On-Board Recorders: Literature and Technology Review

July 2002

Forward

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16 Abstract

The purpose of this study is to summarize a literature review that was conducte d to review past and ongoing studies focusing on commercial vehicle safety, specifically electronic on-board recorders for hours -of-service monitoring. This report also provides summaries of interviews that were conducted with key stakeholders. This inform ation will serve as input to support the development of a framework for the creation of a potential set of performance s tandards related to automatic recording of hours-of-service.

Some of the findings include:
1) There are few on-board technologies available in the marketplace that were designed specifically to capture RODS.
2) The European Union (EU) has made advances in both promoting the use of on-b oard technology as well as defining performance requirements for on-board technology to monitor compliance with hou rs-of-service.
3) In 1988, the Federal Highway Administration (FHWA) recognized that GPS tech nology could provide an opportunity to improve motor carrier compliance with hours-of-service.
4) A 1998 survey conducted by the University of Michigan Transportation Resear ch Institute indicated that electronic records are not cost effective for small fleet operations and there was strong oppositi on to the notion of mandatory on-board recorders.
5) Interviews with technology vendors and engine manufacturers revealed that t here were a number of products on the market that already provide some or all of this functionality.
6) Interviews that were conducted by the FMCSA staff regarding the GPS Techolo gies Pilot Program and general perceptions about on-board recorders revealed that the staff had concerns about the technol ogy limitations, performance requirements, and compliance by the enforcement community.

Overall this study revealed that more research, testing, and feedback is needed .

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Executive Summary

Background

Traditionally, commercial drivers have prepared a record of duty status (RODS) by manually entering their activities in handwritten paper logbooks. In 1988, a final rule was published to allow motor carriers, at their option, to use certain automatic on-board recording devices to record their drivers' RODS. The Federal Motor Carrier Safety Administration (FMCSA) estimates that 4.2 million drivers are required to prepare handwritten RODS. The FMCSA estimates that these drivers and the companies they work for incur a time burden of 161 million hours annually and that the annual direct cost for motor carriers is approximately $63.7 million.

This report summarizes the findings of the *On-Board Recorders: Technology and Literature Review* that was conducted by Cambridge Systematics on behalf of the FMCSA. The technology and literature review consisted of the following:

- Conducting a review of ongoing or completed studies that examined the use of on-board recorders by commercial vehicle operators as a tool for managing drivers' hours-of-service compliance;
- Reviewing existing hours-of-service regulations and on-board recorder performance requirements;
- Conducting an on-line review to identify technologies used by the motor carrier industry to manage a variety of fleet and driver activities;
- Interviewing technology vendors regarding existing technology capabilities, limitations, and future plans; and
- Interviewing FMCSA staff to gain insight regarding the use of on-board recorders to monitor hours-of-service compliance.

Findings

Since 1988, a number of studies and demonstration projects have been conducted to examine the costs, benefits, and feasibility of using on-board recorders to record drivers' hours-of-service. These efforts have produced mixed results and findings. The literature

review and interviews with technology vendors and staff from the FMCSA revealed the following:

- There are few on-board technologies available in the marketplace today that were designed specifically to capture RODS. Despite this, a number of technologies including digital tachographs, engine control modules, and wireless and satellite communications equipment/global positioning systems (GPS), whether used as stand-alone technology or coupled with other technology, provide some or all of the functionality required by 49 CFR 395.15.

- The European Union (EU) has made advances in both promoting the use of on-board technology as well as defining performance requirements for on-board technology used to monitor compliance with hours-of-service. The EU has relied on tachograph technology, which has been criticized somewhat because it is viewed as being susceptible to tampering. Recently the EU has indicated that it may migrate towards the use of electronic tachographs and away from mechanical tachographs. Research is being conducted to examine the benefits of switching to electronic devices.

- In 1998, the Federal Highway Administration (FHWA) recognized that 49 CFR 395.15 was potentially outdated, and that GPS technology could provide an opportunity to improve motor carrier compliance with hours-of-service regulations. The agency introduced a voluntary program that allowed carriers using GPS technology and related safety management computer systems to use these systems to record and monitor drivers' hours-of-service in lieu of a handwritten RODS. One carrier that had already been using GPS technology participated in what came to be known as the GPS Technologies Pilot Project. The goal of this project was to determine whether electronic logs based on GPS data could provide an acceptable level of safety and monitoring accuracy. The project also sought to determine whether 395.15 should be amended to recognize GPS-type systems. The participating carrier claims that the use of GPS has reduced their hours-of-service compliance costs and has produced other operational benefits. No official results or findings have been published by the FMCSA.

- A 1998 study conducted by the University of Michigan Transportation Research Institute examined the costs and benefits of using electronic recorders to monitor driver compliance with hours-of-service regulations. The study also explored industry attitudes toward mandatory use of electronic recorders. The survey that was conducted revealed that electronic recorders are not cost effective for operators of small fleets and there was strong opposition to the notion of mandatory on-board recorders.

- In June 2001, Transport Canada's Transportation and Development Center (TDC) contracted with TECSULT – a consulting company – to undertake Phase I of a research project concerning on-board recorders, smart cards, and digital signature technologies. The objectives of the overall project are to analyze on-board recorder and related technologies in order to demonstrate their use in actual operating situations; assess their ability to improve vehicle fleet management from the perspectives of safety, regulatory enforcement, and transport operations; develop minimum requirements for the

use of these technologies in interprovincial and international transport; and assess the costs and benefits of using them. Phase I culminated with the submission of a final report in December 2001. Additional phases of work may be approved.

- Interviews that were conducted with technology vendors and engine manufacturers revealed that there are a number of products on the market that provide some or all of the functionality defined in 395.15. In spite of this, few vendors actively market these features or have developed products specifically to provide this functionality. This was attributed to a lack a demand from the marketplace and/or uncertainty on the part of vendors regarding the federal requirements.

- Interviews that were conducted with FMCSA staff regarding the GPS Technologies Pilot Project and general perceptions about on-board recorders revealed that staff have concerns about technology limitations (e.g., the ability of one system to capture the data that is perceived to be important), how clearly defined or how well understood today's performance requirements are by the motor carrier industry, and the extent to which the enforcement community is prepared to rely on on-board devices for determining compliance.

Recommendations

Based on the literature review and interviews that were conducted, staff from Cambridge Systematics developed the following recommendations:

- The FMCSA should obtain additional feedback from motor carriers regarding the current and expected future use of on-board recorders. This information would supplement the original information collected by UMTRI and would help to clarify benefits/costs, industry concerns, and future technology purchasing trends.

- Given concerns that surfaced regarding the sufficiency of relying exclusively on GPS data, consider the coupling of technologies that are capable of capturing vehicle location data as well as engine data. This coupling of technology may produce a more comprehensive "snapshot" of driver compliance with hours-of-service regulations.

- Conduct an operational test/demonstration project with one or more motor carriers who may already be using a combination of GPS and system monitoring technologies to determine the most effective combination of technology. Testing a variety of approaches would enable the FMCSA and other key stakeholders to better understand the cost, productivity, and safety benefits that can be attributed to each approach as well as the limitations of each approach.

- Conduct an outreach session with technology vendors and create an ongoing forum to discuss technology trends and limitations, applying technology to hours-of-service regulations, and vendor concerns.

- Update section 395.15 of the Federal Motor Carrier Safety Regulations (FMCSR). Provide more specific guidance to motor carriers, technology vendors, and state enforcement agencies regarding the performance standards for on-board recorders that are used to monitor hours-of-service compliance.

- Evaluate roadside enforcement and compliance review processes and training needs to ensure that processes address the use of on-board technology.

List of Tables

1.0 Introduction

The U.S. Department of Transportation (U.S. DOT) Federal Motor Carrier Safety Administration (FMCSA)[1] regulates the nation's interstate commercial motor carrier industry. One of the agency's primary goals is to improve commercial motor vehicle, operator, and carrier safety. Highway safety concerns stem from the fact that one in eight traffic fatalities in 1997 [in the United States] resulted from a collision involving a large truck.[2] In 1998 alone, 5,374 people were killed and 127,000 were injured in traffic crashes involving commercial motor vehicles.[3] Commercial motor vehicle-related fatal crashes and injuries cost the United States $15 billion annually.[4] The FMCSA's current goal is to reduce the number and severity of large truck-related crashes and fatalities by 50 percent by the end of fiscal year 2009 through inspections, safety awareness programs, compliance reviews, and enforcement measures.[5]

This document summarizes a literature review that was conducted by Cambridge Systematics to review past and ongoing studies focusing on commercial motor vehicle safety, specifically electronic on-board recorders for hours-of-service monitoring. This report also provides summaries of interviews that were conducted by Cambridge Systematics with key stakeholders. This information will serve as input to support the development of a framework for the creation of performance standards related to automatic recording of hours-of-service. This report reviews the following studies:

- A summary of the European experience with hours-of-service compliance using both traditional mechanical tachographs and electronic tachographs with smart card technology;
- Three electronic recorder studies conducted in North America that examine the use of global positioning systems (GPS) and on-board computers in the motor carrier and motor coach industries;

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[1] The Motor Carrier Safety Improvement Act of 1999 established the FMCSA in the U.S. Department of Transportation. On January 4, 2000, the authority previously delegated to the Federal Highway Administration (FHWA) Office of Motor Carrier Safety was rescinded, and was delegated to the FMCSA.

[2] National Highway Traffic and Safety Administration. *Traffic Safety Facts.* 1997.

[3] FMCSA. *Safety Action Plan 2000-2003.* February 2000. Page 1.

[4] Thomas, Neill L. and Deborah M. Freund. *On-Board Recording for Commercial Motor Vehicles and Drivers: Microscopic and Macroscopic Approaches.* Washington.

[5] FMCSA. *2010 Strategy and Performance Planning – Project Description.* December 2000. Page 2.

- Summaries of telephone interviews conducted with companies that manufacture or distribute devices that may be capable of tracking drivers' hours-of-service;
- Summaries of telephone interviews conducted with key FMCSA representatives to gain insight on their experiences with GPS technology for monitoring drivers' working time; and
- A matrix (Appendix A) that provides a sampling of on-board technologies offered by vendors.

1.1 Hours-of-Service Regulations

While numerous factors contribute to commercial motor vehicle accidents, driver error is generally cited as the principle factor in crashes, with inattention and drowsiness being major contributing factors.[6] Consequently, driver compliance with hours-of-service regulations – for example, adhering to on-duty time limits – has a profound influence on the ability of a driver to perform safely and the prevention of fatal accidents.

Traditionally, drivers have prepared a record of duty status (RODS) by manually entering their activities in handwritten paper logbooks. In 1988, a final rule was published to allow motor carriers, at their option, to use certain automatic on-board recording devices to record their drivers' RODS.[7] This provision, later codified in 49 CFR 395.15, was written with a specific technology in mind – on-board recorders linked directly to the vehicle engine.

In the 10 years since this regulation was published, the use of GPS and satellite communications technology has become increasingly prevalent in the trucking industry. Several motor carriers were beginning to use GPS technology to support a variety of fleet management activities including vehicle location, load planning, and to a lessor extent to track and control their drivers' compliance with the hours-of-service regulations. During the 1990s, one carrier also was independently developing a Paperless Log System with the hope of one day eliminating their drivers' responsibilities of maintaining paper records of duty status logs.

Although the use of GPS technology to record driver working time seemed potentially promising to FMCSA officials, the regulations outlined in 49 CFR 395.15 did not specifically permit the use of such devices. The regulations defined automatic on-board recording devices to include "an electric, electronic, electromechanical, or mechanical device capable of recording driver's duty status information accurately and automatically

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[6] FMCSA. *Safety Action Plan 2000-2003.* February 2000.

[7] Federal Register. Volume 63, No 65. April 6, 1998.

as required by 395.15. The device must be integrally synchronized with specific operations of the commercial motor vehicle in which it is installed. At a minimum, the device must record engine use, road speed, miles driven, the date, and time of day." The initial paperless log system developed by a carrier that later participated in the GPS Technologies Pilot did not use engine data to create RODS reports; instead, these paperless log systems produced driving records using GPS position history updates. In April 1998, the FMCSA (formerly the FHWA/OMC) officially recognized the potential benefits of these new wireless satellite recorders. The agency stated that it "believes GPS technology, and many of the complementary safety management computer systems currently being used by the motor carrier industry, provide at least the same degree of monitoring accuracy as the automatic on-board recorders allowed by the Federal Motor Carrier Safety Regulations' (FMCSR), 49 CFR 395.15."[8] This led to a pilot test where volunteer motor carriers were permitted to use GPS technology to meet the "automatic on-board recorder provisions" of CFR 395.15. Ultimately the goal of the pilot was to determine if electronic logs generated by GPS systems could provide an acceptable level of safety and monitoring accuracy, and if so, how to amend CFR 395.15 to recognize these systems. While no formalized conclusion about the outcome of the GPS Technologies Pilot project has yet been formulated, it is already evident that there is a need to strike a balance between the technology that currently exists while protecting the regulatory interests of the federal government.

1.2 Recording Hours-of-Service

Regulations pertaining to commercial vehicle drivers' hours-of-service, RODS, and devices for automatic electronic recording of hours-of-service, are codified in U.S. Federal Regulation Title 49, part 395. The FMCSR, specifically 49 CFR 395.3, restrict a commercial vehicle operator from driving more than 10 hours following a minimum of eight consecutive hours off duty, or driving after 15 hours on duty following a minimum of eight consecutive hours off duty. All drivers are required to take eight consecutive hours of off-duty time. Drivers also are prohibited from operating a commercial vehicle after accumulating 60 hours on duty during any seven consecutive day-period (if the motor carrier does not operate its vehicles every day of the week). However, if the motor carrier operates its vehicles every day of the week, a driver is prohibited from driving after accumulating 70 hours on duty during any eight consecutive days.[9]

The FMCSA estimates that 4.2 million drivers are subject to this regulation and are required to prepare handwritten RODS. The agency estimates that these drivers and the companies for which they work incur a time burden of 161 million hours annually and

[8] U.S. DOT, FHWA. *Global Positioning System (GPS) Technology, Notice of Interpretation request for participation in pilot demonstration project.* 65 FR 16697. April 6, 1998.

[9] 49 CFR part 395.3. *Maximum driving time.*

that the annual direct cost for motor carriers is approximately $63.7 million.[10] The 1998 GPS Technologies Pilot hoped to demonstrate that electronic GPS recorders could ensure compliance with the hours-of-service regulations while demonstrating safety, as well as economic and administrative advantages of eliminating paper RODS.

Those in favor of electronic recorders that rely on GPS asserted that satellite-based recorders are possibly more accurate and resistant to tampering than traditional hours-of-service reporting and tracking methods.[11] Supporters believed that the new digital devices might improve road safety by reducing the number of unsafe carriers and poor drivers, and by decreasing cases of driver fatigue and instances of careless driving. The perception was that by improving the efficiency and ability of carriers to monitor their drivers' working time and by potentially providing more reliable RODS that can be reviewed for compliance purposes, electronic recorders might reduce paperwork, administrative burden, and operational costs. Commercial vehicle operators might reduce their crash-related costs associated with driver drowsiness, as well as unanticipated delays caused by drivers being placed out-of-service for hours-of-service violations. Finally, by automating the entry and review of RODS, motor carriers might streamline their administrative and oversight activities to further increase their savings.

While on-board recorders demonstrate many benefits, they also have limitations. Today's devices cannot record the activity of a driver while the driver is not in a "driving" status, nor can electronic recorders distinguish between on-duty/not-driving and off-duty activities. Electronic recorders cannot discriminate among any of the myriad activities that constitute "on duty, not driving," and science tells us that the physical and mental exertion associated with these tasks differs among individuals.[12] To address these shortcomings it would be desirable for electronic recorders to collect and use the following additional information:

- The number of hours the driver has slept;
- The number of hours the driver has been awake and the precise time the driver awoke; and
- The number of hours that the driver has been on duty but not driving.

