SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Serial Control and Communications Heavy-Duty Vehicle Network - Top-Level Document

RATIONALE

This document has been revised to synchronize terminology that is included in related SAE J1939 recommended practices and technical reports.

FOREWORD

The SAE J1939 communications network is defined using a collection of individual SAE J1939 documents. The SAE J1939 top-level document is the parent document for all other SAE J1939 documents.

The SAE J1939 communications network is a high-speed ISO 11898-1 CAN-based communications network that supports real-time closed loop control functions, simple information exchanges, and diagnostic data exchanges between electronic control units (ECUs) physically distributed throughout the vehicle.

The SAE J1939 communications network is developed for use in heavy-duty environments and suitable for horizontally integrated vehicle industries. The SAE J1939 communications network is applicable for light-duty, medium-duty, and heavy-duty vehicles used on-road or off-road, and for appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include, but are not limited to, on-highway and off-highway trucks and their trailers, construction equipment, and agricultural equipment and implements. The physical layer aspects of SAE J1939 reflect its design goal for use in heavy-duty environments. Horizontally integrated vehicles involve the integration of different combinations of loose package components, like as engine and transmissions, that are sourced from many different component suppliers. The SAE J1939 common communication architecture strives to offer an open interconnect system that allows the ECUs associated with different component manufacturers to communicate with each other.

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For more information on this standard, visit
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1. SCOPE

This top-level document provides a general overview of the SAE J1939 network and describes the subordinate document structure. This document includes definitions of terms and abbreviations which are used among the various SAE J1939 subordinate documents.

1.1 Degree of Openness

An SAE J1939 network is open to the degree that any two ECUs which conform to the same SAE J1939-0X document can be connected via the network and communicate with each other without functional interference. The SAE J1939-0X documents describe a specific type of application, typically representing a specific industry to which it pertains such as agricultural or heavy-duty trucks. It is possible that ECUs will be unable to communicate with one another if they conform to different SAE J1939-0X documents. It is possible that ECUs which conform to different SAE J1939-0X documents can cause degradation or complete disruption of the entire network.

1.2 Proof of Compliance

There is no procedure presently in place to test, validate, or provide formal approval for ECUs utilizing the SAE J1939 network. Each component developer is expected to design their products to the spirit of, as well as the specific content of, this recommended practice. Provisions are made in SAE J1939-11, SAE J1939-14, and SAE J1939-15 for self-certification to these documents. SAE J1939-82 provides methods for self-certifying compliance to several of the other SAE J1939 documents. In the future, additional procedures can be defined and implemented to test new products to ensure full compliance with all appropriate SAE J1939 documents. Until that time, compliance is determined by the manufacturer of the component. Should questions arise regarding the use or interpretation of any part of these recommended practices they should be directed to the SAE Truck and Bus Control and Communications Committee for resolution.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1213	Glossary of Vehicle Networks for Multiplexing and Data Communications
SAE J1939DA	Digital Annex of Serial Control and Communications Heavy-Duty Vehicle Network Data
SAE J1939-1	On-Highway Equipment Control and Communication Network
SAE J1939-2	Agricultural and Forestry Off-Road Machinery Control and Communication Network
SAE J1939-3	On-Board Diagnostics Implementation Guide
SAE J1939-5	Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide
SAE J1939-11	Physical Layer, 250 kbps, Twisted Shielded Pair
SAE J1939-13	Off-Board Diagnostic Connector
SAE J1939-14	Physical Layer, 500 kbps
SAE J1939-15	Physical Layer, 250 kbps, Un-Shielded Twisted Pair (UTP)

SAE J1939-16 Automatic Baud Rate Detection Process

SAE J1939-17 CAN FD Physical Layer, 500 kbps/2 Mbps

SAE J1939-21 Data Link Layer

SAE J1939-22 CAN FD Data Link Layer

SAE J1939-31 Network Layer

SAE J1939-71 Vehicle Application Layer

SAE J1939-73 Application Layer - Diagnostics

SAE J1939-74 Application - Configurable Messaging

SAE J1939-75 Application Layer - Generator Sets and Industrial

SAE J1939-76 SAE J1939 Functional Safety Communications Protocol

SAE J1939-81 Network Management

SAE J1939-82 Compliance

SAE J1939-84 OBD Communications Compliance Test Cases for Heavy-Duty Components and Vehicles

