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	SURFACE VEHICLE RECOMMENDED PRACTICE	J1939-73		REV. SEP2006
		Issued	1996-02	
		Revised	2006-09	
		Superseding	J1939-73 MAR2004	
Application Layer - Diagnostics				

RATIONALE

This SAE Recommended Practice has been updated to support manufacturers' new requirements, and new On Board Diagnostic (OBD) regulatory requirements for light duty, medium duty and heavy duty vehicles. These cover the needs of US EPA, US CARB, EU, and World Wide Harmonization of OBD. The following updates made: APPENDIX G, listing non-OBD fault management narratives, DM22 (Individual Clear/Reset of Active and Previously Active DTC), DM23 (Previously Active Emission Related Faults), DM24 (SPN Support), DM25 (Expanded Freeze Frame), and DM26 (Diagnostic Readiness 3), a revised definition for DM6, and updates to the DM1 for lamp flashing and a fixed 1 second update rate, DM27 (All Pending DTCs), DM28 (Permanent DTCs), DM29 (Regulated DTC Counts), DM30 (Scaled Test Results),DM31(DTC to Lamp Association), DM32 through DM52, and the addition of 2 new FMIs (FMI 20 Data Drifted High, and FMI21 Data Drifted Low).

FOREWORD

The J1939 series of SAE Recommended Practices has been developed by the Truck and Bus Control and Communications Network Subcommittee of the Truck and Bus Electrical and Electronics Committee. The objectives of the subcommittee are to develop information reports, recommended practices, and standards concerned with the requirements, design, and usage of devices which transmit electronic signals and control information among vehicle components.

These SAE recommended practices are intended as a guide toward standard practice and are subject to change so as to keep pace with experience and technical advances.

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1. (R)SCOPE

The SAE J1939 series of recommended practices are intended for light- and heavy-duty vehicle uses on- or off-road as well as appropriate stationary applications which use vehicle-derived components (e.g. generator sets). Vehicles of interest include, but are not limited to: on- and off-highway trucks and their trailers, construction equipment, and agriculture equipment and implements.

The purpose of these documents is to provide an open interconnect system for on-board electronic systems. It is the intention of these documents to allow electronic devices to communicate with each other by providing a standard architecture.

J1939-73 identifies the diagnostic connector to be used for the vehicle service tool interface and defines messages to accomplish diagnostic services. California, EPA, or EU regulated OBD requirements are satisfied with a subset of the specified connector and the defined messages. Diagnostic messages (DMs) provide the utility needed when the vehicle is being repaired. Diagnostic messages are also used during vehicle operation by the networked electronic control modules to allow them to report diagnostic information and self-compensate as appropriate, based on information received. Diagnostic messages include services such as periodically broadcasting active diagnostic trouble codes, identifying operator diagnostic lamp status, reading or clearing diagnostic trouble codes, reading or writing control module memory, providing a security function, stopping/starting message broadcasts, reporting diagnostic readiness, monitoring engine parametric data, etc.

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2. REFERENCES

2.1 Applicable Publications

General information regarding this series of recommended practices is found in SAE J1939. The latest issue of the SAE J1939 publications shall apply.

2.1.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Tel: 877 606-7323 (inside USA and Canada) or 724 776 4970 (Outside USA), www.sae.org. Unless otherwise specified, the latest publication shall apply.

SAE J1587 Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications

SAE J1939-03 On Board Diagnostics Application, Draft; Aug 2006

SAE J1939 Serial Control and Communications Vehicle Network

SAE J1939-13 Off-Board Diagnostic Connector

SAE J1939-21 Data Link Layer

SAE J1939-71 Vehicle Application Layer

SAE J1979 E/E Diagnostic Test Modes

2.1.2 (R)On Board Diagnostics Regulations

Title 13, California Code Regulations, Section 1968.2, Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II) (California Air Resources Board (CARB) Publications are available from the, Air Resources Board, Haagen-Smit Laboratory, 9528 Telstar Avenue, El Monte, CA 91731-2990.)

Title 13, California Code Regulations, Section 1968.2, Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II) (California Air Resources Board (CARB) Publications are available from the, Air Resources Board, Haagen-Smit Laboratory, 9528 Telstar Avenue, El Monte, CA 91731-2990.), Year 2005/6 rule updates.

EPA, Title 40, CFR 86.005-17 (Engines - 8500 to 14000 lbs.) , December 28, 2000

EPA, Title 40, CFR 86.1806-05 (Vehicles - 8500 to 14000 lbs.), December 28, 2000Title 13, California Code of Regulations, Section 1971, Engine Manufacturer Diagnostic System Requirements--2007 and Subsequent Model-Year Heavy-Duty Engines

Title 13, California Code of Regulations, Section 1971.1, On-Board Diagnostic System Requirements for 2010 and Subsequent Model-Year Heavy-Duty Engines (HD OBD)

European Directive 98/69/EC as amended by 99/102/EC, 2001/1/EC, 2001/100/EC and 2002/80/EC (Vehicles <7600 lbs.)

European Union Heavy Duty OBD (vehicles above 7600 lbs) 29 November 2005 (EC Directive 2005/78)

Directive 2005/55/EC of the European Parliament and of the Council of 28 September 2005 as implemented by Commission Directive 2005/78/EC and amended by Commission Directive 2006/51/EC.

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World Wide Harmonized OBD proposed Global Technical Regulation Draft by the Economic Commission for Europe, reference ECE/TRANS/WP.29/GRPE/2006/8/Rev.1/27 March 2006

3. (R)DEFINITIONS

Terms and definitions not found in this section are defined in SAE J1939 or in specific OBD regulations.

3.1 Active

The state used to indicate that a fault is currently occurring. Active dominates Previously Active. A fault cannot be both "Active" and "Previously Active" simultaneously.

3.2 Broadcast

Messages that are sent on a periodic basis without having to be solicited. In some cases Broadcasts may be normally off and solicited to come on and then stay on until they are solicited to turn off (see DM13).

3.3 Calibration

The software installed in a control module. This includes executable code and calibration data.

3.4 (R)Confirmed

Confirmed is a term that is used in conjunction with DTC to identify the DTC as a malfunction that has been concluded to be true or false. For example, when a system declares a malfunction is present then it declares it in DM1 as a confirmed and active DTC. When the system declares a malfunction is no longer present then it declares it in DM2 as confirmed and previously active. To satisfy regulated OBD there may be additional constraints.

3.5 (R)Continuously Monitored Systems

Continuously Monitored Systems are those which are sampled at least two times per second. Note that some continuous monitors may require many conditions to be true before monitoring can be performed.

3.6 Diagnostic Trouble Code

A 4-byte value that identifies the kind of trouble, the associated failure mode and its occurrence count.

3.7 (R)Discriminatory

Discriminatory is a term used to differentiate the type of OBD operator **illumination** scheme that is used by the vehicle when controlling the Malfunction Indicator Lamp (MIL or MI). Discriminatory and Non-Discriminatory operator illumination schemes for the MIL are defined in the WWH OBD global technical regulation. A non-discriminatory scheme will have the MIL on continuously for all OBD malfunctions while the discriminatory MIL scheme will only have the MIL on continuous for malfunctions thought to cause the emissions to exceed the OBD emissions threshold.

3.8 Freeze Frame

A sampling of a group of parameters based on the occurrence of a diagnostic trouble code.

3.9 Key

The result of a set of mathematical operations performed upon a Seed to provide a device with a means of authenticating a Tool's request.

3.10 Malfunction Indicator Lamp

The MIL is used to report trouble codes that are emissions related. Trouble codes that are not emissions related do not illuminate the MIL.

3.11 Memory Access

This defines a set of messages (DM14 through DM18) and outlines the operational procedures for a Tool (or device) wishing to read or write the memory, or storage space, of a device with or without data security.

3.12 Non-continuously Monitored Systems

System monitors that run once a trip or whenever conditions exist .. Trip, in this context, is as defined by OBD regulations. It should be noted that there will be monitors that won't run every trip, e.g. cold-start aid monitors may only run when the **ambient** temperature is below 10 °C (50 °F).

3.13 Object

Some entity within a memory and/or a SPACE.

3.14 Password

The number sent when using a simple authentication technique wherein both the device and Tool have a prior knowledge of the specific number and usually use equality as the verification.

3.15 Pending

Pending is a term used to specify the type of DTC. Pending DTC means a DTC that is stored by the OBD system because a monitor has detected a situation where a malfunction may be present during the current or last completed driving cycle.

3.16 (R)Permanent

Permanent is a term used to label a confirmed and active DTC that is recorded in memory and is not allowed to be erased by the OBD system until the monitoring algorithm has fully executed (i.e., has executed the minimum number of checks necessary for MIL illumination) and determined the malfunction is no longer present. See California Code of Regulation 1971.1.

3.17 Pointer

A term used to label a device that identifies the memory location which should be read or written. Types of pointers include: direct memory address and directed spatial addressing (Suspect Parameter Number (SPN) Space, OEM Proprietary Space, and Reserved to be assigned).

3.18 Port

Physical connection point(s) from a control module to a specific communications link (see DM13).

3.19 Previously Active

The state used to indicate that a fault has occurred but is not presently occurring. A fault cannot be both "Active" and "Previously Active" simultaneously.

3.20 Rationality

Rationality fault diagnostic for an input component means verification of the accuracy of the input signal while in the range of what is physically possible (see APPENDIX A, region b versus region f and g) when compared to all other available information. This is a term that the California Air Resources Board has defined in their OBD rules.

3.21 (R)Readiness Code

The readiness code status bits (i.e. those in DM5) are used in part or in whole to ensure a vehicle (engine) is ready for an emission system inspection. The definition of the complete or incomplete status is provided in regulation(s), including the impact of specific service actions on readiness status. If a status bit for a particular component or system is set to complete, then the OBD system has had the opportunity to run all of the diagnostics relevant to that particular component or system.

For example, on engine start up, it is likely that an EGR monitor might require operation at speed and torque points beyond the idle condition. Therefore, if the system had its diagnostic trouble codes erased and then the engine was restarted, the readiness code for EGR would not be set until the condition for the EGR monitor tests had been executed. It is also expected that other tests, not just the EGR monitors, would need to be performed before the readiness code could be set. Once set to complete, the readiness code status bits shall not change to incomplete each time the vehicle (engine) is powered down.

3.22 Seed

A number sent by a device to a Tool to obtain authentication of the Tool's right to access the device.

3.23 Space

A memory region containing a collection of OBJECTS.

3.24 User_Level

A number sent by a Tool to a device along with an initial request to inform the device of some specific level of access that the Tool wishes to gain.

4. (R)ABBREVIATIONS

CARB	California Air Resources Board
CAL ID	Calibration Identification
CM	SPN Conversion Method
CVN	Calibration Verification Number
DM1	Diagnostic Message 1, Active Diagnostic Trouble Codes
DM2	Diagnostic Message 2, Previously Active Diagnostic Trouble Codes
DM3	Diagnostic Message 3, Diagnostic Data Clear/Reset for Previously Active DTCs
DM4	Diagnostic Message 4, Freeze Frame Parameters
DM5	Diagnostic Message 5, Diagnostic Readiness 1
DM6	Diagnostic Message 6, Emission Related Pending DTCs
DM7	Diagnostic Message 7, Command Non-continuously Monitored Test
DM8	Diagnostic Message 8, Test Results for Non-continuously Monitored Systems
DM9	Diagnostic Message 9, Oxygen Sensor Test Results
DM10	Diagnostic Message 10, Non-continuously Monitored Systems Test Identifiers Support
DM11	Diagnostic Message 11, Diagnostic Data Clear/Reset for Active DTCs
DM12	Diagnostic Message 12, Emissions Related Active DTCs
DM13	Diagnostic Message 13, Stop Start Broadcast
DM14	Diagnostic Message 14, Memory Access Request
DM15	Diagnostic Message 15, Memory Access Response
DM16	Diagnostic Message 16, Binary Data Transfer
DM17	Diagnostic Message 17, Boot Load Data
DM18	Diagnostic Message 18, Data Security
DM19	Diagnostic Message 19, Calibration Information
DM20	Diagnostic Message 20, Monitor Performance Ratio

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DM21	Diagnostic Message 21, Diagnostic Readiness 2
DM22	Diagnostic Message 22, Individual Clear/Reset of Active and Previously Active DTC
DM23	Diagnostic Message 23, Previously Active Emission Related Faults
DM24	Diagnostic Message 24, SPN Support
DM25	Diagnostic Message 25, Expanded Freeze Frame
DM26	Diagnostic Message 26, Diagnostic Readiness 3
DM27	Diagnostic Message 27, All Pending DTCs
DM28	Diagnostic Message 28, Permanent DTCs
DM29	Diagnostic Message 29, Regulated DTC Counts (Pending, Permanent, MIL-On, PMIL-On)
DM30	Diagnostic Message 30, Scaled Test Results
DM31	Diagnostic Message 31, DTC to Lamp Association
DM32	Diagnostic Message 32, Regulated Exhaust Emission Level Exceedance
DM33	Diagnostic Message 33, Emission Increasing Auxiliary Emission Control Device Active Time
DM34	Diagnostic Message 34, NTE Status
DM35	Diagnostic Message 35, Immediate Fault Status
DM36	Diagnostic Message 36, Harmonized Roadworthiness - Vehicle (HRWV)
DM37	Diagnostic Message 37, Harmonized Roadworthiness – System (HRWS)
DM38	Diagnostic Message 38, Harmonized Global Regulation Description (HGRD)
DM39	Diagnostic Message 39, Cumulative Continuous MI – System (HCMI)
DM40	Diagnostic Message 40, Harmonized B1 Failure Counts (HB1C)
DM41	Diagnostic Message 41, DTCs- A, Pending
DM42	Diagnostic Message 42, DTCs- A Confirmed and Active
DM43	Diagnostic Message 43, DTCs- A, Previously Active
DM44	Diagnostic Message 44, DTCs- B1, Pending
DM45	Diagnostic Message 45, DTCs- B1, Confirmed and Active
DM46	Diagnostic Message 46, DTCs- B1, Previously Active
DM47	Diagnostic Message 47, DTCs- B2, Pending
DM48	Diagnostic Message 48, DTCs- B2, Confirmed and Active
DM49	Diagnostic Message 49, DTCs- B2, Previously Active
DM50	Diagnostic Message 50, DTCs- C, Pending
DM51	Diagnostic Message 51, DTCs- C, Confirmed and Active
DM52	Diagnostic Message 52, DTCs- C, Previously Active
DTC	Diagnostic Trouble Code
EDC	Error Detection and/or Correction
EDCP	Error Detection and/or Correction Parameter
FMI	Failure Mode Indicator
FTP	Federal Test Procedure
GTR	Global Technical Regulation
MA	Memory Access
MI	Malfunction Indicator
MIL	Malfunction Indicator Lamp
NA	Not applicable
OBD	On Board Diagnostics
OBD II	On-Board Diagnostics II
OC	Occurrence Count
PG	Parameter Group
PID	Parameter Identifier (SAE J1587 or SAE J1979)

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SPN	Suspect Parameter Number
VVT	Variable Valve Timing and/or Control
WWH	World Wide Harmonized

See SAE J1939 for any terms and or definitions not found in this document.

5. TECHNICAL REQUIREMENTS

5.1 General

The diagnostic definitions provided herein are intended to satisfy the needs of all potential users of the SAE J1939 network. These definitions are intended to be suitable for applications in any of the industry groups defined within SAE J1939. A broad range of capabilities are provided with provision made for future growth. Additional features, Parameter Groups and Parameter definitions will be defined over time; it is anticipated that this document will continuously evolve as long as the SAE J1939 network is an active Recommended Practice. Such growth will be implemented in such a way as to ensure backward compatibility with earlier versions. At the time of initial publication, many of these growth areas are identified but are yet to be defined. Such identification is provided so that the reader will be aware of those additions that are already planned for the document.

5.2 Overview of Diagnostic Requirements

The diagnostic requirements necessary to provide the type of capability our customers, our industry, and the regulatory bodies are demanding is outlined in section 5.2.1. A description of the minimum requirements needed to satisfy regulatory requirements is contained in section 5.2.2. A discussion of the general operating conditions for diagnostic procedures is defined in section 5.2.3.

5.2.1 Diagnostic Capabilities Envisioned

The following capabilities will be defined in this and future publications of this document:

- a. Security - Define a security scheme to be used on the serial data link that allows the industry standard service tools to be able to perform tasks that are necessary during service procedures. This will include accessing diagnostic information, accessing vehicle configuration information and recalibrating control modules.
- b. Connectors - Define the connector to be used for connection to the vehicle SAE J1939 network for service tools. The diagnostic connector is defined in SAE J1939-13.
- c. Diagnostic Status Message Support - Provide a set of messages that allows the reading of fault information, clearing of fault information, monitoring of vehicle parameters, access to vehicle and component configuration, and other related information.
- d. Diagnostic Test Support - Provide a capability that allows the service Tool to put the various controllers into specific test modes in order to determine proper subsystem operation.

5.2.2 Suggested Diagnostic Support

5.2.2.1 (R)Emission Related Components

As a minimum capability, all controllers using SAE J1939 that must comply with regulated On-Board Diagnostics (OBD or OBD II or EOBD, etc.) shall support the functions shown in Table 1. Additionally, these controllers must satisfy the requirements in J1939-03 if required by the regional authority. See Table 2 for the legend defining the entries in the "Required by Regulation" column of Table 1.

(R)TABLE 1 - EMISSION RELATED COMPONENT PGN AND SPN SUPPORT

Row #	Function	PGN	Acronym	SPN #	Required By Regulation (See Table 2)	Description
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Row #	Function	PGN	Acronym	SPN #	Required By Regulation (See Table 2)	Description
Diagnostic Services						
1	Read DTCs	65226	DM1		A,B,C,E,F,G,H,J,K,L	All Active DTCs
2	Read DTCs	65236	DM12		A,B,H,J,K,L	Emissions related active DTCs
3	Read DTCs	64949	DM23		B,H,J,L	Previously Active Emission Related DTCs
4	Read Pending DTCs	65231	DM6		A,B,E,F,G,H,J,K,L	Emission related pending DTCs
5	Read All Pending DTCs	64898	DM27			All pending DTCs inclusive of Emissions and Non-Emissions Related
6	Read Permanent DTCs	64896	DM28		H,J	Emission related permanent DTCs
7	Read DTC Counts	40448	DM29		H,J	Number of regulated DTC counts (Pending, Permanent, MIL-On, PMIL-On)
8	Read DTCs- A, Pending	64863	DM41		L	DTCs where emissions exceed OBD threshold
9	Read DTCs- A, Confirmed and Active	64862	DM42		L	DTCs where emissions exceed OBD threshold
10	Read DTCs- A, Previously Active	64861	DM43		L	DTCs where emissions exceed OBD threshold
11	Read DTCs- B1, Pending	64860	DM44		L	DTCs where emissions may exceed OBD threshold
12	Read DTCs- B1, Confirmed and Active	64859	DM45		L	DTCs where emissions may exceed OBD threshold
13	Read DTCs- B1, Previously Active	64858	DM46		L	DTCs where emissions may exceed OBD threshold
14	Read DTCs- B2, Pending	64857	DM47		L	DTCs where emissions do not exceed OBD threshold
15	Read DTCs- B2, Confirmed and Active	64856	DM48		L	DTCs where emissions do not exceed OBD threshold
16	B2, Previously Active	64855	DM49		L	DTCs where emissions do not exceed OBD threshold
17	Read DTCs- C, Pending	64854	DM50		L	DTCs where emissions do not exceed emission standard
18	Read DTCs- C, Confirmed and Active	64853	DM51		L	DTCs where emissions do not exceed emission standard

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Row #	Function	PGN	Acronym	SPN #	Required By Regulation (See Table 2)	Description
19	Read DTCs- C, Previously Active	64852	DM52		L	DTCs where emissions do not exceed emission standard
20	Read DTCs- Immediate	40704	DM35			Instantaneous status of diagnostic results
21	Read DTCs & timers-	41472	DM32		K	DTCs & timers where OBD emissions threshold exceeded (e.g. NOx exceedance)
22	Scaled Test Results	41984	DM30		H,J,K,L	Test Results Scaling
23	DTC to Lamp Association	41728	DM31			Contains info supplementary to DM1 that can be requested in order to provide lamp info associated with each DTC
24	Clear DTCs	65235	DM11		A,B,C,E,F,G,H,J,K,L	Clear diagnostic information and active DTCs
25	Clear DTCs	65228	DM3		C	Clear diagnostic information and previously active DTCs
26	Freeze Frame Data	65229	DM4		A,C,E,F,G	Freeze frame definition & support (fixed format, DTC and 6 specified parameters)
27	SPN Support	64950	DM24		B,H,J,L	SPN support for Data Stream and Expanded Freeze Frame
28	Expanded Freeze Frame	64951	DM25	3149	B,H,J,L	Expanded Freeze Frame (format allows DTC and manufacturer specified number parameters)
29	Diagnostic Readiness	65230	DM5		A,B,C,E,F,G,H,J,L	OBD compliance, previously active & active DTC count, monitors supported and their status (diagnostic readiness)
30	Diagnostic Readiness for this trip	64952	DM26		B,E,H,J	Monitors supported and their status for this trip
31	Monitor Performance Ratio	49664	DM20		B,H,J	Indicates how often monitors complete compared to vehicle operation.

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Row #	Function	PGN	Acronym	SPN #	Required By Regulation (See Table 2)	Description
32	Emission Increasing-AECD Active Time	41216	DM33		H,J	Engine emissions increasing AECDs & associated timers
33	NTE Status	40960	DM34		H,J	Engine emissions Not-to-Exceed status
34	Harmonized Roadworthiness - Vehicle	64868	DM36		L	Vehicle road worthiness status
35	Harmonized Roadworthiness – System	64867	DM37		L	Engine emissions road worthiness status
36	Harmonized Global Regulation Description	64865	DM38		L	Text description of WWH OBD version
37	Cumulative Continuous MI – System	64865	DM39		L	Cumulative MIL time and DTC-B1 time (largest)
38	Harmonized B1 Failure Counts	64864	DM40		L	DTCs-B1 and individual timers
Communication Services						
39	Communication	59904	RQST		A,B,C,E,F,G,H,J,K,L	Request PGN
40	Communication	59392	ACKM		A,B,C,E,F,G,H,J,K,L	Acknowledgement message
41	Communication	60416	TP.CMxx		A,B,C,E,F,G,H,J,K,L	Transport protocol connection management
42	Communication	60160	TP.DT		A,B,C,E,F,G,H,J,K,L	Transport protocol data transfer
Data Stream						
43	Data Stream	65260	VI	237	A,B,C,E,F,G,H,J,K,L	Vehicle Identification Number (VIN)
44	Data Stream	54016	DM19	1635 1634	A,B,C,E,F,G,H,J,K,L	Calibration identification and verification numbers (CAL ID and CVN)
45	Data Stream	65262	ETI	110	A,B,C,E,F,G,H,J,K,L	Engine Coolant Temperature
46	Data Stream	65265	CCVS	86	A,B,C,E,F,G,H,J,K,L	Wheel-based Vehicle Speed
47	Data Stream	65270	IC1	102	A,B,C,E,F,G,H,J,K,L	Boost Pressure
48	Data Stream	65270	IC1	105	A,B,C,E,F,G,H,J,K,L	Intake Manifold Temperature
49	Data Stream	61443	EEC2	91	A,B,C,E,F,G,H,J,K,L	Accelerator Pedal Position
50	Data Stream	61443	EEC2	92	A,B,C,E,F,G,H,J,K,L	Percent Load at Current Speed

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Row #	Function	PGN	Acronym	SPN #	Required By Regulation (See Table 2)	Description
51	Data Stream	61444	EEC1	513	A,B,C,E,F,G,H,J,K,L	Actual Engine Percent Torque
52	Data Stream	61444	EEC1	190	A,B,C,E,F,G,H,J,K,L	Engine Speed
53	Data Stream	61444	EEC1	899	A,B,C,E,F,G,H,J,K,L	Engine Torque Mode
54	Data Stream	65159	IT6	1436	A,B,E,F,G,H,J,K,L	Actual Ignition Timing
55	Data Stream	49408	DM21	3069	A,B,E,F,G,H,J,K,L	Distance Traveled while MIL activated
56	Data Stream	49408	DM21	3143	B,H,J,K,L	Distance Since DTCs Cleared
57	Data Stream	49408	DM21	3144	B,H,J,K,L	Minutes Run by Engine While MIL activated
58	Data Stream	49408	DM21	3145	B,H,J,K,L	Time Since DTCs Cleared
59	Data Stream	64952	DM26	3150	B,H,J,K,L	Time Since Engine Start
60	Data Stream	34952	DM26	3151	B,H,J,K,L	Number of Warm-Ups Since DTC Cleared
61	Data Stream	TBD			B,H,J,K,L	Additional Data Stream parameters are required for OBD compliance, but they are dependent on the emission solution used for certification. These parameters are in J1939 and/or J1939-71.

(R)TABLE 2 - REGULATION DEFINITION LEGEND

Identifier	Regulating Body	OBD Compliance (SPN 1220)
A	CARB CCR 1968.1, (Vehicles < 14000 lbs.), April 21, 2003	01
B	CARB CCR 1968.2, (Vehicles < 14000 lbs.), April 21, 2003	01 or 03
C ¹	CARB CCR 1971, Engine Manufacturer Diagnostics (EMD), (Vehicles > 14000 lbs.), August 2004, support recommended by manufacturers	17
D	EU (Directive 98/69/EC as amended by 99/102/EC, 2001/1/EC, 2001/100/EC and 2002/80/EC) (Vehicles <7600 lbs.)	6 or 7 or 8 or 9
E	EU (July 2003 Planned Audit to Directive 88/77/EEC) (Vehicles > 7600 lbs.)	14 (Euro IV) 15 (Euro V)
F	EPA, Title 40, CFR 86.005-17, (engines - 8500 to 14000 lbs.), December 28, 2000	02 or 03
G	EPA, Title 40, CFR 86.1806-05, (vehicles - 8500 to 14000 lbs.), December 28, 2000	02 or 03
H	Title 13, California Code of Regulations, Section 1971.1, On-Board Diagnostic System Requirements for 2010 and Subsequent Model-Year Heavy-Duty Engines (HD OBD)	18 or 19 or 20
J	Title 13, California Code of Regulations, Section 1968.2, Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II): Proposed changes Feb. 2006	22
K	Directive 2005/55/EC of the European Parliament and of the Council of 28 September 2005 as implemented by Commission Directive 2005/78/EC and amended by Commission Directive 2006/51/EC.	23
L	World Wide Harmonized On Board Diagnostics, reference: ECE/TRANS/WP.29/GRPE/2006/8/Rev.1/27 March 2006	21

5.2.2.2 Non-emission Related Components

To be determined in later revisions of this document.

5.2.3 General Conditions For Diagnostic Procedures

These guidelines are necessary to ensure proper operation of both the test equipment and the vehicle during diagnostic procedures. Test equipment, when using messages defined in this document, should not affect normal operation of the vehicle except when that is the express purpose of the message.

The off-board test equipment may request data without knowledge of which module on the vehicle will respond. In this case the J1939-21 Request PGN would be directed to the global destination address for the desired information. Additionally there are times where the desired information may be known to only be available from a specific device. When this is the case the information flow is better managed with a request to a specific address other than "global". These guidelines should be followed in order to reduce network traffic. In some vehicles, multiple controllers may respond with the information requested. In addition, a single module may send multiple responses to a single request. Any test device requesting information must, therefore, have provisions for receiving multiple responses.

The on-board systems should respond to a request as defined in SAE J1939-21. With multiple responses possible from a single request, this allows as much time as is necessary for all modules to access the data link and transmit their

¹ EMD does not mandate or require the use of any J1939 services. However, due to the lack of data link standardization requirements, the J1939 committee recommends support of these services for EMD.

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response(s). If there is no response within this time period (i.e. 0.25 seconds), the Tool can either assume no response will be received, or if a response has already been received, that no more responses will be received.

A Tool should always wait for a response from the previous request, or “no response” time-out before sending another request. In no case should a request be sent in less than the times specified in SAE J1939-21 after the previous request. There may be situations where the tool knows that it has received the desired information it needs and then it may proceed to its next operation.

Destination specific requests require a response. If a parameter group is not supported by the control module and a destination specific request was used to request it from the control module, a NACK is required (see SAE J1939-21 PGN 59392). If the request for the parameter group was sent to a global destination address and a given device does not support it, then that device must not NACK the request.

Unless otherwise specified in J1939-73, parameter values should be formatted in accordance with the parameter ranges as defined by SAE J1939-71 section 5.1.3.

In this document, hexadecimal numbers are represented by a subscript 16 (₁₆), binary numbers are represented by a subscript 2 (₂), and decimal numbers have no subscript. In cases where the number base is obvious, the subscript is not included.

5.3 Security

One of the purposes of this Recommended Practice is to provide a standard protocol (a set of capabilities or diagnostic services) to allow users to access and modify memory areas inside a controller on the network. For these tools to be supported by the manufacturers of the ECUs that will be designed to connect to the J1939 network, sufficient protection against “unauthorized” modifications must be included. The messages described in sections 5.7.14 (DM14) through 5.7.18 (DM18) and their subsections are to be used for this purpose.

This security shall not be used to limit access to the capabilities defined in section 5.7.1 (DM1) through section 5.7.13 (DM13) and section 5.7.19 (DM19), but is intended to allow manufacturers to limit the data that can be accessed by the user. The security systems outlined here represent a recommendation for ECU manufacturers and provide flexibility for them to tailor individual systems to their specific security needs. The vehicle modules addressed are those that are capable of having solid-state memory contents altered by an external command sent through this vehicle communication link. Improper memory content alteration could potentially damage the electronics, reduce the vehicle’s compliance to legislated requirements, or breach the vehicle manufacturer’s security interests.

Proper “Unlocking” of the controller shall be a prerequisite to access certain critical on-board controller functions. Access to the on-board controller while in a “Locked” mode is permitted only as determined by the controller’s manufacturer. This may require that the user obtain specific codes or passwords directly from the manufacturer’s representative and may only be possible when using product-specific software. This permits the controller to protect itself from unauthorized intrusion.

The messages in sections 5.7.14 (DM14) through 5.7.18 (DM18) do not attempt to define capability as a requirement for any controller or to specify what information should be subject to any specific security measures; these decisions are left to the controller manufacturer. Implementation of the security system shall not prevent basic diagnostic communications between an external Tool and the on-board controller.

APPENDIX C, APPENDIX D and APPENDIX E contain additional information that may help implementers understand the intended use of these security processes for gaining access to controller memory and the several different modes available for limiting access areas of that memory.

5.4 Diagnostic Connector

The diagnostic connector is defined in SAE J1939-13.

5.5 Parameter Monitoring Requirements

The parameter definitions shall be those of the referenced SAE J1939 Application Layer document. Any parameter that has been defined in an applications layer document and is included in a Parameter Group (PG) shall be used for

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diagnostics. Therefore, if a parameter has already been defined, it will not be redefined for diagnostic purposes. In some cases it will be necessary to identify a closely related parameter, such as the value of the accelerator pedal sensor reading when the failure occurred rather than the current reading of the accelerator pedal sensor.

5.6 Diagnostic Trouble Code Definition

A Diagnostic Trouble Code (DTC) is made up of four (4) independent fields, as follows:

- a. Suspect Parameter Number (SPN) 19 bits
- b. Failure Mode Identifier (FMI) 5 bits
- c. Occurrence Count (OC) 7 bits
- d. SPN Conversion Method (CM) 1 bit

These independent parameters are not used together to form a number. They are merely a set of information that helps in understanding the failure that is being reported.

A diagnostic Tool may also want to use the controller source address and the Name to determine which controller is reporting the diagnostic information. This information is not needed to interpret the SPN but may be beneficial to have during the diagnostic process. Reference SAE J1939 for the Source Address and Name definitions.

Diagnostic trouble codes are transmitted as 4 bytes per trouble code. Those 4 bytes are interpreted as defined in section 5.7.1. In an effort to provide continuity between the diagnostics defined in SAE J1587 to that of SAE J1939-73, the fault encoding format remains very similar. When possible SAE J1587 PID numbers have been mapped one for one as SPNs.

Examples of diagnostic trouble codes (see Table 3):

EXAMPLE 1: This is a SAE J1587 parameter.

SPN=91	Suspect parameter is accelerator pedal position
FMI=3	Failure mode is identified as voltage above normal
OC=5	Occurrence count indicates trouble has occurred 5 times
CM= 0 ₂	(1 bit)

EXAMPLE 2: This is not a parameter communicated as an SAE J1587 PID. Therefore, it is assigned a number above 511.

SPN=656	Suspect parameter is engine injector number 6
FMI=3	Failure mode is identified as voltage above normal
OC=2	Occurrence count indicates trouble has occurred 2 times
CM= 0 ₂	(1 bit)

EXAMPLE 3: Diagnostic Trouble Code as transmitted in diagnostic messages (e.g. DM1)

Given:

Parameter "Pre-Filter Oil Pressure," Suspect Parameter Number 1208
Failure Mode Identifier of 3
Occurrence Count of 10
SPN Conversion Method of 0
All fields of DTC sent in Intel Format (least significant byte first)

	Decimal	Hexadecimal	Binary
SPN	1208	= 4B8 ₁₆	= 000 00000100 10111000 ₂ (19 bits)
FMI	3	= 3 ₁₆	= 00011 ₂ (5 bits)
OC	10	= A ₁₆	= 0001010 ₂ (7 bits)
CM			= 0 ₂ (1 bit)

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TABLE 3 - DTC REPRESENTATION IN CAN DATA FRAME FOR DM1 (BYTE 3 CLOSER TO CAN IDENTIFIER)

J1939 Frame Format	DTC																															
	Byte 3 8 least significant bits of SPN (bit 8 most significant)								Byte 4 second byte of SPN (bit 8 most significant)								Byte 5 3 most significant bits of SPN and the FMI (bit 8 SPN msb and bit 5 FMI msb)								Byte 6							
	SPN																FMI				CM	OC										
	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
	1	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0

J1939 Frame Format

5.7 Diagnostic Parameter Group Definitions

This section contains definitions of those parameter groups that will be used specifically for diagnostics. The format is a little different than the applications SAE J1939-71 layer in that the parameter definitions will follow each parameter group definition as a subsection under that parameter group.

One of the goals of this diagnostic document is to satisfy the OBD requirements. One of the documents that contains many of the OBD requirements is SAE J1979. For that reason, Table 4 was created as a way of identifying how SAE J1939 satisfies the SAE J1979 requirements.

A summary listing of all Diagnostic Modes and PIDs from SAE J1979 and their corresponding SAE J1939 PGNs is provided (see Table 4).

(R)TABLE 4 - SUMMARY OF DIAGNOSTIC MODE ASSIGNMENTS

	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Description	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Mode	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 PID	SAE Truck and Bus Council SAE J1939 Support of Those Functions SAE J1939 DM (PGN)	SAE Truck and Bus Council SAE J1939 Support of Those Functions PGN Description
1	Supported PIDs	01 ₁₆ request 41 ₁₆ response	00	N/A / DM24	J1939-21 and J1939-71 discuss methods to NACK data requests and to indicate non-supported data for systems that do not support DM24. Systems supporting DM24 declare their emissions-related support for parametric data and the DM25 freeze frame.
2	Number of DTCs, MIL status and diagnostic monitors supported and their status	01 ₁₆ request 41 ₁₆ response	01	DM5 (65230)	OBD compliance, previously active and active DTC count, monitors supported and their status (diagnostic readiness)

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	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Description	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Mode	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 PID	SAE Truck and Bus Council SAE J1939 Support of Those Functions SAE J1939 DM (PGN)	SAE Truck and Bus Council SAE J1939 Support of Those Functions PGN Description
3	Parameters related to the engine operation	01 ₁₆ request 41 ₁₆ response	3 to 1B ₁₆	various PGNs	Normally provided PGs will be used to retrieve these parameters; for example, SAE J1939-71 PGN 61444 contains engine speed
4	Determine OBD type supported (OBD II-CARB, OBD-Federal, OBD and OBD II, OBD 1, other)	01 ₁₆ request 41 ₁₆ response	1C ₁₆	DM5 (65230)	Tells which OBD support is provided
5	PIDs supported in freeze frame	02 ₁₆ request 42 ₁₆ response	00	DM4 (65229)	Freeze frame definition and support covered in DM4
6	DTC that caused freeze frame	02 ₁₆ request 42 ₁₆ response	02	DM4 (65229)	Freeze frame PG tells what DTC caused it.
7	PID data value in freeze frame record	02 ₁₆ request 42 ₁₆ response	03 to 0D ₁₆	DM4 (65229)	Freeze frame PG contains all parameters (more than one freeze frame can be supported)
8	Emission-related powertrain DTCs	03 ₁₆ request 43 ₁₆ response	01	DM12 (65236)	Emission-related active DTCs (MIL-on) and lamp status information
9				DM1 (65226) or DM12 (65236)	Active DTCs and lamp status information with DM1 or with DM12 when required ³
10				DM2 (65227) or DM23 (64949)	Previously active DTCs and lamp status information or with DM23 when required
11	Clear emission-related diagnostic information	04 ₁₆ request 44 ₁₆ response	NA	DM11 (65235)	Clear diagnostic information for active DTCs
12				DM3 (62228)	Clear diagnostic information for previously active DTCs

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	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Description	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Mode	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 PID	SAE Truck and Bus Council SAE J1939 Support of Those Functions SAE J1939 DM (PGN)	SAE Truck and Bus Council SAE J1939 Support of Those Functions PGN Description
13	Oxygen sensor monitoring test results	05 ₁₆ request 45 ₁₆ response	NA	DM9 (65233)	No planned message format definition.
14	On-board monitoring test results for non-continuous monitored systems	06 ₁₆ request 46 ₁₆ response	NA	DM10 (65234)	Test IDs supported
15				DM7 (58112)	Invoke test
16				DM8 (65232)	Test Results
17	Request Emission-related pending DTCs	07 ₁₆ request 47 ₁₆ response	NA	DM6 (65231)	Test results for pending DTCs.
18	Request control of on-board system, test, or component	08 ₁₆ request	NA	DM7 (58112)	Command on-board system, test, or component
19		48 ₁₆ response		DM8 (65232)	Results commanded system, test, or component
20	Calibration ID	09 ₁₆ request 49 ₁₆ response	NA	DM19 (54016)	Calibration Information (bytes 5-20 are Calibration ID)
21	Calibration Verification Number	09 ₁₆ request 49 ₁₆ response	NA	DM19 (54016)	Calibration Information (bytes 1-4 are CVN)
22	Monitor Performance Ratio	09 ₁₆ request 49 ₁₆ response	NA	DM20 (49664)	Indicates how often monitors complete compared to vehicle operation.
23	Distance Traveled while MIL is Activated Distance Since DTCs Cleared Minutes Run by Engine while MIL is Activated Time Since Diagnostic Trouble Codes Cleared	01 ₁₆ Request 41 ₁₆ Response	21 ₁₆ 31 ₁₆ 4D ₁₆ 4E ₁₆	DM21 (49408)	Diagnostic Readiness 2, reports the diagnostic information relevant to a second PGN conveying diagnostic readiness.
24	Previously Active Emission Related Faults	03 ₁₆ request 43 ₁₆ response	01	DM23 (64949)	This DM contains DTCs that are confirmed but for which the MIL is off.

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	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Description	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 Mode	SAE Motor Vehicle Council SAE J1979 Functions SAE J1979 PID	SAE Truck and Bus Council SAE J1939 Support of Those Functions SAE J1939 DM (PGN)	SAE Truck and Bus Council SAE J1939 Support of Those Functions PGN Description
25	SPN Support	01 ₁₆ Request 41 ₁₆ Response	00 ₁₆	DM24 (64950)	This message is used to identify those SPNs supported by the product from freeze frames and data stream messages.
26	Expanded Freeze Frame	02 ₁₆ request 42 ₁₆ response	02 ₁₆ to 0D ₁₆	DM25 (64951)	Freeze frame message providing more parameter support than the existing DM4.
27	Continuously Monitored Systems Enable/Completed Status Time Since Engine Start Number of Warm-Ups Since DTCs Cleared Non-continuously Monitored Systems Enable Status Non-continuously Monitored Systems Complete Status	01 ₁₆ Request 41 ₁₆ Response	41 ₁₆ 1F ₁₆ 30 ₁₆	DM26 (64952)	Diagnostic Readiness 3, conveys the pending status of OBD system monitors for the current drive cycle.
28	All Pending DTCs	None	None	DM27 (64898)	This DM conveys all pending DTCs inclusive of emissions and non-emissions related.
29	Permanent DTCs	TBD	TBD	DM28 (64896)	This DM conveys the number of permanent DTCs currently in this category.
30	Regulated DTC Counts	TBD	TBD	DM29 (40448)	This DM conveys the number of regulated DTC counts (Pending, Permanent, MIL-On, PMIL-On)
31	Scaled Test Results	TBD	TBD	DM30 (41984)	This DM conveys test results scaling.
32	DTC to Lamp Association	None	None	DM31 (41728)	This message provides added capability of sharing information about the lamp color associated with each DTC being transmitted in a multiple DTC scenario.

5.7.1 (R)Active Diagnostic Trouble Codes (DM1)

The information communicated is limited to the currently active diagnostic trouble codes (DTCs). The active diagnostic codes are preceded by the diagnostic lamp status. Together they convey the diagnostic condition of the transmitting electronic component to other components on the network. Occurrence counts for currently active diagnostic trouble codes may be provided as described in paragraph 5.7.1.12. DM1 should contain all active DTCs including the emissions-related DTCs.

The defined lamps (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) comprise a component's lamp status. Typically, they are associated with DTCs provided in DM1. If the transmitting electronic component does not have active DTCs, then the lamp status from that component will indicate that the lamps should be off. However, the component controlling the actual lamp illumination must consider the status from all components that provide these lamps before changing the display to the operator. The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. DM1 shall not convey temporary signals to provide for lamp test illumination or DTC flashout. When there are multiple DTCs with different lamp command (for example SPN1213 is for the MIL) and lamp flash (for example SPN3038 is for the flash MIL) requirements then the DTC with the MIL and fast flash takes priority over, MIL with slow flash, which takes priority over the Short MIL, which takes priority over the class C.

There are uses for additional lamp definitions to accomplish specific functions (e.g., a lamp that indicates when cruise control is actively controlling would require a separate lamp in another PG).

Transmission Rate: A DM1 message is transmitted whenever a DTC becomes an active fault and at a normal update rate of only once per second thereafter. If a fault has been active for 1 second or longer, and then becomes inactive, a DM1 message shall be transmitted to reflect this state change. If a different DTC changes state within the 1 second update period, a new DM1 message is transmitted to reflect this new DTC. To prevent a high message rate due to intermittent faults that have a very high frequency, it is recommended that no more than one state change per DTC per second be transmitted.

Thus a DTC that becomes active/inactive twice within a 1 second interval, such as shown in Example Case 1, would have one message identifying the DTC becoming active, and one at the next periodic transmission identifying it being inactive. This message shall be sent every second or in response to a request. Note that this Parameter Group will require using the "Multipacket Transport" Parameter Group (reference SAE J1939-21) when more than one active DTC exists.

DM1 shall be broadcast at 1.0 Hz Rate, even when there are no active faults. This permits instrumentation to detect the loss of the lamp information and take appropriate action. For example, MIL_Status Signal as required by OBD, and illuminate the MIL without querying providers.

Data Length:	Variable
Extended Data Page:	0
Data page:	0
PDU Format:	254
PDU Specific:	202
Default Priority:	6
Parameter Group Number:	65226 (00FECA ₁₆)
Byte: 1	bits 8-7 Malfunction Indicator Lamp Status See 5.7.1.1
	bits 6-5 Red Stop Lamp Status See 5.7.1.2
	bits 4-3 Amber Warning Lamp Status See 5.7.1.3
	bits 2-1 Protect Lamp Status See 5.7.1.4
Byte: 2	bits 8-7 Flash Malfunction Indicator Lamp See 5.7.1.5
	bits 6-5 Flash Red Stop Lamp See 5.7.1.6
	bits 4-3 Flash Amber Warning Lamp See 5.7.1.7
	bits 2-1 Flash Protect Lamp See 5.7.1.8
Byte: 3	bits 8-1 SPN, 8 least significant bits of SPN See 5.7.1.9

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Byte:	4	bits 8-1	(most significant at bit 8) SPN, second byte of SPN	See 5.7.1.9
Byte:	5	bits 8-6	(most significant at bit 8) SPN, 3 most significant bits	See 5.7.1.9
		bits 5-1	FMI	
			(most significant at bit 5)	See 5.7.1.10
Byte:	6	bit 8	SPN Conversion Method	See 5.7.1.11
		bits 7-1	Occurrence Count	See 5.7.1.12

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

a=lamp status
b=SPN
c=FMI
d=CM and OC

Message form will be as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 will have to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than one fault the services of the transport protocol will have to be used.

EXAMPLE 2: The following illustrates the message format for when a request of the DM1 is made and there are zero active faults, or when there are zero active faults and the message is being transmitted at its regular one second interval. The currently defined lamps (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component.

