Clear Roads Development of Interface Specifications for Mobile Data Platforms on DOT Vehicles in Cooperation with Clear Roads

Set of Interface Specifications

April 8, 2010

Prepared for:

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Thursday, April 08, 2010

Wisconsin Department of Transportation
Attn: Kim Linsenmayer
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4802 Sheboygan Avenue, Room 104
P.O. Box 7915
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Dear Kim Linsenmayer,

Please find attached the draft fourth deliverable SPECIFICATION for the project entitled "Clear Roads & Wisconsin DOT's Development of Interface Specifications for Mobile Data Platforms on DOT Vehicles".

Please review as needed. Comments, suggestions, and recommendations received from the Clear Roads staff will be incorporated in the final version.

Please contact me if you require additional information. Thank you for your consideration.

Sincerely,

Gregory E. Thompson

NOTICE:
This research was funded by the Wisconsin Department of Transportation (WisDOT) and the United States Department of Transportation (USDOT) under pooled fund #TPF-5(092) and WisDOT Project #0092-06-22. The information reported is the result of research done under the auspices of the Department and the Clear Roads pooled fund research program. The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the views of the Wisconsin Department of Transportation or the Federal Highway Administration at the time of publication.

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Thank you.

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Development of Interface Specifications for Mobile Data Platforms on DOT Vehicles

I. EXECUTIVE SUMMARY

AVL/GPS/Sensor Data Collection System are typically deployed within transportation maintenance fleets but any public works fleet is a candidate for these types of systems. The work completed on specifications from this project will benefit highway maintenance engineers significantly. Recent events have shaped the world's approach to transportation safety and the marshalling of resources to respond to several potentially damaging scenarios. Paramount to successfully managing these situations is the ability to react in real-time over a wide geographic area using a variety of communications means and a host of emergency and environmental services.

All too often, highway maintenance engineers invest resources into automatic vehicle location and global positioning systems along with several types of sensors, only to find that the systems are proprietary, they are stuck with one type of system, can't leverage new technology, etc. It's not just the AVL/GPS system that may be stagnant, once invested, because of the constant uniqueness of various sensors from salt spreaders to temperature sensors, to plows, hydraulic systems, tilt meters, engine buses, etc. - they are all different. The highway maintenance engineer is faced with one system, no way to compete amongst vendors, for all of these pieces of equipment. Developing a set of standards becomes essential for the success of these systems and the place to start is with the vehicle hardware.

This situation is complex encompassing many facets of technology implementation; however, the need is clear – that is, standardization of the equipment, processes, and interfaces is required in order to leverage the competitive nature of the marketplace, allow users to build on previous inventories without unnecessary trade-ins or scrapping previous systems including valuable data and software interfaces for legacy systems and databases.

Clear Roads has begun this process by contracting for a list of specifications that are generic for the in-vehicle equipment and allow several vendors to compete price-wise and performance-wise for the transportation community. The initial literature search and industry survey (conducted in 2009 as part of this project) has demonstrated that it is not feasible to create a set of specifications that will encompass all vehicles, situations, and previous implementations; nor foresee the future as well as retro-fit the existing systems that encompass on-board equipment as well as embrace sophisticated sensors (salters, engine bus) and original equipment manufacturers (OEM) that build road maintenance vehicles.

This approach builds on previous standardization efforts in process at the Society of Automotive Engineers (SAE) and National Transportation Communications for ITS Protocol (NTCIP). In essence, the specification that follows views the "vehicle as a hub" encompassing several degrees of sophistication. There are several advantages that are leveraged with this approach. This methodology embraces the existing trends in vehicle communication from vehicle to vehicle and vehicle to roadside.

It also leverages the attendant technologies that continue to become faster, more ubiquitous, increased range, and the ability to employ "there's an app for that". The internet, cellular networks, and wireless networks continue to improve coverage areas, speed, throughput, and versatility. This specification leverages those advantages.

Highlights of the specification approach are as follows:

- Specify a modem/GPS unit that uses cellular (both GSM & CDMA), has embedded GPS receiver compatible with NDGPS, and includes a wireless (wi-fi) transceiver. Thus accommodates real-time information as well as perishable information and reduces monthly costs for lengthy transmissions.

- The unit is remotely programmable to allow customization in the type, quantity, and frequency of data and information to be collected.

- Require all sensors to connect to the engine CAN using SAE J1939. This standardizes the data fields and builds upon a system that continues to improve in cost and performance.

- Ensure that vendors provide generic drivers and host end "listener" modules that are included in the price allowing the data to be parsed and sorted to a set of standards the govern a generic transportation database.

- Employ on-board intelligent agent into the firmware of the modem/GPS unit to remotely configure what information is recorded, transmitted, manipulated, and/or used for triggering operational or maintenance requirements.

There has also been significant movement in standardizing transportation means using NTCIP and SAE J1939 documents. These references are also employed in this document and the specification is meant to join with these documents to better standardize these technologies and their implementation in the transportation community.

II. INTRODUCTION

A. Background. The Clear Roads pooled fund research program (www.clearroads.org), in coordination with the Wisconsin Department of Transportation, seeks to develop communication and data format specifications to support mobile data platforms used by State DOT's. The mobile data platforms could be equipment such as, snow plows, end-loaders, supervisor trucks, paint trucks, herbicide sprayers, trailers, oil distributors and other similar equipment used in roadway maintenance operations**.** Agencies that are considering adding GPS/AVL to support the mobile data platform need a set of specifications that will allow them to purchase a variety of different sensors that all use a common communication protocol and data format.

III. OVERVIEW

A. Background. The Clear Roads pooled fund research program (www.clearroads.org), in coordination with the Wisconsin Department of Transportation, seeks to develop communication and data format specifications to support mobile data platforms used by

State DOT's. The mobile data platforms could be equipment such as, snow plows, end-loaders, supervisor trucks, paint trucks, herbicide sprayers, trailers, oil distributors and other similar equipment used in roadway maintenance operations**.** Agencies that are considering adding GPS/AVL to support the mobile data platform need a set of specifications that will allow them to purchase a variety of different sensors that all use a common communication protocol and data format.

B. Approach. The specifications that follow are based upon the concept of operation. A brief summary of methodology is provided below.

1. Users desire to collect engine data as well as vehicle activity. This data provides vehicle health information and leverages the existing communications and location information provided by the AVL/GPS modem unit. The SAE J1939 interface is now standard for transportation vehicles manufactured after 2007. Thus this specification applies to vehicle fleets that provide access to the CANbus using SAE J1939 specifications.

2. The specification provides for the communications modem to be standardized and focused on two methods of wireless communications; cellular and wireless network (e.g. wi-fi, 802.11B/G). This provides the method for data/information to be transmitted from the vehicle to the server; and supplies the means for the system control to communicate to the vehicle. The GPS receiver is included with the communications modem and will have the ability to differentially correct linking with a Beacon Receiver using the Nationwide Differential Global Positioning System (NDGPS).

3. All sensors will be connected to the CANbus; this provides a standard, systematic approach for a variety of third party vehicle subsystems, such as salt spreaders, pavement temperature sensors, hydraulic systems, and discrete sensors that signal plow up/down, broom up/down, doors open/closed, etc.

4. The in-vehicle modem will connect to the CANbus, this will standardize all data gathering accomplished by the vehicle. It provides one common source for vehicle data. It assures in-vehicle equipment can be switched, purchased in phases, and/or upgraded without replacing the entire system or trading in the previous equipment. The previous deliverables for this project have shown that vehicle location by itself is not that useful. Location information is only valuable when tied to vehicle performance or vehicle health information.

5. As new sensors are introduced or as users desire to collect more information, the SAE J1939 specification has place-holders for additional data fields. This feature allows users to switch salt spreaders, pavement temperature sensors, discrete sensors, and others without having to change the in-vehicle modem/GPS units or the host end software packages. Further, because the data fields are standardized and populate a standard transportation database, users will be able to switch, upgrade, and/or employ dual graphical user interfaces – provided they are web based services.

6. The standards in this set of specifications apply only to those host end server applications that are web based. They must browser supported and password secure; that employ graphical user interfaces which access and queries a

transportation database. It allows the user to leverage vendor specific, yet competitive products that can still customize the "look and feel" to particular user requirements.

7. The modem/GPS unit that will be installed in-vehicle must be simple, self contained, yet possess a certain amount of intelligence. It must have the ability to be remotely controlled via wireless communications. It must be able to be configured in order to know what data from the CANbus to collect, when to send data, and to what address. The modem/GPS must all be able to respond – when queried with specific information on how it communications, speed, packet, language, etc. This also necessitates a modem specific listener that must be provided to the host end server in order to parse the data fields correctly. This is similar to servers that have the printer drivers pre-loaded so that any printer can be installed.

8. The communications means would be confined to just two types; cellular and wi-fi. This provides a real-time communication method and maintains a store and forward communication method for transmitting/downloading time-sensitive, perishable information as well as retaining valuable summary information for end of day, end of week larger transmissions. One or both methods may be used.

The above methodology seeks to support several trends in the transportation, communications, web services, and information collection industries and technologies. Viewing the vehicle as a hub is going to expand over the next few years and this specification seeks to be consistent with those types of developments. The internet, cellular networks, wireless communications, and database backed web services will get faster, securer, ubiquitous, and sophisticated. The vehicle hub centric outlook is the key to mesh networks, vehicle to roadside, traffic control, and a host of other enhancements to the motoring public and transportation industries.

