REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
11-01-2022

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Test Operations Procedure (TOP)
01-2-506A Use of Data Bus to Support Performance and Endurance Testing

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHORS

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Automotive Instrumentation Division (TEDT-AT-ADI)
US Army Aberdeen Test Center
6943 Colleran Road
Aberdeen Proving Ground, MD 21005-5059

8. PERFORMING ORGANIZATION REPORT NUMBER
TOP 01-2-506A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Policy and Standardization Division (CSTE-CI-P)
U.S. Army Test and Evaluation Command
6617 Aberdeen Boulevard
Aberdeen Proving Ground, MD 21005-5001

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
Same as item 8

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Statement A. Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
Defense Technical Information Center (DTIC), AD No.:

This TOP supersedes TOP 01-2-506, Use of Controller Area Network (CAN) Data to Support Performance Testing, dated 16 July 2015.

Marginal notations are not used in this revision to identify changes, with respect to the previous issue, due to the extent of the changes.

14. ABSTRACT
This Test Operations Procedure (TOP) provides guidance for using vehicle-based, data bus data during performance and endurance testing of military vehicles.

15. SUBJECT TERMS
Controller Area Network data bus sensor electronic control unit diagnostic trouble codes digital interface

16. SECURITY CLASSIFICATION OF: a. REPORT	B. ABSTRACT	C. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified	SAR	21	19b. TELEPHONE NUMBER *(include area code)*

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

(This page is intentionally blank.)

U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 01-2-506A 11 January 2022
DTIC AD No.

USE OF DATA BUS TO SUPPORT PERFORMANCE AND ENDURANCE TESTING

			Page
Paragraph	1.	SCOPE	2
	1.1	Application	2
	1.2	Background	2
	2.	INSTRUMENTATION	4
	2.1	General	4
	2.2	Instrumentation Setup	4
	2.3	Data Sample Rate	5
	3.	EXAMPLES OF SENSOR DATA USAGE AND VERIFICATION	5
	3.1	Vehicle Speed	6
	3.2	Engine Speed	7
	3.3	Vehicle Odometer	7
	3.4	Fuel Consumption	7
	3.5	Vehicle Transmission Feedback	8
	3.6	Vehicle Stability Systems	8
	3.7	Tire Status	10
	3.8	Fire Control Systems	10
	3.9	JAUS Messages	10
	3.10	Diagnostic Messages	11
	4.	DATA REQUIRED	11
	5.	PRESENTATION OF DATA	11
APPENDIX	A.	GLOSSARY	A-1
	B.	ABBREVIATIONS	B-1
	C.	REFERENCES	C-1
	D.	APPROVAL AUTHORITY	D-1

*This TOP supersedes TOP 01-2-506, Use of Controller Area Network (CAN) Data to Support Performance Testing, dated 16 July 2015.

Approved for public release; distribution unlimited.

1. SCOPE.

This Test Operations Procedure (TOP) provides guidance for using vehicle-based, data bus data during performance and endurance testing of military vehicles.

1.1 Application.

a. Vehicle data bus data may supplement test data from traditionally applied, National Institute of Standards and Technology (NIST)-traceable transducers during testing. Data accuracy shall be verified (when possible), and the verification process, data source, and data channels shall be documented in associated test reports. Documentation should include sample frequency, full-scale range, and data resolution. Data bus data may be used in lieu of traditionally applied transducer data when a transducer fails or becomes inoperable and retesting is not an option.

b. Cases may exist when the accuracy and frequency of data bus data cannot be verified, such as when vehicle-based controllers provide error messages regarding system functions (e.g., electronic stability control system faults). These data may provide highly valuable information, particularly when controller diagnostic information is available for analyzing system performance and limitations. In such cases, use of the data are acceptable provided the data source is stated in the test report.

c. The scope of this TOP is limited to the data bus application layer. Network, data link, and physical layer implementations are not addressed.

1.2 Background.

a. Data bus is a term referring to the communications between multiple computers or components within a computer or network. There are many types of data bus used in the commercial automotive and light truck industry. This document focuses on data bus types common to heavy-duty, military, robotic, and autonomous vehicles. Types include, but are not limited to Society of Automotive Engineers (SAE) J1708[1**], Controller Area Network (CAN), Military Standard (MIL-STD)-1553A[2], and Joint Architecture for Unmanned Systems (JAUS).

b. SAE J1708. SAE J1708 defines a bidirectional, low-speed serial communication link, based on a modification of the RS-485 standard, for heavy-duty vehicles to allow a standard set of messages to be transmitted between multiple microcomputer-based modules. A message can be a maximum of 21 bytes long during mobile operations with the engine running and transmitted at a rate of 9600 bits per second. Each message consists of a Message Identification (MID) character, data characters, and a checksum. First issued in 1986, SAE J1708 may still be used in some heavy-truck, bus, off-highway vehicle, and military generator applications. MIDs can range in number from 0 to 255. MIDs 69 to 86 and 128 to 255, defined in SAE J1922[3] and J1587[4], are the standardized messages transmitted between sensors, electronic control units,