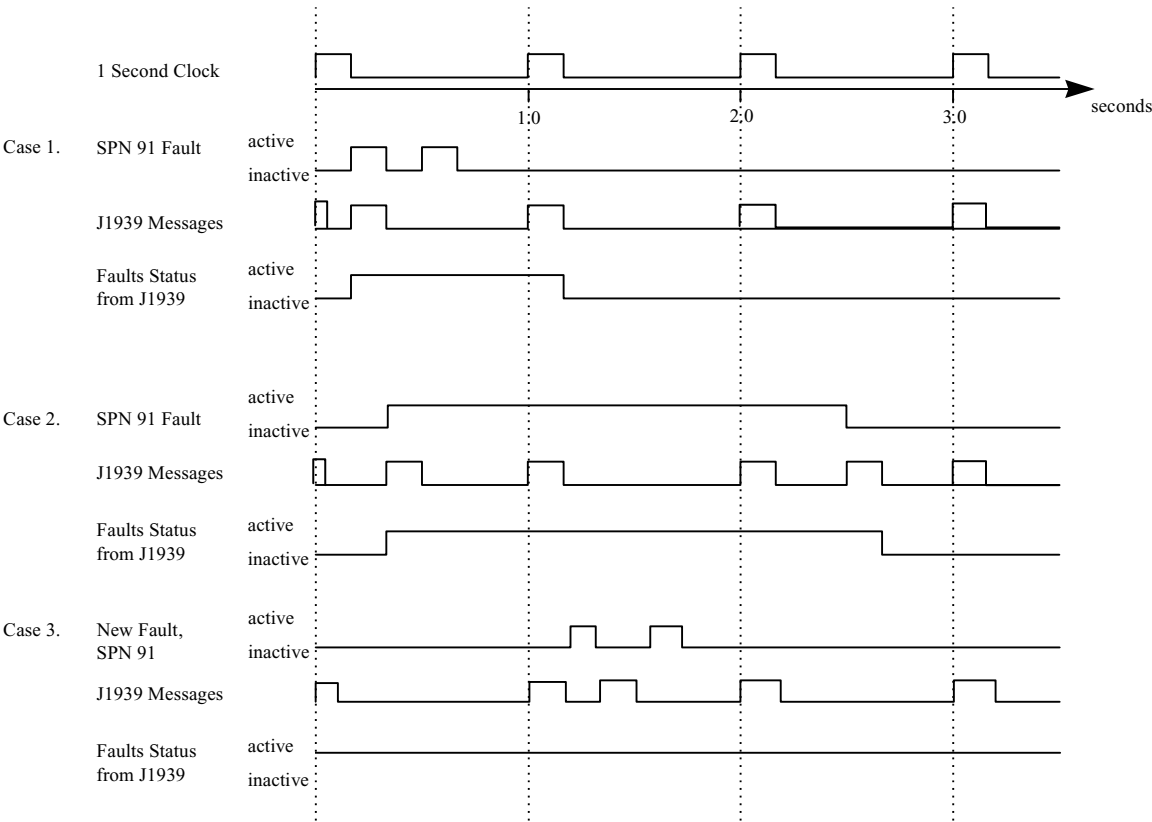
The recommended setting for bytes 6-3 is shown below. The recommended setting shall be used for engines and vehicles complying to government regulated requirements (e.g. OBD, OBD II, EOBD or HD OBD). The original publication of this recommended practice defined that bytes 6 through 3 should be set to all ones when there are zero faults. This particular implementation is no longer permitted. It provides context for existing implementations prior to the adoption of the recommended setting. Use of all ones is shown as the Grandfathered Setting below.

Given:

Byte	1	bits 8-7	= 00
		bits 6-5	= 00
		bits 4-3	= 00
		bits 2-1	= 00
Byte	2	bits 8-7	= 11
		bits 6-5	= 11
		bits 4-3	= 11
		bits 2-1	= 11

	Grandfathered Setting	Recommended Setting
Byte 6-3	SPN = 524,287 -Indicates not available	= 0
	FMI = 31 -Indicates not available	= 0
	OC = 127-Indicates not available	= 0
	CM = 1-Indicates not available	= 0
Byte 7	= 255	= 255
Byte 8	= 255	= 255

EXAMPLE 3: Three cases are enumerated as follows to define the transmission rate requirements (Figure 5-1)



(R)FIGURE 5-1 - DEFINING THE TRANSMISSION RATE REQUIREMENTS

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Case 1 illustrates that not every transition of a fault (active to inactive or inactive to active) results in a SAE J1939 message being sent. In this case, there are no other faults active when the example SPN 91 fault occurs. The SPN 91 fault is the Accelerator Pedal Position parameter which has an update faster than once a second. Therefore, the “SAE J1939 Message” (DM1 message) will be sent every 1 second while this fault is active. Three observations should be made. First, note that the first SAE J1939 message is sent when the “SPN 91 fault” becomes active on the first occurrence and not when it goes inactive for the first occurrence or active/inactive for the second occurrence. The inactive state is sent once at the next normal 1-second update (T=1 second). The second observation is that the “SAE J1939 Message” (DM1) is required to be sent at the 1 second interval even though the fault is no longer active and the actual DM1 message will contain no active faults. This is done as the action to show the fault went away. The way this is done for this specific case (where there are no longer any active faults) is as shown in the preceding Example 2. If there were other active faults they would have been sent in this message. The third observation is that if the second SPN 91 would have been a different SPN it would have been sent prior to the 1 second in a DM1 sent in between normal 1 second updates. The 1 second interval message would not contain this new SPN or SPN 91 assuming they both transitioned on and off before the 1 second message. Therefore, the 1 second DM1 message would still contain no faults.

Case 2 illustrates that the transition states can occur between the normal 1 second intervals. Therefore, a “SAE J1939 Message” is sent in between time equals 0 and time equals 1 to indicate that the SPN 91 fault has gone active. It is sent per the normal 1 second update at the 1 and 2 second points. It is sent at the time between 2 and 3 second to convey the transition to the inactive state. To do this the “J1939 Message” (DM1) is sent as shown in the preceding Example 2.

Case 3 shows the situation where there are already active faults in existence when SPN 91 becomes active. Note that the transition of SPN 91 to active state is sent between the 1 and 2 second points. The message contains all active faults, not just the new one. The transition to the inactive state is sent during the normal 2 second update. This message would contain all active faults and since SPN 91 went inactive it would not be in this message.

5.7.1.1 (R)Malfunction Indicator Lamp

A lamp used to relay only emissions-related trouble code information. This lamp is only illuminated when there is an emission-related trouble code active.

Also see “Table 5: Lamp Command and Lamp flash dependency definition” for the specified operation of the applicable lamp and flash SPNs.

00	Lamp Off
01	Lamp On
10	Short MIL for WWH OBD (for WWH OBD discriminatory display systems, not applicable for other OBD non-discriminatory display systems)
Type:	Status
Suspect Parameter Number:	1213
Reference:	5.7.1, 5.7.2, 5.7.6 and 5.7.12

(R)TABLE 5: LAMP COMMAND AND LAMP FLASH DEPENDENCY DEFINITION (SAME AS TABLE 24)

Possible Commanded Conditions		Required Lamp Output Operation			
Lamp SPNs: 1213; 623; 624; 987	Flash SPNs: 3038, 3039, 3040, 3041	MIL SPN 1213	RSL SPN 623	AWL SPN 624	Protect SPN 987
00	00	Off	Off	Off	Off
00	01	Off	Off	Off	Off
00	10	Off, class C not active	SAE reserved	SAE reserved	SAE reserved
00	11	Off	Off	Off	Off
01	00	On, slow flash	On, slow flash	On, slow flash	On, slow flash
01	01	On, fast flash	On, fast flash	On, fast flash	On, fast flash

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Possible Commanded Conditions		Required Lamp Output Operation			
Lamp SPNs: 1213; 623; 624; 987	Flash SPNs: 3038, 3039, 3040, 3041	MIL SPN 1213	RSL SPN 623	AWL SPN 624	Protect SPN 987
01	10	Off, class C active	SAE reserved	SAE reserved	SAE reserved
01	11	On, don't flash	On, don't flash	On, don't flash	On, don't flash
10	00	Short MI not active	SAE reserved	SAE reserved	SAE reserved
10	01	Short MI active	SAE reserved	SAE reserved	SAE reserved
10	10	SAE reserved	SAE reserved	SAE reserved	SAE reserved
10	11	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	00	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	01	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	10	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	11	Don't Care	Don't Care	Don't Care	Don't Care

5.7.1.2 Red Stop Lamp

This lamp is used to relay trouble code information that is of a severe enough condition that it warrants stopping the vehicle. Also see "Table 5: Lamp Command and Lamp flash dependency definition" for the specified operation of the applicable lamp and flash SPNs.

00 Lamp Off
01 Lamp On
Type: Status
Suspect Parameter Number: 623
Reference: 5.7.1, 5.7.2, 5.7.6 and 5.7.12

5.7.1.3 Amber Warning Lamp

This lamp is used to relay trouble code information that is reporting a problem with the vehicle system but the vehicle need not be immediately stopped. Also see "Table 5: Lamp Command and Lamp flash dependency definition" for the specified operation of the applicable lamp and flash SPNs.

00 Lamp Off
01 Lamp On
Type: Status
Suspect Parameter Number: 624
Reference: 5.7.1, 5.7.2, 5.7.6 and 5.7.12

5.7.1.4 Protect Lamp

This lamp is used to relay trouble code information that is reporting a problem with a vehicle system that is most probably not electronic subsystem related. For instance, engine coolant temperature is exceeding its prescribed temperature range. Also see "Table 5: Lamp Command and Lamp flash dependency definition" for the specified operation of the applicable lamp and flash SPNs.

00 Lamp Off
01 Lamp On
Type: Status
Suspect Parameter Number: 987
Reference: 5.7.1, 5.7.2, 5.7.6 and 5.7.12

5.7.1.5 (R)Flash Malfunction Indicator Lamp (MIL)

This parameter provides the capability to flash the MIL. Also see "Table 5: Lamp Command and Lamp flash dependency definition" for the specified operation of the applicable lamp and flash SPNs.

00	Slow Flash (1 Hz, 50% duty cycle)
01	Fast Flash (2 Hz or faster, 50% duty cycle)
10	Class C DTC (for WWH OBD discriminatory display systems, not applicable for other OBD non-discriminatory display systems)
11	Unavailable / Do Not Flash
Type:	Status
Suspect Parameter Number:	3038
Reference:	5.7.1, 5.7.2, 5.7.6 and 5.7.12

5.7.1.6 (R)Flash Red Stop Lamp (RSL)

This parameter provides the capability to flash the RSL. Also see "Table 5: Lamp Command and Lamp flash dependency definition" for the specified operation of the applicable lamp and flash SPNs.

00	Slow Flash (1 Hz, 50% duty cycle)
01	Fast Flash (2 Hz or faster, 50% duty cycle)
10	Reserved
11	Unavailable / Do Not Flash
Type:	Status
Suspect Parameter Number:	3039
Reference:	5.7.1, 5.7.2, 5.7.6 and 5.7.12

5.7.1.7 (R)Flash Amber Warning Lamp (AWL)

This parameter provides the capability to flash the AWL. Also see "Table 5: Lamp Command and Lamp flash dependency definition" for the specified operation of the applicable lamp and flash SPNs.

00	Slow Flash (1 Hz, 50% duty cycle)
01	Fast Flash (2 Hz or faster, 50% duty cycle)
10	Reserved
11	Unavailable / Do Not Flash
Type:	Status
Suspect Parameter Number:	3040
Reference:	5.7.1, 5.7.2, 5.7.6 and 5.7.12

5.7.1.8 (R)Flash Protect Lamp

This parameter provides the capability to flash the protect lamp. Also see "Table 5: Lamp Command and Lamp flash dependency definition" for the specified operation of the applicable lamp and flash SPNs.

00	Slow Flash (1 Hz, 50% duty cycle)
01	Fast Flash (2 Hz or faster, 50% duty cycle)
10	Reserved
11	Unavailable / Do Not Flash
Type:	Status
Suspect Parameter Number:	3041
Reference:	5.7.1, 5.7.2, 5.7.6 and 5.7.12

5.7.1.9 Suspect Parameter Number

This 19-bit number is used to identify the item for which diagnostics are being reported. The SPN is used for multiple purposes, some of those that are specific to diagnostics are: 1. to identify a least repairable subsystem that has failed; 2. to identify subsystems and or assemblies that may not have hard failures but may be exhibiting abnormal operating performance; 3. identifying a particular event or condition that will be reported; and 4. to report a component and non-

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standard failure mode. SPNs are assigned to each individual parameter in a Parameter Group and to items that are relevant to diagnostics but are not a parameter in a Parameter Group. SPNs are independent of the source address for the message. However, the source address may be necessary to determine which controller on the network performed the diagnosis.

The first 511 SPNs are reserved and will be assigned the exact same number as the Parameter Identifier (PID) used in SAE J1587. That is, the SPN for an accelerator problem will be reported as SPN 91 which is SAE J1587 PID 91. All other SPNs will be numbered sequentially starting at 512 and incrementing by one for each new assignment. Refer to SAE J1939 Appendix C.

Proprietary Suspect Parameter Numbers have been established to allow the reporting of manufacturer specific diagnostics. The interpretation of the diagnostic trouble codes using proprietary SPNs varies by manufacturer. There are 4096 Suspect Parameter Numbers defined for proprietary diagnostics. The SPNs for Proprietary Diagnostics cover the range 520192 to 524287. See APPENDIX F for the list of restrictions for the SPNs for Proprietary Diagnostics.

Data Length:	19 bits
Resolution:	1 SPN/bit
Data Range:	0 to 524,287
Type:	Status
Suspect Parameter Number:	1214
Reference:	5.7.1, 5.7.2, 0, 5.7.6, and 5.7.12

5.7.1.10 Failure Mode Identifier

The FMI defines the type of failure detected in the subsystem identified by an SPN. Note that the failure may not be an electrical failure but may instead be a subsystem failure or condition needing to be reported to the service technician and maybe also to the operator. Conditions can include system events or status that need to be reported. The FMI, SPN, SPN Conversion Method and Occurrence Count fields combine to form a given diagnostic trouble code. The "Reserved to be Assigned by SAE" FMIs will be assigned by the SAE J1939 Control and Communications Subcommittee if additional failure modes become necessary. The currently defined FMIs are listed in APPENDIX A.

Data Length:	5 bits
Resolution:	1 FMI/bit
Data Range:	0 to 31
Type:	Status
Suspect Parameter Number:	1215
Reference:	5.7.1, 5.7.2, 0, 5.7.6, and 5.7.12

5.7.1.11 SPN Conversion Method

When this 1-bit field is equal to a zero, the SPN should be converted as it is defined in this document (see definition below for Version 4). The February 1996 version of J1939-73 contained inadequate definitions to assure consistent implementations. Products implementing to February 1996 version of the document will always have this bit set to a one. When this is the case, the SPN is in either Version 1, 2 or 3 format. The original publication of this recommended practice defined that this bit be set to one. This particular implementation is no longer permitted. It provides context for some implementations prior to the adoption of the recommended setting as zero (version 4 definition).

To clarify the ordering of bits and bytes within the SPN parameter (which is 19 bits long) and to keep that ordering consistent with other parameters in J1939-71 and J1939-73, the bit order has been respecified. See Version 4 below for the recommended formatting. Version 4 is required for any device complying with section 5.2.2.1 for emissions related components.

To reduce problems in interpretation of the SPNs the bit between the FMI field and the Occurrence Count field, previously reserved, will be cleared to zero to identify use of the currently specified SPN bit pattern. This bit now comprises an SPN Conversion Method for the purpose of maintaining usability of those implementations that are already in use.

Data Length:	1 bit
Resolution:	Not Applicable
Data Range:	0 means convert SPNs per the Version 4 definition below 1 means convert SPNs per Version 1, 2 or 3 specified below.

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The four versions of interpretation are:

1. SPN assumed to be sent most significant bit first
2. SPN represented as Intel format for most significant 16 bits with 3 least significant bits of 19 bits in with FMI value.
3. SPN represented as Intel format for all 19 bits (least significant sent first)
4. SPN represented as Intel format for all 19 bits with the SPN Conversion Method set to 0.

Type: Status
 Suspect Parameter Number: 1706
 Reference: 5.7.1, 5.7.2, 0, 5.7.6, and 5.7.12

Given:

SPN 1208 = $4B8_{16}$ = 000 00000100 10111000₂ (19 bits)
 FMI 3 = 3_{16} = 0001₂ (5 bits)
 OC 10 = A_{16} = 0001010₂ (7 bits)
 CM = 0_2 (1 bit)

Version 1.

J1939 Frame Format

DTC																															
Byte 3								Byte 4								Byte 5								Byte 6							
8 most significant bits of 16 most significant bits of SPN (bit 8 most significant)								8 least significant bits of 16 most significant bits of SPN (bit 8 most significant)								3 least significant bits of SPN and the FMI (bit 8 SPN msb and bit 5 FMI msb)															
SPN																FMI				CM	OC										
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0

Version 2.

J1939 Frame Format

DTC																															
Byte 3 8 least significant bits of 16 most significant bits of SPN (bit 8 most significant)								Byte 4 8 most significant bits of 16 most significant bits of SPN (bit 8 most significant)								Byte 5 3 least significant bits of SPN and the FMI (bit 8 SPN msb and bit 5 FMI msb)								Byte 6							
SPN																FMI				CM	OC										
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
1	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0

Version 3.

J1939 Frame Format

DTC																															
Byte 3 8 least significant bits of SPN (bit 8 most significant)								Byte 4 second byte of SPN (bit 8 most significant)								Byte 5 3 most significant bits of SPN and the FMI (bit 8 SPN msb and bit 5 FMI msb)								Byte 6							
SPN																FMI				CM	OC										
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
1	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0

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Version 4.*

Recommended Version

*Effective 1996, Version 4 shall be used for all future OBD applications.

J1939 Frame Format

(R)

DTC																											
Byte 3								Byte 4								Byte 5								Byte 6			
8 least significant bits of SPN (bit 8 most significant)								second byte of SPN (bit 8 most significant)								3 most significant bits of SPN and the FMI (bit 8 SPN msb and bit 5 FMI msb)											
SPN																FMI				CM	OC						
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5
1	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0

5.7.1.12 (R) Occurrence Count

The 7-bit occurrence count field contains the number of times a fault has been independently detected. The occurrence count is reported as 1 the first time the DTC is detected. The occurrence count is not incremented again, until after the DTC has gone to the previously active state and then back active the DTC state when subsequently detected. At this point the occurrence count would be reported as 2. This continues until the DTC has been independently detected 126 times. The occurrence count shall not be incremented from 126 to 127 -- it shall remain at 126 until cleared by DM3 or DM11. If an occurrence count is not available, then this field should be set to all binary ones (127). The occurrence count is not incremented just do to an ignition key-off and ignition key-on. The diagnostic system shall have monitored the system or component (e.g. DTC) to see that it is no longer malfunctioning in order to declare it previously active.

Data length: 7 bits
Resolution: 1 occurrence count/bit
Data range: 0 to 126 (the value 127 is reserved for indicating not available)
Type: status
Suspect parameter number: 1216
Reference: 5.7.1, 5.7.2, 0, 5.7.6, and 5.7.12

5.7.2 Previously Active Diagnostic Trouble Codes (DM2)

The information communicated is limited to the previously active trouble codes. It is used to notify other components on the network of the diagnostic condition of the transmitting electronic component. The data contains a list of diagnostic codes and occurrence counts for previously active trouble codes. Whenever this message is sent, it should contain all previously active trouble codes with an occurrence count not equal to zero. Note that this parameter group will be sent using the "multipacket transport" parameter group as specified in SAE J1939-21 when applicable.

The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flashout.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	203	
Default Priority:	6	
Parameter Group Number:	65227 (00FECB ₁₆)	
Byte: 1	bits 8-7	Malfunction Indicator Lamp Status
	bits 6-5	Red Stop Lamp Status
	bits 4-3	Amber Warning Lamp Status
	bits 2-1	Protect Lamp Status
Byte: 2	bits 8-7	Flash Malfunction Indicator Lamp
	bits 6-5	Flash Red Stop Lamp
	bits 4-3	Flash Amber Warning Lamp

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	bits 2-1	Flash Protect Lamp	See 5.7.1.8
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 5	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
	bits 5-1	FMI (most significant at bit 5)	See 5.7.1.10
Byte: 6	bit 8	SPN Conversion Method	See 5.7.1.11
	bits 7-1	Occurrence Count	See 5.7.1.12

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

a=lamp status (LS)
b=SPN
c=FMI
d=CM and OC

Message form will be as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 will have to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than one fault the services of the transport protocol will have to be used.

EXAMPLE 2: The following illustrates the message format for when a request of the DM2 is made and there are zero previously active faults. The currently defined lamps (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. In this example, the amber lamp is identified as being on.

The recommended setting for bytes 6-3 is shown below. The recommended setting shall be used for engines and vehicles complying to government regulated requirements (e.g. OBD, OBD II, EOBD or HD OBD). The original publication of this recommended practice defined that bytes 6 through 3 should be set to all ones when there are zero faults. This particular implementation is no longer permitted.. It provides context for existing implementations prior to the adoption of the recommended setting. Use of all ones is shown as the Grandfathered Setting below

Given:

Byte 1	bits 8-7	= 00
	bits 6-5	= 00
	bits 4-3	= 01
	bits 2-1	= 00
Byte 2	bits 8-7	= 11
	bits 6-5	= 11
	bits 4-3	= 11
	bits 2-1	= 11

	Grandfathered Setting	Recommended Setting
Byte 6-3	SPN = 524,287 -Indicates not available	= 0
	FMI = 31 -Indicates not available	= 0
	OC = 127-Indicates not available	= 0
	CM = 1-Indicates not available	= 0
Byte 7	= 255	= 255
Byte 8	= 255	= 255

5.7.3 (R)Diagnostic Data Clear/Reset Of Previously Active DTCs (DM3)

All of the diagnostic information pertaining to the previously active trouble codes should be erased when this PG is requested. The diagnostic data associated with active trouble codes will not be affected. Upon the completion of this operation or if there are no faults to clear, a positive acknowledgment shall be sent as required (see SAE J1939-21 PGN 59392). If for some reason a device can not perform the requested action, then it is required to send a negative acknowledgment (see SAE J1939-21 PGN 59392). Implementers be aware that no positive or negative acknowledgment is sent when the request was sent to the global address.

All diagnostic information pertaining to the previously active DTCs includes:

- Number of diagnostic trouble codes
- Diagnostic trouble codes
- Number of Previously Active DTCs and readiness information (can be read with DM5)
- Previously Active DTCs (can be read with DM2)
- Trouble code for freeze frame data
- Freeze frame data (can be read with DM4 and/or DM25)
- Oxygen sensor test data
- Status of system monitoring tests (can be read with DM6)
- On-board monitoring test results (can be read with DM10)
- Distance traveled while MIL is activated (can be read in DM21)
- Number of warm-ups since DTC cleared
- Distance since diagnostic trouble codes cleared
- Minutes run by the engine while MIL is activated
- Time since diagnostic trouble codes cleared
- Other manufacturer specific "clearing/resetting" actions may also occur in response to this request message.

All ECUs shall clear the DTCs and send a Positive Acknowledgement to this request message with ignition ON and with the engine not running.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported and it was a destination specific request for DM3. (see SAE J1939-21 PGN 59392)	
Data Length:	0	
Extended Data Page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	204	
Default Priority:	6	
Parameter Group Number:	65228 (00FECC ₁₆)	

Example:

Given:

1. A tool desires to clear the diagnostic data of the engine.
2. The engine is able to perform the requested action.

The tool shall send the Request PGN 59904 directed specifically to the engine controller with the PGN 65228 as the requested PGN. The engine controller shall respond with the Acknowledgement PGN 59392 indicating that the action was successfully completed for PGN 65228.

5.7.4 Freeze Frame Parameters (DM4)

A freeze frame is defined as the list of recorded parameters at the time a diagnostic trouble code was captured. The freeze frame recorded for each diagnostic trouble code will contain the required parameters first and then any manufacturer specific information. It is possible that controllers will have more than one freeze frame available and each

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may have some manufacturer specific information. A freeze frame is specific to one diagnostic trouble code and one diagnostic trouble code only has one freeze frame. This then limits the amount of freeze frame data per fault and for all faults that are included in this message to 1785 bytes (see SAE J1939-21 transport protocol).

This diagnostic message is best suited for systems which may impact emissions and or be powertrain related. However, the use of this message is not limited to just emission-related failures or just powertrain devices. It can be used to report non-emission related or non-powertrain related failures.

Implementers should refer to the applicable regulation for potential additional Freeze Frame requirements. For instance, some regulations might require the OBD Freeze Frame to have priority over non-OBD Freeze Frames.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	205	
Default Priority:	6	
Parameter Group Number:	65229 (00FECD ₁₆)	
Byte: 1	Freeze Frame Length	See 5.7.4.1
Byte: 2	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 3	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 4	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
	bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10
Byte: 5	bit 8 SPN Conversion Method	See 5.7.1.11
	bits 7-1 Occurrence Count	See 5.7.1.12
Byte: 6	Engine Torque Mode (SPN 899)	See SAE J1939-71
Byte: 7	Boost (SPN 102)	See SAE J1939-71
Byte: 8	Engine Speed (SPN 190) (LSB)	See SAE J1939-71
Byte: 9	(MSB)	
Byte: 10	Engine % Load (SPN 92)	See SAE J1939-71
Byte: 11	Engine coolant temperature (SPN 110)	See SAE J1939-71
Byte: 12	Vehicle Speed (SPN 86) (LSB)	See SAE J1939-71
Byte: 13	(MSB)	
Byte: 14-n	Manufacturer Specific information	

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

NOTE: If no DTCs (active or previously active) have been accumulated, then the response will be:

PGN = 65229

Byte: 1	= 0
5-2	= 0
6	= 255
7	= 255
8	= 255

When byte 1 is equal to zero it identifies to the receiver that the other parameters in the message should not be interpreted. Also notice that the values of the information put in bytes 1 through 5 are zero even though some of the parameters may have normally been set to all ones (binary) to indicate not available.

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EXAMPLE: The following illustrates the message format for when there are more than one freeze frame.

Given:

a=freeze frame length

b=required parameters (bytes 2 through 13 for the first DTC and the corresponding bytes for each of the remaining DTCs)

c=manufacturer specific freeze frame information

Message form will be as follows: a,b,c,a,b,c,a,b,c,a,b,c....etc. The transport protocol of SAE J1939-21 will have to be used to send freeze frames because they are more than 8 data bytes.

5.7.4.1 Freeze Frame Length

The Freeze Frame Length shall be equal to the number of bytes in the required parameters (that is bytes 2 through 13) plus the number of bytes in the manufacturer specific parameters. That is: $a = b + c$

Data Length:	8 bits
Resolution:	1 byte/bit
Data Range:	0 to 255
Type:	Status
Suspect Parameter Number:	1217
Reference:	5.7.4

EXAMPLE

b = 12
c = 2.....oil pressure, intake manifold temperature
a = b + c
a = 12 + 2 = 14

5.7.4.2 Freeze Frame Parameters

The parameters collected in the freeze frame shall use the same scaling as is defined in the SAE J1939-71 document.

5.7.5 Diagnostic Readiness 1 (DM5)

Reports the diagnostics information that relates to diagnostic readiness.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	206	
Default Priority:	6	
Parameter Group Number:	65230 (00FECE ₁₆)	
Byte:	1	Active Trouble Codes
	2	Previously Active Diagnostic Trouble Codes
	3	OBD Compliance
	4	Continuously Monitored Systems Support/Status
	6-5	Non-continuously Monitored Systems Support
	8-7	Non-continuously Monitored Systems Status

5.7.5.1 Active Trouble Codes

Identifies the number of active trouble codes that are present in a specific controller. If no DTCs are active, this field should be set to zero.

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Data Length: 1 byte
 Resolution: 1 trouble code/bit
 Data Range: 0 to 250
 Type: Measured
 Suspect Parameter Number: 1218
 Reference: 5.7.5

5.7.5.2 Previously Active Diagnostic Trouble Codes

Identifies the number of previously active trouble codes that are present in a specific controller. If no DTCs have been previously active, this field should be set to zero.

Data Length: 1 byte
 Resolution: 1 trouble code/bit
 Data Range: 0 to 250
 Type: Measured
 Suspect Parameter Number: 1219
 Reference: 5.7.5

5.7.5.3 (R)OBD Compliance

Identifies the OBD compliance capability of the responding controller. Identifies the requirements level to which the controller was built.

Data Length: 1 byte
 Resolution: See below
 Data Range: 0 to 250
 Type: Measured
 Suspect Parameter Number: 1220
 Reference: 5.7.5

Value	Decimal	Description
00	0	Reserved for assignment by SAE
01	1	OBD II (California Air Resources Board)
02	2	OBD (Federal, EPA)
03	3	OBD and OBD II
04	4	OBD I
05	5	Not intended to meet OBD II requirements
06	6	EOBD
07	7	EOBD and OBD II
08	8	EOBD and OBD
09	9	EOBD, OBD and OBD II
0A ₁₆	10	JOBD
0B ₁₆	11	JOBD and OBD II
0C ₁₆	12	JOBD and EOBD
0D ₁₆	13	JOBD, EOBD and OBD II
0E ₁₆	14	Heavy Duty Vehicles (EURO IV) B1
0F ₁₆	15	Heavy Duty Vehicles (EURO V) B2
10 ₁₆	16	Heavy Duty Vehicles (EURO EEC) C (gas engines)
11 ₁₆	17	Engine Manufacturer Diagnostics (EMD)
12 ₁₆	18	Engine Manufacturer Diagnostics Enhanced (EMD+)
13 ₁₆	19	Heavy Duty/On-Board Diagnostics Partial (CARB CCR 1971.1)
14 ₁₆	20	Heavy Duty/On-Board Diagnostics (CARB CCR 1971.1)
15 ₁₆	21	World Wide Harmonized OBD

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Value	Decimal	Description
16 ₁₆	22	OBD II (California Air Resources Board 2007/2008 revisions)
17 ₁₆	23	Heavy Duty Vehicles (EURO IV / V, revisions specified in 2005 and 2006)
18-FA ₁₆	23-250	To be assigned by SAE/ISO
FB- FF ₁₆	251-255	Per J1939-71 definition

5.7.5.4 Continuously Monitored Systems Support/Status

Identifies the continuously monitored system support and status.

Data Length: 1 byte
Resolution: See below
Data Range: Bit mapped, see below
Type: Measured
Suspect Parameter Number: 1221
Reference: 5.7.5

Byte	Bit	Description
4	8	Reserved for assignment by SAE
	7	Comprehensive component monitoring status
	6	Fuel System monitoring status
	5	Misfire monitoring status

Where each status bit (bits 7, 6, 5) is interpreted:

0 = test complete, not supported

1 = test not complete

4	Reserved for assignment by SAE
3	Comprehensive component monitoring support
2	Fuel system monitoring support
1	Misfire monitoring support

Where each supported bit (bits 3, 2, 1) is interpreted:

0 = test not supported by this controller

1 = test supported by this controller

NOTE: Notice that a bit set to zero can mean test not supported. This is different than the typical J1939 use of the value 1 to indicate not available.

5.7.5.5 (R)Non-continuously Monitored Systems Support

Identifies the non-continuously monitored systems support.

Data Length: 2 bytes (sent as a magnitude; therefore it is byte swapped)
Resolution: See below
Data Range: Bit mapped, see below
Type: Measured
Suspect Parameter Number: 1222
Reference: 5.7.5

Byte	Bit	Description
5	8	EGR system monitoring Support
	7	Oxygen sensor heater monitoring Support
	6	Oxygen sensor monitoring Support
	5	A/C system refrigerant monitoring Support
	4	Secondary air system monitoring Support
	3	Evaporative system monitoring Support
	2	Heated catalyst monitoring Support
	1	Catalyst monitoring Support

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- | | | |
|---|-----|---|
| 6 | 8-6 | Reserved for assignment by SAE |
| | 5 | NMHC converting catalyst |
| | 4 | NOx converting catalyst and/or NOx adsorber |
| | 3 | Diesel Particulate Filter (DPF) |
| | 2 | Boost pressure control system |
| | 1 | Cold start aid system monitoring Support |

Where each bit is interpreted:

0 = test not supported by this controller

1 = test supported by this controller

NOTE: The "Non-continuously Monitored Systems Support" parameter is in the Intel Format (byte-swapped format). Also notice that a bit set to zero means test not supported. This is different than the typical J1939 use of the value 1 to indicate not available.

5.7.5.6 (R)Non-continuously Monitored Systems Status

Identifies the non-continuously monitored systems status. Each bit identifies whether a particular test is complete for a given controller.

Data Length:	2 bytes (sent as a magnitude; therefore it is byte swapped)
Resolution:	See below
Data Range:	Bit mapped, see below
Type:	Measured
Suspect Parameter Number:	1223
Reference:	5.7.5

Byte	Bit	Description
7	8	EGR system monitoring Status
	7	Oxygen sensor heater monitoring Status
	6	Oxygen sensor monitoring
	5	A/C system refrigerant monitoring Status
	4	Secondary air system monitoring Status
	3	Evaporative system monitoring Status
	2	Heated catalyst monitoring Status
6	1	Catalyst monitoring Status
	8-6	Reserved for assignment by SAE
	5	NMHC converting catalyst
	4	NOx converting catalyst and/or NOx adsorber
	3	Diesel Particulate Filter (DPF)
	2	Boost pressure control system
	1	Cold start aid system monitoring Status

Where each bit is interpreted:

0 = test complete, or not supported

1 = test not complete

NOTE: The "non-continuously monitored systems status" parameter is in the Intel format (byte-swapped format). Also notice that a bit set to zero can mean test not supported. This is different than the typical J1939 use of the value 1 to indicate not available.

5.7.6 Pending DTCs (DM6)

The purpose of this DM is to enable the external test equipment to obtain "pending" diagnostic trouble codes detected during current or last completed driving cycle for emission-related components/systems. DM6 is required for all emission related DTCs and is independent of DM12. The intended use of this data is to assist the service technician after a vehicle repair, and after clearing diagnostic information, by reporting test results after a single driving cycle. If the test failed

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during the driving cycle, the DTC associated with that test will be reported. Test results reported by this service do not necessarily indicate a faulty component/system. If test results indicate a failure after additional driving, then the MIL will be illuminated and a DTC will be set and reported with DM1, indicating a faulty component/system. This service can always be used to request the results of the latest test, independent of the setting of a DTC.

Reporting the pending DTCs is done using the same format as is used to report active DTCs.

The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flashout.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	207	
Default Priority:	6	
Parameter Group Number:	65231 (00FECF ₁₆)	
Byte: 1	bits 8-7	Malfunction Indicator Lamp Status
	bits 6-5	Red Stop Lamp Status
	bits 4-3	Amber Warning Lamp Status
	bits 2-1	Protect Lamp Status
Byte: 2	bits 8-7	Flash Malfunction Indicator Lamp
	bits 6-5	Flash Red Stop Lamp
	bits 4-3	Flash Amber Warning Lamp
	bits 2-1	Flash Protect Lamp
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)
Byte: 4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)
Byte: 5	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)
	bits 5-1	FMI (most significant at bit 5)
Byte: 6	bit 8	SPN Conversion Method
	bits 7-1	Occurrence Count

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

a=lamp status (LS)
b=SPN
c=FMI
d=CM and OC

Message form is as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 has to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than one fault, the services of the transport protocol have to be used.

EXAMPLE 2: The following illustrates the message format for when a request of the DM6 is made and all test results indicate no trouble information. The currently defined lamps (Malfunction Indicator Lamp, Red Stop Lamp,

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Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. In this example, the amber lamp is identified as being on.

The recommended setting for bytes 6-3 is shown below. The recommended setting shall be used for engines and vehicles complying to government regulated requirements (e.g. OBD, OBD II, EOBD or HD OBD). The original publication of this recommended practice defined that bytes 6 through 3 should be set to all ones when there are zero faults. This particular implementation is no longer permitted. It provides context for existing implementations prior to the adoption of the recommended setting. Use of all ones is shown as the Grandfathered Setting below.

Given:

Byte 1	bits 8-7 =	00
	bits 6-5 =	00
	bits 4-3 =	01
	bits 2-1 =	00
Byte 2	bits 8-7 =	11
	bits 6-5 =	11
	bits 4-3 =	11
	bits 2-1 =	11

	Grandfathered Setting	Recommended Setting
Byte 6-3	SPN = 524,287 -Indicates not available	= 0
	FMI = 31 -Indicates not available	= 0
	OC = 127-Indicates not available	= 0
	CM = 1-Indicates not available	= 0
Byte 7		= 255
Byte 8		= 255

5.7.7 (R)Command Non-Continuously Monitored Test (DM7)

The purpose of this command in the diagnostic process is to provide the ability to command On-Board Diagnostic monitoring tests of specific components/ systems that are not continuously monitored.

The component manufacturer is responsible to assign test identifiers (TID) and component identifiers for tests of different systems and components. PGN 58112 (DM7) is used to invoke one of the manufacturer defined test identifiers or invoke a standard test or request last measured results. Test results are reported by test identifier using PGN 65232 (DM8) for non-scaled test results. If DM7 or the specific test identifier is not supported, then a NACK is required—SAE J1939-21 PGN 59392) to be returned. For test results that utilize standard scaling refer to DM 30.

Transmission Rate:	Sent whenever a test is desired	
Data Length:	8	
Extended Data Page:	0	
Data page:	0	
PDU Format:	227	
PDU Specific:	Destination Address	
Default Priority:	6	
Parameter Group Number:	58112 (00E300 ₁₆)	
Byte: 1	Test Identifier	See 5.7.7.1
Byte: 2	bits 8-1	SPN, 8 least significant bits of SPN
		(most significant at bit 8)
Byte: 3	bits 8-1	SPN, second byte of SPN
		(most significant at bit 8)
Byte: 4	bits 8-6	SPN, 3 most significant bits
		(most significant at bit 8)
	bits 5-1	FMI
		(most significant at bit 5)
5-8	Reserved for assignment by SAE	

See 5.7.7.1

See 5.7.7.2

See 5.7.7.3

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5.7.7.1 (R)Test Identifier (TID)

The TID has 2 methods to designate the test to be run. The first method uses the TID alone and these test identifiers are manufacturer-defined test identifiers. For this first use there are 64 valid test identifiers, 1 to 64. The second method uses the TID and the SPN / FMI to identify the test.

See the table in this section for values that are available to be used.

Data Length: 1 byte
Resolution: See section 5.7.8 or 5.7.30
Data Range: 0 to 255 per table below
Type: Status
Suspect Parameter Number: 1224
Reference: 0 and 5.7.8 or 5.7.30

Test Identifier Value	Name	Response PGN	Test Results
0	Reserved for SAE Assignment	NA	NA
1-64	Command Manufacturer Specific Test	DM8	Non-standard scaling
65-247	Reserved for SAE Assignment	TBA	NA
248	Command Manufacturer Specific Test	DM30	Standard scaling
249	Command Standard Test	DM30	Standard scaling
250	Return Last Measured Scaled Results	DM30	Standard scaling
251-255	Reserved for SAE Assignment	NA	NA

5.7.7.2 SPN Identifying Component / System

This parameter identifies the component / system that will be tested.

Data Length: 19 bits
Resolution: See below
Data Range: Bit mapped, see below
Type: Status
Suspect Parameter Number: 4148
Reference: 0

5.7.7.3 FMI Identifying Component / System Specific Test

This parameter identifies the failure mode identifier which represents the test(s) that shall be run on the component / system that will be tested.

Data Length: 5 bits
Resolution: See below
Data Range: Bit mapped, see below
Type: Status
Suspect Parameter Number: 4149
Reference: 0

5.7.8 (R)Test Results For Non-Continuously Monitored Systems (DM8)

The purpose of this response PG is to report the test results for one of the non-continuously monitored tests invoked using DM7. The component manufacturer is responsible to assign test identifiers and component identifiers for tests of different systems and components. PGN 58112 (DM7) is used to invoke one of the manufacturer defined test identifiers. Test results are reported by test identifier using PGN 65232 (DM8).

Transmission Rate: Sent in response to PGN 58112 when the results are available
A NACK is required if PG is not supported

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	(see SAE J1939-21 PGN 59392)	
Data Length:	Variable but sent in 8 byte sets (see example)	
Extended Data Page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	208	
Default Priority:	6	
Parameter Group Number:	65232 (00FED0 ₁₆)	
Byte: 1	Test Identifier	See 5.7.7.1
2	Test Type/Component Identifier	See 5.7.8.1
4-3	Test Value	See 5.7.8.2
6-5	Test Limit Maximum	See 5.7.8.3
8-7	Test Limit Minimum	See 5.7.8.4

Further guidelines for the use of the Test Value, Test Limit Maximum and the Test Limit Minimum to convey results for tests are enumerated in Table 6 below. For example with a test where there is not a test limit maximum or test limit minimum the results are determined from the test value alone (cases 1 to 4).

(R)TABLE 6 - TEST RESULTS

Case #	Test Value	Test Maximum	Test Minimum	Interpretation
1.	0000 ₁₆ to FAFF ₁₆	FFFF ₁₆	FFFF ₁₆	Test Pass
2.	FE00 ₁₆ (Error)	FFFF ₁₆	FFFF ₁₆	Test Fail
3.	FB00 ₁₆	FFFF ₁₆	FFFF ₁₆	Test Not Complete
4.	FB01 ₁₆	FFFF ₁₆	FFFF ₁₆	Test Can Not Be Performed
5.	0003 ₁₆	0004 ₁₆	0001 ₁₆	Test Pass
6.	0000 ₁₆	0004 ₁₆	0001 ₁₆	Test Fail
7.	0005 ₁₆	0004 ₁₆	0001 ₁₆	Test Fail
8.	0000 ₁₆	FFFF ₁₆	0001 ₁₆	Test Fail
9.	0002 ₁₆	FFFF ₁₆	0001 ₁₆	Test Pass
10.	FAFF ₁₆	FAFE ₁₆	FFFF ₁₆	Test Fail
11.	AF57 ₁₆	AF59 ₁₆	FFFF ₁₆	Test Pass
12.	0100 ₁₆	FAFE ₁₆	0100 ₁₆	Test Pass
13.	FAFE ₁₆	FAFE ₁₆	0100 ₁₆	Test Pass

Another observation is that if there are more than one test value to report on a given test then the results will be sent using the transport protocol defined in J1939-21. See the following example. If multiple test results are reported, then the component identifier parameter is used to distinguish the different result values. All test identifier values must be the same when multiple test results are reported in one DM8 response.

EXAMPLE:

Given:	Assume three separate Test Values are desired to be communicated.
Where:	a = Test Identifier, b = Test Type/Component Identifier, c = Test Value, d = Test Limit Maximum, e = Test Limit Minimum

Message form will be as follows: a,b,c,d,e,a,b,c,d,e,a,b,c,d,e

The transport protocol of SAE J1939-21 will have to be used when there are more than one Test Value to send because 16 or more data bytes would be required. In this example 24 bytes of data would need sent for three Test Values.

5.7.8.1 Test Type/Component Identifier

This parameter identifies the non-continuously monitored component identifier that was tested. These component identifiers are defined by the manufacturer. They are necessary when multiple components or systems are present on the vehicle and have the same definition of test identifier.

Data Length:	1 byte
Resolution:	See DM10 below
Data Range:	1 to 64 (Note: 0 and 65 to 250 are reserved.)
Type:	Measured
Suspect Parameter Number:	1225
Reference:	5.7.8

5.7.8.2 Test Value

The test value collected during the test. If the test performed does not have both a test limit minimum and maximum, then the appropriate limit value (Maximum or Minimum) should be set to all ones. SAE J1939-71 defines this to mean not available.

Data Length:	2 bytes
Resolution:	Not defined
Data Range:	0 to 64255
Type:	Measured
Suspect Parameter Number:	1226
Reference:	5.7.8

5.7.8.3 (R)Test Limit Maximum

The test value must be less than or equal to Test Limit Maximum in order for the test to pass.

Data Length:	2 bytes
Resolution:	Not defined
Data Range:	0 to 64255
Type:	Measured
Suspect Parameter Number:	1227
Reference:	5.7.8

5.7.8.4 (R)Test Limit Minimum

The test value must be greater than or equal to Test Limit Minimum in order for the test to pass.

Data length:	2 bytes
Resolution:	not defined
Data range:	0 to 64255
Type:	measured
Suspect parameter number:	1228
Reference:	5.7.8

5.7.9 Oxygen Sensor Test Results (DM9)

SAE J1939 will not specify an implementation for this DM. Oxygen sensor test and results should be communicated using DM7 and DM8.

5.7.10 Non-Continuously Monitored Systems Test Identifiers Support (DM10)

The purpose of this PG is to report the list of non-continuously monitored systems tests supported by the controller. The component manufacturer is responsible to assign test identifiers and component identifiers for tests of different systems and components. PGN 58112 (DM7) is used to invoke one of the manufacturer-defined test identifiers. Test results are reported by test identifier using PGN 65232 (DM8). Service tools can determine the supported tests by requesting PGN 65234 (DM10).

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Transmission Rate:	On request using PGN 59904 A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	See SAE J1939-21
Data Length:	8 (this is not byte swapped)	See 5.7.10.1
Extended Data Page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	210	
Default Priority:	6	
Parameter Group Number:	65234 (00FED2 ₁₆)	
Byte: 8-1	Test Identifiers Supported	See 5.7.10.1

5.7.10.1 Test Identifiers Supported

Indicates the test identifiers that the controller supports. Each bit is assigned to one test. Therefore, we can have up to 64 tests without having to use the transport protocol of SAE J1939-21. The assignment of a given test identifier to a given bit is manufacturer specific.

Data Length:	8 bytes	
Resolution:	See below	
Data Range:	64 bits	
Type:	Note: Bit mapped, each bit indicates an individual test identifier	
Suspect Parameter Number:	Measured	
Reference:	1229	
	5.7.10	

Byte	Bit	Description
1	8	Test one
	7	Test two
	6	Test three
	5	Test four
	4	Test five
	3	Test six
	2	Test seven
	1	Test eight
2	8	Test nine
2-8	64-10	Manufacturer assigned test 10 through 64

Where each bit is interpreted:
 0 = test not supported
 1 = test supported

See Table 7 for an example:

TABLE 7 - EXAMPLE - USE OF TEST IDENTIFIERS SUPPORTED

Test Identifier Representations	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
1. Binary	00000100 ₂	00000001 ₂	00000000 ₂	00000101 ₂	10100000 ₂	00000000 ₂	00000000 ₂	00000001 ₂
2. Hex	04 ₁₆	01 ₁₆	00 ₁₆	05 ₁₆	A0 ₁₆	00 ₁₆	00 ₁₆	01 ₁₆
3. Test Identifiers	6	16		30, 32	33, 35			64

5.7.11 (R)Diagnostic Data Clear/Reset For Active DTCs (DM11)

All of the diagnostic information pertaining to the active diagnostic trouble codes should be erased. Sent as a request whenever the service tool wishes to clear/reset diagnostic data for active DTCs. This is expected to occur once the

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problem has been corrected. Upon the completion of this operation or if there are no faults to clear, a positive acknowledgment shall be sent as required (see SAE J1939-21 PGN 59392). If for some reason a device can not perform the requested action, then it is required to send a negative acknowledgement (see SAE J1939-21 PGN 59392). Implementers be aware that no positive or negative acknowledgement is sent when the request was sent to the global address.

All diagnostic information pertaining to the active DTCs includes:

- Number of diagnostic trouble codes
- Diagnostic trouble codes
- Number of Previously Active DTCs and readiness information (can be read with DM5)
- Previously Active DTCs (can be read with DM2)
- Trouble code for freeze frame data
- Freeze frame data (can be read with DM4 and/or DM25)
- Oxygen sensor test data
- Status of system monitoring tests (can be read with DM6)
- On-board monitoring test results (can be read with DM10)
- Distance traveled while MIL is activated (can be read in DM5)
- Number of warm-ups since DTC cleared
- Distance since diagnostic trouble codes cleared
- Minutes run by the engine while MIL is activated
- Time since diagnostic trouble codes cleared
- Other manufacturer specific "clearing/resetting" actions may also occur in response to this request message.

