# Transportation Recorders on Commercial Vehicles

*Paul Menig and Cary Coverdill*
*Freightliner Corporation, 4747 N. Channel Ave. Portland, OR.  97217*

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## INTRODUCTION
Information has been sensed, recorded and off loaded from commercial vehicles for almost twenty years, excluding the recording of speed by tachographs.  The recording devices include trip recorders, engine controls, on-board computers, wireless communications equipment, RADAR collision warning devices and instrument clusters.  The information is used to improve driver safety, help diagnose problems, improve the efficiency of logistics for the fleet, and reduce operating costs.  This paper will provide a brief history of recorders on commercial vehicles, an overview of presently available products, examples of the information available, and a projection of future recording capabilities.

## MAIN SECTION

### HISTORY OF COMMERCIAL VEHICLE RECORDERS
The oldest recording device on commercial vehicles is the tachograph.  Used in numerous countries throughout the world, it has been in existence for decades.  In the early 1980's, solid state based recorders were introduced in North America.  One of the oldest is the Rockwell Tripmaster product, now sold and maintained by Meritor Automotive.  As electronic engines began to take hold after 1985, engine manufacturers looked to take advantage of the computer driving the engine.  This developed into recording features inside of the engine computer and connection to displays for the driver.  In time, the driver displays of some of these manufacturers became recording devices.  At the same time that electronic engines were being introduced, mobile radio, satellite and cellular telephone based equipment was being introduced into commercial vehicles.  This equipment was originally intended solely for helping with the routing and tracking of the vehicle to help with logistics management.  However, as the engines became electronic, providing additional information, and as the users of trip recorders asked for more features, these communications systems became full featured trip recorders with many monitoring capabilities.  More recently, antilock brake controls have become required on commercial vehicles of almost all sizes.  These devices at least record faults in the brake system.  However, as time progresses and suppliers look to differentiate their products, it is expected that additional recording features may become part of these computers.  Vehicle OEM's have looked to the use of the standardized data link on commercial vehicles, combined with the necessity of including engine and brake computers.  As a result, most vehicle OEM's offer dash equipment and instrument clusters that read information off this data bus.  In some cases, this is recorded and in others it is just displayed to the driver.  At least one vehicle OEM has taken that a step further and provides a data logging unit that records information much like the flight recorders of aircraft.  However, rather than recording all information, it concentrates on recording information relevant to computer failures to help with diagnosing the failure.  It is possible for this recorder to record information when an air bag deploys or the antilock brake unit operates.  Finally, RADAR based collision warning systems were introduced on commercial vehicles over five years ago. One option on this product is a Vehicle Information Management System (VIMS) and another is Accident Reconstruction (AR).  These features come very close to the features of the flight recorders on commercial aircraft.

## TYPES OF COMMERCIAL VEHICLE RECORDERS AND EXAMPLES OF RECORDED INFORMATION

*The Tachograph*

The tachograph is a device that graphically records the time and engine speed. The name tachograph comes from the graphical recording of the tachometer or engine speed. In all vehicles, there is 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. Argo and Mannesman VDO are two long time manufacturers of this type of equipment. Many units are built so that they install in the dash directly in front of the driver, next to the vehicle speedometer. An alternate installation is in the dash in front of the passenger. The recordings are done on graph paper, most often installed from the front of the unit. An ink pen records the engine speed on circular graph paper that is automatically advanced according to the internal clock of the tachograph. Graph paper is removed on a regular basis and maintained by the fleet for government records.

Manufacturers have long realized the advantage of using solid state recording of this information and have made available more computerized units. However, legislation in most countries has not yet caught up to the available technology. With computerized units, additional information can be recorded and displayed, often for less money than is required to implement the mechanical graphing mechanism of legal tachographs. Typical of this newer type of unit is the Tacholink On Board Computer. The unit has a liquid crystal display (LCD) with 2 lines of 16 characters, 3 light emitting diodes (LED's), and a smart memory card or RF link interface that allows information to be off loaded or downloaded. The memory is from 512 kilobytes to 1 megabyte and is non-volatile for permanent storage. The unit records the items listed in Table 1.

| Tacholink | Data Recorded | | |
|---|---|---|---|
| | Speed History | Excessive RPM | Heavy Braking |
| | Speed Exceptions | Hours Driven | Journeys |
| | Movement Summary | Fast Accelerations | Accident Reports |
| | Load | Driver ID | Jobs |
| | Idle Time | Fuel Consumption | 2 Analog Inputs |
| | 4 Auxiliary Inputs | Exceeding Driving Time Limits | 2 Temperature Inputs |

Table 1: Tacholink Records Many Items.