Each of these factors contributes to the ability of a driver to perform safely. Most of today's fleet management technology only has the ability to automatically record the number of hours the driver has been driving and/or the location of the vehicle.

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[10]Based on interviews with FMCSA staff conducted in December 2001.

[11]Thomas, Neill L. and Deborah M. Freund, op. cit., p. 2.

[12]Thomas, Neill L. and Deborah M. Freund, op. cit., p. 5.

1.3 Electronic Automatic Recording Devices

The FMCSA defines the following parameters for electronic recorders to meet the requirements of 49 CFR 395.15: "An electric, electronic, electromechanical, or mechanical device capable of recording driver's duty status information accurately and automatically. The device must be integrally synchronized with specific operations of the commercial motor vehicle in which it is installed. At a minimum, the device must record engine use, road speed, miles driven, the date, and the time of day."[13] Initial research suggests that several emerging technologies could potentially meet the requirements of electronic recorders as defined by the regulation. These technologies include:

- **Digital Tachographs** – The digital tachograph is an electronic machine that measures and records a vehicle's speed, distance, and time traveled. The device relies on a direct correlation from the engine speed to the vehicle speed given the different gear ratios of the transmission, the gear ratios of the axle, and the wheel size as measured in revolutions per mile.[14] Typically, the tachograph is comprised of a speedometer/ odometer, a recording unit, an intelligent sensor, one or more smart cards, and a printout device. The digital tachograph differs significantly from traditional mechanical tachographs that simply record data on circular paper cards.

- **Engine Control Modules (ECM)** – The manufacturers of all diesel engines used in commercial vehicles use electronic controls for the pressurization of the fuel, injection of the fuel, and timing.[15] Computer chips and sensors located in a vehicle's engine track engine activity in real time. The ECM communicates via a bus interface to mechanical connections in the vehicle and a dashboard controller. The device monitors and collects information about engine hours, cruise control use, panic stops, fuel consumption, rpm, and speed.

- **Wireless and Satellite Communications Equipment/GPSs** – A system of satellites, computers, and receivers that rely on triangulation to calculate the precise location of a vehicle. Because the system detects motion, the device can determine whether the vehicle is being driven. This information can be used as a proxy for whether the driver is "on or off the clock." The satellite systems integrate well with other communication devices such as cellular phones and mobile radios.

In addition to the aforementioned devices, several display units could potentially be used to enable drivers, enforcement officials, or motor carrier managers to view hours-of-service status information while it is gathered:

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[13] 49 CFR part 395.2. *Definitions, Automatic on-board recording device.*

[14] Menig, Paul and Cary Coverdill. *Transportation Recorders on Commercial Vehicles.* International Symposium on Transportation Recorders. Arlington, Virginia. May 1999. Page 2.

[15] Ibid., p. 4.

- An on-board computer located in a vehicle's dash board;
- A laptop computer that sits on the passenger seat in the truck's cab; and
- A handheld device (PDA) that can be attached to the driver's belt.

1.4 Conclusion

As with all emerging technologies, it is essential to consider and evaluate the various types of electronic recorders, perform a cost-benefit analysis, and explore in detail the various innovations that exist before implementing new rules and regulations. It is critical to evaluate technology against the existing performance standards defined in 395.15 and to determine whether these standards must be updated. The development of standards requires consideration of three areas:

- Enforcement requirements of the FMCSA and state motor carrier enforcement officials (e.g., what data are needed to enforce hours-of-service regulations?);
- On-board recorder technology capabilities, limitations, and likely evolution (e.g., what data could electronic recorders produce?); and
- Motor carrier business practices (e.g., how will motor carriers invest in and use on-board recorder technology?).

The remaining sections of this document summarize the findings of the literature review and interviews conducted with technology vendors and FMCSA staff.

2.0 Summaries of Key Electronic Recorder Studies

Studies that examine the use of electronic recorders and on-board computers in the motor carrier and motor coach industries have been conducted in the United States, Canada, and Europe. These studies explore the current technological trends and provide insight regarding the likely evolution of this technology. This section provides a summary of the literature review that was conducted by Cambridge Systematics.

The following studies and reports were used as the basis for this document:

- "The European Experience with hours-of-service monitoring using tachographs;"
- "The GPS Technologies Pilot" – 1998;
- "Electronic Recorder Study" conducted by the University of Michigan Transportation Research Institute: – June 1998; and
- "Field-Testing of on-board recorder, smart card, and digital signature technology: Phase 1" - Transport Canada Study– June 2001.

2.1 The European Experience with Hours-of-Service Compliance Standards and Technologies

2.1.1 Introduction

The European Union (EU)[1] is the only international body that has collectively instituted a policy on hours-of-service monitoring.[2] In Europe, international legislation outlines measures to ensure road safety, and to promote the health and welfare of commercial vehicle

[1] The Maastricht Treaty, signed in February 1992 and entered into force in November 1993, formed the legislative pathway for the European Union. The former European Economic Community (EEC) issued many of the regulations and legislative acts described in this paper.

[2] Freund, Deborah. *Agency Working Paper: On-board automated recording for commercial vehicle driver's hours-of-service compliance: The European experience.* Page 1.

drivers. Traditionally, the European community has used tachographs – mechanical rotary or electromechanical devices that record data on circular paper cards – to enforce drivers' hours and to record speeding violations. Contrary to this practice, enforcement agencies in the United States, including the FMCSA, have rejected the use of tachographs for this purpose because the devices are highly susceptible to tampering.[3] For example, the units employ either liquid ink, or a stylus on a pressure sensitive medium such as carbon, to create reports. Often, these reports are illegible, inaccurate, and consequently unreliable to use for enforcement purposes. The European Union is in the final stages of creating a new standard for an electronic tachograph, that when implemented properly, might prove to be more accurate and resistant to fraud than its analog predecessor.

2.1.2 An Overview of European Analog and Mechanical Tachograph Performance Standards

Since 1970, the European Economic Community (EEC) has instituted various requirements for equipment used by the transport industry. European Commission Regulation No. 1463/70 called for an analog disk tachograph to ensure compliance with hours-of-service regulations.[4] In 1985, Council Regulations (EEC) No. 3820/85[5] and No. 3821/85[6] were enacted specifically to address this issue. The first document, which focuses on "the harmonization of certain legislation relating to road transport," outlines the general requirements for drivers, driving periods, breaks, and rest periods. The second, which focuses on "recording equipment and road transport," addresses the automatic recording equipment necessary to document drivers' duty and non-duty hours. For example, the regulation specifies that buses carrying more than nine passengers and trucks weighing more than 3.5 metric tons (the equivalent of 7,700 pounds), must use automatic recording devices to record distance, speed, driving time, other work non-driving time, and rest period statistics.

Annex 1 to the European regulations describes the requirements for the development, testing, installation, and inspection of the recording device. It is interesting to note that the European regulations do not specify a particular type of equipment to be used; however, no device other than the tachograph is referenced in the EEC documentation and literature. Further, the regulations allow handwritten paper logs to accompany the automatic logs, but do not permit handwritten records to be maintained exclusively. An

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[3] Thomas, Neill, L and Deborah M. Freund. *On-Board Recording for Commercial Motor Vehicles and Drivers: Microscopic and Macroscopic Approaches.* Washington. Page 3.

[4] Freund, Deborah, op cit, p 1.

[5] Council Regulation (EEC) No. 3820/85: *on the harmonization of certain social legislation relating to road transport.* Official Journal No L 370:1-5. Brussels. Dec. 20, 1985.

[6] Council Regulation (EEC) No. 3821/85: *on recording equipment in road transport.* Official Journal No L 370:8-21. Brussels. Dec. 20, 1985.

amendment to these regulations, Council Regulation 3688/92[7], was signed in 1992 and introduced physical specifications for recording units, such as a continuous plastic-coated stainless steel sheath to protect the cables connecting the recording equipment transmitter.

Despite the European Union's effort to maintain an accurate monitoring system to improve highway safety, the tachograph has been, "criticized for its susceptibility to large-scale fraud, enforcement difficulty and costly company management."[8] Research funded by the British Department of the Environment, Transport, and Regions (DETR) indicates that economic pressures on commercial vehicle operators motivate the majority of this fraud. For example, many drivers choose to drive longer than permitted and ignore the minimum breaks provided by the regulations in order to meet delivery schedules. The research also suggests that most offenses that result in conviction do not involve equipment tampering, but rather exploit procedural weaknesses. For instance, two of the most prevalent forms of fraud include manipulating the tachograph charts so there appears to be more drivers then there actually are, and altering the clock to simulate a rest period.[9]

2.1.3 Digital Tachographs and Smart Card Technology

Severe discontent, followed by a 1998 Explanatory Memorandum[10] to CR 3820/85 led to discussions with the nations of the European Economic Community (EEC), several electronic device manufacturers, and transportation industry representatives. Consequently the notion of a digital tachograph, one that uses an electronic record on a smart card rather than the traditional stylus and paper mechanism, began to evolve as a tool that could improve enforcement of, and compliance with, hours-of-service and mandatory rest periods. Currently, two companies dominate the European tachograph market, with about 75 percent and 25 percent share respectively of the equipment market.[11] These vendors, among many others, suggest that their products offer improved reporting capabilities, operational enhancements, and security features.

As described on one company's web site, "the principal component [of the electronic tachograph] is a microprocessor system with a digital odometer and an analog speedometer using stepping motor technology. Its precise data recording and display meets the strict

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[7] Council Regulation (EEC) No. 3688/92: *on adapting to technical progress.* Official Journal L 374:12-13. Brussels. Dec. 21, 1992.

[8] Hartman, Kate, Pritchard B et al. *Commercial Vehicle Safety – Technology and Practice in Europe.* May 2002. [http://international.fhwa.dot.gov/Pdfs/cvs.pdf]. Page 9.

[9] Anderson, Ross. *On the Security of Digital Tachographs.* Cambridge University Computer Laboratory. [http://www.ftp.cl.cam.ac.uk/ftp/users/rja14/tacho.pdf]. Page 2.

[10] Commission of the European Communities. *Amended Proposal for a Directive of the European Parliament and of the Council concerning the organization of working time for mobile workers performing road transport activities and self-employed drivers.* Brussels. Oct. 11, 2000.

[11] Anderson, Ross, op cit, p 5.

requirements of the European Union regulations."[12] Similar to other European-developed electronic tachographs, this company's unit is comprised of the following features:

- **Registration Unit** – It contains a memory of 365 days.
- **Display** – The unit displays information and warnings in an easily recognizable form;
- **Keypad** – The keypad provides simple and intuitive access to the unit's menus and commands.
- **Interface** – The unit contains a data interface to allow data to be transferred from the device to a PC.
- **Chip card reader** – Two chip card readers accept the driver and co-driver cards. The chip cards (each with a 28-day memory) contain information pertaining to the driver, the company, and the controller.
- **Printer** – The output device produces daily, weekly, monthly reports containing: date/time, name of driver/name of inspector, driving time, standby time, as well as beginning and ending times of all transportation-related activities.
- **Intelligent Sensors** – These devices provide contactless recording, encryption, and transfer of the driving pulses to the registration unit with protection against manipulation.

2.1.4 Electronic Tachograph Functional Requirements and Standards

As the regulatory body for road safety and drivers' working time, the EEC has outlined a broad set of functional requirements for digital tachographs and similar devices. These requirements form the basis for the European performance standards. The following text summarizes Annex 1B of CR 2135/98[13], which outlines several proposed standards created for the new digital tachograph.

- The equipment must be able to record, store, display, and print:
  - **Speed** – The unit will use a speedometer to measure a vehicle's speed and determine when the vehicle is stopped, at rest, or in motion. Maximum and average speeds also are defined.
  - **Distance** – The device will use an odometer to determine the distance traveled by the vehicle to an accuracy of one kilometer. Reverse movement will not affect the clarity and accuracy of the data.

[12]Corporate web site.

[13]Commission of the European Communities. Annex 1(B) of CR 2135/98. Brussels. Sept. 1998.

  - **Time** – Date and time, including breaks and daily rest periods, will be measured to an accuracy of one minute using a digital clock.

- The device must monitor:

  - **Driver activities and status** – The device will distinguish between the status of driving, work, availability, and break/rest time. (e.g., when the vehicle is in motion, "driving" will automatically be selected for the driver and availability will be selected for the co-driver). The device must be capable of determining the momentary speed of the vehicle at a frequency of 1 s for the last 24 hours of use of the vehicle and periods of driving time (times and dates), with an accuracy of one minute.
  - **Smart card insertion and withdrawal** – This measure ensures that the card and the tachograph are valid. The card can only be removed when the vehicle is stationary to help prevent fraud and tampering.
  - **Driver's manual entries** – The device will support manual entry of the time and location where the drivers' daily work periods begin and end.

- **Recording and storing data** – The device will store driver and vehicle activity for 365 days. The data stored into memory will not be affected by power outages. The device also will store calibration data and a record of system failures.

- **Reading from the tachograph card** – The device will be able to read all information gathered from the tachograph and print requested reports.

- **Display** – The display will use numbers (allowing for at least 20 characters in length) and pictograms. By default, the display will turn on the moment the vehicle is in motion.

- **Warnings** – The device will provide audible and visual warnings when it detects a specific event or fault. A 30-second warning message will result if the vehicle is driven without the driver card in place, or with a malfunctioning card in place. Warnings also are given when the driver is within 15 minutes of exceeding his or her allowable driving time or when the driver exceeds the maximum speed limit.

- **Security** – The components of the driver card cannot be falsified or tampered with, and any attempt to do so will be detected. To further prevent fraud, the digital tachograph must be installed by a certified professional, and contain an installation plaque that must be sealed. The system must undergo regularly scheduled inspections and repairs.

- **Installation** – The recording equipment must be protected against accidental damage. Once installed and checked, an installation plaque must be visibly placed beside or on the device. The plaque must be changed each time the equipment is calibrated.

- **Sealing** – The installation plaque and the cables connecting the device must be sealed at all times.

- **Inspection** – An enforcement body will be selected to perform periodic planned and random inspections.

2.1.5 Current Perspectives and Status

Supporters of electronic tachograph technology believe that the digital tachograph and smart card combination could improve driver self-monitoring of hours-of-service compliance. Supporters believe that the new system could be an effective tool for roadside enforcement officials because it might provide better protection of recorded data and might enable a large amount of safety checks to be carried out in a short period of time. An opposing view however, is maintained by the International Road Transport Union (IRU) – which represents operators engaging in passenger transport and road haulage for over 60 countries worldwide. While appreciating the European Union's headway in creating regulations to manage the number of hours per day an individual can operate a commercial motor vehicle, the IRU demands a guarantee that these rules take into account the specific characteristics of goods and passenger transport.[14] The IRU is not convinced that this second generation of electronic recording devices is adequate to support the required functionality.

Despite outlining what is perceived to be a set of achievable standards, there has been a delay in implementing this new technology. Currently, evaluations are still being conducted to determine whether there are benefits to switching from mechanical devices to electronic devices. The enforcement community's concern regarding how to break the encasement seal to verify fraud, and the ability to copy data from a vehicle unit or a driver card represent some of the recurring angst. The Council has determined that by the end of 2003,[15] all commercial motor vehicles will be required to have an electronic tachograph installed; however, as of January 2002, the proposed type specification had not been finalized.

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[14]International Road Transport Union. *IRU position concerning the Commission proposals relating to the organization of working time in road transport.* Mar. 1999.

[15]Freund, Deborah, op cit, p 7.

2.2 The GPS Technologies Pilot Project

2.2.1 Background

In April of 1998, the Federal Highway Administration (FHWA) recognized that 49 CFR 395.15 was potentially outdated, and that global positioning system technology could provide an opportunity to improve motor carrier compliance with hours-of-service regulations. The agency therefore introduced a voluntary program which allowed motor carriers with global positioning system (GPS) technology and related safety management computer systems to use these systems to record and monitor drivers' hours-of-service in lieu of the required handwritten records of duty status. As per this agreement, the agency agreed to allow a transportation company engaged in hauling truckload shipments of general commodities to demonstrate North America's first paperless logging system based on GPS technology.

