4 video cameras also included



DAS box
under passenger's seat

DAS box



Front VORAD



Rearward Camera



Face & Forward Cameras

Data Collection Statistics

- ~ 2.5 million miles of driving data
- ~ 190,000 hours of actigraphy data
- ~ 12 terabytes of data
- In terms of data collected, largest on-road study ever conducted
- Data are presently archived at VTTI “live” on a Storage Area Network (SAN) system
- Great potential exists to mine the data to explore various issues



Finding Critical Incidents

- How are incidents identified in this large data set?
- Five event triggers
 - Longitudinal Acceleration
 - Time-to-Collision
 - Swerve
 - Critical Incident Button
 - Analyst Identified



Data Reduction and Analysis

- Data Directory
 - Used GES, FARS, LTCCS as models
 - Listed all relevant variables
 - Weather, road type, traffic, contributing factors
 - Variables relating to both subject driver/vehicle and other driver/vehicle



Analysis Overview

- Federal Motor Carrier Safety Administration (FMCSA)-sponsored study
 - Investigate research issues relating to:
 - Driver performance
 - *Crash causation* (crash pre-cursors)
 - NOT the safety benefits of DDWS
- Leveraged data from the DDWS FOT (“data mining”)
 - Preliminary analysis
 - May 2004 to May 2005 (75% of data)
 - 95 drivers (94 males, 1 female)
 - Mean age 39.5 years old
 - Mean CMV experience 10.5 years



Research Issues

- Discussions with FMCSA identified four priority issues:
 - Analysis of heavy vehicle safety events
 - Correlates of driver risk
 - *Countermeasure identification*
 - *Driving patterns and work/rest schedules*



Results

- Crashes: 14 + 14 tire strikes = 28 total
- Near-crashes: 98
- Crash-relevant conflicts: 789
- Total safety-critical events (i.e., the sum of the above): 915
- Baseline epochs: 1,072





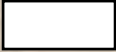
Issue 1: Analysis of Heavy Vehicle Safety Events

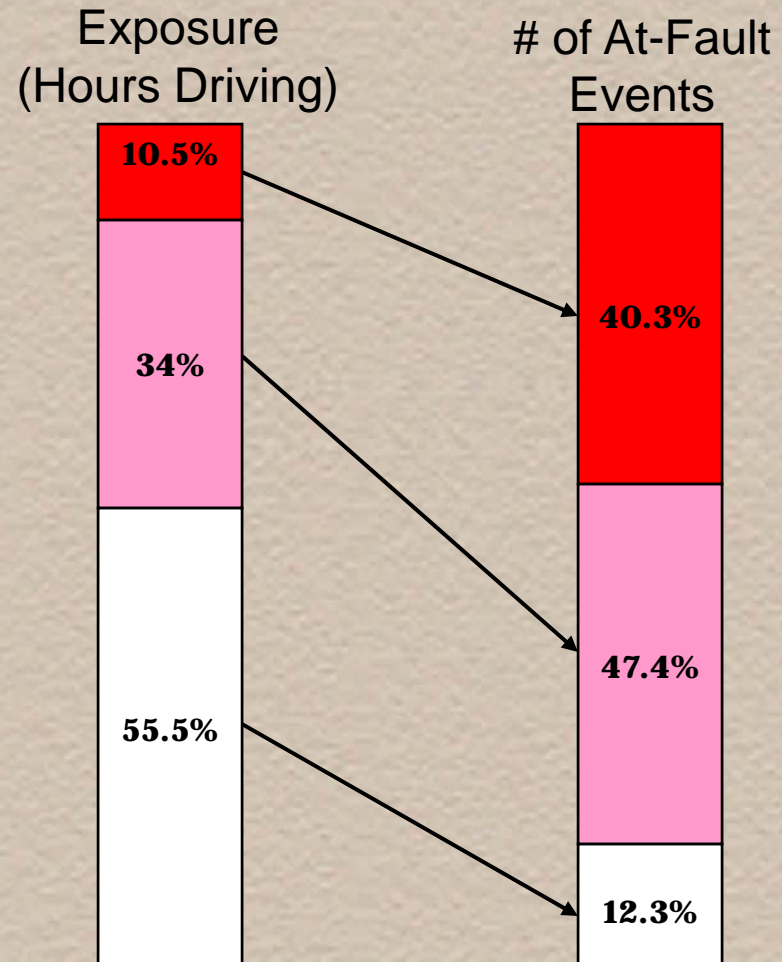
- Top 5 Critical Reasons coded to truck driver (V1):
 - Inadequate evasive action (14%)
 - Internal distraction (10.8%)
 - External distraction (6.2%)
 - Misjudgment of gap or others speed (5.7%)
 - Too fast for conditions (5.4%)
- Top 5 Critical Reasons coded to other driver (V2):
 - Apparent recognition or decision error (18.4%)
 - Aggressive driving (2.1%)
 - Too slow for traffic (1.5%)
 - Other illegal maneuver (1.1%)



Issue 2: Correlates of Driver Risk

95 Drivers:

- Worst 15 
- Middle 30 
- Best 50 



What the Results Mean...

