

Driving Transportation With Technology



U.S. Department of Transportation Federal Motor Carrier Safety Administration

<u>FMCSA's</u> <u>Advanced</u> <u>System</u> <u>Testing</u> utilizing a <u>D</u>ata <u>A</u>cquisition</u> <u>System</u> on the <u>H</u>ighways (FAST DASH)

Evaluation 2: Kinematic-only Onboard Monitoring System

Andrew Krum Senior Research Associate Center for Truck and Bus Safety

TRB 2019 ANB 70(6): Truck and Bus Technology



Introduction

- 5-year Cooperative Agreement between FMCSA and VTTI
- Perform quick-turnaround independent evaluations of promising safety technologies aimed at commercial vehicle operations
- Research plan includes:
 - Functionality testing on Smart Road (system shakedown)
 - 6 month naturalistic driving FOT with up to 20 DAS equipped fleet vehicles
- <u>Determine efficacy</u>, unintended consequences, and user acceptance of the safety system.
- Accident Analysis & Prevention publishing an overview of the first three evaluations available now for limited time free access (Volume 124, March 2019, Krum, et. al.): <u>https://authors.elsevier.com/a/1YNIoLDQt7bv</u>



FAST DASH Program



Data Acquisition System (DAS)

- VTTI's DAS captures three general groups of measures:
 - 1. DAS measures
 - e.g. accelerometer, gyro, radar, video
 - 2. Vehicle network measures
 - e.g. J1939
 - 3. Add-on measures
 - e.g. vendor/manufacturer system monitor/sensor triggers, alerts, and violations



Second Technology Evaluation

Onboard Monitoring System (OBMS) called *waySmart*[™] by *inthinc*[®]

- Key driver monitoring features
 - In-cab coaching (verbal alerts)
 - Safety belt use alerts
 - Speeding, aggressive driving alerts
 - Driver/fleet scoring
 - Fuel usage monitoring



- Elements
 - Real-time in cab safety belt and speeding alerts include 15-sec grace period for drivers to correct before being reported as violations.
 - Severe violations reported to fleet managers immediately as well as regularly scheduled score cards with driver safety and efficiency performance.



Testing Approach

- Instrument 20 commercial vehicles with OBMS and research data acquisition systems (DASs)
- Compare driver performance before and after intervention
 - Evaluated safety measures by determining safety-critical event (SCE) rates before intervention in comparison to after
 - Also evaluated safety measures based on seatbelt and speeding rate trends from baseline to intervention
- Evaluate OBMS violation and audible alerts accuracy based on sample
- Evaluate driver acceptance of OBMS
- 2 months baseline period by mileage (~ 11,600 miles)
- 4 months intervention period by mileage (~ 23,300 miles)



Fleet

- Fleet Selection
 - Number of trucks and drivers available
 - The geographic location of the fleet's terminal
 - 20 class 8 tractors were instrumented
 - 53 ft. box-van trailers
 - Drivers compensated \$50/week plus a \$100 bonus for completing participation
 - Vehicles equipped with PeopleNet[™] electronic log systems
 - Vehicles equipped with electronic roll and stability control systems
 - Vehicles had speed limiters set at 65 MPH manual control; 68 MPH cruise control





Deployment Revenue Data

- Revenue Data Collected
 - 1,196,146 miles across 17 drivers; baseline/intervention





OBMS Settings

- Speeding Alert/Violation
 - Vehicle speed ≥ 5 mph (8.0 km/h) above the posted speed limit
 - Posted speed limit identified by the OBMS proprietary Speed-by-Street[™] technology
- Seatbelt Alert/Violation
 - Vehicle speed ≥ 5 mph (8.0 km/h) AND seatbelt unbuckled
- Aggressive Driving Threshold (scalar)
 - Hard Brake: +2
 - Hard Turn: +3
 - Hard Bump: 0
 - Hard Acceleration: +6
- Audible Alerts Setting (not adjustable)
 - 85 dB at 1 meter

OBMS Driver and Fleet Interaction

- In-Cab Feedback (intervention only)
 - Audible Alerts
 - Provided to driver immediately and at 10-second intervals when performance criteria exceeded
 - Violations
 - Speeding and seatbelt violations occurred with sustained alerts 15 seconds after criteria exceeded
 - Aggressive driving violations occurred immediately after criterion exceeded
- Fleet Manager Feedback (intervention only)
 - Violations available for fleet review on Web portal on the same day
 - Weekly scorecards were emailed to fleet managers summarizing driver-vehicle performance
 - OBMS vendor advised the fleet to coach drivers on a regular basis
 - OBMS vendor requested bi-weekly meetings with fleet management
 - Attendance was infrequent