Another computerized tachograph and on board computer is the Digitax TB912 Black Box & Tachograph.  This unit has the following technical specifications

- Microprocessor with 32KB external EPROM firmware and 128KB data memory
- Memory module of 512KB EEPROM, replaceable from the front
- Chip card reader-writer
- 2 Serial ports, RS232 with communication protocols
- 7 Analog inputs, user assignable
- 3 Analog dedicated inputs for monitoring fuel level, oil pressure, engine temperature
- 5 Digital inputs for brakes and turn indicators, engine on/off, crash sensor
- 3 Digital inputs, user assignable
- 4 Power outputs (12/24V 1.5A) assignable to any event
- Power supply, 10-26 volts
- Input for movement sensor; can be connected to any electronic odometer
- Input for monitoring engine RPM
- Clock calendar operated from internal rechargeable battery
- All inputs filtered for noise immunity.

Optional equipment available includes the following list:

- Operator interface front with keyboard and displays
- Serial port jack connector on the front for direct data download to any portable PC
- Graphic high resolution printer for tachograph reports
- Magnetic card reader
- Satellite GPS receiver for automatic vehicle location
- UHF short range radio modem communication for automatic data download
- Separate keyboard pin-pad for easy operator interface
- Acceleration sensors to store at very high resolution and detail the last 1000 meters of vehicle travel
- Crash sensor
- Cellular phone interface
- Distance and speed definable in Km or Miles

This unit records speed, events and something called “high definition.”  The speed trace keeps track of the vehicle speed at every second for the typical tachograph application.  The event trace can be configured by the user to store more than 60 different kinds of events produced on the vehicle, such as the following:

- Open/close of a driver’s shift, with driver identity
- Start/stop of the vehicle with fuel status
- Change of work type of the driver
- Overspeeding
- High RPM with engine cold
- RPM over a limit
- Monitoring of analog inputs with threshold specification.

The last type of trace, high definition, stores with extreme detail the speed and some events of the last 1000 meters before an accident. This is akin to the black box flight recorder of aircraft.

At this time, it would be good to point out that these recording devices are not constructed in the same fashion as commercial aircraft flight recorders. While these electronic tachographs might be capable of recording information prior to a crash, they are not guaranteed to survive the crash. These recorders often are not even of sufficient design to last the life of the vehicle in normal service. Warranties as short as 3 months may be found and the technical specifications for temperature, vibration and other aspects of vehicle operation are often more suited to equipment on a desk in an office than they are for use in a commercial vehicle.

For additional information on tachographs and tachograph computers, check out the following web sites:

www.zepco.com/tacho/argo.html
www.nlc.net.au/~circuitlink/main.htm
www.vdo.com/vdo/products/iscv.htm
www.digitax.it/

*Early Trip Recorders*
Rockwell (the automotive components division of this company was sold off and is now Meritor Automotive) was among the first companies to introduce an aftermarket computer for recording information about a trip. This product, called Tripmaster, is still available today. With a separate speed input and inputs for various digital and analog values, it is capable of recording a few items on each vehicle. Since it predates the use of the standardized truck data link (SAE J1708/J1587 and SAE J1939), it is more limited in its capabilities than newer units. For more information, check out the web site:

www.meritorauto.com.

*Electronic Engine Controls*
The manufacturers of all diesel engines for commercial vehicles use electronic controls for the pressurization of the fuel, injection of the fuel and timing. First introduced in the mid 1980’s on busses and fire trucks, these controls became standard on all heavy-duty engines between 1991 and 1994. Medium duty engines became standard with these electronic controls in 1998. Both applications were done as a means of meeting more stringent Environmental Protection Agency (EPA) limits for emissions. Once these electronic controls took hold, engine manufacturers looked for additional uses of the computer. Over time, the controls took on additional inputs and outputs, control of power take-off operation, transmissions, and other ancillary controls. The processing power of these computers started with simple 8-bit microcontrollers and has now reached the power of 32-bit processors. Memory internal to the units has grown and the type has changed. It is now common to find nearly a megabyte of memory with most of it of a non-volatile type with some of it readable/writeable for storing information. The physical size of the computer has grown somewhat, with connector pin-counts starting at around 30 and growing to over 140 in some controls today.