All ECUs shall clear the DTCs and send a Positive Acknowledgement to this request message with ignition ON and with the engine not running.

Emission related components shall clear/reset diagnostic data for all active and previously active DTCs.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data length:	0	
Extended data page:	0	
Data page:	0	
PDU Format:	254	
PDU Specific:	211	
Default priority:	6	
Parameter group number:	65235 (00FED3 ₁₆)	

5.7.12 Emissions-Related Active Diagnostic Trouble Codes (DM12)

The information communicated is limited to the currently active emission-related diagnostic trouble codes preceded by the diagnostic lamp status. Both are used to notify other components on the network of the diagnostic condition of the transmitting electronic component. The data contains the lamp status and a list of diagnostic codes and occurrence counts for currently active emission-related diagnostic trouble codes.

The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flashout.

This DM contains DTCs that are confirmed and active and, in general, for which the MIL is on. Specific regulations may permit the MIL to not be illuminated for some emissions related confirmed and active DTCs.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	

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PDU Format:	254		
PDU Specific:	212		
Default Priority:	6		
Parameter Group Number:	65236 (00FED4 ₁₆)		
Byte: 1	bits 8-7	Malfunction Indicator Lamp Status	See 5.7.1.1
	bits 6-5	Red Stop Lamp Status	See 5.7.1.2
	bits 4-3	Amber Warning Lamp Status	See 5.7.1.3
	bits 2-1	Protect Lamp Status	See 5.7.1.4
Byte: 2	bits 8-7	Flash Malfunction Indicator Lamp	See 5.7.1.5
	bits 6-5	Flash Red Stop Lamp	See 5.7.1.6
	bits 4-3	Flash Amber Warning Lamp	See 5.7.1.7
	bits 2-1	Flash Protect Lamp	See 5.7.1.8
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 5	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
	bits 5-1	FMI (most significant at bit 5)	See 5.7.1.10
Byte: 6	bit 8	SPN Conversion Method	See 5.7.1.11
	bits 7-1	Occurrence Count	See 5.7.1.12

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

EXAMPLE 1: The following illustrates the message format for when there are more than one diagnostic trouble code.

Given:

a=lamp status
b=SPN
c=FMI
d=CM and OC

Message form is as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 has to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than one fault the services of the transport protocol have to be used.

EXAMPLE 2: The following illustrates the message format for when a request of the DM12 is made and there are zero active emissions faults. Note that the Malfunction Indicator Lamp is off while any of the other three - Red Stop Lamp, Amber Warning Lamp, and Protect Lamp - could be on. In this example, all three are on.

The recommended setting for bytes 6-3 is shown below. The recommended setting shall be used for engines and vehicles complying to government regulated requirements (e.g. OBD, OBD II, EOBD or HD OBD). The original publication of this recommended practice defined that bytes 6 through 3 should be set to all ones when there are zero faults. This particular implementation is no longer permitted. It provides context for existing implementations prior to the adoption of the recommended setting. Use of all ones is shown as the Grandfathered Setting below.

Given:

Byte 1		
	bits 8-7	= 00
	bits 6-5	= 01
	bits 4-3	= 01
	bits 2-1	= 01
Byte 2		
	bits 8-7	= 11

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bits 6-5 = 11
bits 4-3 = 11
bits 2-1 = 11

	Grandfathered Setting	Recommended Setting
Byte 6-3	SPN = 524,287 -Indicates not available	= 0
	FMI = 31 -Indicates not available	= 0
	OC = 127-Indicates not available	= 0
	CM = 1-Indicates not available	= 0
Byte 7	= 255	= 255
Byte 8	= 255	= 255

5.7.13 Stop Start Broadcast (DM13)

This message is used to stop or start broadcast messages. Additionally it may be used to indicate to other nodes that broadcast messages are being suspended due to commands other than J1939 DM13. The broadcast messages stopped, started, or suspended may be on networks other than SAE J1939.

The following notes help to clarify to use of this command PGN.

1. This command shall only be initiated when the vehicle is at zero kilometers/hour and at zero engine rpm.
2. All nodes shall “power-up” in their normal broadcasting mode. Therefore, if any node was “powered-down”, while in a “Stop Broadcast” condition, it would revert to its normal operation on power-up.
3. This is not a message to ignore all communications. It is a message to minimize network traffic. It is recognized that some network messages may be required to continue even during the “Stop Broadcast” condition. If an unsafe or undesirable vehicle operating condition would result from the lack of normal messages then this mode would cause all nonessential messages to be inhibited.
4. Requests that are generated during the “Stop Broadcast” state should be responded to. However, devices that may be programmed to periodically issue requests should postpone these requests until the “Stop Broadcast” state is exited.
5. All devices that have been told to change state, plus those nodes that may be affected by the absence of broadcast messages could look for the “Hold Signal” as a plausible explanation for why the information is missing. In addition all devices that have been told to change state shall monitor the “Hold Signal”. If the “Hold Signal” disappears for 6 seconds then all applicable nodes shall revert back to the normal state.
6. Diagnostic Trouble Codes should not be recorded for failed communications due to broadcast PGNs missing during the modified Broadcast state. Network devices should look for the Hold signal to be absent for more than 6 seconds before recording any applicable Diagnostic Trouble Code.
7. When this command is used to disable broadcasts of information on other networks it could result in diagnostic trouble codes being reported about this situation. Therefore, it is recommended that the use of this Stop/Start broadcast command be used with caution.

One of the uses for the “Stop Start Broadcast PG” is to reduce network traffic during certain diagnostic procedures. As an example while calibrating a control module, the diagnostic Tool will likely want to stop the normal broadcasts of all network devices keeping in mind the comments made in the notes section above. Another use is that it allows the diagnostic Tool to potentially emulate a remote device during a diagnostic procedure. In this case the diagnostic Tool could generate the messages that the remote device would normally generate.

Transmission Rate: Sent whenever a Stop or Start broadcast event is necessary. To maintain the modified state of the vehicle network(s) the commanding device must send the Hold Signal once every 5 seconds.
A NACK is required if PG is not supported (see J1939-21 PGN 59392).
Note that the NACK is only provided if PGN 57088 is directed to a specific destination address.

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Data Length:	8		
Extended Data Page:	0		
Data Page:	0		
PDU Format:	223		
PDU Specific:	DA		
Default Priority:	6		
Parameter Group Number:	57088 (00DF00 ₁₆)		
Stop Start Broadcast ¹			
Byte: 1	bits 8-7	Current Data Link	See 5.7.13.1
	bits 6-5	J1587	See 5.7.13.2
	bits 4-3	J1922	See 5.7.13.3
	bits 2-1	J1939 Network #1, Primary vehicle network	See 5.7.13.4
Byte: 2	bits 8-7	J1939 Network #2	See 5.7.13.5
	bits 6-5	ISO 9141	See 5.7.13.6
	bits 4-3	J1850	See 5.7.13.7
	bits 2-1	Other, Manufacture Specified Port	See 5.7.13.8
Byte: 3	bits 8-7	SAE J1939 Network #3	See 5.7.13.9
	bits 6-5	SAE Reserved	
	bits 4-3	SAE Reserved	
	bits 2-1	SAE Reserved	
Byte: 4	bits 8-5	Hold Signal	See 5.7.13.10
	bits 4-1	Suspend Signal	See 5.7.13.11
Byte: 5-6		Suspend Duration	See 5.7.13.12
Byte: 7-8		SAE Reserved	

¹ For each of the 2-bit fields in the Stop Start Broadcast command, they are interpreted as follows:

Bits	Information
00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)

The sequence of operation is to first direct DM13 to each (or all) device(s) for which the broadcast state is desired to be modified. The second step is to send DM13 to the global destination address with the appropriate bits set to indicate the "Hold Signal" is being communicated. See Example 1 in Figure 5-2 and Example 2 in Figure 5-3. The Hold Signal allows the issuer of the DM13 message to not have to send DM13 to specific addresses but rather to the group of controllers that were modified or all devices. This reduces the number of messages that are required to keep the modified broadcast state of each individual controller active. This has benefit when the individual devices are commanded to turn off different communication ports.

TABLE 8 - DM13 USAGE REQUIREMENTS

Purpose	Destination Address	Communication Ports	Hold Signal	Receiving Device Required Action
1. Setup broadcasts to be modified	Specific or Global	Set the action for each communications port to: stop, start, or leave as is	Not Available	Modify Broadcast State
2. Hold modified broadcast state	Global	Set action for each communications port to leave as is	All Devices or Devices with Broadcast State changed	Maintain Modified Broadcast State

Purpose	Destination Address	Communication Ports	Hold Signal	Receiving Device Required Action
3. Alert network devices of impending suspended broadcasts	Global	Set all to "Don't Care/take no action".	Not Available	Do not record DTCs due to the absence of broadcast message data.

EXAMPLE 1: The following illustrates the sequence of messages for a command to stop broadcast to 2 specific nodes to turn off all ports.

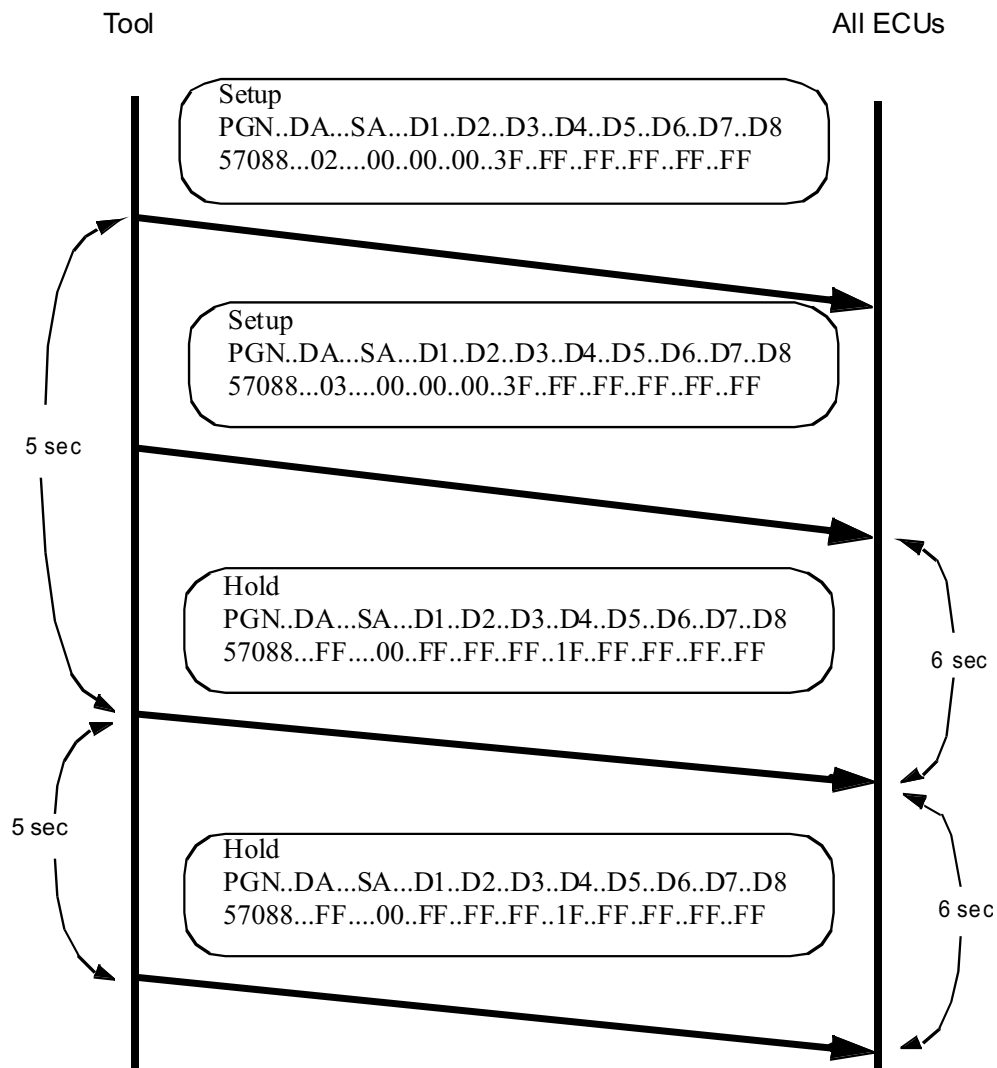


FIGURE 5-2 - STOP START BROADCAST TO 2 SPECIFIC NODES TURNING OFF ALL PORTS

EXAMPLE 2: The following illustrates the sequence of messages for a command to stop broadcast on all nodes and all ports.

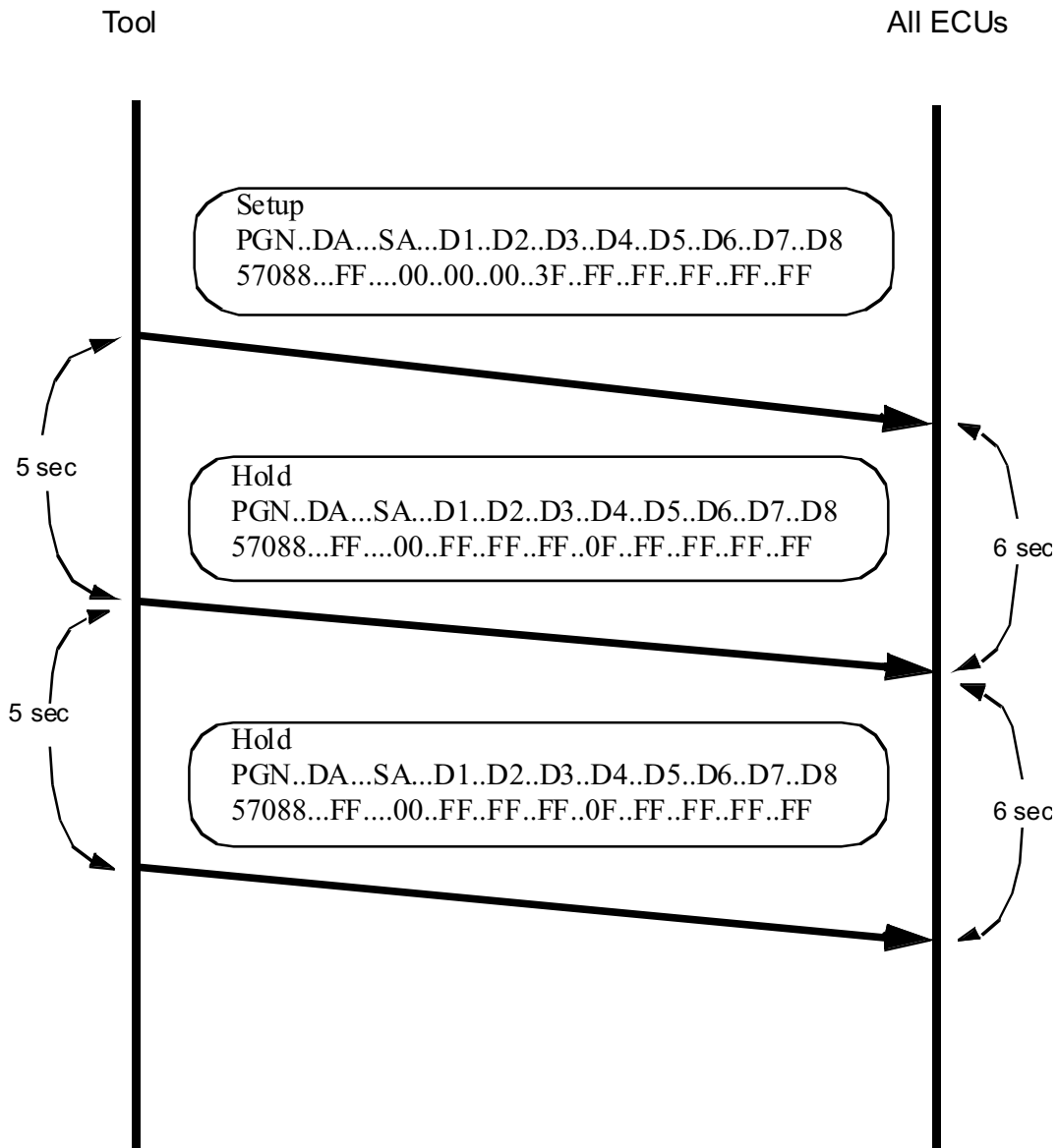


FIGURE 5-3 - STOP START BROADCAST TO 2 SPECIFIC NODES TURNING OFF ALL PORTS

5.7.13.1 Current Data Link

Identifies the action to be performed on the communications port that this parameter was received on.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	1230
Reference:	5.7.13

5.7.13.2 J1587

Identifies the action to be performed on the J1587 communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	608
Reference:	5.7.13

5.7.13.3 J1922

Identifies the action to be performed on the J1922 communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	622
Reference:	5.7.13

5.7.13.4 J1939 Network #1, Primary Vehicle Network

Identifies the action to be performed on the J1939 Network #1, Primary Vehicle Network" communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	639
Reference:	5.7.13

5.7.13.5 J1939 Network #2

Identifies the action to be performed on the J1939 Network #2 communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	1231
Reference:	5.7.13

5.7.13.6 ISO 9141

Identifies the action to be performed on the ISO 9141 communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	1232
Reference:	5.7.13

5.7.13.7 J1850

Identifies the action to be performed on the J1850 communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	1233
Reference:	5.7.13

5.7.13.8 Other, Manufacture Specified Port

Identifies the action to be performed on the "Other, Manufacture Specified Port" communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	1234
Reference:	5.7.13

5.7.13.9 J1939 Network #3

Identifies the action to be performed on the J1939 Network #3 communications port.

00	Stop Broadcast
01	Start Broadcast
10	Reserved
11	Don't Care/take no action (leave as is)
Type:	Status
Suspect Parameter Number:	1235
Reference:	5.7.13

5.7.13.10 Hold Signal

Indicator to all nodes that the communication ports that have been acted upon by the "Stop Start Broadcast" PGN are remaining in the modified state. Therefore all nodes should act accordingly. The Hold signal is required to be broadcast every 5 seconds plus or minus one second. A device requesting stop broadcast must send the hold signal every 5 seconds and if the message is not received for 6 seconds all applicable nodes revert back to their normal state.

HOLD SIGNAL States

Bit States for bits 8-5	Devices to take action
0000	All Devices
0001	Devices whose broadcast state has been modified
0010 to 1110	Reserved
1111	Not Available
Type:	Status
Suspect Parameter Number:	1236
Reference:	5.7.13

5.7.13.11 Suspend Signal

Indicator to all nodes that broadcast messages on the current J1939 datalink are being suspended due to commands other than J1939 DM13. Therefore, the receiving nodes should suspend timeout diagnostics for all messages from the transmitting device. The suspend signal is to be broadcast once, but may be repeated at the option of the transmitting device (if it is capable of doing so) to increase the chances of proper reception by repeating one or two times within the first second of the suspension. If it is able, the transmitter may also send a DM13 message with the suspend signal set to "1110" to indicate that it is returning to full broadcast status.

SUSPEND SIGNAL States**Bit States**

0000	Indefinite suspension of all broadcasts
0001	Indefinite suspension of some messages
0010	Temporary suspension of all broadcasts
0011	Temporary suspension of some messages
0100 TO 1110	SAE Reserved
1110	Resuming normal broadcast pattern
1111	Not Available
Type:	Status
Suspect Parameter Number:	2618
Reference:	5.7.13

Devices to take action

5.7.13.12 Suspend Duration

Indicates the duration of a suspension of broadcast messages when that duration is known by the transmitting device. If the DM13 message is sent with the suspend signal value of 0010 or 0011, the value of this parameter will represent the duration of suspension in seconds. For the suspend signal values of 0000 to 0001, the suspend duration will be sent as Not Available and the duration will be indeterminate. Receivers will know when the suspension is over by the renewed presence of messages from the transmitter either for indefinite suspension or in the case where the transmitter is permitted by an outside command to return to full broadcast status. If it is able, the transmitter may also send a DM13 message with the suspend signal set to "1110" to indicate that it is returning to full broadcast status.

Data Length:	2 bytes
Resolution:	Offset: 0 seconds, 1 sec/bit
Data Range:	0 to 64,255 seconds (0 to 1070.9 minutes)
Type:	Status
Suspect Parameter Number:	2619
Reference:	5.7.13

5.7.14 Memory Access Request (DM14)

The main use for the Memory_Access_Request message is by a tool wishing to alter the memory of a device. The tool uses this message to convey its request as well as any security information that must be passed to the device to prove the tool has authority to request said operation. The message may also be used to obtain the current status of a device in terms of the availability of said device's memory access. The capabilities of the functions are outlined in APPENDIX A. The procedures for data interchange are outlined in APPENDIX C. A memory access state transition diagram (DM14 through DM18) is in APPENDIX C, Figure C 1.

Transmission Rate:	As needed
Data Length:	8
Extended Data Page:	0
Data Page:	0
PDU Format:	217
PDU Specific:	DA
Default Priority:	6
Parameter Group Number:	55552 (00D900 ₁₆)

MEMORY_ACCESS_REQUEST

Byte:	1	bits 8-1	Length/Number Requested (Least significant 8 bits) (Bit 1 is least significant bit)	See 5.7.14.5
Byte:	2	bits 8-6	Length/Number Requested (Most significant 3 bits) (Bit 8 is most significant bit)	See 5.7.14.5
		bit 5	Pointer Type	See 5.7.14.1
		bits 4-2	Command	See 5.7.14.6
		bit 1	SAE Reserved (sent as a 1)	
Byte:	3-5		Pointer	See 5.7.14.3

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	(Byte 3 is least significant byte)	
	(Bit 1 is least significant bit)	
Byte: 6	Pointer Extension	See 5.7.14.2
	(Most significant byte of Pointer/Pointer Extension)	
	(Bit 8 is most significant bit)	
Byte: 7-8	Key/User_Level	See 5.7.14.4

5.7.14.1 Pointer Type

Indicates whether the Pointer and Pointer Extension are direct memory addresses (Pointer Type identifier = 0) or if the Pointer Extension is identifying a particular SPACE with the Pointer referencing a specific OBJECT within that particular SPACE (Pointer Type identifier = 1).

Data Length:	1 bit
Resolution:	Bitmap
Data Range:	0 or 1
0	Direct Memory Addressing
1	Directed Spatial Addressing
Type:	Status
Suspect Parameter Number:	1641
Reference:	5.7.14

5.7.14.1.1 Direct Memory Addressing

A pointer type value of 0 implies a memory access with a direct memory address (in bytes) with the pointer extension (8 bits) simply concatenated as the higher order bits and with the pointer (24 bits) as the lower order bits to form a single 32-bit address. (parsing for device memory widths other than 1 byte is explained within "Memory Parsing" in 5.7.14.3.1.)

5.7.14.1.2 Directed Spatial Addressing

A pointer type value of 1 implies a memory structure where the pointer extension provides identification of a particular space within memory and the pointer provides identification of a specific object within that particular space. This provides a form of directed spatial (object) addressing where the user can control the meaning of the pointer used to interrogate a device. For this directed spatial addressing, half of the available spaces (128 of the 256 formed by the 8-bit pointer extension) will be reserved for assignment by the committee. The other half will be labeled proprietary and not constrained by the standard, allowing manufacturer proprietary assignment. The first committee-assigned space is 0 (i.e. pointer type = 1 and pointer extension = 0) and it is assigned to be the space containing those parameters which can be identified by a particular SPN; this shall be referred to as the SPN space. Objects contained within the direct spatial address space may be variable length and they may have different lengths.

5.7.14.2 Pointer Extension

This 8-bit parameter is either the high order 8 bits of a complete direct memory address, 5.7.14.1.1 (Pointer Type = 0) or the identifier of a particular SPACE, 5.7.14.1.2 (Pointer Type = 1) (see Table 9).

Data Length:	8 bits
Resolution:	Per definitions in this section
Data Range:	0 to 255
Type:	Status
Suspect Parameter Number:	1643
Reference:	5.7.14

TABLE 9 - POINTER EXTENSION STATES
(If Pointer Type Is '1')

Bit States	Pointer Extension States
00000000 ₂	SPN SPACE
00000001 ₂ - 01111111 ₂	Reserved for Assignment by SAE

10000000₂ - 11111111₂

OEM proprietary definition

5.7.14.2.1 SPN Space

A pointer extension value of '0' in combination with a pointer type of '1' implies that the pointer is to the parameter identified by a specific SPN. Hence the data will be the value of the parameter known by that SPN. (note: since some SPNs have no parameter associated with them and in some cases the device may not know the particular SPN's data, the memory access response may be 'busy' with or without an error indicator.) The length of the data associated with each SPN is a function of that SPN and the overall length of the response message data will be the sum of the byte lengths of the data for each of the SPNs, with the actual number of SPNs being determined from the value of length/number requested parameter. The 5 leading bits should be '00000₂' to fill the 24-bit pointer when using a 19-bit SPN. Later at the committee's discretion, functions may be assign to different values of these 5 bits. Therefore, they should be included both when interpreting a value and when sending a value.

5.7.14.2.2 Reserved For Assignment By SAE

Implies these values are not yet defined by the committee and are therefore not available for use. Future versions of this document will assign specific meanings.

5.7.14.2.3 OEM Proprietary Definition

Implies these values are available to OEMs for proprietary definition and use. (one such example use might be for memory block access.)

5.7.14.3 Pointer

If Pointer Type 0 is used, this 24-bit parameter, which has a value of 0 to 16,777,215 (0 to FFFFFFF₁₆) with no reserved ranges, is concatenated with the 8-bit Pointer Extension to form a direct memory address. The address thus formed represents the first address to be accessed within the memory in units of bytes. If Pointer Type 1 is used, the Pointer is to provide the identification of the specific OBJECT within whatever particular SPACE is being identified by the Pointer Extension. The direct memory address should be parsed as outlined below, 5.7.14.3.1, if the device memory width is other than 1 byte.

Data Length:	24 bits
Resolution:	1 byte/bit
Data Range:	0 to 16,777,215 (0 to FFFFFFF ₁₆)
Type:	Status
Suspect Parameter Number:	1644
Reference:	5.7.14

5.7.14.3.1 Memory Parsing

For all memory widths the starting address is simply the pointer extension concatenated with the pointer (the pointer being the lower 24 bits and the extension the upper 8). For memory widths of one byte there is a one-to-one mapping between data and the memory. Hence the first data byte goes into the memory at the starting address, while the second data byte corresponds to the memory at the starting address plus 1. For widths other than 1 byte, the data cannot map directly to the memory, but must be used to assemble the necessary width. Hence it will take as many data bytes per address as seven plus the memory width in bits all divided by 8 ((memory width + 7)/8). To maintain consistency with the rest of this standard the first data byte should be used for the byte containing bits 1 to 8 at the starting address. The second data byte should be used for bits 9 to 16. This should continue for the number of bytes required; then the address should be incremented and those bytes filled. When the memory width is less than 1 byte (as might happen when addressing a 2-bit parameter through the SPN space), a whole byte is used to contain each object's data (in other words no packing is to occur). The two bits will be placed in the least significant bits of the byte. For systems where the memory width is not an integer number of bytes, some bits in the highest byte are unused, reducing transfer efficiency, but enabling all memory widths to be handled. Examples of address calculation and byte association (see also section 5.7.16.2).

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8-bit-wide memory, Pointer Extension = 10_{16} , Pointer = 367800_{16} then the starting memory address is 10367800_{16} and the first byte of Raw Binary Data would map directly into the memory at 10367800_{16} , the second byte of Raw Binary Data would then map into memory 10367801_{16} , and so on until completed.

16-bit-wide memory, Pointer Extension = 10_{16} , Pointer = 367800_{16} then the starting memory address is 10367800_{16} and the first byte of Raw Binary Data would map into bits 1 to 8 of the memory at 10367800_{16} , while the second byte of Raw Binary Data would map into bits 9 to 16 of the same memory. The third byte of Raw Binary Data would then map into bits 1 to 8 of the memory at 10367801_{16} , while the fourth byte of Raw Binary Data would map into bits 9 to 16 of the memory at 10367801_{16} .

32-bit-wide memory, Pointer Extension = 10_{16} , Pointer = 367800_{16} then the starting memory address is 10367800_{16} and the first byte of Raw Binary Data would map into bits 1 to 8 of the memory at 10367800_{16} , while the second byte of Raw Binary Data would map into bits 9 to 16 of the memory at 10367800_{16} , the third byte of Raw Binary Data would then map into bits 17 to 24 of the same memory and the fourth byte of Raw Binary Data would map bits 25 to 32. The fifth byte of Raw Binary Data would then map bits 1 to 8 of 10367801_{16} , while the sixth byte of Raw Binary Data would map into bits 9 to 16 of 10367801_{16} , the seventh byte of Raw Binary Data then mapping bits 17 to 24 and the eighth byte of Raw Binary Data mapping to bits 25 to 32 of the memory.

12-bit-wide memory, Pointer Extension = 10_{16} , Pointer = 367800_{16} then the starting memory address is 10367800_{16} and the first byte of Raw Binary Data would map into bits 1 to 8 there, while bits 9 to 12 of the second byte of Raw Binary Data would map into bits 9 to 12 of 10367800_{16} (bits 13 to 16 are simply unused). The third byte of Raw Binary Data would then map into bits 1 to 8 of 10367801_{16} , while bits 9 to 12 of the fourth byte of Raw Binary Data would map into bits 9 to 12 of 10367801_{16} .

5.7.14.3.2 Handling Of Pointer Offset

When the starting address created by concatenating the pointer extension and the pointer does not represent the beginning of an object, such as a memory block or memory word, the device shall be free to reject the requested memory access operation. If used by the manufacturer, then the appropriate error indicator/EDC parameter may be returned (see Table 12 and section 5.7.15.3).

5.7.14.4 Key/User_Level

This is a 2-byte parameter which is used by the Tool to primarily send a Key to the Device, but which can also be used by the Tool to provide a Password or a User_Level to the Device if desired (see APPENDIX C). This Key/User_Level parameter can be used to send these independent variables since they will never be transmitted within the same message (a Password or User_Level parameter would be sent at the beginning of an operation, while a Key CANNOT be sent until after the receipt of a Seed).

Data Length:	16 bits
Resolution:	Per definitions in this section
Data Range:	0 to 65535 (0 to $FFFF_{16}$)
Type:	Status
Suspect Parameter Number:	1645
Reference:	5.7.14

5.7.14.4.1 Key

The result of a set of mathematical operations performed upon a seed to provide a device with a means of authenticating a tool's request (see Table 10).

TABLE 10 - KEY STATES
(i.e. ONLY for Key and NOT User Level)

Bit States	Key States
0000_{16}	Use Long Seed or Key from Data Security Message
0001_{16} to $FFFE_{16}$	Key Values
$FFFF_{16}$	No Key Available

5.7.14.4.1.1 Use Long Seed Or Key From Data Security Message

The actual seed or key is in the data security message and this is simply a flag.

5.7.14.4.1.2 Key Values

The actual values of the key.

5.7.14.4.1.3 No Key Available

There is no key at this time.

5.7.14.4.2 Seed

A number sent by a device to a tool to obtain authentication of the tool's right to access the device. The tool must return a key, which is a function of the seed, and the key matches the device's expectations to obtain access.

5.7.14.4.3 Password

The number sent when using a simple authentication technique wherein both the device and tool have a prior knowledge of the specific number and usually use equality as the verification.

5.7.14.4.4 User_Level

A number sent by a tool to a device along with an initial request to inform the device of some specific level of access that the tool wishes to gain. In such a case there is probably a following seed and key exchange. Usually the seed and the mathematical operations to calculate the key from it would be a function of the User_Level requested.

5.7.14.4.5 Handling Of Keys Larger Than 16 Bits

If a manufacturer feels a seed/key structure requires a key or seed longer than 16 bits for a particular device, this can be handled with the data security message (see section 5.7.18) and the setting of the Key/User_Level and the seed parameters appropriately (see Table 10 and Table 13). Also see Figure E 9 and Figure E 10.

5.7.14.4.6 Acceptance Rules

The device will establish the set of rules governing acceptance of memory access requests (such as operational mode, User_Level versus memory (object) location versus requested operation, etc.). These rules may be manufacturer specific to prevent unauthorized modification of a device's memory. The command and the length/number requested with the memory access request message(s) should be constant throughout an entire sequence or the device should reject the operation.

5.7.14.5 Length/Number Requested

This is an 11-bit parameter which identifies the amount of memory (i.e. the range within the memory) over which the Tool desires an operation to be carried out when the Command of the Memory Access Request message is a Read, Write, Boot Load, or Error Detection and/or Correction Parameter (EDCP) Generation. For these cases the length is in bytes (cross-reference to 5.7.14.3.1 Memory Parsing) when the Pointer Type is '0' and in objects when the Pointer Type is '1' (example: a length of 2 when referencing the SPN Space with a Pointer of 1648 would imply that you wanted the data of the two parameters with SPNs 1648 and 1649). When the Command is Erase, the length is the number of 'blocks' of memory to be erased. Block size being specific to the device. When the Command of the Memory Access Request is Operation Failed, Operation Completed, or Status Request the length is meaningless. The Tool should therefore send it as '0' and the Device should treat it as 'DO NOT CARE'.

Data Length:	11 bits
Resolution:	Pointer Type 0 = 1 byte/bit Pointer Type 1 = 1 object/bit
Data Range:	0 to 1784
Type:	Status

Suspect Parameter Number: 1640
Reference: 5.7.14

5.7.14.6 Command

This is a 3-bit parameter which allows the Tool to send Commands to the Device. All Memory Access Requests originate at a Tool and are considered Commands. Some of the values within the Command have been overlaid with the same values in Status so perhaps a similar variable can be used.

Data Length: 3 bits
Resolution: 1 bit/command
Data Range: 0 to 7
Type: Status
Suspect Parameter Number: 1642
Reference: 5.7.14

The following Command values for Memory Access Requests (i.e. Tool to Device) are defined:

0 - Erase	See 5.7.14.6.1
1 - Read	See 5.7.14.6.2
2 - Write	See 5.7.14.6.3
3 - Status Request	See 5.7.14.6.4
4 - Operation Completed	See 5.7.14.6.5
5 - Operation Failed	See 5.7.14.6.6
6 - Boot Load	See 5.7.14.6.7
7 - EDCP Generation	See 5.7.14.6.8

5.7.14.6.1 Erase

This command is a block erase where the length is defined as the number of blocks to erase. The length and width of a block are to be defined within the device and must be known by the tool. The pointer is the address where erase should start. If the pointer is not on a block boundary, when corrected for memory width, then the erase is not to be allowed (i.e. the device is to respond with a 'busy' with or without data in the error indicator/EDC parameter per the manufacturer's choice, see C.2.2.1).

5.7.14.6.2 Read

This command allows the transfer of the contents from a device memory to a tool. When this command is accepted, the device transfers the appropriate memory contents to the tool, including initiating a transport protocol session if necessary. See Figure E 1 for an example message sequence used to accomplish a memory read operation with security (short form of security). See Figure E 2 for an example message sequence used to accomplish a memory read operation without security. See Figure E 3 for an example message sequence used to accomplish a multiple memory read operation with security (short form of security). Note that the operation complete message from the tool indicates the session is over from the tool's perspective. See Figure E 7 for an example of a failed memory access read operation.

5.7.14.6.3 Write

This command allows the transfer of the new memory contents from a tool to a device. The device may use a smart write, which will force an erase before write if it is going to be necessary, due to the value being written and the memory type, and if any other memory which will be altered by the erase can be buffered and rewritten to its original value, effecting a transparent write operation. See Figure E 5 for an example message sequence used to accomplish a memory write operation with security (short form of security).

5.7.14.6.4 Status Request

This command allows a tool to interrogate the device to determine the current status of operation. This enables a tool to determine what a device may currently be doing and/or why it has not heard a message indicating operation completed/failed from the device, when the tool itself believes sufficient time has elapsed for the operation. The device responds to this command with either operation completed, operation failed, proceed or busy with a code indicating the current status or error condition within the feedback parameter.

5.7.14.6.5 Operation Completed

This command is sent during a close sequence. Operation completed is sent by the tool during the close sequence of an erase, read, write, boot load, or EDCP generation command to indicate to the device that the tool has heard the device's close and that the close sequence is completed. At the end of a read command, it further indicates that all of the expected memory contents were received. A device's receipt of an operation completed from a tool enables the device to consider the memory access finished. The device should have a time-out function such that on the failure to hear the expected operation completed (or operation failed) from the tool it assumes the memory access operation with the tool is complete. See Figure E 4. The value for this time-out should be 100 ms with no worse than ± 25 ms error. (see also the section entitled operation completed under memory access response - 5.7.15.1.3.)

5.7.14.6.6 Operation Failed

This command is sent by a tool only during the close sequence of a read command to indicate to the device that the expected memory contents were not received. (this initiates no further action from the device.)

5.7.14.6.7 Boot Load

This command allows a tool to transfer the execution of a device to some address and if needed, write new values into this executable memory prior to transfer of execution. When no data is written, the device considers the operation simply a transfer of execution and continues operation with no change in network communications, but with whatever other software changes the manufacturer has chosen to implement. When writing new data any values must be executable and upon a successful close, the device transfers execution to the address specified by the request initiating this operation. Once execution has transferred at the close of a boot load, the device is no longer required (it may do so if its designers choose) to operate upon any messages from nodes other than the specific tool that initiated the boot load. If the device no longer operates upon other messages, the tool is be required to protect the address of the device from any address claim messages sent during the boot load process. If the close sequence of boot load, with data, indicates successful completion, then the tool sends data to the device using the boot load data PGN until the tool determines that the boot load sequence has been completed. The tool then notifies the operator that the operation is complete so that the device (and probably the system and network) can be restarted at its power on self-test. There is no predefined close sequence for the end of the boot load data transfer provided by this standard. It is at the manufacturer's discretion to choose to have such a sequence.

5.7.14.6.8 EDCP Generation

This command allows a Tool to request a device to generate a checksum or other form of memory error detection and correction parameter over some range of memory. It is expected that the Tool must have a prior knowledge of the length and generation procedure used by the device. Parameters greater than 24 bits in length are handled by a looping concatenation structure (see also "EDCP Extension", 5.7.15.2). The memory involved in this operation is the same as that defined within the read operation.

5.7.15 Memory Access Response (DM15)

The main use for the Memory_Access_Response is for a device to answer a tool which has attempted to access the memory within the device. With this message the device can request further security responses from the requestor (see Figure E 6) as well as tell the requestor what is or is not allowed. The completion status of a memory operation may also be transferred with this message. A memory access state transition diagram (DM14 through DM18) is in APPENDIX C.

Transmission Rate:	As needed
Data Length:	8
Extended Data Page:	0

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Data Page: 0
PDU Format: 216
PDU Specific: DA
Default Priority: 6
Parameter Group Number: 55296 (00D800₁₆)

MEMORY_ACCESS_RESPONSE

Byte: 1	bits 8-1	Length/Number Allowed (Least significant 8 bits) (Bit 1 is least significant bit)	See 5.7.15.5
Byte: 2	bits 8-6	Length/Number Allowed (Most significant 3 bits) (Bit 8 is most significant bit)	See 5.7.15.5
	bit 5	SAE Reserved	
	bits 4-2	Status	See 5.7.15.1
	bit 1	SAE Reserved	
Byte: 3-5		Error Indicator/EDC Parameter (Byte 3 is least significant byte) (Bit 1 is least significant bit)	See 5.7.15.3
Byte: 6		EDCP Extension (When used as an EDCP extension, this is the most significant byte) (Bit 8 is most significant bit)	See 5.7.15.2
Byte: 7-8		Seed	See 5.7.15.4

5.7.15.1 Status

This is a 3-bit parameter which allows the Device to return its Status. All Memory Access Requests originate at a Tool and are considered Commands. All Memory Access Responses originate at a Device and are considered Status. The device may choose to send further information on its status within the Error Indicator/EDC Parameter (see sections 5.7.15.2 and 5.7.15.3.)

Data Length: 3 bits
Resolution: 1 status value/bit
Data Range: 0 to 7
Type: Status
Suspect Parameter Number: 1646
Reference: 5.7.15

The following Status values for Memory Access Responses (i.e. Device to Tool) are defined:

0 - Proceed	See 5.7.15.1.1
1 - Busy	See 5.7.15.1.2
2 - Reserved	
3 - Reserved	
4 - Operation Completed	See 5.7.15.1.3
5 - Operation Failed	See 5.7.15.1.4
6 - Reserved	
7 - Reserved	

5.7.15.1.1 Proceed

This Status is sent from a Device to indicate that a specific Tool may continue with the sequence of a memory access operation the Tool had requested. When sent as a response to a Status Request command, this means the Device is not

presently engaged in any Memory Access Operation (i.e. is not Busy). Optionally, at the manufacturer's preference, the Error Indicator/EDC Parameter may contain the Error Indicator for the previous operation the Device had performed (should be FFFFFFFF₁₆ otherwise).

5.7.15.1.2 Busy

This Status is sent from the Device to indicate to a Tool that there is a condition which prevents the sequence from continuing. The Length/Number Allowed parameter will be zero, the Error Indicator/ EDC Parameter will contain a value indicating the condition which is preventing the Memory Access from continuing, with the manufacturer having a choice of how detailed the Error Indicator is (see 5.7.15.3), and the value of the other parameters will be treated as Do Not Care. When issued as a response to a Memory Access Status Request command, this means the Device may still be busy and in the process of completing a requested operation (this includes but is not limited to: transmitting/ receiving Data required for an operation, erasing memory, or programming memory). See Figure E 8 for an example use of the busy indication.

5.7.15.1.3 Operation Completed

This Status is sent during a close sequence or in response to a Status Request command. Operation Completed is sent as status from the Device during the close sequence of an Erase, Read, Write, Boot Load, or EDCP Generation command to indicate that the request was successfully completed, there may be an EDC value contained within the Error Indicator/EDC Parameter. This Status is the start of the close sequence for all successful Commands which operate upon a Device's memory. A Device's receipt of an Operation Completed from a Tool enables the Device to consider the Memory Access finished. (See also Operation Completed under Memory Access Request - 5.7.14.6.5.) The Device should have a time-out such that on failure to hear the expected Operation Completed (or Operation Failed) from the Tool it closes the session. The value for this time-out should be 100 ms with no worse than ±25 ms error. See Figure E 4 for an example where the Tool does not send the required operation complete message. When the Operation Completed message is sent by a Device in response to a Status Request, it indicates that the last operation was successfully completed only if the close sequence has not been completed. Once the close sequence is completed for an operation, a Device no longer needs to maintain any data about that operation and may send a Status of Proceed, with or without the Error Indicator value from the previous operation, in response to a Status Request.

5.7.15.1.4 Operation Failed

This Status is sent during a close sequence or in response to a Status Request command. Operation Failed is sent as status from the Device during the close sequence of an Erase, Write, Boot Load or EDCP Generation command to indicate that the request was unsuccessful, the Error Indicator/EDC Parameter should contain an Error Indicator. When sent in response to a Status Request, it indicates that the last operation failed only if the close sequence has not been completed. Once the close sequence is completed for an unsuccessful operation, the Device sends the Proceed status in response to a Status Request.

5.7.15.2 EDCP Extension

This is an 8-bit parameter used to identify how to handle the data in the Error Indicator/ EDC Parameter. This EDCP Extension parameter is used within the Memory Access Response message (Device to Tool). Meaning must be determined from a table of predefined values (see Table 11). If there is no Error Indicator/EDC Parameter being sent then this (EDCP Extension) parameter must be properly set (1111111₂). The use of the Error Indicator/EDC Parameter is at the manufacturer's discretion, but it must be properly set relative to this parameter. For example: Suppose the unit is not willing to reveal the current cause of an error for security reasons, then if this EDCP Extension is set to 00000110₂ then the Error Indicator/EDC Parameter must be set to 000001₁₆ to indicate the error is not identified (see Table 11).

Data Length:	8 bits
Resolution:	1 state/bit
Data Range:	0 to 255 (0 to FF ₁₆)
Type:	Status
Suspect Parameter Number:	1647
Reference:	5.7.15

TABLE 11 - EDCP EXTENSION STATES

Bit States	EDCP Extension States
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Bit States	EDCP Extension States
00000000 ₂	Completed - all of the EDC Parameter has been sent
00000001 ₂	Reserved - to be assigned by SAE
00000010 ₂	More - Concatenate the following data as Higher order EDC Parameter
00000011 ₂	More - Concatenate the following data as Lower order EDC Parameter
00000100 ₂ - 00000101 ₂	00000100 ₂ - 00000101 ₂
00000100 ₂ - 00000101 ₂	Data in Error Indicator/EDC Parameter is an Error Indicator
00000111 ₂	Data in Error Indicator/EDC Parameter is an Error Indicator and Data in Seed is an expected time to completion
00001000 ₂ - 11111110 ₂	Reserved - to be assigned by SAE
11111111 ₂	No Error Indicator/EDC Parameter Available

5.7.15.2.1 Completed

An EDCP Extension value of '0' implies all of the EDC Parameter has been sent within the Error Indicator/EDC Parameter.

5.7.15.2.2 More - Concatenate As Higher

Implies the following EDCP components should be concatenated as the next HIGHER order with those previously received.

5.7.15.2.3 More - Concatenate As Lower

Implies the following EDCP components should be concatenated as the next LOWER order with those previously received.

5.7.15.2.4 Error Indicator/EDC Parameter Data Is An Error Indicator

Implies the following data is an Error Indicator value and not a component of an EDCP.

5.7.15.2.5 Error Indicator/EDC Parameter Is An Error Indicator And Data In Seed Is An Expected Time To Completion

Implies the following data is an Error Indicator value and not a component of an EDCP, as well as the Seed parameter contains an expected time to completion. Time value shall have a resolution of 0.1 seconds per bit.

5.7.15.2.6 No EDCP Available

Implies there are no EDCP components available in this system - and could easily imply that an EDCP is not even used.

5.7.15.3 Error Indicator/EDC Parameter

This is a 24-bit parameter which has two uses. One is to transfer a checksum, CRC or other type of EDC parameter (or any segment thereof) from a device to a Tool within the Memory Access Response message. The second use is to send an Error Indicator any time the Device is not able to complete or act upon a Tool's request. Some Error Indicator States are predefined (see Table 12) although it is up to the manufacturer to decide if a particular error will be identified. (If identified, the predefined value is to be used.) The Tool is responsible for knowing the EDC Parameter generation techniques used by the device. The Tool is also responsible for the verification that the EDCP is correct. The EDCP is sent within the Close sequence (see APPENDIX C) at the completion of each operation. Since some users may wish an EDCP greater than 24 bits there is provision to form a larger value by concatenation. In such cases the EDCP Extension parameter is used to determine the direction of concatenation and the completion of the concatenation sequence. An

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EDCP Extension value of “all 1’s” implies that the EDCP, as well as the extension, is not available and is not really being used by the device. In such cases the value in the EDCP has no meaning (see Table 12).