** Superscript numbers correspond to Appendix C, References.

and computers. The SAE J1922 and J1587 standards lay out the format of standard data messages needed to monitor vehicle systems. MIDs 0 to 9, 12 to 68, and 88 to 127 should be defined in an interface control document (ICD), typically available from the manufacturer or the program management office. The ICD should define the available proprietary SAE J1708 messaging, MIDs 112 to 127, and diagnostic messages (DM).

c. CAN. A CAN is a standardized digital interface that allows high-speed communication of information in a vehicle between sensors, electronic control units, and computers. A number of sources provide details on the implementation and common message formats, including International Organization for Standardization (ISO) 11898 (Parts 1 through 6)[5] and the SAE J1939[6,7,8]. Bosch first published the specification CAN 2.0 in 1991. CAN is a message-based protocol with two different formats. The first format uses an 11-bit message identifier and is referred to as CAN 2.0A. The second format uses an extended 29-bit message identifier and is referred to as CAN 2.0B.

(1) The SAE J1939 protocol, a high-speed successor to SAE J1708, is a variant of CAN 2.0B and is the SAE recommended practice for communication and diagnostics of vehicle systems in the heavy-truck, bus, and off-highway vehicle industry. The SAE J1939 protocol is present in many wheeled military vehicles and applied to engines used in military generators. The SAE J1939 standards collection (J1939 and J1939 supplemental documents) lays out the format of standard data messages needed to monitor vehicle systems. The SAE J1939 standards also provide the framework for receiving real-time diagnostic error messages and reading historical fault codes from vehicle systems.

(2) Besides standard SAE J1939 and CAN messaging, most military vehicle systems utilize proprietary CAN messages. An ICD, available from the manufacturer or the program management office, should define the available proprietary CAN messaging and DMs.

d. MIL-STD-1553. The United States Air Force (USAF) published a multiple redundant serial data bus standard for use with military avionics in 1973. MIL-STD-1553 allows data to be transferred between up to 31 avionics devices on a data bus utilizing time division multiplexing. SAE and the Department of Defense produced a number of revisions and change notices over the years to further define the standard and the options it provides to users. Of note is Notice 2 for MIL-STD-1553B[9], where the terms “aircraft” and “airborne” were removed to allow greater usage of the standard outside of the avionics community. While the 1553 protocol remains present in avionics, it is also found in weapon systems, tanks, and artillery systems.

(1) The 1553 standard defines the bus protocol and message structure, but does not define a standard set of messages. Messages are manufacturer defined for the bus controller and remote terminals on the data bus. An ICD, available from the manufacturer, system integrator, or the program office, should define the messages for each device on the data bus to be decoded by a bus monitor.

(2) Adaptations of MIL-STD-1553 are currently in use mainly in the avionics industry to reduce the weight of components and cabling and increase data bus speeds. MIL-STD-1773[10] is a newer version of MIL-STD-1553B[11] using fiber optic cabling in place of the

twisted pair cabling. Ethernet based MIL-STD-1553 is another adaptation that allows easier interfacing of different subsystems through software rather than additional hardware while utilizing more modern internet protocol (IP) addressing and messaging.

e. JAUS. Initially named Joint Architecture for Unmanned Ground Systems (JAUGS) by the United States Department of Defense in 1995, JAUS began as a need to standardize a component-based message passing architecture and increase the interoperability between a controller of the unmanned ground vehicle(s) and the vehicle(s) being controlled. The JAUGS Reference Architecture (RA) was released in 1997 and included the initial messaging standards and interoperability requirements. By 2002, the standard was expanded to include all classes of unmanned systems and was renamed JAUS. The SAE Unmanned Systems Committee (AS-4) adopted the standard in 2004 and has continued development of JAUS. A number of SAE sources provide details on the implementation and common message formats for the service-based framework based on the JAUS RA (RA33P1[12], RA33P2[13], RA33P3[14]), including AS5669A[15], AS5710A[16], and AS6009[17].

(1) AS5669A, the JAUS/ Software Defined Protocols (SDP) Transport Specification, defines the transport standards and the packet characteristics while allowing the physical layer to be implemented over IP-based networks (user datagram protocol (UDP) and transmission control protocol (TCP)) or serial links. AS5710A and AS6009 define the JAUS Core Service and Mobility Service Sets, respectively.

(2) JAUS Service Interface Definition Language (JSIDL) documents, available from the manufacturer, system integrator, or the program office, should define the service-based messages on the data bus.

2. INSTRUMENTATION.

2.1 General.

Test instrumentation systems should be capable of recording data bus data, diagnostic messaging information, and traditional user-installed sensor data simultaneously during testing, when needed. For typical operation, the data acquisition system should remain in a passive state to avoid interaction with any of the controllers or systems on the data bus.