The participating carrier endeavored to illustrate the benefits of electronic recorders compared to traditional handwritten logs. The study aimed to demonstrate that the use of electronic recorders could increase motor carrier safety, reduce administrative time and costs and improve driver compliance with federal hours-of-service regulations.[16] Ultimately, the goal of the GPS Technologies Pilot Project was to determine if electronic logs created by GPS systems could provide an acceptable level of safety and monitoring accuracy. The project also sought to determine if § 395.15 should be amended to recognize GPS-type systems.

2.2.2 Paperless Log System

As early as 1992, the carrier that participated in the pilot project installed satellite communication units in its trucks. This was later followed by an initiative to develop new technology that could improve safety and eliminate drivers' task of manually entering paper logs. From 1995 to 1998, 2,000 drivers working for the pilot carrier tested the new Paperless Log System while continuing to use the traditional paper logbooks. On June 10, 1998, the FHWA officially authorized the participating carrier's adoption of the Paperless Log System, and discontinuance of the paper logbooks.[17]

Today, 6,000-8,000 of the participating carrier's drivers use the Paperless Log System in their trucks. The system relies on GPS technology. Satellite communications determine the exact position of the participating carrier's trucks and process messages from its drivers in real-time. The participating carrier's corporate web site indicates that its system

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[16]U.S. Department of Transportation, *Federal Highway Administration Authorizes Paperless Log System.* Press Release. June 10, 1998.

[17]Information collected from the participating carriers' web site.

enables load planners, fleet managers and drivers to pre-plan load assignments to maximize productivity within the legal driving hour limits.[18] The participating carrier's drivers have access to a rectangular keyboard, approximately the same size as a laptop computer, with an LCD (Liquid Crystal Display) screen. The screen – equipped with a backlight for nighttime viewing – has the ability to display up to four lines of text at once.

According to the participating carrier's company web site, the system operates via a satellite location system that transmits data from its trucks on the road to the carrier's main facility. Satellite position histories, driver messages, and manually entered macros (two-digit numeric codes that indicate the driver's duty status) are sent via satellite to the company's headquarters and automatically trigger the creation of log records. The company's web site indicates that the system calculates "driving time" by determining the time and distance between truck location updates. The distance traveled within the time elapsed is computed by comparing the longitudes and latitudes from the truck's current position and the position from the previous satellite update. In this manner, the participating carrier claims that it is able to observe and control its drivers' fulfillment of the hours-of-service regulations.

To determine a driver's duty status, the participating carrier's system relies on several underlying default assumptions. Under certain pre-determined circumstances, such as the vehicle being idle for two hours, the system defaults to these built-in assumptions to determine a drivers' duty status. The default duty status is triggered and remains active unless the driver intervenes by manually entering a different macro. The carrier's system utilizes the following default assumptions:

- If a vehicle is idle for more than two hours, the system automatically records the time as "sleeper berth";
- If a vehicle is idle for less than two hours, driver duty status is recorded as "off-duty";
- Driving time is not recorded when a truck with a trailer travels less than 15 miles, or a truck without a trailer travels less than 25 miles; and
- If a driver does not specify how long he or she was "on-duty not driving," the system automatically records a default time of 15 minutes for loading and unloading.

2.2.3 Enforcement

At the roadside, inspection officers and enforcement personnel are able to review a driver's hours-of-service compliance by examining the display unit inside the truck. If the inspector prefers a hard copy of the record of duty status, he or she can request that one be faxed to a roadside weigh station facility. During a compliance review at the carrier's base of operations, the inspector can view the record of duty status online. If the inspector

[18] Ibid.

has questions or requires further information, he or she can request a hardcopy of the rec??ord of duty status from the carrier.

2.2.4 Findings

Using the Paperless Log System, the participating carrier's drivers no longer must contend with manually calculating their available driving hours for a given eight-day work period. According to its web site, the participating carrier believes that without the hassle of completing paper logbooks, their drivers could better focus on driving,[19] while staff at the company's headquarters could monitor the electronic records, identify load delivery problems, and make adjustments for on-time delivery, such as swapping loads with other drivers who have available hours. The participating carrier states on its web site that the company believes that its drivers are more compliant with the hours-of-service regulations since the company is better able to pre-plan assignments and organize deliveries according to drivers' work schedules and available hours.

The participating carrier asserts on the company's web site that its system produces results comparable to carriers who use traditional handwritten paper logs. The trucking company claims that the use of electronic recorders enables its drivers to use their time more efficiently and to be more productive. According to the participating carrier, the Paperless Log System reduces paperwork by eliminating the need for drivers to manually draw lines and perform calculations in their paper logbooks. Moreover, the participating carrier believes that highway safety is improved because drivers' attentiveness and awareness of their driving habits has increased since switching to the more automated system.

Despite these claims by the participating carrier, no official results or findings have been published by the FMCSA that support or conflict with the company's claims. Qualitative feedback from staff at the FMCSA on this topic can be found in Section 4.0 of this report.

2.3 Electronic Recorder Study – June 1998 Conducted by the University of Michigan Transportation Research Institute (UMTRI)

2.3.1 Background

In 1998, the FHWA engaged the University of Michigan Transportation Research Institute (UMTRI) to study the costs and benefits of using electronic recorders to monitor driver compliance with hours-of-service regulations. The study also sought to explore and assess

[19] Ibid.

industry attitudes toward mandatory use of electronic recorders. It is important to note that the study did not address the relationship between on-board recorder use and compliance with hours-of-service regulations, nor the relationship of hours-of-service to fatigue or safety.[20]

Through the cooperation of several trucking industry associations, the UMTRI Electronic Recorder Study gathered information and opinions from trucking companies and motor coach operators concerning the use of mandatory electronic recorders. The following associations agreed to participate in the study:

- National Private Truck Council (NPTC);
- Owner Operator Independent Drivers Association (OOIDA);
- Independent Truck Drivers Association (ITDA);
- American Bus Association (ABA); and
- United Motorcoach Association.

2.3.2 Methodology

The study was conducted using a four-page survey tool that was created through the collaboration of several agencies. The questionnaire focused on the costs and benefits of using electronic recorders to record hours-of-service. Three versions of the questionnaire were developed to target for-hire-trucking firms, owner-operators, and bus fleets. Various trucking associations, including the National Private Truck Council (NPTC) and the Owner Operator Independent Drivers Association (OOIDA), volunteered to administer the survey. The questionnaire collected basic census data about the type of company or operation, then asked participants more specific questions about electronic recorder use, and their means for recording driver hours-of-service. Finally, the questionnaire prompted respondents for a description of the effects mandatory electronic recorder use would have on their business. The data that was collected during the survey was then analyzed using a statistical analysis software package.

2.3.3 Summary of Findings

2.3.3.1 Response Rate

It is important to note that the UMTRI Electronic Recorder Study had a very low response rate. Only 1,200 responses were received out of approximately 10,000 distributed surveys.

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[20]Campbell, Kenneth L and Sylvia Wanner Lang. *Electronic Recorder Study: Final Report.* June 1998. University of Michigan Transportation Research Institute.

Consequently, the information contained in the following sections can only be considered as representative of the responses received.[21]

2.3.3.2 *Electronic Recorder (ER) Use*

A technical brief which was published by the Federal Highway Administration Office of Motor Carriers in February 1999, summarizes the findings of the UMTRI study. The technical brief indicates:

- Of the 1,200 responding fleets, 175 reported using electronic recorders: 137 truck fleets, 24 bus fleets, and 14 owner-operators.
- Carriers equip their fleets with electronic recorders for a variety of economic, regulatory, and operational reasons. At least one-third of the large truck fleets or NPTC member respondents reported use of electronic recorders, but electronic recorders use is much lower in all other groups queried.
- There is a clear correlation between fleet size and the use of electronic recorders. Only a small percentage of small truck fleets and owner operators reported using the technology while representatives from larger fleets indicated that the technology was being used widely. This is significant because approximately 90 percent of all carriers regulated by the FMCSA operate less than nine trucks.
- The survey suggests that private fleets are more likely to use electronic recorders with the hours-of-service function.
- Of the 137 truck fleets with electronic recorders, 57 percent used recorders equipped with the hours-of-service function.
- Only 37 truck fleets out of 1,200 responses used electronic recorders as their primary method of hours-of-service compliance.
- Most of the truck fleets that used electronic recorders for hours-of-service were NPTC members, and the rest were large or medium private truck fleets.
- None of the responding for-hire fleets or owner-operators used electronic recorders as the primary method for hours-of-service compliance monitoring.
- Only one bus fleet used electronic recorders as the primary method for hours-of-service compliance monitoring.

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[21] United States Department of Transportation. *Tech Brief: Electronic Recorder Study.* Publication No. FHWA-MCRT-99-007. Feb. 1999.

2.3.3.3 *Cost/Benefit Analysis of Electronic Recorder Hours-of-Service Functions:*

To conduct a cost/benefit analysis, information pertaining to electronic recorder installation costs, as well as operating, and maintenance costs, was gathered from the survey. The amount of time required by drivers to record hours-of-service using electronic logs versus paper logs also was compared. In addition to this, the administrative tasks associated with hours-of-service, including time spent monitoring, summarizing, storing/ retrieving, and auditing hours-of-service records, were examined. The most relevant findings are summarized below:

- Carriers install electronic recorders for various reasons, including operating cost management and to support real-time communication with vehicle drivers. Less than 25 percent of the carriers surveyed installed electronic recorders primarily for hours-of-service recording.

- Electronic recorder acquisition and installation costs average $2,000 or less per vehicle. This cost can vary substantially depending on when the unit is acquired and based on the level of functionality provided. Annual operating costs are typically less than $200 per vehicle. Most carriers that have purchased electronic recorders for their fleets believe that they have recovered their investment within three years of purchasing the device.

- Carriers who do not use electronic recorders to conduct hours-of-service monitoring cited excessive cost as the primary reason that they do not use the devices.

- Survey respondents indicated that the primary operational benefit of electronic hours-of-service recording is a reduction in time required for drivers to record hours-of-service and the administrative time fleet managers spend summarizing, storing, retrieving, and auditing hours-of-service records. Use of electronic recorders to maintain hours-of-service records saves drivers on average 20 minutes per day in comparison to paper logbooks. Administrative personnel also save 20 minutes per driver per month using electronic recorders.

- Benefits of using electronic recorders include better and more economical fleet management as well as reduced administration costs.

- Most carriers that were surveyed saw no significant operational benefits of mandatory use of electronic recorders to record drivers' hours-of-service, and believe such a requirement would result in high initial capital and system maintenance costs, while having little or no effect on commercial vehicle safety.

2.3.4 Conclusion

Due to the low response rate, the information obtained in the study can only be considered representative of the responses received. Nonetheless, these responses provided no evidence that electronic recorders are cost-effective in small fleets. Furthermore, the

overwhelming view of fleets of all sizes is that mandatory electronic recorder use would require extremely high expenditures with minimal benefits. The study further concludes that electronic recorders are useful in controlling hours-of-service only to the extent that carrier management is committed to controlling hours-of-service. An electronic recorder provides information about hours-of-service but the information has no impact if it is not reviewed and acted upon.

2.4 Transport Canada Study – October 2001 Field Testing of On-Board Recorder, Smart Card and Digital Signature Technology: Phase 1

2.4.1 Background

In June 2001, Transport Canada's Transportation and Development Center (TDC) contracted with TECSULT – a consulting company – to undertake Phase 1 of a research proj??ect concerning on-board recorders, smart cards, and digital signature technologies.[22] Phase 1 of this study culminated with the submission of a final report in December 2001. If the project is approved to proceed, Phase 1 (preliminary project development) will be followed by three additional phases involving, respectively: development of detailed functional requirements and pilot operational plan; equipment development and installation, implementation of the pilot operation, collection and analysis of data; and, development of conclusions and recommendations.

The objectives of the overall project are to:

- Analyse on-board recorder and related technologies in order to demonstrate their use in actual operating situations;
- Assess their ability to improve vehicle fleet management from the perspectives of safety, regulatory enforcement and transport operations;
- Develop minimum requirements for the use of these technologies in interprovincial and international transport; and
- Assess the costs and benefits of using them.

The project also was intended to analyse stakeholder attitudes toward these devices, and promote further technological developments by manufacturers by facilitating introduction of new applications to an initial number of motor carrier operations.

[22]Public Works and Government Services Canada Western Quebec Region and TECSULT. *Field Testing of on-board recorder, smart card and digital signature technology: Phase 1.* Sept. 2001.

The first part of Phase 1 aimed to produce a realistic profile of current on-board recorder technologies and monitoring devices available to the motor carrier and motor coach industries. The second part consisted of developing the concept of a pilot operation and evaluation to be conducted in subsequent phases, including data collection and analysis, to achieve the overall project's objectives. Phase 1 also included the preparation of a preliminary work plan, budget, and schedule for the realization of the overall project and each of its phases.

The Phase 1 study was conducted in conjunction with several national and provincial transportation agencies, in addition to Transport Canada, including the Quebec Department of Transportation, Ontario Ministry of Transportation, Société d'assurance automobile du Québec (SAAQ, Quebec's automobile insurance board), the Quebec Trucking Association, and a motor carrier.

2.4.2 Methodology

After conducting an extensive Internet-based literature review that provided 324 potentially relevant hits, a total of 244 firms were selected and categorized as shown in Table 2.1.

Table 2.1 Preliminary Selection of Firms

Type of Business	Number Selected
On-board computers	73
On-board software programs	98
Smart cards	43
Digital signature	10
On-board electronic weighing	20
Total	**244 firms**

After a series of further reviews, analysis, and consultations with the project steering committee, TECSULT identified a final group of 16 companies with technology that would provide an overview of the state-of-the-art in the field. These companies either provide services or manufacture/distribute equipment that potentially could be used for hours-of-service monitoring and other safety/productivity applications that could benefit from on-board recording functionality. The research team distributed survey and analysis sheets to the participating companies and then invited the firms to present their product information to Transport Canada. The survey and presentation covered eight main themes:

1. **Type of System** – Data gathering methods, information storage, and data integrity;
2. **Communication Systems** – Operating platforms, software packages, communication technologies, and the unit cost of each device;
3. **On-Board System Functionality** – Hours-of-service monitoring strategy, dangerous goods management, speed management, fuel management, safety management;
4. **Supplier/Manufacturer Characteristics and Inventory** – History and location of the company, research and development methods;
5. **Set-Up Problems and Obstacles** – Human factors, regulatory factors, economic factors;
6. **Training;**
7. **Accessible Languages (i.e., English or French);** and
8. **Cost/Benefit Analysis.**

2.4.3 Findings

Of the 16 companies that were invited to respond to the survey, 11 replied and each of these companies also gave an on-site presentation and answered questions from the proj??ect's steering committee members. A brief summary of the findings concerning currently available functional capabilities and other related technical and operational elements are found in Table 2.2 below. These findings are based on a consensus of the steering committee members after examination of the data and the results of the on-site meetings with the companies. A more detailed review of the findings, compiled with information gathered through Internet research, telephone interviews, and vendor meetings, can be found in Appendix A. (Vendor names and specific identifying material from interviews have been removed because they are not essential for purposes of this report and because of the rapidly evolving nature of the technology in this field).

