Connected Commercial Vehicles—Retrofit Safety Device Kit Project

Data Acquisition System (DAS) Documentation

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16. Abstract

Connected vehicle wireless data communications can enable safety applications that may reduce injuries and fatalities. Cooperative vehicle-to-vehicle (V2V) safety applications will be effective only if a high fraction of vehicles are equipped. Deployment of V2V technology will be enhanced if it is available not only for manufacturing in new vehicles but also for retrofit to existing vehicles. The objective of the Connected Commercial Vehicles—Retrofit Safety Device (CCV-RSD) Kit Project was to develop complete hardware and software that can be used in various brands and models of heavy trucks. The RSD kits provide the functionality needed for cooperative V2V and vehicle-to-infrastructure (V2I) safety applications to support the Model Deployment and other USDOT connected vehicle projects. This project included testing and documentation needed for installation, operation, enhancement, and maintenance of the units. These retrofit kits were built so they could be installed in existing class 6, 7, or 8 trucks. The RSD kits achieved a V2V and V2I functionality similar to that of the Connected Commercial Vehicles—Integrated Truck vehicles, where onboard equipment was integrated with newly manufactured truck tractors.

An essential element of the developmental testing of these safety devices is the ability to record and examine the operation of the truck, its driver, and the safety system. This capability was provided by a Data Acquisition System (DAS) installed on each of the test vehicles. The DAS communicated with the RSD, the vehicle's internal data bus, a set of accelerometers, and video cameras. It recorded all of the Basic Safety Messages (BSMs) transmitted by the RSD and the BSMs that the RSD received from other units. This document describes the design of the DAS, its specifications, and instructions for operating it.

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SI* (MODERN METRIC) CONVERSION FACTORS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
APPROXIMATE CONVERSIONS TO SI UNITS				
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
APPROXIMATE CONVERSIONS FROM SI UNITS				
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
^oC	Celsius	1.8C+32	Fahrenheit	^oF
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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LIST OF ABBREVIATIONS

BHI	Bridge Height Inform
BSW	Blind Spot Warning
CAN	Control and Navigation (bus)
CCV	Connected Commercial Vehicles
COTS	Commercial Off the Shelf
CSW	curve speed warning
DAS	Data Acquisition System
DSRC	Dedicated Short-Range Communication
EEBL	Emergency Electronic Brake Lights
FCW	Forward Collision Warning
IMA	Intersection Movement Assist
IMU	Inertial Measurement Unit
NHTSA	National Highway Traffic Safety Administration
RSE	Roadside Equipment
SQL	Structured Query Language
UMTRI	University of Michigan Transportation Research Institute
USDOT	United States Department of Transportation
VRTC	Vehicle Research and Test Center
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
WSU	Wireless Safety Unit

EXECUTIVE SUMMARY

The Connected Commercial Vehicles—Retrofit Safety Device (CCV-RSD) Kit Project involved the development, validation, and field testing of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) safety applications for commercial vehicles. The V2V and V2I capability were built in a device that would be retrofit to an existing truck tractor, and the device was delivered as a kit for installation.

A Data Acquisition System (DAS) was installed along with the RSD kit in every tractor in this project. Its purpose was to record the actions of the RSD kit and of surrounding remote vehicles. It provided data for research. The DAS is not a part of the functioning of the RSD.

The DAS installed in the tractor used for the functional performance tests recorded the relative positions of the host truck and remote vehicle and of the timings of the driver alerts. This information was the basis for determining that the test had been conducted according to the procedure and that the RSD kit performed properly. A DAS was installed in each of the eight tractors in the model deployment. These DASs recorded all the movements of the tractors and their interactions with the V2V equipment on the other vehicles in the study. This information will be used to assess the performance of all connected vehicles in the study.

This document describes how the DAS works and how to work it. The DAS recorded the location and motions of the host vehicle, all Basic Safety Messages (BSMs) transmitted and received, and video of the interior and exterior. Summary data was transmitted during the model deployment to ensure the equipment was working properly; full data was downloaded following the study by connecting a network cable to the DAS and logging in.

CHAPTER 1. INTRODUCTION

The Connected Commercial Vehicles—Retrofit Safety Device Kit Project is one of several inter-related research projects addressing the use of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless technologies for highway safety. The project is developing and field testing a set of driver assistance functions for commercial vehicles to assess the technical performance, driver acceptance, and fleet perspectives for these connected-vehicle functions. The assistance systems include the following crash warning applications: forward crash warning (FCW), electronic emergency brake lamps (EEBL), intersection movement assist (IMA), blind spot indication (BSD), and curve speed warning (CSW).

The team developed and built kits for a Retrofit Safety Device (RSD). These kits were installed on eight truck tractors for the Safety Pilot Model Deployment. To test the functioning of the kits and monitor their performance, a Data Acquisition System (DAS) was installed in each tractor.

PURPOSE OF THIS DOCUMENT

This document addresses the data acquisition system (DAS) installed on the eight tractors. Specifically the report:

- Describes the architecture of the RSD system on the tractors and the DAS's place within that larger system.
- Describes the DAS main module, its sensors, and its connections to the vehicle and the rest of the RSD system.
- Describes the data that the DAS captures.
- Describes how partners can use the DAS for specific data collection tasks.

These topics are covered in the remaining sections.

RSD TRACTORS

The RSD systems were installed on class-8 tractors owned and operated by Sysco Foods Detroit, LLC. All eight tractors were Freightliner day cabs. The tractors were essentially identical, with the largest exception being that seven had single drive axles and one had tandem drive axles. Six of the units were built in 2013 and two in 2012. All units were equipped with an automatic transmission. Figure 1 shows one of the tractors.

UMTRI

Figure 1. Photo. A Sysco tractor with the RSD kit installed. The arrow points to the right-side DSRC antenna.

CHAPTER 2. DAS SYSTEM SPECIFICATIONS

The DAS consists of the main module and remotely mounted sensors, antennas, and other devices. The DAS is not necessary for the functioning of the RSD safety applications; it records the actions of the host vehicle itself and its driver and RSD safety equipment.

ROLE OF THE DAS

The DAS has two principal roles, the first of which is to collect data during the use of the RSD system onboard the vehicles. These data include:

- Data that describe vehicle travel and driver actions.
- Wireless communication packet information exchanged between the RSD vehicles and nearby vehicles equipped with connected vehicle systems.
- Safety application alert flags and key data that is used to make that decision.
- DAS sensor data, collected to support analysis of the RSD system performance and its effect on driver performance.
- Signals from the vehicle's J1939-standard CAN bus.
- Video image streams and cabin audio surrounding the basic safety application alerts.

The second function is to remotely monitor the functionality and health of the RSD system and the vehicle so that issues can be quickly detected and addressed.

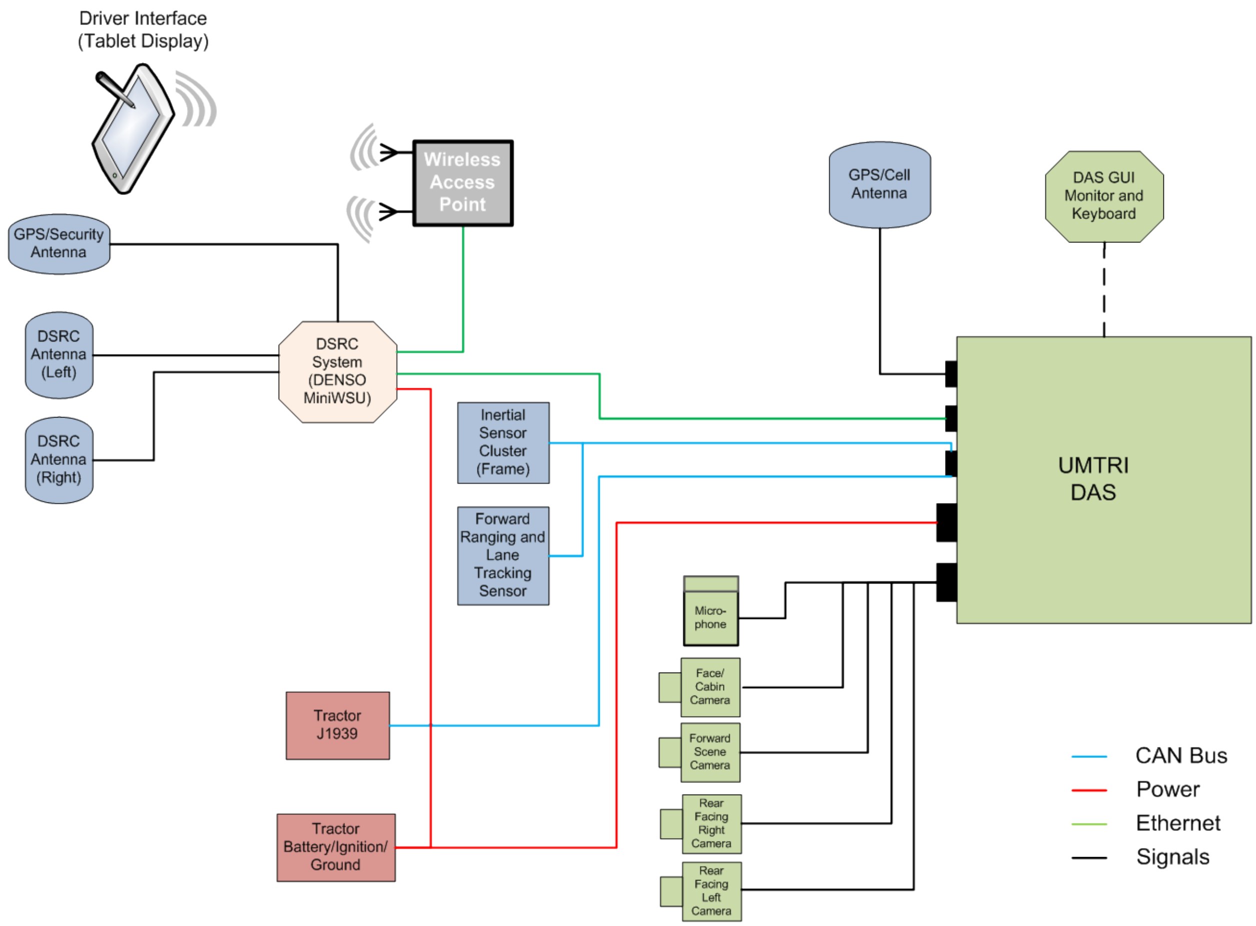
RSD AND DAS SYSTEM ARCHITECTURE

Figure 2 shows elements of the DAS as well as RSD elements that interface with the DAS. The main interfaces to the DAS are:

- A project CAN bus. The project CAN bus serves to connect the DAS to an UMTRI sensor cluster (labeled IMU in figure 2; see also figure 6). The cluster contains a three-axis accelerometer and a yaw rate sensor. The project CAN bus also connects the DAS to a vision-based ranging and lane-tracking sensor that provides measurements of range to vehicles ahead and the tractor's position in the lane.

- The vehicle's factory-installed SAE J1939 CAN bus. The J1939 bus carries a host of signals between factory-installed elements on the vehicle, including basic signals such as speed, brake switch status, and sometimes other signals such as headlamp or turn signal status. (The DENSO miniWSU does not connect to the vehicle bus.)

- A hardwired Ethernet connection to a combination wireless access point and Ethernet switch. This provides the DAS with direct hardwire access to the DENSO miniWSU device that serves as the basic safety application platform, as well as the platform for all V2V and V2I communications. This connection provides the DAS with all basic safety application data (including driver alerts and supporting information), as well as sent and received V2V and V2I messages.



UMTRI

Figure 2. Diagram. Schematic of the DAS within the RSD architecture.

- GPS signal. The miniWSU and the DAS have independent GPS receivers and separate GPS antennas. The DAS the GPS antenna also serves as a cell antenna and is mounted on the lower right corner of the windshield. The miniWSU the GPS antenna is mounted on top of the radio enclosure located on a mounting bar across the rear of the cab near the roof line. This antenna also serves as the security antenna for the miniWSU and interfaces with other DSRC devices to download security certificates during the Model Deployment test.

- Cellular modem antenna. Upon each key-off, the DAS sends a subset of data via commercial cellular data channels to servers at UMTRI to support the remote monitoring of the DAS and the systems that are directly interfaced with the DAS. The cellular modem antenna was packaged with the GPS antenna.

- Video cameras. Four video cameras are mounted on the vehicle to capture the activity outside and inside the vehicle cab.

- Forward: mounted on the windshield to capture the forward scene.

- Cabin: mounted on the windshield to capture the driver's face, head and upper body movements.
- Left: mounted near the top-left rear (driver's side) of the cab to capture remote vehicles in the space adjacent to the tractor and trailer.
- Right: mounted near the top-right rear (pass. side) of the cab to capture remote vehicles in the space adjacent to the tractor and trailer.
- Vehicle ignition and power. These signals are used—with significant logic and filtering – to trigger the powering up and down of the DAS and its peripheral devices.
- Microphone. A microphone is mounted near the driver-vehicle interface as a way of recording the sound of warnings and serves as one verification method that the alert requests by the miniWSU actually resulted in audible alerts.

The tablet, which serves as the driver-vehicle interface, communicates directly with the miniWSU via a wireless connection. There is no connection between the tablet and the DAS.

IN-CAB RELATED COMPONENTS

This section describes the individual DAS and DSRC-related RSD elements in more detail and shows the mounting location on the RSD vehicles.

DAS Main Module

Figure 3 shows that many of the larger components were mounted under the passenger seat inside of the vehicle's cabin. As shown in the figure, the UMTRI DAS is mounted within the main supports of the seat with the wireless access point and integrated Ethernet switch mounted just above the DAS.

DENSO Access Point

UMTRI DAS (Side view)

UMTRI

Figure 3. Photo. Components were mounted under the passenger seat.

Figure 4 shows that the tablet device is located near the driver. Sysco tractors have two existing logistics/telematics systems. They are shown as the screen in the upper part of the figure and the phone-like cradle shown behind the RSD/DVI tablet. Given these existing devices and a restriction on obscuring the driver's view of the roadway, the option to mount the tablet on an existing structural post in the location shown in the figure was selected.

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Figure 4. Photo. Tablet location.

DAS Main Module

The DAS units used in the RSD project were the fifth generation ("GEN5") DAS pictured in figure 5. This the latest generation, similar to those used in recent field operational tests, is more compact and more efficient. It has the capability to record hundreds of signals simultaneously and capture multiple video streams and audio. In addition to the eight RSD tractors, the same DAS was used on 100 ASD-equipped vehicles and three transit buses in the Safety Pilot Model Deployment.

UMTRI

Figure 5. Photo. GEN5 DAS.

The DAS contains a both UMTRI-designed and commercial off-the-shelf elements. The GEN5 DAS has been optimized to reduce size and costs for the connected vehicle project set, and is intended for long-term unattended operation. The DAS uses a single-board computer, with power managed via a sophisticated power controller board and backup battery. The DAS features multiple CAN bus inputs, multiple video inputs, audio, gigabit Ethernet ports, USB ports, automotive data storage devices, a GPS receiver, and a cellular modem. The DAS parses, time-stamps, and stores hundreds of variables using a commercial off-the-shelf central processor and automotive-grade data storage media. The DAS can store data for months at a time. The DAS generates files that are stored onboard the vehicle, and are then downloaded periodically, so that the data can be loaded into databases suitable for analysis or delivery to the Independent Evaluator for this project (USDOT Volpe Center). A cellular modem enables a subset of critical data to be sent over the air, including numerical and video data, to allow remote monitoring of the DAS and systems that interface with the DAS.

Sensor Cluster (IMU)

The sensor cluster continuously measures yaw rate and lateral and longitudinal acceleration, and provides those data to the DAS via the project CAN bus. The sensor cluster is a production-grade triaxial accelerometer from a Tier 1 supplier. It is installed in a watertight enclosure and attached to a steel cross-member positioned laterally between the two frame rails of the tractor as shown in figure 6. The size of the enclosure is approximately 6 in. x 4 in. x 3 in. Various installation configurations were investigated, and this installation was selected as the best compromise between the goals of minimizing sprung-mass coupling effects that occur when mounting on the body (e.g., body roll appearing as lateral acceleration) and avoiding the packaging constraints and vibration effects of a front axle location. The figure shows the cluster enclosure is mounted on the lateral center-line near the vertical center of gravity location. The sensor cluster is powered directly from the vehicle via switched power.

UMTRI IMU (Grey Box)

UMTRI

Figure 6. Photo. Protective enclosure with sensor cluster mounted to the tractor frame.

Forward-Ranging and Lane-Position Sensor and Forward and Cabin Cameras

A vision-based module is used to measure the distance to vehicles ahead, as well as estimating the tractor's lateral position within the lane. This device, from the vehicle component supplier Mobileye, is used as a sensor instead of radar for three reasons: the vision-based sensor also provides lane position, the unit does not protrude from the front of the vehicle as a radar would, and the vision-based sensor is simpler to install, align, and calibrate. The latter two reasons are important because they reduce the probability of damage to the unit and the resulting loss of data, and it reduces the down-time of the tractor for installation of the RSD system. The sensor provides information about the forward scene such as the number of same- and opposite-direction vehicles, the relative distance and speed of other vehicles, and the relative location of vehicles with reference to the host vehicle. Additionally, the sensor also has the ability to track lane boundary markers and provide measures of the host-vehicles position within a lane. Figure 7 shows the sensor installation on the windshield of a tractor. The sensor is mounted within the wiper pattern of the truck so that its operation in rainy conditions is assured. This sensor requires a one-hour calibration process during installation using a calibrated visual target.

Also shown in figure 7 are the Forward and Cabin camera locations. The forward camera is mounted in a custom fabricated mount that serves two functions: a) it holds the camera at a fixed and defined angle relative to the windshield and b) it provides a shroud to prevent reflections (mainly from the reflective windshield glass) from appearing in the camera image. Both the Forward ranging sensor and Forward camera are mounted within the area covered by the vehicle windshield wiper. The cabin camera is small and discreet. It also is mounted with a custom fixture created specifically for this application with a compound fixed angle that orients the camera both downward and toward the driver relative to the slope of the windshield. Just above the Cabin camera, is an array of infrared LEDs to provide illumination (invisible to the driver) of the cabin area during dark night-time hours.

miniWSU, DSRC Antennas, and Rear-Facing DAS Cameras

Figure 8 shows the location of the DENSO wireless safety unit (the "miniWSU" model) and the three associated DSRC antennas. A primary objective of the up-fit and design was to keep the cable distance between the miniWSU and the DSRC antennas as short and straight as possible, thereby minimizing signal loss from the antennas and increasing the range of communication between radios in different vehicles. Another objective was to provide some degree of "retrofit" capability by having a mounting that can be customized to many models of tractor. This was accomplished by mounting the miniWSU in an enclosure located outside the cab in the center of the vehicle. This enclosure is shown in figure 8 along with the DSRC antennas. DENSO's miniWSU device sends data to the DAS via an Ethernet switch and a hardwire Ethernet connection that runs from the miniWSU to where the DAS is located under the passenger seat. Alerts generated by the safety applications in the miniWSU are recorded by the DAS, as well as many additional data channels from the miniWSU. This includes all V2V and V2I messages sent and received as well as intermediate target location and classification data.