The Caterpillar engine control is the most full featured, at least as far as pins on the connector and storage of information. This engine control stores such items as those shown in Table 2:

| Caterpillar Engine Control | Data Recorded | | |
|---|---|---|---|
| | State Line Crossing | Driver ID | Instantaneous Fuel Economy |
| | Average Fuel Economy | Fuel Used | Trip Length |
| | Trip Time | Trip Average Speed | Vehicle Speed |
| | Cruise Set Speed | Instantaneous Fuel Rate | Engine Load Percent |
| | Engine RPM | PTO Set RPM | Fuel Temperature |
| | Boost Pressure | Coolant Temperature | Oil Pressure |
| | Cold Mode on/off | Multi Torque on/off | Intake Manifold Temperature |
| | Ambient Air Temperature | High Coolant Temperature Warning | Very High Coolant Temperature Warning |
| | Low Oil Pressure Warning | Very Low Oil Pressure Warning | Low Coolant Level |
| | Very Low Coolant Level | High Intake Air Temperature Warning | Very High Intake Air Temperature Warning |
| | Low Voltage | Vehicle Overspeed | Engine Overspeed |
| | Lifetime Totals for average fuel economy, distance, average speed, fuel used, time, PTO fuel, PTO time, idle fuel, idle time, percent idle time | Leg Totals for average fuel economy, distance, average speed, fuel used, time, PTO fuel, PTO time, idle fuel, idle time and percent idle time | Trip Totals for average fuel economy, distance, average speed, fuel used, time, PTO fuel, PTO time, idle fuel, idle time and percent idle time |
| | Next Preventative Maintenance | Last Preventative Maintenance | Preventative Maintenance Overdue |
| | Engine Fault Codes | Hard Braking Warning | |

Table 2: Caterpillar Engine Control Has Extensive Information Stored in It.

The Cummins Engine electronic control is not nearly as extensive in its recording capabilities, preferring instead to store it in a separate engine display mounted in the cab as explained in the section on engine and message displays. However, as shown in Table 3, the control does store a few items.

| Cummins Engine Control | Data Recorded | | |
|---|---|---|---|
| | Trip Fuel | Trip Time | Trip Distance |
| | Fuel Used while Driving | Driving Distance | Distance in Cruise Control |
| | Distance in Top Gear | Idle Fuel | Idle Time |
| | PTO Fuel | PTO Time | PTO Distance |
| | Number of Sudden Decelerations | Number of Brake Applications per 1000 miles | Lifetime distance, run time, fuel economy |
| | Diagnostic Faults | | |

Table 3: Cummins Engine Control Records a Few Items.

The Detroit Diesel engine control is somewhere between the other two in its recording of information in the engine control, as shown in Table 4.

| Detroit Diesel Engine Control | Data Recorded | | |
|---|---|---|---|
| | Trip Data | ECM Software Version | Vehicle ID |
| | Trip Miles | Trip Fuel | Trip Fuel Economy |
| | Trip Time | Trip Average Speed | Driving Time |
| | Driving Percent | Driving Distance | Driving Fuel |
| | Driving Fuel Economy | Cruise Time | Cruise Percent |
| | Cruise Distance | Cruise Fuel | Cruise Fuel Economy |
| | Idle Time | Idle Percent | Idle Fuel |
| | Fast Idle Time | Fast Idle Percent | Fast Idle Fuel |
| | Speeding Count | Active Engine Faults | Historical Engine Faults |
| | Engine Hours | Over Rev Count | Optimized Idle Time |
| | Time in Speed Bands | Time in RPM Bands | Number of Brake Applications |
| | Number of Hard Braking Applications | | |

Table 4: Detroit Diesel Engine Control Records Numerous Items.

While this information is several years old, it gives a good idea of the type and extent of information that is, or can be, recorded in the engine computers. Each engine manufacturer is constantly looking for ways to differentiate their product. This often includes providing additional information that is stored in the computer, displayed to the driver, or communicated to the fleet manager.