SAE J1939-90 OBD Traceability Matrix

2.1.2 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 7498 Information Processing Systems - Open Systems Interconnection (OSI) - Basic Reference Model

ISO 11898-1:2015 Road Vehicles - Controller Area Network (CAN) - Part 1: Data Link Layer and Physical Signaling

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

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

SAE J1708 Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications

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

2.2.2 ASAM (Association for Standardisation of Automation and Measuring Systems) Publications

Available from ASAM, Altlaufstr. 40, 85635 Höhenkirchen, Germany, www.asam.net.

ASAM MCD-1 CCP CAN Calibration Protocol

ASAM MCD-1 XCP The Universal Measurement and Calibration Protocol Family

2.2.3 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 11783 Tractors and Machinery for Agriculture and Forestry - Serial Control and Communications Data Network (Parts 1 through 14)

ISO 11992 Road Vehicles - Electrical Connections Between Towing and Towed Vehicles - Interchange of Digital Information (Parts 1, 2, and 3)

ISO 15765-3 Road Vehicles - Diagnostics on Controller Area Network (CAN) - Part 3: Implementation of Unified Diagnostic Services (UDS on CAN)

2.2.4 NMEA (National Marine Electronics Association) Publications

Available from National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Arlington, VA 22209, Tel: 703-841-3200, www.nema.org.

NMEA 2000 NMEA 2000 Interface Standard

3. DEFINITIONS AND ABBREVIATIONS

Definitions provided herein supersede those contained in SAE J1213. SAE J1213 applies throughout otherwise.

3.1 Definitions

3.1.1 ACKNOWLEDGMENT

An SAE J1939 Parameter Group (message) used to indicate the positive or negative response to a received message or a requested action.

3.1.2 ADDRESS

The 8-bit numeric value used to identify a device communicating on an SAE J1939 network, also known as an SAE J1939 Address. SAE J1939 addresses are used with SAE J1939 data frames to identify the source of a message (source address), and sometimes the intended destination of a message (destination address).

3.1.3 ADDRESS ARBITRATION

The SAE J1939 process for multiple controller applications to resolve conflicts when attempting to acquire an address on an SAE J1939 network.

3.1.4 APPLICATION LAYER PROTOCOL DATA UNIT (A_PDU)

This SAE J1939 application layer protocol data unit contains the PG identity (PGN), the PG data, and supporting metadata necessary for use in a D_PDU.

3.1.5 BRIDGE

A network device used to transfer message frames between two network segments with the same data link protocol and network address space. A bridge permits communication between network segments that can have physical layer differences, such as the media, the electrical interface, and data rate. A bridge can filter message frames transferred between network segments.

3.1.6 BUS

See segment (3.1.65).

3.1.7 CAN DATA FRAME

Generic term referring to any of the ISO 11898-1 CBFF, CEFF, FBFF, and FEFF data frames.

3.1.8 CLASSICAL BASE FRAME FORMAT (CBFF)

An ISO 11898-1 CAN data frame with an 11-bit identifier, a single bit rate, and a maximum data field length of 8 bytes.

3.1.9 CLASSICAL EXTENDED FRAME FORMAT (CEFF)

An ISO 11898-1 CAN data frame with a 29-bit identifier, a single bit rate, and a maximum data field length of 8 bytes.

3.1.10 CONTROLLER APPLICATION (CA)

The software application that performs a system control function, such as controlling the transmission or engine, and communicates on the SAE J1939 network. The software in an ECU can consist of one or more controller applications for one or more system control functions.

3.1.11 CYCLIC REDUNDANCY CHECK (CRC)

An error control mechanism for detecting transmission errors.

3.1.12 DATA FIELD

The part of a CAN data frame that contains the data (payload). Data field is not equivalent to PG Data (see 3.1.49). For CBFF and CEFF data frames, the longest data field is 8 bytes. For FBFF and FEFF data frames, the longest data field is 64 bytes.