2.2 Instrumentation Setup.

a. J1708. Data acquisition system setup for J1708 recording requires an RS-485 compatible connection attached to the diagnostic port of the system under test. A list of desired parameters to be recorded can be identified utilizing the vendor-provided ICD or the SAE J1587 and J1922 standards. Parameters available for monitoring will vary depending on the number and type of electronic control units on the test item.

b. CAN. The setup of a data acquisition system for CAN bus recording requires an integrated CAN controller card connection attached to the diagnostic port of the system under test. Typically, the CAN controller is configured to remain in a passive state so as not to have a detrimental impact on the system. Once the desired messages and signals to be recorded have been defined, the available signals can be identified by three methods: a database CAN (DBC) file, a vendor-provided ICD, or a scan and analysis of the vehicle data bus. The DBC file type is a common format compatible with most data acquisition and CAN programs. The DBC file contains the description of the connected controllers, messages, and signals for the CAN network. If a DBC file is not available, it is good practice to develop a DBC file for each CAN network that will be recorded during testing. A DBC file can be built from the vendor provided ICD and then used to configure the appropriate signal channels on the data acquisition system. If no documentation is available, a scan (using a commercial CAN analyzer) of the CAN data bus provides an overview of available messages and signals. The CAN data bus scan can then be compared to the SAE J1939 and ISO standards to determine the available signals. The number of signals available for monitoring varies depending on the age and electrical complexity of the system under test.

c. MIL-STD-1553. An integrated 1553 protocol device, configured as a bus monitor and attached to a transformer or direct coupled stub, is required for the setup of the data acquisition system for MIL-STD-1553 recording. A vendor-provided ICD is required to determine a list of desired parameters to be recorded.

d. JAUS. Data acquisition systems setup for JAUS over IP-based network recording require a netTAP compatible connection to the ethernet bus of the system under test. The preferred method of connection is to have an available port on a network switch within the test system set to mirror the traffic on the ethernet data bus to prevent reliability issues. The second method of connection is to place the netTAP device in-line with the system's ethernet data bus to collect the data packets. JAUS over serial recording requires a serial compatible connection attached to the serial data bus of the system under test. Typically, the data acquisition system records the data packets transmitted across the JAUS data bus and the desired messages are parsed out of the data file during post-processing utilizing the message information in the JSIDL documents.

2.3 Data Sample Rate.

The data sample rate for data bus data varies depending upon the data bus type and each message transmitted. Most data bus data are known as an asynchronous data stream, meaning the data bus messages and signals arrive at different times and are not synchronized with each other. The sample rates of the data channels are not necessarily consistent and therefore should not be used for any data that requires a frequency domain analysis. The sample rate of the data bus data should be verified before test execution to verify that the data bus data provides the necessary information to analyze system performance. If data with synchronized time steps are required, then user-installed instrumentation should be added to meet test data requirements.

3. EXAMPLES OF DATA USAGE AND VERIFICATION.

The following examples highlight some common data bus data that have been recorded and utilized for vehicle analysis. This is not an exhaustive list.

3.1 Vehicle Speed.

a. SAE J1587 lists a Parameter Identification (PID) parameter as Road Speed, providing the indicated vehicle velocity. The SAE J1939 digital annex[18] lists a data channel in the cruise control/vehicle speed (CCVS) message as an estimate for wheel-based vehicle speed. The road speed and wheel-based vehicle speed estimate signals typically are provided from the engine controller, brake system controller, or both. The vehicle speed can be verified by comparison to global positioning system (GPS) sensor data, or another calibrated speed sensor installed on the vehicle. The acceptable error of vehicle speed measurement for use during vehicle endurance testing is specified in the instrumentation section of TOP 02-02-505A[19]. The acceptable error of data used as a substitute for vehicle performance testing is typically specified in the instrumentation section of the appropriate performance TOP.

b. The data bus vehicle speed channel is typically a direct measure of the axle rotation speed. Therefore, in conditions where the tire loses traction with the ground, the reported vehicle speed will not be an accurate indication of vehicle speed. A typical case for using the data bus reported vehicle speed is when foliage or an obstructed view of the sky causes loss of GPS signal. The wheel-based data can be verified from data collected when a GPS signal was available. An example of this test usage case is presented in Figure 1.