IV. CONCEPT OF OPERATION

A. Architecture. This specification addresses the on-board data collection and communications equipment for road maintenance vehicles. It describes the interface between a host end server application or graphical user interface and the modem/GPS unit on-board the vehicle. The relationship between these and other logical components is depicted in Figures 1, 2, and 3. This section describes the physical architecture and linkages between the various subsystems comprising and AVL/GPS data collection system. However, one should realize that the actual physical arrangement of these components may vary from implementation to implementation.

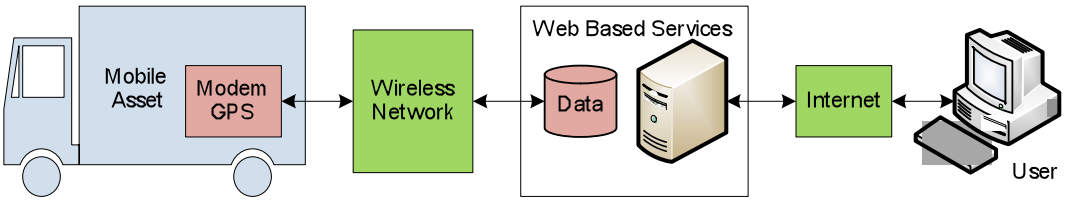


Figure 2: Block Diagram Illustrating Vehicle to User

Figure 1 shows the basic building blocks of an AVL/GPS data collection system. The modem/GPS unit on board the vehicle provides the communications connection for exporting the information off the road maintenance vehicle. The wireless network can take many forms but functions as the ubiquitous network of radio transmission and the internet and provides a seamless interface from the vehicle to the host end web based services. These can be located anywhere there is network access and provide web services that have become standard for people seeking information. That also becomes the hub of database integration to maximize the potential of AVL/GPS data collection systems by leveraging existing legacy systems such as fuel management, timecard, or repair work order systems.

Figure 2 provides the next level of detail in showing how each subset links from the vehicle to the user. The sensors are connected to the CANbus where the data becomes available and is continuously active. The modem/GPS unit is connected to the CANbus and is programmed to collect the user defined data and transmit at user determined intervals. The wireless network functions as the link from the vehicle to the host end server. The listeners and database need to be standardized as well.

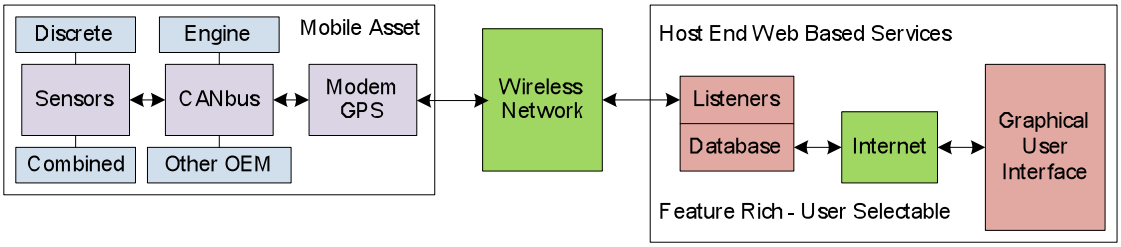


Figure 2: Block Diagram of On-board Equipment & Host End Services

Figure 3 illustrates the functional level of detail for the on-board equipment. The boxes colored in green are example sensors that could be used for road maintenance vehicles. As depicted in Figures 1 and 2, the sensors are connected to the CANbus and the data is sent to the wireless network by the modem/GPS unit.

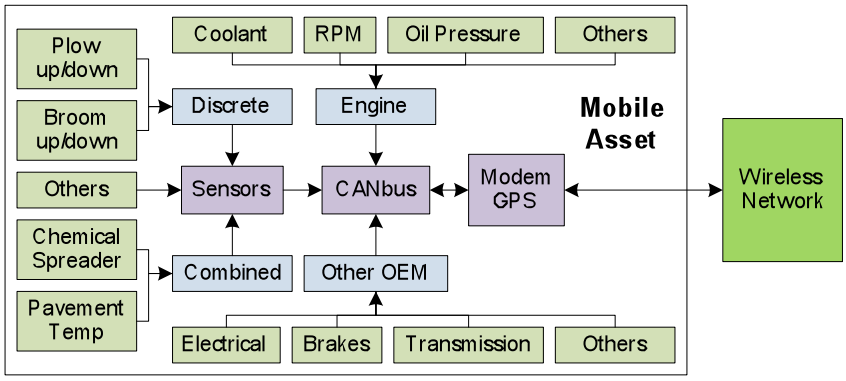


Figure 3: Functional Level for On-Board Capabilities

B. On-Board Intelligence. The modem/GPS unit is programmed to "listen" for desired data on the CANbus, extract it, and tag it with date, time, latitude, longitude, speed, heading, etc. and other sensor information. Then package it for transmission or on-board data storage. The modem/GPS unit must have some type of intelligent agent that

can be remotely programmed to configure the modem/GPS unit for this customizable feature.

One of the facts learned in the literature search and survey portions of this study is that no two customers or users want the exact same data. Thus, the on-board modem/GPS unit needs to be configurable or customizable. The intelligent agent does not need to be standardized because this allows modem/GPS manufacturers to be performance and feature competitive. Users of a small amount of data collection may elect to turn this feature off. See figure 4 below.

The modem/GPS unit needs to employ another intelligent agent as part of its firmware that provides system recognition and can provide key interface data when queried by the host end. Thus, when a new modem/GPS unit is activated that unit is prepared to handshake with the host end to tell it model number & serial number, other identification data, which listener to use, data speed, and other parameters in order to successfully communicate its information.

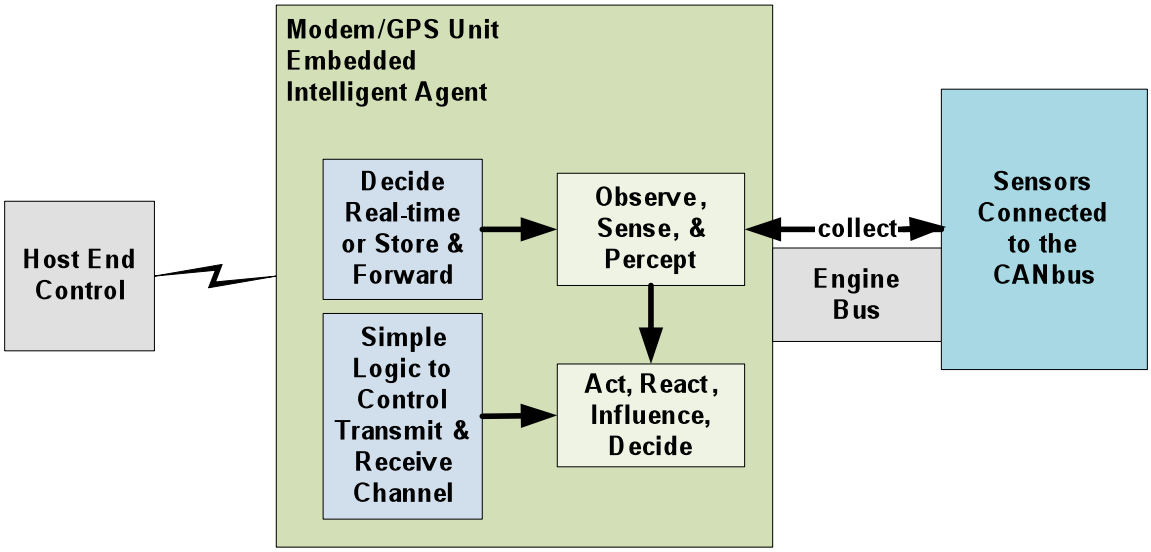


Figure 4: Intelligent Agent Example for Modem/GPS

V. SPECIFICATIONS

A. General. The modem/GPS unit shall be configured in a single enclosure that monitors engine performance, sensors, information devices, and diagnostic information via connection to engine and machine control units through the controller area network (CANbus). The unit will provide GPS location tracking, time and date, and cellular reporting to internet-based back-end applications and/or wireless networks (Wi-Fi). The unit will be designed for comprehensive fleet management of the on-board data knowledge gathering system and shall enable the collection of a wide variety of real-time data – from mileage, engine hours, location, driver performance and vehicle metrics to hours of service and threshold monitoring of various engine parameters. In addition it will collect a wide assortment of sensor data and third party information devices – from salt spreaders, pavement temperature thermometers, and mirror surface cleaners to discrete sensors that trigger plow up/down, hopper open/closed, and lights on/off.

B. Data Monitoring. Data gathering from the vehicle will be collected from the CANbus. All devices known as sensors will be connected to the CANbus so that data fields are available on the CANbus as needed. The modem/GPS unit will monitor equipment performance and diagnostics through a connection to the SAE J1939 port for engines that support J1939 and OBD-CAN communications. Engine parameters and sensor device information will be monitored for high-high, high, low and low-low thresholds and statistics will be logged and sent in real-time (as needed) and/or an "end of day report", "engine on/off report" or based on event definitions, if desired. The modem/GPS unit shall be capable of monitoring information that is already present on the SAE J1939 CANbus and capable of requesting information from any of the control units (ECU or MCU) connected to the CANbus. The unit must support the highest speed of the SAE J1939 interface to the CANbus as specified in the Society of Automotive Engineers (SAE) documentation as of January 2008.