3.1.13 DATA PAGE (DP)

a. A 1-bit field in the 29-bit identifier in an SAE J1939 data frame that is used together with the EDP bit to classify and indicate how the 29-bit identifier is to be interpreted. Refer to SAE J1939-21 or SAE J1939-22 for the interpretations of the EDP and DP combinations.

b. A 1-bit field of the four fields that comprise the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

3.1.14 DATALINK LAYER PROTOCOL DATA UNIT (D_PDU)

The SAE J1939 datalink layer protocol data unit for transmitting A_PDUs by the CAN controller.

3.1.15 DESTINATION ADDRESS (DA)

a. The use of an SAE J1939 Address to explicitly identify the intended receiver of an SAE J1939 message or SAE J1939 data frame.

b. The interpretation of the PDU specific (PS) field in the 29-bit identifier of a D_PDU1 data frame.

3.1.16 DEVICE

A physical component with one or more network connections.

3.1.17 DIAGNOSTIC TROUBLE CODE (DTC)

A 4-byte data structure that describes a detected failure for a suspected parameter or system condition. The DTC consists of an SPN and an SAE J1939 Failure Mode Indicator (FMI), where the SPN identifies the parameter or condition being diagnosed and the FMI identifies the type of failure detected.

3.1.18 D_PDU1 DATA FRAME

The destination-specific form of the SAE J1939 data frame. The 29-bit identifier of the CEFF or FEFF data frame uses 8 bits as the SAE J1939 address of the destination of the data frame and 10 bits to identify the PGN of the SAE J1939 PG associated with the data frame data field. The SAE J1939 PG is identified by the EDP, DP and PF values of its PGN; the PS value of the PGN is always 0. A D_PDU1 SAE J1939 data frame has a PF field with a value less than 240.

3.1.19 D_PDU2 DATA FRAME

The broadcast-only form of the SAE J1939 data frame. The 29-bit identifier of the CEFF or FEFF data frame uses 18 bits to identify the PGN of the SAE J1939 PG associated with the data frame data field. The SAE J1939 PG is identified by the EDP, DP, PF, and PS values of its PGN. A D_PDU1 SAE J1939 data frame has a PF field with a value greater than or equal to 240.

3.1.20 ELECTRONIC CONTROL UNIT (ECU)

A computer based electronic assembly that can send or received SAE J1939 messages.

3.1.21 END OF FRAME (EOF)

A 7-bit field sequence specified by ISO 11898-1 for marking the ending of a CAN data frame.

3.1.22 EXTENDED DATA PAGE (EDP)

a. A 1-bit field in the 29-bit identifier of an SAE J1939 data frame that is used together with the DP bit to classify and indicate how the 29-bit identifier is to be interpreted. Refer to SAE J1939-21 or SAE J1939-22 for the interpretations of the EDP and DP combinations.

b. A 1-bit field of the four fields that comprise the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

3.1.23 FD BASE FRAME FORMAT (FBFF)

An ISO 11898-1 CAN data frame with an 11-bit identifier, a flexible bit rate, and a maximum data field length of 64 bytes.

3.1.24 FD EXTENDED FRAME FORMAT (FEFF)

An ISO 11898-1 CAN data frame with a 29-bit identifier, a flexible bit rate, and a maximum data field length of 64 bytes.

3.1.25 FUNCTION

a. An 8-bit field in the SAE J1939 NAME object that identifies the function performed by the controller application.

b. A description of the basic purpose or activity of a controller application, relative to controlling or monitoring a particular system or subsystem. For example, “engine control” is an appropriate function description of the controller application controlling the engine operations.

3.1.26 GATEWAY

A network device which transfers messages between two dissimilar networks. A gateway repackages data into new message groups and performs address translation when transferring messages from one network segment to another.

3.1.27 GROUP EXTENSION (GE)

Describes the interpretation of the PDU specific (PS) field in the 29-bit identifier of a D_PDU2 format SAE J1939 data frame. The group extension is the PS value of the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

3.1.28 IDENTIFIER

a. The identifier field bits in the arbitration field of a CEFF, CBFF, FEFF, or FBFF data frame.

b. General reference to an SAE J1939 numeric value used to identify a specific piece of information, such as an SAE J1939 PGN, SAE J1939 SPN, SAE J1939 NAME Function, or SAE J1939 Manufacturer code.