Table 2.2 Summary Chart

Analysis of Operational Functionality of On-Board Recorders[23]

	Types of Systems							Systems and Communications			Suppliers and Inventory				
Company	Data gathering without communications interface	Data gathering with communications interface	Information Storage	Printing of Information	Data Integrity	Reconstruction of Events	Electronic Signature	Operating Platform	Communications Technologies	Communications Unit Costs	Units in Service		Research and Development	Management and Manufacturing Standards	Customer Service
A	yes	yes	yes	yes	yes	yes	no	win	yes	nd	no (1)		yes	yes (2)	nd
B	yes	yes	yes	yes	nd	no	yes	palm	yes	yes	10		yes	nd	nd
C	yes	yes	yes	yes	yes	yes	no	win NT	yes	yes	400		yes	nd	yes
D	yes	yes	yes	yes	yes	yes	yes	win CE	yes	yes	79		yes	yes	yes
E	no	yes	yes	no	yes	no	no	N/A	yes	yes	yes		yes	N/A	yes
F	yes	yes	yes	yes	yes	yes	yes	win	yes	yes	56k		yes	yes	yes
G	yes	yes	yes	yes	yes	yes	nd	win	yes	yes	20k(4)		yes	nd	yes
H	yes	yes	yes	yes	yes	yes	yes	win	yes	yes	85		yes	yes	yes
I	yes	yes	yes	yes	yes	no	no	win	yes	yes	300		yes	nd	yes
J	yes	yes	yes	yes	yes	yes	no	win	yes	yes	1,500		yes	yes	yes
K	yes	yes	yes	yes	nd	nd	yes	win	yes	yes	nd		yes	yes	yes

					On-board System Functionality												
Company	Set-up Problems and Obstacles	Available Languages	Cost Benefits	Training	Operator Permit	Vehicle File	Driver Qualifications	Vehicle Characteristics	Dangerous Goods	Daily Check	Hours of Service	Customs Procedures	Speed Management	Safety Management	Fuel Management	Other Functions/Value Added	Participation in a Demonstration Project
A	nd	En-Fr	nd	nd	nd	nd	nd	nd	nd	nd	yes	nd	yes	nd	nd	no	yes
B	high	En-Fr	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	yes
C	low	En-Fr	yes	yes	yes	no	no	no	no	yes	no	no	yes	yes	yes(3)	no	yes
D	low	Eng	yes	yes	no	yes	yes	yes	no	yes	yes	no	yes	yes	yes	no	yes
E	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
F	low	Eng	yes	yes	yes	yes	yes	no	no	yes	yes	no	yes	yes	yes	no	yes
G	low	En-Fr	yes	yes													
H	low	En-Fr	yes	yes	yes	yes	yes	yes	no	yes	yes	no	yes	yes	yes	yes	yes
I	low	En-Fr	yes	yes	no	no	no	no	no	no	no	no	no	no	no	yes	yes
J	low	En-Fr	yes	yes	yes	yes	yes	no	yes	yes	yes(5)	no	yes	yes	yes	no	yes
K	medium	En-Fr	yes	yes	no	yes	no	yes	no	no	no	no	yes	yes	yes	yes	yes

Legend:

nd not determined	(1) 200 units being tested
N/A non-applicable	(2) Beta
	(3) Except for tax on gas
	(4) In Canada plus 380K in the United States
	(5) Requires Reprogramming

Note: In order to verify the accuracy of the manufacturers' responses, TECSULT also interviewed clients who use the manufacturers' products to fulfill their trucking needs Generally, the results were consistent with those of the manufacturers and vendors

[23] Ibid.

While the above findings are all relevant, one of the most pertinent findings for purposes of this report concerns whether the manufacturers currently provide equipment that supports hours-of-service monitoring. Of the companies surveyed, six were determined to provide it, while the remaining five did not or could not be determined.

Examination of various elements concerning regulatory conformance was a central element of the Phase 1 study. The study found that the majority of products would not support full compliance with national regulations. The survey further indicated that the majority of manufacturers surveyed were not fully aware of the regulations for the motor carrier freight and motor coach industries. The TECSULT Phase 1 report states that although the majority of manufacturers asserted that they could provide the functionality that would meet regulatory compliance requirements, none of them could clearly demonstrate that they actually did. After analyzing this apparent inconsistency, TECSULT concluded that this is simply because the devices were not actually conceived with the intention of fulfilling a legal obligation but rather to satisfy specific client requirements.[24] Moreover, the larger manufacturers claim that their products can indeed be modified to meet certain functionality requirements, if the government and enforcement personnel precisely defined the specifications.

After completing Phase 1 of this study, TECSULT observed that Canada currently lacks a precise legal framework concerning the technical specifications that electronic on-board recorders must meet to demonstrate compliance with specific regulatory requirements. Although manufacturers of these products currently seem not to be fully aware of the regulations, they have demonstrated an interest in participating in pilot projects, as well as modifying their equipment to meet specific legal requirements.

2.4.4 Next Steps

In order to proceed with the second phase of this study, TECSULT recommended structuring the study around its three main elements, as follows:[25]

- Evaluate, by actual in-service testing, the technical, operational and administrative processes necessary to record, on electronic medium, the pre-departure verification reports with digital signatures, and to allow the legal recognition of this approach;
- Evaluate the use of smart cards (or memory boards), to store driver hours of service and pre- /post- trip inspections with digital signatures, as well as checking for compliance of these data with the requirements and regulations of the participating agencies;

[24] Ibid, p 18.

[25] Ibid, p 25.

- Define the minimum requirements (and/or standards) to allow for effective and efficient use of these technologies by carriers and road administrators in intraprovincial, interprovincial, and international transport.

TECSULT estimated that the work on Phases 2 through 4 would take approximately 29 months to complete. During Phase 2, TECSULT recommends preparing precise functional and technical specifications in order to allow interested manufacturers an equal opportunity to participate in the project and modify their equipment to meet the requirements.

It also was recommended that work on Phase 2 begin almost immediately if it is desired to have the field operation and testing start in early 2003. Finally, it was recommended that there be a continuing technology monitoring throughout the course of the project, particularly concerning developments in the United States and Europe, to adjust the work as may be appropriate to benefit from these developments to the maximum possible extent.

3.0 Phone Interviews with Technology Vendors and Users

3.1 Interview Guide

Cambridge Systematics (CS) conducted interviews with companies that manufacture or distribute devices, such as Global Positioning Systems (GPS), Engine Control Modules (ECM), and on-board recording systems, in order to gather assessments of the different technologies that currently exist to support hours-of-service monitoring.

The following interview guide was prepared to ask vendors about their products:

- Describe your product – What are the technical features and general features?
- When is the product available? If available now, who distributes it?
- What is the product's basic functionality?
- What are the computer/technical specs of the product?
- What type of display is available? (touch screen, LCD)
- How is data input in the device (keyboard, mouse, and stylus PDA pen)?
- What software is needed to run the product?
- What third-party software/products does the unit require?
- What third-party software/products does the unit integrate well with?
- Do you certify that the product complies with Federal Hours of Service Regulations?
- What criterion is used for determining on/off duty and engine idle time?
- What data is necessary to capture for hours-of-service?
- Do you have any insight/opinions/thoughts about how to deal with hours-of-service monitoring in the future?
- What issues do you see as relevant for hours-of-service monitoring in the future?

- Who are your competitors?
- If truck or engine manufacturer: "What is your preference for vendors"?

3.2 Summary of Telephone Interviews: Electronic Recorder/On-Board Computer Manufacturers

This section presents summaries of interviews conducted with representatives from companies that manufacture and distribute products for hours-of-service monitoring. The following companies were interviewed:

- Qualcomm;
- @Track Communications;
- Cadec Corporation; and
- InfoSat.

3.2.1 Qualcomm – 1-800-348-7227

Description: Qualcomm is a wireless communications and software company founded in 1985. The Qualcomm web site states that the company holds 80 percent market share in satellite tracking and fleet management systems. Qualcomm's most widely used software, OMNITRACKS, is a fleet management system, which includes two-way mobile communications hardware, fleet management software, and satellite tracking. Recently, Qualcomm acquired the Eaton Fleet Advisor System, which has driver log capabilities and a fuel tax charger. Qualcomm is in the process of integrating this newly acquired device into the current MVPc product.[1]

- **The Product:** "Qualcomm's OMNITRACKS system with SensorTracks and MVPc software is optimal for hours-of-service monitoring. The system monitors engine activity and produces managerial reports."
- **Compliance with 395.15:** "The device is compliant with federal regulations."
- **How does device gather engine information?** – "The device uses software called SENSORTRACKS that attaches to the engine via a J1708 bus line (electrical connection)."
- **How does the system gather location/motion information?** – "The system tracks vehicle motion and a driver's specific location on the road with universal GPS coverage.

[1] Qualcomm web site: http://www.qualcomm.com.

Since the system detects motion, it can determine the vehicle's engine status. For example, the system can distinguish between when a truck's engine is running because the vehicle is in motion, as opposed to when the engine is running while the driver is in the sleeper berth and is using the radio, heat, or air conditioning."

- **How is idle time determined?** – "Software conducts calculations based on the number of drivers, as well as time, and the length of the drive. The software's underlying algorithm concludes that the driver is off-duty if the driver's vehicle is idle and the driver has exceeded his allowable time limit. This assumption can lead to conflicting results and, therefore, the default can be adjusted per company."

- **The Display:** "Two units are available: 1) standard and 2) enhanced. The MVPc device uses the enhanced display, which has backlights built into the screen and a miniature keyboard."

- **Audible Notifications:** "Audible alert features are available and will sound an alarm/ warning notification if a driver exceeds a specified speed. Currently, however, the device will not sound an alert if the driver has been driving too long or is not obeying a particular hours-of-service regulation. Qualcomm intends to add this feature in the near future."

- **Security:** "The device is generally tamperproof. However, a driver can manually enter two-digit numeric macros to override the system assumptions.

- "Despite attempts to create an error-free system, the device bears potential faults: For example, when a driver enters the vehicle, he must log-on with unique ID number and pass code. As soon as the vehicle's motor starts, the log begins to track and monitor the driver's activities. If there is a team of drivers, only the member driving must log on initially. Therefore, when there is a change of drivers, the first driver must log out before the new driver logs on. If the drivers forget to do this accidentally, the system is unaware that there has been a switch in vehicle operators. Therefore, when the first driver's hour limit is up, the log will conclude that the driver was on duty too long."

- "The information can be modified following the error; however, to ensure the integrity of the data, only the system administrator at the main computer can make these changes. Although the driver usually does not have authority to alter the log, this feature can be overridden."

- **Software and Hardware Integration:** "The MVPc unit can integrate with most third-party software. Although different components can be bought, all devices that are sold by Qualcomm require the GPS functionality. All Qualcomm solutions provide new communication capabilities that can be installed by Qualcomm. However, a carrier can decide to attach OMNITRACKS to their former communication system (i.e., pager, cell telephone, etc.). In other words, the Qualcomm device can integrate with the system already employed by the carrier. A potential client is not obligated to buy the full system."

- **What are your opinions/thoughts about the future of hours-of-service monitoring? –** "The DOT has pending legislation to implement compulsory electronic recording devices. The most recent public hearing placed the legislation back on the shelf. Most truck companies are not very willing to adopt the technology. The reason most often given is cost. However, if demand increases, Qualcomm will pursue this matter further."

3.2.2 @Track Communications/Highway Master – 972-301-2000

- **Description:** According to its corporate web site, @Track Communications provides intelligent wireless communications products and services using state-of-the-art technologies and networks. With customers, including Wal-Mart, and member companies of SBC Communications, Inc., the company offers mobile communications, emergency dispatch, fleet management, and mobile-asset-tracking systems. Currently holding 45 U.S. and foreign patents, with additional patents pending, @Track offers industry leading, innovative, vehicle fleet management solutions through its ability to combine wireless data and voice technologies with GPS-satellite-tracking capabilities. @Track is headquartered in Richardson, Texas.[2]

- CS did not receive feedback from a qualified representative despite multiple attempts; and

- The contact thinks that Highway Master *"might"* have hours-of-service capabilities, but is not sure what software will need to run on it.

3.2.3 Cadec Corporation – 1-800-252-2332

Description: Cadec Corporation states on its company web site that it is an employee-owned company with 25 years of leadership in the transportation technology industry. Cadec is a pioneer in the field of on-board computer systems and was the first company to successfully launch an integrated application for driver coaching and driver feedback.[3]

- **The Product:** "Mobius TTS is a fully integrated product that combines GPS and other technologies. Mobius TTS uses Engine Control Module (ECM) technology to connect directly to the vehicle's engine. The device collects information about RPM, speed, hours-of-service, GPS, etc. The product has an open architecture that can be adapted to the needs of individual companies."

- **Compliance with 395.15:** "Mobius TTS is compliant with hours-of-service regulations."

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[2] @Track web site: http://www.at-track.com.

[3] Cadec web site: http://www.cadeccorp.com.

- **The Display:** "Vehicle operators have access to graphical and text output of their activities. For safety reasons, this information is not available to the driver while the vehicle is in motion, but can be viewed when the vehicle is idle."

- **Audible Notifications:** "Audible notifications are available. This is a user or company-preference, and can be adjusted based on a carrier's standards and/or individual driver requirements."

- "Mobius TTS is one product that combines many features beyond those required for hours-of-service monitoring. Cadec claims that, if a client were interested in a smaller system that could be used only for hours-of-service tracking, the client would have to purchase an older model of Cadec's products."

- **Relationship with DOT:** "Cadec works very closely with the DOT, especially since the DOT trains on Cadec systems. Cadec claims that, if in the future hours-of-service rules change, then Mobius TTS can be modified easily. Cadec, however, did not disclose the direction in which it is heading with the Mobius TTS product."

3.2.4 InfoSat – 419-281-7161

Description: According to its corporate web site, INFOSAT has been designing, integrating, and commissioning remote communications systems since 1986. InfoSat's customers include some of the world's most prominent resource companies, network operators, broadcasters, and government agencies. Combining satellite communications (MSAT) and on-board computers, INFOSAT's Fleet Management service provides the tools to increase fleet utilization, control variable expenses, and improve operating costs. The company, based in Canada and headquartered in Vancouver, BC, has representation in the state of Ohio.[4]

- **The Product:** "Infosat's Automated Vehicle Location System (AVL) unit has a terminal built-in with a GPS chip. Outbound messages are sent by the chip at predetermined times. The signal is then forwarded to a server containing a map layout, and a vehicle's coordinates are automatically plotted on this map. There is no engine connection available and Infosat currently does not have the interest to create one. No communication beyond the AVL unit is required between the driver and the dispatcher to track vehicle location. The AVL is a communicator/pipeline only."

- **Compliance with 395.15:** "Infosat's web site and literature claims that the AVL unit is industry compliant. However, when interviewing Infosat, the representative stated that their product is not industry compliant. In fact, the representative was not familiar with the notion of hours-of-service monitoring and stated that Infosat does not intend to develop devices to monitor hours of service or engine activity."

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[4] Infosat web site: http://www.infosat.com.

- **Integration:** "If the carrier needed additional cellular phones or communications devices, the client would have to use a third-party appliance. Infosat claims that their product is compatible with most vendors."

- **Partnerships:** "Infosat is developing a partnership with Cabit Systems and Traxis. Both companies have a "box" unit that is designed to monitor essential engine activities. The unit checks criteria, such as breaking time, RPM, speed, acceleration rates, etc."

- **Input device:** "The input device for the Traxis system is a keyboard."

- **What type of criteria or devices do you think should be developed to create hours-of-service monitoring devices?** "A device that will trigger the engine and will record and send real-time engine activity back to the dispatcher."

3.3 Summary of Telephone Interviews: Truck/Engine Manufacturers

This section presents summaries of interviews with truck and engine manufacturers. The following companies were interviewed:

- Cummins Engines;
- Mack;
- Freightliner;
- Caterpillar; and
- Detroit Diesel.

3.3.1 Cummins Engine Company – 781-329-1750

Description: As stated on its corporate web site and in its literature, Cummins Engine Company is a worldwide designer and manufacturer of diesel engines. Cummins also produces natural gas engines, engine components, and subsystems.[5]

- **The Product:** "To track vehicle movement, the RoadRelay system uses an ECM located on the engine. This information is extracted from the engine computer and is then sent to a display unit in the dashboard of the vehicle for the driver to view. RoadRelay monitors fuel, panic stops, cruise control, and engine hours, etc."

[5] Cummins web site: http://www.cummins.com.