The modem/GPS unit is an integrated data monitoring and information gathering in-vehicle device. It provides telemetry (measurement and evaluation at a distance) and alarm notification system designed to work seamlessly with electronic engine controllers (ECUs) and other devices that support the SAE J1939 protocol over CANbus.

The modem/GPS unit monitors many conditions and transmits them via GSM or CDMA cellular or wireless network (Wi-Fi) to the web services application.

For a J1939 interface, the modem/GPS unit monitors up to 32 PGNs at a time, the maximum number of PGNs that can be monitored is several hundred. CANbus speeds up to 1.25Mbits/second are supported. This information is sent to the internet-based web services systems based on time and/or events.

When housed in the Deutsch weatherproof enclosure the modem/GPS unit connects to the ECU through a single Deutsch wiring harness. The cellular, Wi-Fi, and GPS antenna connections; plus the power, ignition, and ground power terminals are included in the modem/GPS unit.

Antenna connections are 1 SMA connection for the GPS and 1 SMA-RP (reverse polarity) connection for the cellular (GSM or CDMA) and internal antenna for the Wi-Fi.

Data gathering that includes transmitting weather data and vehicle system status shall use standards NTCIP 1204 and SAE J2735 for units, resolution, offsets, etc.

All data gathering will be accomplished via the CANbus using the SAE J1939 interface. (Light truck models (i.e. pickups) will use the ODB II interface for the CANbus.) The ODB II interfaces are not standard amongst all truck models; there are at least three versions. Thus the ODB II interface is not described in detail for this specification. The following two subparagraphs describe example SAE J1939 group parameter numbers (PGN) and suspect parameter numbers (SPN). The values are only provided as examples but serve to illustrate that the CANbus has the placeholder and data capability to provide a suitable data bus for supporting "vehicle as a hub" operations. The PGN and SPN assignments would require application to the appropriate society of automotive engineers (SAE) guidance committee. Instructions for applying requesting these assignments are provided in the following reference.

SAE J1939 MAR2009
"Surface Vehicle Recommended Practice"
Issued: 2000-04
Revised: 2009-03
Superseded: 2007-10
Entitled:
"Recommended Practice for Serial Control and Communications Vehicle Network"

Requests for new assignments from the society of automotive engineers are explained in paragraph 4.4 on page 21 of 481 of this document (reference).

The following assignments are provided as examples only to illustrate that suspect parameter numbers (SPN) and parameter group numbers (PGN) are available and encouraged for use by the J1939 interface on the CANbus. The ones that are labeled auxiliary and open for use are:

Page 132 of 481 SPN-701 to SPN-719 and PGN = 42752
Page 387 of 481 SPN-3840 to SPN-3871 and PGN = 42752
Page 388 of 481 SPN-3872 to SPN-3903 and PGN = 42496
Page 388 of 481 SPN-3904 to SPN-3935 and PGN = 42240

a. Engine parameters monitored and computed.
The following are a list of the data fields that can be collected from the CANbus from original equipment manufacturer (OEM) sensors. It is important to note that although all of this information is available it is unlikely that any one customer will want all of it. It is just as unlikely that any two customers will want the same data. Thus, it is important that space is available, that placeholders are in place, and that the equipment can be programmed to collect the exact information required and has a common, generic field to store it in. These fields make up records which are stored in a commonly configured "Transportation Database". See Table 1 below.

PGN	PGN Description	SPN	SPN Description
57344	Cab Message 1	1856	Seat Belt Switch
57344	Cab Message 1	1655	Vehicle Limiting Speed Governor Decrement Switch
57344	Cab Message 1	1654	Vehicle Limiting Speed Governor Increment Switch
57344	Cab Message 1	1653	Vehicle Limiting Speed Governor Enable Switch
57344	Cab Message 1	3695	Diesel Particulate Filter Regeneration Inhibit Switch
57344	Cab Message 1	3696	Diesel Particulate Filter Regeneration Force Switch
57344	Cab Message 1	1666	Automatic Gear Shifting Enable Switch
57344	Cab Message 1	1656	Engine Automatic Start Enable Switch
57344	Cab Message 1	1683	Auxiliary Heater Mode Request
57344	Cab Message 1	1685	Request Engine Zone Heating
57344	Cab Message 1	1686	Request Cab Zone Heating
57344	Cab Message 1	2596	Selected Maximum Vehicle Speed Limit
57344	Cab Message 1	1691	Cab Interior Temperature Command

PGN	PGN Description	SPN	SPN Description
59392	Acknowledgment Message	2541	Control Byte (ACKM)
59392	Acknowledgment Message	2542	Group Function Value (ACK)
59392	Acknowledgment Message	2543	Parameter Group Number (ACK)
59392	Acknowledgment Message	2544	Group Function Value (NACK)
59392	Acknowledgment Message	2545	Parameter Group Number (NACK)
59392	Acknowledgment Message	2546	Group Function Value (NACK_AD)
59392	Acknowledgment Message	2547	Parameter Group Number (NACK_AD)
59392	Acknowledgment Message	2548	Group Function Value (NACK_Busy)
59392	Acknowledgment Message	2549	Parameter Group Number (NACK_Busy)
59904	Request	2540	Parameter Group Number (RQST)
61184	Proprietary A	2550	Manufacturer Specific Information (PropA_PDU1)
61440	Electronic Retarder Controller 1	900	Retarder Torque Mode
61440	Electronic Retarder Controller 1	571	Retarder Enable – Brake Assist Switch
61440	Electronic Retarder Controller 1	572	Retarder Enable – Shift Assist Switch
61440	Electronic Retarder Controller 1	520	Actual Retarder – Percent Torque
61440	Electronic Retarder Controller 1	1085	Intended Retarder Percent Torque
61440	Electronic Retarder Controller 1	1082	Engine Coolant Load Increase
61440	Electronic Retarder Controller 1	1667	Retarder Requesting Brake Light
61440	Electronic Retarder Controller 1	4233	Retarder Road Speed Limit Switch
61440	Electronic Retarder Controller 1	4234	Retarder Road Speed Exceeded Status
61440	Electronic Retarder Controller 1	1480	Source Address of Controlling Device for Retarder Control
61440	Electronic Retarder Controller 1	1715	Drivers Demand Retarder – Percent Torque
61440	Electronic Retarder Controller 1	1716	Retarder Selection, non-engine
61440	Electronic Retarder Controller 1	1717	Actual Maximum Available Retarder – Percent Torque
61441	Electronic Brake Controller 1	561	ASR Engine Control Active
61441	Electronic Brake Controller 1	562	ASR Brake Control Active
61441	Electronic Brake Controller 1	563	Anti-Lock Braking (ABS) Active
61441	Electronic Brake Controller 1	1121	EBS Brake Switch
61441	Electronic Brake Controller 1	521	Brake Pedal Position
61441	Electronic Brake Controller 1	575	ABS Off-road Switch
61441	Electronic Brake Controller 1	576	ASR Off-road Switch
61441	Electronic Brake Controller 1	577	ASR “Hill Holder” Switch
61441	Electronic Brake Controller 1	1238	Traction Control Override Switch
61441	Electronic Brake Controller 1	972	Accelerator Interlock Switch
61441	Electronic Brake Controller 1	971	Engine Derate Switch
61441	Electronic Brake Controller 1	970	Engine Auxiliary Shutdown Switch
61441	Electronic Brake Controller 1	969	Remote Accelerator Enable Switch
61441	Electronic Brake Controller 1	973	Engine Retarder Selection
61441	Electronic Brake Controller 1	1243	ABS Fully Operational
61441	Electronic Brake Controller 1	1439	EBS Red Warning Signal
61441	Electronic Brake Controller 1	1438	ABS/EBS Amber Warning Signal (Powered Vehicle)
61441	Electronic Brake Controller 1	1793	ATC/ASR Information Signal

PGN	PGN Description	SPN	SPN Description
61441	Electronic Brake Controller 1	1481	Source Address of Controlling Device for Brake Control
61441	Electronic Brake Controller 1	2911	Halt brake switch
61441	Electronic Brake Controller 1	1836	Trailer ABS Status
61441	Electronic Brake Controller 1	1792	Tractor-Mounted Trailer ABS Warning Signal
61442	Electronic Transmission Controller 1	560	Transmission Driveline Engaged
61442	Electronic Transmission Controller 1	573	Transmission Torque Converter Lockup Engaged
61442	Electronic Transmission Controller 1	574	Transmission Shift In Process
61442	Electronic Transmission Controller 1	4816	Transmission Torque Converter Lockup Transition in Process
61442	Electronic Transmission Controller 1	522	Percent Clutch Slip
61442	Electronic Transmission Controller 1	606	Engine Momentary Overspeed Enable
61442	Electronic Transmission Controller 1	607	Progressive Shift Disable
61442	Electronic Transmission Controller 1	1482	Source Address of Controlling Device for Transmission Control
61442	Electronic Transmission Controller 1	191	Transmission Output Shaft Speed
61442	Electronic Transmission Controller 1	161	Transmission Input Shaft Speed
61443	Electronic Engine Controller 2	558	Accelerator Pedal 1 Low Idle Switch
61443	Electronic Engine Controller 2	559	Accelerator Pedal Kickdown Switch
61443	Electronic Engine Controller 2	1437	Road Speed Limit Status
61443	Electronic Engine Controller 2	2970	Accelerator Pedal 2 Low Idle Switch
61443	Electronic Engine Controller 2	91	Accelerator Pedal Position 1
61443	Electronic Engine Controller 2	92	Engine Percent Load At Current Speed
61443	Electronic Engine Controller 2	974	Remote Accelerator Pedal Position
61443	Electronic Engine Controller 2	29	Accelerator Pedal Position 2
61443	Electronic Engine Controller 2	2979	Vehicle Acceleration Rate Limit Status
61443	Electronic Engine Controller 2	3357	Actual Maximum Available Engine – Percent Torque
61444	Electronic Engine Controller 1	899	Engine Torque Mode
61444	Electronic Engine Controller 1	4154	Actual Engine – Percent Torque High Resolution
61444	Electronic Engine Controller 1	512	Driver's Demand Engine – Percent Torque
61444	Electronic Engine Controller 1	513	Actual Engine – Percent Torque
61444	Electronic Engine Controller 1	1483	Source Address of Controlling Device for Engine Control
61444	Electronic Engine Controller 1	1675	Engine Starter Mode
61444	Electronic Engine Controller 1	2432	Engine Demand – Percent Torque
61444	Electronic Engine Controller 1	190	Engine Speed