3.1.29 IDLE

A state on the CAN bus where no node is transmitting or attempting to transmit data.

3.1.30 IMPLEMENT

A tool or piece of equipment consisting of one or more ECUs which can be attached to or detached from the vehicle as a unit.

3.1.31 MEDIA

The physical entity which conveys the electrical transmission (or equivalent means of communication) between ECUs on the network. For SAE J1939-11, the media consists of shielded twisted pair copper wires. For SAE J1939-15, the media consists of un-shielded twisted pair copper wires.

3.1.32 MESSAGE

See SAE J1939 Message (3.1.62).

3.1.33 MESSAGE FRAME

See SAE J1939 Data Frame (3.1.61).

3.1.34 MULTIPACKET MESSAGE

An SAE J1939 PG that can have PG data longer than the data field of an SAE J1939 data frame. When the PG data is longer than the data field of an SAE J1939 data frame, multiple SAE J1939 data frames are used to transmit the PG data over a data link.

3.1.35 NAME

An 8-byte value describing the primary function of a CA and its instance on the network or system.

3.1.36 NEGATIVE ACKNOWLEDGE (NACK)

A form of the Acknowledgement PG that indicates a request message is not understood or a requested action was not performed.

3.1.37 NETWORK INTERCONNECTION ECU (NIECU)

An ECU that provides interconnection of messages between one or more network segments. The standard types of NIECUs are repeater, bridge, router, and gateway.

3.1.38 NETWORK SEGMENT

See segment (3.1.65).

3.1.39 NODE

A specific hardware connection of an ECU to the physical media. A node can have more than one SAE J1939 source address claimed on the network if its software consists of multiple controller applications for multiple system control functions.

3.1.40 NON-VOLATILE

Retention of changeable memory values even though power is turned off for any reason. This term is used with respect to data values, such as claimed source addresses or NAMEs, that can change during use. Read only memory (ROM) is technically non-volatile, but is not changeable during use and thus not what is referred to by this term within these documents.

3.1.41 ORIGINATOR

A controller application that is the original communication endpoint for a transmitted SAE J1939 data frame or SAE J1939 message.

3.1.42 PACKET

See SAE J1939 data frame (3.1.61).

3.1.43 PARAMETER GROUP (PG)

An SAE J1939 standardized message for conveying data for zero or more data parameters. Parameter groups communicate application layer data and commands, such as engine speed or valve actuator position, application layer diagnostic information, such as active diagnostic trouble codes (DTC), as well as fundamental communication services, such as PG requests, transport protocol, and address claim.

A parameter group describes a PDU at the highest originating or consuming OSI layer. For SAE J1939, most PGs describe a PDU at the application layer; however, for some PGs, such as the Transport Protocol PGs, a PG can describe a PDU at OSI layers between the application layer and data link layer. Parameter groups are not defined specific to any source address thus allowing any source to send any PG.

Each SAE J1939 PG is assigned a unique Parameter Group Number (PGN). The PG data definition defines the collection of data parameters (SPs) and the placement of the parameter's data in the PG data.

3.1.44 PARAMETER GROUP NUMBER (PGN)

A numeric value assigned to each defined SAE J1939 PG and used to uniquely identify the parameter group. The PGN is a numeric representation of the Extended Data Page (EDP), Data Page (DP), PDU format (PF), and PDU specific (PS) values assigned to an SAE J1939 Parameter Group.

3.1.45 PDU FORMAT (PF)

a. An 8-bit field of the four fields that comprise the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

b. An 8-bit field in the 29-bit identifier of an SAE J1939 data frame. The value of the PF field identifies the data frame as either a D_PDU1 or D_PDU2 data frame.

3.1.46 PDU SPECIFIC (PS)

a. An 8-bit field of the four fields that comprise the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

b. An 8-bit field in the 29-bit identifier of an SAE J1939 data frame. The interpretation of the PS field differs between D_PDU1 and D_PDU2 data frames. For a D_PDU1 data frame, the PS field is interpreted as the destination address of the data frame. For a D_PDU2 data frame, the PS field is the group extension containing the PS value of the PGN of the PG.