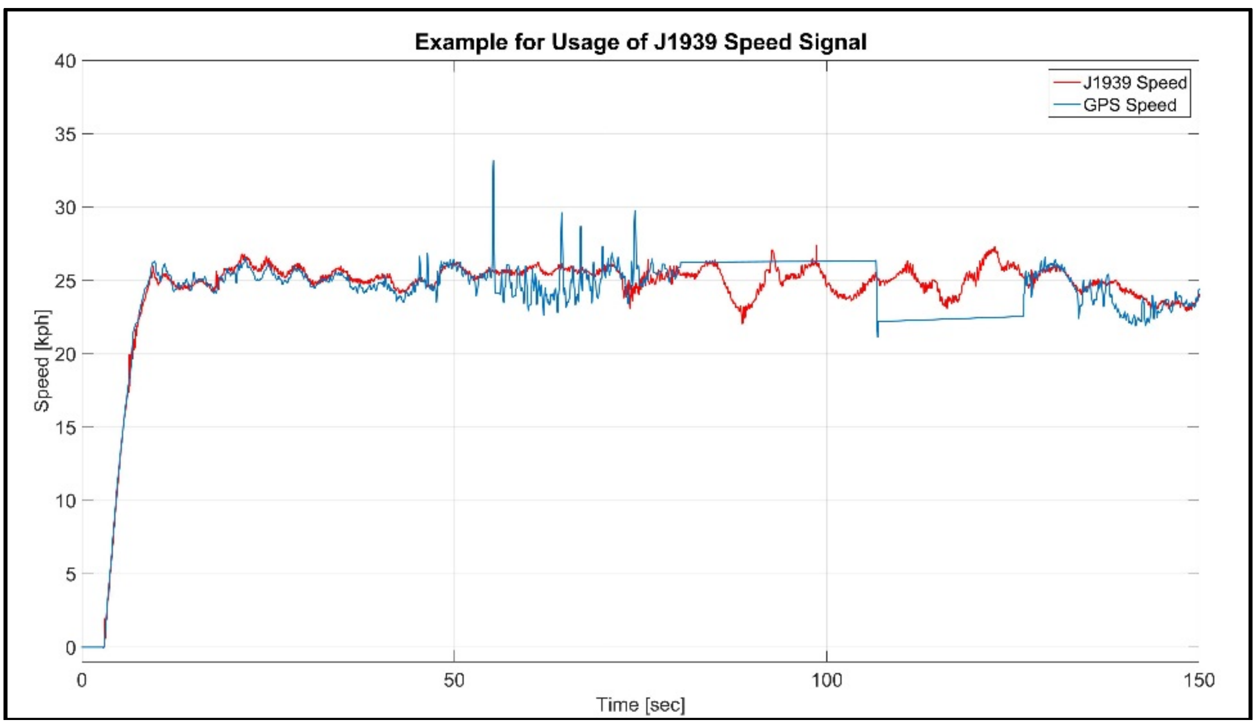

Figure 1. Example scenario for J1939 vehicle velocity usage.

3.2 Engine Speed.

SAE J1587 lists a PID parameter as Engine Speed, providing the rotational velocity of the crankshaft. The SAE J1939 digital annex lists a channel in the electronic engine controller 1 (EEC1) message as an estimate for engine rotational speed. The engine speed signals are provided by the vehicle's engine controller. The engine speed can be verified at idle using a stroboscope or pulse emitting sensor integrated into the data acquisition system. The acceptable error of engine speed measurement for use during vehicle endurance testing is specified in the instrumentation section of TOP 02-02-505A. The acceptable error of engine speed data used in a system performance analysis is typically provided in the instrumentation section of the applicable TOP.

3.3 Vehicle Odometer.

a. SAE J1587 lists a PID parameter as Total Vehicle Distance, providing the accumulated distance travelled by the vehicle during its operation. The SAE J1939 digital annex lists several channels that provide an estimate of the distance traveled by a vehicle. The messages are high-resolution vehicle distance (VDHR) and vehicle distance (VD). The vehicle mileage messages are often redundantly broadcast on the data bus by multiple controllers. Therefore, the specific distance message should be verified and compared to the actual odometer value shown on the vehicle's gauge cluster unit.

b. The vehicle odometer is typically used for tracking mileage throughout vehicle testing. The odometer reading is used in analysis for distance-based system reliability estimates. Therefore, it is essential to validate the accuracy of the odometer reading, so that test results between different vehicles systems have a meaningful correlation. The odometer reading can be verified by comparison to the distance measured by a calibrated fifth wheel installed on the vehicle. The acceptable error of the vehicle odometer measurement for use during vehicle endurance testing is specified in the instrumentation section of TOP 02-02-505A.

3.4 Fuel Consumption.

a. SAE J1587 lists a PID parameter as Fuel Rate (Instantaneous), providing the amount of fuel consumed by the engine per unit of time. The SAE J1939 digital annex lists several common channels for monitoring vehicle fuel usage. The message fuel economy liquid (LFE) provides a real-time estimate of the vehicle fuel rate and fuel economy. The message fuel consumption liquid (LFC) is a request-based message that provides an estimate of total vehicle fuel consumption. A request-based message requires the instrumentation to send a request to the engine controller to supply the desired message. Another request-based message, idle operation (IO), can potentially provide the total idle fuel consumption.

b. Fuel consumption data accuracy should be validated prior to, or during fuel consumption testing using a calibrated external fuel flow measurement system (described in TOP 02-2-603A[20]) as a reference. The data bus fuel rate channel should be integrated and compared to the total consumption measured with the fuel measurement system. Scalar correction factors can be determined and applied to the data bus Fuel Rate (Instantaneous) or fuel rate LFE message data by averaging or least-squares fitting multiple test runs at different speeds and terrain types. A comparative example of data from an external fuel measurement system (fuel meter), uncorrected J1939 fuel data, and corrected J1939 fuel data are presented in Figure 2.