PGN	PGN Description	SPN	SPN Description
61445	Electronic Transmission Controller 2	524	Transmission Selected Gear
61445	Electronic Transmission Controller 2	523	Transmission Current Gear
61445	Electronic Transmission Controller 2	526	Transmission Actual Gear Ratio
61445	Electronic Transmission Controller 2	162	Transmission Requested Range
61445	Electronic Transmission Controller 2	163	Transmission Current Range
61450	Engine Gas Flow Rate	2659	Engine Exhaust Gas Recirculation (EGR) Mass Flow Rate
61450	Engine Gas Flow Rate	132	Engine Inlet Air Mass Flow Rate
61452	Electronic Transmission Controller #8	3030	Transmission Torque Converter Ratio
64892	Diesel Particulate Filter Control 1	3697	Diesel Particulate Filter Lamp Command
64892	Diesel Particulate Filter Control 1	3699	Diesel Particulate Filter Passive Regeneration Status
64892	Diesel Particulate Filter Control 1	3700	Diesel Particulate Filter Active Regeneration Status
64892	Diesel Particulate Filter Control 1	3701	Diesel Particulate Filter Status
64892	Diesel Particulate Filter Control 1	3702	Diesel Particulate Filter Active Regeneration Inhibited Status
64892	Diesel Particulate Filter Control 1	3703	Diesel Particulate Filter Active Regeneration Inhibited Due to Inhibit Switch
64892	Diesel Particulate Filter Control 1	3704	Diesel Particulate Filter Active Regeneration Inhibited Due to Clutch Disengaged
64892	Diesel Particulate Filter Control 1	3705	Diesel Particulate Filter Active Regeneration Inhibited Due to Service Brake Active
64892	Diesel Particulate Filter Control 1	3706	Diesel Particulate Filter Active Regeneration Inhibited Due to PTO Active
64892	Diesel Particulate Filter Control 1	3707	Diesel Particulate Filter Active Regeneration Inhibited Due to Accelerator Pedal Off Idle
64892	Diesel Particulate Filter Control 1	3708	Diesel Particulate Filter Active Regeneration Inhibited Due to Out of Neutral
64892	Diesel Particulate Filter Control 1	3709	Diesel Particulate Filter Active Regeneration Inhibited Due to Vehicle Speed Above Allowed Speed
64892	Diesel Particulate Filter Control 1	3710	Diesel Particulate Filter Active Regeneration Inhibited Due to Parking Brake Not Set

PGN	PGN Description	SPN	SPN Description
64892	Diesel Particulate Filter Control 1	3711	Diesel Particulate Filter Active Regeneration Inhibited Due to Low Exhaust Gas Temperature
64892	Diesel Particulate Filter Control 1	3712	Diesel Particulate Filter Active Regeneration Inhibited Due to System Fault Active
64892	Diesel Particulate Filter Control 1	3713	Diesel Particulate Filter Active Regeneration Inhibited Due to System Timeout
64892	Diesel Particulate Filter Control 1	3714	Diesel Particulate Filter Active Regeneration Inhibited Due to Temporary System Lockout
64892	Diesel Particulate Filter Control 1	3715	Diesel Particulate Filter Active Regeneration Inhibited Due to Permanent System Lockout
64892	Diesel Particulate Filter Control 1	3716	Diesel Particulate Filter Active Regeneration Inhibited Due to Engine Not Warmed Up
64892	Diesel Particulate Filter Control 1	3717	Diesel Particulate Filter Active Regeneration Inhibited Due to Vehicle Speed Below Allowed Speed
64892	Diesel Particulate Filter Control 1	3718	Diesel Particulate Filter Automatic Active Regeneration Initiation Configuration
64892	Diesel Particulate Filter Control 1	3698	Exhaust System High Temperature Lamp Command
64892	Diesel Particulate Filter Control 1	4175	Diesel Particulate Filter Active Regeneration Forced Status
64946	Aftertreatment 1 Intermediate Gas	3249	Aftertreatment 1 Exhaust Gas Temperature 2
64946	Aftertreatment 1 Intermediate Gas	3250	Aftertreatment 1 Diesel Particulate Filter Intermediate Gas Temperature
64946	Aftertreatment 1 Intermediate Gas	3251	Aftertreatment 1 Diesel Particulate Filter Differential Pressure
64946	Aftertreatment 1 Intermediate Gas	3252	Aftertreatment 1 Exhaust Gas Temperature 2 Preliminary FMI
64946	Aftertreatment 1 Intermediate Gas	3253	Aftertreatment 1 Diesel Particulate Filter Delta Pressure Preliminary FMI
64946	Aftertreatment 1 Intermediate Gas	3254	Aftertreatment 1 Diesel Particulate Filter Intermediate Gas Temperature Preliminary FMI
64972	Operators External Light Controls Message	2873	Work Light Switch
64972	Operators External Light Controls Message	2872	Main Light Switch
64972	Operators External Light Controls Message	2876	Turn Signal Switch
64972	Operators External Light Controls Message	2875	Hazard Light Switch

PGN	PGN Description	SPN	SPN Description
64972	Operators External Light Controls Message	2874	High-Low Beam Switch
64972	Operators External Light Controls Message	2878	Operators Desired Back-light
64972	Operators External Light Controls Message	2877	Operators Desired – Delayed Lamp Off Time
64973	Windshield Wiper & Washer controls	1858	Intermittent Wiper Control
64973	Windshield Wiper & Washer controls	2636	Windshield Wiper Motor ON/OFF
64973	Windshield Wiper & Washer controls	2637	Windshield Wiper Motor Speed
64973	Windshield Wiper & Washer controls	2863	Front Operator Wiper Switch
64973	Windshield Wiper & Washer controls	2864	Front Non-operator Wiper Switch
64973	Windshield Wiper & Washer controls	2865	Rear Wiper Switch
65098	Electronic Transmission Controller 7	4176	Transmission Current Range Display Blank State
65098	Electronic Transmission Controller 7	4178	Transmission Service Indicator
65098	Electronic Transmission Controller 7	1850	Transmission Requested Range Display Blank State
65098	Electronic Transmission Controller 7	1849	Transmission Requested Range Display Flash State
65098	Electronic Transmission Controller 7	3086	Transmission Ready for Brake Release
65098	Electronic Transmission Controller 7	2945	Active Shift Console Indicator
65098	Electronic Transmission Controller 7	2900	Transmission Engine Crank Enable
65098	Electronic Transmission Controller 7	1851	Transmission Shift Inhibit Indicator
65098	Electronic Transmission Controller 7	2539	Transmission Mode 4 Indicator
65098	Electronic Transmission Controller 7	2538	Transmission Mode 3 Indicator
65098	Electronic Transmission Controller 7	2537	Transmission Mode 2 Indicator
65098	Electronic Transmission Controller 7	2536	Transmission Mode 1 Indicator
65098	Electronic Transmission Controller 7	3289	Transmission Requested Gear Feedback
65098	Electronic Transmission Controller 7	4250	Transmission Mode 5 Indicator
65098	Electronic Transmission Controller 7	4251	Transmission Mode 6 Indicator