3.1.47 PDU1 FORMAT

a, The classification of an SAE J1939 Parameter Group that can be sent to a specific destination address (DA). The PGN's PF value is less than 240 and the PGN's PS value is always 0.

b. The destination-specific form of the SAE J1939 data frame. See D_PDU1 Data Frame (3.1.18).

3.1.48 PDU2 FORMAT

a. The classification of an SAE J1939 Parameter Group that can only be sent broadcast. The PGN's PF value is greater than or equal to 240.

b. The broadcast-only form of the SAE J1939 data frame. See D_PDU2 Data Frame (3.1.19).

3.1.49 PG DATA

A structured data object containing the parameter data for an SAE J1939 Parameter Group. The contents and structure of the data is specified in the PG data definition. PG data is not be confused with the data field of a CAN data frame (see 3.1.12).

3.1.50 PG DATA DEFINITION

Specifies the content and structure of the PG data; i.e., the data for an SAE J1939 parameter group. The definition specifies the parameter data content (by SP) and the position of the data for each parameter within the data object. Parameter data position is specified as either an absolute position (specific byte and bits placement) or relative position (subsequent placement following data for another parameter). The structured data object is defined with a fixed (non-variable) length or a variable length.

3.1.51 POSITIVE ACKNOWLEDGE (ACK)

A form of the Acknowledgment PG that indicates the requested action is understood and performed.

3.1.52 PREFERRED ADDRESS

A recommended address for a controller application to first attempt to claim during address claim. Preferred addresses are assigned by the SAE J1939 Committee for system functions that are fairly common across most industries. The SAE J1939 Committee has discontinued assignment of new industry group-specific preferred addresses.

3.1.53 PRIORITY

A 3-bit field in the 29-bit identifier of the SAE J1939 CEFF and FEFF data frames and the 11-bit identifier of the SAE J1939 CBFF data frame. The priority field is only used to influence which CBFF, CEFF or FEFF data frame gets transmitted when two or more nodes are contending to send CBFF, CEFF and/or FEFF data frames on the bus. The priority field is not used for filtering received SAE J1939 data frames. A default priority value is specified for each SAE J1939 Parameter Group. Applications are generally permitted to use a different priority value from the specified default priority, but this should be done only as required to resolve system issues, such as bus access problems with certain messages.

3.1.54 PROTOCOL DATA UNIT (PDU)

A single unit of information for communicating or exchanging data over a network. Along with the data, a PDU includes OSI layer specific information and metadata, such as data identification or addresses. The PDU is exchanged between different OSI layers. A PDU at a specific OSI layer is prefaced by an indication of the layer; e.g., A_PDU identifies an application layer PDU while D_PDU identifies a data link layer PDU.

3.1.55 RECIPIENT

A controller application that is a communication endpoint for a transmitted SAE J1939 data frame or SAE J1939 message.

3.1.56 RECEIVER

See recipient (3.1.55).

3.1.57 REPEATER

A physical layer network device that receives a digital signal from one network segment and regenerates the digital signal on another network segment, with no processing of the data in any manner. The data rate, data link protocol, and address space are the same on both network segments connected by a repeater.

3.1.58 ROUTER

A network device that transfers message segments between network segments with independent address spaces, data rates, and/or media. The data link protocol is the same between network segments connected by a router. A router remaps the addresses for a message segment that is transferred between network segment. A router uses some form of an address look up table that associates an address on one network segment with a corresponding address on the other network segment.

3.1.59 RESPONDER

A controller application that transmits an SAE J1939 data frame or SAE J1939 message in response or reaction to a received SAE J1939 data frame or SAE J1939 message.

3.1.60 SAE J1939 COMMITTEE

Abbreviated reference for the SAE Truck and Bus Control and Communications Committee.