- Driver-related factors are most important
- Minimize internal distractions
 - No cell-phone while driving policy?
- Defensive driving is critical and should be a major component of a fleet's training program
 - *Smith System*
 - *FMCSA-VTTI's "Driving Tips" website (Winter 2008)*
- There is a need to reach/educate the light vehicle driver and there is a need to reach law enforcement officers (need for more aggressive enforcement of existing laws)
- Incidents often occur when driver appears to be really comfortable with things...



Implications Beyond Trucks

- Do these findings apply to car drivers and other fleet drivers?
- YES, with regard to driver behavior being key
- In VTTI's 100-Car Study, *Inattention to the forward roadway* was the primary contributing factor
- 80% of all crashes and 65% of all near crashes involved at least one form of driving inattention just prior to (i.e., within 3 seconds) the onset of the conflict
- 86% of the lead vehicle crashes, the headway at the onset of the event was > than 2.0 seconds



Summary

- Naturalistic data collection provides a new and unique perspective to assess crash causation
- Provides an “instant replay” of the incident, and allows you to focus on driver behavior and crash pre-cursors
- This information is otherwise gained from eyewitness reports, police reports, second hand observations
- But, these aren't always accurate...



Analysis of Risk as a Function
of Driving-Hours 1 Through 11:
Implications for the Hours-of-
Service Regulations for
Commercial Vehicle Drivers



Project Overview

- The revised Hours-of-Service (HOS) regulations were published on April 28, 2003
- Two main changes:
 - Increase in off-duty time from 8 to 10 hr
 - Hanowski, Dingus, Sudweeks, Olson and Fumero (2005)
 - Increase in allowable driving time from 10 to 11 hr
 - Mixed results
 - Hanowski et al. (2005) & Wylie et al., (1996) found no effect of time-on-task
 - Park, Mukherjee, Gross, and Jovanis (2005) did find an effect, but relied on retrospective fleet crash reports



Method and Research Questions

- 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)
- Analysis included:
 - Critical incidents as a function of driving-hours 1 through 11
 - Critical incidents as a function of time-of-day



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



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:

Critical Incidents per Driving-Hour

Total Opportunities per Driving-Hour

- Examples:

– Driving Hour 1: Rate = 0.026

122 Critical Incidents

4748 Opportunities

– Driving Hour 11: Rate = 0.015

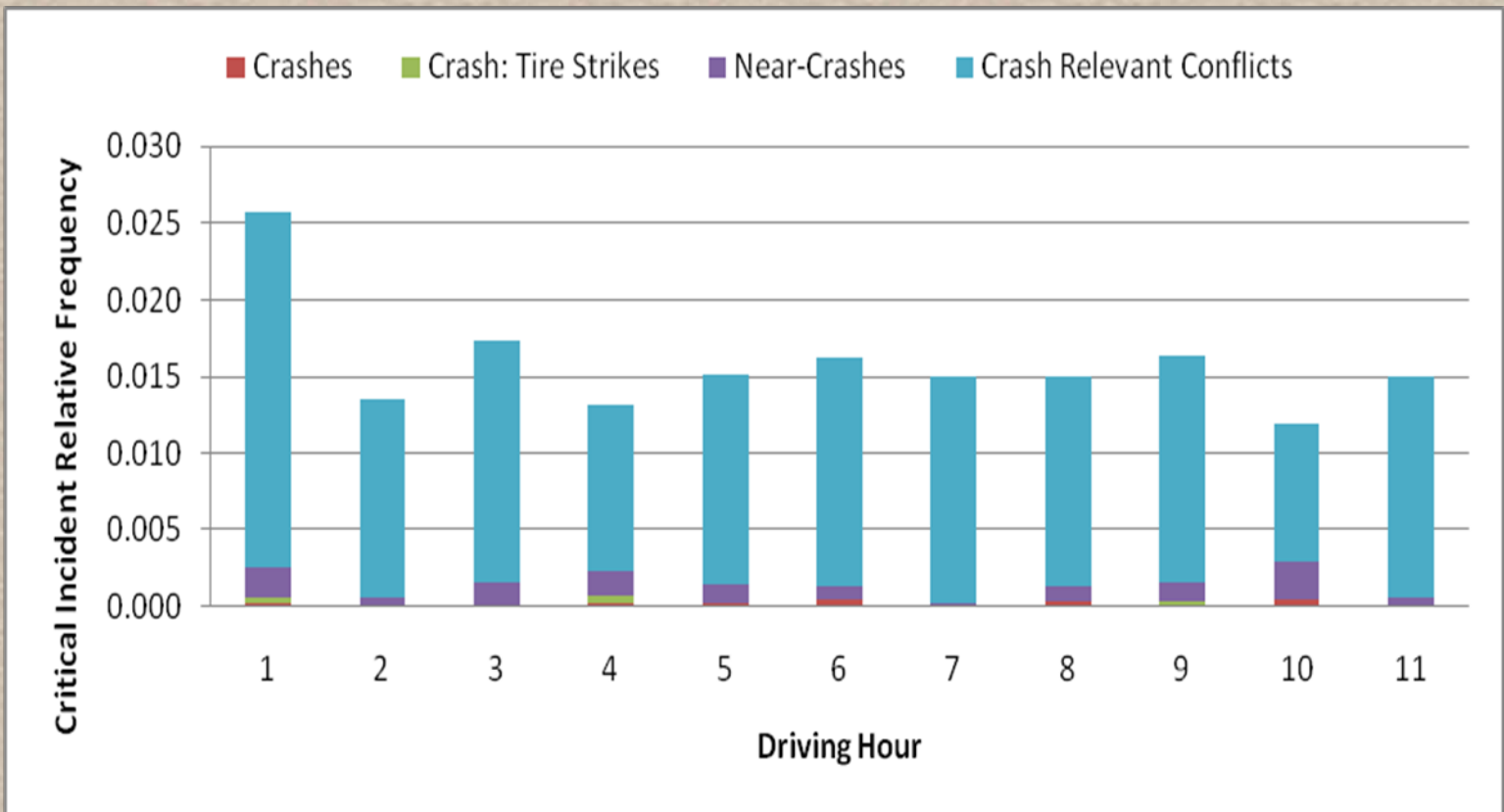
23 Critical Incidents

1535 Opportunities

- Odds ratios on the rates were evaluated