Data Length: 24 bits
Resolution: Per definitions in this section
Data Range: 0 to 16,777,215 (0 to FFFFFFF₁₆)
Type: Status
Suspect Parameter Number: 1648
Reference: 5.7.15

TABLE 12 - ERROR INDICATOR STATES (ONLY WHEN EDCP EXTENSION = 6)

Bit States	Error Indicator States
000000 ₁₆	No Error
000001 ₁₆	Error NOT identified
000002 ₁₆	Currently processing for someone else
000003 ₁₆ - 00000F ₁₆	Reserved - to be assigned by SAE
000010 ₁₆	Currently processing Erase Request
000011 ₁₆	Currently processing Read Request
000012 ₁₆	Currently processing Write Request
000013 ₁₆	Currently processing Status Request
000014 ₁₆	Reserved - to be assigned by SAE
000015 ₁₆	Reserved - to be assigned by SAE
000016 ₁₆	Currently processing Boot Load Request
000017 ₁₆	Currently processing EDCP Generation Request
000018 ₁₆ - 00001E ₁₆	Reserved - to be assigned by SAE
00001F ₁₆	Currently processing unspecified request from this address
000020 ₁₆	EDC parameter not correct for data stream
000021 ₁₆	RAM did not verify on Write
000022 ₁₆	FLASH did not verify on Write
000023 ₁₆	PROM did not verify on Write
000024 ₁₆	Internal failure preventing request (i.e. within the ECU)
000025 ₁₆ - 0000FF ₁₆	Reserved - to be assigned by SAE
000100 ₁₆	Addressing or DATA General Error
000101 ₁₆	Addressing Error - Address not on a valid boundary (Block, Word, Object, etc.)
000102 ₁₆	Addressing Error - Length not valid for memory structure and operation
000103 ₁₆	Addressing Error - required memory exceeded available memory
000104 ₁₆	Addressing Error - requested operation requires prior erase of DATA memory
000105 ₁₆	Addressing Error - requested operation requires prior erase of PROGRAM memory
000106 ₁₆	Addressing Error - requested operation requires prior execution transfer and erase of PROGRAM memory
000107 ₁₆	Addressing Error - requested address for Boot Loader execution transfer is NOT within executable memory
000108 ₁₆	Addressing Error - requested address for Boot Loader execution transfer is NOT on valid boundary
000109 ₁₆	DATA Error - data does NOT conform to expected or allowed value ranges
00010A ₁₆	DATA Error - NAME does NOT conform to expected value
00010B ₁₆ - 000FFF ₁₆	Reserved - to be assigned by SAE
001000 ₁₆	Security Error General
001001 ₁₆	Security Error - Invalid Password
001002 ₁₆	Security Error - Invalid User Level

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Bit States	Error Indicator States
001003 ₁₆	Security Error - Invalid Key {Seed}
001004 ₁₆	Security Error - NOT in Diagnostic mode
001005 ₁₆	Security Error - NOT in Engineering or Development mode
001006 ₁₆	Security Error - Engine running
001007 ₁₆	Security Error - Vehicle NOT in "Park" or otherwise NOT stationary
001008 ₁₆ - 00FFFF ₁₆	Reserved - to be assigned by SAE
010000 ₁₆	Abort from external to normal software process
010001 ₁₆	Too Many Retries - module exceeding a set number of retries
010002 ₁₆	NO response in the time allowed
010003 ₁₆	Transport of data NOT initiated within the time allowed
010004 ₁₆	Transport of data NOT completed within the time allowed
010005 ₁₆ - FFFFFE ₁₆	Reserved - to be assigned by SAE
FFFFFF ₁₆	No Error Indicator Available

5.7.15.3.1 No Error

An Error Indicator value of '0' implies no error was detected by the Device. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.2 Error Not Identified

Implies the Device could (or would) NOT identify the specific error preventing continued operation. This value is to be used by the manufacturer when the Device is unable (or unwilling) whether by design or failure to generate a more detailed summary of the fault or condition preventing continued operation on the given Memory Access Request. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.3 Currently Processing For Someone Else

Implies that the Device is processing a Memory Access for some other address than the one which just requested. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.4 Currently Processing Some Request For This Device

There are several errors which could be the result of the Device already being busy processing a Memory Access Request from this address. Since it was thought by some that it would be nice to know the specific operation underway, several errors have been assigned. It is planned that these errors will be grouped between the values 10₁₆ and 1F₁₆. The specific request can then be identified by the lower nibble of lower byte of Error Indicator/ EDC parameter as:

5.7.15.3.4.1 Currently Processing Erase Request

Implies that the Device is processing a Memory Access Erase from this address already. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.4.2 Currently Processing Read Request

Implies that the Device is processing a Memory Access Read from this address already. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.4.3 Currently Processing Write Request

Implies that the Device is processing a Memory Access Write from this address already. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.4.4 Currently Processing Status Request

Implies that the Device is processing a Memory Access Status Request from this address already. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.4.5 Currently Processing Boot Load Request

Implies that the Device is processing a Memory Access Boot Load from this address already. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.4.6 Currently Processing EDCP Generation Request

Implies that the Device is processing a Memory Access EDCP Generation Request from this address already. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.4.7 Currently Processing Unspecified Request

Implies that the Device is not identifying the specific Request it is presently processing, but is identifying that it is from this address. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.5 Some Failure

There are several errors which can be sent to indicate that an operation has failed. Some errors do not indicate the exact problem but more the event. Members of this form of error will be grouped between values 20₁₆ and FF₁₆. The presently assigned errors are:

5.7.15.3.5.1 EDC Parameter Not Correct For Data Stream

Implies that EDC was not correct for the data. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.5.2 RAM Did Not Verify On Write

Identifies that some failure has caused RAM not to verify following a write. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.5.3 FLASH Did Not Verify On Write

Identifies that some failure has caused a FLASH memory not to verify following a write. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.5.4 PROM Did Not Verify On Write

Identifies that some failure has caused a PROM memory not to verify following a write. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6 Addressing Or Data Errors

There are several errors which imply that something was wrong with the addressing of the request or the data sent for the request. These errors have been grouped with a lower value of 100₁₆ and the specific error can be parsed on the value of the lower byte as:

5.7.15.3.6.1 Addressing Or Data General Error

Identifies that the failure has been within the addressing or data but that it can not be identified further. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6.2 Addressing Error - Length Not Valid For Memory Structure And Operation

Identifies that the failure has been a length which is not compatible with the memory and/or the particular operation attempted upon said memory. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6.3 Addressing Error- Required Memory Exceeded Available Memory

Identifies that the failure has been a request for which there is not sufficient memory available. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6.4 Addressing Error - Requested Operation Requires Prior Erase Of DATA Memory

Identifies that the failure has been a request for which there needed to be an erase of some DATA memory prior to the requested operation. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6.5 Addressing Error - Requested Operation Requires Prior Erase Of PROGRAM Memory

Identifies that the failure has been a request for which there needed to be an erase of some PROGRAM memory prior to the requested operation. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6.6 Addressing Error - Requested Operation Requires Prior Execution Transfer And Erase Of PROGRAM Memory

Identifies that the failure has been a request for which there needed to be a transfer of execution to some other program segment and an erase of some PROGRAM memory prior to the requested operation. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6.7 Addressing Error - Requested Address For Boot Loader Execution Transfer Is NOT Within Executable Memory

Identifies that the failure has been a request to transfer execution to some address not in an executable memory. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.6.8 Addressing Error - Requested Address For Boot Loader Execution Transfer Is NOT On A Valid Boundary

Identifies that the failure has been a request to transfer execution to some address not on a valid boundary within executable memory. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7 Security Error

There are several errors which imply that something was wrong with the security used within the request. These errors have been grouped with a lower value of 1000₁₆ and the specific error can be parsed on the value of the lower byte as:

5.7.15.3.7.1 Security Error General

Identifies that the failure has been within the security but that it is not (or can not be) identified any further. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7.2 Security Error - Invalid Password

Identifies that the failure has been an invalid Password for the requested operation. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7.3 Security Error - Invalid User Level

Identifies that the failure has been an invalid User Level for the requested operation. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7.4 Security Error - Invalid Key{Seed

Identifies that the failure has been an invalid Key returned for the Seed that was provided for the requested operation. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7.5 Security Error - NOT In Diagnostic Mode

Identifies that the failure has been that the unit is not in some Diagnostic mode prior to the requested operation. This is an allowable manufacturer additional requirement. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7.6 Security Error - NOT In Engineering Or Development Mode

Identifies that the requested operation requires that the unit be in an Engineering or Development mode prior to the requested operation. This is an allowable manufacturer additional requirement. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7.7 Security Error - Engine Running

Identifies that the requested operation requires the engine to be stopped prior to the requested operation. This is an allowable manufacturer additional requirement. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.7.8 Security Error - Vehicle NOT In PARK Or Otherwise NOT Stationary

Identifies that the requested operation requires the vehicle to be in Park or otherwise not able to move prior to the requested operation. This is an allowable manufacturer additional requirement. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.8 Time-Out Errors

There are several errors which imply that something has taken too long or too many tries and the unit has given up. These errors have been grouped with a lower value of 10000₁₆ and the specific error can be parsed on the value of the lower byte as:

5.7.15.3.8.1 Abort From External To Normal Software Process

Identifies that some event within the unit has caused an abort of this software process. Hence this Memory Access operation has also been terminated. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.8.2 Too Many Retries

Identifies that the failure has been an excessive number of attempts were made without the desired event occurring. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.8.3 No Response In Time Allowed

Identifies that there has been a time-out within the process, although no further identification of the time-out is possible. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.8.4 Transport Of Data NOT Initiated Within The Time Allowed

Identifies that there has been a time-out within the process, and that it was in waiting for the establishment of the transport session to send the data. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.8.5 Transport Of Data NOT Completed Within The Time Allowed

Identifies that there has been a time-out within the process, and that it has taken too long for the transport session to complete the sending the data. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.3.9 No Error Indicator Available

Implies there is no Error Indicator AVAILABLE at this time. (Note: The Error Indicator is only valid when EDCP Extension = 6, see section 5.7.15.3.)

5.7.15.4 Seed

This is a 16-bit parameter which is used by the Device primarily to send a Seed to a Tool, when using a Seed/Key type security system. It is also used by the Device to signal the Tool that the Device is satisfied that a complete Key has been received or that the Data Security message is expected to contain the Seed data. This parameter can also contain an expected time to completion when the EDCP Extension is 7 (see section 5.7.15.3). The Seed is to be the mathematical basis upon which any Key is calculated. The Device verifies the validity of the Key {Seed} from the Tool and enable memory access operations appropriately. See also section 5.7.14.4, Key/User_Level and Table 13.

Data Length:	16 bits
Resolution:	Per definitions in this section
Data Range:	0 to 65535 (0 to FFFF ₁₆)
Type:	Status
Suspect Parameter Number:	1599
Reference:	5.7.15

TABLE 13 - SEED STATES

Bit States	Seed States
0	Seed Completed - begin sending key
1	Use Long Seed or Key from Data Security Message
2 - FFFE ₁₆	Seed values
FFFF ₁₆	No Further Key required of Tool

5.7.15.4.1 Seed Completed

A specific value to indicate that no further Seed or Seed segments is going to be provided by the Device, see also section 5.7.14.4.5, Handling of Keys Larger than 16 Bits, and section 5.7.15.4.4, No Further Key Required of Tool. The Tool should understand it is to begin the operation supposing that the operation is allowed within the Status parameter and that a non-zero length has been allowed.

5.7.15.4.2 Use Long Seed Or Key From Data Security Message

The actual Seed or Key is in the Data Security message.

5.7.15.4.3 Seed Values

The actual numeric values which can be used for Seeds.

5.7.15.4.4 No Further Key Required Of Tool

A specific value to indicate that no Key or further Key segments is required of the Tool to begin this operation, see also section 5.7.14.4.5, Handling of Keys Larger than 16 Bits, and section 5.7.15.4.1, Seed Completed.

5.7.15.4.5 Handling Of Keys Larger Than 16 Bits

If a manufacturer feels a Seed/Key structure requires a Key or Seed longer than 16 bits for a particular Device, this can be handled with the Data Security message (see "Data Security (DM18)", 5.7.18) and the setting of the Key/User_Level and the Seed parameters appropriately (see Table 10 and Table 13).

5.7.15.4.6 Acceptance Rules

The Device establishes the set of rules governing acceptance of memory access requests (such as operational mode, User_Level versus Memory (OBJECT) Location versus requested operation, etc.). These rules may be manufacturer specific to prevent unauthorized modification of a Device's memory. The manufacturer also has the option to allow an initial operation by a Tool to establish a security level and then let the device honor multiple requests from the same Tool (i.e. the network node whose Source Address matches the Source Address originally used by the Tool opening the original memory access operation, the manufacturer has the option to further check the NAME to address association) without further security operations. This optional re-entrant security is to be considered completely ended when the Tool sends a 'close' or the device time-outs waiting for the Tool's 'close'.

5.7.15.4.7 Expected Time To Completion Values

The expected time to completion of an operation when the device is already processing a request. Numeric values are in milliseconds.

5.7.15.5 Length/Number Allowed

When the Status of the Memory Access Response message is a Proceed, an 11-bit parameter identifies the amount of memory (i.e. the range of memory) over which the Device is willing to allow a particular operation to be carried out. For 'Proceed' the length value is either in bytes or objects (see Length/Number Requested in Section 5.7.14.5). When the Status of the Memory Access Request is Busy, Operation Failed, or Operation Completed the length is meaningless. The Device should therefore send it as '0' and the Tool should treat it as 'DO NOT CARE'.

Data Length:	11 bits
Resolution:	1 byte/bit or object/bit or other
Data Range:	0 to 1784
Type:	Status
Suspect Parameter Number:	1649
Reference:	5.7.15

5.7.16 Binary Data Transfer (DM16)

Used primarily to transfer data for the memory access commands. A memory access state transition diagram (DM14 through DM18) is in APPENDIX C.

Transmission Rate:	As needed
Data Length:	Variable (8 to n)
Extended Data Page:	0
Data Page:	0
PDU Format:	215
PDU Specific:	DA
Default Priority:	6
Parameter Group Number:	55040 (00D700 ₁₆)

BINARY_DATA_TRANSFER

Byte:	1	Number of Occurrences of Raw Binary Data	See 5.7.16.1
Bytes:	2-8	Raw Binary Data	See 5.7.16.2
Bytes:	9-n	Raw Binary Data - when multipacketed	See 5.7.16.2

5.7.16.1 Number of Occurrences of Raw Binary Data

This is an 8-bit (1-byte) parameter to be sent within the Binary Data Transfer PGN to provide information on the number of Raw Binary Data parameters which will follow when the message is single packet. Its value is between 1 and 7 when the

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Binary Data Transfer PGN is not multipacketed. If the message is multipacketed then the value of this parameter is to be 255 (FF₁₆). When the message is multipacketed the number of occurrences of the Raw Binary Data parameter must be determined from the Total Message Size parameter (see J1939-21) sent in the connection request message.

Data Length:	8 bits
Resolution:	1 byte/bit
Data Range:	1 to 7 or 255
	Values 0 or 8 to 254 are not used
Type:	Status
Suspect Parameter Number:	1650
Reference:	5.7.16

5.7.16.2 Raw Binary Data

This is a 1-byte parameter representing the value for 1 byte of memory. It can have any value between 0 and 255 (0 and FF₁₆) with no reserved values. The number of occurrences of this parameter within a message can range from 1 to 1784 (1 less than the 1785 transport limit to account for the parameter - Number of Occurrences of Raw Binary Data). When more than 7 occurrences are to be sent a transport protocol session must be used (remember 1 of the 8 message data bytes was used for the Number of Occurrences of Raw Binary Data parameter). The Number of Occurrences of Raw Binary Data parameter must be used to determine the message length when single packeted. In this case the Number of Occurrences of Raw Binary Data parameter provides the number of Raw Binary Data parameters being sent. This value plus 1 is the number of data bytes within the single packet message. When there are greater than 7 occurrences of the Raw Binary Data parameter to be sent, transport protocol will be needed and it will be necessary to send the Sequence Number (J1939-21 section 3.10.12) from the transport session. Hence the first transport packet will have the Sequence Number, along with the 'Number of Occurrences of Raw Binary Data' parameter and 6 occurrences of this (Raw Binary Data) parameter. In each subsequent transport packet there will be the Sequence Number and 7 occurrences of this (Raw Binary Data) parameter. The Sequence Number must be used to calculate the occurrence number of each of the Raw Binary Data parameters. Also as outlined in J1939-21 the last packet, although 8 bytes in length, may contain fewer than 7 occurrences of this parameter and the Total Message Size parameter (sent in the session connection message) must be used to identify when the end of data is reached. An example of the positioning of the Raw Binary Data within the messages is shown in Table 14 through Table 16. For an example of parsing memory with widths other than 8 bits, see section 5.7.14.3.1.

Data Length:	8 bits
Resolution:	Not applicable
Data Range:	0 to 255 (0 to FF ₁₆)
Type:	Status
Suspect Parameter Number:	1651
Reference:	5.7.16

TABLE 14 - MESSAGE APPEARANCE WHEN MULTIPACKETED

Message	CAN ID	CAN DB1	CAN DB2	CAN DB3	CAN DB4	CAN DB5	CAN DB6	CAN DB7	CAN DB8
First Packet of a transport session	Transport Protocol - Data Transfer Message	Sequence Number J1939-21 3.10.12	Number of Occurrences of Raw Binary Data (value = FF ₁₆)	Raw Binary Data - #1	Raw Binary Data - #2	Raw Binary Data - #3	Raw Binary Data - #4	Raw Binary Data - #5	Raw Binary Data - #6
Second Packet of a transport session	Transport Protocol - Data Transfer Message	Sequence Number J1939-21 3.10.12	Raw Binary Data - #7	Raw Binary Data - #8	Raw Binary Data - #9	Raw Binary Data - #10	Raw Binary Data - #11	Raw Binary Data - #12	Raw Binary Data - #13
Last Packet of a transport session	Transport Protocol - Data Transfer Message	Sequence Number J1939-21 3.10.12	Raw Binary Data - #(Total Message Length - 2)	Raw Binary Data - #(Total Message Length - 1)	FF ₁₆	FF ₁₆	FF ₁₆	FF ₁₆	FF ₁₆

TABLE 15 - MESSAGE APPEARANCE - 7 OCCURRENCES OF RAW BINARY DATA (I.E, WITHOUT TRANSPORT)

Message	CAN ID	CAN DB1	CAN DB2	CAN DB3	CAN DB4	CAN DB5	CAN DB6	CAN DB7	CAN DB8
When not a transport session	Binary Data Transfer Message	Number of Occurrences of Raw Binary Data (value = 07 ₁₆)	Raw Binary Data - #1	Raw Binary Data - #2	Raw Binary Data - #3	Raw Binary Data - #4	Raw Binary Data - #5	Raw Binary Data - #6	Raw Binary Data - #7

TABLE 16 - MESSAGE APPEARANCE - 4 OCCURRENCES OF RAW BINARY DATA (I.E, WITHOUT TRANSPORT)

Message	CAN ID	CAN DB1	CAN DB2	CAN DB3	CAN DB4	CAN DB5	CAN DB6	CAN DB7	CAN DB8
When not a transport session with less than 7 occurrences of Raw Binary Data	Binary Data Transfer Message	Number of Occurrences of Raw Binary Data (value = 04 ₁₆)	Raw Binary Data - #1	Raw Binary Data - #2	Raw Binary Data - #3	Raw Binary Data - #4	FF ₁₆	FF ₁₆	FF ₁₆

5.7.17 Boot Load Data (DM17)

Used primarily to load boot data/program into a device when a memory access boot load command has been issued. A memory access state transition diagram (DM14 through DM18) is in APPENDIX C. The CAN data length code of the message is set to 8 bytes to deliberately avoid the use of transport protocol and thereby reduce the program overhead that would need to be functional within a device while its program is being reloaded.

Transmission Rate: As needed
 Data Length: 8
 Extended Data Page: 0
 Data Page: 0
 PDU Format: 214
 PDU Specific: DA

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Default Priority:	6	
Parameter Group Number:	54784 (00D600 ₁₆)	
BOOT_LOAD_DATA		
Byte: 1-8	Boot Load Data	See 5.7.17.1

5.7.17.1 Boot Load Data

This is a 1-byte parameter using the same SLOT as the Raw Binary Data. There shall be 8 occurrences of this parameter in the message. The meaning of this parameter is proprietary. The structure used to reference the program and verify the data is also proprietary.

Data length:	8 bits
Resolution:	not applicable
Data range:	0 to 255 (0 to FF ₁₆)
Type:	status
Suspect parameter number:	1652
Reference:	5.7.17

5.7.18 Data Security (DM18)

The data security parameter group is used to send security entities of a given type and length. These entities are data produced by or used for applications of cryptography and supporting procedures to ensure data security. Also included is the provision to provide a long seed and long key to be used with memory access functions. The capabilities of the long seed and key are outlined in APPENDIX D. A memory access state transition diagram (DM14 through DM18) is in APPENDIX C.

Transmission Rate:	As needed	
Data Length:	Variable (8 to n)	
Extended Data Page:	0	
Data Page:	0	
PDU Format:	212	
PDU Specific:	DA	
Default Priority:	6	
Parameter Group Number:	54272 (00D400 ₁₆)	
DATA_SECURITY		
Byte: 1	bits 8-1	Security Entity Length (Least significant 8 bits) (Bit 1 is least significant bit) See 5.7.18.2
Byte: 2	bits 8-5	Security Entity Length (Most significant 4 bits) (Bit 8 is most significant bit) See 5.7.18.2
	bits 4-1	Security Entity Type See 5.7.18.1
Byte: 3-n		Data Security Parameter (Least significant byte is Byte 3) (Bit 1 is least significant bit) (Most significant byte is Byte n) (Bit 8 is most significant bit) See 5.7.18.3

5.7.18.1 Security Entity Type

This 4-bit parameter that indicates whether the data in the following Security Entity parameter is to be used as a Long Seed, Long Key, Session Key, or Certificate (see Table 17.)

Data Length:	4 bits
Resolution:	1 type/bit
Data Range:	0 to 15 (see Table 17)
Type:	Status
Suspect Parameter Number:	1479

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Reference: 5.7.18

TABLE 17 - SECURITY ENTITY TYPES

Bit States	Security Entity Type
0000 ₂	Data is Long Seed
0001 ₂	Data is Long Key
0010 ₂	Data is Session Key
0011 ₂	Data is Certificate
0100 ₂ - 1111 ₂	Reserved - future assignment

5.7.18.1.1 Data Is Long Seed

A Security Entity Type value of 0000₂ implies that the data in the following Data Security parameter is to be used as a Long Seed. It is most likely then going from a Device to a Tool.

5.7.18.1.2 Data Is Long Key

A Security Entity Type value of 0001₂ implies that the data in the following Data Security parameter is to be used as a Long Key. In general this would imply previous receipt of a Long Seed upon which to base the Long Key. Also the direction would typically be from a Tool to a Device.

5.7.18.1.3 Data Is Session Key

A Security Entity Type value of 0010₂ implies that the data in the following Data Security parameter is to be used as a Session Key. The Session Key is sent encrypted by using a secret key (symmetric encryption) or the public key of the addressed ECU (asymmetric encryption). The addressed ECU has to decrypt the Session Key before it can be used. The length of the decrypted Session Key is 8 bytes. In the case of using asymmetric encryption the Session Key is put into the first 8 bytes of the data string to be encrypted, followed by 8 bytes, each filled with FF₁₆, and arbitrary numbers for the remaining bytes. This provides a mechanism for the receiving ECU to check if its decryption was successful.

5.7.18.1.4 Data Is Certificate

A Security Entity Type value of 0011₂ implies that the data in the following Data Security parameter is to be used as a Certificate.

5.7.18.2 Security Entity Length

This 12-bit parameter contains the length, in bytes, of the Data Security Parameter.

Data Length:	12 bits
Resolution:	1 byte/bit
Data Range:	0 to 1785
Type:	Status
Suspect Parameter Number:	1596
Reference:	5.7.18

5.7.18.3 Data Security Parameter

This Parameter is used to send the data for the Data Security message. There are presently four different items defined. The Data Security Parameter shall be sent least significant byte first.

Data Length:	Variable (length given in the Security Entity Length parameter)
Resolution:	1 byte/bit
Data Range:	0 to 1785
Type:	Status
Suspect Parameter Number:	1597
Reference:	5.7.18

5.7.18.3.1 Long Seed

When the Security Entity Type value is 0000₂ the data is a Long Seed. The long seed is a number. The number is sent (sometimes randomly) when requesting message or application authentication to rule out replay attacks. (See APPENDIX D.)

5.7.18.3.2 Long Key

When the Security Entity Type value is 0001₂ the data is a Long Key. The long key is a number. This number represents a mathematical function of a previously received Long Seed sent when attempting to justify one's request for a message or application. (See (APPENDIX D.)

5.7.18.3.3 Session Key

When the Security Entity Type value is 0010₂ the data is a Session Key. In this application the Long Seed/Key Data Parameter must be interpreted only if it contains a Session Key.

5.7.18.3.4 Certificate

When the security entity type value is 0011₂ the data is a certificate. Parameter group to be sent on request from an ECU authorized by a certification authority to send authentication messages. Acceptance of the certificate is a prerequisite for the receiving unit to send a session key. The certificate is only needed when the establishment of a session key is based on an asymmetric encryption procedure. For symmetric encryption the installation of the secret key and the algorithm used is not specified here. The content of the certificate is given by ISO/IEC 9594-8 with the subject being the sender of the message. The certificate contains the public key of the sender.

5.7.19 (R)Calibration Information (DM19)

Provides information about the calibration to an interrogating tool (see Figure 5-4).

If DM19 is requested before computation of the Calibration Verification Number is complete then the responder shall send the Acknowledgement PGN with mode set to three to indicated that the tool should request DM19 at a later time.

Transmission Rate:	On request using PGN 59904 (See SAE J1939-21 PGN 59904). A NACK is required if PG is not supported. (See SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Function:	Provide information about the calibration to scan Tool	
Data page:	0	
PDU Format:	211	
PDU Specific:	DA	
Default Priority:	7	
Parameter Group Number:	54016 (00D300 ₁₆)	
Bytes 1-4:	Calibration Verification Number (Byte 1 is least significant byte)	See 5.7.19.1
Bytes 5-20:	Calibration ID (Byte 5 is least significant byte)	See 5.7.19.2

Definitions:

a=Calibration Verification Number (CVN)
b=Calibration Identification (Cal ID)

Message format shall be as follows: a,b,a,b,a,b ...etc. The transport protocol of SAE J1939-21 is used when DM19 requires more than 8 data bytes to convey response.

5.7.19.1 Calibration Verification Number

Four-byte checksum of the entire calibration. Includes code and data. Excludes parameters that exist only in RAM, nonvolatile parameters that change values during the life cycle of the module (hours of operation, miles, number of on/off cycles, freeze frame data, etc.), or nonemissions-related parameters that may be changed by the operator (offsets for real-time clocks, user selectable preferences, etc.). If the checksum is less than 4 bytes, it must be padded with 0016 (the 0016 pad is placed in the most significant byte(s) when needed). The checksum algorithm shall be more robust than a two's complement checksum. Implementers should refer to the applicable regulation for potential additional checksum algorithm requirements. For instance, some regulations might require the calibration verification number to use more sophisticated algorithms that use polynomials or roll functions such that it is very difficult to "tweak" other calibration values to get back to the original CVN value.

Data Length:	4 bytes
Resolution:	Not applicable
Data Range:	0 to 4,294,967,295 (00 00 00 00 ₁₆ to FF FF FF FF ₁₆)
Type:	Hexadecimal
Suspect Parameter Number:	1634
Reference:	5.7.19

5.7.19.2 Calibration Identification

Sixteen-byte calibration identification number. Uniquely identifies the software installed in the control module. The calibration ID must be unique, but does not need to be 16 bytes long. If the Calibration ID is less than 16 bytes, those unused bytes are reported at the end of the calibration ID as 00₁₆ (the 00₁₆ pad is placed in the least significant bytes of the Calibration Identifier when needed). The 00₁₆ if needed is added to the end of the ASCII character string for Calibration Identification.

Data Length:	16 bytes
Resolution:	Not applicable
Data Range:	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ₁₆ to FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF ₁₆
Type:	ASCII and limited to printable characters only
Suspect Parameter Number:	1635
Reference:	5.7.19

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EXAMPLE: The following example shows how a 3-byte Calibration Verification Number ABCDEF₁₆ and a 10-byte Calibration ID "CONTENDER1" would be sent. The hexadecimal representation for the ASCII "CONTENDER1" is

ASCII:	C	O	N	T	E	N	D	E	R	1
Hex:	43	4F	4E	54	45	4E	44	45	52	31

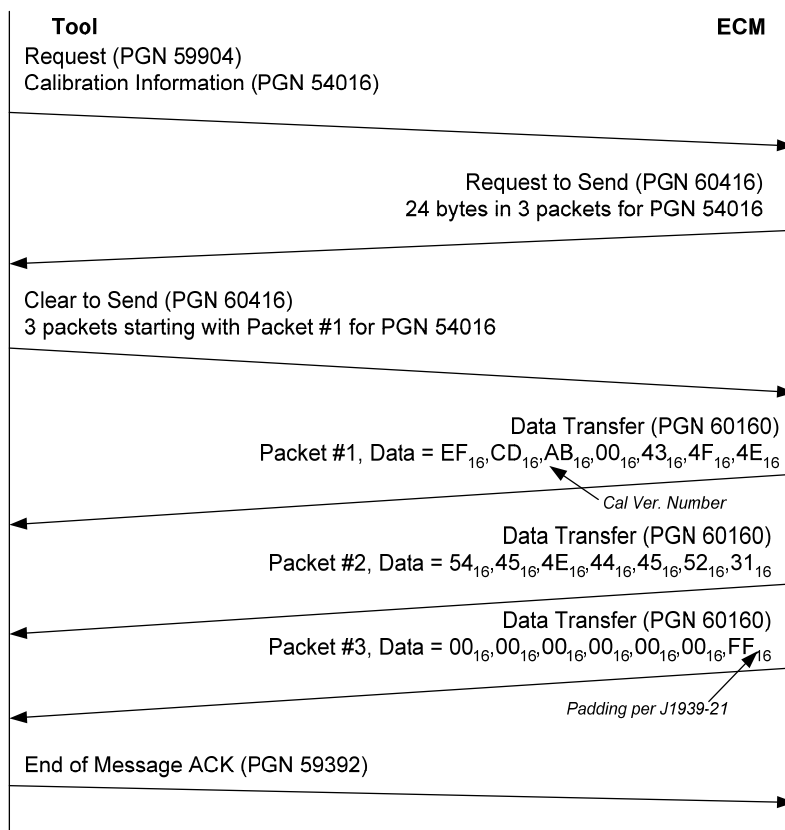


FIGURE 5-4 - EXAMPLE OF TOOL REQUESTING THE CALIBRATION ID AND CVN FROM AN ECM

NOTE: The Calibration Verification Number is sent LSB-MSB per J1939-71 practice for numeric values so the last byte is the padding per J1979. Note also that Calibration ID is sent per J1939-71 standard practice for ASCII values. Finally, note on this example that the entire calibration information PGN is 20 bytes long so the last byte in the data transfer is FF₁₆ per J1939-21.

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EXAMPLE: The following examples show how an ECM sends 3 pairs of 3-byte Calibration Verification Numbers ABCDEF16 and a 10-byte Calibration ID "CONTENDER1". The hexadecimal representation for the ASCII "CONTENDER1", "Contender2", and "Contender3" is shown below:

ASCII:	C	O	N	T	E	N	D	E	R1
Hex:	43	4F	4E	54	45	4E	44	45	52 31

ASCII	C	O	N	T	E	N	D	E	R2
Hex:	43	4F	4E	54	45	4E	44	45	52 32

ASCII	C	O	N	T	E	N	D	E	R3
Hex:	43	4F	4E	54	45	4E	44	45	52 33

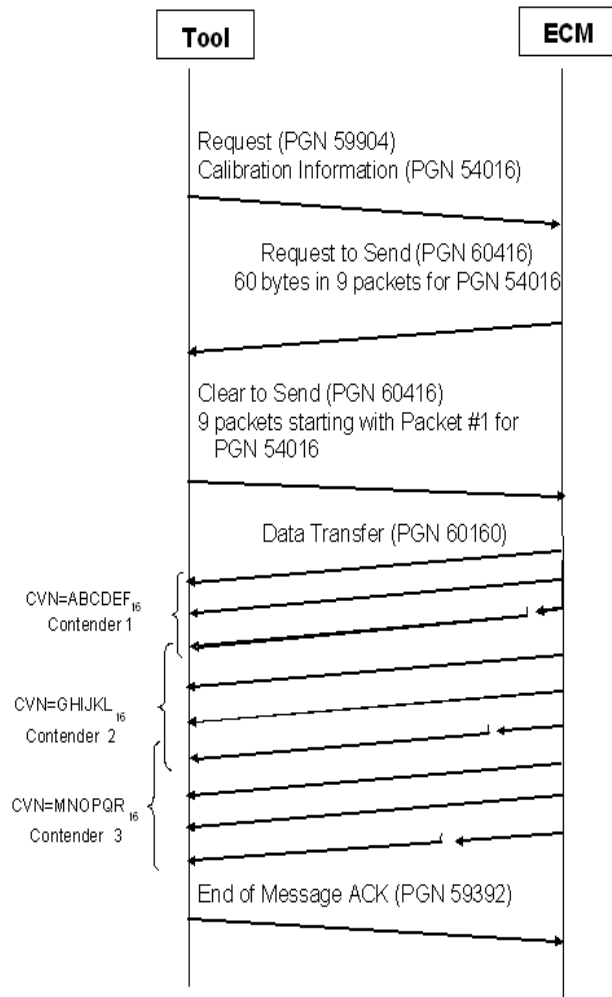


FIGURE 5-5 - EXAMPLE OF TOOL REQUIRING THE CAL ID AND CVNS FROM AN ECM (WITH MORE THAN ONE TO REPORT)

The overlapping brackets in Figure 5-5 illustrate that the CAL ID/CVN pairs are sent back to back and therefore the end of the "Contender 1" is in the same packet that starts CAL ID for "Contender 2" and the packet for the last part of "Contender 2" shares a packet with the start of the CAL ID for "Contender 3".

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5.7.20 (R)Monitor Performance Ratio (DM20)

Legislated On-Board Diagnostics requirements specify that manufacturers must monitor all emission and OBD system related components throughout the expected life of the vehicle. Manufacturers are to monitor all components that impact engine emissions. The monitor performance ratio indicates how often the OBD system monitors particular components compared to the amount of vehicle operation.

The ratio for each parameter is defined as the numerator divided by the denominator. The requirements for incrementing the numerator and denominator are defined on an individual monitor basis.

Only the applicable monitor performance data are required to be reported according to the regulations. However the Ignition Cycle Counter and the OBD Monitoring Conditions Encountered (e.g. CARB's General Denominator) are required in all transmissions of DM20.

Transmission Rate:	On request	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	194	
PDU Specific:	Destination Address	
Default Priority:	06	
Parameter Group Number:	49664 (00C200 ₁₆)	
Bytes 1-2	Ignition Cycle Counter	See 5.7.20.1
Bytes 3-4	OBD Monitoring Conditions Encountered	See 5.7.20.2
Bytes 5-7	SPN of Applicable System Monitor	See 5.7.20.3
Bytes 8-9	Applicable System Monitor Numerator	See 5.7.20.4
Bytes 10-11	Applicable System Monitor Denominator	See 5.7.20.5

Definitions:

a=Ignition Cycle Counter
b=OBD Monitoring Conditions Encountered
c=SPN which defines the monitor ratio being reported
d=Monitor Ratio Numerator
e=Monitor Ratio Denominator

Message format shall be as follows: a,b,c,d,e,c,d,e,c,d,e,c,d,e,...etc. The transport protocol of SAE J1939-21 is used when DM20 requires more than 8 data bytes to convey response.

Table 18 identifies some of the possible performance monitor ratios that a system may report. It contains an indication of those CARB required in their March 2003 OBD II document (California Code of Federal Regulation 1968.2).

(R)TABLE 18 - SAE J1939-73 MONITOR PERFORMANCE

Row #	SPN #	Required by Regulation (See Table 2)	Name
1	3048	B,H,J	Ignition Cycle Counter
2	3049	B,H,J	OBD Monitoring Conditions Encountered Counts
3	3050	B,H,J	Catalyst Bank 1 System Monitor
4	3051	B,H,J	Catalyst Bank 2 System Monitor
5	3052		Misfire Monitor
6	3053	B,H,J	Evaporative System Monitor
7	3054	B,H,J	Secondary Air System Monitor (AIR Monitor)
8	3055		Fuel System Monitor
9	3056	B,H,J	Oxygen (or Exhaust Gas) Sensor Bank 1 Monitor
10	3057	B,H,J	Oxygen (or Exhaust Gas) Sensor Bank 2 Monitor

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Row #	SPN #	Required by Regulation (See Table 2)	Name
11	3058	B,H,J	EGR System Monitor
12	3059		Positive Crankcase Ventilation System Monitor
13	3060		Engine Cooling System Monitor
14	3061		Cold Start Emission Reduction Strategy System Monitor
15	3062		Air Conditioning System Component Monitor
16	3063		Direct Ozone Reduction Monitor
17	3064	H,J	Diesel Particulate Filter Monitor
18	3065		Comprehensive Component Monitor
19	3155	B,H,J	Variable Valve Timing and/or Control (VVT)

5.7.20.1 Ignition Cycle Counter

The ignition cycle counter is defined as a single counter that defines the number of ignition cycles. Requirements for incrementing the denominator are specified in the appropriate legislative documents.

Data Length: 2 bytes
Resolution: 1/bit, 0 offset
Data Range: 0 to 65535
Type: Measured
Suspect Parameter Number: 3048
Reference: 5.7.20

5.7.20.2 OBD Monitoring Conditions Encountered

OBD Monitoring Conditions Encountered Counts displays the number of times that the vehicle has been operated in the specified OBD monitoring conditions (e.g. CARB defines this as the general denominator).

Data Length: 2 bytes
Resolution: 1/bit, 0 offset
Data Range: 0 to 65535
Type: Status
Suspect Parameter Number: 3049
Reference: 5.7.20

5.7.20.3 SPN of Applicable System Monitor

This 3 byte field will contain the SPN of the system monitor for which Monitor ratio is being reported. The SPN will be positioned in the least significant 19 bits of the 3 byte field.

Data Length: 3 bytes (the most significant 5 bits will be set to all ones)
Resolution: Not applicable
Data Range: 0 to 524287
Type: Status
Suspect Parameter Number: 3066
Reference: 5.7.20

5.7.20.4 Applicable System Monitor Numerator

The number of times a vehicle has been operated such that all conditions necessary for the Applicable System Monitor to detect a malfunction have been encountered (e.g. CARB numerator requirements).

Data Length: 2 bytes
Resolution: 1/bit, 0 offset
Data Range: 0 to 65535
Type: Status

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Suspect Parameter Number: 3067
Reference: 5.7.20

5.7.20.5 Applicable System Monitor Denominator

The number of times a vehicle has been operated that constitutes a driving cycle where this Applicable System Monitor could be operated per regulatory requirements (e.g. CARB denominator requirements).

Data Length: 2 bytes
Resolution: 1/bit, 0 offset
Data Range: 0 to 65535
Type: Status
Suspect Parameter Number: 3068
Reference: 5.7.20

5.7.21 Diagnostic Readiness 2 (DM21)

Reports the diagnostic information relevant to a second PGN conveying diagnostic readiness. See also (DM5, sect. 5.7.5).

Transmission Rate: On request using PGN 59904 (See SAE J1939-21 PGN 59904).
A NACK is required if PG is not supported.
(See SAE J1939-21 PGN 59392)

Data Length: 8 bytes
Extended Data Page: 0
Data Page: 0
PDU Format: 193
PDU Specific: Destination Address
Default Priority: 6
Parameter Group Number: 49408 (00C100₁₆)

Bytes: 1-2	Distance Traveled While MIL is Activated	See 5.7.21.1
Bytes: 3-4	Distance Since DTCs Cleared	See 5.7.21.2
Bytes: 5-6	Minutes Run by Engine While MIL is Activated	See 5.7.21.3
Bytes: 7-8	Time Since Diagnostic Trouble Codes Cleared	See 5.7.21.4

5.7.21.1 Distance Traveled While MIL is Activated

The kilometers accumulated while the MIL is activated. See the rollover clearing requirements defined in legislative documentation referenced in section 2.1.2 of this document.

Data Length: 2 bytes
Resolution: 1 km/bit; 0 km offset
Data Range: 0 to 64255 km units
Type: Measured
Suspect Parameter Number: 3069
Reference: 5.7.21

5.7.21.2 Distance Since Diagnostic Trouble Codes Cleared

Distance accumulated since emission related DTCs were cleared (via an external test equipment or possibly, a battery disconnect). This parameter (SPN) is not associated with any particular emission related DTC. It is simply an indication for I/M (Inspection/Maintenance), of the last time an external test equipment was used to clear emission related DTCs. If greater than 64,255 km have occurred, CLR_DIST (SPNa) shall remain at 64,255 km and not wrap to zero.

Data Length: 2 bytes
Resolution: 0 km., 0 km offset
Data Range: 0 to 64255 km units
Type: Measured
Suspect Parameter Number: 3143
Reference: 5.7.21

5.7.21.3 Minutes Run by Engine While MIL is Activated

Accumulated count (in minutes) while the MIL is activated (on). Conditions include: Reset to \$0000 when MIL state changes from deactivated to activated by this ECU; accumulate counts in minutes if MIL is activated (ON); Do not change value while MIL is not activated (OFF); Reset to \$0000 if diagnostic information is cleared either by DM11 or 40 warm-up cycles without MIL activated; and do not wrap to \$0000 if value is 64255.

Data Length:	2 bytes
Resolution:	1 min., 0 min. offset
Data Range:	0 to 64255 min
Type:	Measured
Suspect Parameter Number:	3144
Reference:	5.7.21

5.7.21.4 (R)Time Since Diagnostic Trouble Codes Cleared

Engine running time accumulated since emission related DTCs were cleared (via an external test equipment or possibly, a battery disconnect). This SPN is not associated with any particular emission related DTC. It is simply an indication for I/M (Inspection/Maintenance), of the last time external test equipment was used to clear emission related DTCs. If greater than 64,255 minutes have occurred, CLR_TIME (SPNc) shall remain at 64,255 minutes and not wrap to zero.

Data Length:	2 bytes
Resolution:	1 min., 0 min. offset
Data Range:	0 to 64255 min
Type:	Measured
Suspect Parameter Number:	3145
Reference:	5.7.21

5.7.22 (R)Individual Clear/Reset Of Active And Previously Active DTC (DM22)

All of the diagnostic information pertaining to the specified diagnostic trouble code should be erased when the CLR_PA_REQ or CLR_ACT_REQ action of this PG is requested. This PGN is used to provide the DTC clear/reset services offered with DM3 and DM11 but for individual DTCs. When the individual clear of a previously active DTC is performed, the diagnostic data associated with active trouble codes will not be affected. Upon the completion of a requested clear/reset operation, a positive acknowledgement using CLR_PA_ACK or CLR_ACT_ACK, respectively, is required.

The SPN format shall follow version 4 as specified in section 5.7.1.11

Transmission Rate:	As needed		
Data Length:	8 bytes		
Extended Data Page:	0		
Data page:	0		
PDU Format:	195		
PDU Specific:	Destination Address		
Default Priority:	6		
Parameter Group Number:	49920 (00C300 ₁₆)		
Byte: 1	Individual DTC Clear/Reset Control Byte	See 5.7.22.1	
Byte: 2	Control Byte Specific Indicator for Individual DTC Clear	See 5.7.22.2	
Bytes: 3-5	Reserved for Assignment by SAE		
Byte: 6	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
7	bits 8-1	SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
8	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
	bits 5-1	FMI (most significant at bit 5)	See 5.7.1.10

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Data ranges for parameters used by this Group Function:

Control byte: 1-3, 17-19. 0, 4-16, and 20-254 are Reserved for SAE Assignment.

Request to Clear/Reset Previously Active DTC (DM22.CLR_PA_REQ)

Byte:	1	Control byte = 1, Request to Clear/Reset Previously Active DTC (CLR_PA_REQ)	See 5.7.22.1
	2-5	Reserved for Assignment by SAE (Fill with \$FF)	
	6	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
	7	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
	8	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
		bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10

Positive Acknowledge of Clear/Reset Previously Active DTC (DM22.CLR_PA_ACK)

Byte:	1	Control byte = 2, Positive Acknowledge of Previously Active DTC Clear/Reset (CLR_PA_ACK)	See 5.7.22.1
	2-5	Reserved for Assignment by SAE (Fill with \$FF)	
	6	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
	7	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
	8	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
		bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10

Negative Acknowledge of Clear/Reset Previously Active DTC (DM22.CLR_PA_NACK)

Byte:	1	Control byte = 3, Negative Acknowledge of Previously Active DTC Clear/Reset (CLR_PA_NACK)	See 5.7.22.1
	2	Control Byte Specific Indicator (see Table 20)	See 5.7.22.2
	3-5	Reserved for Assignment by SAE (Fill with \$FF)	
	6	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
	7	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
	8	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
		bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10

Request to Clear/Reset Active DTC (DM22.CLR_ACT_REQ)

Byte:	1	Control byte = 17, Request to Clear/Reset Active DTC (CLR_ACT_REQ)	See 5.7.22.1
	2-5	Reserved for Assignment by SAE (Fill with \$FF)	
	6	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
	7	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
	8	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
		bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10

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Positive Acknowledge of Clear/Reset Active DTC (DM22. CLR_ACT_ACK)

Byte:	1	Control byte = 18, Positive Acknowledge of Active DTC	See 5.7.22.1
		Clear/Reset (CLR_ACT_ACK)	
	2-5	Reserved for Assignment by SAE (Fill with \$FF)	
	6	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
	7	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
	8	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
		bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10

Negative Acknowledge of Clear/Reset Previously Active DTC (DM22.CLR_ACT_NACK)

Byte:	1	Control byte = 19, Negative Acknowledge of Active DTC	See 5.7.22.1
		Clear/Reset (CLR_ACT_NACK)	
	2	Control Byte Specific Indicator (see Table 20)	See 5.7.22.2
	3-5	Reserved for Assignment by SAE (Fill with \$FF)	
	6	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
	7	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
	8	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
		bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10

5.7.22.1 Individual DTC Clear/Reset Control Byte

A numeric indication of the message function and content within the individual DTC Clear message. See Table 19.