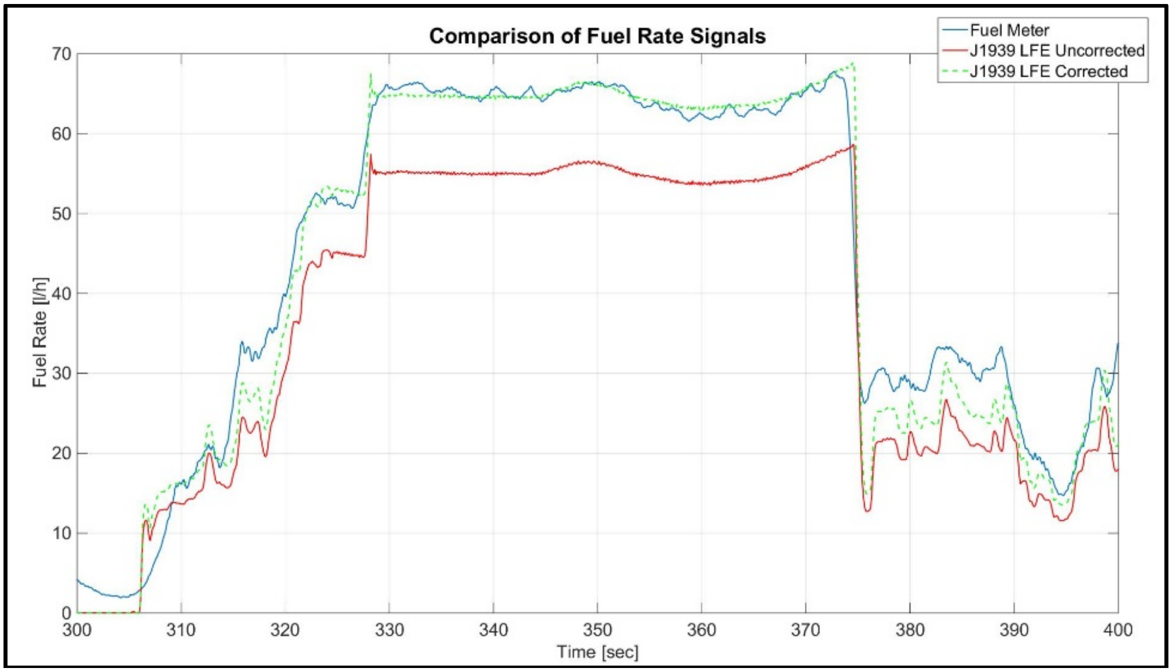

Figure 2. Comparison of fuel rate data.

SAE J1587 lists two PID parameters and the SAE J1939 digital annex lists messages that monitor transmission operating states. For many performance tests it is important to know the current transmission gear setting, as well as torque converter state. PIDs Transmission Range Attained and Transmission Range Selected on the J1708 data bus and the message electronic transmission controller 2 (ETC2) on the CAN data bus provide data channels for monitoring the current and selected transmission gears. The same PIDs on the J1708 data bus and the messages electronic transmission controller 8 (ETC8) and electronic transmission controller 1 (ETC1) on the CAN data bus provide information about the transmission torque converter status. The operating state of the torque converter is critical information for powertrain testing. If available on the J1708 or CAN data bus, this information should be captured for all powertrain related performance testing.

3.6 <u>Vehicle Stability Systems</u>.

a. SAE J1587 lists a PID parameter as Anti-lock Braking System (ABS) Control Status, identifying the current state of the anti-lock braking system control functions, warning lamp, and switch. The SAE J1939 digital annex provides messages that monitor the status and functionality of vehicle ABS, anti-slip regulation/traction (ASR), and electronic stability control systems (ESC). The ESC systems are referred to as vehicle dynamic control (VDC) systems in the SAE J1939 documents. The proper functionality of vehicle dynamic control systems is necessary for conducting braking, acceleration, and steering and handling performance tests. The message electronic brake controller 1 (EBC1) provides the status of ABS and traction control systems. The message also provides an indication if the brake controller is intervening with vehicle operation. The messages vehicle dynamic stability control 1 (VDC1) and VDC2 provide status information for the vehicle's dynamic stability control operation. The VDC2 data channel provides the active feedback for the ESC system sensors. Vehicle steering wheel angle, yaw rate, lateral acceleration, and longitudinal acceleration are also available signals associated with vehicle stability control.