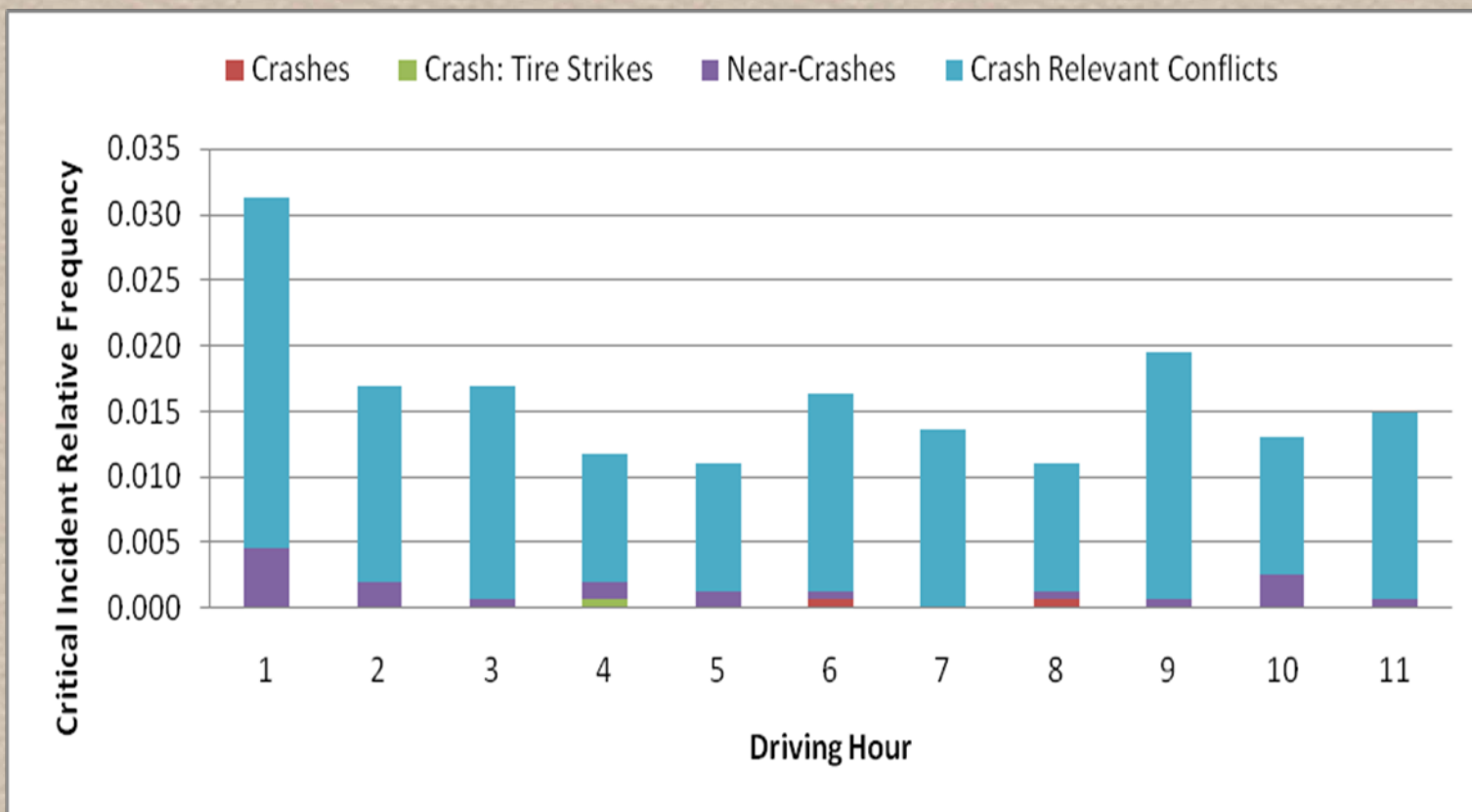


Time-on-Task Results: At-fault



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

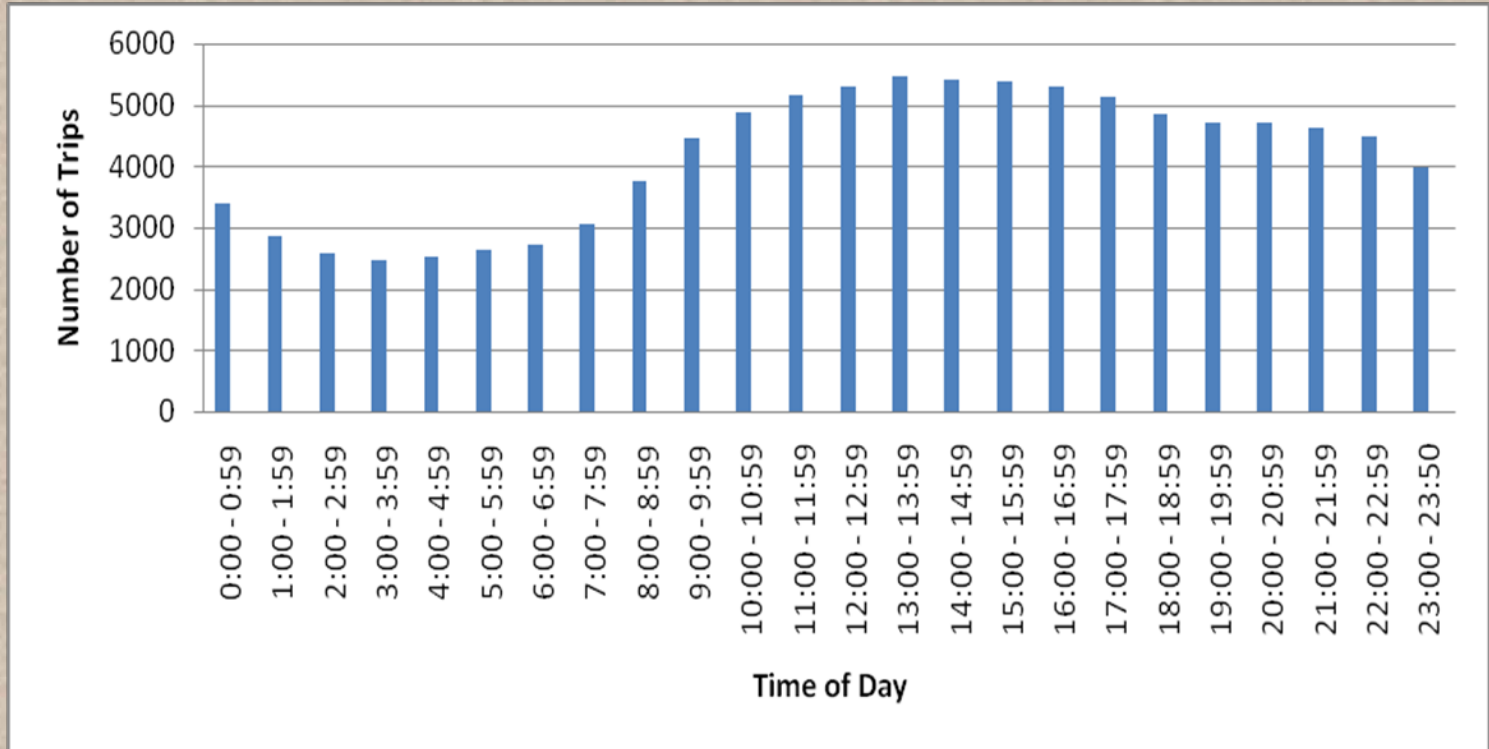
Time-on-Task Results: 11th Hour Drives (N=1535 trips), At-fault



