TechBrief

The goal of the Federal Motor Carrier Safety Administration (FMCSA) is to reduce the large truck fatality rate by 41 percent from 1996 to 2008. This reduction translates into a rate of 1.65 fatalities in truck crashes per 100 million miles of truck travel.

The Office of Bus and Truck Standards and Operations develops and promotes national motor carrier safety program goals, priorities and initiatives. It provides technical expertise and advice in the development and deployment of motor carrier safety programs, including the development of regulations. The Office determines national motor carrier safety operational program requirements, standards, and procedures for vehicle and roadside operations, driver and carrier operations, and bus safety.

The Office of Bus and Truck Standards and Operations produced this Tech Brief.

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FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION

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Vehicle Data Recorders

Project Funding

Under the provisions of Section 5117 of the Transportation Equity Act for the 21st Century of 1998 (TEA-21), Congress authorized the U.S. Department of Transportation (USDOT) to:

> "...conduct research on the deployment of a system of advanced sensors and signal processors in trucks and tractor trailers to determine axle and wheel alignment, monitor collision alarm, check tire pressure and tire balance conditions, measure and detect load distribution in the vehicle, and adjust automatic braking systems."

As a result of a comprehensive technology scan (as well as numerous interviews with key industry stakeholders such as truck manufacturers, fleet operators, suppliers, and regulators) a variety of research areas were identified including an assessment of the potential for developing cost-effective vehicle data recorder (VDR) solutions for various applications.

Background

By observing and analyzing vehicle performance parameters, driver inputs, and vehicle responses, manufacturers and operators of commercial motor vehicles can gain improved operational utility, achieve new levels of safety and security, and have at their disposal a wealth of new information to help them learn from vehicle events. Such real-time monitoring and data-logging opportunities include improved vehicle interaction, driver training and oversight, occupant-protection systems, and driver-collision-avoidance systems. Systems that record specific vehicle inputs, component conditions, and dynamic responses from the period immediately preceding a crash, through the actual event, offer safety agencies and vehicle manufacturers additional opportunities to gain knowledge that can be used to reduce the likelihood of future crashes. Coupled with recent innovations in telematics that provide dramatic increases in bandwidth and data transmission rates, these technologies offer new opportunities for improving vehicle safety, reliability, and efficiency.

Early in this project, it was decided to explore both productivity and safety potential benefit scenarios. In consultation with the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA), "vehicle data recorder" (VDR) was settled on as a collective term for technologies that perform one or both of these functions.

The primary objective of the project was to explore the potential for the development of cost-effective VDR solutions tailored to varied applications or market segments. Through a combination of technical research and analysis, including business-related, cost-benefit assessments, potential VDR configurations ranging from fundamental to comprehensive were explored.

Overview of Approach

Work on this project consisted of the following subtasks:

- Capture the available results of this research and synthesize information from the commercial vehicle user, original equipment manufacturer (OEM), equipment supplier, and recorder manufacturer communities. The results of this formed the foundation for the development of VDR alternative concepts and the evaluation of potential benefits and costs. The focus was not to serve as a liaison for sharing of information among third parties, but as a means of gathering information.

- Conduct a comprehensive literature search and review of documents published by public, quasi-public (e.g., associations, committees, coalitions, institutions, etc.), and private companies that have performed VDR-related research and development. These institutions and companies included the various public-private partnerships and consortia that have formed under the provisions of the Intermodal Surface Transportation Efficiency Act and TEA-21 legislation.
- Identify specific VDR features and capabilities available and incorporated in commercially available VDRs, estimate the costs associated with those features, and develop an understanding of the cost drivers for VDR design.
- Profile high-level VDR functional requirements extracted from industry, academic, and government findings (NHTSA, FHWA [Federal Highway Administration], TRB [Transportation Research Board], and ATA/TMC [American Trucking Associations' Technology & Maintenance Council]), survey and interview key industry stakeholders, and assess end-user needs and expectations regarding VDR capabilities and required data parameters.
- Develop several VDR concepts with different levels of sophistication. VDR concepts were formulated and targeted in the following end-use applications: accident reconstruction and crash causation, operational efficiency, and driver monitoring.
- Develop technical and performance descriptions for each VDR concept to assist in the analysis of the development and manufacturing costs.
- Profile and analyze advanced VDR technologies that could be added to any of the concepts developed.
- Identify and estimate the costs and benefits for each of the VDR concepts developed. Costs (including those for engineering development, application programming, and hardware) were developed for each concept based on the technical and performance requirements developed. An overview of the business-case justification that typical fleets use in purchasing VDRs and the likely benefits of these systems was also developed.

Alternative VDR Concepts

Using industry and government findings from NHTSA, FHWA, and ATA/TMC, along with surveys and interviews with key industry stakeholders, the contractor team profiled end-user needs and expectations regarding VDR capabilities and required data parameters. Several industry and government organizations have released findings related to the specific data parameters that VDRs should record. These data parameters were then categorized into five data sets based on qualitative rankings and applicability.

Five distinct concepts were developed to represent practical combinations of features and capabilities that would address requirements for differing market segments. Specifically, the following VDR and event data recorder (EDR) concepts were developed, as shown in Table 1.