PGN	PGN Description	SPN	SPN Description
65098	Electronic Transmission Controller 7	4252	Transmission Mode 7 Indicator
65098	Electronic Transmission Controller 7	4253	Transmission Mode 8 Indicator
65098	Electronic Transmission Controller 7	4261	Transmission Reverse Gear Shift Inhibit Status
65198	Air Supply Pressure	46	Pneumatic Supply Pressure
65198	Air Supply Pressure	1086	Parking and/or Trailer Air Pressure
65198	Air Supply Pressure	1087	Service Brake Circuit 1 Air Pressure
65198	Air Supply Pressure	1088	Service Brake Circuit 2 Air Pressure
65198	Air Supply Pressure	1089	Auxiliary Equipment Supply Pressure
65198	Air Supply Pressure	1090	Air Suspension Supply Pressure
65198	Air Supply Pressure	1351	Air Compressor Status
65203	Fuel Information (Liquid)	1028	Total Engine PTO Governor Fuel Used
65203	Fuel Information (Liquid)	1029	Trip Average Fuel Rate
65213	Fan Drive	975	Estimated Percent Fan Speed
65213	Fan Drive	977	Fan Drive State
65213	Fan Drive	4212	Fan Drive Bypass Command Status
65213	Fan Drive	1639	Fan Speed
65213	Fan Drive	4211	Hydraulic Fan Motor Pressure
65214	Electronic Engine Controller 4	166	Engine Rated Power
65214	Electronic Engine Controller 4	189	Engine Rated Speed
65214	Electronic Engine Controller 4	3669	Engine Rotation Direction
65214	Electronic Engine Controller 4	3671	Crank Attempt Count on Present Start Attempt
65215	Wheel Speed Information	905	Relative Speed; Front Axle, Left Wheel
65215	Wheel Speed Information	906	Relative Speed; Front Axle, Right Wheel
65215	Wheel Speed Information	907	Relative Speed; Rear Axle #1, Left Wheel
65215	Wheel Speed Information	908	Relative Speed; Rear Axle #1, Right Wheel
65215	Wheel Speed Information	909	Relative Speed; Rear Axle #2, Left Wheel
65215	Wheel Speed Information	910	Relative Speed; Rear Axle #2, Right Wheel
65215	Wheel Speed Information	904	Front Axle Speed
65216	Service Information	911	Service Component Identification
65216	Service Information	912	Service Component Identification
65216	Service Information	915	Service Delay/Calendar Time Based
65216	Service Information	913	Service Component Identification
65216	Service Information	914	Service Distance
65216	Service Information	916	Service Delay/Operational Time Based
65217	High Resolution Vehicle Distance	917	High Resolution Total Vehicle Distance
65217	High Resolution Vehicle Distance	918	High Resolution Trip Distance
65226	Active Diagnostic Trouble Codes	987	Protect Lamp
65226	Active Diagnostic Trouble Codes	624	Amber Warning Lamp
65226	Active Diagnostic Trouble Codes	623	Red Stop Lamp

PGN	PGN Description	SPN	SPN Description
65226	Active Diagnostic Trouble Codes	1213	Malfunction Indicator Lamp
65226	Active Diagnostic Trouble Codes	3041	Flash Protect Lamp
65226	Active Diagnostic Trouble Codes	3040	Flash Amber Warning Lamp (AWL)
65226	Active Diagnostic Trouble Codes	3039	Flash Red Stop Lamp (RSL)
65226	Active Diagnostic Trouble Codes	3038	Flash Malfunction Indicator Lamp (MIL)
65226	Active Diagnostic Trouble Codes	1215	Failure Mode Identifier
65226	Active Diagnostic Trouble Codes	1216	Occurrence Count
65226	Active Diagnostic Trouble Codes	1706	SPN Conversion Method
65226	Active Diagnostic Trouble Codes	1214	Suspect Parameter Number
65227	Previously Active Diagnostic Trouble Codes	987	Protect Lamp
65227	Previously Active Diagnostic Trouble Codes	624	Amber Warning Lamp
65227	Previously Active Diagnostic Trouble Codes	623	Red Stop Lamp
65227	Previously Active Diagnostic Trouble Codes	1213	Malfunction Indicator Lamp
65227	Previously Active Diagnostic Trouble Codes	3041	Flash Protect Lamp
65227	Previously Active Diagnostic Trouble Codes	3040	Flash Amber Warning Lamp (AWL)
65227	Previously Active Diagnostic Trouble Codes	3039	Flash Red Stop Lamp (RSL)
65227	Previously Active Diagnostic Trouble Codes	3038	Flash Malfunction Indicator Lamp (MIL)
65227	Previously Active Diagnostic Trouble Codes	1215	Failure Mode Identifier
65227	Previously Active Diagnostic Trouble Codes	1216	Occurrence Count
65227	Previously Active Diagnostic Trouble Codes	1706	SPN Conversion Method
65227	Previously Active Diagnostic Trouble Codes	1214	Suspect Parameter Number
65229	Freeze Frame Parameters	1217	Freeze Frame Length
65229	Freeze Frame Parameters	1215	Failure Mode Identifier
65229	Freeze Frame Parameters	1216	Occurrence Count
65229	Freeze Frame Parameters	1706	SPN Conversion Method
65229	Freeze Frame Parameters	1214	Suspect Parameter Number
65229	Freeze Frame Parameters	4263	Manufacturer Specified Information
65230	Diagnostic Readiness 1	1218	Active Trouble Codes
65230	Diagnostic Readiness 1	1219	Previously Active Trouble Codes
65230	Diagnostic Readiness 1	1220	OBD Compliance
65230	Diagnostic Readiness 1	1221	Continuously Monitored Systems Support/Status
65230	Diagnostic Readiness 1	1222	Non-continuously Monitored Systems Support
65230	Diagnostic Readiness 1	1223	Non-continuously Monitored Systems Status

PGN	PGN Description	SPN	SPN Description
65236	Emissions Related Active DTCs	987	Protect Lamp
65236	Emissions Related Active DTCs	624	Amber Warning Lamp
65236	Emissions Related Active DTCs	623	Red Stop Lamp
65236	Emissions Related Active DTCs	1213	Malfunction Indicator Lamp
65236	Emissions Related Active DTCs	3041	Flash Protect Lamp
65236	Emissions Related Active DTCs	3040	Flash Amber Warning Lamp (AWL)
65236	Emissions Related Active DTCs	3039	Flash Red Stop Lamp (RSL)
65236	Emissions Related Active DTCs	3038	Flash Malfunction Indicator Lamp (MIL)
65236	Emissions Related Active DTCs	1215	Failure Mode Identifier
65236	Emissions Related Active DTCs	1216	Occurrence Count
65236	Emissions Related Active DTCs	1706	SPN Conversion Method
65236	Emissions Related Active DTCs	1214	Suspect Parameter Number
65242	Software Identification	965	Number of Software Identification Fields
65242	Software Identification	234	Software Identification
65243	Engine Fluid Level/Pressure 2	164	Engine Injection Control Pressure
65243	Engine Fluid Level/Pressure 2	157	Engine Injector Metering Rail 1 Pressure
65243	Engine Fluid Level/Pressure 2	156	Engine Injector Timing Rail 1 Pressure
65243	Engine Fluid Level/Pressure 2	1349	Engine Injector Metering Rail 2 Pressure
65244	Idle Operation	236	Engine Total Idle Fuel Used
65244	Idle Operation	235	Engine Total Idle Hours
65247	Electronic Engine Controller 3	514	Nominal Friction – Percent Torque
65247	Electronic Engine Controller 3	519	Engine's Desired Operating Speed Asymmetry Adjustment
65247	Electronic Engine Controller 3	2978	Estimated Engine Parasitic Losses – Percent Torque
65247	Electronic Engine Controller 3	3237	Aftertreatment 1 Intake Dew Point
65247	Electronic Engine Controller 3	3238	Aftertreatment 1 Exhaust Dew Point
65247	Electronic Engine Controller 3	3239	Aftertreatment 2 Intake Dew Point
65247	Electronic Engine Controller 3	3240	Aftertreatment 2 Exhaust Dew Point
65247	Electronic Engine Controller 3	515	Engine's Desired Operating Speed
65247	Electronic Engine Controller 3	3236	Aftertreatment 1 Exhaust Gas Mass Flow
65249	Retarder Configuration	901	Retarder Type
65249	Retarder Configuration	902	Retarder Location
65249	Retarder Configuration	557	Retarder Control Method (Retarder Configuration)
65249	Retarder Configuration	551	Percent Torque At Idle, Point 1 (Retarder Configuration)
65249	Retarder Configuration	552	Percent Torque At Maximum Speed, Point 2 (Retarder Configuration)
65249	Retarder Configuration	553	Percent Torque At Point 3 (Retarder Configuration)
65249	Retarder Configuration	554	Percent Torque At Point 4 (Retarder Configuration)
65249	Retarder Configuration	555	Percent Torque At Peak Torque, Point 5 (Retarder Configuration)
65249	Retarder Configuration	546	Retarder Speed At Idle, Point 1 (Retarder Configuration)