Data Length: 1 byte
Resolution: 1/bit, 0 offset
Data Range: 0 to 250 (See Table 19)
Type: Status
Suspect Parameter Number: 3034
Reference: 5.7.22

TABLE 19 - INDIVIDUAL DTC CLEAR/RESET CONTROL BYTE

Control Byte Values	Individual DTC Clear/Reset Control Byte
0	Reserved for SAE Assignment
1	Request to Clear/Reset a Specific Previously Active DTC
2	Positive Acknowledge of Clear/Reset of a Specific Previously Active DTC
3	Negative Acknowledge of Clear/Reset of a Specific Previously Active DTC
4-16	Reserved for SAE Assignment
17	Request to Clear/Reset a Specific Active DTC
18	Positive Acknowledge of Clear/Reset of a Specific Active DTC
19	Negative Acknowledge of Clear/Reset of a Specific Active DTC
20-250	Reserved for SAE Assignment
251-255	Per J1939-71 definition

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5.7.22.2 Control Byte Specific Indicator for Individual DTC Clear

A numeric value with interpretation that is specific to the Control Byte Value within the Individual DTC Clear message.

Data Length: 1 byte
 Resolution: 1/bit, 0 offset
 Data Range: 0 to 250 (See Table 20)
 Type: Status
 Suspect Parameter Number: 3035
 Reference: 5.7.22

NOTE: For Control Byte Values 3 and 19 of an Individual DTC clear/reset request, see the Negative Acknowledge Indicators for Individual DTC Clear table for interpretation (Table 20).

TABLE 20: NEGATIVE ACKNOWLEDGE INDICATORS FOR INDIVIDUAL DTC CLEAR

Bit States	Negative Acknowledge Indicators for Individual DTC Clear
0	General Negative Acknowledge
1	Access Denied (Security Denied Access)
2	Diagnostic Trouble Code unknown/does not exist
3	Diagnostic Trouble Code no longer Previously Active
4	Diagnostic Trouble Code no longer Active
5-250	Reserved for SAE Assignment
251-255	Per J1939-71 definition

5.7.23 (R)Previously Active Emission Related Faults (DM23)

This DM contains DTCs that are confirmed and previously active for which the MIL is off.

The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flashout.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	181	
Default Priority:	6	
Parameter Group Number:	64949 (00FDB5 ₁₆)	
Byte: 1	bits 8-7	Malfunction Indicator Lamp Status
	bits 6-5	Red Stop Lamp Status
	bits 4-3	Amber Warning Lamp Status
	bits 2-1	Protect Lamp Status
Byte: 2	bits 8-7	Flash Malfunction Indicator Lamp
	bits 6-5	Flash Red Stop Lamp
	bits 4-3	Flash Amber Warning Lamp
	bits 2-1	Flash Protect Lamp
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)
Byte: 4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)
Byte: 5	bits 8-6	SPN, 3 most significant bits

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		(most significant at bit 8)	
	bits 5-1	FMI, (most significant at bit 5)	See 5.7.1.10
Byte: 6	bit 8	SPN Conversion Method	
		(shall be sent as a 0)	See 5.7.1.11
	bits 7-1	Occurrence Count	See 5.7.1.12

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

a=lamp status
b=SPN
c=FMI
d=CM and OC

Message form will be as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 will have to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than one fault the services of the transport protocol will have to be used.

EXAMPLE 2: The following illustrates the required message format for reporting DM23 when there are zero active faults. The currently defined lamps (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) shall reflect the present state of the transmitting electronic component.

The required settings for bytes 6-3 for reporting no DTC information is shown below. Implementations are required to set bytes 6 through 3 to all zeros and bytes 7 and 8 to all ones when there are no trouble codes to report

Given:

Byte 1	bits 8-7	= 00 (example of reporting 'off')
	bits 6-5	= 00 (example of reporting 'off')
	bits 4-3	= 00 (example of reporting 'off')
	bits 2-1	= 00 (example of reporting 'off')
Byte 2	bits 8-7	= 11 (example of reporting not available/don't care)
	bits 6-5	= 11 (example of reporting not available/don't care)
	bits 4-3	= 11 (example of reporting not available/don't care)
	bits 2-1	= 11 (example of reporting not available/don't care)

Required Setting

Byte 6-3	SPN	= 0 (required setting for reporting no diagnostic trouble code)
	FMI	= 0 (required setting for reporting no diagnostic trouble code)
	OC	= 0 (required setting for reporting no diagnostic trouble code)
	CM	= 0 (required setting for reporting no diagnostic trouble code)
Byte 7		= 255
Byte 8		= 255

5.7.24 (R)SPN Support (DM24)

This message is used to identify those SPNs supported by the product for DM25, expanded freeze frame and data stream messages. The data stream messages are those PGNs that contain the SPNs reported in DM24.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
Data Length:	8 bytes (Variable, typical engine could be 50 para x 4 = 200 bytes)	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	

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PDU Specific:	182	
Default Priority:	6	
Parameter Group Number:	64950 (00FDB6 ₁₆)	
Byte: 1 bits 8-1	SPN Supported, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.24.1
Byte: 2 bits 8-1	SPN Supported, second byte of SPN (most significant at bit 8)	See 5.7.24.1
Byte: 3 bits 8-6	SPN Supported, 3 most significant bits (most significant at bit 8)	See 5.7.24.1
bits 5-4	Reserved for SAE Assignment	
bits 3	Supported in Scaled Test Results	See 5.7.24.4
bits 2	Supported in Data Stream	See 5.7.24.3
bits 1	Supported in Expanded Freeze Frame	See 5.7.24.2
Byte: 4 bits 8-1	SPN Data Length	See 5.7.24.5

Given:

A=SPN supported
B=SPN support type
C=SPN data length

Message form will be as follows: a,b,c,a,b,c,a,b,c....etc

TABLE 21 - SPN REPRESENTATION IN CAN DATA FRAME FOR DM 24

Byte 1: 8 least significant bits of SPN (bit 8 most significant)								Byte 2 second byte of SPN (bit 8 most significant)								Byte 3: 3 most significant bits of SPN (bit 8 MSB)			Byte 3: bits 5-1 identify SPN Support types				
SPN																Support Types							
8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1

5.7.24.1 SPN Supported

This parameter defines each SPN that is supported by the ECU in Data Stream, Expanded Freeze Frame, or Scaled Test Results. Any SPN not supported for at least one of these purposes will not be transmitted in this parameter group.

Data Length:	19 bits
Resolution:	1 SPN per bit
Data Range:	0 to 524287 (00 00 00 ₁₆ to 7F FF FF ₁₆)
Type:	Status
Suspect Parameter Number:	3146
Reference:	5.7.24

TABLE 22 - SPN SUPPORT TYPE

SPN Support Types	Definition
Bit 1	Supported in Expanded Freeze Frame (e.g., DM25)
Bit 2	Supported in Data Stream
Bit 3	Supported in Scaled Test Results (e.g., DM30)
Bit 4	SAE Reserved
Bit 5	SAE Reserved

5.7.24.2 Supported in Expanded Freeze Frame

This parameter defines whether the applicable parameter (that is the SPN) is supported in the expanded freeze frame message, DM25.

Data Length:	1 bit
Resolution:	Not applicable
Data Range:	0 to 1 (0 ₂ to 1 ₂)
Type:	Status
Suspect Parameter Number:	4100
Reference:	5.7.24

5.7.24.3 Supported in Data Stream

This parameter defines whether the applicable parameter (that is the SPN) is supported in the Data Stream messages.

Data Length:	1 bit
Resolution:	Not applicable
Data Range:	0 to 1 (0 ₂ to 1 ₂)
Type:	Status
Suspect Parameter Number:	4101
Reference:	5.7.24

5.7.24.4 Supported in Scaled Test Results

This parameter defines whether the applicable parameter (that is the SPN) is supported in the Scaled Test Results message, DM30.

Data Length:	1 bit
Resolution:	Not applicable
Data Range:	0 to 1 (0 ₂ to 1 ₂)
Type:	Status
Suspect Parameter Number:	4102
Reference:	5.7.24

5.7.24.5 SPN Data Length

The number of data bytes associated with the SPN in the Freeze Frame.

The SPN data length is required to ensure old and new OBD tool compatibility with vehicle OBD Systems. For instance, if the vehicle supports a new SPN then the tool will know how to parse the data in the expanded freeze frame to bypass the unresolved SPN. SPN data value scaling is per the applicable J1939 specification (J1939-71, J1939-75, etc.). The SPN Data Length of "1" shall be reported for partial byte parameters (less than 8 bits).

Data Length:	1 byte
Resolution:	1 data byte
Data Range:	0 to 250
Type:	Status
Suspect Parameter Number:	4103
Reference:	5.7.24

5.7.25 (R)Expanded Freeze Frame (DM25)

Freeze frame message providing more parameter support than the existing DM4.

A freeze frame is defined as the list of recorded parameters at the time a diagnostic trouble code was captured. The freeze frame recorded for each diagnostic trouble code will contain the required parameters first and then any manufacturer specific information. It is possible that controllers will have more than one freeze frame available and each may have some manufacturer specific information. A freeze frame is specific to one diagnostic trouble code and one diagnostic trouble code only has one freeze frame. This then limits the amount of freeze frame data per fault and for all faults that are included in this message to 1785 bytes (see SAE J1939-21 transport protocol).

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This diagnostic message was created for systems which may impact emissions and/or be powertrain related. However, the use of this message is not limited to just emission-related failures or just powertrain devices. It can be used to report non-emission related or non-powertrain related freeze frame failures.

The order of the freeze frame data parameters will be per the order defined in DM 24. The parameter length for each individual SPN in the freeze frame is also determined from the information provided in DM24.

Implementers should refer to the applicable regulation for potential additional Freeze Frame requirements. For instance, some regulations might require the OBD Freeze Frame to have priority over non-OBD Freeze Frames.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	183	
Default Priority:	6	
Parameter Group Number:	64951 (00FDB7 ₁₆)	
Byte: 1	Expanded Freeze Frame Length	See 5.7.25.1
Byte: 2	bits 8-1 SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 3	bits 8-1 SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 4	bits 8-6 SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
	bits 5-1 FMI (most significant at bit 5)	See 5.7.1.10
Byte: 5	bit 8 SPN Conversion Method	See 5.7.1.11
	bits 7-1 Occurrence Count	See 5.7.1.12
Byte: 6 - n	SPN Data	See 5.7.25.2

EXAMPLE 1: The following illustrates the message format for when there is more than one freeze frame.

Given:

a=expanded freeze frame length
b=DTC associated with freeze frame SPN data (for example, bytes 2,3,5 above)
c=freeze frame supported SPN data (See Example 2)

Message form will be as follows: a,b,c,a,b,c,a,b,c,a,b,c....etc. The transport protocol of SAE J1939-21 will have to be used to send freeze frames because they are more than 8 data bytes.

EXAMPLE 2: Illustration of a DM25 Expanded Freeze Frame message (see figure Figure 5-6) when supplied with the data identified in Table 23 .

Given:

1=SPN 91 (Accelerator Pedal Position)
2= Failure Mode Of 3, Voltage Above Normal, is occurring
3=DM24 (Response per Table 21)

TABLE 23 - EXAMPLE DM24 RESPONSE

	SPN #	# Data Bytes	Used in Extended Freeze Frame
Engine Speed	190	2	Yes
Engine Coolant Temperature	110	1	No
Vehicle Speed	86	1	Yes

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Accelerator	91	1	Yes
-------------	----	---	-----

Results: DM25 as shown below

	DTC					Expanded Freeze Frame Data				
Byte 1	Byte 2	Byte 3	Byte 4	Byte 5		Byte 6	Byte 7	Byte 8	Byte 9	
Expanded Freeze Frame Length	SPN			FMI	CM	Occurrence Count	Data for SPN 190		Data for SPN 86	Data for SPN 91
8 ₁₀	91 ₁₀			3	0	1	8000 ₁₀		100 ₁₀	254 ₁₀

FIGURE 5-6 - EXAMPLE DM25

EXAMPLE 3: The following illustrates the DM25 message content when there are zero freeze frames to report.

The DM25 message content when there are zero freeze frames will report the value zero (0x00) for the Expanded Freeze Frame length, all zeros (0x00) for each of the bytes 2 through 5, and all ones (0xFF) for each of the bytes 6 through 8.

Byte 1 = 0

Byte 2-5

SPN = 0

FMI = 0

CM = 0

OC = 0

Byte 6 = 255

Byte 7 = 255

Byte 8 = 255

5.7.25.1 Expanded Freeze Frame Length

The Freeze Frame Length is the number of bytes to convey the DTC and the data of all parameters (SPNs) in the Freeze Frame.

Data Length: 8 bits
Resolution: 1 byte/bit
Data Range: 0 to 255
Type: Status
Suspect Parameter Number: 3149
Reference: 5.7.25

EXAMPLE: This example is showing a very short expanded freeze frame just to illustrate the use of the “expanded freeze frame length field”.

Given:

a = expanded freeze frame length

b = DTC associated with freeze frame SPN data (for example, bytes 2,3,5 above)

c = freeze frame supported SPN data (See Example 2)

Length is calculated as follows:

b=4

c=4.....engine speed, vehicle speed, accelerator

$$a = b + c$$
$$a = 4 + 4 = 8$$

5.7.25.2 SPN Data

The SPN data field represents the data pertaining to one or more SPNs that were reported in DM24. The order and number of bytes per SPN is determined from the DM24 response.

In DM25, an entire byte is used for each parameter if the parameter itself is less than 8 bits long. The SPN data value shall be placed into the byte right justified to the least significant bit, regardless of its defined position in the normal data PGN. Any remaining bits of the data byte shall be reported as '0'. For example, if SPN 559 (accelerator pedal kick-down switch) is reported as a DM25 freeze frame parameter, the SPN 559 data will reside in bits 1 and 2 of the byte in DM25, even though this parameter data reported in bits 3 and 4 of PGN 61443. The remaining unused bits of this byte in the DM25 message will be filled with '0'. Each of the remaining 6 most significant bits of this freeze frame byte (bit 2 to bit 8) will be filled with '0'

5.7.26 (R)Diagnostic Readiness 3 (DM26)

This message conveys information useful in determining whether the OBD system has a defect or not. This specific message conveys the pending status of OBD system monitors for the current drive cycle. It, along with the data from DM5 and DM21, are used to formulate OBD system readiness. Note that this parameter group will be sent using the "multipacket transport" parameter group as specified in SAE J1939-21 when applicable.

The bits in SPNs 3152, 3153 and 3154 shall report two pieces of information for each monitor:

- 1) Monitor enable status for the current driving cycle. This bit shall indicate when a monitor is disabled in a manner such that there is no likely or reasonable way for the driver to operate the vehicle to allow the monitor run. Typical examples are:
 - Engine-off soak not long enough (e.g., cold start temperature conditions not satisfied),
 - Monitor maximum time limit or number of attempts/aborts exceeded,
 - Ambient air temperature too low or too high,
 - BARO too low (high altitude).

The monitor shall not indicate "disabled" for operator-controlled conditions such as rpm, load, accelerator position, minimum time limit not exceeded, etc.

- 2) Monitor completion status for the current driving/monitoring cycle. Status shall be reset to "not complete" upon starting a new monitoring cycle. Note that some monitoring cycles can include various engine-operating conditions; other monitoring cycles begin after the ignition key is turned off. Some status bits on a given vehicle can utilize engine-running monitoring cycles while others can utilize engine-off monitoring cycles. Resetting the bits to "not complete" upon starting the engine will accommodate most engine-running and engine-off monitoring cycles, however, manufacturers are free to define their own monitoring cycles.

NOTE: DM26 bits shall be utilized for all non-continuous monitors which are supported, and change completion status in DM5. If a non-continuous monitor is not supported or always shows "complete", the corresponding DM26 bits shall indicate disabled and complete. DM26 bits may be utilized at the vehicle manufacturer's discretion for all continuous monitors which are supported with the exception of the bit that shall always show CCM (Comprehensive Component Monitoring) as enabled for spark ignition and compression ignition engines.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported	
	(see SAE J1939-21 PGN 59392)	
Data Length:	Variable (presently 8 bytes)	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	184	
Default Priority:	6	
Parameter Group Number:	64952 (00FDB8 ₁₆)	

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Byte:	1-2	Time Since Engine Start	See 5.7.26.1
	3	Number of Warm-ups Since DTCs Cleared	See 5.7.26.2
	4	Continuously Monitored Systems Enable/Completed Status	See 5.7.26.3
	5-6	Non-continuously Monitored Systems Enable Status	See 5.7.26.4
	7-8	Non-continuously Monitored Systems Complete Status	See 5.7.26.5

5.7.26.1 Time Since Engine Start

The time since key-on that the engine has been running. RUNTM (i.e. Time Since Engine Start) shall increment while the engine is running. It shall freeze if the engine stalls. RUNTM shall be reset to zero during every control module power-up and when entering the key-on, engine off position. RUNTM is limited to 64255 seconds and shall not wrap around to zero.

Data Length: 2 bytes
Resolution: 1 sec
Data Range: 0 to 64255
Type: Measured
Suspect Parameter Number: 3150
Reference: 5.7.26

5.7.26.2 Number of Warm-ups Since DTCs Cleared

Number of OBD warm-up cycles since all DTCs were cleared (via an external test equipment or possibly, a battery disconnect.) A warm-up is defined in the OBD regulations to be sufficient vehicle operation such that coolant temperature rises by at least 22 °C (40 °F) from engine starting and reaches a minimum temperature of 70 °C (160 °F) (60 °C (140 °F) for diesels). This SPN is not associated with any particular DTC. It is simply an indication for I/M, of the last time an external test equipment was used to clear DTCs. If greater than 250 warm-ups have occurred, WARM_UPS (i.e. Number of Warm-ups Since DTCs Cleared) shall remain at 250 and not wrap to zero.

Data Length: 1 byte
Resolution: 1 trouble code/bit
Data Range: 0 to 250
Type: Measured
Suspect Parameter Number: 3151
Reference: 5.7.26

5.7.26.3 Continuously Monitored Systems Enable/Completed Status

This parameter identifies the continuously monitored system enable/completed support and status.

Data Length: 1 byte
Resolution: See below
Data Range: Bit mapped, see below
Type: Measured
Suspect Parameter Number: 3152
Reference: 5.7.26

Byte:	4	bit 8	Reserved for assignment by SAE	
		bit 7	Comprehensive component completed	See 5.7.26
		bit 6	Fuel System monitoring completed	See 5.7.26
		bit 5	Misfire monitoring completed	See 5.7.26

Where each completed bit (bits 7, 6, 5) is interpreted:

0 = monitor complete this monitoring cycle, or not supported (YES)
1 = monitor not complete this monitoring cycle (NO)

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See DM5 to determine which monitors are supported.

bit 4	Reserved for assignment by SAE
bit 3	Comprehensive component monitoring enabled
bit 2	Fuel system monitoring enabled
bit 1	Misfire monitoring enabled

Where each enabled bit (bits 3, 2, 1) is interpreted:

- 0 = monitor disabled for rest of this monitoring cycle or not supported (NO)
- 1 = monitor enabled for this monitoring cycle (YES)

5.7.26.4 Non-Continuously Monitored Systems Enable Status

Enable status of non-continuous monitors this monitoring cycle.

Data Length: 2 bytes
(sent as a magnitude; therefore it is byte swapped)
Resolution: See below
Data Range: Bit mapped, see below
Type: Measured
Suspect Parameter Number: 3153
Reference: 5.7.26

Byte: 5	bit 8	EGR system monitoring Enabled
	bit 7	Oxygen sensor heater monitoring Enabled
	bit 6	Oxygen sensor monitoring Enabled
	bit 5	A/C system refrigerant monitoring Enabled
	bit 4	Secondary air system monitoring Enabled
	bit 3	Evaporative system monitoring Enabled
	bit 2	Heated catalyst monitoring Enabled
	bit 1	Catalyst monitoring Enabled
Byte: 6	bits 8-6	Reserved for assignment by SAE
	bit 5	NMHC converting catalyst
	bit 4	NOx converting catalyst and/or NOx adsorber
	bit 3	PM filter
	bit 2	Boost pressure control system
	bit 1	Cold start aid system monitoring Enabled

Where each Enable bit is interpreted:

- 0 = test monitor disabled for rest of this monitoring cycle (NO)
- 1 = monitor enabled for this monitoring cycle (YES)

5.7.26.5 Non-Continuously Monitored Systems Complete Status

Completion status of non-continuous monitors this monitoring cycle. Each bit identifies whether a particular test is complete for a given controller.

Data Length: 2 bytes
(Sent as a magnitude; therefore it is byte swapped)
Resolution: See below
Data Range: Bit mapped, see below
Type: Measured
Suspect Parameter Number: 3154
Reference: 5.7.26

Byte: 7	bit 8	EGR system monitoring Enabled
	bit 7	Oxygen sensor heater monitoring Enabled
	bit 6	Oxygen sensor monitoring Enabled

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	bit 5	A/C system refrigerant monitoring Enabled
	bit 4	Secondary air system monitoring Enabled
	bit 3	Evaporative system monitoring Enabled
	bit 2	Heated catalyst monitoring Enabled
	bit 1	Catalyst monitoring Enabled
Byte: 8	bits 8-6	Reserved for assignment by SAE
	bit 5	NMHC converting catalyst
	bit 4	NOx converting catalyst and/or NOx adsorber
	bit 3	PM filter
	bit 2	Boost pressure control system
	bit 1	Cold start aid system monitoring Complete

Where each bit is interpreted:

- 0 = monitor complete this monitoring cycle, or not supported (yes)
- 1 = monitor not complete this monitoring cycle (no)

5.7.27 (R)All Pending DTCs (DM27)

The purpose of this DM is to enable the external test equipment to obtain all "pending" diagnostic trouble codes detected during current or last completed driving cycle for all components/systems, including emission-related components/systems. DM27 can be used for all DTCs and is independent of DM6 and DM12. The intended use of this data is to assist the service technician after a vehicle repair, and after clearing diagnostic information, by reporting test results after a single driving cycle. If the test failed during the driving cycle, the DTC associated with that test will be reported. Test results reported by this service do not necessarily indicate a faulty component/system. If test results indicate a failure after additional driving, then the MIL will be illuminated and a DTC will be set and reported with DM1, indicating a faulty component/ system. This service can be used to request the results of the latest test, independent of the setting of a DTC.

Reporting the pending DTCs is done using the same format as is used to report active DTCs.

The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flashout.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported	
	(see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	130	
Default Priority:	6	
Parameter Group Number:	64898 (00FD82 ₁₆)	
Byte: 1	bits 8-7	Malfunction Indicator Lamp Status
	bits 6-5	Red Stop Lamp Status
	bits 4-3	Amber Warning Lamp Status
	bits 2-1	Protect Lamp Status
Byte: 2	bits 8-7	Flash Malfunction Indicator Lamp
	bits 6-5	Flash Red Stop Lamp
	bits 4-3	Flash Amber Warning Lamp
	bits 2-1	Flash Protect Lamp
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN
		(most significant at bit 8)
Byte: 4	bits 8-1	SPN, second byte of SPN

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Byte: 5	bits 8-6	(most significant at bit 8) SPN, 3 most significant bits	See 5.7.1.9
		(most significant at bit 8) FMI	See 5.7.1.10
Byte: 6	bit 8	(most significant at bit 5) SPN Conversion Method	See 5.7.1.11
	bits 7-1	Occurrence Count	See 5.7.1.12

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

a=lamp status (LS)

b=SPN

c=FMI

d=CM and OC

Message form is as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 has to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than one fault, the services of the transport protocol have to be used.

EXAMPLE 2: The following illustrates the required message format for reporting DM27 when there are zero pending faults. The currently defined lamps (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) shall reflect the present state of the transmitting electronic component.

The required settings for bytes 6-3 for reporting no DTC information is shown below. Implementations are required to set bytes 6 through 3 to all zeros and bytes 7 and 8 to all ones when there are no trouble codes to report

Given:

Byte 1	bits 8-7	= 00 (example of reporting 'off')
	bits 6-5	= 00 (example of reporting 'off')
	bits 4-3	= 00 (example of reporting 'off')
	bits 2-1	= 00 (example of reporting 'off')
Byte 2	bits 8-7	= 11 (example of reporting not available/don't care)
	bits 6-5	= 11 (example of reporting not available/don't care)
	bits 4-3	= 11 (example of reporting not available/don't care)
	bits 2-1	= 11 (example of reporting not available/don't care)

Required Setting

Byte 6-3	SPN	= 0 (required setting for reporting no diagnostic trouble code)
	FMI	= 0 (required setting for reporting no diagnostic trouble code)
	OC	= 0 (required setting for reporting no diagnostic trouble code)
	CM	= 0 (required setting for reporting no diagnostic trouble code)
Byte 7		= 255
Byte 8		= 255

5.7.28 (R)Permanent DTCs (DM28)

The purpose of this DM is to provide the list of permanent DTCs that are currently present. Permanent DTCs are defined as a confirmed or active MIL-on fault code that is currently commanding the MIL on and is stored in non-volatile memory.

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The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flashout.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	128	
Default Priority:	6	
Parameter Group Number:	64896 (00FD80 ₁₆)	
Byte: 1	bits 8-7	Malfunction Indicator Lamp Status
	bits 6-5	Red Stop Lamp Status
	bits 4-3	Amber Warning Lamp Status
	bits 2-1	Protect Lamp Status
Byte: 2	bits 8-7	Reserved for SAE assignment Lamp Status
	bits 6-5	Reserved for SAE assignment Lamp Status
	bits 4-3	Reserved for SAE assignment Lamp Status
	bits 2-1	Reserved for SAE assignment Lamp Status
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN
		(most significant at bit 8)
Byte: 4	bits 8-1	SPN, second byte of SPN
		(most significant at bit 8)
Byte: 5	bits 8-6	SPN, 3 most significant bits
		(most significant at bit 8)
	bits 5-1	FMI
		(most significant at bit 5)
Byte: 6	bit 8	SPN Conversion Method
	bits 7-1	Occurrence Count

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

a=lamp status (LS)
b=SPN
c=FMI
d=CM and OC

Message form will be as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 will have to be used to send the information because it requires more than 8 data bytes. Actually any time there is more than one fault the services of the transport protocol will have to be used.

EXAMPLE 2: The following illustrates the message format for when a request of the DM28 is made and there are zero previously active faults. The currently defined lamps (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. In this example, the amber lamp is identified as being on.

The required setting for bytes 6-1 is shown below.

Given:

Byte 1 bits 8-7 = 00 (example of reporting 'off')

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bits 6-5 = 00 (example of reporting 'off')
bits 4-3 = 01 (example of reporting 'on')
bits 2-1 = 00 (example of reporting 'off')
Byte 2 bits 8-7 = 11 (example of reporting not available/don't care)
bits 6-5 = 11 (example of reporting not available/don't care)
bits 4-3 = 11 (example of reporting not available/don't care)
bits 2-1 = 11 (example of reporting not available/don't care)

Required Setting

Byte 6-3	SPN	= 0
	FMI	= 0
	OC	= 0
	CM	= 0
Byte 7		= 255
Byte 8		= 255

5.7.29 (R)DTC Counts (DM29)

The purpose of this DM is to identify the number of DTCs in each category. The categories are pending, all pending, MIL-on, previously MIL-on, and permanent DTCs.

Transmission Rate:	On request using PGN 59904 (See SAE J1939-21 PGN 59904). A NACK is required if PG is not supported. (See SAE J1939-21 PGN 59392)	
Data Length:	8 bytes	
Extended Data Page:	0	
Data Page:	0	
PDU Format:	158	
PDU Specific:	Destination Address	
Default Priority:	6	
Parameter Group Number:	40448 (009E00 ₁₆)	
Byte: 1	Pending DTCs	See 5.7.29.1
Byte: 2	All Pending DTCs	See 5.7.29.2
Byte: 3	MIL-On DTCs	See 5.7.29.3
Byte: 4	Previously MIL-On DTCs	See 5.7.29.4
Byte: 5	Permanent DTCs	See 5.7.29.5
Bytes: 6-8	Reserved for SAE assignment	

5.7.29.1 Pending DTCs

Identifies the current number of emission related pending DTCs (DM6).

Data Length:	1 byte
Resolution:	1 trouble code/bit
Data Range:	0 to 250
Type:	Measured
Suspect Parameter Number:	4104
Reference:	5.7.29

5.7.29.2 All Pending DTCs

Identifies the current total number of pending DTCs, including emission related ones (DM27).

Data Length:	1 byte
Resolution:	1 trouble code/bit
Data Range:	0 to 250
Type:	Measured

Suspect Parameter Number: 4105
Reference: 5.7.29

5.7.29.3 MIL-On DTCs

Identifies the current number of MIL-On DTCs (DM12)..

Data Length: 1 byte
Resolution: 1 trouble code/bit
Data Range: 0 to 250
Type: Measured
Suspect Parameter Number: 4106
Reference: 5.7.29

5.7.29.4 Previously MIL-On DTCs

Identifies the current number of previously MIL-On DTCs (DM23).

Data Length: 1 byte
Resolution: 1 trouble code/bit
Data Range: 0 to 250
Type: Measured
Suspect Parameter Number: 4107
Reference: 5.7.29

5.7.29.5 Permanent DTCs

Identifies the current number of permanent DTCs (DM28).

Data Length: 1 byte
Resolution: 1 trouble code/bit
Data Range: 0 to 250
Type: Measured
Suspect Parameter Number: 4108
Reference: 5.7.29

5.7.30 (R)Scaled Test Results (DM30)

This message conveys the scaled test results for the applicable test requested in DM7. The SPN and FMI convey the specific DTC for which the results are being reported.

Transmission Rate: Sent in response to PGN 58112 when the results are available
A NACK is required if PG is not supported
(see SAE J1939-21 PGN 59392)

Data Length: Variable
Extended Data Page: 0
Data Page: 0
PDU Format: 164
PDU Specific: Destination Address
Default Priority: 6
Parameter Group Number: 41984 (00A400₁₆)

Byte: 1		Test Identifier	See 5.7.7.1
Byte: 2	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 3	bits 8-1	SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 4	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9

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	bits 5-1	FMI	See 5.7.1.10
		(most significant at bit 5)	
Byte:	5-6	SLOT Identifier	See 5.7.30.1
Byte:	7-8	Test Value	See 5.7.30.2
Byte:	9-10	Test Limit Maximum	See 5.7.30.3
Byte:	11-12	Test Limit Minimum	See 5.7.30.4

EXAMPLE 1: The following illustrates the message format for when there is more than one test result to communicate.

Given:

a = Test Identifier
b = SPN
c = FMI
d = SLOT Identifier
e = Test Value
f = Test Limit Maximum
g = Test Limit Minimum

Message form will be as follows: a,b,c,d,e,f,g,a,b,c,d,e,f,g, a,b,c,d,e,f,g, a,b,c,d,e,f,g,....etc. The transport protocol of SAE J1939-21 has to be used to send the scaled test results message because it contains more than 8 data bytes.

5.7.30.1 SLOT Identifier

The SLOT Identifier is used to determine the multiplier and offset to be used to scale the test value, test limit maximum, and test limit minimum so that the results are displayable in engineering units. The SLOT identifiers are defined in J1939-71.

Data Length: 2 bytes
Resolution: Not defined
Data Range: 0 to 64255
Type: Measured
Suspect Parameter Number: 4109
Reference: 5.7.30

5.7.30.2 Test Value

The test value collected during the test. If the test performed does not have both a test limit minimum and maximum, then the appropriate limit value (Maximum or Minimum) should be set to all ones. SAE J1939-71 defines this to mean not available. The test value shall be scaled according to the SLOT definition in J1939-71. The test value shall follow the conventions of table 5 when applicable.

Data Length: 2 bytes
Resolution: Not defined
Data Range: 0 to 64255
Type: Measured
Suspect Parameter Number: 4110
Reference: 5.7.30

5.7.30.3 Test Limit Maximum

The test value must be less than or equal to Test Limit Maximum in order for the test to pass The test limit maximum shall be scaled according to the SLOT definition in J1939-71.

Data Length: 2 bytes
Resolution: Not defined
Data Range: 0 to 64255
Type: Measured
Suspect Parameter Number: 4111

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Reference: 5.7.30

5.7.30.4 Test Limit Minimum

The test value must be greater than or equal to Test Limit Minimum in order for the test to pass. The test limit minimum shall be scaled according to the SLOT definition in J1939-71.

Data Length: 2 Bytes
Resolution: Not Defined
Data Range: 0 To 64255
Type: Measured
Suspect Parameter Number: 4112
Reference: 5.7.30

5.7.31 (R)DTC To Lamp Association (DM31)

This message shall provide the applicable lamp(s) for each individual DTC. Only the lamp(s) associated with the specific DTC shall be reported. Those lamp(s) that are not relevant to the specific DTC should be reported as not available (i.e. report as 11). Each DTC reported shall indicate the relevance of each of the SAE specified lamps in DM 31. The use of the lamp fields are unique to this message. Other DMs, such as DM1 and DM2, always report the composite status of the lamps for the reporting system. In DM31 the lamp information reported is specific to each DTC and only that DTC. See "Table 24" for additional specifications regarding the lamp information in DM 31. The device(s) receiving this message can deduce the composite status of the SAE DM31 specified lamps for the transmitting device by properly considering all lamp values for each of the specific DTCs.

The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) and the associated flash lamp information shall indicate the applicable lamp(s) for the specific DTC. The lamp information for each specific DTC shall not convey temporary signals to provide for lamp test illumination or DTC flashout.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	163	
PDU Specific:	Destination Address	
Default Priority:	06	
Parameter Group Number:	41728 (00A300 ₁₆)	
Byte: 1	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8) See 5.7.1.9
Byte: 2	bits 8-1	SPN, second byte of SPN (most significant at bit 8) See 5.7.1.9
Byte: 3	bits 8-6	SPN, 3 most significant bits (most significant at bit 8) See 5.7.1.9
	bits 5-1	FMI (most significant at bit 5) See 5.7.1.10
Byte: 4	bit 8	SPN Conversion Method See 5.7.1.11
	bits 7-1	Occurrence Count See 5.7.1.12
Byte: 5	bits 8-7	DTCx Malfunction Indicator Lamp Support & Status See 5.7.31.1
	bits 6-5	DTCx Red Stop Lamp Support & Status See 5.7.31.2
	bits 4-3	DTCx Amber Warning Lamp Support & Status See 5.7.31.3
	bits 2-1	DTCx Protect Lamp Support & Status See 5.7.31.4
Byte: 6	bits 8-7	DTCx Flash Malfunction Indicator Lamp Support & Status See 5.7.31.5
	bits 6-5	DTCx Flash Red Stop Lamp Support & Status See 5.7.31.6
	bits 4-3	DTCx Flash Amber Warning Lamp Support & Status See 5.7.31.7
	bits 2-1	DTCx Flash Protect Lamp Support & Status See 5.7.31.8

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127.

TABLE 24: DTCX LAMP COMMAND AND LAMP FLASH DEPENDENCY DEFINITION (SAME AS TABLE 5)

Possible Commanded Conditions		Required Lamp Output Operation			
Lamp SPNs: 4113; 4114; 4115; 4116	Flash SPNs: 4117; 4118; 4119; 4120	DTCx MIL SPN 4113	DTCx RSL SPN 4114	DTCx AWL SPN 4115	DTCx Protect SPN 4116
00	00	Off, slow flash	Off	Off	Off
00	01	Off, fast flash	Off	Off	Off
00	10	Off, class C not active	SAE reserved	SAE reserved	SAE reserved
00	11	Off, don't flash	Off	Off	Off
01	00	On, slow flash	On, slow flash	On, slow flash	On, slow flash
01	01	On, fast flash	On, fast flash	On, fast flash	On, fast flash
01	10	Off, class C active	SAE reserved	SAE reserved	SAE reserved
01	11	On, don't flash	On, don't flash	On, don't flash	On, don't flash
10	00	Short MI not active	SAE reserved	SAE reserved	SAE reserved
10	01	Short MI active	SAE reserved	SAE reserved	SAE reserved
10	10	SAE reserved	SAE reserved	SAE reserved	SAE reserved
10	11	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	00	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	01	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	10	SAE reserved	SAE reserved	SAE reserved	SAE reserved
11	11	Don't Care	Don't Care	Don't Care	Don't Care

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

- a = SPN
- b = FMI
- c = CM and OC
- d = DTCx Malfunction Indicator Lamp Support & Status
- e = DTCx Red Stop Lamp Support & Status
- f = DTCx Amber Warning Lamp Support & Status
- g = DTCx Protect Lamp Support & Status
- h = DTCx Flash Malfunction Indicator Lamp Support & Status
- i = DTCx Flash Red Stop Lamp Support & Status
- J = DTCx Flash Amber Warning Lamp Support & Status
- K = DTCx Flash Protect Lamp Support & Status

Message form will be as follows: a,b,c,d,e,f,g,h,i,j,k, a,b,c,d,e,f,g,h,i,j,k, a,b,c,d,e,f,g,h,i,j,k, a,b,c,d,e,f,g,h,i,j,k,....etc. In this example, the transport protocol of SAE J1939-21 will have to be used to send the information because it requires more than 8 data bytes.

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EXAMPLE 2: The following illustrates the message format for when a request of the DM31 is made and there are zero DTCs to report.

Required Response:

Byte 1-4	SPN	= 0
	FMI	= 0
	OC	= 0
	CM	= 0
Byte 5	bits 8-7	= 00
	bits 6-5	= 00
	bits 4-3	= 00
	bits 2-1	= 00
Byte 6		= 255
Byte 7		= 255
Byte 8		= 255

5.7.31.1 DTCx Malfunction Indicator Lamp Support & Status

This parameter indicates the support and status of the Malfunction Indicator Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx Flash MIL Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, short MIL active, short MIL not active, etc.)

If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00, 01, or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

00	Lamp Off
01	Lamp On
10	Short MI
11	Unavailable
Type:	Status
Suspect Parameter Number:	4113
Reference:	5.7.31

5.7.31.2 DTCx Red Stop Lamp Support & Status

This parameter indicates the support and status of the Red Stop Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx Flash Red Stop Lamp Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, etc.)

If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00, 01, or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

00	Lamp Off
01	Lamp On
10	Reserved for SAE Assignment
11	Unavailable
Type:	Status
Suspect Parameter Number:	4114
Reference:	5.7.31

5.7.31.3 DTCx Amber Warning Lamp Support & Status

This parameter indicates the support and status of the Amber Warning Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx Flash Amber Warning Lamp Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, etc.)

If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00, 01, or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

00	Lamp Off
01	Lamp On
10	Reserved for SAE Assignment
11	Unavailable
Type:	Status
Suspect Parameter Number:	4115
Reference:	5.7.31

5.7.31.4 DTCx Protect Lamp Support & Status

This parameter indicates the support and status of the Protect Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx Flash Protect Lamp Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, etc.)

If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00, 01, or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

00	Lamp Off
01	Lamp On
10	Reserved for SAE Assignment
11	Unavailable
Type:	Status
Suspect Parameter Number:	4116
Reference:	5.7.31

5.7.31.5 DTCx Flash Malfunction Indicator Lamp Support & Status

This parameter indicates the support and status of the Flash MIL Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx MIL Command Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, short MIL active, short MIL not active, etc.)

If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00, 01, or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

This parameter provides the capability to flash the MIL.

00	Slow Flash (1 Hz, 50% duty cycle)
01	Fast Flash (2 Hz or faster, 50% duty cycle)
10	Class C DTC (for WWH OBD discriminatory display systems, not applicable for other OBD non-discriminatory display systems)

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11 Unavailable / Do Not Flash
Type: Status
Suspect Parameter Number: 4117
Reference: 5.7.31

5.7.31.6 DTCx Flash Red Stop Lamp Support & Status

This parameter indicates the support and status of the Flash Red Stop Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx Red Stop Lamp Command Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, etc.)

If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00 or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

00 Slow Flash (1 Hz, 50% duty cycle)
01 Fast Flash (2 Hz or faster, 50% duty cycle)
10 SAE Reserved
11 Unavailable / Do Not Flash
Type: Status
Suspect Parameter Number: 4118
Reference: 5.7.31

5.7.31.7 DTCx Flash Amber Warning Lamp Support & Status

This parameter indicates the support and status of the Flash Amber Warning Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx Amber Warning Lamp Command Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, etc.)

If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00 or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

00 Slow Flash (1 Hz, 50% duty cycle)
01 Fast Flash (2 Hz or faster, 50% duty cycle)
10 SAE Reserved
11 Unavailable / Do Not Flash
Type: Status
Suspect Parameter Number: 4119
Reference: 5.7.31

5.7.31.8 DTCx Flash Protect Lamp Support & Status

This parameter indicates the support and status of the Flash Protect Lamp as it pertains to the specific DTCx. This parameter in combination with DTCx Protect Lamp Command Support & Status provides two separate pieces of information. See Table 24. One is whether this parameter pertains to the specific DTC. If it does pertain to the specific DTC then the value indicates whether the lamp operation that is applicable for the DTCx (i.e. currently off, on, on and slow flash, on and fast flash, etc.)

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If this lamp is applicable to the associated specific DTC then the value for this parameter shall convey the current state for this DTC (i.e. 00 or 10). If this lamp is not applicable to the currently active DTC then value shall be reported as Unavailable (i.e. 11). None, one, or more than one of lamps may be associated with each specific DTC.

00	Slow Flash (1 Hz, 50% duty cycle)
01	Fast Flash (2 Hz or faster, 50% duty cycle)
10	SAE Reserved
11	Unavailable / Do Not Flash
Type:	Status
Suspect Parameter Number:	4120
Reference:	5.7.31

5.7.32 (R)Regulated Exhaust Emission Level Exceedance (DM32)

DM32 provides the DTCs and associated timers related to a regulated exhaust emission level exceedance due to an emission control system malfunction. The DTCs that are reported may be active or previously active. For example DM32 can be used to provide the DTCs and associated timers related to regulated exhaust NOx emission level exceedance due to an emission control system malfunction as is required with European heavy duty OBD. Those reported shall include active or previously active DTCs.

Transmission Rate:	On Request	
	If requested, A NACK is required if PG is not supported	
	(See SAE J1939-21 PGNs 59904 and 59392)	
Data Length:	variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	162	
PDU Specific:	Destination Address	
Default Priority:	6	
Parameter Group Number:	41472 (00A200 ₁₆)	
Byte: 1	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8) See 5.7.1.9
Byte: 2	bits 8-1	SPN, second byte of SPN (most significant at bit 8) See 5.7.1.9
Byte: 3	bits 8-6	SPN, 3 most significant bits (most significant at bit 8) See 5.7.1.9
	bits 5-1	FMI (most significant at bit 5) See 5.7.1.10
Byte: 4-5		DTCx Total ActiveTime See 5.7.32.1
Byte: 6-7		DTCx Total Previously Active Time See 5.7.32.2
Byte: 8		DTCx Time Until Derate See 5.7.32.3
Byte: 9-n		repeat pattern for bytes 1-8 see example.

EXAMPLE 1: The following illustrates the message format for multiple regulated exhaust emission exceedance DTCs with their timers.

Given:

a= SPN
b= FMI
c= DTCx Total ActiveTime
d= DTCx Total Previously Active Time
e= DTCx Time Until Derate

Bytes 1-8 in the DM32 definition establish the pattern for tokens a, b, c, d, and e. This pattern is repeated as many times as is necessary to report the NOx exceedance DTC and the associated timers that the system supports. Ten DTCs will result in a data length of 80 bytes and appear as abcde abcde abcde abcde abcde abcde abcde abcde abcde abcde in the reply. This message will be sent with J1939-21 defined transport protocol for any system reporting 2 or more NOx exceedance DTCs.

5.7.32.1 DTCx Total ActiveTime

This timer provides the total number of hours the DTCx has been confirmed and active. This is the cumulative time so if the DTCx goes inactive and then confirmed and active again then it must continue to count from its previous value. The timer value is allowed to be erased after 400 days or 9600 hour of operation with the associated DTC being previously active during that period. Each timer is preceded in the data by a DTC (SPN + FMI) with which it is associated.

Data Length:	2 bytes
Resolution:	0.2 hr/bit, 0 offset
Data Range:	0 to 12851 hr Operational Range: same as data range
Type:	Measured
Suspect Parameter Number:	4121
Reference:	5.7.32

5.7.32.2 DTCx Total Previously Active Time

This timer provides the number of hours the NOx malfunction has been confirmed and previously active. This is the cumulative time during the 400 days or 9600 hours of operation. Each timer is preceded in the data by the DTC (SPN + FMI) with which it is associated.

Data Length:	2 bytes
Resolution:	0.2 hr/bit, 0 offset
Data Range:	0 to 12851 hr Operational Range: same as data range
Type:	Measured
Suspect Parameter Number:	4122
Reference:	5.7.32

5.7.32.3 DTCx Time Until Derate

This timer provides the number of hours the malfunction has until the OBD required derate will occur. Each timer is preceded in the data by a DTC (SPN + FMI) with which it is associated. If the specific DTC is not required by the applicable OBD regulation to have a torque derate then this parameter shall be sent as "not available". If the DTC is currently previously active then the count shall be sent as 62.5 hours. When the counter reaches zero it shall remain at zero while the malfunction is active.

Data Length:	1 byte
Resolution:	0.25 hr/bit, 0 offset
Data Range:	0 to 62.5 hr Operational Range: same as data range
Type:	Measured
Suspect Parameter Number:	4123
Reference:	5.7.32

5.7.33 (R)Emission Increasing Auxiliary Emission Control Device Active Time (DM33)

The total engine run time while each of the Emission Increasing Auxiliary Emission Control Devices (EI-AECDs) is active. This service can support up to 198 EI-AECDs (due to TP data limits). EI-AECDs with variable actions or degrees of action, two separate engine run time totals shall be reported - one timer for total active time when commanding up to, but not including, 75% reduction of the maximum emissions control effectiveness and one timer for total active time when commanding 75% or more reduction of the maximum emissions control effectiveness. EI-AECDs with single actions, only one timer shall be kept to total the active time.