Some engine manufacturers are capable of using an RS232 serial port to provide some of this information to wireless communications systems so that fleets can access the information more frequently than they physically see the vehicle. Contact the engine manufacturer for information, or check out their web sites at:

www.caterpillar.com
www.cummins.com
www.detroitdiesel.com

*Wireless Communications Equipment*
The payoff for electronics on trucks is in improved fuel economy, reduced maintenance and more time hauling freight and producing revenues. Trucks are unlike most other capital assets in that they are constantly moving and are out of touch with a supervisor for long periods of time. Even aircraft are seen and inspected much more regularly than over the road trucks. Wireless communications from this moving asset back to the fleet office became available in the late 1980's with the ARDIS, RAM Mobile Data and Qualcomm OmniTRACS systems. The Qualcomm system, in particular, with its dual satellite based communications and its ability to triangulate and locate a truck (long before the Global Positioning Satellite system was available) made it a favorite of large fleets. More recently, American Mobile Satellite Corporation purchased some of the above systems and others and merged them into a system capable of cellular phone, mobile packet radio and satellite communications. Highway Master has been popular among some fleets with its analog cellular phone based system. Combined, these devices are installed in approximately 350,000 of the over 2.5 million class 8 commercial vehicles. All of these systems offer options to send wireless information from the truck that is collected from another computer on the truck via an RS232 serial link. Also, all offer the option of connecting to the standard data link on the truck, SAE J1708/J1587, for collecting information. Some of these systems act only to forward information recorded elsewhere, while some take in and record information themselves and sometimes preprocess it, providing only exception reporting to the fleet to reduce the messaging costs for wireless communications. Qualcomm has extended the capability to include the trailer with a product called TrailerTRACS. This system is capable of recording refrigerator temperatures on a trailer and sending the information to the tractor using a proprietary form of power line carrier communications. The information can then be relayed through satellite communications to the fleet office.

For more information, check out these web sites:

www.qualcomm.com/OmniTRACS/
www.skycell.com/commframe.html
www.highwaymaster.com

*Engine and Message Displays*
Soon after electronic engine controls started recording information, fleets and drivers wanted the information displayed to drivers so that immediate action could be taken, to improve fuel economy in particular. The Caterpillar Information Display (ID), Cummins RoadRelay and DetroitDiesel ProDriver are products in this category. These units are typically about the size of a radio and mount in the dash, to the right of the steering wheel in most cases. In general, they have a few buttons and multiple lines of alphanumeric display. The information displayed is very similar to that listed above in what is recorded by the engine controls. In the case of Cummins, while less information is recorded in the engine control, more information is recorded in the engine display. Comparing the combination of the engine control and the engine display as a group from each manufacturer, there is about as much difference as there is between the features in Word and Wordperfect word processor programs. Some of the feature

differences are just nice to have and there are people that will argue vehemently for their favorite, indispensable feature.

Vehicle OEM's saw the potential for the engine display by the mid 1990's. Kenworth, Mack, Volvo, Sterling and Freightliner all offer displays that mount in the dash, on the dash or are part of the instrument cluster, for displaying some of the same information that is provided by the engine displays. Generally, these units display information and lack the recording capability internally. Instead, they rely on the engine control to store the information. Some of these units will record faults from various electronic controls on the truck, keep track of what computers are installed on the truck, and vehicle identification. For more information, check out these web sites:

www.Freightliner.com
www.Macktrucks.com
www.Paccar.com
www.volvo.com
www.Sterling.com
www.xata.com
www.caterpillar.com
www.cummins.com
www.detroitdiesel.com

*Antilock Brake Controls*
Antilock brake controls became legally required between 1996 and 1999. Today they are required on all commercial vehicles above 10,000 pounds, whether they are hydraulically braked or pneumatically (air) braked. By law, these units must record faults within the antilock brake system, such as a malfunctioning solenoid valve or a wheel speed sensor with problems. No other recording requirements exist at this time. However, as discussed in the section on the future of recording units on trucks, these units are likely to grow in their capabilities, including the ability to record information during a hard braking event. There are four or more manufacturers of antilock brakes in North America for commercial vehicles. Check out their web sites for additional information.

www.meritorauto.com
www.alliedsignal.com
www.kelseyhayes.com
www.eaton.com
www.haldex.com or www.midland.com

*Instrument Clusters*
With the advent of the standard data links in trucks, SAE J1708/J1587 and SAE J1939, sensor information is readily available, eliminating the need for separate sensors for different functions. For instance, the engine control needs to sense the output shaft speed of the transmission, as does the transmission electronic control, as does the speedometer in the dash. Rather than having three speed sensors, it is possible to have a single speed sensor that is connected to the transmission control. The transmission control broadcasts the information on one of the data links to the engine control. The engine control is programmed with axle ratios and tire sizes to convert the output shaft speed to vehicle speed. The engine control, in turn, broadcasts the vehicle speed on the SAE J1708/J1587 data link. The instrument cluster reads the information off this data link and drives an air core or stepper motor speedometer, or a digital display of speed. Beginning in about 1994, vehicle OEM's have been adding electronics to the instrument clusters in this way to reduce the number of wires in the dash and the number of sensors and connectors on the vehicle. Numerous units are available from suppliers such as

Pollak (Stoneridge Transportation Electronics Division), VDO North America, Ametek-Dixson, ATI, Stewart-Warner and DATCON.