PGN	PGN Description	SPN	SPN Description
65249	Retarder Configuration	548	Maximum Retarder Speed, Point 2 (Retarder Configuration)
65249	Retarder Configuration	549	Retarder Speed At Point 3 (Retarder Configuration)
65249	Retarder Configuration	550	Retarder Speed At Point 4 (Retarder Configuration)
65249	Retarder Configuration	547	Retarder Speed At Peak Torque, Point 5 (Retarder Configuration)
65249	Retarder Configuration	556	Reference Retarder Torque (Retarder Configuration)
65251	Engine Configuration 1	539	Engine Percent Torque At Idle, Point 1 (Engine Configuration)
65251	Engine Configuration 1	540	Engine Percent Torque At Point 2 (Engine Configuration)
65251	Engine Configuration 1	541	Engine Percent Torque At Point 3 (Engine Configuration)
65251	Engine Configuration 1	542	Engine Percent Torque At Point 4 (Engine Configuration)
65251	Engine Configuration 1	543	Engine Percent Torque At Point 5 (Engine Configuration)
65251	Engine Configuration 1	534	Engine Maximum Momentary Override Time Limit (Engine Configuration)
65251	Engine Configuration 1	535	Engine Requested Speed Control Range Lower Limit (Engine Configuration)
65251	Engine Configuration 1	536	Engine Requested Speed Control Range Upper Limit (Engine Configuration)
65251	Engine Configuration 1	537	Engine Requested Torque Control Range Lower Limit (Engine Configuration)
65251	Engine Configuration 1	538	Engine Requested Torque Control Range Upper Limit (Engine Configuration)
65251	Engine Configuration 1	3344	Support Variable Rate TSC1 Message
65251	Engine Configuration 1	3345	Support TSC1 Control Purpose Group 1
65251	Engine Configuration 1	3346	Support TSC1 Control Purpose Group 2
65251	Engine Configuration 1	3347	Support TSC1 Control Purpose Group 3
65251	Engine Configuration 1	3348	Support TSC1 Control Purpose Group 4
65251	Engine Configuration 1	188	Engine Speed At Idle, Point 1 (Engine Configuration)
65251	Engine Configuration 1	528	Engine Speed At Point 2 (Engine Configuration)
65251	Engine Configuration 1	529	Engine Speed At Point 3 (Engine Configuration)
65251	Engine Configuration 1	530	Engine Speed At Point 4 (Engine Configuration)
65251	Engine Configuration 1	531	Engine Speed At Point 5 (Engine Configuration)

PGN	PGN Description	SPN	SPN Description
65251	Engine Configuration 1	532	Engine Speed At High Idle, Point 6 (Engine Configuration)
65251	Engine Configuration 1	545	Engine Gain (Kp) Of The Endspeed Governor (Engine Configuration)
65251	Engine Configuration 1	544	Engine Reference Torque (Engine Configuration)
65251	Engine Configuration 1	533	Engine Maximum Momentary Override Speed, Point 7 (Engine Configuration)
65251	Engine Configuration 1	1712	Engine Extended Range Requested Speed Control Range Upper Limit (Engine configuration)
65251	Engine Configuration 1	1794	Engine Moment of Inertia
65251	Engine Configuration 1	1846	Engine Default Torque Limit
65252	Shutdown	593	Engine Idle Shutdown has Shutdown Engine
65252	Shutdown	594	Engine Idle Shutdown Driver Alert Mode
65252	Shutdown	592	Engine Idle Shutdown Timer Override
65252	Shutdown	590	Engine Idle Shutdown Timer State
65252	Shutdown	591	Engine Idle Shutdown Timer Function
65252	Shutdown	985	A/C High Pressure Fan Switch
65252	Shutdown	875	Refrigerant Low Pressure Switch
65252	Shutdown	605	Refrigerant High Pressure Switch
65252	Shutdown	1081	Engine Wait to Start Lamp
65252	Shutdown	1110	Engine Protection System has Shutdown Engine
65252	Shutdown	1109	Engine Protection System Approaching Shutdown
65252	Shutdown	1108	Engine Protection System Timer Override
65252	Shutdown	1107	Engine Protection System Timer State
65252	Shutdown	1111	Engine Protection System Configuration
65252	Shutdown	2815	Engine Alarm Acknowledge
65252	Shutdown	2814	Engine Alarm Output Command Status
65252	Shutdown	2813	Engine Air Shutoff Command Status
65252	Shutdown	2812	Engine Overspeed Test
65252	Shutdown	3667	Engine Air Shutoff Status
65253	Engine Hours, Revolutions	247	Engine Total Hours of Operation
65253	Engine Hours, Revolutions	249	Engine Total Revolutions
65254	Time/Date	959	Seconds
65254	Time/Date	960	Minutes
65254	Time/Date	961	Hours
65254	Time/Date	963	Month
65254	Time/Date	962	Day
65254	Time/Date	964	Year
65254	Time/Date	1601	Local minute offset
65254	Time/Date	1602	Local hour offset
65257	Fuel Consumption (Liquid)	182	Engine Trip Fuel
65257	Fuel Consumption (Liquid)	250	Engine Total Fuel Used

PGN	PGN Description	SPN	SPN Description
65259	Component Identification	586	Make
65259	Component Identification	587	Model
65259	Component Identification	588	Serial Number
65259	Component Identification	233	Unit Number (Power Unit)
65260	Vehicle Identification	237	Vehicle Identification Number
65262	Engine Temperature 1	110	Engine Coolant Temperature
65262	Engine Temperature 1	174	Engine Fuel Temperature 1
65262	Engine Temperature 1	52	Engine Intercooler Temperature
65262	Engine Temperature 1	1134	Engine Intercooler Thermostat Opening
65262	Engine Temperature 1	175	Engine Oil Temperature 1
65262	Engine Temperature 1	176	Engine Turbocharger Oil Temperature
65263	Engine Fluid Level/Pressure 1	94	Engine Fuel Delivery Pressure
65263	Engine Fluid Level/Pressure 1	22	Engine Extended Crankcase Blow-by Pressure
65263	Engine Fluid Level/Pressure 1	98	Engine Oil Level
65263	Engine Fluid Level/Pressure 1	100	Engine Oil Pressure
65263	Engine Fluid Level/Pressure 1	109	Engine Coolant Pressure
65263	Engine Fluid Level/Pressure 1	111	Engine Coolant Level
65263	Engine Fluid Level/Pressure 1	101	Engine Crankcase Pressure
65264	Power Takeoff Information	90	Power Takeoff Oil Temperature
65264	Power Takeoff Information	980	Engine PTO Governor Enable Switch
65264	Power Takeoff Information	979	Engine Remote PTO Governor Preprogrammed Speed Control Switch
65264	Power Takeoff Information	978	Engine Remote PTO Governor Variable Speed Control Switch
65264	Power Takeoff Information	984	Engine PTO Governor Set Switch
65264	Power Takeoff Information	983	Engine PTO Governor Coast/Decelerate Switch
65264	Power Takeoff Information	982	Engine PTO Governor Resume Switch
65264	Power Takeoff Information	981	Engine PTO Governor Accelerate Switch
65264	Power Takeoff Information	2897	Operator Engine PTO Governor Memory Select Switch
65264	Power Takeoff Information	3447	Remote PTO Governor Preprogrammed Speed Control Switch #2
65264	Power Takeoff Information	3448	Auxiliary Input Ignore Switch
65264	Power Takeoff Information	186	Power Takeoff Speed
65264	Power Takeoff Information	187	Power Takeoff Set Speed
65265	Cruise Control/Vehicle Speed	69	Two Speed Axle Switch
65265	Cruise Control/Vehicle Speed	70	Parking Brake Switch
65265	Cruise Control/Vehicle Speed	1633	Cruise Control Pause Switch
65265	Cruise Control/Vehicle Speed	3807	Park Brake Release Inhibit Request
65265	Cruise Control/Vehicle Speed	595	Cruise Control Active
65265	Cruise Control/Vehicle Speed	596	Cruise Control Enable Switch
65265	Cruise Control/Vehicle Speed	597	Brake Switch
65265	Cruise Control/Vehicle Speed	598	Clutch Switch
65265	Cruise Control/Vehicle Speed	599	Cruise Control Set Switch
65265	Cruise Control/Vehicle Speed	600	Cruise Control Coast (Decelerate) Switch

PGN	PGN Description	SPN	SPN Description
65265	Cruise Control/Vehicle Speed	601	Cruise Control Resume Switch
65265	Cruise Control/Vehicle Speed	602	Cruise Control Accelerate Switch
65265	Cruise Control/Vehicle Speed	86	Cruise Control Set Speed
65265	Cruise Control/Vehicle Speed	976	PTO Governor State
65265	Cruise Control/Vehicle Speed	527	Cruise Control States
65265	Cruise Control/Vehicle Speed	968	Engine Idle Increment Switch
65265	Cruise Control/Vehicle Speed	967	Engine Idle Decrement Switch
65265	Cruise Control/Vehicle Speed	966	Engine Test Mode Switch
65265	Cruise Control/Vehicle Speed	1237	Engine Shutdown Override Switch
65265	Cruise Control/Vehicle Speed	84	Wheel-Based Vehicle Speed
65266	Fuel Economy (Liquid)	51	Engine Throttle Position
65266	Fuel Economy (Liquid)	3673	Engine Throttle 2 Position
65266	Fuel Economy (Liquid)	183	Engine Fuel Rate
65266	Fuel Economy (Liquid)	184	Engine Instantaneous Fuel Economy
65266	Fuel Economy (Liquid)	185	Engine Average Fuel Economy
65269	Ambient Conditions	108	Barometric Pressure
65269	Ambient Conditions	172	Engine Air Inlet Temperature
65269	Ambient Conditions	170	Cab Interior Temperature
65269	Ambient Conditions	171	Ambient Air Temperature
65269	Ambient Conditions	79	Road Surface Temperature
65270	Inlet/Exhaust Conditions 1	81	Engine Diesel Particulate Filter Inlet Pressure
65270	Inlet/Exhaust Conditions 1	102	Engine Intake Manifold #1 Pressure
65270	Inlet/Exhaust Conditions 1	105	Engine Intake Manifold 1 Temperature
65270	Inlet/Exhaust Conditions 1	106	Engine Air Inlet Pressure
65270	Inlet/Exhaust Conditions 1	107	Engine Air Filter 1 Differential Pressure
65270	Inlet/Exhaust Conditions 1	112	Engine Coolant Filter Differential Pressure
65270	Inlet/Exhaust Conditions 1	173	Engine Exhaust Gas Temperature
65271	Vehicle Electrical Power 1	114	Net Battery Current
65271	Vehicle Electrical Power 1	115	Alternator Current
65271	Vehicle Electrical Power 1	167	Charging System Potential (Voltage)
65271	Vehicle Electrical Power 1	168	Battery Potential / Power Input 1
65271	Vehicle Electrical Power 1	158	Keyswitch Battery Potential
65272	Transmission Fluids 1	123	Clutch Pressure
65272	Transmission Fluids 1	124	Transmission Oil Level
65272	Transmission Fluids 1	126	Transmission Filter Differential Pressure
65272	Transmission Fluids 1	127	Transmission Oil Pressure
65272	Transmission Fluids 1	3027	Transmission Oil Level High / Low
65272	Transmission Fluids 1	3028	Transmission Oil Level Countdown Timer
65272	Transmission Fluids 1	3026	Transmission Oil Level Measurement Status
65272	Transmission Fluids 1	177	Transmission Oil Temperature
65274	Brakes	116	Brake Application Pressure
65274	Brakes	117	Brake Primary Pressure
65274	Brakes	118	Brake Secondary Pressure
65274	Brakes	619	Parking Brake Actuator