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Transmission Rate: On request using PGN 59904 (See SAE J1939-21)
Data Length: Variable
Extended Data Page: 0
Data page: 0
PDU Format: 161
PDU Specific: Destination Address
Default Priority: 6
Parameter Group Number: 41216 (00A100₁₆)

<i>Start Position</i>	<i>Length</i>	<i>Parameter Name</i>	<i>SPN</i>
1	1 byte	El-AECD Number	See 5.7.33.1
2-5	4 byte	El-AECD Engine Hours Timer 1	See 5.7.33.2
6-9	4 byte	AECD Engine Hours Timer 2	See 5.7.33.3

EXAMPLE 1—The following illustrates the message format when there are more than one El-AECDs supported by the ECU

Given:

a= El-AECD Number
b= El-AECD Engine Hours Timer 1
c= AECD Engine Hours Timer 2

Message form is as follows: a,b,c, a,b,c, a,b,c, a,b,c....etc.

5.7.33.1 El-AECD Number

The manufacturer assigned number for the specific El-AECD.

Data Length: 1 byte
Resolution: 1 /bit , 0 offset
Data Range: 0 to 250
Type: Status
Suspect Parameter Number: 4124
Reference: 5.7.33

5.7.33.2 El-AECD Engine Hours Timer 1

The total engine running hours recorded in the first timer for the El-AECD. For El-AECDs requiring only a single timer, Timer 1 shall be used to report the total engine hours for the El-AECD. For El-AECDs requiring two timer, Timer 1 shall report the total engine hours when the El-AECD is commanding reduced emission control effectiveness up to but not including 75 percent of the maximum reduced emission control effectiveness.

NOTE: If the timer for any of the El-AECDs has reached the maximum data range, the timer values for all El-AECDs shall be divided by two to avoid overflow problems.

Data Length: 4 bytes
Resolution: 1 minute/bit, 0 minutes offset
Data Range: 0 to 4,211,081,215 minutes
Type: Measured
Suspect Parameter Number: 4125
Reference: 5.7.33

5.7.33.3 AECD Engine Hours Timer 2

The total engine running hours for the second timer for the El-AECD. For El-AECDs requiring only a single timer, Timer 2 shall be reported as "Not Available" For El-AECDs requiring two timer, Timer 2 shall report the total engine hours when

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the EI-AECD is commanding reduced emission control effectiveness of 75 percent or more of the maximum reduced emission control effectiveness.

NOTE: If the timer for any of the EI-AECDs has reached the maximum data range, the timer values for all EI-AECDs shall be divided by two to avoid overflow problems.

Data Length: 4 bytes
Resolution: 1 minute/bit, 0 minutes offset
Data Range: 0 to 4,211,081,215 minutes
Type: Measured
Suspect Parameter Number: 4126
Reference: 5.7.33

5.7.34 (R)NTE Status (DM34)

The status of engine operating in the NTE control areas for given pollutants, such as NO_x and PM. The operating status includes outside the NTE control area, inside the NTE control area, inside the manufacturer-specific NTE carve-out area, and the deficiency active area.

Transmission Rate: On request using PGN 59904 (See SAE J1939-21)
Data Length: Variable
Extended Data Page: 0
Data page: 0
PDU Format: 160
PDU Specific: Destination Address
Default Priority: 6
Parameter Group Number: 40960 (00A000₁₆)

<i>Start Position</i>	<i>Length</i>	<i>Parameter Name</i>	<i>SPN</i>
1.7	2 bits	NO _x NTE Control Area Status	See 5.7.34.1
1.5	2 bits	Manufacturer-specific NO _x NTE Carve-out Area Status	See 5.7.34.2
1.3	2 bits	NO _x NTE Deficiency Area Status	See 5.7.34.3
1.1	2 bits	Reserved (set to 11)	
2.7	2 bits	PM NTE Control Area Status	See 5.7.34.4
2.5	2 bits	Manufacturer-specific PM NTE Carve-out Area Status	See 5.7.34.5
2.3	2 bits	PM NTE Deficiency Area Status	See 5.7.34.6
2.1	2 bits	Reserved (set to 11)	
3-8	6 bits	Reserved for SAE Assignment	

5.7.34.1 NO_x NTE Control Area Status

Status of engine operation within the bounded region of the engine's torque and speed map where emissions must not exceed a specific emission cap for NO_x under the NTE requirement.

00 - Outside Control Area
01 - Inside Control Area
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range:same as data range
Type: Status
Suspect Parameter Number: 4127
Reference: 5.7.34

5.7.34.2 Manufacturer-specific NOx NTE Carve-out Area Status

Status of engine operation within the manufacturer specific NOx NTE carve out area. The manufacturer specific NOx NTE carve-out area is defined as bounded regions within the NTE control area for NOx where the manufacturer has limited NTE testing. If the application does not have a manufacturer specific NOx NTE carve-out area, then the application shall report "Not Available". If supported and the engine is operating outside of the NOx NTE Control Area (SPN YY1), then this status shall be reported as "Outside Area".

00 - Outside Area
01 - Inside Area
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range:same as data range
Type: Status
Suspect Parameter Number: 4128
Reference: 5.7.34

5.7.34.3 NOx NTE Deficiency Area Status

Status of engine operation within the NOx NTE Deficiency Area. The NOx NTE Deficiency Area is defined as bounded regions or conditions within the NTE control area for NOx where the manufacturer has received a deficiency. If the application does not have, then the application shall report "Not Available". If supported and the engine is operating outside of the NOx NTE Control Area (SPN YY1), then this status shall be reported as "Outside Area".

00 - Outside Area
01 - Inside Area
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range:same as data range
Type: Status
Suspect Parameter Number: 4129
Reference: 5.7.34

5.7.34.4 PM NTE Control Area Status

Status of engine operation within the bounded region of the engine's torque and speed map where emissions must not exceed a specific emission cap for PM under the NTE requirement.

00 - Outside Control Area
01 - Inside Control Area
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range:same as data range
Type: Status
Suspect Parameter Number: 4130
Reference: 5.7.34

5.7.34.5 Manufacturer-specific PM NTE Carve-out Area Status

Status of engine operation within the manufacturer specific PM NTE carve out area. The manufacturer specific PM NTE carve-out area is defined as bounded regions within the NTE control area for PM where the manufacturer has limited NTE testing. If the application does not have a manufacturer specific PM NTE carve-out area, then the application shall report "Not Available". If supported and the engine is operating outside of the PM NTE Control Area (SPN YY4), then this status shall be reported as "Outside Area".

00 - Outside Area
01 - Inside Area
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range:same as data range
Type: Status
Suspect Parameter Number: 4131
Reference: 5.7.34

5.7.34.6 PM NTE Deficiency Area Status

Status of engine operation within the PM NTE Deficiency Area. The PM NTE Deficiency Area is defined as bounded regions or conditions within the NTE control area for PM where the manufacturer has received a deficiency. If the application does not have, then the application shall report "Not Available". If supported and the engine is operating outside of the PM NTE Control Area (SPN YY1), then this status shall be reported as "Outside Area".

00 - Outside Area
01 - Inside Area
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range:same as data range
Type: Status
Suspect Parameter Number: 4132
Reference:5.7.34

5.7.35 (R)Immediate Fault Status (DM35)

The purpose of this DM is to enable the external test equipment to obtain the instantaneous status of diagnostic results. (This status is reported using the DTCs that are associated with each of the diagnostic algorithms.) DM35 is similar to DM1 and DM27. Whereas DM27 latches the pending state for 2 drive cycles and DM1 may latch the active state for 3 drive cycles with OBD, DM35 does not latch on and DTCs can be removed from the list as required.

The intended use of this data is for troubleshooting intermittent wiring problems. For example, it can be used to report the information from a "wobble test" mode where the purpose is to find wiring hardness problems by pulling on wires and/or components.

Reporting the Immediate DTCs is done using the same format as is used to report active DTCs.

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The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flash out.

See APPENDIX H for how this diagnostic messages relates to other diagnostic messages that convey various kinds of DTCs.

Transmission Rate: On request using PGN 59904 See SAE J1939-21
A NACK is required if PG is not supported (see SAE J1939-21 PGN 59392)

- a) Unlike DM1, this service is by request only.
- b) Once requested, this service should continue to transmit until key-off.
- c) Once requested, this service should be transmitted whenever there is a change of status in this DTC list.
- d) Message intervals should not be more frequent than 250ms.
- e) Optionally, this service may transmit a message every second in addition to or in lieu of transmitting on each status change.
- f) Optionally, the service may begin or terminate transmission in response to a DM7 "Command Non-continuously Monitored Test" message.
- g) In the case where an ECU only transmits on change of state, a service tool may optionally request the message every few seconds as required.

Data Length:	Variable
Extended Data Page:	0
Data page:	0
PDU Format:	159
PDU Specific:	Destination Address
Default Priority:	6
Parameter Group Number:	40704(009F00 ₁₆)

Byte: 1	bits 8-7	Malfunction Indicator Lamp Status	See 5.7.1.1
	bits 6-5	Red Stop Lamp Status	See 5.7.1.2
	bits 4-3	Amber Warning Lamp Status	See 5.7.1.3
	bits 2-1	Protect Lamp Status	See 5.7.1.4
Byte: 2	bits 8-7	Flash Malfunction Indicator Lamp	See 5.7.1.5
	bits 6-5	Flash Red Stop Lamp	See 5.7.1.6
	bits 4-3	Flash Amber Warning Lamp	See 5.7.1.7
	bits 2-1	Flash Protect Lamp	See 5.7.1.8
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 5	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
	bits 5-1	FMI (most significant at bit 5)	See 5.7.1.10
Bytes: 6	bit 8	SPN Conversion Method	See 5.7.1.11
	bits 7-1	Occurrence Count	See 5.7.1.12

NOTES

- a) When the occurrence count is not available it should be set to all ones.
- b) Unlike DM1, this service is by request only.
- c) The message format will follow that of DM1/DM2/DM6/DM27, etc, in that the lamps bits will be the current status of lamps. (ie. Lamp bits in DM35 will be numerically the same value as that in DM1).

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5.7.36 (R)Harmonized Roadworthiness - Vehicle (DM36 - HRWV)

HRWV provides the aggregated roadworthiness from the VOBD (Vehicle On-Board Diagnostics) to a scan tool or similar inquiry device. The VOBD function aggregates HRWS messages from individual subsystems or components, summing the number of components or subsystems that are not roadworthy and summing the number of incomplete critical diagnostics. Vehicle Non-Roadworthy Component Count counts the number of components that declare their (sub-) system to not be roadworthy. VOBD functions and processes are described in J1939-03

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported	
	(See SAE J1939-21 PGN 59392)	
Data Length:	8	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	100	
Default Priority:	6	
Parameter Group Number:	64868 (00FD64 ₁₆)	
Byte: 1	Vehicle Non-Roadworthy Component Count	See 5.7.36.1
Byte: 2	bits 8-7 Vehicle Continuous Malfunction Indicator	See 5.7.36.2
2	bits 6-5 Vehicle Malfunction Indicator Display Strategy	See 5.7.36.3
2	bits 4-1 Vehicle Malfunction Indicator Activation Mode	See 5.7.36.4
Bytes: 3-4	Vehicle Incomplete Monitor Count	See 5.7.36.5
Bytes: 5-6	Vehicle Current MI Accumulated Time	See 5.7.36.6
Bytes 6-8	Reserved (pad with 0xFF)	

Note: This construction for HRWV is intended to support future high speed interrogation of the vehicle where timing constraints may not support the use of the transfer PGN to provide a list of individual answers, without requiring the high speed gateway device to act as a cache for all individual subsystems and act as the VOBD function. This will likely require the VOBD function to retain a record of HRWS receipts in order to aggregate them correctly. Ongoing schemes to increment or decrement Vehicle Non-Roadworthy Component Count or Vehicle Incomplete Monitor Count will be difficult to develop, and would likely require a periodic re-initialization to insure accurate counts.

5.7.36.1 Vehicle Non-Roadworthy Component Count

Vehicle Non-Roadworthy Component Count provides the sum of the (sub-) system or component non-roadworthiness counts. (See 5.7.37.1.) If the sum of all the counts is greater than 250, the value 250 shall be reported.

Data Length:	1 byte
Resolution:	1 count / bit 0 offset
Data Range:	0 to 250 counts Operational Range: same as data range
Type:	Status
Suspect Parameter Number:	4133
Reference:	5.7.36

5.7.36.2 Vehicle Continuous Malfunction Indicator

Vehicle Continuous Malfunction Indicator indicates that one or more (sub-) systems or components requires that the Malfunction Indicator (MI) to be steady burning.

00	Vehicle MI is not continuous
01	Vehicle MI is continuous
10	Reserved
11	Not available/Not required of this vehicle.
Data Length:	2 bits
Resolution:	4 states/2 bit, 0 offset
Data Range:	0 to 3 Operational Range: same as data range
Type:	Status
Suspect Parameter Number:	4134

Reference: 5.7.36

5.7.36.3 Vehicle Malfunction Indicator Display Strategy

Vehicle Malfunction Indicator Display Strategy indicates if any system is configured to employ a discriminatory MI display. The value 0b00 indicates that all systems employ a non-discriminatory MI display.

00 – All systems employ a non-discriminatory MI display
01 – Some system employs a discriminatory MI display
10 – Reserved
11 – Not available/Not required of this vehicle.
Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status
Suspect Parameter Number: 4135
Reference: 5.7.36

5.7.36.4 Vehicle Malfunction Indicator Activation Mode

The Vehicle Malfunction Indicator Status provides the most severe form of MI display required by the failure status of any sub-system or component. For the enumeration shown, the MI Activation Mode is ordered from least severe to most severe. MI Activation Mode 1 indicates no malfunctions.

0000 – MI Activation Mode 1 (Off)
0001 – MI Activation Mode 2 (On Demand MI)
0010 – MI Activation Mode 3 (Short MI)
0011 – MI Activation Mode 4 (Continuous MI)
0100 – 1101 Reserved
1110 – Error
1111 – Not available/Not required of this system.
Data Length: 4 bits
Resolution: 16 states/4 bit, 0 offset
Data Range: 0 to 15 Operational Range: same as data range
Type: Status
Suspect Parameter Number: 4136
Reference: 5.7.36

Note: MI Activation Mode 1 affirms that there are no malfunctions. No malfunction is consistent with the use of 0000. The term, 'Mode 1' is used to match the GTR regulation text.

5.7.36.5 Vehicle Incomplete Monitor Count

Vehicle Incomplete Monitor Count provides the number of incomplete diagnostic monitors for a given sub-system or component. A count of zero means that all monitors are complete and the vehicle is "ready" for inspection. If the sum exceeds 64 512 counts, then the value 64 512 shall be reported.

Data Length: 2 byte
Resolution: 1 count / bit, 0 offset
Data Range: 0 to 64 255 counts Operational Range: same as data range
Type: Status
Suspect Parameter Number: 4137
Reference: 5.7.36

5.7.36.6 Vehicle Current MI Accumulated Time

Vehicle Current MI Accumulated Time reports the accumulated count (in minutes) that the MIL is activated (on) for the current MI activation (or the last MI activation). Conditions include: Reset to 0x0000 when MIL state changes from deactivated to activated by a (sub-) system or component. Accumulate counts in minutes if MIL is activated (ON) -- do not change value while MIL is not activated (OFF); Do not wrap to 0x0000 if value is 64 511. This number should be the

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largest value of SPN 3144, Minutes Run by Engine While MIL is Activated, available from all applicable (sub-) systems or components, when no components demand the MI to light. SPN 3144 is contained in DM21.

Data Length: 2 bytes
Resolution: 1 min., 0 min. offset
Data Range: 0 to 64 255 min. Operational Range: same as data range
Type: Measured
Suspect Parameter Number: 4138
Reference: 5.7.36

5.7.37 (R)Harmonized Roadworthiness – System (DM37 - HRWS)

HRWS reports subsystem (or component) roadworthiness to the VOBD function to aggregate in the HRWV message (See 5.7.36). The VOBD function aggregates HRWS messages from individual components summing the number of components or subsystems that are not roadworthy and summing the number of incomplete critical diagnostics. This collaboration process is discussed in J1939-03.

Transmission Rate: 0.1 Hz or On Change but no greater than 1 Hz
If requested, A NACK is required if PG is not supported
(See SAE J1939-21 PGNs 59904 and 59392)
Data Length: 8
Extended Data Page: 0
Data page: 0
PDU Format: 253
PDU Specific: 99
Default Priority: 6
Parameter Group Number: 64867 (00FD63₁₆)

Byte: 1		System Non-Roadworthy Component Count	See 5.7.37.1
Byte: 2	bits 8-7	System Continuous Malfunction Indicator	See 5.7.37.2
	2 bits 6-5	System Malfunction Indicator Display Strategy	See 5.7.37.3
	2 bits 4-1	System Malfunction Indicator Activation Mode	See 5.7.37.4
Bytes: 3-4		System Incomplete Monitor Count	See 5.7.37.5
Bytes: 5-8		Reserved (pad with 0xFF)	

5.7.37.1 System Non-Roadworthy Component Count

System Non-Roadworthy Component Count provides the number of components (or sub-sub-systems) that a (sub-) system has determined are not roadworthy. Sub-systems or components that provide System Continuous Malfunction Indicator Status shall provide a minimum count of one, when they report their System Continuous Malfunction Indicator (See 5.7.37.2) as 0b01, System MI is continuous. If the calculated count for a sub-system is greater than 250, the value 250 shall be reported.

Data Length: 1 byte
Resolution: 1 count / bit 0 offset
Data Range: 0 to 250 counts Operational Range: same as data range
Type: Status
Suspect Parameter Number: 4139
Reference: 5.7.37

5.7.37.2 System Continuous Malfunction Indicator

System Continuous Malfunction Indicator indicates that the system requires its (or the emissions malfunction indicator) to be steady burning.

00 – System MI is not continuous
01 – System MI is continuous
10 – Reserved

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11 – Not available/Not required of this system.

Data Length: 2 bits

Resolution: 4 states/2 bit, 0 offset

Data Range: 0 to 3 Operational Range: same as data range

Type: Status

Suspect Parameter Number: 4140

Reference: 5.7.37

5.7.37.3 System Malfunction Indicator Display Strategy

System Malfunction Indicator Display Strategy indicates whether the system uses a non-discriminatory MI display or a discriminatory MI display as permitted by local regulations.

00 – System employs a non-discriminatory MI display

01 – System employs a discriminatory MI display

10 – Reserved

11 – Not available/Not required of this system.

Data Length: 2 bits

Resolution: 4 states/2 bit, 0 offset

Data Range: 0 to 3 Operational Range: same as data range

Type: Status

Suspect Parameter Number: 4141

Reference: 5.7.37

5.7.37.4 System Malfunction Indicator Activation Mode

The System Malfunction Indicator Status provides the form of MI display required by the failure status of the sub-system or component. For the enumeration shown, the MI Activation Mode is ordered from least severe to most severe. MI Activation Mode 1 indicates no malfunctions.

0000 – MI Activation Mode 1 (MI Off)

0001 – MI Activation Mode 2 (On Demand MI)

0010 – MI Activation Mode 3 (Short MI)

0011 – MI Activation Mode 4 (Continuous MI)

0100 – 1101 Reserved

1110 – Error

1111 – Not available/Not required of this system.

Data Length: 4 bits

Resolution: 16 states/4 bit, 0 offset

Data Range: 0 to 15 Operational Range: same as data range

Type: Status

Suspect Parameter Number: 4142

Reference: 5.7.37

Note: MI Activation Mode 1 affirms that there are no malfunctions. No malfunction is consistent with the use of 0000. The term Mode 1 is used to match the GTR regulation text.

5.7.37.5 System Incomplete Monitor Count

System Incomplete Monitor Count provides the number of incomplete diagnostic monitors for a given sub-system or component. A count of zero means that all monitors are complete and the vehicle is “ready” for inspection.

Data Length: 2 byte

Resolution: 1 count / bit 0 offset

Data Range: 0 to 64 512 counts

Type: Status

Suspect Parameter Number: 4143

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Reference: 5.7.37

5.7.38 (R)Harmonized Global Regulation Description (DM38 - HGRD)

HGRD provides a description of the UN/ECE WWH OBD Global Technical Regulation (GTR) to which the sub-system or component complies. The description may include the identification of any local regulation amending or tailoring GTR content to the region.

Transmission Rate:	On request using PGN 59904 A NACK is required if PG is not supported (See SAE J1939-21 PGN 59392)	See SAE J1939-21
Data Length:	variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	98	
Default Priority:	6	
Parameter Group Number:	64866 (00FD62 ₁₆)	
Byte: 1-n	Global Technical Regulation Description	See 5.7.38.1

5.7.38.1 Global Technical Regulation Description

Global Technical Regulation Description provides a textual description of the Global Technical Regulations to which the sub-system or component complies. Individual components may comply with different regulations. See J1939-03 regarding reporting descriptions for multiple components.

Data Length:	Variable - up to 200 characters (May be "" delimited)
Resolution:	ASCII, 0 offset
Data Range:	0 to 127 per byteOperational Range: same as data range
Type:	Status
Suspect Parameter Number:	4144
Reference:	5.7.38

NOTE - The ASCII character "" is reserved as a delimiter in similar SPNs – it may only be used in descriptions to delimit specific regulation references. Data range is restricted to 0-127 in harmony with the definition of character data in ISO PAS 27145-2. See J1939-71's application of the ISO Latin 1 character set for more information.

This information is not anticipated to be provided as a part of any high speed sorting of vehicles for inspection and enforcement. It may be provided using the transfer PGN through a gateway.

5.7.39 (R)Cumulative Continuous MI – System (DM39 - HCMI)

HCMI provides the system specific cumulative.

Transmission Rate:	On Request If requested, A NACK is required if PG is not supported (See SAE J1939-21 PGNs 59904 and 59392)	
Data Length:	8	
Extended Data Page:	0	
Data page:	0	
PDU Format:	253	
PDU Specific:	97	
Default Priority:	6	
Parameter Group Number:	64865 (00FD61 ₁₆)	
Byte: 1-4	System Cumulative Continuous MI Time	See 5.7.39.1
Byte: 5-6	System Greatest B1 Counter	See 5.7.39.2
Byte: 7-8	Reserved (pad with 0xFF)	

5.7.39.1 System Cumulative Continuous MI Time

System Cumulative Continuous MI Time provides the total amount of time that the MI has been demanded to be illuminated during the life of the (sub-) system or component.

Data Length:	4 bytes
Resolution:	0.05 hr/bit, 0 offset
Data Range:	0 to 210 554 060.75 hr Operational Range: same as data range
Type:	Measured
Suspect Parameter Number:	4145
Reference:	5.7.39

Note: a vehicle-centric view of this parameter is not indicated by GTR Module B, 4.7.1.2 Module B, 4.7.1 has been interpreted to indicate a vehicle centric view for the current MI counter as provided by HRWV. DM21 defines the current MI counter.

5.7.39.2 System Greatest B1 Counter

System Greatest B1 Counter provides the total amount of time that one or more B1 DTCs have been active. ..

Data Length:	2 bytes
Resolution:	0.1 hr/bit, 0 offset
Data Range:	0 to 6 425.5 hr Operational Range: same as data range
Type:	Measured
Suspect Parameter Number:	4146
Reference:	5.7.39

5.7.40 (R)Harmonized B1 Failure Counts (DM40 - HB1C)

HB1C provides the system specific individual B1 failure counters, when supported by the system.

Transmission Rate:	On Request If requested, A NACK is required if PG is not supported (See SAE J1939-21 PGNs 59904 and 59392)		
Data Length:	variable		
Extended Data Page:	0		
Data page:	0		
PDU Format:	253		
PDU Specific:	96		
Default Priority:	6		
Parameter Group Number:	64864 (00FD60 ₁₆)		
Byte: 1	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 2	bits 8-1	SPN, second byte of SPN (most significant at bit 8)	See 5.7.1.9
Byte: 3	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)	See 5.7.1.9
	bits 5-1	FMI (most significant at bit 5)	See 5.7.1.10
Byte: 4-5		Failure Specific B1 Counter	See 5.7.40.1
Byte: 6-n		repeat pattern for bytes 1-5 see example.	

EXAMPLE 1: The following illustrates the message format for multiple B1 counters.

Given:

a=SPN
b=FMI
c=Failure Specific B1 Counter

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Bytes 1-5 above establish the pattern for tokens a, b, and c. This pattern is repeated as many times as is necessary to report the Failure Specific B1 Counters that the system supports. Ten counters will result in a data length of 50 bytes and appear as abc abc abc abc abc abc abc abc abc abc in the reply. This message will be broadcast with transport protocol for any system supporting 2 or more B1 failure counters.

5.7.40.1 Failure Specific B1 Counter

The Failure Specific B1 Counter provides an individual B1 counter, supported by the system. The counter provides the number of hours the B1 failure has been confirmed and active. Each counter is preceded in the data by a class B1 failure DTC (SPN + FMI) with which it is associated.

Data Length:	2 bytes
Resolution:	0.1 hr/bit, 0 offset
Data Range:	0 to 6 425.5 hr Operational Range: same as data range
Type:	Measured
Suspect Parameter Number:	4147
Reference:	5.7.40

5.7.41 (R)A, Pending (DM41) (as part of Harmonized Failure Classification DTC Reporting)

Failures are partitioned by severity in harmonized regulations into classifications A, B1, B2, and C. Failures in each of these categories are further classified as pending, confirmed and active, and confirmed and previously active. This creates a cross product of twelve composite categories. Table 25 below shows the messages defined used to communicate individual composite categories. Table 26 assigns the PGNs to be used. The PGNs for DM6, DM12 and DM23 are previously provided in other sections and are not repeated in Table 25. Each composite category uses the same structure for reporting a list of DTCs. This structure is shared with DM1, DM2, DM6, DM12, and DM23.

For backwards compatibility faults reported using DMx1 – DMxC should also be reported using DM6, DM12, and DM23. DM6 would provide the pending DTCs for all classes A, B1, B2, and C. DM12 would provide all confirmed and active DTCs in classes A, B1, B2, and C. Finally, DM23 would provide all confirmed and previously active DTCs in classes A, B1, B2, and C. This construction assumes that an engine or vehicle will not simultaneously comply with both UN/ECE WWH OBD GTR and California Air Resources Board HD OBD or OBD II regulations.

5.7.41.1 Harmonized Failure Classification DTC Reporting Messages

Table 25 displays the 12 messages used to convey DTCs by WWH OBD severity class and status.

TABLE 25– FAULT REPORTING MESSAGES BY STATUS AND SEVERITY CLASS

Status / Severity Class	Class A	Class B1	Class B2	Class C	<i>All</i>
Pending	DM41	DM44	DM47	DM50	DM6
Confirmed & Active	DM42	DM45	DM48	DM51	DM12
Previously Active	DM43	DM46	DM49	DM52	DM23

Table 26 assigns PGNs to the messages displaying their PF and PS field values. All the PGNs are in Data Page 0 and Extended Data Page 0 as described in J1939-21.

TABLE 26 PGN ASSIGNMENTS FOR HARMONIZED FAILURE REPORTING

Message	PGN	PGN ₁₆	PF	PS	Severity Class / Status
DM41	6486 3	00FD5F	253	95	A, Pending
DM42	6486 2	00FD5E	253	94	A, Confirmed and Active
DM43	6486 1	00FD5D	253	93	A, Previously Active
DM44	6486 0	00FD5C	253	92	B1, Pending
DM45	6485 9	00FD5B	253	91	B1, Confirmed and Active
DM46	6485 8	00FD5A	253	90	B1, Previously Active
DM47	6485 7	00FD59	253	89	B2, Pending
DM48	6485 6	00FD58	253	88	B2, Confirmed and Active
DM49	6485 5	00FD57	253	87	B2, Previously Active
DM50	6485 4	00FD56	253	86	C, Pending
DM51	6485 3	00FD55	253	85	C, Confirmed and Active
DM52	6485 2	00FD54	253	84	C, Previously Active

5.7.41.2 Harmonized Failure Classification DTC Reporting Message Format

Reporting the Harmonized Failure Classification DTC Reporting Messages is done using the same format as is used to report DM6, DM12, DM23, DM1 and DM2. The lamp information (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. The lamp information shall not convey temporary signals to provide for lamp test illumination or DTC flash out.

Transmission Rate:	On request using PGN 59904	See SAE J1939-21
	A NACK is required if PG is not supported (See SAE J1939-21 PGN 59392)	
Data Length:	Variable	
Extended Data Page:	0	
Data page:	0	
PDU Format:	See Table 26	
PDU Specific:	See Table 26	
Default Priority:	6	
Parameter Group Number:	See Table 26	
Byte: 1	bits 8-7	Malfunction Indicator Lamp Status
	bits 6-5	Red Stop Lamp Status
	bits 4-3	Amber Warning Lamp Status
	bits 2-1	Protect Lamp Status
Byte: 2	bits 8-7	Flash Malfunction Indicator
	bits 6-5	Flash Red Stop Lamp
	bits 4-3	Flash Amber Warning Lamp
	bits 2-1	Flash Protect Lamp
Byte: 3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)
Byte: 4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)
Byte: 5	bits 8-6	SPN, 3 most significant bits (most significant at bit 8)
	bits 5-1	FMI (most significant at bit 5)
Byte: 6	bit 8	SPN Conversion Method
	bits 7-1	Occurrence Count

NOTE: When the occurrence count is not available it should be set to all ones which is a value of 127. The method for providing the SPN shown above matches the figure for version 4 in the definition for SPN 1706. The version 4 method is the only method to be used for reporting SPNs in DTCs for OBD II, HD OBD, and UN/ECE WWH OBD GTR.

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The following two examples illustrate special cases for reporting DTCs.

EXAMPLE 1: The following illustrates the message format for when there is more than one diagnostic trouble code.

Given:

a=lamp status (LS)
b=SPN
c=FMI
d=CM and OC

Message form is as follows: a,b,c,d,b,c,d,b,c,d,b,c,d....etc. In this example, the transport protocol of SAE J1939-21 has to be used to send the information because it requires more than 8 data bytes. Transport protocol services must be used any time there is more than one fault to be sent in a message defined in Table 25.

EXAMPLE 2: The following illustrates the message format for when a request of any DMx1-DMxC message is made and all test results indicate no trouble information. The currently defined lamps (Malfunction Indicator Lamp, Red Stop Lamp, Amber Warning Lamp, and Protect Lamp) should reflect the present state of the transmitting electronic component. In this example, only the Red Stop Lamp is identified as being on.

Bytes 3-6 shall be set as shown below. Previous drafts provided alternate settings that are obsolete for HD OBD, OBD II, and UN/ECE GTR compliant engines. The recommended setting for bytes 6-3 is shown below.

Given:

Byte 1	bits 8-7 =	00
	bits 6-5 =	01
	bits 4-3 =	00
	bits 2-1 =	00
Byte 2	bits 8-7 =	11
	bits 6-5 =	11
	bits 4-3 =	11
	bits 2-1 =	11
Byte 3-6	SPN	= 0
	FMI	= 0
	OC	= 0
	CM	= 0
Byte 7	=	255
Byte 8	=	255

5.7.42 (R)A, Confirmed and Active (DM42)

See 5.7.41 for the message definition.

5.7.43 (R)A, Previously Active (DM43)

See 5.7.41 for the message definition.

5.7.44 (R)B1, Pending (DM44)

See 5.7.41 for the message definition.

5.7.45 (R)B1, Confirmed and Active (DM45)

See 5.7.41 for the message definition.

5.7.46 (R)B1, Previously Active (DM46)

See 5.7.41 for the message definition.

5.7.47 (R)B2, Pending (DM47)

See 5.7.41 for the message definition.

5.7.48 (R)B2, Confirmed and Active (DM48)

See 5.7.41 for the message definition.

5.7.49 (R)B2, Previously Active (DM49)

See 5.7.41 for the message definition.

5.7.50 (R)C, Pending (DM50)

See 5.7.41 for the message definition.

5.7.51 (R)C, Confirmed and Active (DM51)

See 5.7.41 for the message definition.

5.7.52 (R)C, Previously Active (DM52)

See 5.7.41 for the message definition.

APPENDIX A - FAILURE MODE IDENTIFICATION CODES

A.1 GENERAL RULES

The following definitions shall be applicable when using FMIs. Examples have been included to help achieve consistent usage of the failure mode identifiers. Not all FMIs are applicable to a given SPN. For example, a controller diagnosing a particular input, such as SPN 91 (Accelerator Pedal Position) may use FMI 3 and 4 and therefore, would not use FMIs 5 and 6.

A.1.1 Assumptions and Definitions Used for the FMI Definitions

Data - any information pertaining to physical conditions that is communicated to an electronic module in the form of voltage, current, PWM signals, or data streams.

Real world - mechanical parameters or operating conditions that can be measured in the form of voltage, current, PWM signals, data streams, etc.

Signal range - definitions are shown in Figure A 1 which also contains the definitions for regions a through k.

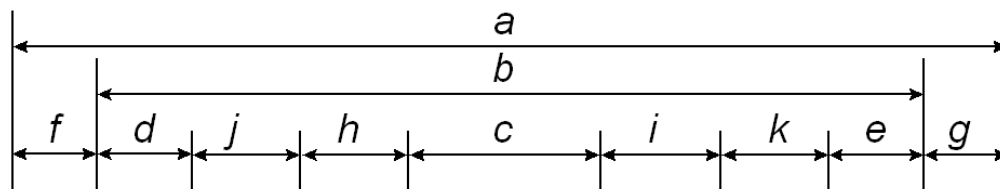


FIGURE A 1 - SIGNAL RANGES

Region a	Total signal input range possible that can be seen by an electronic module.
Region b	Total signal range physically possible as is defined by an application. The CARB defined Rationality fault diagnostic condition is applicable anywhere in this region.
Region c	Range defined as normal for a given real world measurement.
Region d	Range defined as below normal, Most Severe Level, of what is considered normal for the given real world measurement.
Region e	Range defined as above normal, Most Severe Level, of what is considered normal for the given real world measurement.
Region f	Range which is low outside the range of what is considered physically possible for a given system, indicating a short to a low source has occurred.
Region g	Range which is high outside the range of what is considered physically possible for a given system, indicating a short to a high source has occurred.
Region h	Range defined as below normal, Least Severe Level, of what is considered normal for a given real-world measurement.
Region i	Range defined as above normal, Least Severe Level, of what is considered normal for a given real-world measurement.
Region j	Range defined as below normal, Moderately Severe Level, of what is considered normal for a given real-world measurement.

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Region k Range defined as above normal, Moderately Severe Level, of what is considered normal for a given real-world measurement.

A.1.2 FMI and Description

A.1.2.1 FMI=0 - Data Valid But Above Normal Operational Range - Most Severe Level

The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal as determined by the predefined most severe level limits for that particular measure of the real world condition (Region e of the signal range definition). Broadcast of data values is continued as normal.

A.1.2.2 FMI=1 - Data Valid But Below Normal Operational Range - Most Severe Level

The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal as determined by the predefined least severe level limits for that particular measure of the real world condition (Region d of signal range definition). Broadcast of data values is continued as normal.

A.1.2.3 (R)FMI=2 - Data Erratic, Intermittent Or Incorrect

Erratic or intermittent data includes all measurements that change at a rate that is not considered possible in the real world condition and must be caused by improper operation of the measuring device or its connection to the module. Broadcast of data value is substituted with the "error indicator" value.

Incorrect data includes any data not received and any data that is exclusive of the situations covered by FMIs 3, 4, 5 and 6 as follows in A.1.2.4 through A.1.2.7. Data may also be considered incorrect if it is inconsistent with other information collected or known about the system. See FMI 20 and FMI 21 for systems which desire to have separate DTCs for a rationality check for data drifted high and another DTC for a rationality check for data drifted low for the same component.

FMI 2 is applicable for rationality type failures (see section 3.20).

A.1.2.4 FMI=3 - Voltage Above Normal, Or Shorted To High Source

- a. A voltage signal, data or otherwise, is above the predefined limits that bound the range (Region g of the signal range definition). Broadcast of data value is substituted with the "error indicator" value.
- b. Any signal external to an electronic control module whose voltage remains at a high level when the ECM commands it to low. Broadcast of data value is substituted with the "error indicator" value.

A.1.2.5 FMI=4 - Voltage Below Normal, Or Shorted To Low Source

- a. A voltage signal, data or otherwise, is below the predefined limits that bound the range (Region f of the signal range definition). Broadcast of data value is substituted with the "error indicator" value.
- b. Any signal external to an electronic control module whose voltage remains at a low level when the ECM commands it to high. Broadcast of data value is substituted with the "error indicator" value.

A.1.2.6 FMI=5 - Current Below Normal Or Open Circuit

- a. A current signal, data or otherwise, is below the predefined limits that bound the range (Region f of the signal range definition). Broadcast of data value is substituted with the "error indicator" value.
- b. Any signal external to an electronic control module whose current remains off when the ECM commands it on. Broadcast of data value is substituted with the "error indicator" value.

A.1.2.7 FMI=6 - Current Above Normal Or Grounded Circuit

- a. A current signal, data or otherwise, is above the predefined limits that bound the range (Region f of the signal range definition). Broadcast of data value is substituted with the "error indicator" value.

- b. Any signal external to an electronic control module whose current remains on when the ECM commands it off. Broadcast of data value is substituted with the “error indicator” value.

A.1.2.8 FMI=7 - Mechanical System Not Responding Or Out Of Adjustment

Any fault detected as the result of an improper mechanical adjustment or an improper response or action of a mechanical system that, with a reasonable confidence level, is not caused by an electronic or electrical system failure. This type of fault may or may not be directly associated with the value of general broadcast information.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.9 FMI=8 - Abnormal Frequency Or Pulse Width Or Period

To be considered in cases of FMI 4 and 5. Any frequency or PWM signal that is outside the predefined limits which bound the signal range for frequency or duty cycle (outside Region b of the signal definition). Also if the signal is an ECM output, any signal whose frequency or duty cycle is not consistent with the signal which is emitted. Broadcast of data value is substituted with the “error indicator” value.

A.1.2.10 FMI=9 - Abnormal Update Rate

Any failure detected when receipt of data via the data link or as input from a smart actuator or smart sensor is not at the update rate expected or required by the ECM (outside Region c of the signal range definition). Also any error detected causing the ECM not to send information at the rate required by the system. This type of fault may or may not be directly associated with the value of general broadcast information.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.11 FMI=10 - Abnormal Rate Of Change

Any data, exclusive of the abnormalities covered by FMI 2, that is considered valid but whose data is changing at a rate that is outside the predefined limits that bound the rate of change for a properly functioning system (outside Region c of the signal range definition). Broadcast of data values is continued as normal.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.12 FMI=11 - Root Cause Not Known

It has been detected that a failure has occurred in a particular subsystem but the exact nature of the fault is not known. Broadcast of data value is substituted with the “error indicator” value.

A.1.2.13 FMI=12 - Bad Intelligent Device Or Component

Internal diagnostic procedures have determined that the failure is one which requires the replacement of the ECU, used here to mean the packaged unit that includes some microprocessor and its associated components and circuits. It can be assumed that the communications subsystem is not the part that has failed, and that the manufacturer has determined that there is no serviceable component smaller than the ECU involved in the failure. Broadcast of data value is substituted with the “error indicator” value if appropriate, as there may or may not be any broadcast data involved. This error is to include all internal controller trouble codes that can not be caused by connections or systems external to the controller.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.14 FMI=13 - Out Of Calibration

A failure detected that can be identified to be the result of not being properly calibrated. This may be the case for a subsystem which can identify that the calibration attempting to be used by the controller is out of date. Or it may be the case that the mechanical subsystem is determined to be out of calibration. This failure mode does not relate to the signal range definition as do many of the FMIs.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.15 FMI=14 - Special Instructions

"Special Instructions" is the FMI to be used when the on-board system can isolate the failure to a small number of choices but not to a single point of failure. When this FMI is used, there is a clear necessity for the service technician to take some action to complete the specific diagnosis, and the Manufacturer has provided instructions for the completion of that diagnosis. There are two cases where this will be used: 1. for emission-related diagnostics where the particular failure cannot be separated between a sensor out of range and the case where the actual value is at the edge of a diagnostic region, and 2. for the older SPN 611 to 615 where the problem is in determining which of two or more circuits (which may interact) is the one that needs repair.

SPNs 611 through 615 are defined as "System Diagnostic Codes" and are used to identify failures that cannot be tied to a specific field replaceable component. Specific subsystem fault isolation is the goal of any diagnostic system, but for various reasons this cannot always be accomplished. These SPNs allow the manufacturer some flexibility to communicate non-"specific component" diagnostic information. Since SPNs 611-615 use the standard SPN/FMI format it allows the use of standard diagnostic tools, electronic dashboards, satellite systems and other advanced devices that scan Parameter Groups containing the SPN/FMI formats. Because manufacturer defined codes are not desirable in terms of standardization, the use of these codes should only occur when diagnostic information cannot be communicated as a specific component and failure mode.

Possible reasons for using a System Diagnostic Code include:

1. Cost of specific component fault isolation is not justified, or
2. New concepts in Total Vehicle Diagnostics are being developed, or
3. New diagnostic strategies that are not component specific are being developed.

Due to the fact that SPNs 611-615 are manufacturer defined and are not component specific, FMIs 0-13 and 15-31 have little meaning. Therefore, FMI 14, "Special Instructions", is usually used. The goal is to refer the service personnel to the manufacturer's troubleshooting manual for more information on the particular diagnostic code. This failure mode does not relate to the signal range definition as do many of the FMIs. This type of fault may or may not be directly associated with the value of general broadcast information.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.16 FMI=15 - Data Valid But Above Normal Operating Range - Least Severe Level

The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal as determined by the predefined least severe level limits for that particular measure of the real world condition (Region i of signal range definition). Broadcast of data values is continued as normal.

A.1.2.17 FMI=16 - Data Valid But Above Normal Operating Range - Moderately Severe Level

The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal as determined by the predefined moderately severe level limits for that particular measure of the real world condition (Region k of signal range definition). Broadcast of data values is continued as normal.

A.1.2.18 FMI=17 - Data Valid But Below Normal Operating Range - Least Severe Level

The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal as determined by the predefined least severe level limits for that particular measure of the real world condition (Region h of signal range definition). Broadcast of data values is continued as normal.

A.1.2.19 FMI=18 - Data Valid But Below Normal Operating Range - Moderately Severe Level

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The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal as determined by the predefined moderately severe level limits for that particular measure of the real world condition (Region j of signal range definition). Broadcast of data values is continued as normal.

A.1.2.20 FMI=19 - Received Network Data In Error

Any failure that is detected when the data received via the network is found substituted with the "error indicator" value (i.e. FE₁₆, see J1939-71). This type of failure is associated with received network data. The component used to measure the real world signal is wired directly to the module sourcing the data to the network and not to the module receiving the data via the network. This FMI is applicable to Regions f and g of the signal range definition. This type of fault may or may not be directly associated with the value of general broadcast information.

A.1.2.21 (R)FMI=20 - Data Drifted High

Systems which use one DTC to report, data drifted high and data drifted low, rationality failures for a component shall use FMI 2. When a product has separate DTCs for a rationality check for data drifted high and another DTC for a rationality check for data drifted low for the same component it shall then use FMI 20 and FMI 21 accordingly.

The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal when compared to other measurements. This may include sensor drifts, measurements that do not seem possible when compared with other data, measurements that change at a rate that is not considered possible in the real world or whose values themselves do not seem possible in the real world. It is understood that it is not feasible to always differentiate the cause of the data drifted low (e.g. Is the INTAKE MANIFOLD PRESSURE low because the sensor has drifted or is there a mechanical problem with either the turbocharger or the hose connections?) This FMI is applicable to Region b of the signal range definition. Broadcast of data value is substituted with the "error indicator" value.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.22 (R)FMI=21 - Data Drifted Low

Systems which use one DTC to report, data drifted high and data drifted low, rationality failures for a component shall use FMI 2. When a product has separate DTCs for a rationality check for data drifted high and another DTC for a rationality check for data drifted low for the same component it shall then use FMI 20 and FMI 21 accordingly.

The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal when compared to other measurements. This may include sensor drifts, measurements that do not seem possible when compared with other data, measurements that change at a rate that is not considered possible in the real world or whose values themselves do not seem possible in the real world. It is understood that it is not feasible to always differentiate the cause of the data drifted low (e.g. Is the INTAKE MANIFOLD PRESSURE low because the sensor has drifted or is there a mechanical problem with either the turbocharger or the hose connections?) This FMI is applicable to Region b of the signal range definition. Broadcast of data value is substituted with the "error indicator" value.

This FMI is applicable for rationality type failures (see section 3.20).

A.1.2.23 FMI=22-30 - Reserved For SAE Assignment

A.1.2.24 FMI=31 - Condition Exists

This FMI is used to indicate that the condition identified by the SPN exists when no other applicable FMI exists or in cases when the reported SPN name spells out the component and a non-standard failure mode. This type of fault may or may not be directly associated with the value of general broadcast information. This FMI will mean "not available" when the associated SPN is also "not available" as when the remainder of a packet is filled with binary ones after all data has been transmitted.

This FMI is applicable for rationality type failures (see section 3.20).

APPENDIX B- ASSUMPTIONS USED TO DESIGN MEMORY ACCESS

B.1 ASSUMPTIONS USED IN THE DESIGN OF MEMORY ACCESS

- B.1.1 Memory data is transferred in byte pieces and if the memory width is other than an integer number of bytes an extra full byte is used to contain the remaining bits.
- B.1.2 It would be useful to have a direct address into memory, as well as, a spatial (object or symbolic) referencing address. (As an example: a single 24-bit address would suffice for the direct address while 256 16-bit addresses could divide space and the standard could predefine the meaning of the first 128 spaces, while allowing the users to define and use the other 128 spaces proprietarily. It appears a 5-bit space identifier and a 19-bit object identifier would work since it would allow referencing SPNs directly - although a different length may be ultimately chosen - in fact presently the pointer is 24 bits while the pointer extension is 8 bits.)
- B.1.3 It is desired to generate a memory access function without adding another transport protocol capable of handling more than 1785 bytes to the standard; thereby data transfers are limited to lengths under 1785 bytes (J1939-21 section 3.10.1.1).
- B.1.4 Several security types must be handled to satisfy all users. They are:
 - B.1.4.1 No security
 - B.1.4.2 Password form of security
 - B.1.4.3 Re-entrant security, which the manufacturer may optionally chose to implement, where the device allows multiple operations after a security level has been established
 - B.1.4.4 Some more elaborate scheme similar to Seed/Key
 - B.1.4.5 A User_Level request, which controls the User's privileges with the option for further security
 - B.1.4.6 A means of increasing the effective Seed/Key size by requiring multiple iterations and/or mathematically combining the Seeds and Keys.
- B.1.5 Minimum number of new PGNs would be preferred (so that filtering and software overhead are minimized), so items that are time/message independent are combined (overlaid) to reduce the message set. (Obviously the message set can be extended if the overlaying appears too complex or is desired for any other reason.)
- B.1.6 Prefer single packet messages for the Memory Access invocation and control to reduce software overhead and improve speed of interchange, while need multipacketed messages for data transfer to provide reasonable lengths and improve transfer efficiency.
- B.1.7 Reprogramming of 'program memory' could be handled by any one of 3 general choices:
 - B.1.7.1 Use of a Write operation in combination with some form of execution control table for enabling/disabling execution within sections of the program memory that are being modified in combination with a hardware configuration such that writing to these sections of program does not interfere with operation of other sections of program.
 - B.1.7.2 A Boot Loader approach where a proprietary program for reloading executable memory is loaded using the memory access operation of the standard and execution is then transferred to this proprietary reloading program. There is no need to standardize the data transfer utilized by or the operation of this proprietary reloading program, but only the memory access operation loading said program and transferring control to it.
 - B.1.7.3 A completely proprietary technique, which is already possible using other features of this network standard.
- B.1.8 Memory need only be addressed in one direction. Assume start at the lowest address and operate toward a

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higher address for this proposal (i.e. only an incrementing pointer is provided).