3.1.61 SAE J1939 DATA FRAME

A CEFF, FEFF, CBFF or FBFF CAN data frame where the bits in the CAN data frame identifier are interpreted according to their meaning as assigned by SAE J1939-21 or SAE J1939-22. For a CEFF or FEFF CAN data frame, the bits in the 29-bit identifier are interpreted according to their meaning as assigned by SAE J1939-21 or SAE J1939-22. For a CBFF or FBFF CAN data frame, the bits in the 11-bit identifier are interpreted according to their meaning as assigned by SAE J1939-21 or SAE J1939-22. An SAE J1939 data frame can contain an SAE J1939 message in its entirety or a fragment of an SAE J1939 message.

3.1.62 SAE J1939 MESSAGE

An SAE J1939 Parameter Group, consisting of the PGN (PG identifier), the entire PG data, and its metadata. SAE J1939 message refers to a PDU at the application layer; however, for some PGs, such as the Transport Protocol PGs, SAE J1939 message can refer to PDUs at OSI layers between the application layer and data link layer. An SAE J1939 message can be transmitted in its entirety in a single SAE J1939 data frame or it can be transmitted in its entirety using multiple SAE J1939 data frames.

3.1.63 SAE J1939 MESSAGE FRAME

See SAE J1939 Data Frame (3.1.61).

3.1.64 SAE J1939 NOT AVAILABLE BIT ENCODING

The SAE J1939 data encoding practice for encoding PG data bits that are (a) unassigned (unspecified), (b) unsupported, or (c) data is not available/not provided. Per this data encoding practice, such PG data bits are encoded with a 1b. This practice allows a recipient of the PG data to determine if data is provided for any data parameter assigned to those PG data bits. This practice also allows the SAE J1939 Committee to assign a data parameter to unassigned PG data bits of a PG at a future time.

3.1.65 SEGMENT

A physical section of a vehicle or system communications network, bounded by the ECUs and network interconnection ECUs directly to it. Multiple segments can be connected together by NIECUs.

3.1.66 SOURCE ADDRESS (SA)

a. An 8-bit field in the 29-bit identifier of an SAE J1939 data frame that identifies the SAE J1939 address of the originator of the data frame. See also address (3.1.2).

b. The SAE J1939 address used by a Controller Application as its address on a network.

3.1.67 START OF FRAME (SOF)

A 1-bit field specified by ISO 11898-1 for indicating the beginning of the frame.

3.1.68 SUSPECT PARAMETER (SP)

A diagnosable data parameter, component, event, or condition. An SAE J1939 SP has a text label which describes the parameter, component, event, or condition. An SP can have data encoding definition for parametric data associated with the parameter, component, event, or condition.

3.1.69 SUSPECT PARAMETER NUMBER (SPN)

A 19-bit number used to identify a particular Suspect Parameter. The primary use of the SPN is as part of an SAE J1939 diagnostic trouble code (DTC), where the SPN identifies the element, component, or parameter suspected of exhibiting the diagnostic condition. The SPN is also used by Parameter Group definitions to identify or cross reference each data parameter contained within its PG data. An SPN assignment has a text label which describes the SP. An SPN assignment can include a data encoding definition for an SP that can have associated parametric data.

3.1.70 SUBNETWORK

General term referring to a SAE J1939 segment on an SAE J1939 network with multiple segments. Subnetworks can include: tractor, trailer, implement, and braking system. Subnetworks can be separated by a bridge or router to minimize total bus loading. Collectively, the subnetworks are the vehicle’s SAE J1939 network.

3.1.71 TRANSMITTER

The node that is originating the SAE J1939 data frame on the SAE J1939 network.

3.1.72 VEHICLE

A machine which, in most applications, includes a capability to propel itself and includes one or more SAE J1939 segments. A vehicle can be assembled of one or more vehicle systems connected together to form the whole vehicle.

3.1.73 VEHICLE SYSTEM

A subcomponent of a vehicle, or a component that is analogous to a subcomponent of a vehicle, that includes one or more SAE J1939 segments and can be connected or disconnected from the vehicle. A vehicle system can be made up of one or more functions, which have ECUs that are connected to an SAE J1939 segment of the vehicle system.