Note that the DAS does not interface with the tablet that serves as the driver interface for the safety applications. DAS data indicating driver alerts come from the miniWSU's commands given to the tablet. The DAS does not have information regarding the tablet's operational state (e.g., powered up or down), except through the DAS microphone mounted near the tablet.

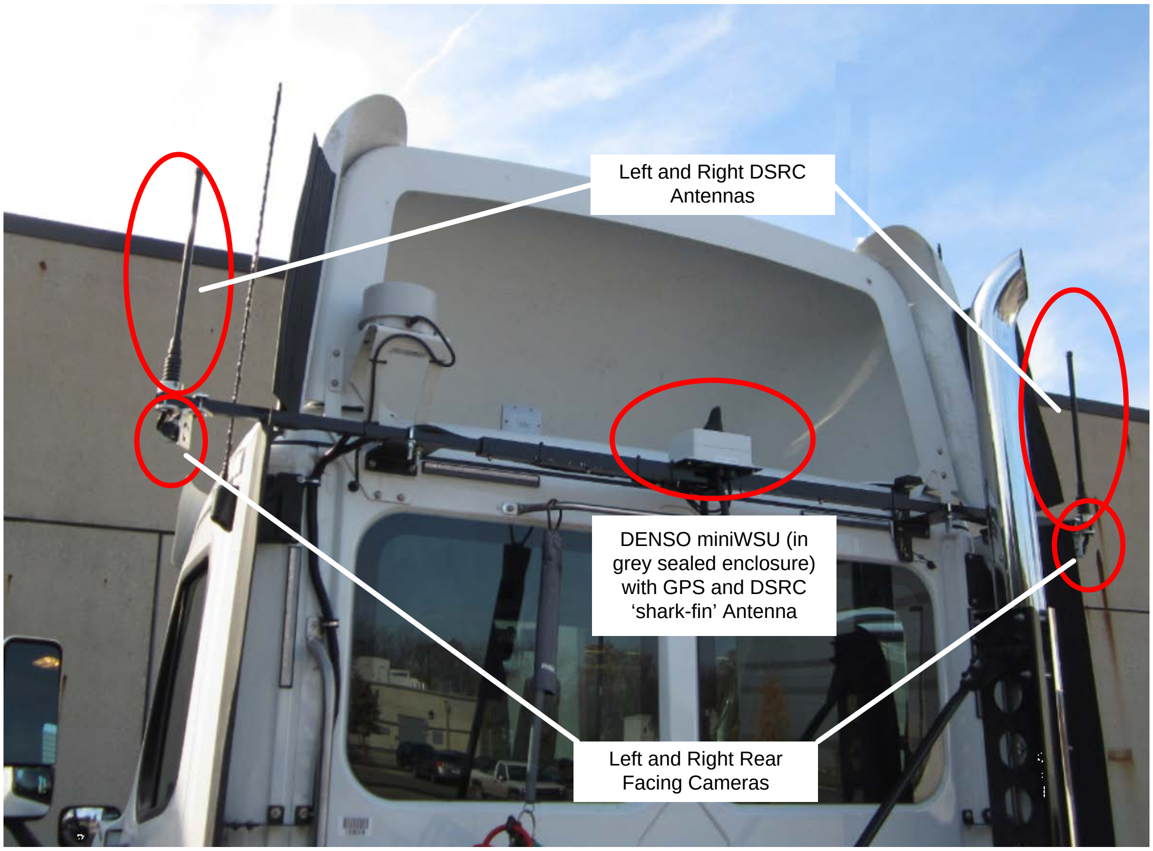
Also shown in figure 8 are the left and right rear facing cameras. These cameras provide images of the area adjacent to the tractor and trailer. They are used for validating the presence of adjacent vehicles when Blind-spot Warnings (BSW) are issued.

DAS Video Images

Four video cameras are installed in the RSD vehicles as part of the UMTRI DAS system. Sample images are shown in figure 9. The cameras are grey-level ("black and white") to provide better night-time imagery and to produce a more manageable volume of data. The camera frame rates are 10 Hz for Cabin and Forward and 2 Hz for Right and Left. The images are compressed spatially and temporally using an mpeg-4 compression technique. They are time stamped for synchronizing with the other DAS and miniWSU data.

UMTRI

Figure 7. Photo. Cabin and forward scene camera with forward-ranging and lane tracking module.



UMTRI

Figure 8. Photo. DSRC Antennas and rear facing cameras.

UMTRI

Figure 9. Photo. Samples of views from the video cameras on the tractor.

DAS Microphone

A compact microphone that is less than 0.25 in. diameter is installed just under the tablet to record audio from alerts. This provides a confirmation, should a question arise, of whether an alert requested by the miniWSU was actually presented to the driver.

DAS GPS and Cellular Modem

The DAS has its own GPS receiver. In addition to location and path information, the GPS provides accurate and high-resolution timing data that is used to synchronize all data elements, including host-to-remote vehicles data. The GPS unit is built into the DAS (shown in figure 10 before installing into the DAS enclosure) and it is connected to an integrated GPS/cellular antenna that is mounted on the lower right corner of the tractor windshield.

The cellular modem within the DAS main module is connected to the GPS integrated antenna. The modem enables the remote monitoring of the status of DASs as well as the general health of the RSD system and the tractor activity. At the end of each ignition cycle, a connection to a commercial cellular provider is attempted to transfer an extensive subset of data back to UMTRI servers. These data are described in Chapter 3.

UMTRI

Figure 10. Photo. GPS receiver for the DAS.

CHAPTER 3. DAS DATA DESCRIPTION

A subset of the data collected during each trip is transmitted to UMTRI when the engine is turned off at the end of the trip. The full data set is accumulated on the DAS and can be downloaded when a computer is connected directly to the DAS.

MONITORING VEHICLE TRAVEL AND FLEET HEALTH WITH THE DAS

At the end of each ignition cycle (or "trip") the DAS sends a compact set of data over the cellular modem. These data include snapshot images to verify camera operation, summary statistics about the trip (e.g., speed, distance, braking, etc.), statistics about forward objects ("targets") from the vision-based ranging sensor, statistics about other connected vehicles and units of Roadside Equipment (RSE) that were encountered, summary information about alerts (e.g., which remote vehicle was involved, where the event occurred, kinematics of the event, a short video clip), and various diagnostic parameters about the vehicle, the GPS, amount of data recorded, and more.

These data allow monitoring of the vehicle operation and the overall health and functionality of the DAS and the elements that send data to the DAS, whether directly or indirectly. Appendix B provides a list of the data elements that are sent by cellular modem.

DAS DATA ARCHIVE

The main DAS data set is much more complete than the data sent by cellular modem. The main data set is downloaded from the DAS to a laptop via a hardwire Ethernet connection by UMTRI staff during periodic visits to the truck depot. The download time is approximately one hour per month of data collected. A complete listing of the main DAS data is provided in Appendix C.

CHAPTER 4. INSTRUCTIONS FOR DAS USE

The DAS is a research device whose software is proprietary to UMTRI and integrated into a larger architecture that includes data definition, collection, auditing, archiving, and analysis. Although this device is reconfigurable and designed to migrate from one project to another with relatively little effort, it is not designed as a general purpose data collection system for commercial use. The DAS has also been designed for use by experts and even many of the experienced UMTRI engineers and users of DAS data do not directly reconfigure the system. However, UMTRI has supported the use of the DAS by research partners including USDOT, Battelle, and others. This section describes how such partners are instructed on its use for limited data collection efforts, such as test track studies or limited field data collection. The process assumes collaboration between the research partner and UMTRI, with both parties performing essential tasks for the collection of data.

The process begins with UMTRI configuring the DAS for the appropriate data collection, which usually takes on one of two forms when working with a research partner: (1) turnkey data collection for unstructured field studies, such as one in which the research partners uses a test vehicle over a period of days, weeks, or months, and wishes to collect data on the experience for later analyses, or (2) a test mode, in which a passenger in the vehicle has access to a computer display in the vehicle that displays live data. In the engineering test mode, the operator is trained and may start and stop data collection at will. Examples of this are engineering or human factors studies on test tracks or public roads.

The second part of the process is that the research partner is provided with a laptop with pre-loaded software that manages the offloading of data from the DAS. This is usually an UMTRI laptop to significantly simplifying computer security issues. The laptop and the DAS communicate in a manner similar to an UMTRI hardwire download, with each side logging facts about the data transaction in order to detect errors, manage files and folders, and allow confident deletion of data from the DAS.

The third part is that the data is transferred to UMTRI through convenient means, and UMTRI loads the data into a Microsoft SQL database. UMTRI can then share the database or process the data and share data or results. Some experienced users (e.g., NHTSA VRTC staff) are shown an alternative to this third step, in which the UMTRI laptop loads the data into a local MySQL database, and the user exports data into another format. In any case, the UMTRI video requires custom software to view since it is composed of MPEG4 video frames imbedded in a stripped-down container file to reduce file sizes and improve analysts' speed to access individual frames.

