Tech Brief

FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION

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Onboard Monitoring and Reporting for Commercial Motor Vehicle Safety

Introduction

The “Onboard Monitoring and Reporting for Commercial Motor Vehicle (CMV) Safety” research project consists of two phases:

- Phase 1 covered the “Proof of Concept” and development of a prototype technology suite to be installed in a tractor. FMCSA worked with the California Department of Transportation (Caltrans) and the University of California Partners for Advanced Transit and Highways (PATH) to successfully complete Phase 1 in May 2007.
- Phase 2 is the Field Operational Test (FOT).

The goal of this effort is to develop an onboard monitoring system (OBMS) – a prototype hardware and software suite that allowed for online measurement of a set of driving characteristics that are indicators of unsafe driving behavior. Using the prototype suite, feedback can be supplied to drivers in real-time or provided to carrier management via a roll-up report for delayed discussion with the driver. This would allow truck drivers to significantly improve their attentiveness and enhance their safety performance. Five “core behavioral categories,” shown in Table 1 served as the basis for the onboard monitoring system:

1. Speed Selection
2. Following Behavior
3. Attention/Inattention
4. Fatigue
5. General Safety (good driving practices)

Prototype Design

In Phase 1 of the project, research was conducted to figure out what driver performance metrics should be monitored. This was done by looking at and better understanding contributing factors in crashes in order to decide if technology can address the issue. Researchers met with drivers to discuss how the technology should communicate feedback, e.g. real time, delayed, audio, or haptic. A prototype suite of the technologies was developed, installed and tested in a tractor cab.

In the prototype development work, the monitored parameters and type of feedback to be given were systematically selected by examining data collected on Commercial Motor Vehicle (CMV) crash causes. One of the most definitive works on this topic was the Large Truck Crash Causation Study (LTCCS), which included 963 car/truck crashes. The joint study between FMCSA and NHTSA was in progress during the time it was examined for inclusion in this OBMS study. An interim report on the project status (Blower and Campbell, 2002) laid out the methodology for the study. Another important study, Council et al. (2003), examined the North Carolina crash database from 1994 to 1997, which included 16,264 car-truck crashes.

Programs of the Federal Motor Carrier Safety Administration (FMCSA) encompass a range of issues and disciplines, all related to motor carrier and bus safety and security. FMCSA's Office of Analysis, Research and Technology (ART) defines a "research program" as any systematic study directed toward fuller scientific discovery, knowledge, or understanding that will improve safety, and reduce the number and severity of commercial motor vehicle crashes. Similarly, a "technology program" is a program that adopts, develops, tests, and/or deploys innovative driver and/or vehicle best safety practices and technologies that will improve safety and reduce the number and severity of commercial motor vehicle crashes. An "analysis program" is defined as economic and environmental analyses done for the agency's rulemakings, as well as program effectiveness studies, state-reported data quality initiatives, and special crash and other motor carrier safety performance-related analyses. A “large truck” is any truck with a Gross Vehicle Weight rating or Gross Combination Weight rating of 10,001 pounds or greater.

Currently, ART is conducting programs in order to produce safer drivers, improve safety of commercial motor vehicles, produce safer carriers, advance safety through information-based initiatives, and improve security through safety initiatives. The study described in this Tech Brief was designed and developed to support the strategic objective to improve the safety of commercial motor vehicles. The primary goals of this initiative are to improve truck and motorcoach performance through vehicle-based safety technologies and infrastructure.

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Table 1. Summary of OBMS Suite: Functions, Monitored Elements, and Feedbacks

Core Behavioral Categories	Potential Behaviors/ Parameters Monitored	Required Sensors or Subsystems	Potential Driver Feedback Real-Time	Potential Driver Feedback Offline
1. Speed Selection	Speed versus: – Speed Limit – Traffic Flow – Curve Speed – Road Surface – Grade	– Vehicle J-bus Access – GPS – Database of Speed Limits – Road Surface/ Weather – Radar or Lidar – Accelerometer	Visual feedback of recommended and maximum speed limits	Summary metrics such as the time spent over the recommended and maximum speed limits
2. Following Behavior	– Following Distance – Forward-Collision Warnings – Driver Response to Cut-ins	– Forward-Collision Warning System (FCWS) Radar – Lidar Video Recording	– Visual feedback of following time-gap shown – Auditory alerts for following too closely and approaching too fast	– Summary of time spent following too closely – Number of warning incidents – Video review of warning incidents
3. Attention/ Inattention	– Road/Lane Departures – Hard Braking Events – Hard Steering Events – Eye-Off-the-Road	– Road Departure Warning System (RDWS or LDWS) – Accelerometer – Steering Angle – Steering Gyro – Video Recording – Eye/Face Tracking	Visual and auditory alerts of lane departures or eyes-off-the-road for too long	Summary metrics such as: – Frequency of lane departures – Hard braking events – Hard steering incidents
4. Fatigue	– Road/Lane Departures – Lane Position – Hard Braking Events – Hard Steering Events – Eye Closure (PERCLOS) – Hours of Service (HOS) Compliance	– RDWS/LDWS – Eye Tracking – Accelerometer – Steering Angle – Steering Gyro – Video Recording – EOBR (Electronic Onboard Recorder for HOS)	Visual and auditory alerts of: – Lane departures – Lane weaving – Eye closure – HOS compliance	Summary metrics such as: – Frequency of lane departures – Hard braking events – Hard steering incidents – HOS compliance
5. General Safety	– Safety Belt Use – Lane Change Turn Signal Use – Lane Change Blind -Spot Check – Proper Mirror Adjustment – Fuel Economy – Engine Overspeed (RPMs) – Acceleration – Deceleration (Downshifting) – Gear selection on grades	– Safety Belt Monitor – Video Recording – RDWS/LDWS – Eye/Face Tracking – Accelerometer – Vehicle J-bus Access – MiscWire Taps	– Visual and auditory alerts if safety belt is not in use – Visual feedback on other parameters	Summary metrics such as time spent using the safety belt and the other listed parameters