PGN	PGN Description	SPN	SPN Description
65274	Brakes	3557	Parking Brake Red Warning Signal
65274	Brakes	3808	Park Brake Release Inhibit Status
65275	Retarder Fluids	119	Hydraulic Retarder Pressure
65275	Retarder Fluids	120	Hydraulic Retarder Oil Temperature
65276	Dash Display	80	Washer Fluid Level
65276	Dash Display	96	Fuel Level 1
65276	Dash Display	95	Engine Fuel Filter Differential Pressure
65276	Dash Display	99	Engine Oil Filter Differential Pressure
65276	Dash Display	38	Fuel Level 2

Table 1: Engine Parameters

b. Sensors monitored and computed. The following are a list of sensor parameters that can be collected from the CANbus. These include pavement temperature sensor, salt spread controller, and discrete sensors. See Table 2 below.

PGN	PGN Description	SPN	SPN Description
	Infrared Pavement Temperature Sensor		
42752	Air Temperature	701	
42752	Pavement Temperature	702	
42752	Ambient Temperature	703	
	Chemical Spread Controller – Granular and/or Liquid		
42496	Event ID	3872	
42496	Spreader Status	3873	
42496	Spreader Mode	3874	
42496	Spreader Units	3875	
42496	Vehicle	3876	MPH
42496	Distance Total	3877	MI
42496	Material Type	3878	
42496	Granular Material	3879	lbs/mi
42496	Spinner Lane	3880	%
42496	Granular	3881	lbs
42496	Spinner	3882	
42496	Prewet	3883	gal/ton
42496	Prewet	3884	gal
42496	Direct	3885	gal/mi
42496	Direct	3886	gal
42496	Lane	3887	
42496	Road	3888	°F
42496	Operation	3889	
42496	Driver	3890	
42496	Spread Controller	3891	
42496	Operation	3892	IN
42496	Prewet Loop	3893	
42496	Operation	3894	
42496	Direct App	3895	

PGN	PGN Description	SPN	SPN Description
42496	Unit ID	3896	
42496	Current Speed	3897	
42496	Current Spread Rate	3898	
42496	Speed Constant Low	3899	
42496	Speed Constant High	3900	
42496	Auger Minimum Value	3901	
42496	Auger Constant	3902	
42496	Auger Drag	3903	
42240	Auger Jam	3904	
42240	Spinner Max	3905	
42240	Auger Spread Rate	3906	
42240	High Pressure	3907	
42240	Fluid Temperature	3908	
42240	Wetting Constant	3909	
42240	Wetting Max	3910	
42240	Wetting Slip	3911	
42240	Fluid Type	3912	
42240	Storm Total Distance	3913	Material 1 Miles
42240	Storm Total Distance	3914	Material 2 Miles
42240	Storm Total Distance	3915	Material 3 Miles
42240	Storm Total Distance	3916	Material 4 Miles
42240	Season Total Distance	3917	Material 1 Miles
42240	Season Total Distance	3918	Material 2 Miles
42240	Season Total Distance	3919	Material 3 Miles
42240	Season Total Distance	3920	Material 4 Miles
42240	Storm Total Log	3921	Material 1 Pounds
42240	Storm Total Log	3922	Material 2 Pounds
42240	Storm Total Log	3923	Material 3 Pounds
42240	Storm Total Log	3924	Material 4 Pounds
42240	Season Total Log	3925	Material 1 Pounds
42240	Season Total Log	3926	Material 2 Pounds
42240	Season Total Log	3927	Material 3 Pounds
42240	Season Total Log	3928	Material 4 Pounds
42240	Season Total Distance	3929	Prewet Miles
42240	Season Total Distance	3930	Anti Ice Miles
42240	Season Total Distance	3931	Prewet Miles
42240	Season Total Distance	3932	Anti Ice Miles
42240	Storm Total Log	3933	Prewet Gallons
42240	Storm Total Log	3934	Anti Ice Gallons
42240	Season Total Log	3935	Prewet Gallons
42752	Season Total Log	3841	Anti Ice Gallons
42752	Blast ON	3842	Miles
42752	Spreader Rate	3843	Rate of Spreader
42752	Spinner Rate	3844	Rate of Spinner
42752	Prewet Rate	3845	Rate of Prewet
42752	Mode	3846	Mode of Operation
42752	Code Checksum	3847	Checksum control

PGN	PGN Description	SPN	SPN Description
42752	Software Revision	3848	Current Revision
42752	Discrete Sensors	3849	
42752	Main plow up/down	704	discrete change in state
42752	Right wing plow up/down	705	discrete change in state
42752	Left wing plow up/down	706	discrete change in state
42752	Under body blade up/down	707	discrete change in state
42752	Salt spread controller on/off	708	discrete change in state
42752	Broom up/down	709	discrete change in state
42752	Hopper open/closed	710	discrete change in state
42752	Warning lights on/off	711	discrete change in state
42752	Laser sensor active/inactive	712	discrete change in state
42752	Accelerometer over threshold	713	discrete change in state
42752	Barometer reading	714	inches
42752	Wind speed	715	mph
42752	Wind direction	716	360 degrees
42752	Humidity	3840	Percentage
42752	Surface Condition	717	
42752	Precipitation Status	718	
42752	Visibility	719	

Table 2: Sensor Parameters

C. Store and Forward. When communication to the host end server-based application is not available, the modem/GPS unit will store the reports for later transmission to the application. Each report stored will contain the date/time and GPS information in addition to other engine data that was to be reported. The modem/GPS unit will save the store and forward records in memory that is battery-backed up by an on-board battery.

The modem/GPS unit will also be able to parse real-time data that requires immediate transmission from less critical (not as time sensitive) information that can be transmitted at end of day or when the vehicle returns to “base”. This data can be transferred via Wi-Fi thereby not incurring wireless data charges as if a cellular connection was employed. This store and forward feature is configurable by the user during firmware modifications and upgrades.

D. Network Communications. The modem/GPS unit will support communication to the server-based application via both the GSM and CDMA cellular networks. The communication link will be bi-directional, allowing for information initiated by the modem/GPS unit or the server-based application. The modem/GPs units will be able to data transfer as well as SMS text messaging. FTP must be supported for “over the air” code updates and configuration changes.

1. Modem/GPS unit to server. Information passing from the modem/GPs unit to the server must require a positive acknowledgement from the server-based back-end to ensure that data is being received by the application, not just the network.

Reports from the system to the server must include, but are not limited to:

- Pings to keep the network service active

- Periodic current data reports based on a pre-defined, yet user- or server-adjustable frequency. Information in the current report to include:
    - Unique ID of the equipment
    - Date/time
    - GPS location
    - any and all monitored and computed values
- Diagnostic report containing information about any diagnostics reported from any Controller Unit on the SAE J1939 bus.
- Idle exception report containing:
    - Unique ID
    - Date/time
    - GPS location
    - Idle duration
    - Fuel used during idle event
- Movement reports based on movement of equipment over ground
- Geofence violation reports
- Change of course reports
- Any monitored or computed value that exceeds the high-high, high, low or low-low thresholds
- Daily reports
- Engine on/off
- End of trip
- Power up

2. Server to modem/GPS unit. The modem/GPS unit will support download of a new application and complete re-configuration from communication initiated from the server. This allows for adding new capabilities to the modem/GPS unit without having to send personnel to service the unit.

The modem/GPS unit must support unsolicited transmissions from the server-based application to perform the following functions:

- Request a current data report
- Modify a geo-fence definition
- Modify any configuration parameter in the telemetry system
- Send Event Log via FTP to designated FTP site and filename
- Send Current Data report via FTP to designated FTP site and filename
- Send current system configuration via FTP to designated FTP site and filename
- Request for telemetry system to upgrade telemetry application firmware from a designated FTP site
- Send parameter changes to a CANbus device
- Send data to a Modbus slave device

3. SMS to modem/GPS unit. The ability to communicate from anywhere to the modem/GPS unit and receive timely data is required. The modem/GPS unit must be able to receive SMS messages directly from cell-phones, e-mail or any SMS-enabled Gateway. This alleviates the requirement for all maintenance personnel to have Internet-enabled PCs on hand.