The following section describes the process of using the DAS and copying files from the DAS.

EQUIPMENT NEEDED

The equipment needed to move files from a DAS includes:

- DAS Mode control box (see figure 11) and GEN5 conversion wire harness.
- A pre-configured laptop with UMTRI FileMover software program and SQL Server client and server services installed.
- Ethernet crossover cable.
- Vehicle ignition key.
- Optional—AC power for the laptop.

UMTRI

Figure 11. Photo. DAS mode controller (a.k.a. Blue Box).

FILE DOWN-LOAD PROCEDURE

The following procedure details how to connect an UMTRI configured laptop to the GEN5 DAS, authenticate with the DAS, and run a customized executable program that moves files from the DAS to the laptop. For reference, figure 12 shows the DAS interface panel with labels identifying ports. The status LED lights for the DAS are shown bottom/left of the figure. The DAS mode control harness connects to the DAS via the Service connector. The Ethernet cable connects to the Download port.

Before beginning the download process make sure the vehicle and DAS are fully powered off (no status LED lights illuminated).

1. **Boot-up the laptop and login**[1] using the following login and password.[2]

   User name: LaptopUserName

   Password: LaptopPassword

[1] It is recommended to plug-in the laptop for this procedure since disk write speeds will be faster if the laptop is powered from an external supply as opposed to its internal battery.

[2] The laptop IP address must be on the same sub-net as the DAS.

Verify that SQL Server services are running.[3] This can be done two ways: a) Under Computer Management; select SQL Server 20XX Services. The services named SQL Server (MSSQLSERVER) must be running. If it is not running, start the service. b) Using the start menu or from the desktop, launch SQL Server Management Studio and enter the following: Server type: Database Engine; Server name: *LapTopName*; select Windows Authentication and Connect. If the services are running, the program will show a screen similar to figure 13.

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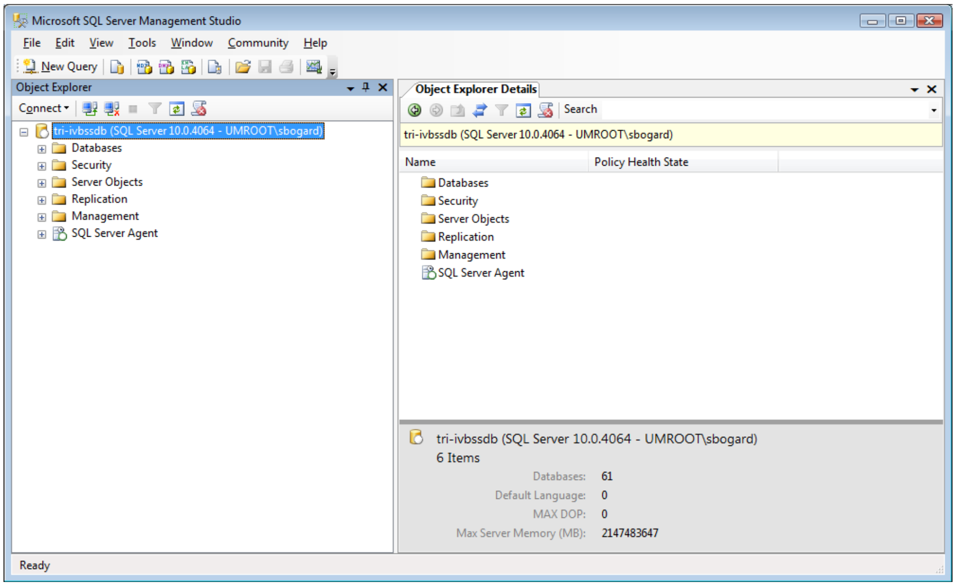
Figure 12. Photo. Interface panel on the GEN5 DAS.

[3] SQL Server is necessary for this process because catalog information that details all the files generated by the DAS will be copied into a catalog located in an SQL database on the laptop. Among other functions, the catalog 'tells' the program which files to copy to the laptop ensuring that only files generated by the DAS since the last download are copied to the laptop.



UMTRI

Figure 13. Screen shot. Microsoft SQL Server Management Studio.

2. **Connect the Ethernet cable to the DAS Download port and the laptop.**

3. **Connect the UMTRI DAS Mode control box to the DAS Service port**. The box setting must be:

Power switch: OFF
Dial: Maint

4. **Power-up the vehicle**. To boot the DAS the ignition signal must high by setting the ignition key to the on position (ideally, the vehicle is running to avoid battery discharge). Note: For the DAS to boot a minimum voltage threshold must be met. At times starting the vehicle is necessary to meet this minimum threshold.

5. **Authenticate to the DAS**: Before beginning to authenticate, confirm that the DAS is fully booted (about 30 seconds). To authenticate, double click the shortcut icons on the desktop. (Alternatively, if the laptop is configured, you can launch a windows explorer and enter the computer name, e.g., \\DasName). If authentication does not occur, check that the laptop and DAS have consistent IP addresses.

Name[4]: DasName
IP: 000.000.000.000
User name: LoginName
Password: (Call UMTRI for this)

6. **Confirm Successful Authentication**: After the laptop is authenticated, a browser window will show the shared folders on the DAS.

7. **Launch FileMover.exe** program located on the desktop. The program control form is shown in figure 14.

8. **Enter DAS and Device number and Select "Copy files from DAS to Server"** button and confirm you want to continue.[5]

DAS Number: Das Number
Device Number: Device Number

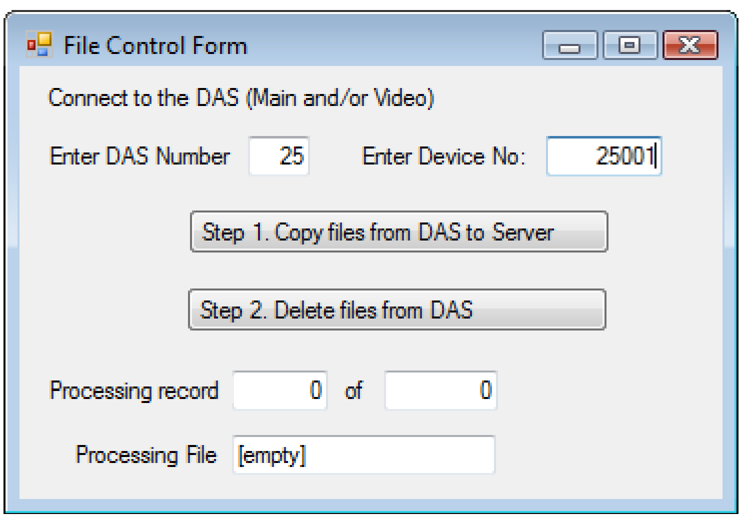


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Figure 14. Screen shot. FileMover program interface.

[4] Each UMTRI DAS is assigned a unique name and number which is indicated by a label on the DAS enclosure.
[5] The program will display a "Done" dialog box when finished.

LOADING A DATABASE

This section details the process to load binary files from the DAS into a database. If not running on the laptop, launch Microsoft SQL Server Management Studio as shown in figure 13. This process assumes you are familiar with SQL Server Management Studio. If not, there are many references available:

- Browse the applicable database.
- Browse Programmability:Stored Procedures.
- **Execute** the stored procedure **EnterFilesInDatabase** (Display the Messages tab for status information).
- **When EnterFilesInDatabase is finished, Execute** the stored procedure called **RunMe** to post process the raw tables and synchronize data collected from different sources.

CHAPTER 5. SUMMARY

This report provides a description of the data acquisition system (DAS) installed with the Battelle team RSD kits on eight class-8 tractors for participation in the Safety Pilot Model Deployment. The DAS captures a comprehensive set of data addressing the vehicle operation, driving activities and performance, V2V and V2I data exchanges, and details of the safety applications' driver alerts and supporting data. The DAS interfaces with several sensors and modules that together provide these data. This document presented the DAS itself as well as the supporting sensors and modules, the manner in which these were installed on RSD vehicles, and lists the data that is captured from the system.

APPENDIX A. OVER-THE-PHONE DATA ON THE CONNECTED COMMERCIAL VEHICLES—RETROFIT SAFETY DEVICE KIT

This appendix presents the data that is transferred over cellular networks to UMTRI for the Connected Commercial Vehicles—Retrofit Safety Device Kit Project. A cellular link is attempted after every ignition cycle. If the link is not completed or that ignition cycle's data is not completely transferred before the link is dropped, another attempt is made upon key-off on the subsequent ignition cycle.

Details of the numerical data transferred over-the-modem during Model Deployment are shown in the sections below. In addition to the measures given below, the host vehicle device and trip numbers will also become part of the data archive. This is often referred to as the "phone" database. This database is used for monitoring the fleet and should not be used in final safety analyses because the main data set that is described in Appendix C is more comprehensive and has had more care in ensuring completeness.

SUMMARY RECORDS

The Summary table includes aggregated measures across an entire trip. There is one record per trip in the database.

Table 1. Over-the-phone measures captured in the Summary file.