Speeding Trend Results

- Paired One-Side T-test
- Wilcoxon Signed Rank Test



SPEED

LIMIT

Speeding Trend Results

- Wilcoxon Signed Rank Test
 - Median rate of first two-week window intervention significantly below baseline

SPEED

IMIT

• W = 55.5, p = 0.0067

• Median rate 9th two-week window intervention <u>not</u> significantly below baseline



Seatbelt Trend Results

- Paired One-Sided T-test
- Wilcoxon Signed Rank Test





Seatbelt Trend Results

- Wilcoxon Signed Rank Test
 - Median rate of first two-week window intervention significantly below baseline
 - W = 74.5, p < 0.0001
 - Median rate of all two-week windows during intervention remained significantly below baseline





Aggressive Driving Observations

• Across the collection of the 17 drivers who accounted for 1.2 million miles, only 30 distinct aggressive driving violations were recorded by the OBMS.

Violation Type	Mean Speed at Violation (mph)	Min Speed at Violation (mph)	Max Speed at Violation (mph)
Hard Brake (n = 11)	28.6	4.2	54.7
Hard Turn (n = 18)	18.8	10.0	40.5
Hard Bump (n = 1)	NA	61.3	61.3

Violation Type	Mean g- Force	Min g- Force	Max g- Force
Hard Brake (dvX) [n = 11]	0.53	0.45	0.62
Hard Turn (dvY) [n = 18]	0.43	0.40	0.61
Hard Bump (dvZ) [n = 1]	NA	0.37	0.37

OBMS Accuracy Assessment

- Random sampling applied across all drivers during the intervention period.
- Sampling count was proportional to each driver's mileage.
- Sampling applied on both OBMS violation and non-violation naturalistic data.
 - According to recorded violations validated on DAS video and vehicle network data (J1939 vehicle speed).
 - To determine actual poor performance and false positives
 - According to recorded non-violations validated similarly.
 - To determine actual good performance and false negatives
- Both speed and seatbelt violations were validated along with audible alerts for both.



OBMS Accuracy Assessment cont..

- Speeding Accuracy: DAS J1939 vehicle speeds compared to DAS forward-camera or Google Maps identified posted speed limits.
 - Violations (689) sampled from DAS collected OBMS data.
 - Non-violations (701) sampled among vehicles speeds \geq 25 MPH.
- Speed limit signs were confirmed for both mph and km/h (Canada).
- Speeding criteria was 5 mph over the posted speed limit;
 - However, the test only scored a violation as a false positive if the vehicle speed was 4 MPH (above posted speed) or lower.
 - Similarly, the test only scored a violation as a false negative if the vehicle speed was 6 MPH (above posted speed) or higher.



SPEED

LIMIT

OBMS Accuracy Results

- Speeding Accuracy:
 - A large proportion (83.0%) of sampled speeding violations occurred between 60 and 85 mph.
 - Violations (see figure):
 - Correct: 593 (86.07%)
 - False Positives: 96 (13.93%)

- Non-violations:
 - Correct: 674 (96.15%)
 - False Negatives: 27 (3.85%)

SPEED

IMI



OBMS Accuracy Results

- Seatbelt Accuracy:
 - A large proportion (84.6%) of sampled seatbelt violations occurred in parking lots. Separately, 93.3% occurred at speeds under 15 MPH.
 - Violations (see figure):
 - Correct: 358 (100%)
 - False Positives: 0

- Non-violations:
 - Correct: 449 (100%)
 - False Negatives: 0





Conclusions

- OBMS speed monitoring correctly identified CMV speeding on average 86 percent of the time.
- The rate of speeding violations per 1,000 miles averaged across all drivers was significantly reduced (37%) from baseline to the first two-week intervention period.
- The OBMS seatbelt monitoring correctly identified when the seatbelt was unlatched 100 percent of the time.
 - Sampled checks of seatbelt worn status confirmed that drivers did not attempt to circumvent the buckle sensor by sitting on the belt. Some loose wear observed.
- The rate of seatbelt violations was significantly reduced (56%) from baseline to the first two-week intervention window. Effect remained across intervention.
- Drivers were generally accepting of the verbal feedback on speeding if it was accurate—especially with grace period before violation recorded in system



Thank you



Andrew Krum

akrum@vtti.vt.edu