Table 1: VDR and EDR Concepts

Concept 1	A low-cost event-triggered data recorder for recording baseline accident data
Concept 2	A more advanced event-triggered data recorder that incorporates advanced sensor technologies
Concept 3	A baseline continuous vehicle data recorder that records maintenance and operational data meant to improve fleet operations
Concept 4	An advanced continuous data recorder that includes additional driver monitoring parameters
Concept 5	A "full-featured" VDR that might include both accident data and operational efficiency data

Advanced VDR Technologies

In addition to the VDR "baseline" concepts, a listing of advanced VDR technologies that could be added to any of the five concepts was developed. These include:

- Additional internal memory storage (e.g., a storage upgrade to record more event data)
- Removable storage media (e.g., magnetic, optical, solid-state memory)
- On-board vehicle network communication and downloading (e.g., CAN, IDB, serial)
- Vehicle location, direction of travel, and absolute time (e.g., Global Positioning Systems)
- Digital imaging (e.g., video)
- Sensor for determining the relative location of nearby vehicles (e.g., radar, ultrasonic)
- Short-range wireless communications (e.g., infrared, Bluetooth, WiFi 802.11)
- Long-range wireless communications (e.g., satellite, cellular)
- Driver performance (e.g., attentive driver monitoring, drowsy driver warning)
- Tractor-to-trailer communications

Cost-Benefit Analysis

To better understand the benefits associated with various configurations and concepts, benefits were addressed for devices that: (1) could be used to record event data, and (2) could be used to record operational data. To understand the costs and benefits associated with single-purpose accident EDR, Concept 1 was analyzed. To understand the costs and benefits of VDRs targeted at improving operational efficiency (including driver and vehicle monitoring, vehicle tracking, and maintenance management), Concept 3 was analyzed. Concept 5 was also profiled in order to develop a cost-benefit analysis for a "full-featured" VDR that would record both accident event as well as provide more traditional operational data used by fleets.

In general, both VDR and EDR devices can benefit the commercial vehicle industry and society as a whole, but these benefits would likely be spread across three primary stakeholder groups: (1) fleets, (2) OEMs, and (3) public sector. Benefits for fleets would primarily focus on improving operational efficiency and reducing operational costs. Benefits for OEMs would likely come from reducing liability costs and improving vehicle designs and safety. Benefits for public-sector stakeholders (such as transportation agencies, law enforcement, and the general public) would likely include improved vehicle safety; fewer crashes, injuries, and fatalities; and improved inspection capabilities.

To better understand the potential development and production costs for the concept VDRs, technical and performance descriptions of each concept were shared with a leading suppler of high-volume custom vehicle electronics for commercial heavy-duty vehicles. The supplier went through the standard development and estimation process, working with their engineering team and their sales and pricing team to gain a detailed understanding of the concepts. This supplier then developed an estimated cost analysis for each concept. The team felt that this approach provided a more accurate estimate of the costs broken down into three parts: engineering development costs, application programming costs, and hardware piece costs. In addition, a combined per-unit cost was totaled based upon order quantities of 10,000+ units per year supplied to OEMs for installation as part of new vehicle builds. In developing a cost estimate for this concept, a cost precision of ±15 percent was used.

It should be noted that this estimate is based on information from just one vendor and is only intended to provide a preliminary cost estimate for each generalized concept. It is entirely possible that should an OEM choose to source and install such a concept in its vehicles, the costs would vary, perhaps significantly, depending upon quantities, vendor incentives, and manufacturing and component technologies used. In addition, these costs are intended to represent manufacturing and assembly costs, not necessarily retail costs to a customer or fleet. Table 2 shows a summary of these costs.

Availability:
The study final report (FMCSA-PSV-06-001) is available from the U.S. Department of Transportation.

Key Words:
Commercial motor vehicles, event data recorders, on-board recorders, vehicle data recorders

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Table 2: VDR Concept Cost Estimate Summary

	Estimated Piece Cost (±15%)	One-Time Tooling and Layout Cost	Software Development Cost	Amortized Per Unit Cost (based on 10,000 units)
Concept #1 "Core" Event Data Recorder	$260	$20,000	$15,000 to $30,000	$265 (assuming $25,000 for SW)
Concept #3 "Core" Vehicle Data Recorder	$140	$20,000	$15,000 to $30,000	$145 (assuming $25,000 for SW)
Concept #5 "Comprehensive" EDR and VDR	$450	$20,000	$20,000 to $40,000	$460 (assuming $25,000 for SW)

Of course, these costs would be cost per unit as sold by a vendor to a vehicle OEM. It is anticipated that there would be additional costs associated with integrating the unit into the vehicle (e.g., mounting, wire harnesses, service and repair manuals) and adding the product to the line card and assembly line. It is likely that an OEM would add a 30 to 50 percent markup to a fleet to cover these costs and secure a profit.

In conducting this study, it became clear that return-on-investment calculations for VDRs (from the fleet operator's perspective) are challenging for two main reasons. First, benefits are often defined in terms of increased productivity, efficiency, competitiveness and/or improved safety. All of these measures would vary depending on a particular fleet's situation--and even for a specific fleet's situation, they are very difficult to quantify. Second, costs are difficult to obtain from commercial suppliers of VDR equipment and services. The costs are often embedded (or bundled) within a vehicle price, and/or within a larger telematics service offering. More importantly, the market price of some products and services is not necessarily indicative of pure manufacturing cost. The commercial vehicle telematics, communications, and vehicle data recorder industry is in many ways in its infancy. As such, suppliers with innovative ideas that improve a fleet's competitiveness may well be able to command premium prices that are not cost-based.