Name	Type	Units	Description
AvailableDistanceLeft	Single Float	m	Distance Mobileye left boundary was available
AvailableDistanceRight	Single Float	m	Distance Mobileye right boundary was available
BrakeCount	Long Integer	none	Count of brake applications
Das	Byte	none	Das number
Distance	Single Float	m	Trip distance
Driver	Short Integer	none	Driver number
EmergencyShutDown	Byte	none	Shut down request from Blue Earth micro because of out-of-range
EndTime	Long Integer	cs	Last time of test
HistWiper	CategoryHistogram	none	Wipers histogram
Latitude	Double Float	deg	Latitude from Ublox GPS
Longitude	Double Float	deg	Longitude from Ublox GPS
Odometer	Single Float	m	Vehicle Odometer
ParkingBrake	Byte	none	Parking brake active
Speed	Single Float	m/s	Vehicle speed from transmission
StartTime	Long Integer	cs	First time of test
TODTripStart	Double Float	none	Absolute date/time corresponding to test time = 0 in access date/time format based on computer clock
TripStart	Double Float	none	Absolute date/time corresponding to test time = 0 in access date/time format
UmtriBusErrors	Long Integer	none	Umtri can bus errors
UmtriBusOverruns	Long Integer	none	Umtri can bus overruns
Vehicle	Short Integer	none	Vehicle number
VehicleBusErrors	Long Integer	none	J1939 can bus errors
VehicleBusOverruns	Long Integer	none	J1939 can bus overruns
VehicleType	Byte	none	Enumerated list of vehicle types and models for Model Deployment
Vgt25Distance	Single Float	m	Distance above 25 mph
WarmStart	Byte	none	True if ignition happened with the das already running
WiperDistance	Single Float	m	Distance wipers were on

Source: UMTRI

DIAGNOSTICS RECORDS

The contents of the Diagnostics summary measures, shown in table 2 will include at a minimum the following collection of histogram and aggregated statistics. There is one Diagnostic record created per trip.

Table 2. Over-the-phone measures captured in the Diagnostic file.

Name	Type	Units	Description
HistCycleDuration	FloatHistogram	none	Cycle duration Histogram
HistCycleTime	FloatHistogram	none	Cycle time Histogram
HistDasTemperature	FloatHistogram	none	Das temperature Histogram
HistDasVoltage	FloatHistogram	none	DAS voltage histogram
HistNumberOfRv	CategoryHistogram	none	Histogram of number of remote vehicles
HistNumTargets	CategoryHistogram	none	Histogram of Mobileye number of obstacles
HistRange	FloatHistogram	none	Range Histogram from the ACC1 message
HistRangeRate	FloatHistogram	none	Rangerate Histogram from the ACC1 message
HistVgt25	CategoryHistogram	none	Velocity > 25 mph histogram
UmtriBusErrors	Long Integer	none	UMTRI's project CAN bus errors

Source: UMTRI

TRANSITIONAL REMOTE-VEHICLE EVENT RECORDS

One transitional event file will be created and sent over the phone at the end of each trip. This file contains the identification and time for at most nine remote vehicles (the number of remote vehicles being tracked may be changed upward). The format for the transition file is shown below in table 3.

Table 3. Over-the-phone measures captured in the remote vehicle transition file.

Name	Type	Units	Description
Time	Long Integer	cs	Time in centiseconds since das started
ChannelId	Short Integer	none	Channel Identification number in DAS
Value	Short Integer	none	Remote Vehicle Fixed Identification Number

Source: UMTRI

TRIGGERED EVENT RECORDS

Two triggered event data files were transferred to UMTRI following each trip. They contain instantaneous snapshots of the conditions at the time of events. One file detailed the conditions when cautionary-level warnings were given to the driver; the other, when imminent-level warnings were given. In addition to the measures listed in table 4 and table 5, the files will also contain the Device and Trip number and Time of the event.

Table 4. Over-the-phone measures captured in the Inform Event triggered summary.

Name	Type	Units	Description
InformHvAx	Single Float	m/s^2	Host vehicle longitudinal acceleration at inform
InformHvBrake	Byte	none	State of host vehicle brake at inform
InformHvRange	Single Float	m	Host vehicle range from Mobileye (Radar) at the time of a inform
InformHvRangeRate	Single Float	m/sec	Host vehicle range rate from Mobileye (Radar) at the time of a inform
InformHvSpeed	Single Float	m/sec	Host vehicle speed from transmission at the time of a inform
InformRvAx	Single Float	m/s^2	Remote vehicle longitudinal acceleration from BSM at the time of inform
InformRvBrake	Byte	none	Remote vehicle brake status from BSM at the time of a inform
InformRvDevice	Short Integer	none	Remote vehicle device number of inform
InformRvHeading	Single Float	deg	Remote vehicle heading from BSM at the time of a inform
InformRvLatitude	Double Float	deg	Remote vehicle latitude from BSM at the time of a inform
InformRvLatOffset	Single Float	m	Remote vehicle lateral offset from target class at the time of a inform
InformRvLocation	Byte	none	Location of the Inform, enumerated type.
InformRvLongitude	Double Float	deg	Remote vehicle longitude from BSM at the time of a inform
InformRvLongOffset	Single Float	m	Remote vehicle longitude offset from target class at the time of a inform
InformRvRandomId	Short Integer	none	Remote vehicle device number of inform
InformRvSpeed	Single Float	m/s	Remote vehicle speed from BSM at the time of a inform
InformTcRange	Single Float	m	Remote vehicle range from target classification at the time of a inform
InformTcRangeRate	Single Float	m/s	Remote vehicle range rate from target classification at the time of a inform
InformType	Byte	none	Type of inform, enumerated type, FCW, IMA, etc.

Source: UMTRI

Table 5. Over-the-phone measures captured in the Warning Event triggered summary.

Name	Type	Units	Description
WarningHvAx	Single Float	m/s^2	Host vehicle longitudinal acceleration at Warning
WarningHvBrake	Byte	none	State of host vehicle brake at Warning
WarningHvRange	Single Float	m	Host vehicle range from Mobileye (Radar) at the time of a Warning
WarningHvRangeRate	Single Float	m/s	Host vehicle range rate from Mobileye (Radar) at the time of a Warning
WarningHvSpeed	Single Float	m/s	Host vehicle speed from transmission at the time of a Warning
WarningRvAx	Single Float	m/s^2	Remote vehicle longitudinal acceleration from BSM at the time of Warning
WarningRvBrake	Byte	none	Remote vehicle brake status from BSM at the time of a Warning
WarningRvDevice	Short Integer	none	Remote vehicle device number of Warning
WarningRvHeading	Single Float	deg	Remote vehicle heading from BSM at the time of a Warning
WarningRvLatitude	Double Float	deg	Remote vehicle latitude from BSM at the time of a Warning
WarningRvLatOffset	Single Float	m	Remote vehicle lateral offset from target class at the time of a Warning
WarningRvLocation	Byte	none	Location of the Warning, enumerated type.
WarningRvLongitude	Double Float	deg	Remote vehicle longitude from BSM at the time of a Warning
WarningRvLongOffset	Single Float	m	Remote vehicle longitude offset from target class at the time of a Warning
WarningRvRandomId	Short Integer	none	Remote vehicle device number of Warning
WarningRvSpeed	Single Float	m/s	Remote vehicle speed from BSM at the time of a Warning
WarningTcRange	Single Float	m	Remote vehicle range from target classification at the time of a Warning
WarningTcRangeRate	Single Float	m/s	Remote vehicle range rate from target classification at the time of a Warning
WarningType	Byte	none	Type of Warning, enumerated type, FCW, IMA, etc.

Source: UMTRI

SUB-SAMPLED TIME HISTORY RECORDS

The DAS sends abbreviated GPS bread crumbs over the cellular modem. Two sets of sub-sampled time history data are transferred. The first set, shown in table 6, shows the host-vehicle GPS data record. Table 7 shows GPS data from each remote vehicle, as it is included in the over-the-phone database. As currently implemented these data will be sub-sampled at 0.5 Hz (a new record every 2 s). One host-vehicle file and one remote-vehicle file are transferred per trip.

Table 6. Over-the-phone measures for sub-sampled Host vehicle GPS measures.

Name	Type	Units	Description
GpsHeading	Single Float	deg	GPS heading from Ublox GPS
GpsSpeed	Single Float	m/s	Speed from GPS
GpsTime	Long Integer	ms	GPS millisecs in week from GPS
GpsWeek	Short Integer	none	GPS week from GPS
Latitude	Double Float	deg	Latitude from Ublox GPS
Longitude	Double Float	deg	Longitude from Ublox GPS
Time	Long Integer	cs	Time in centiseconds since das started

Source: UMTRI

Table 7. Over-the-phone measures sub-sampled Remote vehicle GPS measures.

Name	Type	Units	Description
RangeTc	Double Float	m	Target classification range to RV
LocationClassTc	Byte	none	Target classification location class (enumeration)
LatitudeRv	Double Float	deg	Remote Vehicle Latitude
LongitudeRv	Double Float	deg	Remote Vehicle Longitude
HeadingRv	Single Float	deg	Remote Vehicle Heading
RvRandomIdRv	Short Integer	none	Remote Vehicle Temporary Id
RvDeviceRv	Short Integer	none	Remote Vehicle Device Id
SpeedRv	Single Float	m/s	Remote Vehicle Speed
ReceivedGpsTimeRv	Big Integer	ms	System time when message is received

Source: UMTRI

SNAPSHOTS

An image from each camera will be captured and sent over the phone to verify that the cameras are working and in focus. These images are taken once per trip and are selected by sending the first image after the vehicle speed exceeds 25 mph. An example set of snapshot images is shown below in Figure 15. These depict snapshots from a DAS in a passenger vehicle, but the RSD images are handled in the same manner.

A set of images is also captured and sent corresponding to each basic safety application event.