When these units have microprocessors for accepting information on the data link and driving gauges and displays, or connecting to wireless communications equipment, they can record information. Typically, they record fault information from the different computers in the vehicle. They may also record what computers are supposed to be on the vehicle and simple service information such as time or miles till the next scheduled maintenance. All of these units record odometer information, meeting the legal requirements associated with this information. Additionally, they may record trip information such as trip miles and trip hours.

For more information, try these web sites:

www.Freightliner.com
www.Macktrucks.com
www.Paccar.com
www.volvo.com
www.Sterling.com

*Data Logging Units*
Freightliner Corporation manufactures and sells with some of its trucks a computer known as the Data Logging Unit. This unit provides a memory that records information continuously. When an event occurs, the unit continues recording and stores information from one minute before the event to one minute after the event. Its primary purpose is for diagnostics of difficult to determine problems such as low power complaints and shifting problems. An event can be defined as a sensor exceeding some set limit, an electronic control declaring that some sensor or actuator has failed, or the driver pressing a button in the dash. The information recorded is all available on the standard data link, J1708/J1587. Service technicians have analyzed various problems with trucks and determined what information is needed for various complaints. Thus, an overtemperature problem with the engine records one set of data while a transmission shifting problem records something else. This is done to maximize the use of the memory and reduce the amount of meaningless data that is recorded. However, if the driver presses the button in the dash, all available information is recorded. For more information, try:

www.Freightliner.com

*RADAR Collision Warning*
The first commercially available collision warning system was probably a limited production, laser based unit on Nissan Diesel commercial vehicles in Japan only in 1989. In 1992, VORAD introduced a RADAR based system on Greyhound buses called the T-200. In 1993, Mitsubishi introduced a laser system for Japanese domiciled trucks and buses. In 1994, a joint venture between Eaton and VORAD, Eaton-VORAD Technologies, introduced an improved version called the EVT-200 for commercial truck applications. Initially installed in the aftermarket, by the end of 1995 it was installed as a factory built option on Freightliner Century Class vehicles. Navistar, Volvo and Mack now offer the system in various installed configurations. In late 1998, a further enhanced device, the EVT-300, was introduced with an optional adaptive cruise control feature to be available in 1999.

The main purpose of this product is to detect vehicles in front of the equipped vehicle, and provide a visual and audible warning to the driver when the following distance is less than some limits. Following distance is a combination of vehicle speed, differential speed to the vehicle in front, and distance to the vehicle in front, as measured by the Doppler RADAR. The unit provides a light emitting diode (LED) to indicate that it has detected a vehicle in front as far away as 110 meters (350 feet.) At 2-3 seconds following distance, a green colored LED is illuminated. At 1-2 seconds following distance, an amber LED is illuminated and a short beep is heard. At less than 1 second following distance, a red LED is illuminated and a series of sharp, short beeps is heard by the driver.

A major option for this product is a Vehicle Information Management System (VIMS). This feature adds from 32Kbytes to 128Kbytes of battery backed memory to the computer for storing information. Sample information recorded is shown in Table 5.

| Eaton-VORAD Technologies EVT-300 VIMS | Data Recorded | | |
|---|---|---|---|
| | Segment Start | Segment End Time | Segment Date |
| | Hours of Operation | Maximum Speed | Time and Date of Maximum speed |
| | Time speed is between different limits | Engine Idle Time | Segment Miles |
| | Segment Average Speed | Average Following Distance | Average Following Time |
| | # of 3 Second Alerts | # of 1-2 Second Alerts | # of 1 Second Alerts |

Table 5: Eaton-VORAD Technologies EVT-300 VIMS Records Unique Items.