- **The Software:** "The INROADS product is a software package that includes INFORM and INSPEC. The INSPEC software looks at engine codes, maximum speed, etc. The unit captures real-time information only. The product does not and cannot produce reports unless it uses additional software. The information is logged in a database and can be retrieved with INFORM software."

- **GPS:** "The RoadRelay device is not manufactured with a built-in GPS system, but a carrier can choose to add a GPS. Cummins does neither the installation nor the configuration themselves for a GPS unit. Cummins does not have a preferred vendor for satellite technologies."

- **Hours-of-service monitoring:** "The vehicle operator enters a unique ID number at the start time of a trip leg (portion of trip). The device logs the driver's activities until the driver manually stops the log. RoadRelay does not eliminate paper logs; it simply facilitates the recording process."

- **Compliance with 395.15:** "RoadRelay is not industry compliant."

- **Security:** "RoadRelay has anti-theft features."

- **Integration:** "The device integrates with Cummins, CAT, and Detroit Engines. However, with engines other than Cummins, the information may not be logged exactly the same."

- **Display:** "RoadRelay display – two by four inches in dashboard of vehicle."

- **Audible Notifications:** "No audible alarms available. All warnings and messages are visual."

- **Cost:** "RoadRelay alone without GPS and without installation is approximately $500 per vehicle. RoadRelay with GPS and without installation is approximately $800 per vehicle."

3.3.2 Mack – 610-709-3751

Description: According to its web site and corporate literature, Mack is one of North America's largest producers of heavy-duty trucks. In addition to major product components, the company also markets a line of medium-duty diesel trucks across North America.[6]

[6] Mack web site: http://www.macktrucks.com/index4.html.

- **Product:** "VIP and Guard Dog. These systems do not use engine computer chips for monitoring."

- "ECM's are used for preventive maintenance functions (for example, predicting when a new oil change is needed)."

- "Mack is currently working with a company called TruckLine to install GPS systems."

3.3.3 Kenworth Truck Company – 425-828-5000

Description: As stated on its company web site, Kenworth Truck Company, a division of PACCAR Inc., is a leading manufacturer of heavy and medium duty trucks. Founded in 1923, Kenworth has an extensive dealer network of more than 290 dealer locations in the United States and Canada. This dealer network provided parts, service, and body shop support for customers.[7]

- A phone interview with a Kenworth representative revealed that, "Kenworth has no interest in pursuing the development of devices for hours-of-service recording, because their clients are opposed to such units. Kenworth states that the majority of commercial vehicle drivers view the implementation of on-board recorders as a punitive measure. Drivers feel that these devices are a modern form of the Orwellian 'Big Brother'."

3.3.4 Freightliner – 503-745-8000

Description: As stated on its web site, Freightliner manufactures, sells, and services several world-renowned brands of trucks. Freightliner is one of the world's most aggressive product developers devoting resources to understanding what truck owners need and want, and finding ways to deliver products to match their expectations.[8]

- **The Product:** "Freightliner developed a proprietary on-board computer unit called the Truck Productivity Computer, which was released in December 2000. It is an on-board computer embedded inside a dashboard radio. It operates on a Windows Operating System and uses voice recognition."

- During a telephone interview with a representative at Freightliner, the representative referred to a press release where he was quoted describing the unit. "Freightliner's Truck Productivity Computer is an on-board computer, communications interface, vehicle information display, GPS; AM/FM stereo, weather/ RDS receiver and compact disc player – all in one. The device features a Hitachi SH4 166 MHz processor, an 80-pixel by 320-pixel electro-luminescent display, intuitive controls,

[7] Kenworth web site: http://www.kenworth.com.

[8] Freightliner web site: http://www.freightliner.com.

universal serial bus (USB); connections, IrDA port, and RS-232 serial port. The Truck Productivity Computer fits into the standard radio slot in a commercial vehicle dashboard and is intended as an alternative to current mobile computing options for commercial truck operators. Freightliner LLC is North America's largest heavy-duty truck manufacturer and a leading manufacturer of Class 4-8 vehicles."[9]

- **Hours-of-Service Monitoring:** "Freightliner is ready and prepared to implement hours-of-service technology, but their clients have shown little demand for these devices. They had begun to market an hours-of-service monitoring product, but since there was no interest, the company scaled back their efforts. At the time of their initial press release, Freightliner mentioned that the company was in the process of developing software for the unit. However, nearly a year and a half later, they have not yet developed the software for it."

- "Freightliner would like to venture into this arena eventually, especially if the federal government creates a mandatory requirement for electronic recorders in commercial vehicles. Freightliner hopes to one day offer a complete one-stop package, so that when a client buys a truck, they will receive a built-in GPS and electronic recorder. Freightliner has experienced a tremendous amount of resistance from the trucking community and, therefore, does not believe that this will happen in the near future."

- "Freightliner engines have electronic controls. However, engine controls provide no hours-of-service capabilities. If Freightliner does pursue this venture of developing electronic recorders, the company intends to do it using GPS devices and not with engine computer chips."

- **Partnerships:** "In the past, Freightliner has worked with Qualcomm, but is unsure if the product developed for the GPS Technologies Pilot can be adapted for other clients."

3.3.5 Caterpillar – 1-800-587-2787

Description: According to its corporate web site, Caterpillar Inc. is the world's largest manufacturer of construction and mining equipment, diesel, and natural gas engines, and industrial gas turbines. Headquartered in Peoria, Illinois, it is a Fortune 100 company, ranked number one in its industry, and with more than $26 billion in assets.[10]

- "CAT does not create the on-board computer or the chip that resides on the vehicle engine. Instead, CAT relies on the products offered by the engine manufacturing company."

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[9] Ibid.

[10] Caterpillar web site: http://www.caterpillar.com.

3.3.6 Detroit Diesel – 313-592-5990

Description: As stated on its company web site, Detroit Diesel Corporation (DDC) designs manufacturers and services heavy-duty diesel and alternative fuel engines. The company, a subsidiary of DaimlerChrysler AG, offers a complete line of engines from 22 to 10,000 horsepower for the marine, military, construction, industrial, generator-set, mining, trucking, and automotive markets.[11]

- **The Product:** "Detroit Diesel manufactures a proprietary ECM that attaches to the engine of a truck. The ECM is a maintenance tool with management features that monitors in real-time how much fuel is being used by the engine, the speed of the vehicle, RPM, etc. The real-time clock captures information and displays it either on a handheld reader or through software on a laptop computer. Typically, the vehicle operator would not use these devices; rather, a maintenance individual would use it."

- "Although it monitors in real-time, the ECM does not contain a diagnostic tool that evaluates in real-time. That is, it is not possible to preset an alarm to sound when the driver reaches a certain speed or has exceeded his driving limit."

- **Partnerships:** "The ECM does not create reports and, therefore, requires third-party software to complete this task. Detroit Diesel often uses the Qualcomm system for report creation."

- "Detroit Diesel's ECM currently does not have the capacity to create driver logs, and the company does not intend to pursue this venture. Due to the absence of demand, the company has little inclination to create a driver's log system. The company prefers to focus their efforts on other technologies for tracking fuel with engines."

[11] Detroit Diesel web site: http://www.detroitdiesel.com.

4.0 FMCSA Staff Interviews – Questions and Answers

4.1 Introduction

As the Federal agency responsible for safety oversight of the nation's interstate commercial motor carrier industry, the FMCSA has a vested interest in the technologies used for recording drivers' hours-of-service. Since 1998, the FMCSA has conducted studies, demonstrations, and pilot tests to determine whether GPS systems and similar technologies provide at least the same degree of monitoring accuracy as automatic on-board recorders and handwritten paper logbooks.

Interviews were conducted with key FMCSA representatives to gain insight on their experiences with GPS technology for monitoring drivers' working time. Because the GPS Technologies Pilot represents the initial attempt to use GPS technology for hours-of-service monitoring, the interviews in this section focus primarily on the FMCSA staff's observations of that pilot project.

4.2 FMCSA Interview Questions

The following interview guide was prepared to solicit feedback from FMCSA staff about the GPS Technologies Pilot project and the future of electronic on-board recorders.

General Background Questions

- What has your involvement to date been in terms of examining opportunities to use on-board technologies to monitor hours-of-service compliance?
- What was your role during the GPS Technologies Pilot project?
- What was the impetus for this project?
- What steps were taken by the participating carrier/FMCSA in advance of the demonstration (planning, policy changes, development of evaluation criteria, etc.)?

- Who were the key individuals at the FMCSA who were involved in the demonstration project?
- What role did Qualcomm play or other third parties, if applicable?

GPS Technologies Pilot Demonstration Questions

- How many trucks/drivers were involved?
- What business process or technology changes were required to support the demonstration project?
- What training was provided to people impacted by the pilot project (law enforcement officials, drivers, dispatchers, etc.)?
- What was the reaction of the various individuals who were impacted by the pilot project?
- What is your sense in terms of how the pilot project impacted safety/compliance?
- What worked well? What were the most significant benefits?
- What didn't work well? What were the most significant drawbacks?
- What should have been done differently?
- What conclusions can you draw from this pilot project that need to be incorporated into future rules that focus on electronic monitoring of hours-of-service compliance?
- What is the status of the pilot project today? Is the participating carrier still using this approach? Do they still maintain paper logs as well?
- Have other companies expressed interest? Why/Why not?

Other Questions

- Are today's performance requirements under § 395.15 sufficient? If no, what additional performance requirements need to be addressed?
- Which parties need to be involved in the development of these performance requirements?
- What technologies should be looked at beyond on-board computers?
- What data must be captured to demonstrate compliance?

- What technology issues/limitations should be considered?
- What enforcement/fleet management issues must be considered?
- What is industry's position on a mandatory requirement for electronic monitoring of hours-of-service?

4.3 Summary of Findings from the FMCSA Interviews

An analysis of the responses gathered from the interviews indicates that in most instances, all the representatives held similar perspectives and opinions about the GPS Technologies Pilot Project. This section summarizes the feedback received from the interviews with FMCSA staff. The responses are organized and broken down into the following main themes:

- General pilot project questions;
- Specific findings of the pilot project; and
- Future of electronic on-board recorders.

General Pilot Project Questions

The Impetus for the GPS Technologies Pilot Project

The FMCSA representatives that were interviewed cited several reasons for pursuing the project including:

- **Interest in eliminating handwritten paper logs and improving compliance with hours-of-service regulations:** Commercial vehicle operators do not always accurately log their on-duty times as required by federal regulation. The FMCSA staff that were interviewed believed that the use of this technology could possibly improve the tracking and enforcement of driver hours-of-service compliance.
- **Economic benefits:** Management at the participating carrier believed that on-board recorders could address some of the key concerns faced by the trucking industry including the timeliness of delivery, improved service, maximization of driver working hours and equipment, and real-time audits of driver hours to determine which driver should deliver which load.
- **Reduced administrative costs:** Electronic on-board recorders were perceived as a potential tool to increase motor carriers' efficiency and productivity and to reduce the cost and time of paperwork related to manually tracking drivers' hours-of-service.

- **Logistical benefits:** The FMCSA staff believed that the participating carrier's management viewed on-board technology as a tool to improve the management of their assets, specifically in terms of load assignment and planning.

- **Communication:** GPS technology was expected to facilitate and improve dispatch decisions, dispatcher support, and increase the efficiency of driver/dispatcher management. It was anticipated that electronic recorders would improve dispatcher-to-driver communication by capturing RODS without the need to speak directly with the driver to monitor their status.

- **New recruitment tool for drivers:** According to the FMCSA staff that were interviewed, the trucking industry has a very high turnover rate and electronic recorders were expected to lure new recruits. It was believed that the introduction of electronic logbooks could be an incentive to drivers, as they would no longer be required to complete logs by hand, a required but sometimes tedious task.

Planning the Pilot Project

Prior to the start of the GPS Technologies Pilot project, staff from the FMCSA, representatives from Qualcomm™ – a manufacturer of GPSs and communication technologies – and members of the participating carrier's team convened to design the pilot project. This process included the evaluation of planning procedures, business processes, policy changes, and system evaluation criteria. According to the FMCSA staff that were interviewed, key elements of this process included:

- The creation of a memorandum of understanding detailing the development and planning steps necessary to ensure that the recording equipment would meet the desired legal requirements and specifications;

- The development of a plan to fund the demonstration;

- Demonstrations by Qualcomm™ – the vendor of the GPS used in the GPS Technologies Pilot Project – to explain the relevant features of its product;

- System development phases included defining the system's underlying algorithms, developing and coding the software, and conducting dry runs of the software and equipment; and

- Training was provided to the participating carrier's drivers to ensure proper use of the system.

Training Needs for Enforcement Personnel

According to the FMCSA staff, at the time of the initial demonstration very little training was provided to the enforcement community. Training consisted of a videotape and information package that was mailed to all Motor Carrier Safety Assistance Program (MCSAP) lead agencies and a presentation that was given at a Commercial Vehicle Safety

Alliance (CVSA) conference during a general session. The FMCSA staff that were interviewed agreed that in the future, two distinct levels of training will be necessary: one for roadside enforcement officials and a second for compliance review officers. To meet these needs, the FMCSA has recently developed training courses about on-board recorders. A pilot presentation was held in December 2001.

According to several FMCSA staff, training should be provided to enforcement personnel because the inspectors and compliance review officers may be unfamiliar with how to interpret electronic records of hours-of-service data. In response to this, the CVSA has recently started to offer an electronic on-board recorder course to the enforcement community. Targeted towards state and federal officials, this two-day program provides a hands-on approach to analyzing electronic recorder data. The course provides an overview of the history of on-board recorder technologies and explains how data is captured. The program emphasizes that data is sometimes inaccurate and teaches inspectors how to verify that the data is "clean." The course, however, is oriented towards roadside enforcement activities and not the compliance review performed at the motor carrier's place of business.

The FMCSA respondents stated that both general and detailed guidance and information material should be created for drivers and enforcement personnel. This should include a manual about operating the device, and a specific listing of the laws related to hours-of-service recording. Furthermore, these individuals believe that the current Memorandum of Understanding and other pertinent documents must be more detailed and easier to interpret.

GPS Technologies Project Impact Perceptions

The following feedback was received during interviews conducted by Cambridge Systematics with FMCSA staff, and reflects the perceived impacts of the GPS Technologies Pilot project.

Impact on drivers: According to the FMCSA staff that were interviewed, two opposing views emerged from the group of drivers who participated in the GPS Technologies Pilot project. The FMCSA staff generally perceived that the younger generation of drivers viewed the technology favorably. This positive reaction might stem from the fact that younger drivers appreciated the system's hands-off approach as well as the perceived efficiency and productivity improvements. Further, the younger drivers – who are perhaps less financially stable than their more senior peers – recognized that the demonstration project and its underlying logic was advantageous for drivers seeking to maximize their driving time and therefore their compensation. Contrary to this positive reaction, the FMCSA staff perceived that several (primarily older) drivers were intimidated by the on-board recording technology or viewed the system as an infringement on their privacy because of the ongoing monitoring.

Enforcement impacts: Similar to the varying driver reactions, roadside enforcement personnel and compliance review officers held different views about the recording devices. According to the FMCSA staff, one camp of enforcement personnel applauded the system

for its quick auditing capabilities. The other camp seemed more skeptical about the use of technology. This may stem from several factors including:

- **Process Changes** – The switch from paper logs to electronic ones may cause feelings of distrust as inspection officers accustom themselves to reading and interpreting log data from a digital screen as opposed to examining a log book.

- **Technology Issue** – A sense of distrust may arise because of the fact that officers may not believe that technology is a reliable means by which to track hours-of-service compliance.

- **Reliability Concerns** – Some individuals believe that information system records may not present an accurate depiction of RODS. Distrust may arise from being unsure of the validity of the system's underlying algorithms and driver-entered macros.