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Figure 15. Screen shot. Example snapshot images.

APPENDIX B. DATA ACQUISITION DATA ON THE CONNECTED COMMERCIAL VEHICLES—RETROFIT SAFETY DEVICE KIT PLATFORM

This appendix provides a listing of the data signals captured by the DAS on the RSD project. These data include signals coming from several sensors or modules; data from the tablet is not recorded.

The main database includes several tables that are inter-related and can be joined together using the table key indices or fields. Each table has many records, and the tables can be categorized by what that record represents, e.g., a moment in time, an entire trip, characteristics of a specific event. Table 8 lists the tables and fields for the database that is being provided to the USDOT Volpe Center in their role as independent evaluator. Table 8 is sorted by table, and then by field ID.

Some fields represent categorical variables that can take on only a small number of values. For instance, in table 8, the ninth row shows that ID = 181 is a field named BoundaryLeft which represents the DAS's forward vision sensor's perception of the type of lane marker to the left of the equipped vehicle. The StyleId is given as "408." The field will can take on a number of different integer values, and the meaning of each of those values is given in table 9 under StyleID = 408. Table 9 shows that there are seven types of boundary types for that variable.

These database tables are common across platforms—car, bus, motorcycle, truck. The documentation includes a few measures that do not apply across all platforms. For example, PRNDL transmission values are not available on the J1939 bus and are zero for commercial vehicles.

Table 8. Main DAS data set tables and fields.

Id	Table	TableDescr	Name	Units	Description	StyleId
128	AudioTimes	Audio timestamps(time when AudioNew = true)	AudioCount	none	Audio frame count	0
245	AudioTimes	Audio timestamps(time when AudioNew = true)	TimeCs	cs	Time in centiseconds since das started	0
43	DataDas	Main Das Data Record	AccelPedal	%	Accelerator pedal	0
123	DataDas	Main Das Data Record	Altitude	m	Height above the ellipsoid	0
219	DataDas	Main Das Data Record	AvailableLeft	none	Left boundary availability	1
220	DataDas	Main Das Data Record	AvailableRight	none	Right boundary availability	1
1037	DataDas	Main Das Data Record	Ax	m/s^2	Longitudinal accel from IMU	0
1038	DataDas	Main Das Data Record	Ay	m/s^2	Lateral accel from the IMU	0
181	DataDas	Main Das Data Record	BoundaryLeft	none	Left lane boundary type	408
182	DataDas	Main Das Data Record	BoundaryRight	none	Right lane boundary type	408
46	DataDas	Main Das Data Record	Brake	none	Brake light active	11
53	DataDas	Main Das Data Record	CruiseEngaged	none	Cruise control active	1
51	DataDas	Main Das Data Record	Distance	m	Trip distance	0
21	DataDas	Main Das Data Record	GpsHeading	deg	GPS heading from Ublox GPS	19
18	DataDas	Main Das Data Record	Latitude	deg	Latitude from Ublox GPS	15
19	DataDas	Main Das Data Record	Longitude	deg	Longitude from Ublox GPS	15
222	DataDas	Main Das Data Record	NumTargets	none	Number of obstacles ahead	0

Id	Table	TableDescr	Name	Units	Description	StyleId
234	DataDas	Main Das Data Record	Range	m	Forward Object 1 longitudinal position relative to the reference point.	0
235	DataDas	Main Das Data Record	RangeRate	m/s	Forward Object 1 relative longitudinal velocity	0
39	DataDas	Main Das Data Record	Speed	m/s	Vehicle speed from transmission	36
11	DataDas	Main Das Data Record	Time	cs	Time in centiseconds since das started	0
57	DataDas	Main Das Data Record	TurnSignal	none	Turn signal	32
1039	DataDas	Main Das Data Record	YawRate	deg/s	Yaw rate from the IMU	0
123	DataGpsDas	Gps log record	Altitude	m	Height above the ellipsoid	0
28	DataGpsDas	Gps log record	Differential	none	True if GPS fix is differential	1
26	DataGpsDas	Gps log record	FixMode	none	GPS fix mode	74
29	DataGpsDas	Gps log record	GpsBytes	none	Number of bytes in GPS buffer for debug.	0
21	DataGpsDas	Gps log record	GpsHeading	deg	GPS heading from Ublox GPS	19
22	DataGpsDas	Gps log record	GpsSpeed	m/s	Speed from GPS	36
25	DataGpsDas	Gps log record	GpsTime	ms	GPS millisecs in week from GPS	0
24	DataGpsDas	Gps log record	GpsWeek	none	GPS week from GPS	0
18	DataGpsDas	Gps log record	Latitude	deg	Latitude from Ublox GPS	15
19	DataGpsDas	Gps log record	Longitude	deg	Longitude from Ublox GPS	15
20	DataGpsDas	Gps log record	NumberOfSats	none	Number of satellites from Ublox GPS	0

Id	Table	TableDescr	Name	Units	Description	StyleId
27	DataGpsDas	Gps log record	Pdop	none	GPS pdop	0
245	DataGpsDas	Gps log record	TimeCs	cs	Time in centiseconds since das started	0
238	DataGpsDas	Gps log record	UtcTime	ms	UTC millisecs in week from GPS	0
239	DataGpsDas	Gps log record	UtcWeek	none	UTC week from GPS	0
188	DataLane	Data Record for Lane Tracking	LaneDistanceLeft	m	Left lane position measured from the boundary to the camera	0
187	DataLane	Data Record for Lane Tracking	LaneDistanceRight	m	Right lane position measured from the right boundary to the camera	0
218	DataLane	Data Record for Lane Tracking	LaneHeading	none	Lane heading	0
184	DataLane	Data Record for Lane Tracking	LaneQualityLeft	none	Left lane quality	0
183	DataLane	Data Record for Lane Tracking	LaneQualityRight	none	Right lane quality	0
284	DataRv	Remote Vehicle	RvDevice	none	Remote Vehicle Id	0
280	DataRv	Remote Vehicle	LatitudeRv	deg	Remote Vehicle Latitude	0
281	DataRv	Remote Vehicle	LongitudeRv	deg	Remote Vehicle Longitude	0
282	DataRv	Remote Vehicle	ElevationRv	m	Remote Vehicle Altitude	0
283	DataRv	Remote Vehicle	HeadingRv	deg	Remote Vehicle Heading	0
285	DataRv	Remote Vehicle	YawrateRv	deg/s	Remote Vehicle yaw rate	0
286	DataRv	Remote Vehicle	AxRv	m/s^2	Remote Vehicle longitudinal accereration	0
287	DataRv	Remote Vehicle	SpeedRv	m/s	Remote Vehicle Speed	36

Id	Table	TableDescr	Name	Units	Description	StyleId
288	DataRv	Remote Vehicle	BrakeRv	none	Remote vehcile brake active	0
290	DataRv	Remote Vehicle	GpsTimeRv	ms	Remote Vehicle GPS Time	0
291	DataRv	Remote Vehicle	GpsCoastRv	none	1 = coasting in progress. 0 = no coasting	0
1099	DataTa	Threat Arbitration	RvDevice	none	Threat RV Unique Id	0
534	DataTa	Threat Arbitration	ThreatAppId	none	Threat application Id from DENSO WSU	406
535	DataTa	Threat Arbitration	ThreatState	none	DENSO WSU threat State	404
540	DataTa	Threat Arbitration	ThreatLevel	none	Threat level from DENSO WSU	0
536	DataTa	Threat Arbitration	ThreatPriority	none	Threat priority from DENSO WSU	0
537	DataTa	Threat Arbitration	ThreatLocation	none	Threat location from DENSO WSU	110
539	DataTa	Threat Arbitration	GpsTimeWsu	msec	GPS Time (Epoch) from WSU	0
269	DataTc	Target Classification	GpsTimeTc	msec	Target classification GPS time (epoch)	0
270	DataTc	Target Classification	LongOffsetTc	m	Target classification longitudinal offset	0
271	DataTc	Target Classification	LatOffsetTc	m	Target classification lateral offset	0
272	DataTc	Target Classification	RangeTc	m	Target classification range to RV	0
273	DataTc	Target Classification	RangeRateTc	m/s	Target classification range rate to RV	0
274	DataTc	Target Classification	AzimuthTc	deg	Target classification azimuth angle to RV	0
275	DataTc	Target Classification	RelHeadingTc	deg	Target classification host and remote vehicle relative heading	0

Id	Table	TableDescr	Name	Units	Description	StyleId
276	DataTc	Target Classification	LocationClassTc	none	Target classification location class (enumeration)	110
277	DataTc	Target Classification	NoLocationClassTc	none	Reason for removing target classification	0
500	DataWsu	Wsu Measures	GpsValidWsu	none	GPS Valid from WSU	1
501	DataWsu	Wsu Measures	GpsTimeWsu	msec	GPS Time (Epoch) from WSU	0
502	DataWsu	Wsu Measures	LatitudeWsu	deg	Latitude from WSU receiver	0
503	DataWsu	Wsu Measures	LongitudeWsu	deg	Longitude from WSU receiver	0
504	DataWsu	Wsu Measures	AltitudeWsu	m	Altitude from WSU receiver	0
505	DataWsu	Wsu Measures	GpsHeadingWsu	deg	Heading from WSU GPS receiver	0
506	DataWsu	Wsu Measures	GpsSpeedWsu	m/s	Speed from WSU GPS receiver	0
507	DataWsu	Wsu Measures	HdopWsu	none	Horizontal dilution of precision	0
508	DataWsu	Wsu Measures	PdopWsu	none	Position dilution of precision	0
509	DataWsu	Wsu Measures	FixQualityWsu	none	GPS Fix Quality	0
510	DataWsu	Wsu Measures	GpsCoastingWsu	none	GPS Coasted	0
511	DataWsu	Wsu Measures	ValidCanWsu	none	Valid Vehicle Can message to WSU	1
512	DataWsu	Wsu Measures	YawRateWsu	deg/s	Yaw rate from vehicle can via WSU	0
513	DataWsuRaw	Wsu Measures	SpeedWsu	kph	Speed from vehicle can via WSU	0
515	DataWsuRaw	Wsu Measures	TurnSngLWsu	none	Left turnsignal from vehicle can via WSU	11
514	DataWsuRaw	Wsu Measures	TurnSngRWsu	none	Right turnsignal from vehicle can via WSU	11