When connected to a personal computer for off-loading the information, various reports can be generated. These include:

- Trip Segment Report
- Performance Summary Report
- RPM/Speed Summary Report
- Exception Report
- Braking Performance Summary Report
- Vehicle/Driver Productivity Summary Report
- Driver Detail Report

Another important option for this product is the Accident Reconstruction module. This provides continuous loop recording of data as in a commercial aircraft flight recorder. The unit can record 2 incidents/accidents. Each incident records 2-20 minutes of information at rates of 16 times per second. Information recorded includes time, vehicle ID, vehicle speed, steering angle, turn signal status, brake status, braking events, range to vehicle, closing speed, side sensor status, alarms given, alarm settings, etc. The information for one incident/accident can be permanently recorded by pressing a button after the incident. Another can be recorded automatically by removing the power from the computer. Interpretation of the data can only be done by the manufacturer. The unit must be returned to Eaton-VORAD Technologies. The user can then be provided with information, including graphs of the recorded data. Expert witness testimony is available as well.

One final option for this product is QVIMS. "Q" most likely stands for Qualcomm. This option allows the Vehicle Information Management System data to be sent to the fleet using the Qualcomm satellite communications system. Many on-board computers are creating interfaces to the major suppliers of communications equipment (see section later in this paper) to allow fleets to get access to information more often than the 4-6 weeks between physically seeing the driver at a main terminal.

More information is available at:

www.eaton.com/VORAD/

FUTURE RECORDING CAPABILITIES

With the computers already in place on the truck and the features already available, it is easy to see that additional recording capabilities will be offered in the future. The cost of the electronic control on the engine, and the memory needed for recording, is very small compared to the cost of the engine. The same is not true of the antilock brake system computer or the instrument cluster. However, even these are likely to increase their recording capabilities in the future, at least in optional upgrades. This section suggests some of the changes that can be expected.

*Additional Diagnostics Information*

Diagnostics information today is generally limited to a minimal description of the component and the type of failure. As time progresses, more trending of information will occur. For instance, the Mercedes-Benz diesel engines in cars have a Flexible Service System that monitors the usage of the engine and determines service intervals based on experience and extensive laboratory testing so that the time between service stops is maximized for a particular style of driving and engine usage. The engine in a truck is a good candidate for some of this type of recording, as are the brakes. Brakes are serviced or checked today based mostly on miles. Fleets want the brakes to last more than 350,000 miles without need for relining them. Some fleets today cannot seem to get 100,000 miles out of a set of brake shoes while others are able to go 450,000 miles. Smart recording equipment and trend information will make it possible for more fleets to safely extend the time between manual checks of the brakes.

*Prognostics Information*

Ideally, fleets want trucks to run all the time, want to service vehicles only when they absolutely need it, and want to replace something just before it breaks, rather than having a truck down on the road side or at an ill equipped location. This takes extending the trending and recording described above to its ultimate extent. There are already programs for factory equipment that are capable of detecting when a drill in a computer numerical control machine (CNC machine) is about to break. By monitoring the speed, the forces and the sound of the drill, people have found that they can reliably predict when the drill is going to break. They then stop the machine before that occurs and change the drill. The cost of the drill is small. But, if the drill breaks in an expensive titanium aircraft part, the cost of the broken drill bit can be enormous and the time wasted extensive. Statistical process control charts, X bar and R bar, are another form of prognostics used in factories. By carefully understanding a process in the factory, controlling it and measuring it repeatedly, it is possible to see trends early and keep the process in control. Similar techniques will be applied in the future as engineers better understand the engine, clutch, transmission, axle and brakes. Already there are some companies offering equipment to help predict loss of a wheel end in Canada, where there are stiff fines for loss of a wheel. The engine fueling system is probably the best understood item on a truck today. Yet, it would seem that there is still much more room for understanding of basic mechanisms to prevent premature failure of injectors and loss of gaskets.

*Safety Information*
Now that antilock brakes are required on all commercial vehicles, it is only natural to expect that these units will begin recording information about wheel speeds. Before too much time has passed, temperatures at wheel ends will be monitored along with calculating the braking torque applied. As more companies opt for adaptive cruise control and collision warning systems, the type of information recorded today by the Eaton-VORAD Technologies EVT-300 will become more widespread.