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



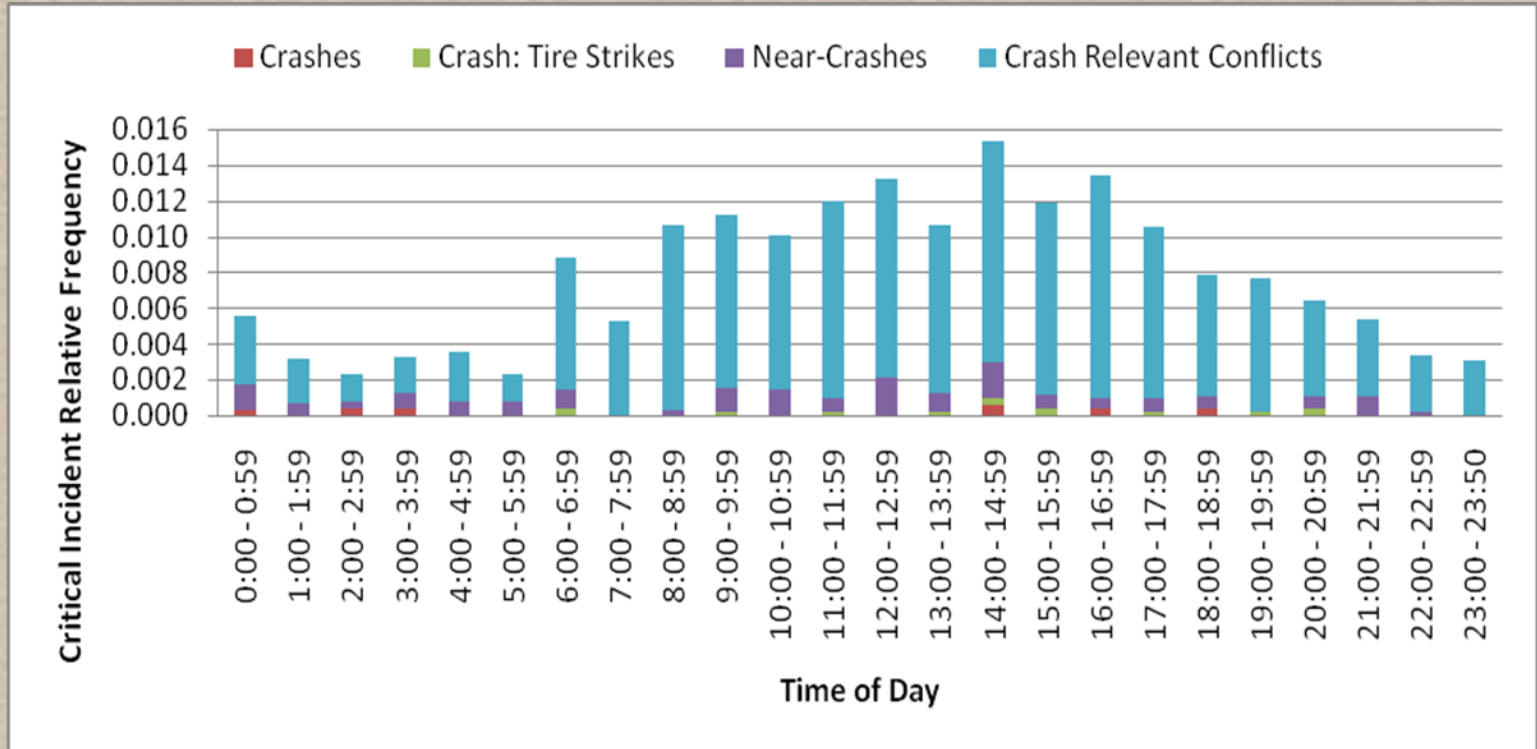
Time-of-Day Results



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



Time-of-Day Results



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

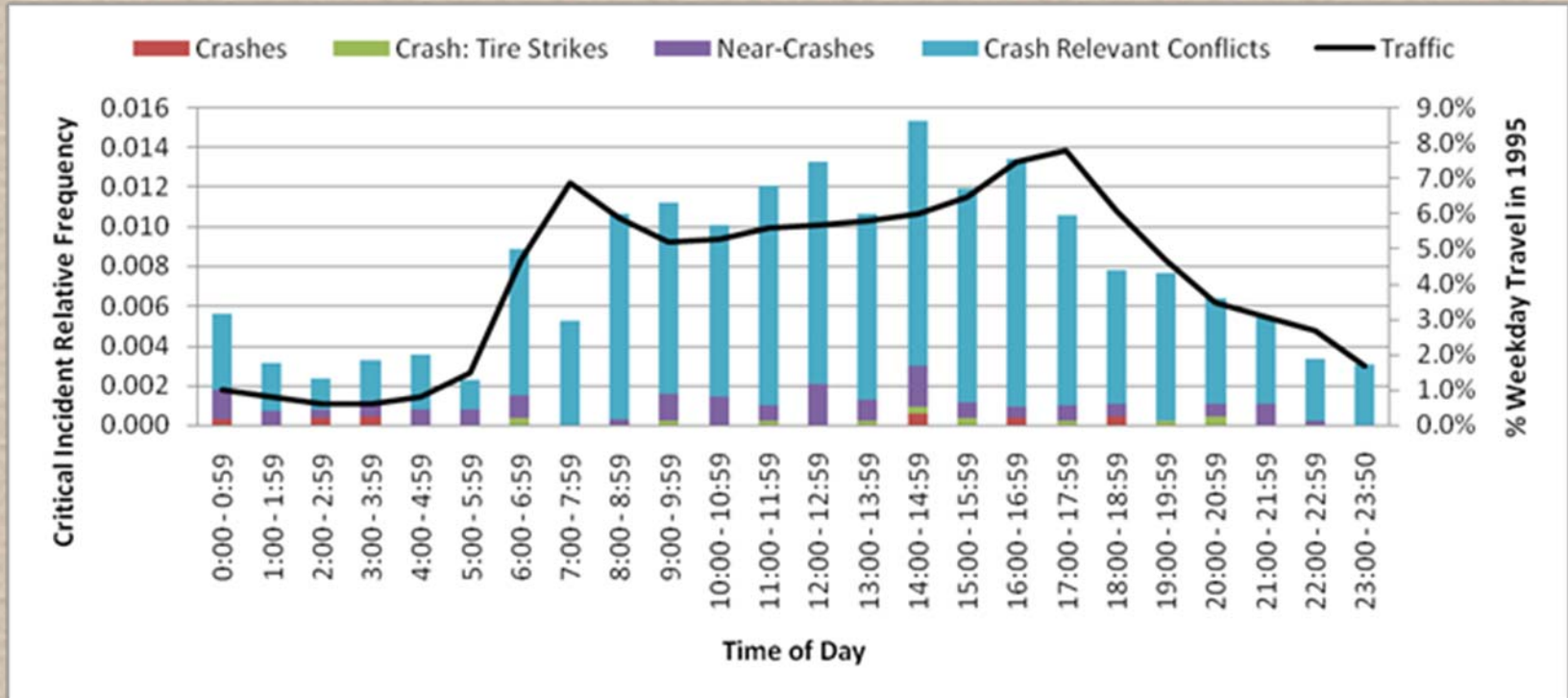


Time-of-Day Follow-Up Analyses

- 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...



Time-of-Day/Traffic Density Results



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

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



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



What Can Drivers Do?

- Come to work well rested
 - Need to be ready physically and mentally
- Know that the early in the shift, they may come across relatively more difficult driving situations (for a number of reasons)
 - Be vigilant and “expect the unexpected”
 - Practice defensive driving
- When driving in traffic, situation awareness must be such that it can accommodate the increased demands



Questions?



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