Id	Table	TableDescr	Name	Units	Description	StyleId
516	DataWsuRaw	Wsu Measures	BrakeAbsTcsWsu	none	Brake, ABS, and traction control from vehicle can via WSU	0
517	DataWsuRaw	Wsu Measures	AxWsu	m/s^2	Longitudinal accel from vehicle can via WSU	0
518	DataWsuRaw	Wsu Measures	PrndlWsu	none	PRNDL from vehicle can viaWSU	403
519	DataWsuRaw	Wsu Measures	VsaActiveWsu	none	Stability control active from vehicle can via WSU	0
520	DataWsuRaw	Wsu Measures	HeadlampWsu	none	Headlamp state from vehicle can via WSU	0
521	DataWsuRaw	Wsu Measures	WiperWsu	none	Wiper state from vehicle can via WSU	0
522	DataWsuRaw	Wsu Measures	ThrottleWsu	none	Throttle from vehicle can via WSU	0
523	DataWsuRaw	Wsu Measures	SteerWsu	deg	Steer from vehicle can via WSU	0
414	EvtDetect	Detect triggered series	RvDevice	none	Remote vehicle device number of detect	0
408	EvtDetect	Detect triggered series	DetectType	none	Type of detection, enumerated type, fcw, ima, etc.	406
1037	EvtDetect	Detect triggered series	HvAx	m/s^2	Longitudinal accel from the IMU	0
46	EvtDetect	Detect triggered series	HvBrake	none	Brake light active	11
21	EvtDetect	Detect triggered series	HvGpsHeading	deg	GPS heading from Ublox GPS	19
18	EvtDetect	Detect triggered series	HvLatitude	deg	Latitude from Ublox GPS	15
19	EvtDetect	Detect triggered series	HvLongitude	deg	Longitude from Ublox GPS	15
234	EvtDetect	Detect triggered series	HvRange	m	Object 1 longitudinal position relative to the reference point.	0

Id	Table	TableDescr	Name	Units	Description	StyleId
235	EvtDetect	Detect triggered series	HvRangeRate	m/s	Relative longitudinal velocity of object1	0
39	EvtDetect	Detect triggered series	HvSpeed	m/s	Vehicle speed from transmission	36
412	EvtDetect	Detect triggered series	RvLocation	none	Location of the detection, enumerated type.	110
450	EvtDetect	Detect triggered series	RvAx	m/s^2	Remote vehicle longitudinal acceleration from BSM at the time of detect	0
449	EvtDetect	Detect triggered series	RvBrake	none	Remote vehicle brake status from BSM at the time of a detect	11
443	EvtDetect	Detect triggered series	RvHeading	deg	Remote vehicle heading from BSM at the time of a detect	0
544	EvtDetect	Detect triggered series	RvRandomId	none	Remote vehicle device number of detect	0
444	EvtDetect	Detect triggered series	RvLatitude	deg	Remote vehicle latitude from BSM at the time of a detect	0
445	EvtDetect	Detect triggered series	RvLongitude	deg	Remote vehicle longitude from BSM at the time of a detect	0
448	EvtDetect	Detect triggered series	RvLatOffset	m	Remote vehicle lateral offset from target class at the time of a detect	0
447	EvtDetect	Detect triggered series	RvLongOffset	m	Remote vehicle longitude offset from target class at the time of a detect	0
441	EvtDetect	Detect triggered series	RvSpeed	m/s	Remote vehicle speed from BSM at the time of a detect	0

Id	Table	TableDescr	Name	Units	Description	StyleId
442	EvtDetect	Detect triggered series	TcRange	m	Remote vehicle range from target classification at the time of a detect	0
446	EvtDetect	Detect triggered series	TcRangeRate	m/s	Remote vehicle range rate from target classification at the time of a detect	0
415	EvtInform	Inform triggered series	RvDevice	none	Remote vehicle device number of inform	0
409	EvtInform	Inform triggered series	InformType	none	Type of inform, enumerated type, FCW, IMA, etc.	406
1037	EvtInform	Inform triggered series	HvAx	m/s^2	Longitudinal accel from IMU	0
46	EvtInform	Inform triggered series	HvBrake	none	Brake light active	11
21	EvtInform	Inform triggered series	HvGpsHeading	deg	GPS heading from Ublox GPS	19
18	EvtInform	Inform triggered series	HvLatitude	deg	Latitude from Ublox GPS	15
19	EvtInform	Inform triggered series	HvLongitude	deg	Longitude from Ublox GPS	15
234	EvtInform	Inform triggered series	HvRange	m	Object 1 longitudinal position relative to the reference point.	0
235	EvtInform	Inform triggered series	HvRangeRate	m/s	Relative longitudinal velocity of object 1	0
39	EvtInform	Inform triggered series	HvSpeed	m/s	Vehicle speed from transmission	36
410	EvtInform	Inform triggered series	RvLocation	none	Location of the Inform, enumerated type.	110
440	EvtInform	Inform triggered series	RvAx	m/s^2	Remote vehicle longitudinal acceleration from BSM at the time of inform	0

Id	Table	TableDescr	Name	Units	Description	StyleId
439	EvtInform	Inform triggered series	RvBrake	none	Remote vehicle brake status from BSM at the time of a inform	11
433	EvtInform	Inform triggered series	RvHeading	deg	Remote vehicle heading from BSM at the time of a inform	0
542	EvtInform	Inform triggered series	RvRandomId	none	Remote vehicle device number of inform	0
434	EvtInform	Inform triggered series	RvLatitude	deg	Remote vehicle latitude from BSM at the time of a inform	0
435	EvtInform	Inform triggered series	RvLongitude	deg	Remote vehicle longitude from BSM at the time of a inform	0
438	EvtInform	Inform triggered series	RvLatOffset	m	Remote vehicle lateral offset from target class at the time of a inform	0
437	EvtInform	Inform triggered series	RvLongOffset	m	Remote vehicle longitude offset from target class at the time of a inform	0
431	EvtInform	Inform triggered series	RvSpeed	m/s	Remote vehicle speed from BSM at the time of a inform	0
432	EvtInform	Inform triggered series	TcRange	m	Remote vehicle range from target classification at the time of a inform	0
436	EvtInform	Inform triggered series	TcRangeRate	m/s	Remote vehicle range rate from target classification at the time of a inform	0
413	EvtWarning	Warning triggered series	WarningRvDevice	none	Remote vehicle device number of warning	0

Id	Table	TableDescr	Name	Units	Description	StyleId
407	EvtWarning	Warning triggered series	WarningType	none	Type of warning, enumerated type, fcw, ima, etc.	406
1037	EvtWarning	Warning triggered series	HvAx	m/s^2	Longitudinal accel from the IMU	0
46	EvtWarning	Warning triggered series	HvBrake	none	Brake light active	11
21	EvtWarning	Warning triggered series	HvGpsHeading	deg	GPS heading from Ublox GPS	19
18	EvtWarning	Warning triggered series	HvLatitude	deg	Latitude from Ublox GPS	15
19	EvtWarning	Warning triggered series	HvLongitude	deg	Longitude from Ublox GPS	15
234	EvtWarning	Warning triggered series	HvRange	m	Object 1 longitudinal position relative to the reference point.	0
235	EvtWarning	Warning triggered series	HvRangeRate	m/s	relative longitudinal velocity of object1	0
39	EvtWarning	Warning triggered series	HvSpeed	m/s	Vehicle speed from transmission	36
411	EvtWarning	Warning triggered series	RvLocation	none	Location of the warning, enumerated type.	110
430	EvtWarning	Warning triggered series	RvAx	m/s^2	Remote vehicle longitudinal acceleration from BSM at the time of warning	0
429	EvtWarning	Warning triggered series	RvBrake	none	Remote vehicle brake status from BSM at the time of a warning	11
423	EvtWarning	Warning triggered series	RvHeading	deg	Remote vehicle heading from BSM at the time of a warning	0
543	EvtWarning	Warning triggered series	RvRandomId	none	Remote vehicle device number of warning	0