Perceived Safety and Regulatory Compliance Impacts

The FMCSA representatives who were interviewed generally agreed that there have been no documented improvements in compliance or safety. Despite this, the FMCSA staff maintain a general perception that since the pilot began, there has been a heightened sense of driver awareness about the need to adhere to hours-of-service regulations. The individuals who were interviewed also believe that it is difficult to recognize improvements in compliance because the participating carrier was considered to be a safe and compliant carrier before the demonstration began.

Other individuals maintain that the participating carrier's implementation did indeed increase hours-of-service compliance and safety by providing a specific tool to improve the accuracy and reliability of the hours-of-service records, and by indirectly helping to prevent driver fatigue-related accidents. However, of those who recognize a positive impact of the project, most still believe that standards, specifically related to GPS technology, must be developed to further impact motor carrier safety and that the benefits can only be confirmed when more field data and information is gathered.

Specific Findings of the GPS Technologies Pilot Project

Perceived Benefits Produced by the GPS Technologies Pilot Project

According to the FMCSA representatives who were interviewed, the GPS Technologies Pilot Project produced the following perceived benefits:

- **Elimination of handwritten paper logbooks:** The success of the demonstration is reinforced by the fact that the participating carrier's drivers were able to eliminate the use of paper logbooks from their daily tasks. Management from the participating carrier claim that this has led to a reduction of time and money spent on administrative paperwork.

- **Increase in hours-of-service compliance:** Because drivers were given specific duty status choices in the new software, it is perceived that drivers more accurately reported the length of time that they were on duty and the lengths of their breaks, etc. Further, the FMCSA staff stated that since the pilot began, there has been a heightened sense of driver awareness, which has led drivers to make a more concerted effort to monitor their duty status. This has consequently led to a perceived increase in compliance.

- **Increased accuracy:** The device provides more stringent reporting capabilities than paper logs, specifically in terms of what inputs the driver may provide given their duty status, and therefore might provide a more accurate picture of a driver's overall duty status. The participating carrier's system has 100 percent audit capabilities of the regulation's 10-, 15-, and 70-hour permitted working time segments.

- **Driver performance:** It was initially perceived that users of the paperless system demonstrated a decrease in driver out-of-service (OOS) rates. However, it is important to recognize that in the past, nearly 40 percent of OOS violations (industry-wide) result from either the driver not having a log or the log not being current. With the introduction of the electronic recorder, these two common infractions do not occur and therefore the 40 percent OOS rate is eliminated.

- **Crash rates:** There have been no statistically significant findings with respect to crash reductions linked to the demonstration project.

Perceived Drawbacks of the Paperless Log System – How can technology be improved and how should § 395.15 be amended to better reflect the needs of monitoring hours-of-service?

The FMCSA officials that were interviewed agreed that current on-board recorder performance standards are not well understood by commercial vehicle operators and the enforcement community. Furthermore, the representatives stated that elements of §395.15 should be better defined in the following areas:

Data Gathering Methods and System Assumptions

- The Pilot Project employed GPS technology that relies on satellite signal transmissions to pinpoint a vehicle's location and movement. The system's underlying algorithms or macros determine a driver's duty status. The FMCSA staff caution that the use of these built-in system assumptions could potentially lead to an inaccurate picture of a driver's available working time and total distance traveled. In this demonstration for example, the participating carrier captured hourly GPS data points (pings) and messages from the driver and translated this data into a measurement of distance traveled. Although this calculated distance is accurate for point-to-point travel, it is not accurate for total distance traveled especially when the vehicle does not travel in a straight line.

- One FMCSA respondent recommended the creation of standards for the information systems carriers use to store electronic logs, particularly in terms of the format in which the logs are presented to compliance review officers. Just as there are concerns about

the potential for a variety of display formats with on-board devices and the challenges this poses to enforcement officials, there are similar concerns that the back-end systems that carriers use to store the electronic logs will present the data in a variety of formats, making it difficult for enforcement officials to review and interpret the logs.

- Another FMCSA respondent claimed that assumptions regarding on-/off-duty status were flawed because they did not correspond exactly to the definition of driver breaks outlined in § 395.15. Currently, for example, when a vehicle is motionless for two hours or longer, the system defaults to "sleeping berth." In the future, it is instead recommended that vehicle stationary time err on the side of safety; that is, not assuming that the driver is sleeping.

Standards and Regulations

- The FMCSA officials generally agreed that the Memorandum of Understanding carried by drivers during the pilot was not specific enough with respect to standards for GPS technology. It was therefore recommended that future regulations or guidelines be created to better define and cover all contingencies. Furthermore, it was recommended that a single standard that can be verified by roadside enforcement officials and compliance review officers be created.

Engine

- The FMCSA staff who were interviewed generally maintain similar perceptions about the sufficiency of satellite data to monitor driver working time. They generally believe that a link to the vehicle engine and axle coupled with vehicle location technology would be optimal and that vehicle location data alone is insufficient. In other words, some type of combination between the new GPS technology and the "integrally synchronized" on-board recorder technology defined in § 395.2.

Security

- Despite efforts to create a tamperproof system, it would appear that some drivers who participated in the GPS Technologies Pilot project found ways to alter the data to their benefit while at the same time compromising safety. The FMCSA staff who were interviewed therefore believe that the device must be more resistant to improper data entry.

- FMCSA staff indicated that motor carriers are concerned about data privacy (i.e., protection of what motor carriers view to be confidential business data) and how the data produced by on-board systems will be used by the enforcement community. This must be considered when evaluating hours-of-service regulations and the use of on-board systems to monitor hours-of-service compliance.

- One FMCSA representative recommended the implementation of a certification process for ensuring and determining the accuracy of data transmitted by on-board systems.

Need for a Governing Enforcement Body

- The FMCSA respondents generally agreed that a governing enforcement body should oversee the maintenance and calibration of on-board systems. The FMCSA would enforce and ensure that the devices used to capture hours-of-service data are both consistent in the way they collect and process data.

In-Cab Display

- According to some FMCSA officials, the in-cab display units used by the participating carrier during the demonstration project did not provide enough detail for the drivers. FMCSA staff also recommended that a display standard be developed to ensure that data is displayed consistently across vendors' platforms.

Training

- Most FMCSA staff that were interviewed believe that limited training was provided to the enforcement community with respect to the systems with which they would be interacting at the roadside and in conjunction with the compliance review process. Future deployments must include a more rigorous training program for enforcement officials and compliance review officers.

The Future of Electronic On-Board Recorders

The Future of Electronic On-Board Recorders – Are today's performance requirements under § 395.15 sufficient? If no, what additional performance requirements must be addressed?

The FMCSA staff who were interviewed generally agreed that if GPS technology were deemed to be acceptable for hours-of-service monitoring, the current performance standards outlined in regulation 395.15 must be modified to specifically include provisions for GPS technology. Furthermore, FMCSA staff recommended that the regulations should specify exactly which information the GPS unit must capture in order to be considered compliant. Standards should be created to specify links between the engine, transmission, drive train, and the GPS and/or on-board computer. The system also must capture data from the vehicle's engine such as rpms, vehicle speed, etc.

Which parties should be involved in the development of these performance requirements?

The FMCSA representatives recommended the inclusion of the following transportation organizations in the creation and development of future performance requirements:

- FMCSA;
- State DOTs;

- Public- and private-sector transportation representatives representing Canada and Mexico;
- The ATA and other U.S. motor carrier industry organizations;
- Roadside input (CVSA);
- Individual motor carriers;
- Electronic recorder vendors;
- Safety advocacy organizations; and
- Technical standards/oversight organizations that are not composed of vendors, to certify the devices.

What technologies should be looked at beyond on-board computers?

The FMCSA representatives outlined the following technologies as being potentially useful for monitoring hours-of-service:

- GPS;
- Engine Control Modules (ECM);
- Electronic tachographs; and
- Handheld GPS systems, which include a passive GPS receiver that is hooked up to a cellular phone. Each hour, the telephone places a call to the main center.

In your opinion, why have carriers been reluctant to adopt this technology?

The FMCSA staff believe that the following reasons could potentially explain why be carriers may be reluctant to implement electronic recording devices:

- Cost.
- Carriers believe they would not use all the functions that are available from on-board computers.
- Education – Carriers are not educated or aware of the benefits of electronic recorder technologies.
- It is perceived that some carriers currently operate illegally (i.e., they do not comply with hours-of-service regulations). Electronic recorders would put them in a position where they would have to gather information that could document those practices, increasing the possibility that they would be subject to enforcement action and monetary penalties that could put them out of business. Carriers who knowingly are

violating hours-of-service regulations clearly would not be interested in investing in technology that draws attention to this practice.

What is industry's position on a mandatory requirement for electronic monitoring of hours-of-service?

- The FMCSA staff generally perceive that a mandate to use electronic on-board recorders is not on the immediate horizon.
- A bill that would have required trucks registered in California to be equipped with electronic on-board recorders was passed by the California Senate, but did not receive sufficient votes for passage by the California's Assembly's Transportation Committee. It could be re-introduced early in 2002.[1]
- Some FMCSA staff indicated that the current administration is pro-business and is unlikely to take action at a time when the economy is slow and where others factors, such as driver shortages, are impacting the trucking industry.

[1] "California Bill Dies in Committee Vote," Transport Topics, July 23, 2001, p.6.

5.0 Findings and Recommendations

This section summarizes the findings of the literature review and interviews that were conducted by Cambridge Systematics and lays out a series of recommendations regarding the development of performance standards for electronic on-board recorders.

5.1 Key Findings

The literature review and interviews that were conducted by Cambridge Systematics revealed several key findings.

- The use of on-board technology to support the monitoring of hours-of-service compliance has been limited to date. This can be attributed to several factors including:
  - Few vendors have developed technology that is specifically intended to support hours-of-service monitoring. Interviews that were conducted with technology vendors suggest that the primary reason for this is that vendors do not perceive a strong demand for this functionality in the marketplace. Vendors also indicated that the high cost of on-board devices has limited motor carrier investment to date.
  - The federal government does not require motor carriers to use on-board recorders to capture RODS (i.e., use of on-board recorders is voluntary not mandatory).
  - The costs and benefits of using on-board technology to maintain RODS and to manage drivers' hours-of-service are not clear cut. Potential costs include one-time capital purchase, installation and training, as well as ongoing maintenance costs. Potential benefits may stem from productivity and safety improvements.
- Despite the fact that few vendors have developed on-board technology specifically to support hours-of-service management, several existing or emerging on-board systems could potentially meet the requirements specified under § 395.15. Specifically, these technologies appear to be capable of supporting some or all of the data collection and monitoring capabilities that are likely to be necessary in order to maintain an electronic logbook, and many of these technologies are prevalent in the motor carrier industry. There appear to be four broad categories of technology worth considering. These include:

- Digital tachographs;
- Engine Control Modules (ECM);
- Vehicle location/wireless communications technology; and
- Hybrid technology – combining more than one of the above technologies.

- After reviewing § 395.15 and based on the literature review and interviews, staff at Cambridge Systematics believe that today's on-board recorder performance standards are insufficient because several elements of the regulation can be viewed as being open to interpretation. For example, while section 395.15 specifies the information that on-board recording devices must be capable of capturing and displaying, the regulation does not specify how the information should be displayed through on-board devices. This is problematic for vendors who may be seeking to develop compliant on-board systems as well as enforcement personnel who are faced with the need to interpret output from a variety of on-board systems at the roadside that may be displayed in more than one format. There are several additional elements of § 395.15 that seemingly are in need of further clarification. These are discussed in Section 5.2.

- There is a limited body of work pertaining to motor carrier perceptions about the use of on-board technology for managing hours-of-service compliance. This is in part because of the fact that few carriers are using on-board technology today for managing hours-of-service compliance.

- European countries have required motor carriers to use on-board recorders (specifically, tachographs) to maintain records of duty status since the 1970s. Representatives from the FMCSA have indicated that the use of tachographs as a stand-alone approach for demonstrating compliance with hours-of-service requirements is unacceptable because of concerns about device tampering. Despite the reluctance to rely on tachographs exclusively for hours-of-service monitoring, a number of "lessons learned" can be drawn for the European experience including:

  - The need to have clearly defined performance standards/requirements for the on-board technologies. Without these standards it is difficult for vendors to develop products that meet the needs of regulators and industry.
  - The need to have an ongoing process or forum for discussing the effectiveness of the regulations and how the evolution of technology factors into regulations. The European experience suggests that rulemaking is an ongoing process that must embrace technology evolution and research pertaining to driver fatigue, etc., and that there is a constant need to re-evaluate the effectiveness of regulations in light of these developments.
  - The potential need to consider making on-board technology for monitoring hours-of-service compliance mandatory for some or all segments of industry in order to ensure widespread use.

- The GPS Technologies Pilot project produced mixed results. While the demonstration project proved that GPS technology could be used as a tool for monitoring and

demonstrating hours-of-service compliance, there were a number of potential shortfalls identified by Cambridge Systematics during the review of this demonstration project and through discussions with FMCSA staff including:

- The demonstration project was conducted with the understanding that the participating carrier's drivers would enter macros indicating their duty status. In cases where the system defaulted because drivers had forgotten to enter macros, the agreement specified that drivers would update the electronic log with the appropriate duty status macro so that an accurate record was maintained. It would appear, based on discussions with FMCSA staff, that in a number of cases drivers were not entering duty status macros as required. This may have impacted the accuracy of the driver logs and compromised safety during the demonstration project.
- The level of training provided to the enforcement community, particularly roadside inspectors, does not appear to have been sufficient. The lack of training appears to have manifested itself in the form of inconsistent enforcement practices in the field. Specifically, feedback from FMCSA personnel suggest that it was perceived that some roadside inspectors were un-trusting of the technology and therefore were more likely to scrutinize a driver's hours-of-service log; alternatively, some inspectors elected not to scrutinize a driver's hours-of-service log because they were unfamiliar with the technology and/or did not know how to interpret the information at their disposal. The FMCSA and other organizations such as the CVSA already have begun to address this issue through new training programs targeted at the enforcement community that focus specifically on on-board technology.
- Relying exclusively on vehicle location data proved to be a problem from an enforcement perspective in terms of verifying "driving time" with 100 percent accuracy. Based on the findings of the demonstration project, it would appear that in addition to collecting information about the location of a vehicle, a more comprehensive approach to calculating driving time would be to combine vehicle location and engine data (e.g., data pertaining to the vehicle's speed, rpms, etc.). The coupling of these data would significantly reduce the need to develop and rely on duty status default assumptions. Essentially the coupling of vehicle location and engine data would improve the quality of the data that is being used to generate the driver log, and would paint a more comprehensive and defendable picture of hours-of-service compliance because it would help to substantiate actual driving time versus simply time elapsed from point A to point B.
- It is unclear what if any impact the demonstration project had on the participating carrier's overall compliance with hours-of-service requirements. It would appear that despite some of the positive outcomes of the demonstration project, the system did not prove to be "tamperproof" as required under § 395.15.

- Many vendors indicated that personal privacy is likely to be a major issue for drivers and may be a key determinant of whether motor carriers elect to make use of technology to support hours-of-service monitoring.

- Even the most effective on-board technology will not enable regulators to determine how drivers have conducted themselves while they are off duty and/or on duty, not

driving. Most on-board devices were not developed to provide this functionality; however, this is critical because research suggests that the amount and/or quality of sleep that drivers get while they are off duty is a key safety factor.

5.2 Recommendations

Based on the literature review and interviews that were conducted, staff from Cambridge Systematics have developed the following recommendations:

- The FMCSA should obtain feedback from motor carriers regarding the current and expected future use of on-board recorders. This information would supplement the original project conducted by UMTRI. This feedback will help to identify:
  - The costs and benefits of using on-board recorders for managing hours-of-service compliance from a motor carrier's perspective;
  - Specific concerns that industry has regarding the use of on-board recorders for managing hours-of-service compliance (e.g., personal privacy, etc.); and
  - Future technology purchasing trends (i.e., in which systems will motor carriers invest and how does this impact the development of standards and rulemaking).