*Operational Cost Information*
Fleets are driven to use electronics to improve their operations, ultimately realizing a cost advantage for a specific level of service compared to their competitors. Every aspect of cost will be tracked in the future, such as:

- Time spent on duty but not driving
- Time spent planning a trip
- Time spent driving in various modes
- Time spent waiting for shippers
- Engine usage
- Brake usage
- Transmission usage
- Clutch usage
- Fuel used
- Oil used
- Other Lubricants used
- Tire temperatures, pressures and tread usage

*Driver Information*
Driver behavior has a huge impact on the safety of trucks and on the operating costs of the fleet. Since drivers are employees or contractors working on their own for extended periods of time, there will always be a need to track the driver. Today that includes fuel usage, braking events and following distances. We can expect additional information in the future such as:

- Accelerator pedal usage and movement
- Brake usage, including pressure applied, deceleration rates of the vehicle, use of traction control
- Number and length of ABS events
- Steering wheel usage
- Time drivers hands are on the wheel and time manipulating switches on the dash, such as the radio and Heating, Ventilating and Air Conditioning (HVAC) system
- Number of clutch applications, clutch slippage
- Time in each gear, time to shift gears, speed when shifting gears
- Time sleeping and resting
- Time spent doing paperwork

*Government Information*
While fleets and the government have not yet resolved issues of privacy of information and how information can be used by the government, fleets will be interested in reducing paperwork associated with providing information to the government.  Already, fuel tax information is electronically determined and often forwarded to the fleet for automatic calculation of tax, or to a third party for this.  One fleet, Werner, is working with the government to test electronic driver log information using wireless communications and automatic vehicle locating equipment.  Safety inspections and weight information seem to be the areas of most concern to fleets.  Once these concerns are overcome, it is likely that fleets using electronic recording of information will be rewarded with more time hauling revenue producing freight and less time at road side inspections, weigh stations and toll booths.

*On-Board versus Off-Board Recording*
Memory costs for equipment that can operate long periods on a commercial vehicle will always be significantly higher than the cost for memory in a desk-top computer in an office environment or in a computer room.  Fleets and government agencies want timely information, but the costs of wireless communications, while decreasing, are driven by the amount of information needed to be transmitted.  Therefore, there will always be a trade-off between on-board recording of information and off-board recording of information.  Also, the computers on a truck are unlikely to ever be as rugged as the flight recorders on commercial aircraft that can withstand a crash.  Thus, it is important to off-load information regularly.  Two options becoming available in the next several years are lower costs for higher speed wireless connections to the Internet, and Internet connections at fuel stops around the country.  An over the road truck has probably 300 gallons of fuel at most.  At 6.5 miles per gallon of fuel, the truck can travel 2000 miles before refueling.  That distance will be covered in about 35 hours of driving, which a single driver will cover in 3-5 days even if he has to take a day off.  Thus, fuel stops represent an excellent place to off-load information from a truck, minimize the memory on the truck, and minimize wireless messaging costs.  Some products are already available that provided serial off-loading of information through connections right at the fuel nozzle, making the process as simple as adding fuel and subtracting data.

## CONCLUSIONS

Commercial vehicles already use various recorders extensively.  Every new vehicle contains at least an engine controller and an antilock brake controller that records fault information and some service and operational information.  In excess of 10% of the class 8 vehicles in operation use additional recording equipment such as trip recorders, engine displays and communications equipment.  0.1% of existing class 8 vehicles and 1.5% of new class 8 vehicles employ more extensive recording similar to the flight recorders of commercial aircraft.  These recording devices have had a positive impact on the operations of fleets employing them.  These fleets have seen improvements in safety, productivity, and operating costs.  The increasing use of electronics on vehicles for control and entertainment will provide numerous possibilities for increased recording of information in the future.

## ACKNOWLEDGEMENTS
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## REFERENCES
1. Various supplier literature and applications manuals
2. Web sites referenced throughout the paper

## BIOGRAPHIES
Paul Menig is presently responsible for all electrical and electronics activities at Freightliner. Prior to joining Freightliner he worked at several locations of Eaton Corporation and at two locations of General Electric. Paul's career has always involved developing teams of people to implement distributed microprocessor controls with communications. He has worked in smart guided bombs, life-saving medical equipment, factory automation and truck electronics.

Cary Coverdill is presently responsible for applications engineering, documentation, and development of tools and processes to assure that electronically intensive commercial vehicle products are integrated such that they can be built, supported and operated effectively. Cary developed the Freightliner Data Logging Unit and has two patents related to recording information in commercial vehicles. In addition, Cary has extensive experience in dealing with commercial vehicle communications systems, recorders and on-board computers. Prior to joining Freightliner, Cary developed electronic engine controls for the passenger car market at American Motors and Chrysler.