The concept of onboard driver monitoring comes from the behavior-based safety approach. Using this method, safe behavior is rewarded and unsafe behavior is discouraged and improved upon, thereby proactively improving overall safety. Implementing an onboard driver-monitoring, behavior-based safety approach generally requires four steps (Sherry, 2001):

1. Identify behaviors which may be precursors to increased crash rates.
2. Determine cost-effective ways to monitor safe and unsafe behaviors.
3. Determine the best way to provide the driver with feedback which rewards safe behavior and discourages unsafe behavior.
4. Establish management and driver acceptance to the program.

These four steps constitute the fundamental basis or philosophy of OBMS. The pragmatic or implementation dimension was built upon this and consumed approximately 80 percent of the time and resources of the project. The project was tailored to and performed with the principles of systems engineering due to the ambitious project scope – to first research the aforementioned elements of an OBMS system, then, on a fast track, develop a prototype and set the stage for an FOT.

In the language of systems engineering, integration is a term used to describe the combining of components or subsystems to form a complete functional end-product system. Hardware and software components must be identified or constructed, and connected to one another. Planning is essential, both before and during the development of the component subsystems. Unforeseen difficulties connecting component pieces of a project can yield old plans obsolete, and a dynamic approach is needed for integration.

Integration was especially important for this project, as the project consisted of combining data from the truck serial buses, various Commercial Off-the-Shelf (COTS) systems, and custom-built devices that mounted on the truck, which were processing the data both on the truck itself and offline.

Prototype

For the OBMS prototype, if feedback was supplied by a COTS system, that feedback was kept. Additional feedback was provided via audio channel and via surrogate instrument cluster displayed in a 7-inch LCD screen. As shown in the screen displayed here, the suggested speed for the given road surface and curvature is the portion of the circular speedometer gauge not outlined in red. The suggested safe following-distance feedback, again providing for the prevailing road surface condition (and for this function, by the sensed "field" of other forward vehicles), is the color and size of the vehicle shown at the bottom of the surrogate cluster. In this instance, the vehicle is colored green; when following too closely for prevailing conditions, the vehicle changes to yellow, then red, and grows or remains constant. Also, beneath the green vehicle icon is the car following gap, given in seconds. Finally, the "driver ID", "HOS [hours of service] remaining" and "Alertness Index" are also provided as direct feedback of a prototypical digital tachometer. A drowsiness/alertness warning which supplements that subsystem's COTS-based feedback is also provided.

Researcher: This study, “Onboard Monitoring and Reporting for Commercial Motor Vehicle Safety” was conducted by the University of California Partners for Advanced Transit and Highway (PATH).

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Conclusion

This prototype suite is unique in that it is aimed squarely at safety and not necessarily toward other fleet operational goals; however, the overall philosophy is that it is an operational imperative to reduce crashes and, therefore, fatalities, injuries, and property damage due to CMV drivers. The main means to lower the amount of CMV driver errors is to improve driver performance through onboard monitoring systems, coupled with appropriate feedback to the driver.

This project served as a foundation to illustrate how to design and build an OBMS that may provide the best, most lasting mechanism to encourage good driving behavior by recognizing and correcting self-induced hazardous driving situations.

Phase 2: Field Operational Test

The field operational test of the OBMS for Commercial Motor Vehicle Safety is expected to commence by the end of 2008. It will involve tractors instrumented with the OBMS suite of technologies. The study will assess the changes in driving methods of about 50 CMV drivers with varying levels of experience and safety. The project is expected to take about 4 years to complete.

The OBMS system, subsystem, hardware, software, protocols and algorithms to be used will all be developed, built and tested. Included in this task are hardware fabrication and software development, as well as configuration of the data acquisition system and interfaces. Enhancements and finalization of the performance of the algorithms will address at a minimum, excessive speed, following distance, and driver fatigue. This task will include the design and development of a comprehensive systems acceptance test (SAT) for the “master” first suite(s). All subsequent suites must also pass this SAT to assure the vehicles and OMBS are ready for the study. It is envisioned that the vehicles to be used in the study will be placed into service as they become available following instrumentation, resulting in a staggered or rolling start.