- The GPS Technologies Pilot project raises significant questions about the sufficiency of using GPS technology as a stand-alone solution for monitoring hours-of-service compliance. Based on our review of other technologies and their capabilities and the shortfalls of the demonstration project, we strongly recommend consideration of engine monitoring technology for monitoring hours-of-service compliance. Specifically, we recommend the coupling of technologies that are capable of capturing vehicle location data as well as engine data. We believe this coupling of technology will produce a more comprehensive "snapshot" of driver compliance with hours-of-service regulations because an enforcement official will be able to determine not only where a driver started and finished his/her trip, they also will have a clearer picture of what happened between points A and B. For example, if on-board systems capture vehicle location and vehicle speed data, it will be easier to verify the number of hours a driver has been on duty as opposed to relying exclusively on vehicle location data.

- Conduct an operational test/demonstration project with one or more motor carriers who may be using a combination of GPS and system monitoring technologies to determine the most effective combination of technology. Similar to the GPS Technologies Pilot project, it would be beneficial to define and conduct an operational test that involves the use of vehicle location technology linked with other vehicle components (e.g., the vehicle's engine, transmission, odometer) to determine the effectiveness of linking these capabilities and the impact they have on safety and productivity. Testing a variety of approaches would enable the FMCSA and other key stakeholders

to better understand the cost, productivity, and safety benefits that can be attributed to each approach as well as the limitations of each approach.

- Conduct an outreach session with technology vendors and create an ongoing forum to discuss technology trends and limitations, applying technology to hours-of-service regulations, and vendor concerns. We believe that it will be critical to establish a dialogue between the FMCSA and the various vendors who provide on-board systems. This may help to ensure that:
  - Vendors understand current motor carrier regulations and how the systems they have or are developing can be used by motor carriers to comply with these regulations;
  - The FMCSA understands what new systems the vendor community is developing and updates regulations to keep pace with advances in on-board systems; and
  - On-board device standards are discussed in a public forum that promotes interoperability and uniformity.
- Revise section 395.15 of the FMCSR. Irrespective of whether the FMCSA endorses the recommendation to couple vehicle location and engine data, staff from Cambridge Systematics believe it is critical for the FMCSA to update § 395.15 to provide more specific guidance to motor carriers, technology vendors, and state enforcement agencies regarding the performance standards for on-board recorders that are used to monitor hours-of-service compliance. Specifically, we recommend that the FMCSA give further consideration to:
  - Defining the range of acceptable on-board systems that may be used to maintain/generate an electronic driver log – Specifically, if certain on-board devices such as tachographs are viewed as being unacceptable by the FMCSA, the regulations should clarify this.
  - Standardizing the in-cab display of driver logbooks – This may help to cut down on the number of systems with which enforcement personnel come into contact that display data in different formats.
  - Development of a formal vendor certification process or compliance testing program – The current approach, which relies on self-certification, does not appear to be sufficient. Cambridge Systematics recommends that the FMCSA consider a more structured approach to vendor certification such as a "Certification Board" that is comprised of industry experts and representatives from the FMCSA.
  - Development of specific standards for equipment calibration and maintenance – section 395.15 does not provide specific guidance to motor carriers regarding the ongoing maintenance and calibration standards for on-board systems.
  - Define driver and dispatcher training requirements – The FMCSR does not provide specific guidance to motor carriers regarding driver training requirements. Clarifying training requirements may not only help to ensure that drivers know how to

use on-board systems to comply with hours-of-service regulations, it also may help to heighten awareness about the need to comply with these regulations.

- Evaluate roadside enforcement and compliance review processes and training needs. While efforts have been made to roll-out new training programs that address the use of technology and hours-of-service, we believe that it is critical for the FMCSA to evaluate the effectiveness of these programs after they have been delivered and to consider whether additional training is necessary and/or the extent to which roadside enforcement process or compliance review processes may need to be updated to reflect modifications to hours-of-service regulations.

Appendix A

Sampling of On-Board Technologies

Sampling of On-Board Technologies

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Autocoach – Fleet Management System • Tachograph *Source: • http://www.stonebennett.com/ac/home.html	**Operating system/hardware/software:** • Windows CE Operating System • Intel 166Mhz Pentium Processor with MMX technology **Technical specifications:** • Operating temperature range from -40°C to +85°C • Interface with SAE J1708 data link • 10 Base T Ethernet connection (optional) • Integrated Spread Spectrum Radio • GPS (optional) • 12 Customer usable digital inputs • 6 Customer usable analog inputs • 4 RS-232 serial ports • Standard printer connection	**Display:** • EL display technology • Touch-screen display can monitor 14 digital inputs, plus analog inputs **Reports:** • Creates DOT driver logs • Creates over 50 standard reports

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Cadec – Mobius TTS • On-board computer • GPS receiver standard with the on-board computer, as well as event location stamping and breadcrumb trail tracking • Creates DOT-compliant hours-of-service logs • Automated DOT compliance audits • Route information • Real-time event notification • Detailed driver and vehicle information • Delivery and pick-up tracking • Integrated on-board data with back-office enterprise • Minute-by-minute log details • Programmable, multilingual prompts * Source: • http://www.cadeccorp.com/index.asp • Cadec corporate brochure	**Operating system/hardware/software:** • Windows CE • High-powered Intel Strong ARM processor with 32-bit RISC technology **Technical specifications:** • Engine interfaces for J1708, J1939 • Will meet or exceed SAE J1455 requirements for electrical systems in trucks • Has electronic dash and mechanical connections to the vehicle • 32 MB of on-board memory, plus 2 PCMCIA slots for additional flash memory storage • 18 digital and analog switch inputs and outputs for recording and control of auxiliary devices • 4 RS232 ports for addition of printers, communications devices, and handheld (PDA) equipment • Uses a GPS receiver to provide event location stamping	**Display:** • LCD graphical touch-screen display – sunlight readable for day, and back-lit for night • User-friendly driver interface with drop-down lists • Text messages can be displayed when the vehicle is not in motion • DOT logs are graphically displayed along with hours-of-service information **Reports:** • Produces drivers' daily logs • View daily totals of driver on-duty driving time, off-duty time, and sleep periods • Produces a report of drivers' available hours • Produces a report of DOT violations for a certain time period • Log includes co-driver name • Log includes summary of shipping numbers/commodities per location, as required by DOT • Automates DOT compliance audits

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Cabit Systems – Cabit Online Service Bureau (OSB) • Uses GPS for messaging and locating truck • Provides logbook capabilities • Does not support hours-of-service monitoring • Capable of multi-languages • Includes an electronic bills of lading program • Allows drivers and dispatchers to update the status of a shipment in real-time *Sources: • http://www.cabit.com/ • Cabit Systems corporate brochure	**Operating system/hardware/software:** • Company offers online dispatching products that are compatible with Palm (PDA) software • Compatible over various wireless networks **Technical specifications:** • Not available	**Display:** • Displays on a Palm OS unit (Palm Pilot, Handspring, etc.) • Uses Palm stylus pen for input • Main screen contains icons **Reports:** • Accident details, vehicle problems, log book, fuel consumption, etc.

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Caterpillar – Caterpillar Fleet Information Software (FIS) and ADEM 2000 System • Engine Control Module (ECM) • Programmable logic controller (PLC) links engine and compressor by way of a feed-back loop • Engine control regulates fuel combustion and provide self-diagnostic capabilities • Engine control stores the following data: – State line crossings – Driver IDs – Fuel economy statistics – Trip statistics, such as length, time, average speed, etc. – Engine RPM – Low voltage, vehicle over-speed, engine overspeed – Next, last, and overdue preventative maintenance warnings	**Operating system/hardware/software:** • A hand-held portable data terminal allows a PC to extract data from up to 200 engine ECMs in less than 10 seconds each • Software identifies which vehicles are turning in low fuel economy, operating at excessive speeds, or spending too much time idling **Technical specifications:** • RS232 interface allows communication with single/multiple engines from a central control room at a remote location • Problem diagnosis from remote locations • Provides communication either by modem or satellite • Nearly all controls are programmed to prevent engine damage by shutting down the engine if key parameters are outside acceptable limits • Electronic control system detects fault conditions and logs them in memory • Off-site engine monitoring and control capabilities • Technicians can check engine performance by reading routine operating parameters • Compatibility with additional vehicle systems to provide seamless integration and maximize performance	**Display:** • Dashboard display allows drivers to see how they are performing with real-time, visual feedback on engine operating conditions • Provides drivers with a variety of information such as fuel usage, average miles per gallon, and oil pressure • Lit or flashing LEDs on the control panel display engine faults • LED indicates problems with gauges, fluid levels, fuel supply, air intake, as well as exhaust, ignition, and starting systems, etc. **Reports:** • Creates reports to analyze driver, vehicle, and overall fleet performance • Provides the ability to design custom reports to tailor information to specific needs • The unit reports critical or vital fault codes as they happen, and provides a code number and brief description of the fault

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Caterpillar – Caterpillar Fleet Information Software (FIS) and ADEM 2000 System (continued) • Sensors continuously measure: – Starting air pressure, filtered/unfiltered engine oil pressure – Oil temperature, coolant level/temperature, fuel temperature – Crankcase pressure – Inlet air temperature – Cylinder exhaust temperature, exhaust stack temperature – Ignition timing, detonation *Source: • http://www.cat.com/		

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Datacom – Mobilus Optimum • Internet capable • Captures distance, speed, and RPMs • Does not provide hours-of-service capabilities • Captures customized data, such as excess speeds, incidents of hard breaking, engine speeds, distances traveled, door openings, alarms triggered, etc. • Locates vehicle within 5 meters • Manages shipments in real-time • Provides route optimization • Logs the time of vehicle incidents • Provides remote diagnostics and ongoing maintenance • Sets geographic and temporal boundaries on vehicle use *Sources: • http://www.datacom.com/ • Datacom corporate brochure	**Operating system/hardware/software:** • Operates over the Internet • Uses ASP web features that can be configured to specific company needs • Connected to a wireless network covering 99% of North America's cellular system, along with most of Central and South America **Technical specifications:** • **Primary source – 9/36** volts DC at 1.5 Amps • Backup battery – 12 volts • Memory – 512 kb for data storage • 8 programmable digital inputs/outputs • 6 analog inputs • 2 optically isolated inputs • GPS receiver – 12 channels, L1 frequency, C/A code, update rate of 1Hz • SAE J1455 standard • Cellular – 3 watts AMPS	**Display:** • Not Available **Reports:** • Automated generation of reports to ensure proper monitoring and control of vehicles

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Cummins Engines – Road Relay 4 • On-board vehicle/engine monitoring system • Displays real-time, engine, and vehicle information • Notifies drivers when they overspeed or idle excessively • Ability to set and monitor fleet performance standards, then compare individual vehicle or driver performance against set standards • Logs fuel consumption, idle time, PTO time, and fault activity • Records panic stops, 75 seconds of detailed vehicle data, such as RPM, mph, brake, and clutch activity • Conducts fuel tax monitoring • Provides unique driver IDs • Provides route recorder • Available in 6 languages *Sources: • http://www.cummins.com/ • Cummins Inc. corporate brochure	**Operating system/hardware/software:** • Uses a Windows-based reporting software package • Software acquires downloads of trip information from the datalink for database storage, and then creates reports or graphs by individual vehicle, driver, sub-fleets, or entire fleet **Technical specifications:** • J1587/J1939 datalinks • Battery backed	**Display:** • Screen is 20 character x 4 lines • Contains a backlight for night viewing • Provides driver coaching pop-ups • Unit contains 12 icon/numeric keys **Reports:** • Produces reports on fuel, performance, safety, fault activity, comparison, exception, service, and maintenance categories

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Freightliner • On-board computer and GPS • Communications interface • Vehicle information display • AM/FM stereo and compact disc player • Weather/RDS receiver • Currently does not support hours-of-service monitoring The on-board computer has the following capabilities: • Routing and scheduling, turn-by-turn directions, vehicle tracking, shipment tracking, GPS navigation, breakdown management, driver performance monitoring, vehicle diagnostic information, driver and dispatch e-mail, Internet access, logistics management, freight tracking, emergency assistance, satellite radio, fuel optimization, and integration with handheld devices *Source: • http://www.freightliner.com/news Press_detail.asp?id=77 • Freightliner corporate brochure	**Operating system/hardware/software:** • Device features a Hitachi SH4 166 MHz processor • Uses Microsoft Windows CE for automotive operating system, which provides drivers and passengers with hands-free communication, access to personalized information on the Internet, the ability to summon emergency services and roadside assistance **Technical specifications:** • USB • IrDA port and RS-232 serial port • Uses voice interactive software	**Display:** • 80-pixel by 320-pixel screen • Electro-luminescent display • Intuitive controls • Fits into the standard radio slot in a commercial vehicle dashboard **Reports:** • Uses varying third-party software packages to create reports

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Elcon Mobility • GPS receiver and smart antenna • System provides hours-of-service monitoring capabilities • Provides protection against illegal manipulation • Unit has standard car radio dimensions **Optional Features:** • Fleet management • Accident data recorder • European tachograph • Data transmission • Electronic toll collection *Source: • http://www.elcon-mobility.com/v2/elcon_e/index.htm	**Operating system/hardware/software:** • Device interfaces to back office system using Windows platform **Technical specifications:** • Uses a GPS receiver and smart antenna	**Display:** • Not Available **Reports:** • Not Available

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Qualcomm – OmniTRACS • On-board computer and mobile communications system • Automatic vehicle tracking • Provides two-way data messaging and satellite positioning • Internet e-mail from the comfort and safety of the truck • Uses integrated dispatch software • Integrates driver's location and data messages into fleet management software • Provides fleet dispatchers with hourly reports on the position of all their rigs • Real-time data communication and seamless, nationwide coverage • Automatic vehicle tracking with GPS • Data integration capabilities	**Operating system/hardware/software:** • MVPc in-vehicle computer operates on a Windows CE platform • Runs on a variety of hardware platforms and is fully compatible with a variety of operating systems • Designed to fully support communications from the host computer at the main control center • Uses a directional antenna for real-time communication **Technical specifications:** • Interface port – 9-pin male DSUB shell size E • Memory expansion – Compact FLASH, Type I • PCMCIA – User-accessible Type I or II PCMCIA 2.1 compliant slot, or one dedicated internal Type III slot • Peripheral expansion – Port to support future expansion modules for communication or software debugging (for example, low speed IrDA, high-speed USB, RS-232, Ethernet, or parallel) • Monitors devices tied into J1708 data link	**Display:** • Enhanced display unit for driver to enter information and read messages sent from dispatcher • 15 line by 40 character display supports text and graphics • LEDs – 3 user-configurable LEDs • Touch screen capability • Uses a QWERTY keyboard that is backlit and spill-resistant • Pointing device – Tethered stylus for use with analog resistive touchscreen • Speakers, microphones, and audio jacks **Reports:** • Produces trip reports and DOT logs • Uses application links to interface with application and operations software already in use, including accounting, dispatch, load planning, maintenance requests, payroll, etc. • Driver performance monitoring reports • Vehicle performance reports

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Infosat Telecommunications • Automated Vehicle Location (AVL) System • Combines satellite communications, GPS, and Internet access • Provides customized fleet management • Driver log capability is industry compliant • Uses real-time load tracking and schedule updates • Provides driver and vehicle performance monitoring • Provides information to dispatchers to keep themselves and their clients up-to-date with the exact whereabouts of their goods at all times • Satellite communications improve prediction of pick-up and delivery times • Dispatch radio service *Source: • http://www.infosat.com	**Operating system/hardware/software:** • Messaging and mapping software with additional GIS tools **Technical specifications:** • Uses two-way messaging and real-time positioning via a satellite network • North America-wide satellite coverage • Includes antenna for data and/or voice communications • In-cab unit with portable memory card and built-in GPS receiver	**Display:** • Displays last known or current location for any number of vehicles • Displays location history of vehicles • Animates vehicle's route at a user-specified rate of playback, with GPS location markers flashing to simulate actual vehicular path **Reports:** • Fuel management and fuel tax reporting • Trip/route productivity • Electronic driver logs (industry compliant) • Alarm state reporting