- B.1.9 Also assume that for multipacket data sets the transport packet number must be combined with the pointer provided in the original memory access to decode the address(es) for each packet.
- B.1.10 All Memory Access Requests originate at a Tool and are considered commands to the device. The device however controls whether the request is handled.
- B.1.11 Design to provide access for a single 'Tool' to access a single 'Device'. Then later if it is desired, one can allow any node to function as a 'Tool' communicating with any other node, functioning as a 'Device'. Also if an OEM desires to allow more than one Tool to access their Device simultaneously all they need additional is software to handle the different accesses.

B.2 ASSUMPTIONS FOR DATA SECURITY

- B.2.1 More of the committee members desired to use two messages over a single message, which at times was single-frame and at other times multiframe, necessitating transport session.
- B.2.2 A single message containing either a Seed or a Key is better than a separate message for Seed and another for Key, since it uses fewer PGNs.
- B.2.3 A length parameter, while not inherently required, simplifies software handling enough to warrant inclusion.
- B.2.4 No need to pack these parameters, as it still takes a minimum of 5 frames to send any Seed or Key with a length between 8 and 13 bytes, so leave separate for ease of parsing.

APPENDIX C- APPLICATION RULES REGARDING MEMORY ACCESS PGNS

Memory Access State Transition Diagram

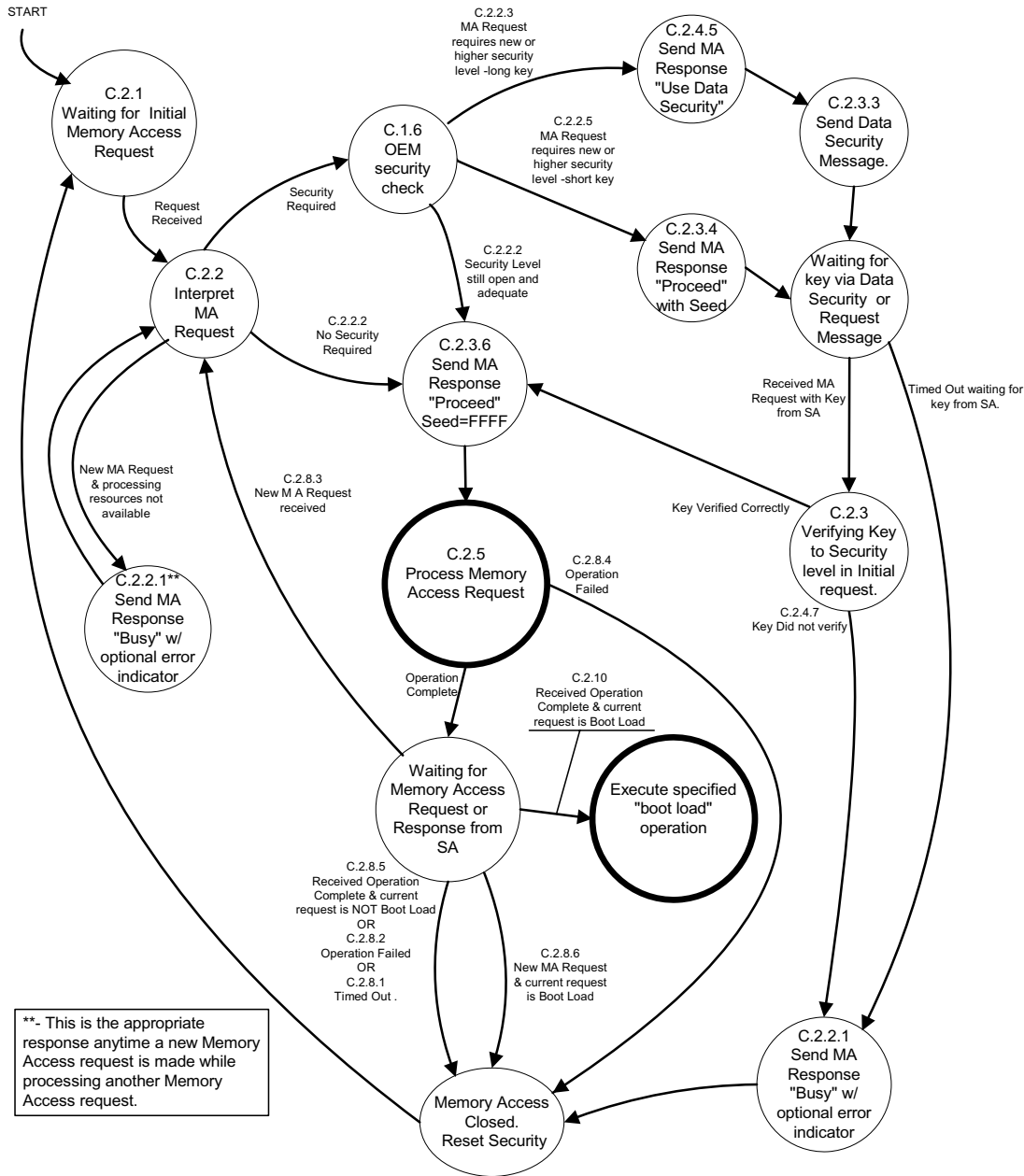


FIGURE C 1 - MEMORY ACCESS STATE TRANSITION DIAGRAM

C.1 GENERAL RULES

The following general rules must be considered:

- C.1.1 Only Memory Access Operations initiated by a Tool (using Memory Access Request) are required to be honored. However, the manufacturer may chose to allow any network node to operate as either a Tool or Device, as long as it meets the functions presented in APPENDIX C for Tool or Device.
- C.1.2 A Device is required to support only one session of Memory Access at any one time (it may therefore reject all

other requests with Status of Busy).

- C.1.3 A Tool may be designed to initiate Memory Access Operations with more than one Device at any given time.
- C.1.4 There will be no specific messages to:
 - C.1.4.1 "Undo" a write request.
 - C.1.4.2 Abort an operation (obviously, failure to transfer data, etc. will cause a failure which could be construed an abort).
- C.1.5 A Device may impose any number of additional constraints on when memory access requests are honored (see 5.7.14.4).
- C.1.6 A manufacturer may choose to allow their Device(s) to allow re-entrant security, wherein a Tool which has already made a Memory Access Request and established a security level may send additional Memory Access Requests following the successful completion of the present operation, using the established security.
- C.1.7 The Device needs time-out functions for:
 - C.1.7.1 Failure to receive further security from a Tool when the Device has required same
 - C.1.7.2 Failure to receive a complete transfer of the data set once an operation was allowed
 - C.1.7.3 Failure to hear a close from a Tool
- C.1.8 A Tool needs time-out functions for:
 - C.1.8.1 Failure to receive a Memory Access Response from a Device to which it has sent a Request
 - C.1.8.2 Failure to receive a complete transfer of the data set once a read operation was allowed
 - C.1.8.3 Failure to hear a close from a Device

C.2 THE FOLLOWING IS A NARRATIVE OF A TYPICAL APPLICATION OF THIS PROTOCOL:

It is only required that Memory Access operations be available once a node has become operational upon the network and satisfied any manufacturer specific interlock requirements. Software functions which will need to be finished before Memory Access becomes available include Address claiming, updating of instance fields within the NAME and any other configuration matters that the manufacturer deems necessary as a precursor to allowing operation of the Memory Access software. A diagram showing the memory access state transitions for a device has been included along with message transmission diagrams for several cases APPENDIX E. These diagrams should be used along with the following text to generate the software modules for a device. There is presently no diagram for a Tool and the text and message transition diagrams in APPENDIX E should be used as the reference in designing the Tool's software.

- C.2.1 Initial Memory Access Request - The Tool sends a Memory Access Request to the Device. This consists of the address of the memory within the Device to be accessed (Pointer, Pointer Extension, and Pointer Type), the length of the memory the Tool desires to operate upon (Length/Number Requested), the operation requested (Command = Erase, Read, Write, Boot Load, or EDCP Generation), and if utilized by the Device any necessary User_Level or Password information within the Key/User_Level parameter. If needed, based upon the device's particular requirements, it extracts from the Message Identifier (J1939-21 Section 3.1): the source (J1939-21 Section 3.2.6) and destination (J1939-21 Sections 3.2.4, 3.2.5, and 3.2.5.1).
- C.2.2 Device response to initial Memory Access Request - The device responds to this request with a Memory Access Response as follows:
 - C.2.2.1 If the Device is busy or has identified an error within the request (such as the pointer is not on a memory boundary for the memory being selected, the space being undefined, etc.), the Device transmits a Seed of all

1's (FFFF₁₆) and a Status of Busy with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension, and the Length/Number Allowed to be '0'. The Number Allowed needs not be interpreted by the Tool, as it has no specific meaning in the context of this message. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The Tool needs to try again later. Go to C.2.3.1.

- C.2.2.2 If the Device is not busy, and no security is required, or was established in a previous operation (as would occur when the manufacturer has allowed re-entry to the memory access operation for a Tool which has as yet not issued a 'close'), or the Password transmitted has been accepted, the Device transmits the allowed number of objects or memory length within Length/Number Allowed, a Seed of all 1's (FFFF₁₆) to indicate no further Key is required (5.7.15.4 and Table 13), and a Status of Proceed with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter (most likely 00₁₆ since no error) as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The requested operation can begin. (Remember that for the optional manufacturer re-entry the device may have other established rules regarding whether the re-entrant operation was truly at the security level previously established.) Go to C.2.5.
- C.2.2.3 If the Device is not busy, and 'long' Seed/Key security is required and if a valid User_Level was provided, (when utilized by the device), the Device transmits a Length/Number Allowed of 0, a Seed equal to 1 (0001₁₆) and a Status of Proceed with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter (most likely 00₁₆ since no error) as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. Memory Access may continue. Go to C.2.3.3.
- C.2.2.4 If the Device is not busy, but security was required and some security violation or error has occurred (such as: an invalid User_Level or Password), the Device transmits a Seed of all 1's (FFFF₁₆) and a Status of Busy, with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate, and the Length/Number Allowed to be '0'. The Number Allowed needs not be interpreted by the Tool, as it has no specific meaning in the context of this message. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The Tool needs to try again later. Go to C.2.3.1.
- C.2.3 Tools action on security response - The Tool responds to the Memory Access Response message(s) controlling security of a Memory Access Operation in one of several ways. (Remember that the Tool always has a choice of how to handle the EDCP Extension and Error Indicator/EDC Parameter. While the Tool is NOT required to assign any meaning to these items, it may optionally (at the manufacturer's discretion) make use of the assigned values and definitions (see 5.7.15.3) to imply specific meanings. This supposes that the device being communicated with has also chosen to use the EDCP Extension and Error Indicator/EDC Parameter to indicate error conditions. The responses are as follows:
- C.2.3.1 If the Tool receives a Memory Access Response with a Status of Busy, it needs to try the request again later, unless the busy was really indicating an error in the Request. If the manufacturer has provided diagnostics of such errors this will be indicated by the EDCP Extension and the error identification will be within the Error Indicator/EDC Parameter. If there was an identified error the Tool could then chose to correct the 'problem' and issue another request. (It is felt that some manufacturers will wish to provide no further indication of invalid security, as this would only aide those trying to defeat the security. This is their choice - 5.7.15.3.) Go to C.2.1.

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- C.2.3.2 If the Tool sees a Memory Access Response with a Status of Proceed, a Length/Number Allowed of 0, and a Seed equal to all 0's (0000₁₆), then the Seed (5.7.15.4) has been sent previously by the device and the device is expecting the Tool to begin sending the Key corresponding to the Seed (using another Memory Access Request message). This request should contain the Key based upon the received Seed, plus all of the Memory Access Request parameters (Pointer Type, Pointer Extension, Pointer, Length/Number Requested, and Command) that were in the initial Request. Go to C.2.4.
- C.2.3.3 If the Tool sees a Memory Access Response with a Status of Proceed, a Length/Number Allowed of 0, and a Seed equal to 1 (0001₁₆), then a 'Long' Seed and Key are to be used (see also Data Security message document). The Tool should now expect a Data Security message (with a Long Seed). Following the receipt of a Long Seed from a Data Security message, the Tool should reply with the corresponding Long Key using another Data Security message. The Device then answers the Tool with another of the messages identified here in section C.2.3. Go to C.2.3.
- C.2.3.4 If the Tool sees a Memory Access Response with a Status of Proceed, a Length/Number Allowed of 0, and a Seed not equal to 0, 1, or all 1's (0000₁₆, 0001₁₆, or FFFF₁₆) then this is the Seed from the device. The Tool may now begin sending the Key corresponding to the Seed, using another Memory Access Request message. This request should contain the Key based upon the received Seed, plus all of the other Memory Access Request parameters (Pointer Type, Pointer Extension, Pointer, Length/Number Requested, and Command) that were in the initial Request. Go to C.2.4.
- C.2.3.5 If the Tool sees a Memory Access Response with a Status of Proceed, a Length/Number Allowed of 0, and a Seed equal to all 1's (FFFF₁₆), then the device feels the Key transfer has been completed, but that the Key verification is not completed (or some other similar delay) and the operation can not yet begin. There may have been an Error Indicator in the Error Indicator/EDC Parameter, at the manufacturer's choice (5.7.15.3). The Tool must not begin data transfer yet (if there is to be one). The Tool should in general send another Memory Access Request to the Device, with a Key of all 1's (FFFF₁₆) plus all of the other Memory Access Request parameters (Pointer Type, Pointer Extension, Pointer, Length/Number Requested, and Command) that were in the initial Request. Go to C.2.4. However, if the Tool is waiting for data from the Device, it may chose simply to continue waiting instead of sending another Request. Go to C.2.5.
- C.2.3.6 If the Tool sees a Memory Access Response with a Status of Proceed, a non-zero Length/Number Allowed, and a Seed equal to all 1's (FFFF₁₆), then the device feels the data transfer may begin. The Tool should consider the device is now ready to begin the requested operation. Go to C.2.5.
- C.2.4 If the Device has not previously signaled that it was Busy, it responds to the next Memory Access Request with a Memory Access Response as follows:
- C.2.4.1 If the Device has become busy, the Device transmits a Seed of all 1's (FFFF₁₆) and a Status of Busy with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension, and the Length/Number Allowed to be '0'. The Number Allowed needs not be interpreted by the Tool, as it has no specific meaning in the context of this message. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The Tool needs to try again later. Go to C.2.3.1 to see Tool's action.
- C.2.4.2 If the Device is still not busy, and security was required (including receipt of a valid User_Level, if it was required), and the device feels a complete Key has been received, thus requiring no additional Seed/Key combinations, but the device has as yet been unable to complete the verification of the Key, the Device transmits a zero for Length/Number Allowed, a Seed of all 1's (FFFF₁₆), and a Status of Proceed with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. Go to C.2.3 to see Tool's action.

- C.2.4.3 If the Device is still not busy, and security was required (including receipt of a valid User_Level, if it was required), and the device feels a complete Key has been received, thus requiring no additional Seed/Key combinations, and the device has validated (accepted) the Key, the Device transmits a nonzero Length/Number Allowed (with the value representing the actual length the device is willing to allow the Tool to operate upon), a Seed of all 1's (FFFF₁₆), and a Status of Proceed with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The requested operation can begin. Go to C.2.3 to see Tool's action.
- C.2.4.4 If the Device is still not busy, and security was required (including receipt of a valid User_Level, if it was required), but that the Seed has NOT been sent yet and the use of a Long Seed/Key (see section 5.7.18) is NOT required, the Device transmits a Length/Number Allowed of 0, a Seed not equal to either all 0's or all 1's (0000₁₆ or FFFF₁₆) or '1' (implying use Long Seed see Table 13) and a Status of Proceed with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. Memory Access may continue. Go to C.2.3 to see Tool's action.
- C.2.4.5 If the Device is still not busy, and security was required (including receipt of a valid User_Level, if it was required), but the use of a LONG SEED/KEY (see section 5.7.18) is required, the Device transmits a Length/Number Allowed of 0, a Seed equal to 1 (0001₁₆) and a Status of Proceed with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The Device should also transmit a Data Security message with an appropriate Seed (outlined within the Data Security message documentation). Memory Access may continue. Go to C.2.3 to see Tool's action.
- C.2.4.6 If the Device is still not busy, and security was required (including receipt of a valid User_Level if it was required), and the Seed has been sent but reception of the Key has NOT occurred, and the device has timed-out waiting for the Tool, the Device may transmit another Memory Access Response message with a Length/Number Allowed of 0, a Seed equal to all 0's (0000₁₆) and a Status of Proceed with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. Memory Access may continue. Go to C.2.3 to see Tool's action. Alternately the device may choose to discontinue the operation. Go to C.2.10.
- C.2.4.7 If the Device is still not busy, and security was required, and an invalid Key was received, the Device transmits a Seed of all 1's (FFFF₁₆) and a Status of Busy with the EDCP Extension set to either No Error Indicator/EDC Parameter Available (FF₁₆) or Data in Error Indicator/EDC Parameter is an Error Indicator (06₁₆ or 07₁₆) as desired by the manufacturer, the Error Indicator/EDC Parameter as appropriate for the EDCP Extension, and the Length/Number Allowed to be '0'. The Number Allowed needs not be interpreted by the Tool, as it has no specific meaning in the context of this message. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The Tool must try again later if it desires to obtain the requested action. Go to C.2.3.1 to see Tool's action.
- C.2.5 Begin a requested Memory Access Operation, when the Tool has seen a Status of Proceed and a Seed equal to all 1's (FFFF₁₆), then it recognizes that the Device is willing to allow the requested Memory Access Operation

to begin. The device should have retained any internal state information indicating that it has signaled the Tool of its own readiness to allow said operation. The next step depends upon the type of Operation initiated with the Command parameter of the initial Memory Access Request. (Note: The Command and the Length/Number Requested within the Memory Access Request message(s) should have been either constant or changed to what the device was willing to allow (C.2.4.3), any other alteration during the sequence should cause the Device to reject the operation - see 5.7.14.4.6.)

- C.2.5.1 If the Memory Access Request Command was an Erase, the Device should process the Erase command that it allowed and when completed initiate the Close Sequence. Go to C.2.6.
- C.2.5.2 If the Memory Access Request Command was a Read, the Tool allows the Device to initiate a transfer using the Binary Data Transfer PGN, either as a single packet or as a multipacketed message within a transport session depending upon the Length involved (If a transport session is required it follows the rules in SAE J1939-21). When the transfer is completed, the Device initiates the Close Sequence. Go to C.2.6.
- C.2.5.3 If the Memory Access Request Command was a Write or a Boot Load with data (non-zero Length / Number Requested), the Device allows the Tool to initiate a transfer using the Binary Data Transfer PGN, either as a single packet or as a multipacketed message within a transport session depending upon the Length involved (if a transport session is required, it follows the rules in SAE J1939-21). When the transfer is completed and when the write operation has finished (successfully or not), the Device initiates the Close Sequence. If the command was a Boot Load without data (zero Length / Number Requested), the Device should initiate the Close Sequence exactly as when a data transfer had completed. Go to C.2.6.
- C.2.5.4 If the Memory Access Request Command was an EDCP Generation, the Device reads the data from the length of memory at the address it has allowed access to and then generate the requested checksum (or CRC, etc.) for these locations. When the checksum is generated, the Device initiates the Close Sequence. Go to C.2.6.
- C.2.6 Memory Access Close Sequence is initiated upon completion of a Memory Access operation, as follows:
 - C.2.6.1 If the Memory Access Request Command was an Erase, Write, Boot Load, or EDCP Generation, the Device transmits a Memory Access Response with a Status of Operation Completed or Operation Failed depending upon the success/failure of the requested operation. The EDCP Extension identifies whether the Error Indicator/EDCP is used (remember this is at the manufacturer's discretion). It also identifies how to interpret itself and said Error Indicator/EDC Parameter. The Length/Number Allowed should be 0, the Seed should be equal to all 0's (0000₁₆) and the Error Indicator/EDC Parameter as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to these items, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The Tool may interpret the Length/Number Allowed and Seed parameters as having no meaning. This Memory Access Response is to be transmitted only after any internal processes invoked by the Memory Access have completed. Go to C.2.7.
 - C.2.6.2 If the Memory Access Request Command was a Read, the Device transmits a Memory Access Response with a Status of Operation Completed or Operation Failed depending upon the success/failure of the requested operation. The EDCP Extension identifies whether the Error Indicator/EDCP is used and/or how to handle itself and said Error Indicator/EDC Parameter. The Length/Number Allowed should be 0, the Seed should be equal to all 0's (0000₁₆) and the Error Indicator/EDC Parameter as appropriate for the EDCP Extension. The Tool has a choice with handling of the EDCP Extension and Error Indicator/EDC Parameter. The Tool is NOT required to assign any meaning to the EDCP Extension and Error Indicator/EDC Parameter, but may optionally (at the manufacturer's discretion) use the assigned values and definitions to imply specific meanings. The Tool may interpret the Length/Number Allowed and Seed parameters as having no meaning (it may also chose to simply dispose of them). This Memory Access Response is transmitted immediately after the Binary Data Transfer has completed (Transport Session has closed if one was required for the data transfer). Go to C.2.7.
- C.2.7 When the Tool receives the Memory Access Response from the Device indicating operation completed or failed, and the Tool wishes to end the memory access connection, it transmits a Memory Access Request indicating a status of either Operation Completed or Operation Failed, from its perspective. (The Tool should have checked the EDCP Extension and Error Indicator/EDC Parameter as a part of its decision process). The

Tool should send another Memory Access Request to the Device, with a Key of all 1's (FFFF₁₆) plus all of the other Memory Access Request parameters (Pointer Type, Pointer Extension, Pointer, Command and Length/Number Allowed) that were in the initial Request (exception that the Length/Number Requested may also be the value it changed to when the device indicated it was willing to allow the operation (C.2.4.3)). The Device may treat all of these other parameters as having no meaning. In the case of Boot Load, a Memory Access Request of Operation Failed from the Tool shall prevent the Device from transferring execution to the address specified within the original Boot Load request.

- C.2.8 After the Device initiates the Close Sequence, it waits for a Memory Access Request from the Tool. The action taken by the Device depends upon the original request, as well as the Response from the Tool. The following are the possible Device actions. Note: It is expected that only a successful completion of the execution of the Boot Load Command prevents the system from returning to the same operational mode it was in prior to the Memory Access Request which initiated a Boot Load operation. Go to C.2.9.
- C.2.8.1 If there is no response from the Tool within 100 ms (tolerance of (25 ms), plus any additional delay needed to account for the delay of any bridges within the system, of the Device transmission, the Device shall reset any optional re-entrant security levels and return to the initial state for memory access and to whatever operation mode it was in prior to the original Memory Access Request and may optionally consider this Operation Failed.
- C.2.8.2 If the Memory Access Response from the Device to initiate the Close Sequence was Operation Failed then regardless of the response from the Tool, the Device shall reset any optional re-entrant security levels and return to the initial state for memory access and to whatever operation mode it was in prior to the original Memory Access Request and shall consider this Operation Failed.
- C.2.8.3 If the response from the Tool (i.e. the Tool with the source address from which the initial memory access operation came) is another memory access request, and the manufacturer has allowed the optional re-entrant security and the initial request was other than Boot Load, the Device shall consider this Operation Completed and shall return to the internal state where it processes the memory access requests with re-entrant security.
- C.2.8.4 If the response from the Tool is Operation Failed, the Device shall reset any optional re-entrant security levels and return to the initial state for memory access and to whatever operation mode it was in prior to the original Memory Access Request and shall consider this Operation Failed.
- C.2.8.5 If the Memory Access Response from the Device to initiate the Close Sequence was Operation Completed and the Memory Access Request from the Tool to complete the Close Sequence was Operation Completed, then the Device resets any optional re-entrant security levels and returns to operational mode it was in prior to the Memory Access Request which initiated this sequence, unless the request was a Boot Load Command. When the request has been a Boot Load command the Device should transfer execution. Go to C.2.9.
- C.2.8.6 If the response from the Tool is another memory access request, and the initial operation was Boot Load, the Device shall reset any optional re-entrant security levels and return to the initial state for memory access and to whatever operation mode it was in prior to the original Memory Access Request, thus effectively considering the Boot Load operation failed.
- C.2.9 If a Boot Load Command is successfully completed (Both the Tool and the Device sent Operation Completed), then the Device transfers execution to the address that was determined from the Pointer, Pointer Extension, and Pointer Type of the initial Memory Access Request. At such time several results are possible, they are:
- C.2.9.1 If there was no data to be sent (a zero Length/Number Requested in original request) the device will simply transfer execution to another location (may be used simply as a means to invoke a new mode of program operation within the device, such as 'reset', switch to an internal 'loader', etc.).
- C.2.9.2 If there was new data transferred it may have been a new program which the device is simply to begin operating from. One possibility for this new program is that it is a reprogramming program designed to provide a more time efficient means of reprogramming the device's executable memory. In such a case, the Tool and the Device may then intercommunicate by means of the Boot Load Data PGN. This Boot Load Data PGN can be transmitted from the Tool to the Device with the parameters in any format which meets the

needs of the Device being programmed. The Boot Load Data PGN can be transmitted from the Device to the Tool as an ACK/NAK sequence or to control timing in any way deemed necessary to achieve the transfer between the Tool and the Device. It is expected that the device will no longer respond to any other PGNs transmitted to it; however, the Tool will be required to maintain communications to the remainder of the network devices. It will also become the Tool's further responsibility to act on the Device's behalf in any Network Management functions, in particularly to prevent an Address Claim by any other node of the address being used by the Device being programmed.

- C.2.9.3 If there was new data transferred it may simply have been an addition to the existing program. This possibility would have required the manufacturer to have left space available for such an addition and have used a memory type that could have new data added without damage to the old. Should this have been the case execution would simply transfer to the new address just as when no new data had been added. Whether or not a reset or other operation would be necessary would be at the manufacturer's discretion.
- C.2.10 If a Tool fails to hear the Memory Access Response message with operation completed or operation failed from a Device within what it considers to be appropriate time, it may send a Memory Access Request of Status Request to the Device. If the Tool receives no response within 0.25 seconds, it shall consider the Device is not going to respond and return to a mode of operation appropriate for this 'failure' (i.e. try to determine if the Device is still operating, if data has been damaged, etc.). If the Tool receives a Memory Access Response of Proceed from the Device, the Tool should recognize that the Device has already returned to the waiting for request state and considers the previous request completed and whether it was successful or failed can no longer be determined. The Tool may wish to attempt to determine why the device completed without it hearing the response (possible reasons are the response was not sent, bus communication is impaired, device had timed-out hearing the Tool at one of the interchange points, etc.).

APPENDIX D- APPLICATION RULES REGARDING DATA SECURITY MESSAGE (DM18)

D.1 GENERAL RULES

The following general rules must be adhered to:

- D.1.1 The message should only be sent to a specific destination, never to the global address or the unavailable address.
- D.1.2 A Tool or a Device must have set the Key parameter in the Memory Access Request message or the Seed parameter in the Memory Access Response message (as appropriate) to identify that the Long Seed/Key is being used prior to transmission of the Data Security message by either. This enables the software in both to have a basis upon which to 'flag' that the Data Security message is going to be used to provide Long Seed/Key.
- D.1.3 A Tool or a Device upon seeing either a Memory Access Request message or a Memory Access Response message identifying that the Long Seed/Key is being used shall set the appropriate 'flags' within the respective software such that they look for the Data Security message and process it.

D.2 MESSAGE EXCHANGE RULES

The following outlines the procedure for using the Data Security message to send/receive Long Seed/Key within a Memory Access sequence.

- D.2.1 A Device that has received a Memory Access Request message (see Memory Access Request [section 5.7.14] and Response [section 5.7.15] documentation) for which it is going to send a Seed using the Data Security message should set the Seed parameter within the Memory Access Response message to indicate that the Seed will actually be sent using the Data_Security message. The Data Security message with the Long Seed should then be sent within 0.25 seconds of the Memory Access Response message. (A Tool may use a time-out of twice this value plus whatever bridge delays it has determined is appropriate for the particular system. This requires the Tool to have identified the system prior to this operation.)
- D.2.2 A Tool that has received a Data_Security message containing a Long Seed from a Device should send the Long Key of that Long Seed back to the Device with the Data Security message within 0.25 seconds. (Note that bridges, when utilized, need to be accounted for in the time-out number. A Device may use a time-out of twice this value plus whatever bridge delays it has determined is appropriate for the particular system. This, of course, requires the Device to have identified the system prior to this operation.)
- D.2.3 A Device that has received a Data Security message containing a Long Key (presumably of a Long Seed it had previously sent) from a Tool should verify the Seed and then continue with the Memory Access as outlined in APPENDIX C of the Memory Access Request and Response operation. (The two cases of Seed verified and failed are outlined separately. See Figure E 9 and Figure E 10)

APPENDIX E- MEMORY ACCESS INFORMATION

This is an Example of a Memory Access "READ MEMORY" request from tool to device using the Transport Layer to send data. This transaction includes the use of the security features of memory access.

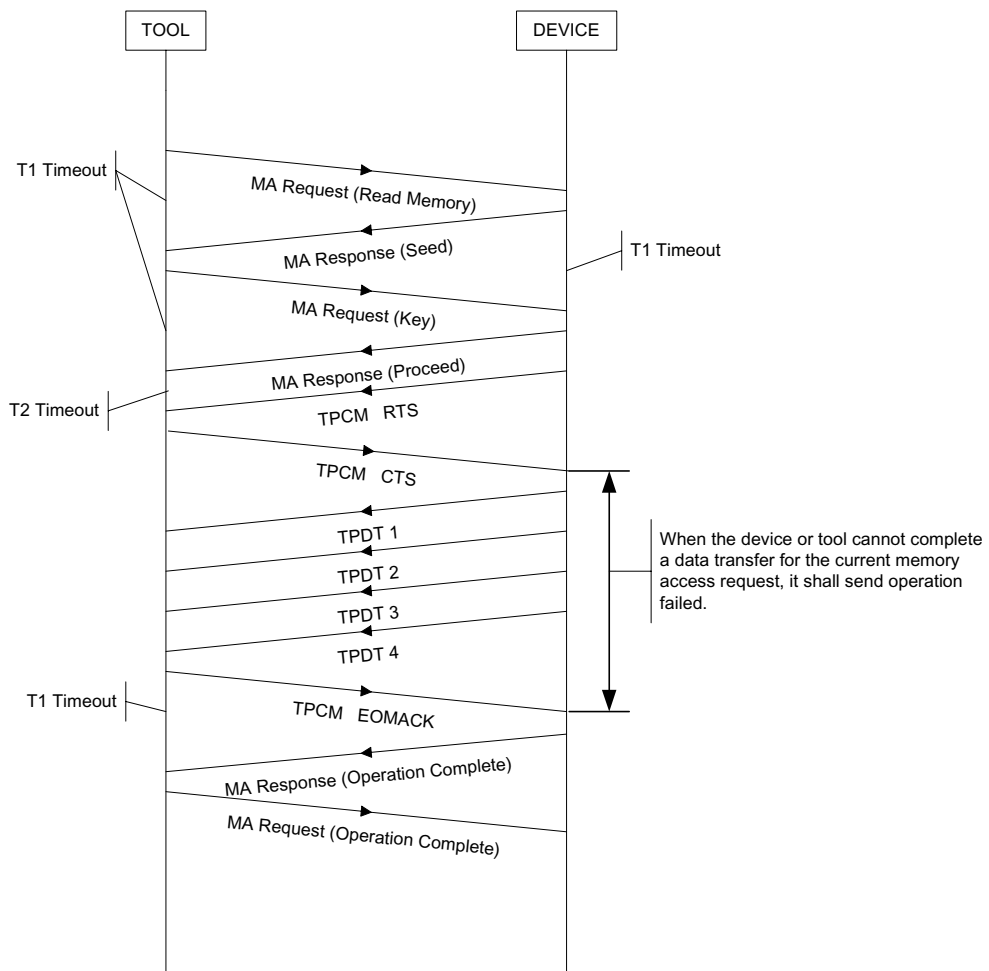


FIGURE E 1 - EXAMPLE - MESSAGE SEQUENCE TO ACCOMPLISH MEMORY READ OPERATION WITH SECURITY (SHORT FORM OF SECURITY)

This is an Example of a Memory Access request from tool to device without security and without using the transport layer.

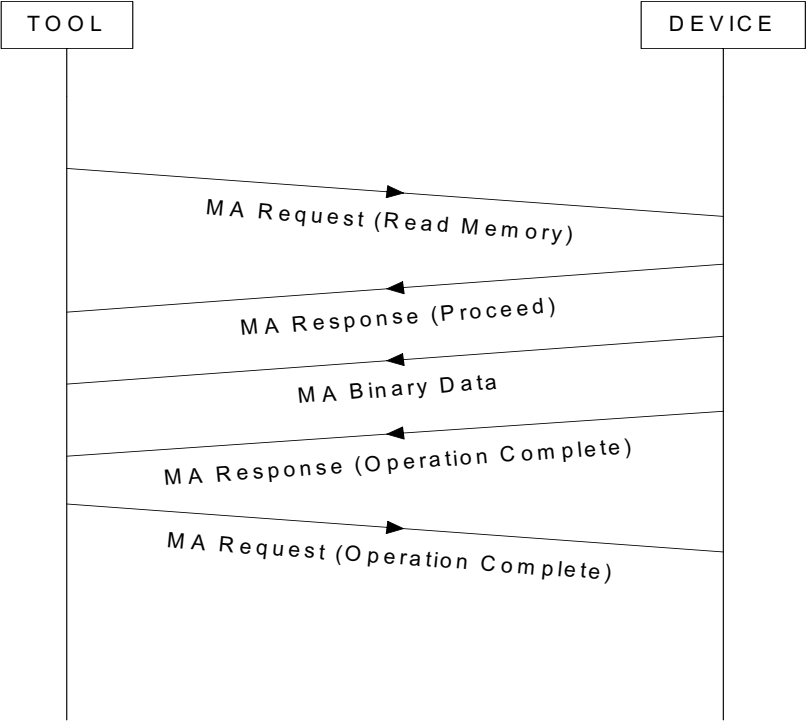


FIGURE E 2 - EXAMPLE - MESSAGE SEQUENCE TO ACCOMPLISH MEMORY READ OPERATION WITHOUT SECURITY

This is an Example of a Memory Access request from tool to device without using the transport layer. With multiple requests including security handling.

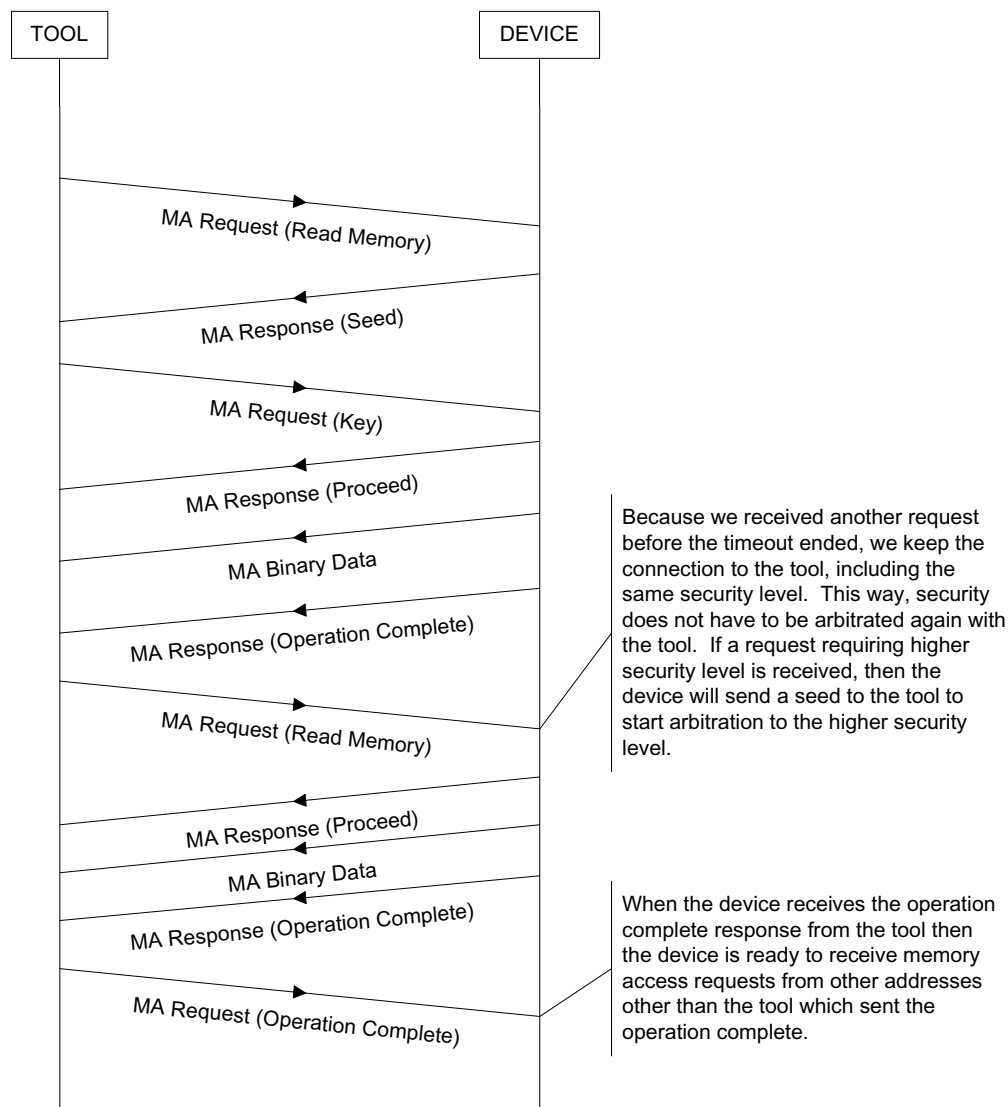


FIGURE E 3 - EXAMPLE - MESSAGE SEQUENCE TO ACCOMPLISH MULTIPLE MEMORY READ OPERATION WITH SECURITY (SHORT FORM OF SECURITY)

This is an Example of a Memory Access request from tool to device when the tool does not send and operation complete.

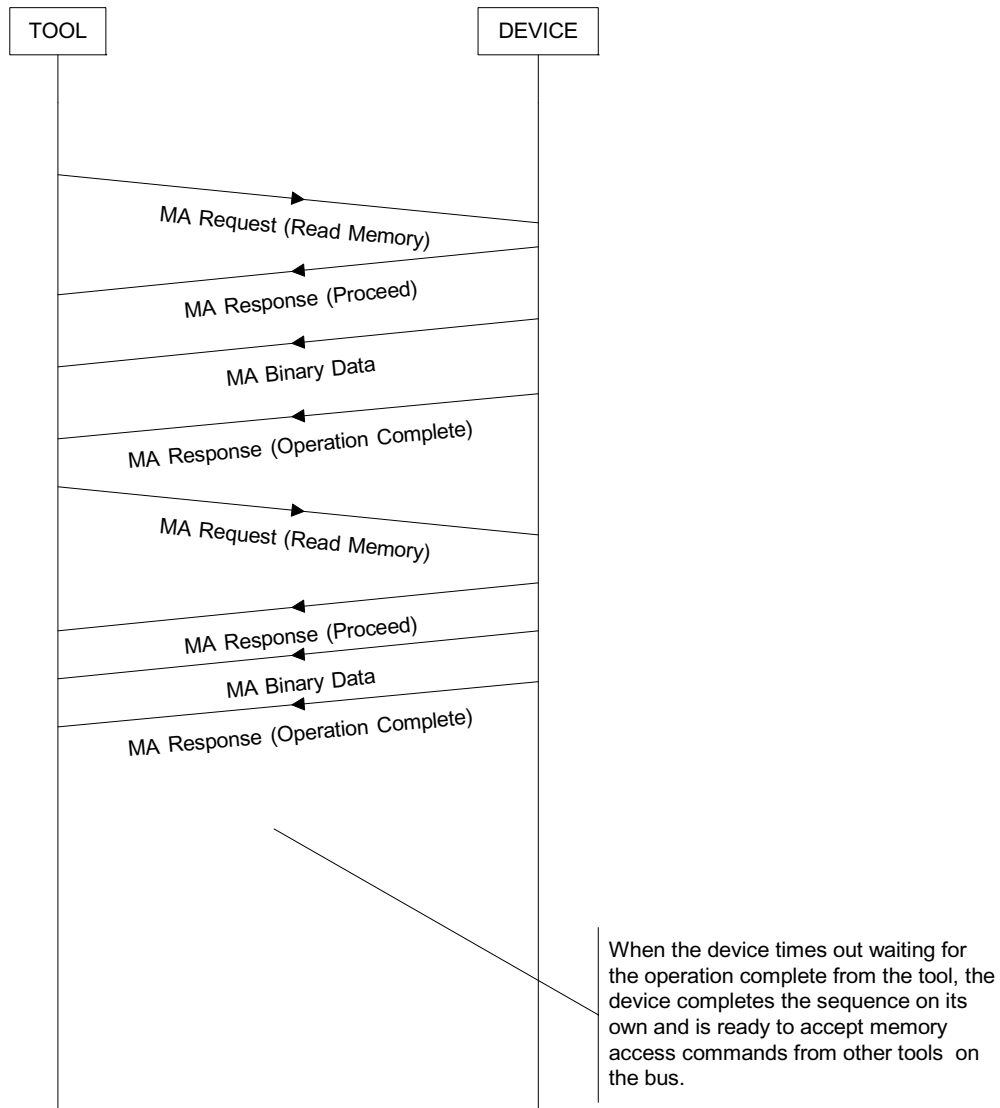


FIGURE E 4 - EXAMPLE - TOOL DOES NOT SEND AN OPERATION COMPLETE TO CONCLUDE THE MEMORY ACCESS SESSION

This is an Example of a Memory Access "WRITE MEMORY" request from tool to device using the Transport Layer to send data. This transaction includes the use of the security features of memory access.

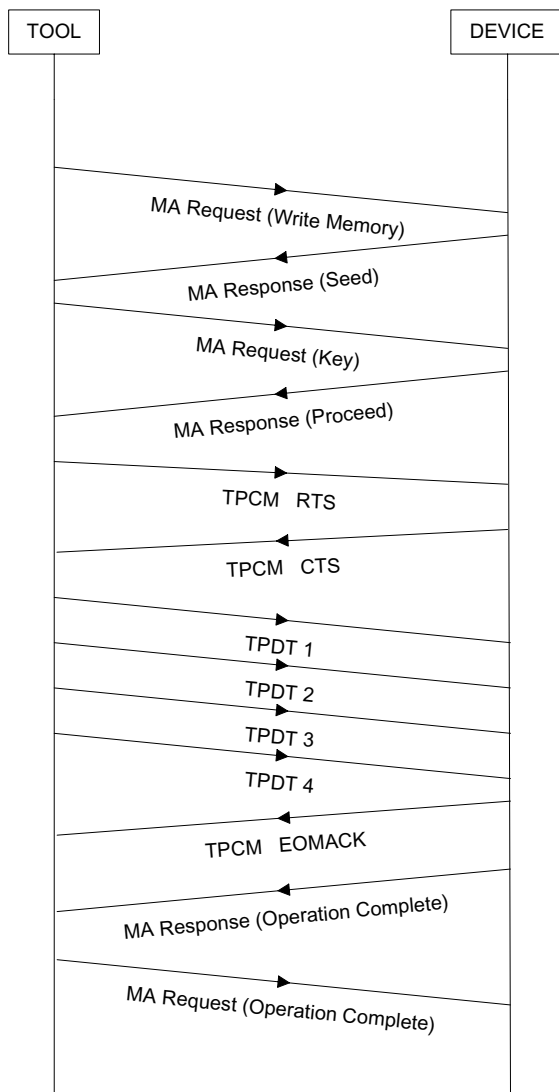


FIGURE E 5 - EXAMPLE - WRITE MEMORY USING TRANSPORT PROTOCOL TO SEND THE DATA; ALSO USES THE SHORT FORM OF SECURITY

This is an Example of Memory Access requests from tool to device when security levels of the requests change from one request to another.