b. The system status signals can be verified prior to testing by disabling the systems and monitoring the state of the fully-operational status channels. The vehicles often provide a switch on the dash to disable the stability or traction control systems. The dynamic signals from the VDC2 message can be verified with the installation of a calibration-traceable inertial system mounted inside the vehicle cab. The inertial system should be located as close as possible to the sensor used for the vehicle stability control system. The data from the two inertial systems are compared for validation of the vehicle's signal data. A comparative example of CAN data used during steering and handling testing is shown in Figure 3. The VDC operational channel indicates that the stability control system was being intermittently switched off by the vehicle controller during testing. In one case, the system switched off during a test run. Using the CAN data the test engineer was able to determine that the system was not functioning properly, and which test runs were invalid for analysis purposes.

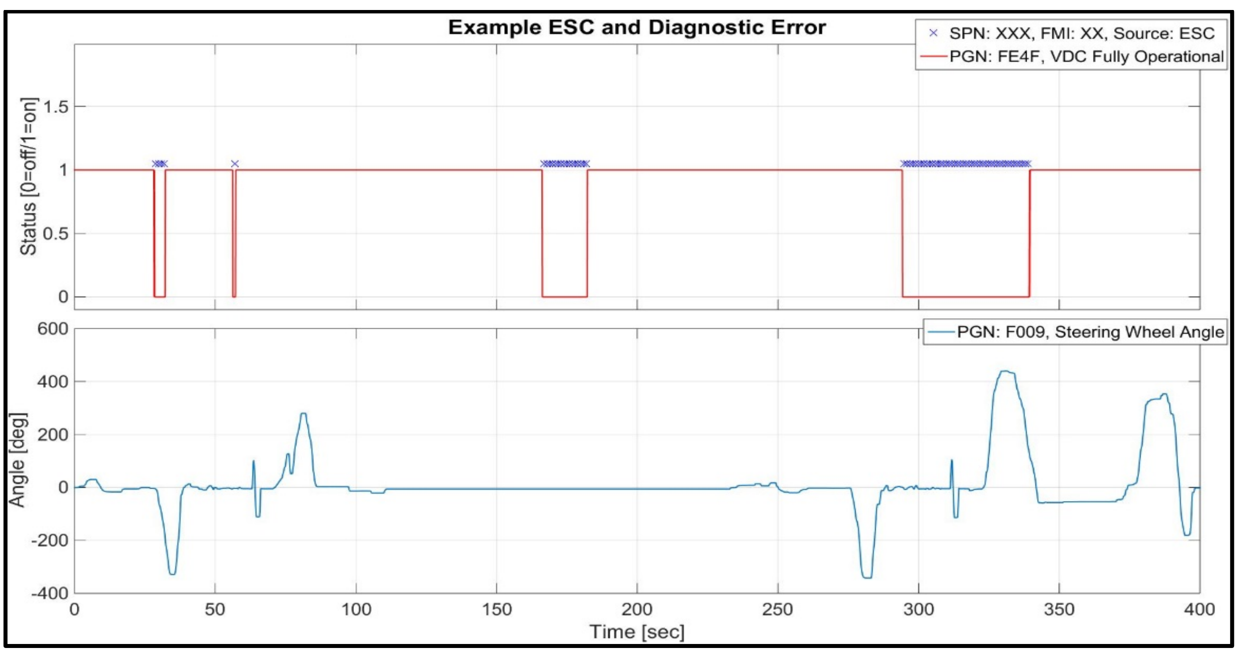

Figure 3. Example of diagnostic trouble codes (DTC) and stability system data.

3.7 Tire Status.

Most military vehicles currently include a central tire inflation system (CTIS). The CTIS is controlled by inputs from the driver, based on the vehicle weight and expected terrain type. The CTIS usually broadcasts vehicle tire pressure, driver selected settings, and any system faults. SAE J1587 lists multiple PIDs for monitoring tire pressure and CTIS conditions, referred to as tire pressure control system. The SAE J1939 digital annex lists the Tire Condition (TIRE) message for monitoring tire pressure and CTIS conditions. Tire pressure is an important data channel to monitor during steering and handling and braking tests. The accuracy of the J1708 and CAN tire pressure data may be verified by comparing to a calibrated tire pressure gauge. The accuracy should be checked at two different tire pressure settings. The measurements should fall within the tolerances specified in TOP 02-02-704A[21].