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Qualcomm – Fleet Advisor*	**Operating system/hardware/software:**	**Display:**
• Transportation logistics management system consisting of real-time communications, GPS, full function on-board computing using the MVPc™ in-vehicle computer, and back-office software networking • Automated DOT-compliant driver logs • State mileage application simplifies IFTA regulatory compliance • Generates time stamps and GPS locations at each stop • On-board computer allows dispatchers to generate routes manually with graphic drag and drop features • Using GPS technology, arrivals/departures are fully automated • Device automates the functions of recording, processing, archiving DOT logs • Creates metrics on vehicle speeding, idling, over-revving, rapid decels, critical decels, MPG, etc. • Records arrivals/departures, state line crossings, entering/leaving toll roads	• Uses a Pentium-based PC as its central hardware platform • Uses the Windows operating system • Uses two separate microprocessors that operate in tandem • Processor #1 – Communicates with drivers with a context-sensitive interactive graphic display • Processor #2 – Records speed, RPMs, SAE J1708 diagnostic signals, etc. **Technical specifications:** • Data is stored on cards • Each unit has a built-in card slot to upload route schedules, DOT logs, and other information provided on the storage card by the dispatch center • Uses GPS technology to locate vehicle en-route	• Icon-assisted display for each input • Touch-screen prompts drivers for other events and transactions, such as delivery and pickup, overage and shortage, damages and returns of goods, or entering and leaving toll roads **Reports:** • DOT compliant driver logs. FleetAdvisor displays and maintains DOT-related seven-/eight-day detail activities, current trip DOT activities, and a complete record of all edited DOT logs, including originals • Driver record of duty status, summaries/details of driver availability, DOT exceptions, etc. • Details of driver session, performance, and activity • Incidents of critical deceleration • Trip details, location activity details/summaries, route details/summaries • IFTA-specific reports, such as vehicle mileage, fuel summary, odometer calibration • Location specific reports, including location activity summary, location activity details, scheduled route details, and transactions details

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Qualcomm – OmniTRACS (continued) Driver performance monitoring system helps drivers improve their driving habits: • Provides real-time feedback to dispatcher and driver • Isolates performance within driver's control, over-the-air exception monitoring, speed, RPM, and idle time (short and long) • Differentiates between acceptable idle and unacceptable idle based on parameters that are preset by the company • Provides built-in protection, so system tampering can be detected *Sources: • http://www.qualcom.com/qwbs/index.html • Qualcomm corporate brochure		

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Roadtronic – Roadpartner • On-board data acquisition system • Monitors hours-of-service, travel, and DOT logs • Monitors fuel consumption, engine idling • Verifies safety/security procedures • Provides critical exception reporting for speeding, excessive idling, breaking, stop duration, location • Provides warnings for open doors, driver comparisons, overall fleet performance • Optimizes vehicle activities, such as multi-vehicle positioning and monitoring on digital maps • Monitors routes driven, speed, idling, stops made, delivery verification, driver log verification • Multi-lingual capabilities *Source: • http://www.roadtronic.com/en/ • Roadtronic company literature	**Operating system/hardware/software:** • Windows 95-98/2000/NT • Visual Basic enhanced • GPS links with Excel automatic report • Integrates with other applications (maintenance, AVL, accounting, etc.) **Technical specifications:** • Unit concealed in vehicle dash • 20 inputs (brakes, doors, hood, etc.) • 8 control outputs (alarm, locks, starter, etc.) • 384 k memory (complete trip data) • GPS and digital mapping • 4 RS232 serial ports • Performs direct downloading on-site • Unit has direct connection to control station • Transfers can also be performed via RF, cellular, or satellite network • 2 simultaneous logbook recording capabilities • 16 programmable keys • 1.5 Mb memory • Battery backup	**Display:** • Vehicle status keypad/driver message indicator can be mounted on vehicle dashboard • Stop status buttons, message indicator • Customizable based on customer requirements • Text and graphical display • Storage on key and system (1.5 Mb) • In-vehicle printing available • Possibility of disabling keypad when vehicle is in use **Reports:** • Provides critical exception reporting on speeding, excessive idling, breaking, stop duration, location, special events, such as open doors, driver comparisons, overall fleet performance, etc. • Door and/or compartment monitoring, driver notification, vehicle shutdown, alarm outputs, event re-creation, and risk management • Vehicle status reporting • Fuel mileage reporting • Conducts trend analysis

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Qualcomm – Fleet Advisor* (continued) • Handles team drivers and slip seat operations • Retains details of seven/eight days of DOT-related activities • Once the driver logs on in the vehicle, the route is downloaded into the in-cab on-board computer • At the end of a route, the data storage card downloads trip and schedule information from the on-board computer • The driver must manually touch Arrive/ Leave icons for the first time at any destination. The device then stores the destination coordinates in its database and automatically determines all subsequent arrivals and departures at that destination without any prompt from the driver. Note: In 2001, the assets of Eaton's Trucking Information Services business unit, including Fleet Advisor®, were sold to Qualcomm Wireless Business Solutions). *Sources: • http://www.eaton.com/index.html • http://www.qualcom.com/qwbs/ products/fleetadvisor.html		

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Tetra Communications – VICTOR™ • Modular on-board computer, combined with communications system and company-based software • On-board computer with programmable data acquisition • Uses sensors, integrated GPS module, real-time messaging to conduct hours-of-service monitoring • System does not currently have a regulatory compliant logbook • Next generation electronic logbook is in development and pending the finalizing of European Union requirements • Vehicle location and route integrity can be monitored and optimized • Unit registers all vehicular data and wirelessly transfers it to the company's information system • Provides real-time two-way data messaging between dispatch and driver	**Operating system/hardware/software:** • Windows NT compatible • Client/server software is used to store, organize, and visually present the vehicular data recorded • Open architecture makes data readily available to all fleet management personnel • Drives wireless short-range data downloads and uploads • Accommodates a variety of dash or floor-mounted supports **Technical specifications:** • GPS receiver, bar code reader, terrestrial and/or satellite communications • Rugged design meets SAE J1455 standards • Interfaces to J-Bus (SAE J-1587 and SEA J-1708) • Interfaces to controller area network (SAE J-1939) • Multiple analog and digital I/O ports • Large memory recording capacity • Blackbox with circular buffer • Wireless data downloads • Electronic key (driver ID) • Two serial interfaces to support hand-held computer, bar code reader • Optional controller area network interface	**Display:** • Multi-functional screen is highly legible from all angles and in all lighting conditions • Screen uses vacuum fluorescent display (VFD) technology • Screen size is 8 lines by 21 characters in text mode • Features four intensity levels per pixel • Driver-friendly scrollable menus with universal pictograms • Uses a QWERTY ergonomic keyboard with 40 backlit keys • Entries can be keyed in whether in cradle or hand-held position **Reports:** • Organizes data into easy to read reports (HTML) • Produces a trip segmentation report, which includes departure, arrival, and idle time • Records and reports data, such as speed, distance, RPMS, acceleration/deceleration, braking, fuel consumption, driver activities, and route integration

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities

Terion – FleetView

- On-board computer designed for mobile applications
- Satellite positions sent automatically when vehicle starts or ends motion, and on a custom configurable interval when vehicle is moving
- Automatic position reports outside of coverage stored in memory and retried until acknowledgement received
- Enhances logistics, security
- Improves scheduling and dispatching
- Improves customer service, driver retention
- Driver configurable local time zone
- Power save mode when vehicle is not running
- The unit is awakened when a message is being received
- Ability to send/receive "free form" text messages to/from the dispatch computer
- Address book feature

*Source:

- http://www.terion.com/
- Terion corporate brochure

Operating system/hardware/software:

- Over-the-air software download capability enables functional upgrades without touching installed hardware
- Transceiver unit mounts on the back of the cab wall or under the bunk
- Small, rugged self-contained package
- In-cab driver's terminal will work well in every type of cab interior

Technical specifications:

- GPS receiver uses a three-watt advanced mobile phone system and cellular transmit/receive module
- Sophisticated power management circuitry, extensive processing capability
- Tested to applicable SAE environmental requirements
- FCC approved
- Upgradable memory

Display:

- High resolution monochrome display with adjustable contrast
- Extra bright message light with ultra-wide viewing angle
- Backlit elastomeric keypad, sealed, and impervious to spills
- PC-like keyboard layout, with glove-compatible spacing
- Full numeric entry keypad with on-screen calculator function
- Keyboard lockout option when vehicle is in motion
- Integrated one-button emergency message key
- Special function keys to simplify use
- High-volume message notification beeper
- "No signal" indicator
- Integrated "Help" text function

Reports:

- Creates custom reports
- Reports indicate location and status of all assets
- Displays asset utilization patterns based on vehicle motion

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
TMI Communications – Satellite Packet Data Services and Terminal • Satellite packet terminal includes tracking, messaging, monitoring, GPS • Unit supports hours-of-service monitoring • Provides fleet and load management • Credit card verification • E-mail • Mobile computing • Data message broadcasting • System provides security against fraudulent communicator use through unique access keys *Sources: • http://www.tmi.ca/ • TMI Communications corporate brochure	**Operating system/hardware/software:** Unit comprised of: • GPS satellite • A mobile terminal • A satellite and data hub • Backhaul system with Internet, frame relay, public-switched network, leased line) • Host application **Technical specifications:** • L-band satellite technology with built-in GPS • Coverage includes all of North America and Central America • Lightweight, less than 3 lbs. • Discrete inputs and outputs for monitoring applications • RS-232 connection for optimal DTE • Uses an industry-standard open interface for easy communications between remote applications and the packet data terminal • Provides messaging services for bi-directional messages and host-to-remote/multiple remote broadcast • Host application development is quick and easy through an API that requires no special cards or software	**Display:** • Not available **Reports:** • Vehicle position reporting

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Tetra Communications – VICTOR™ (continued) • Accurate pick-up information transmitted back to company loading dock • Provides on-the-go re-routing instructions • Provides morning delivery schedule uploads *Source: • http://www.govictor.com/en/ index.html • Tetra Communications corporate brochure		

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Tripmaster • 240/GPS – On-board data collection module of the Tripmaster system • Unit supports hours-of-service monitoring • Records distance, start/end time, average speed, time over speed limit, instances of acceleration/ deceleration, etc. • Measures equipment warm-up and cool-downs • Verifies time and speed/brake events leading to an accident • Unit tracks, stores, and displays information for over 500 trips • Driver can select from four trip types: business, personal, commute, and other • Data is extracted from the in-cab unit via a data link cable connected to a module at one of the company's facilities • Data is automatically transferred into the dedicated, stand-alone PC, via another cable connected to the extraction module *Sources: • www.tripmaster.com • Tripmaster corporate brochure • Tripmaster company literature	**Operating system/hardware/software:** • Microsoft Windows platform • ODBC compliant – Unit can monitor multiple drivers or use the ID code to track vehicle locations • Password protection provides security for data and settings • Tamper indicator reveals unauthorized use; tamper log records time and date of last 10 instances of unauthorized use • No data lost if power is removed **Technical specifications:** • Local area radio frequency system with infrared direct extraction • Transceiver with 3,000-foot range • FCC certified with 2.4 GHZ band • DT-240/GPS system tracks road speed, mileage, etc. • Memory card system • Multiple sensor inputs: Standard vehicle speed sensor (SS) or electronic engine control (EEC) (J-1708 vehicle data bus) for maximum data collection capability • Multiple data extraction methods: Tripmaster Wireless™, Tripmaster Traveler Card, Infrared Direct Extraction, or handheld computer	**Display:** • Driver Data Terminal II (DDT) is a rugged, palm-sized keypad • Large, easy to read screen with scrolling features and both alpha and numeric input • Flexible programming capabilities • Fill-in-the-blank forms • Terminal – Offers multiple handheld terminal options, such as the Tripmaster DDT 1, DDT 2, or can be integrated with popular handheld computers **Reports:** • Software and open-database on a Microsoft Windows platform generates reports • Analyzes productivity and performance issues, such as stop times, deliveries, mileage, speed, etc. • DDT couples with the DT-240/GPS and facilitates paperless DOT reporting and electronic trip reports

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
VDO Kienzle (Europe) • Electronic tachograph • A microprocessor system with a digital odometer and an analog speedometer using stepping motor technology *Source: • www.vdokienzle.com/	**Operating system/hardware/software:** • Unit contains a data interface to allow data to be transferred from the device to a PC **Technical specifications:** • Registration unit contains a memory of 365 days • Two chip card readers accept the driver and co-driver cards • Chip cards (each with a 28-day memory) contain information about the driver, company, controller • Intelligent sensors provide contactless recording, encryption, and transfer of the driving pulses to the registration unit with protection against manipulation	**Display:** • Unit displays information and warnings in an easily recognizable form • Keypad provides easy and intuitive access to the unit's menus and commands **Reports:** • Unit contains a printer that produces daily, weekly, monthly reports of statistics, such as date/time, name of driver/name of inspector, driving time, standby time, etc.

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
VDO North America/VDO Fleet Systems – Electronic Tachograph • Electronic tachograph • Monitors hours-of-service, distance, and speed • Instrument is a combination clock, speedometer, odometer, tachometer, and recorder • Collects a record of all vehicle activity over any period, up to eight days • Compact and tamper-proof • Records driver ID, trip start, depart and end times, standing times, distance traveled, odometer readings, and 5 driving violations (over-speeding, over-revving, harsh braking, excessive idle, and green band driving violations) • Vehicle service reminder *Sources: • http://www.vdona.com/homepage/homepage.html • VDO North America corporate brochure	**Operating system/hardware/software:** • Windows-based application software that runs on Windows 3.1, 95, 98, or Windows NT • Unit is either a separate instrument on the dash or mounted with a bracket anywhere in the vehicle, even in the trunk • Data export to Access and other Microsoft applications • Software available in 8 languages • Wizards simplify tasks, such as initializing data plugs • Security – Special keys ensure that only authorized persons have access to the charts **Technical specifications:** • Optional starter circuit interruption • Large memory capacity (in excess of 700 trips between downloads) • Unit can use existing wiring and cabling to obtain the information necessary for recording • A smart card is supplied to each driver and stores record of duty status and other statistics • Stores 30 days of hours-of-service data (in-cab module stores information for 365 days)	**Display:** • Reports can be previewed on screen, allowing driver to decide what to print • Graphing facilities allows one to produce two- and three-dimensional graphs and change graph types at the click of a button **Reports:** • Creates reports of driving errors and graphs by driver and by vehicle • Provides driver scoring reports and graphs • Creates reports and graphs on fuel consumption • Produces an activity timeline, which is a graphical view of a 24-hour period of vehicle activity produces trip reports by driver and by vehicle

Sampling of On-Board Technologies (continued)

Company – Product Name	Platform/Technical Specifications	Display and Reporting Capabilities
Xata Corp – Distributed Information System • On-board computers, mobile communications, satellite positioning, fleet management, route optimization package • Order entry and routing/dispatch information are imported into the fleet management system • Data is transmitted to a data station located in the terminal, where the trucking operation is based • Drivers off-load routing/dispatch information from the data station and store it on their driver key • Key is a floppy disk that also contains each driver's identification and hours-of-service records • Drivers download the routing/ dispatch, ID, and log information from the key into the driver computer mounted on the truck's dashboard • System captures information for electronic fuel tax calculations • System automatically updates a driver's hours-of-service status, which is constantly shown on the screen *Source: • http://www.xata.com/	**Operating system/hardware/software:** • Runs on PC, Unix, AS400 and system 38 platforms • Minimum requirements are a 133 MHz processor, 32MB of memory, and 300 MB of hard drive space • Uses dispatch and Internet software to improve fleet productivity and profitability **System contains four basic components:** • Driver computer • Driver key – Floppy disk • Data station • Fleet management system software Technical specifications: • Not available	**Display:** • Computer screen displays real-time feedback on speed, fuel consumption, location, routes, and engine diagnostics **Reports:** • Not available