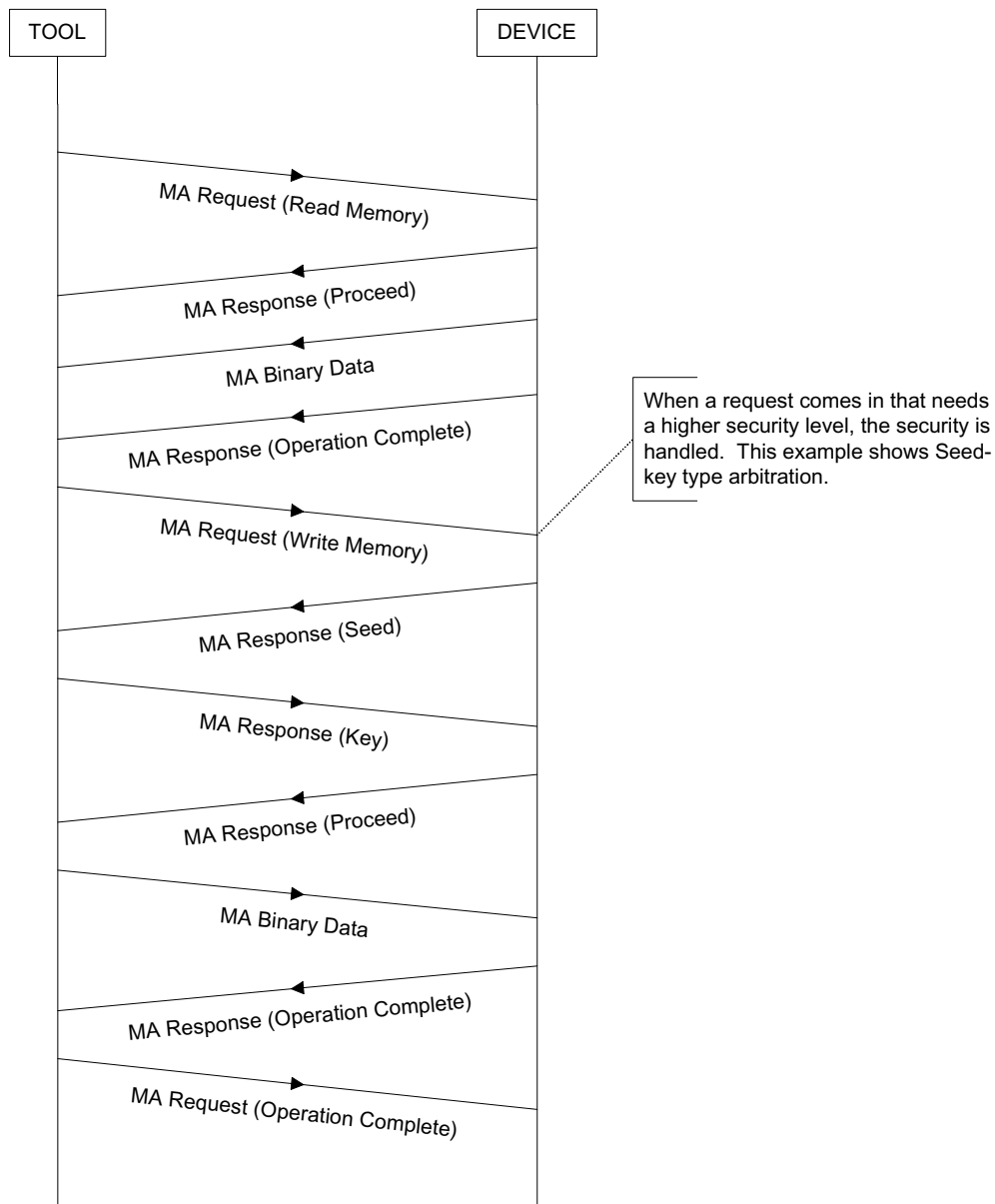


FIGURE E 6 - EXAMPLE - MEMORY ACCESS TOOL TO DEVICE OPERATIONS REQUIRING DIFFERENT SECURITY LEVELS

This is an Example of Memory Access requests from tool to device when security levels of the requests change from one request to another.

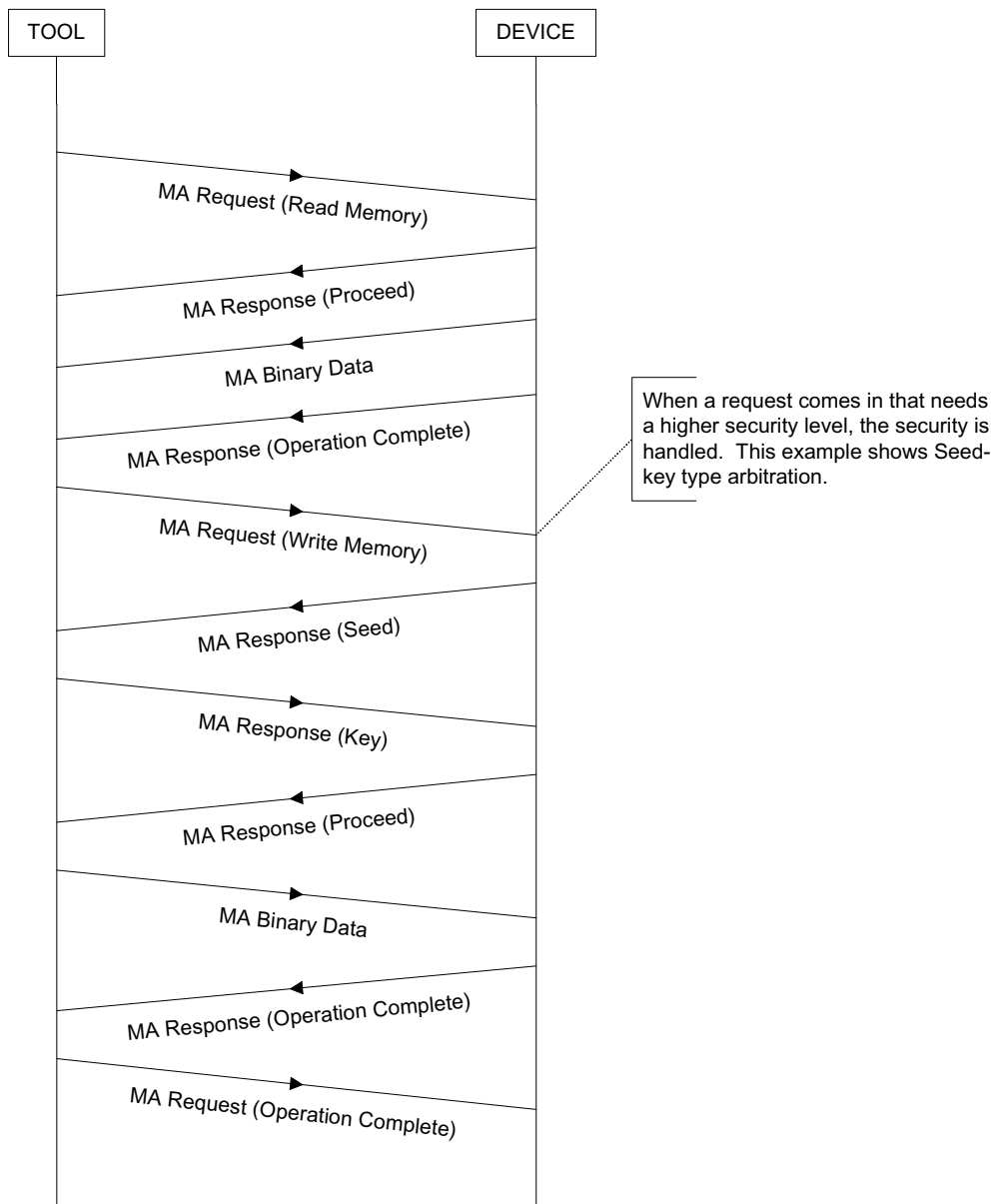


FIGURE E 7 - EXAMPLE - MEMORY ACCESS OPERATION FAILED DUE TO TRANSPORT PROTOCOL SESSION FAILURE

This is an Example of a Memory Access request from tool to device when security is not verified.

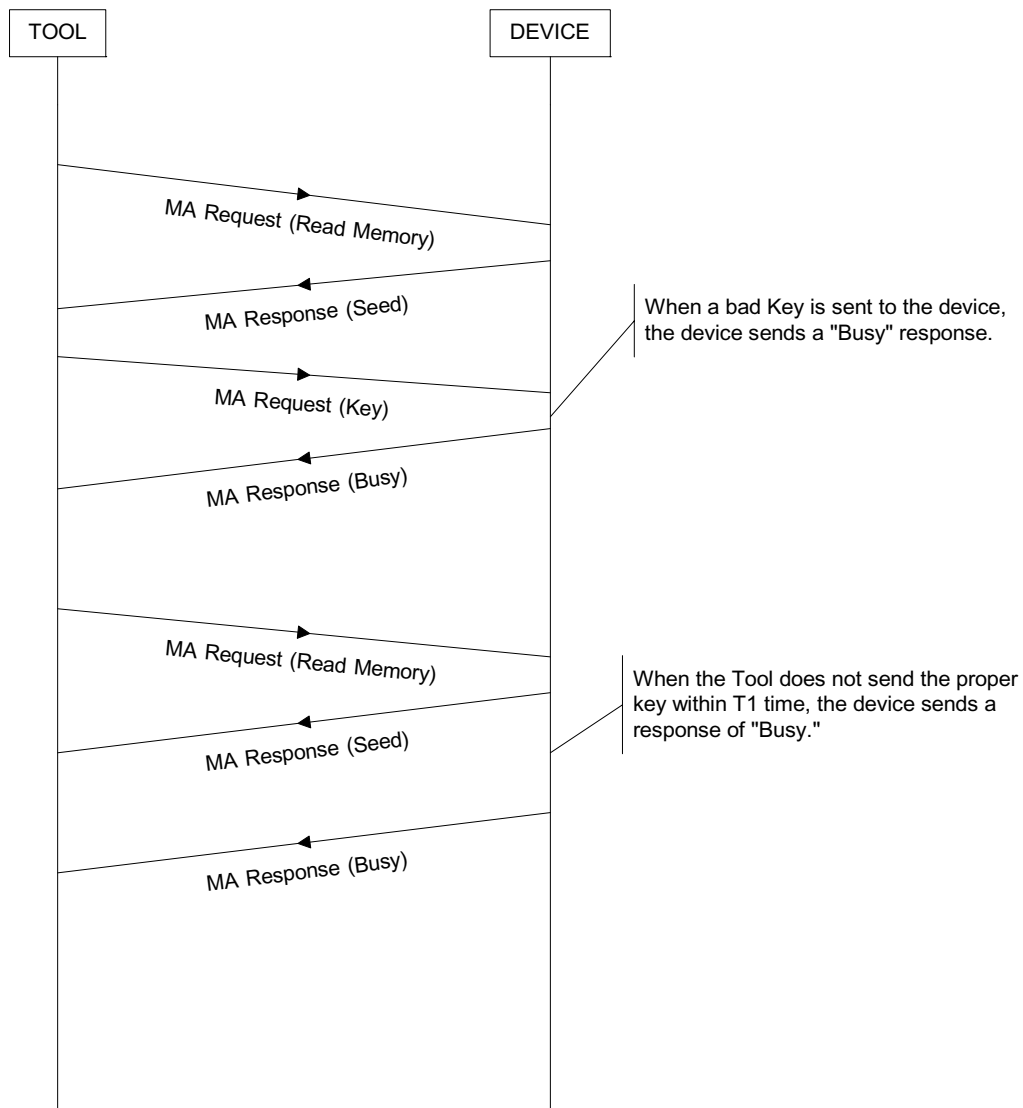


FIGURE E 8 - EXAMPLE - MEMORY ACCESS OPERATION WHERE SECURITY IS NOT VERIFIED

This is an Example of a Memory Access request from tool to device with long seed/key security when the key is verified..

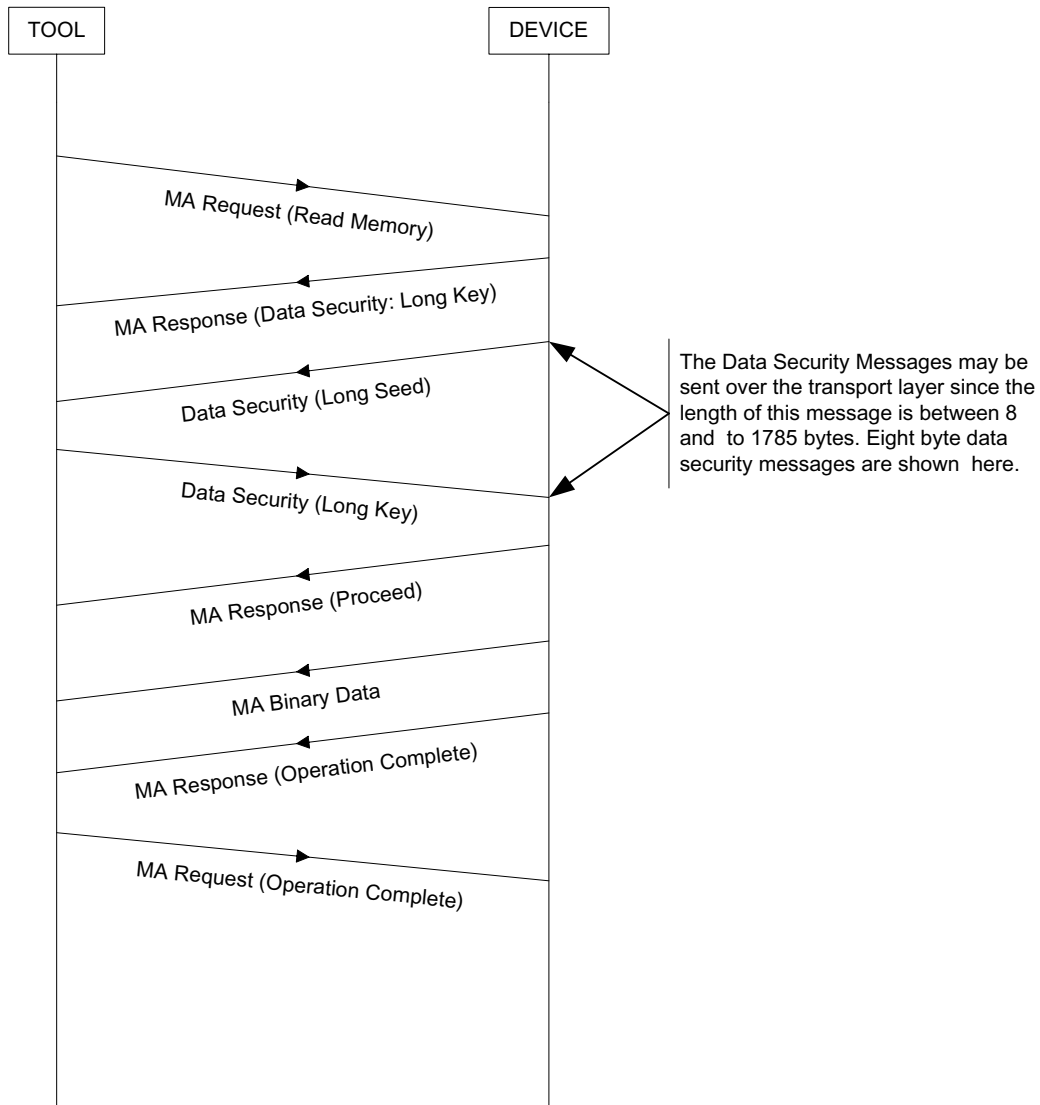


FIGURE E 9 - EXAMPLE - MEMORY ACCESS OPERATION USING THE LONG SEED AND KEY

This is an Example of a Memory Access request from tool to device with long seed/key security when the key is not verified..

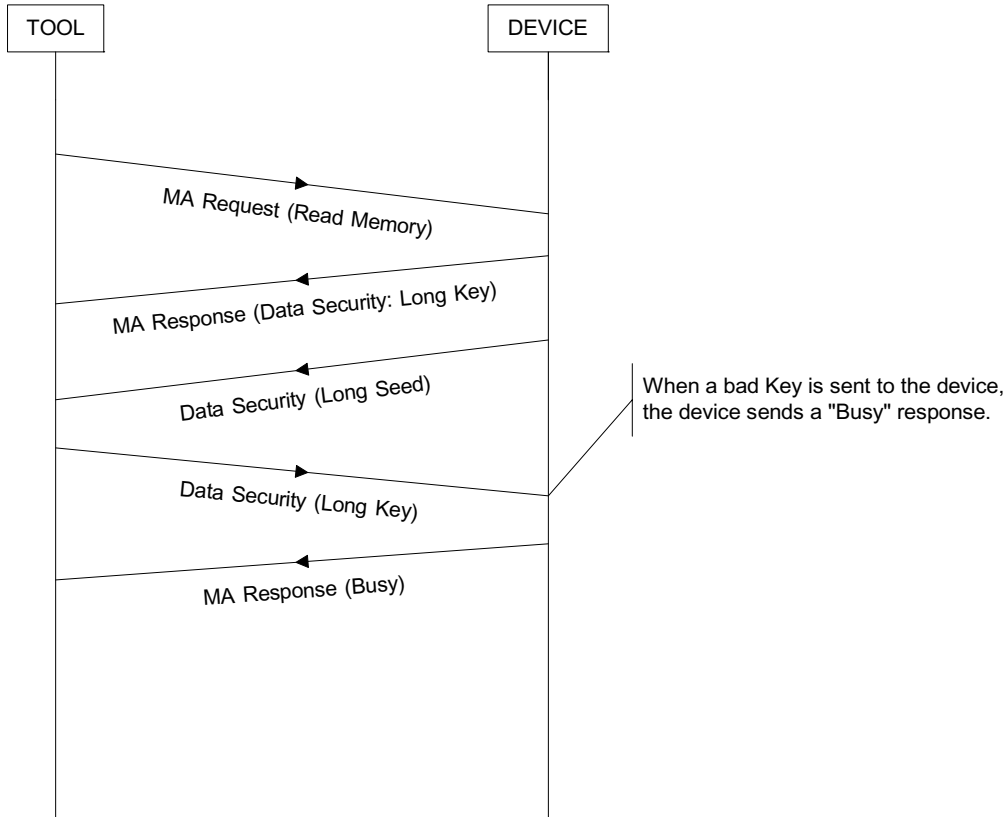


FIGURE E 10 - EXAMPLE - TOOL DOES NOT SEND VALID KEY SO DEVICE RESPONDS WITH "BUSY"

APPENDIX F- RESTRICTIONS ASSOCIATED WITH PROPRIETARY SPNS

1. When Suspect Parameter Number assignment is contemplated, J1939 defined SPNs (SPNs 0 to 520191) should be considered along with Proprietary SPNs (520192 {7F000₁₆} through 524287 {7FFFF₁₆}). If the information to be diagnosed is of **general interest**, then a J1939 defined SPN (**SPNs 0 to 520191**) should be sought through the SAE J1939 Subcommittee. If the diagnosed information is **emissions-related**, then a J1939 defined SPN (**SPNs 0 to 520191**) shall be sought through the SAE J1939 Subcommittee.
2. **The Suspect Parameter Numbers for Proprietary Diagnostics shall not be used for communicating emissions-related diagnostics.** If the diagnosed information is emissions-related, then a J1939 defined SPN (SPNs 0 to 520191) should be sought through the SAE J1939 Subcommittee.
3. The interpretation of the Diagnostic Trouble Codes using Proprietary SPNs varies by manufacturer. For example even though two different implements may use the same Proprietary SPN for their diagnostics, manufacturer "A's" reported diagnostic using a proprietary SPN is more likely to be different from manufacturer "B's" diagnostic using the same proprietary SPN. The interpretation of the Diagnostic Trouble Codes with Proprietary SPNs is dependent on the source address of the Diagnostic Message. The source address and its associated Manufacturer ID from its J1939 NAME should be used if a device is to translate Proprietary SPN Diagnostic Trouble Codes to manufacturer specific text descriptions.
4. Generic scan tools, service tools, and other ECUs should be capable of presenting DTCs with Proprietary SPNs in its numerical representation (i.e., SPN-FMI). However, this SAE Standard does not require the translation of these DTCs into any textual representation by generic scan tools, service tools, and other ECUs. Generic scan tools, service tools, and other ECUs are encouraged to present a generic phrase, such as "See Manufacturer Service Literature" or "Description Not Available" when encountering DTCs with Proprietary SPNs.
5. This SAE Standard imposes no restrictions upon performing textual translations of DTCs with Proprietary SPNs by scan tools, service tools, and other ECUs designed by or designed for a specific manufacturer. Any devices which perform textual translations of DTCs with Proprietary SPNs must use the appropriate information, including source address and the associated J1939 NAME, when performing these translations.
6. Each ECU manufacturer is responsible for the appropriate management of their assignments and usage of the Proprietary Diagnostic SPNs if these are utilized by their products.

APPENDIX G- FAULT MANAGEMENT NARRATIVE

Appendix G provides examples that illustrate potential operating sequences for managing faults and managing which messages are used to communicate them. Section G.1 introduces Appendix G. Section G.2 reviews the Active and Previously Active concepts for non-OBD regulated systems and components. Section G.3 narrates OBD II concepts as defined by 13 CCR 1968.2.

G.1 FAULT MANAGEMENT NARRATIVE - INTRODUCTION

Section G.1 defines the scope of Appendix G, and identifies the purpose of the models given in Figure G 1 and Figure G 2.

G.1.1 Fault Management Narrative Models

Figure G 1 and Figure G 2 illustrate the relationships between diagnostic messages used to provide diagnostic conditions or diagnostic trouble codes (DTCs) from the vehicle's electronic components to a diagnostic service tool. The figures focus upon defining when particular J1939 services are used, based on when the diagnostic condition was detected. The figures 'sort' DTCs, showing when DM1, DM2, DM6, DM12, and DM23 are used to convey the status of the condition. DM6 (pending), DM12 (confirmed, MIL on) and DM23 (confirmed, MIL off) are required by governmental regulations of emissions-related, OBD-compliant components or systems.

G.1.2 Fault Narrative Model Limitations

These figures are not exhaustive. In Figure G 2, many additional requirements defined or implied by 13 CCR 1968.2 are not modeled. For example, the effects of a diagnostic clear request (DM3/DM11) are not modeled. Requirements to store and manage freeze frame information (provided by DM24/DM25) when conditions are detected are also not discussed.

G.1.3 Fault Management Narrative Organization

Figure G 1 models fault reporting for components and systems that are not emissions related. Figure G 2 models fault reporting for OBD-compliant components and systems meeting Title 13 California Code of Regulations Section 1968.2. The figures show how the status of a fault or DTC is managed. The reporting requirements are then noted as semantic actions for individual states. The narrative for Figure G 1 is given in section G.2. Figure G 2 is discussed in section G.3.

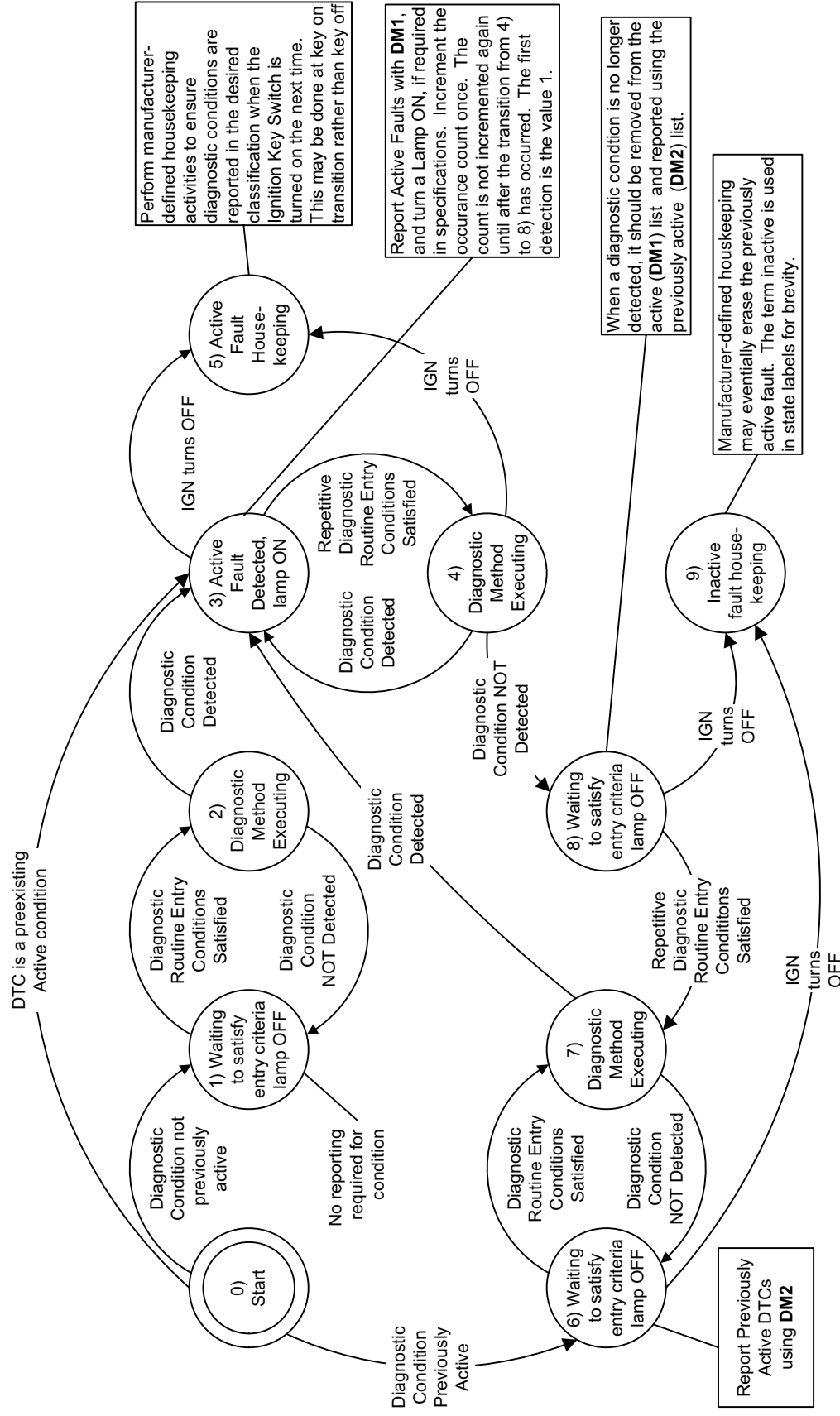


FIGURE G 1 - DIAGNOSTIC REPORTING SERVICES BEFORE HD OBD

G.2 FAULT MANAGEMENT NARRATIVE FOR NON-OBD-RELATED COMPONENTS/SYSTEMS

Sections G.2.1 through G.2.4 discuss Figure G 1. Together, they form a narrative for components that are not emissions-related and have not been regulated.

G.2.1 Fault Management Narrative for Non-OBD-Related Components Introduction

Figure G 1 shows the relationship between DM1 and DM2 for components and systems that are not required to comply with OBD provisions. These components will not support DM6, DM12 and DM23. They will use DM1 to indicate active diagnostic conditions, and DM2 to provide previously active diagnostic conditions. Figure G 1 shows an abstract model of events. Diagnostic method details are not shown to focus upon illustrating the relationship between DM1 and DM2.

Figure G 1 presents a state transition diagram that treats each fault or DTC as a separate token. By placing the set of DTCs supported by the system as tokens into state 0, the diagram sorts the DTCs, identifying the subsets of active and previously active DTCs. Figure G 1 also discusses how the occurrence count is incremented, when the 'DTC' is detected. State labels use the term 'inactive' to describe the previously active faults reported by DM2 to better fit the label into the circles in Figure G 1.

G.2.2 Fault Management Narrative for Non-OBD-Related Components Active DTCs

The state transition diagram begins at state 0. In state 0, each DTC waits for the diagnostic process to begin. In Figure G 1, the process uses a transition of the ignition key from off to on. A DTC may transition to one of three states from state 0. If the DTC was not detected previously, it transitions to state 1 and waits for its entry conditions to be satisfied. When entry conditions are satisfied, state 2 models its evaluation process.

After a decision is reached in state 2, the DTC transitions from state 2 back to state 1 or forward to state 3. State 3 captures the Active Faults for detected diagnostic conditions. Transitions into state 3 from state 2 or into state 3 from state 7 increment the occurrence count for the DTC. The occurrence count is not incremented when state 3 is entered from state 4. Depending upon the severity of the condition, a lamp may be lit when the condition has been detected. MIL-status will not be indicated on for non-OBD-related com

Diagnostics are usually evaluated iteratively. In Figure G 1 this is modeled by the cycles from state 2 to state 1, from state 7 to state 6, and from state 4 back to state 3. These cycles maintain the initial sorting from state 0, keeping the Active and Previously Active subsets separate from each other and the rest of the DTCs. Repeated evaluation of a diagnostic method, after it has been detected, can lead to the conclusion that the failure condition detected is no longer present. This is modeled by the transition from state 4 to state 8. During this transition any lamp that was illuminated for the DTC is extinguished. Section G.2.3 discusses the previously active states in the model.

The DTC can be recognized as a previously existing active fault. In this case, the DTC transitions from state 0 to state 3. Upon a transition from state 0 to state 3, a 'trouble lamp' may be turned on, but the occurrence count is not incremented.

G.2.3 Fault Management Narrative for Non-OBD-Related Components Previously Active DTCs

The state transition diagram begins at state 0. In state 0, each DTC waits for the diagnostic process to begin. In Figure G 1, the process uses a transition of the ignition key from off to on. A DTC may transition to one of three states from state 0. If the DTC was not detected previously, it transitions to state 1 and waits for its entry conditions to be satisfied.

Previously Active DTCs transition from state 0 to state 6 in Figure G 1. Since they are not active, they do not require any lamp to illuminate. After the entry conditions are satisfied, the DTC token transitions from state 6 to state 7. The DTC transitions from state 7 back to state 6 or forward to state 3, after a diagnostic decision has been reached in state 7. State 3 captures the Active DTCs for detected conditions. Section G.2.2 discusses Figure G 1 for active faults.

G.2.4 Fault Management Narrative for Non-OBD-Related Components Housekeeping

Housekeeping across key-on/key-off cycles is modeled in states 5 and 9. The transition from state 0 to state 3 shows one effect of 'housekeeping'. For this transition, the existence of a DTC was recalled from the prior key cycle, and is now provided using DM1. The transition from state 0 to state 3 does not increment the occurrence count.

Information can be saved to administer the transitions from state 0 to states 1, 3, and 6, depending upon the memory capabilities of the component. Clearly components with only volatile memory (ROM and RAM memory) will not be capable of transitioning from state 0 to states 6 or 3. They will not provide occurrence counts across key cycles.

In this example, ignition key cycles are discussed as the defining trip events. Other endpoints are possible. For example, the endpoints may be defined by engine-start to engine start. Definitions in OBD regulations include engine start endpoints. The J1939-73 standard does not require a specific endpoint definition for DM1 and DM2 for all vehicle components.

G.3 J1939-73 FAULT MANAGEMENT FOR 1968.2 NARRATIVE

Sections G.3.1 and G.3.2 provide a narrative for Figure G 2 which models the relationships among DM1, DM2, DM6, DM12 and DM23.

G.3.1 J1939-73 Fault Management for 1968.2 Narrative Introduction

Figure G 2 shows a state transition diagram that illustrates the use of J1939 diagnostic services for reporting diagnostic trouble codes (DTCs) under the requirements of 13 CCR 1968.2. The construction of DM12 and DM23 definitions require Figure G 2 to illustrate the rules for MIL Illumination. Since the regulation discusses fault recording in terms of drive cycles, Figure G 2 shows the consequences of drive cycles on the diagnostics results, and does not discuss ignition key state transitions.

Like Figure G 1, Figure G 2 sorts DTCs by treating them as tokens in the state transition diagram. The state transitions sort the DTC tokens into Pending (DM6) and Confirmed faults (DM12, DM23). Confirmed faults are defined in J1939-73 to be further distinguished by whether they commanding the MIL to light. DM12 conveys confirmed faults that require the MIL to be on. DM23 conveys confirmed faults after the MIL is permitted to be turned off.

To appropriately discuss MIL illumination and fault deletion from the confirmed fault list, two variables are provided for each DTC token that the semantic actions of the state transition diagram maintain. The MIL Countdown counter manages the three sequential 'pass' results needed to turn the MIL off. MIL Warmup Countdown tracks the 40 warmup cycles required before a confirmed fault may be erased.

Reporting OBD DTCs using the existing the Active (DM1) and Previously Active (DM2) services can further enhance service. Figure G 2 shows the linkage between pending and confirmed concepts for OBD and the Active / Previously Active concepts that J1939-73 originally provided. Through this linkage, the OBD faults can be reported in a way that is backwards compatible with prior J1939-73 versions. Thus, this construction creates two separate sets of services to report a DTC. Figure G 2 shows how the sets interrelate.

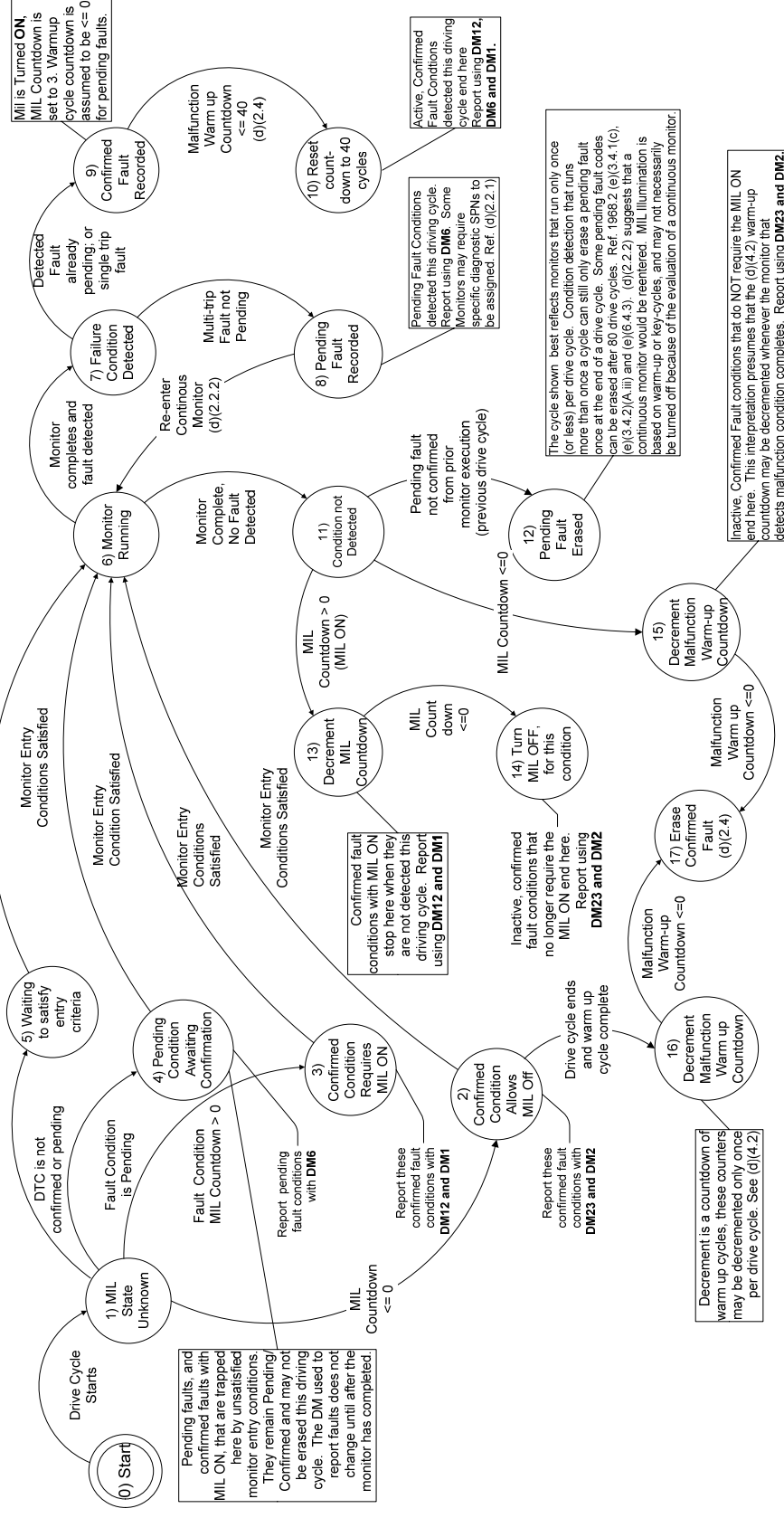


FIGURE G 2 - J1939-73 FAULT MANAGEMENT FOR 1968.2

Like Figure G 1, Figure G 2 sorts DTCs by treating them as tokens in the state transition diagram. The state transitions sort the DTC tokens into Pending (DM6) and Confirmed faults (DM12, DM23). Confirmed faults are defined in J1939-73 to be further distinguished by whether they commanding the MIL to light. DM12 conveys confirmed faults that require the MIL to be on. DM23 conveys confirmed faults after the MIL is permitted to be turned off.

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G.3.2 J1939-73 Fault Management for 1968.2 - Initial State

Like Figure G 1, Figure G 2 sorts DTCs by treating them as tokens in the state transition diagram. Each of the states on Figure G 2 is numbered starting with the initial state, 0. Individual diagnostic conditions transition among the states.

All diagnostic conditions are treated as undetected, and untested, for the current drive cycle when the drive cycle starts. Then the diagnostic conditions or DTCs progress through the states based on past detection history and detection during the current drive cycle. Because the ignition key may be turned off at any time, nearly all states shown are practically final states as well. Some diagnostic methods may not meet their enable or entry criteria in a given drive cycle. Figure G 2 models entry criteria concepts to show the consequences of drive cycles on the services used to report faults.

State 0 transitions to state 1, when a drive cycle starts (immediately after the engine starts). The transitions from state 1 determine whether the MIL should be illuminated from a previously reported, confirmed fault code (shown in state 3), or may remain unlit (after the bulb check). DTCs that have a MIL Countdown greater than 0 driving cycles progress to state 3 and cause the MIL to illuminate. [See 13 CCR 1968.2 (d)(2.3)]. All other DTCs progress to states 2, 4, or 5 depending on whether they are recorded as confirmed (state 2), pending (state 4) or not pending or confirmed (state 5).

G.3.3 J1939-73 Fault Management for 1968.2 Narrative - Detected Conditions

Some diagnostics algorithms require specific operating conditions before they can be evaluated. Continuous diagnostics monitor DTCs transition to state 6 from states 2, 3, 4, and 5 without delay. Monitors with entry conditions, wait until their entry conditions are satisfied. When the monitor completes, it makes a single decision whether the fault condition (DTC) is detected or not detected. Detected faults transition to state 7. Faults that were not detected transition to state 11.

A detected condition may be previously pending. This is modeled by the transition from state 7 to state 9. Detection of a pending fault makes it confirmed. The MIL must be illuminated. Here, a countdown counter is shown being set to 3 to accommodate the three subsequent trip illuminations required of confirmed faults. [See 13 CCR 1968.2 (d)(2.3).] The transition from state 9 to state 10 insures that the warm-up cycle countdown to erase the confirmed fault is set to 40 warm-up cycles, after the MIL is turned on. [(d)(2.4)]. Fault Conditions that dwell in state 10 are reported as Confirmed Faults using DM12. They are also reported as Pending Faults using DM6, because they were detected during the current drive cycle [(d)(2.2.1)]. Finally, they shall be reported as active faults using DM1.

The transition from state 7 to state 8 illustrates the requirements for detected conditions that were not previously pending. When pending faults are recorded [(d)(2.2.1)], they are reported with DM6. They may become confirmed with an iterative evaluation of the test method shown by the transition from state 8 to state 6. [See 13 CCR 1968.2 (d)(2.2.2).] Regardless, they transition from state 1 to state 4 after the next drive cycle restarts the model.

G.3.4 J1939-73 Fault Management for 1968.2 Narrative - Undetected Conditions

State 11 begins the processes for diagnostic conditions that were not detected this driving cycle. State 12 illustrates the erasure of pending faults when they are not detected in the succeeding drive cycle. State 13 signals the illumination of

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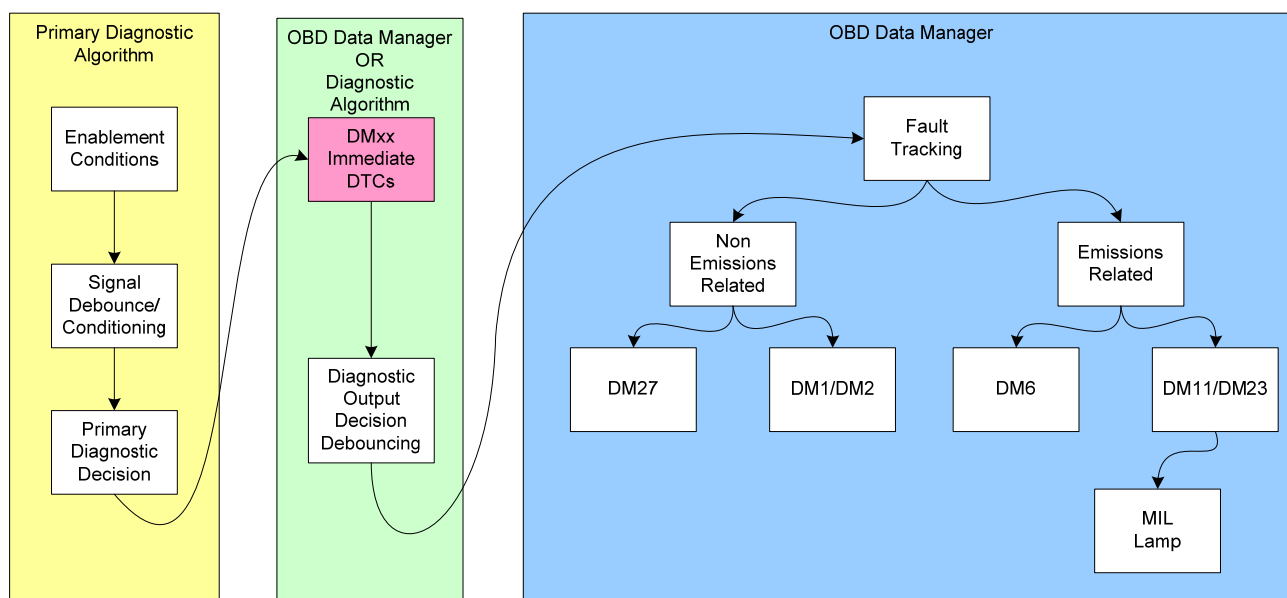
the MIL. DTCs remaining in state 13 require the MIL to be illuminated. The transition from state 13 to state 14 signals that the MIL may be extinguished for the condition. Conditions in state 13 are reported using DM12 and DM1, because they are commanding the MIL ON. Conditions in State 14 are reported with DM23 and DM2.

State 15 begins the process for erasing confirmed fault conditions. If a diagnostic condition no longer commands the MIL on and passes its diagnostics, it may begin the process of counting down its cycles to erasure, shown in state 17. The warm-up cycle countdown is permitted in (d)(4.2) does not require the diagnostic to have completed as long as a qualified warm-up cycle was achieved. This is shown by the transitions from state 2 to state 16 and from state 16 to state 17.

Transitions from states 10, 12, 13, 14, 15, 16, and 17 back to state 6 for continuous diagnostics are not shown. They do not improve the illustration of the relationships of J1939-73 DM1, DM2, DM6, DM12, and DM23 services. The explicit modeling of cycling would have to also include provisions to insure that counters based on warm up cycles are not decremented more than once a warm-up cycle.

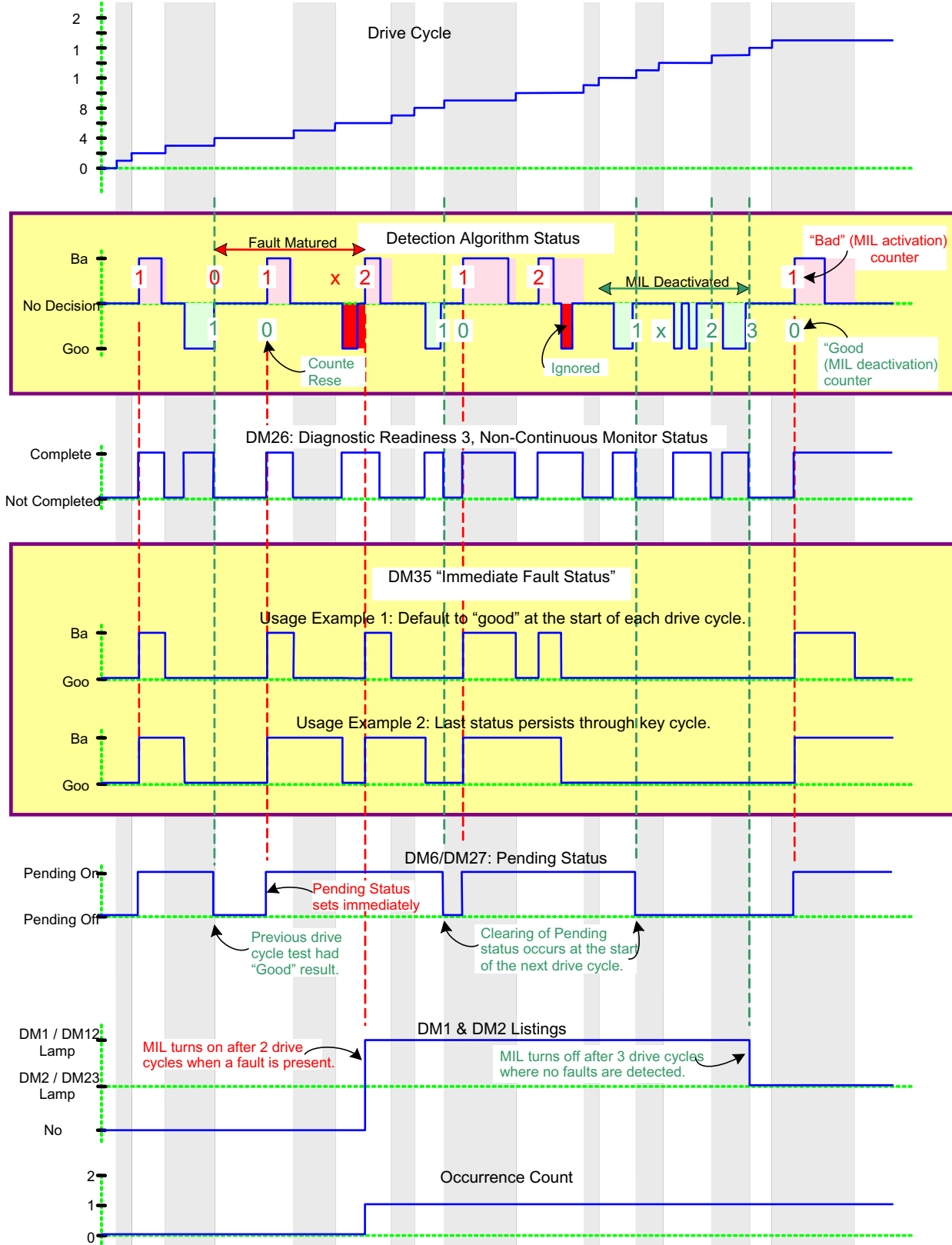
APPENDIX H(R)- DIAGNOSTIC TROUBLE CODE MESSAGE USAGE AND ASSOCIATION

This appendix provides examples that illustrate potential operating sequences for managing faults and managing which messages are used to communicate them. Figure xx shows a possible flow and progression from first detection to an OBD DTC being logged.



(R)FIGURE H - 1; MALFUNCTION DETECTION TO CONFIRMED DTC

OBD 2-Trip Logic



(R)FIGURE H- 2; OBD II TRIP LOGIC