The ETS supports receiving of SMS (text messages) to perform the following functions:

- Request a current data report
- Modify a geo-fence definition
- Modify any configuration parameter in the modem/GPS unit
- Send Event Log via FTP to designated FTP site and filename
- Send Current Data report via FTP to designated FTP site and filename
- Send current system configuration via FTP to designated FTP site and filename
- Request for modem/GPs unit to upgrade telemetry application firmware from a designated FTP site

E. Communications networks supported. The network support in the modem/GPS unit must be designed to address currently available technologies, yet not preclude emerging technologies. The modem/GPS unit should be built such that new network technologies can be implemented without replacing the entire modem/GPS unit system, only the network interface mechanism.

The modem/GPS unit must support the GSM cellular network for bi-directional communication with the server-based back-end application. The modem/GPS unit must also support satellite and CDMA communication for those areas where GSM is unavailable.

The following capabilities are included in the GSM support.

- Quad-band GSM (850/900/1800/1900 Mhz)
- UDP and TCP protocol
- 'Always on' connection
- Over-the-air modification of IP and Port
- Connection to Remote Diagnostics/Configuration application

The following capabilities are included in the Satellite support.

- Serial port connection to external satellite network system
- Automatic fall back when GSM not available

The following capabilities are included in the CDMA support.
Integrated CDMA support in the same enclosure instead of GSM

1. GPS capabilities. The modem/GPS unit must contain its own on-board GPS. The GPS must provide location, date/time, speed and direction information. The modem/GPS unit will use the GPS to provide the following:

- Geofences
    - Rectangular
    - Into and out of notifications
    - A minimum of 50 unique geo-fences

- Work with a Beacon Receiver using the NDGPS. Nationwide Differential Global Positioning System (NDGPS) provides accurate positioning and location information to travelers, emergency response units, and other customers. The system provides 1- to 3-meter (m) navigation accuracy. This improves collision notification systems, enables cooperative vehicle-highway collision-avoidance systems, and provides more accurate in-vehicle route guidance systems.

2. Cellular. The modem/GPS unit will support communication to the server-based application via both the GSM and CDMA cellular networks. The communication link will be bi-directional, allowing for information initiated by the modem/GPS unit or the server-based application.

3. Wireless network or Wi-Fi. The IEEE 802.11B/G specification (ISO/IEC 8802-11) is an international standard describing the characteristics of a wireless local area network (WLAN). The name Wi-Fi (short for "Wireless Fidelity", sometimes incorrectly shortened to WiFi) corresponds to the name of the certification given by the Wi-Fi Alliance. The modem/GPS unit shall be able to communicate all data gathering operations via the Wi-Fi network. This has the potential of reducing monthly wireless fees for important yet not dire information. The unit will be configurable to send perishable information in pseudo real-time (using cellular) and non-perishable (yet significant information) during those moments when the vehicle is capable of accessing the Wi-Fi network.

4. Other communications means - SMS Test Messaging. The modem/GPS unit can receive and act on SMS commands to perform several functions. Primarily SMS commands are issued to change internal channel configurations settings.

SMS Command Format	Parameter Description	Function
<UPDTSRVR>	None	Instructs the mmodem/GPS unit to send an Update event to the internet application.
<CONFIG(x,<i,>y,zzzz)>	x = line type code <i,> = optional index value y = field type code zzzz = field value	See Making Configuration Changes Page 40 for details on valid values.
<ADIPREQ(ip, port, s)>	ip = ip to communicate to host over-the-air programming application port = port number of the over-the-air programming application s = reserved	Informs the modem/GPS unit to disconnect from the internet application and connect to the Host End Remote Diagnostic application for over-the-air programming and diagnostics. If no connection is established, the modem/GPS unit will automatically re-connect to the internet application

F. On-going support. The AVL/GPS system must have the following capabilities to improve training, troubleshooting, and product/system support; all accessible on a supported web portal with unique ID and password.

- Internet access web site
- Help desk
- User manuals
- Troubleshooting procedures
- Tutorials for training
- Assistance for modifying configuration software of the modem/GPS unit

1. Configuration and application program. The modem/GPS unit is designed to provide a highly configurable, robust platform for remote monitoring applications. The powerful 32-bit processor, FLASH and SRAM allow:

- Virtual real-time transfer of monitored conditions,
- Local computations from monitored conditions,
- User-specified PGNs & SPNs to be monitored,
- Event and data logging,
- Exception reporting to Internet-based applications,
- Connecting to the modem/GPS unit or equipment attached to the unit via a wireless connection,
- Remote wireless programming and diagnostics,
- E-mail or SMS messaging sent on monitored conditions,
- Parameter setting via SMS messaging,
- GSM or CDMA and/or Wi-Fi

2. Over the air (OTA) remote control. The modem/GPS unit must have built-in communication tools to allow for configuration and complete program changes via over-the-air (OTA) or direct connection.

G. Physical & Environmental. The modem/GPs unit must be available in the following packing options; Deutsch enclosure. The modem/GPS unit must operate under the following power conditions:

- Operating power: 9-32VDC
- Sleep (low power) mode - less than 6 ma @ 12VDC
- Monitoring mode - 40ma @ 12VDC
- Cellular transmit mode - 600ma peak @ 12VDC
- Industrial temperature range -40 to +70C

The modem/GPS unit when housed in a Deutsch EEC enclosure must be successfully tested under the following conditions:

- Submersed under 5’ of water
- Power washed for 3 minutes

The antenna connections for the integral GSM/GPRS/CDMA/GPS module must have two SMA connectors that are of different polarity to eliminate incorrect connections making installing easier.

- GPS – SMA
- GSM/GPRS/CDMA – SMA-RP (reverse polarity)

1. Mounting the Antenna. The antenna supports both GSM/CDMA and GPS in a single unit. In order for the GPS portion of the antenna to operate, it needs to be mounted horizontally with a view of the sky. If the antenna is mounted outside and may be subject to lightning, a surge arrestor should be inserted between the modem/GPS unit and the antenna. If the antenna is mounted inside, it can be affixed to or mounted near a window.

2. General. The modem/GPS unit shall connect to the CANbus using one of he two cable connectors listed in Table 3 below. The 9 pin and/or 6 pin Deutsch connector is dependent upon the vehicle manufacturer.

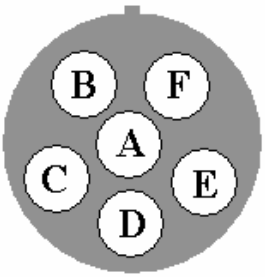
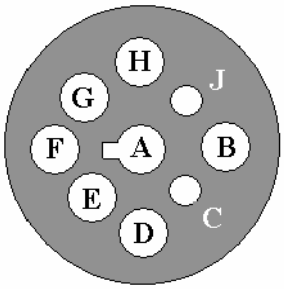
Connector	Pin-outs	Picture
Deutsch HD16-6-12S 6-pin connector ---------- A - J1587 + B - J1587 - C - Power + D - NC E - Ground F – NC		
Deutsch HD16-9-1939S 9-pin connector ---------- A - Ground B - Power + C - J1939 + D - J1939 - E – J1939 Shield F - J1587 + G - J1587 - H - NC J – NC		

Table 3: Connectors

3. Visual alerts. The following visual signals will be available for viewing when powering up the modem/GPS unit.

LED 1 - System – Green

State	Rate	Definition
Blink	0.2 hz	Sleep Mode
Blink	1 hz	CPU Run
Blink	5 hz	Loader Mode (all other LEDs are off)
On or Off	Solid	Failure

LED 2 – Cell Activity/Registration – Red

State	Rate	Definition
Blink	Rapid (burst)	Rx/Tx Activity
Blink	1 hz	Not Registered
Off	Solid	Registered

LED 3 – Cell Faults – Red

State	Rate	Definition
Blink	10 hz	No SIM card
On	Solid	Not Ready/Fault

Blink	1 hz	Error
Off	Solid	Ok

LED 4 – CAN/J1708 Status – Red

State	Rate	Definition
On	Solid	Fault
Off	Solid	No Faults/Operational

LED 5 – GPS Status – Red

State	Rate	Definition
Blink	1 hz	No Fix
Off	Solid	Fix

LED 6 – MODBUS Status – Red

State	Rate	Definition
Blink	Rapid (burst)	Rx/Tx Activity or Activity on Port 2
On	Solid	Fault (timeout,error)
Off	Solid	No Faults

LED 7 – User 1 – Red

State	Rate	Definition
Blink	Rapid (burst)	Activity on Port 3
On	Solid	Fault
Off	Solid	No Faults

4. Power management. The power requirements are shown below.

Pin	Signal Name	Description	Input or Output
1	Power	12V (nominal) Power Input	Input
2	Ignition	Ignition or Input #0	Input
3	GND	Ground	---

H. Certifications. The following certifications must have been met by the modem/GPS unit:

- FCC, PTCRB and ATT approvals for GSM/GPRS end-user applications
- Operating vibration: exceeds SAE J1455 vibration levels
- Operating shock: exceeds SAE J1455 shock levels
- Enclosure: exceeds IP65/NEMA 4X
- RoHS compliant

I. Warranty. The modem/GPS unit must have a 1-year limited warranty covering defects in manufacturing for parts and labor.