3.8 Fire Control Systems.

a. Although standard defined messages are not present in MIL-STD-1553 communications, fire control systems on wheeled and tracked vehicle platforms and howitzers use the data bus to report multiple system status channels and sensor data used for the firing mission. Status channels can provide information on when the system is armed, if a fire inhibit is present, and when the trigger is pulled. Counts of rounds fired and rounds remaining as well as round type can be obtained on some systems. If the weapon system has a laser range finder, a status channel may indicate when the laser range finder was activated and data channels may report back the first and last range returns. Sensors within the system can provide the GPS location of the vehicle as well as target location based on the range to target, azimuth, and elevation of the gun tube. Depending on the weapon system, many other status and data channels may be available to assist with testing of the system.

b. The system status signals can be verified prior to testing by first verifying that the weapon system does not have live munitions. Some weapon systems have simulation rounds that can be used to troubleshoot the fire control system. These simulation rounds, or other purpose built simulation tools, should be used to verify the 1553 data. The system can be armed/disarmed and the trigger pulled while monitoring the states of the appropriate status channels. The laser range finder can be aimed at a target of known distance and compared to the reported range value data. Exercising the gun tube along with physical measurements can verify the reported azimuth and elevation data. Due to the nature of this data bus, many other manufacturer specific channels can be recorded/monitored and be useful to measure performance of the system. Verification of these data will need to be handled on a case by case basis.

3.9 JAUS Messages.

a. JAUS messages are routinely recorded during testing of autonomous systems for future querying, if needed. Message and channel definitions for JAUS data are typically defined in JSIDL documents or ICD's provided by the manufacturer. Status channels can provide information on the system states, and modes of operation. Sensors within the system can provide the GPS location, as well as other data related to the current state of robotic subsystems.

b. The system status signals can be verified prior to testing by first verifying the systems current mode, and comparing to JAUS channel value. Due to the nature of this data bus, many other manufacturer specific channels can be recorded/monitored and be useful to measure performance of the system. Verification of these data will need to be handled on a case by case basis.

3.10 Diagnostic Messages.

a. The SAE J1708 and J1939 protocols provide standardized reporting of DTCs. Although available for recording, the J1708 DTCs have not been used in past performance and endurance testing and, therefore, are not discussed in more detail. Refer to SAE J1587 for additional reference on J1708 DTCs. The J1939 DTCs are integer fault codes that describe the failure type and count of the failure occurrences. DTCs are available in several request-based messages, however this TOP focuses only on the active diagnostic trouble codes message (DM1). The DM1 message provides a method to indicate active faults recognized by the system controllers. The active faults can often be associated with anomalies seen during vehicle performance testing. Not all vehicle diagnostic trouble codes are actively broadcasted. Only DTCs selected by the specific subsystem vendor are actively broadcasted. The DTC provides the suspect parameter number (SPN), failure mode identifier (FMI), and occurrence count (OC). The SPN and FMI can then be mapped to either a standard contextual definition or a proprietary definition provided in a manufacturer's ICD.

b. An example of a DTC used during steering and handling testing is presented in Figure 3. An intermittent fault was present during a steering and handling test. The fault message coincided directly with the disabling of the stability control system. The CAN data provided insight into an intermittent fault that would have otherwise been difficult to recognize and diagnose.

4. DATA REQUIRED.

The data bus data required to support vehicle performance or endurance testing is dependent upon the subject of the performance or endurance subtest. All data to be collected should be documented in the test plan, to include the method and instrumentation used, and should be agreed upon by the U.S. Army Test and Evaluation Command (ATEC) System Team (AST). Section 3 of this TOP provides examples of data that can be collected from the vehicle data bus.

5. PRESENTATION OF DATA.

The format for data presentation should be determined by the AST. Examples of how data can be presented are provided in Figures 1 through 3 of this TOP.

(This page is intentionally blank.)

APPENDIX A. GLOSSARY.

Term	Definition
Failure Mode Identifier (FMI)	The FMI defines the type of failure detected in the subsystem identified by an SPN (SAE J1939-73).
Suspect Parameter Number	This 19-bit number is used to identify the item for which diagnostics are being reported (SAE J1939-73).
Diagnostic Trouble Code (DTC)	A 4 byte value that identifies the kind or trouble, the associated failure mode, and its occurrence count (SAE J1939-73).

(This page is intentionally blank.)

APPENDIX B. ABBREVIATIONS.

ABS	anti-lock braking system
ASR	anti-spin regulation
AST	U.S. Army Test and Evaluation Command (ATEC) System Team
ATEC	U.S. Army Test and Evaluation Command
CAN	Controller Area Network
CCVS	cruise control/vehicle speed
CTIS	central tire inflation system
DBC	Controller Area Network (CAN) database file
DM	diagnostic message
DTC	diagnostic trouble code
EBC	electronic brake controller
EEC	electronic engine controller
ESC	electronic stability control
ETC	electronic transmission control
FMI	failure mode identifier
GPS	global positioning system
ICD	interface control document
IO	idle operation
IP	internet protocol
ISO	International Organization of Standardization
JAUGS	Joint Architecture for Unmanned Ground Systems
JAUS	Joint Architecture for Unmanned Systems
JSIDL	JAUS Service Interface Definition Language
LFC	fuel consumption liquid
LFE	fuel economy liquid
MID	message identification
MIL-STD	Military Standard
NIST	National Institute of Standards and Technology
OC	occurrence count

APPENDIX B. ABBREVIATIONS.