Id	Table	TableDescr	Name	Units	Description	StyleId
424	EvtWarning	Warning triggered series	RvLatitude	deg	Remote vehicle latitude from BSM at the time of a warning	0
425	EvtWarning	Warning triggered series	RvLongitude	deg	Remote vehicle longitude from BSM at the time of a warning	0
428	EvtWarning	Warning triggered series	RvLatOffset	m	Remote vehicle lateral offset from target class at the time of a warning	0
427	EvtWarning	Warning triggered series	RvLongOffset	m	Remote vehicle longitude offset from target class at the time of a warning	0
421	EvtWarning	Warning triggered series	RvSpeed	m/s	Remote vehicle speed from BSM at the time of a warning	36
422	EvtWarning	Warning triggered series	TcRange	m	Remote vehicle range from target classification at the time of a warning	33
426	EvtWarning	Warning triggered series	TcRangeRate	m/s	Remote vehicle range rate from target classification at the time of a warning	0
89	IndexCabin	Index records for cabin video	CabinCount	none	Cabin video frame count	0
91	IndexCabin	Index records for cabin video	CabinKey	none	True if new Cabin video frame is a key frame	1
90	IndexCabin	Index records for cabin video	CabinSize	none	Size of Cabin video frame	0
1015	IndexCabin	Index records for cabin video	VideoTime	cs	Time in centiseconds since das started	0
81	IndexForward	Index records for forward video	ForwardCount	none	Forward video frame count	0

Id	Table	TableDescr	Name	Units	Description	StyleId
83	IndexForward	Index records for forward video	ForwardKey	none	True if new forward video frame is a key frame	1
82	IndexForward	Index records for forward video	ForwardSize	none	Size of Forward video frame	0
1015	IndexForward	Index records for forward video	VideoTime	cs	Time in centiseconds since das started	0
85	IndexLeft	Index records for left video	LeftCount	none	Left video frame count	0
87	IndexLeft	Index records for left video	LeftKey	none	True if new Left video frame is a key frame	1
86	IndexLeft	Index records for left video	LeftSize	none	Size of Left video frame	0
1015	IndexLeft	Index records for left video	VideoTime	csec	Time in centiseconds since das started	0
143	IndexRight	Index records for right video	RightCount	none	Right video frame count	0
145	IndexRight	Index records for right video	RightKey	none	True if new Right video frame is a key frame	1
148	IndexRight	Index records for right video	RightSize	none	Size of Right video frame	0
1015	IndexRight	Index records for right video	VideoTime	cs	Time in centiseconds since das started	0
56	Summary	Summary record	StartTime	cs	First time of test	0
52	Summary	Summary record	EndTime	cs	Last time of test	0
30	Summary	Summary record	Driver	none	Driver number	38
32	Summary	Summary record	Das	none	Das number	0
59	Summary	Summary record	Vehicle	none	Vehicle number	0
348	Summary	Summary record	VehicleType	none	Type of vehicle	0

Id	Table	TableDescr	Name	Units	Description	StyleId
47	Summary	Summary record	BrakeCount	none	Count of brake applications	0
51	Summary	Summary record	Distance	m	Trip distance	0
124	Summary	Summary record	WiperDistance	m	Distance wipers were on	0
107	Summary	Summary record	Vgt25Distance	m	Distance above 25 mph	0
231	Summary	Summary record	AvailableDistanceLeft	m	Distance left boundary was available	0
232	Summary	Summary record	AvailableDistanceRight	m	Distance right boundary was available	0
41	Summary	Summary record	WarmStart	none	True if ignition happened with the das already running	1
35	Summary	Summary record	EmergencyShutDown	none	Shut down request from Blue Earth micro because of out-of-range	0
18	Summary	Summary record	Latitude	deg	Latitude from Ublox GPS	15
19	Summary	Summary record	Longitude	deg	Longitude from Ublox GPS	15
63	Summary	Summary record	Odometer	m	Odometer	0
67	Summary	Summary record	Prndl	none	Prndl	80
39	Summary	Summary record	Speed	m/s	Vehicle speed from transmission	36
17	Summary	Summary record	TODTripStart	none	Absolute date/time corresponding to test time = 0 in access date/time format based on computer clock	0
14	Summary	Summary record	TripStart	none	Absolute date/time corresponding to test time = 0 in access date/time format	0
217	TrnBytes	Byte Transition Record	ConstructionArea	none	Construction area	0

Id	Table	TableDescr	Name	Units	Description	StyleId
48	TrnBytes	Byte Transition Record	CruiseEnabled	none	Cruise control enabled	2
68	TrnBytes	Byte Transition Record	CruiseStatus	none	Cruise status	83
223	TrnBytes	Byte Transition Record	CutinLeft	none	Left close range cut in	0
224	TrnBytes	Byte Transition Record	CutInRight	none	Right close range cut in	0
227	TrnBytes	Byte Transition Record	FailSafe	none	Fail safe	0
55	TrnBytes	Byte Transition Record	HeadLamp	none	Head lamps	72
67	TrnBytes	Byte Transition Record	Prndl	none	Prndl	80
225	TrnBytes	Byte Transition Record	SafeToGo	none	Go!	0
243	TrnBytes	Byte Transition Record	TcsActive	none	Traction control Active	1
57	TrnBytes	Byte Transition Record	TurnSignal	none	Turn signal	32
105	TrnBytes	Byte Transition Record	Vgt25	none	True if velocity >= 25 mph	1
58	TrnBytes	Byte Transition Record	Wiper	none	Wiper switch state	63
46	TrnBytes	Byte Transition Record	Brake	none	Brake light active	11
53	TrnBytes	Byte Transition Record	CruiseEngaged	none	Cruise control active	1
64	TrnBytes	Byte Transition Record	VsaActive	none	Vsa active	1

Source: UMTRI

Table 9. DAS Database Categorical Value Styles.

StyleId	StyleName	Value	Meaning of Value
1	TrueFalse	0	False
1	TrueFalse	1	True
2	EnabledDisabled	0	Disabled
2	EnabledDisabled	1	Enabled
11	OnOff	0	Off
11	OnOff	1	On
32	TurnSignalUmtri	0	None
32	TurnSignalUmtri	1	Left
32	TurnSignalUmtri	2	Right
32	TurnSignalUmtri	3	Both
63	WiperUmtri	0	Off
63	WiperUmtri	1	Delay
63	WiperUmtri	2	Low
63	WiperUmtri	3	High
63	WiperUmtri	4	Mist
63	WiperUmtri	5	Error
72	HeadLampUmtri	0	Off
72	HeadLampUmtri	1	Low
72	HeadLampUmtri	2	High
72	HeadLampUmtri	3	Both
72	HeadLampUmtri	4	Parking
72	HeadLampUmtri	5	Other
74	GpsFixModes	0	Unknown
74	GpsFixModes	1	0D
74	GpsFixModes	2	2DHold
74	GpsFixModes	3	2D
74	GpsFixModes	4	3D
74	GpsFixModes	5	OverDetermined
80	Prndl	0	Shifting
80	Prndl	1	Park
80	Prndl	2	Reverse
80	Prndl	3	Neutral

StyleId	StyleName	Value	Meaning of Value
80	Prndl	4	Drive
80	Prndl	5	Drive4
80	Prndl	6	Third
80	Prndl	7	Second
80	Prndl	8	First
83	CruiseStatus	0	InNotActive
83	CruiseStatus	1	InActive
83	CruiseStatus	2	NotInNotActive
83	CruiseStatus	3	NotInActive
110	ThreatLocationCamp	0	Unknown
110	ThreatLocationCamp	1	Ahead
110	ThreatLocationCamp	10	AheadFarLeft
110	ThreatLocationCamp	11	AheadFarRight
110	ThreatLocationCamp	12	BehindFarLeft
110	ThreatLocationCamp	13	BehindFarRight
110	ThreatLocationCamp	14	OncomingFarLeft
110	ThreatLocationCamp	15	OncomingFarRight
110	ThreatLocationCamp	16	IntersecLeft
110	ThreatLocationCamp	17	IntersecRight
110	ThreatLocationCamp	18	SideLeft
110	ThreatLocationCamp	19	SideRight
110	ThreatLocationCamp	2	Behind
110	ThreatLocationCamp	3	Oncoming
110	ThreatLocationCamp	4	AheadLeft
110	ThreatLocationCamp	5	AheadRight
110	ThreatLocationCamp	6	BehindLeft
110	ThreatLocationCamp	7	BehindRight
110	ThreatLocationCamp	8	OncomingLeft
110	ThreatLocationCamp	9	OncomingRight
403	PrndlWsu	0	Shifting
403	PrndlWsu	1	Park
403	PrndlWsu	2	Reverse
403	PrndlWsu	3	Neutral

StyleId	StyleName	Value	Meaning of Value
403	PrndlWsu	4	Drive
403	PrndlWsu	5	Drive4
403	PrndlWsu	6	First
403	PrndlWsu	7	Second
403	PrndlWsu	8	Third
403	PrndlWsu	9	Fourth
406	ThreatTypeUMTRI	0	None
406	ThreatTypeUMTRI	1	Fcw
406	ThreatTypeUMTRI	10	Cicas
406	ThreatTypeUMTRI	11	Other
406	ThreatTypeUMTRI	12	System
406	ThreatTypeUMTRI	2	Eebl
406	ThreatTypeUMTRI	3	Ima
406	ThreatTypeUMTRI	4	ImaLeft
406	ThreatTypeUMTRI	5	ImaRight
406	ThreatTypeUMTRI	6	Bsw
406	ThreatTypeUMTRI	7	BswLeft
406	ThreatTypeUMTRI	8	BswRight
406	ThreatTypeUMTRI	9	Csw
408	BoundaryType	0	Dashed
408	BoundaryType	1	Solid
408	BoundaryType	2	Undecided
408	BoundaryType	3	RoadEgde
408	BoundaryType	4	Double
408	BoundaryType	5	BottsDots
408	BoundaryType	6	Invalid

Source: UMTRI

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1200 New Jersey Avenue, SE
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