PID	parameter identification
RA	reference architecture
SAE	Society of Automotive Engineers
SDP	software defined protocol
SPN	suspect parameter number
TCP	transmission control protocol
TIRE	tire condition
TOP	Test Operations Procedure
UDP	user datagram protocol
USAF	United States Air Force
VD	vehicle distance
VDC	vehicle dynamic control
VDHR	high resolution vehicle distance

.

APPENDIX C. REFERENCES.

1. SAE J1708, Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications, August 2004.

2. MIL-STD-1553A Notice 5, Multiplex Applications Handbook, 3 May 2013.

3. SAE J1922, Powertrain Control Interface for Electronic Controls Used in Medium- and Heavy-Duty Diesel On-Highway Vehicle Applications, September 2000.

4. SAE J1587, Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications, February 2002.

5. ISO 11898: Road Vehicles - Controller area network (CAN) - Part 1 through Part 6:

   ISO 11898-1: Data link layer and physical signaling: 2003.
   ISO 11898-2: High-speed medium access unit: 2003.
   ISO 11898-3: Low-speed, fault-tolerant, medium-dependent interface: 2006.
   ISO 11898-4: Time-triggered communication: 2004.
   ISO 11898-5: High-speed medium access unit with low-power mode: 2007.
   ISO 11898-6: High-speed medium access unit with selective wake-up functionality: 2013.

6. SAE J1939, Serial Control and Communications Heavy Duty Vehicle Network - Top Level Document, 14 August 2013.

7. SAE J1939-71, Vehicle Application Layer, 28 April 2014.

8. SAE J1939-73, Application Layer - Diagnostics, 24 July 2013.

9. MIL-STD-1553B Notice 2, Digital Time Division Command/Response Multiplex Data Bus, 8 September 1986.

10. MIL-STD-1773, Fiber Optics Mechanization of an Aircraft Internal Time Division Command/Response Multiplex Data Bus, 20 May 1988.

11. MIL-STD-1553B, Aircraft Internal Time Division Command/Response Multiplex Data Bus, 21 September 1978.

12. RA33P1, JAUS Reference Architecture Specification, Volume II, Part 1, Architecture Framework, Version 3.3, 22 June 2007.

13. RA33P2, JAUS Reference Architecture Specification, Volume II, Part 2, Message Definition, Version 3.3, 22 June 2007.

APPENDIX C. REFERENCES.

14. RA33P3, JAUS Reference Architecture Specification, Volume II, Part 3, Message Set, Version 3.3, 22 June 2007.

15. SAE AS5669 Revision A, (R) JAUS / SDP Transport Specification, August 2014.

16. SAE AS5710 Revision A, (R) JAUS Core Service Set, April 2015.

17. SAE AS6009, JAUS Mobility Service Set, April 2009.

18. SAE J1939- 20150220 Digital Annex (technical data in spreadsheet form), 20 February 2015.

19. TOP 02-2-505A, Inspection and Preliminary Operation of Vehicles, 22 October 2018.

20. TOP 02-2-603A, Vehicle Fuel Consumption, 10 May 2012.

21. TOP 02-2-704A, Tires, 15 December 2015.

APPENDIX D. APPROVAL AUTHORITY.

CSTE-CI 11 January 2022

MEMORANDUM FOR

Commander, U.S. Army Operational Test Command
Director, U.S. Army Evaluation Center
Commanders, ATEC Test Centers
Technical Directors, ATEC Test Centers

SUBJECT: Test Operations Procedure 01-2-506A, Use of Data Bus to Support Performance and Endurance Testing

1. Test Operations Procedure (TOP) 01-2-506A, Use of Data Bus to Support Performance and Endurance Testing, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency.

2. Scope of the document. This TOP provides guidance for using vehicle-based, data bus data during performance and endurance testing of military vehicles.

3. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

4. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-CI), 6617 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

ZWIEBEL.MICHAEL.J.1229197289 Digitally signed by ZWIEBEL.MICHAEL.J.1229197289 Date: 2022.01.13 10:17:47 -05'00'

MICHAEL J. ZWIEBEL
Director, Directorate for Capabilities Integration (DCI)

(This page is intentionally blank.)

Forward comments, recommended changes, or any pertinent data, which may be of use in improving this publication to the following address: Policy and Standardization Division (CSTE-CI-P), U.S. Army Test and Evaluation Command, 6617 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Automotive Instrumentation Division (TEDT-AT-ADI), US Army Aberdeen Test Center, 6943 Colleran Road, Aberdeen Proving Ground, MD 21005-5059. Additional copies can be requested through the following website: https://www.atec.army.mil/publications/documents.html, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.