3.2 Abbreviations

ABS	Antilock Braking System
ACK	Acknowledge (positive acknowledge)
ASCII	American Standard Code for Information Interchange
CA	Controller application
CAN	Controller Area Network
CBFF	Classical Base Frame Format
CEFF	Classical Extended Frame Format
Con-Ag	Construction-agriculture industry
CRC	Cyclic redundancy check
DA	Destination Address
DF	Data frame
DLC	Data length code
DP	Data Page
ECM	Engine control module
ECU	Electronic control unit
EDP	Extended Data Page
EOF	End of frame
FBFF	Flexible Data Rate Base Frame Format
FEFF	Flexible Data Rate Extended Frame Format
GE	Group extension
ID	Identifier
LSB	Least significant byte or least significant bit
MAC	Medium access control
MSB	Most significant byte or most significant bit
NA	Not allowed or not available
NACK	Negative-acknowledge
OSI	Open system interconnect
P	Priority

PDU Protocol data unit

PF PDU format

PG Parameter Group

PGN Parameter Group Number

PID Parameter identifier

PS PDU specific

PTO Power take-off

R Reserved

SA Source address

SID Subsystem identifier

SLOT Scaling, Length, Offset, and Transfer function

SP Suspect parameter

SPN Suspect parameter number

un Undefined

3.3 Documentation Structure and Guide

Table 1 lists all of the individual SAE J1939 documents and a brief summary of the technical content of each document. The summary lists key technical content for each document as an aid to find certain SAE J1939 technical topics.

Table 1 - Summary of SAE J1939 documents

Document	Content Summary
SAE J1939: General documents	
SAE J1939	• General introduction to SAE J1939 network
SAE J1939-0X: Industry or application network	
SAE J1939-1	• Minimum set of SAE J1939 documents for on-highway equipment
SAE J1939-2	• Application of SAE J1939 in agricultural and forestry equipment
SAE J1939-3	• Technical requirements for heavy-duty vehicle use of SAE J1939 to meet OBD requirements
SAE J1939-5	• Application of SAE J1939 for compliance with OBD-M requirements for marine sterndrive and inboard spark ignited engines
SAE J1939-1X: Physical layer documents	
SAE J1939-11	• Technical specifications for CAN 250 kbit/s SAE J1939 network with shielded twisted cable • Network topology constraints, such as number of nodes, stub lengths, backbone lengths, location of terminating resistors, etc. • CAN bit timing register settings requirements • ECU electrical characteristics • Cabling electrical characteristics • Electrical signal timing requirements
SAE J1939-13	• Diagnostic connector electrical and mechanical requirements • Diagnostic connector pin assignments, connector keying, etc. • Vehicle and off-board requirements for Type I and Type II diagnostic connectors

Document	Content Summary
SAE J1939-14	• Technical specifications for CAN 500 kbit/s SAE J1939 network • Network topology constraints, such as number of nodes, stub lengths, backbone lengths, location of terminating resistors, etc. • CAN bit timing register settings requirements • ECU electrical characteristics • Cabling electrical characteristics • Electrical signal timing requirements
SAE J1939-15	• Technical specifications for CAN 250 kbit/s SAE J1939 network with unshielded twisted cable • Network topology constraints, such as number of nodes, stub lengths, backbone lengths, location of terminating resistors, etc. • CAN bit timing register settings requirements • ECU electrical characteristics • Cabling electrical characteristics • Electrical signal timing requirements
SAE J1939-16	• Network requirements for baud rate detection • Process to detect the baud rate of an SAE J1939 network segment
SAE J1939-17	• Technical specifications for a CAN FD 500 kbit/s / 2Mbit/s SAE J1939 network • Network topology constraints, such as number of nodes, stub lengths, backbone lengths, location of terminating resistors, etc. • CAN bit timing register settings requirements • ECU electrical characteristics • Cabling electrical characteristics • Electrical signal timing requirements
SAE J1939-2X: Data link layer	
SAE J1939-21	• Data link layer specification for a CAN SAE J1939 network • SAE J1939 Request and Acknowledgement PGs (A_PDUs) and behavior requirements • SAE J1939 Transport Protocol PGs (CTS/RTS and BAM) (T_PDUs) and behavior requirements • SAE J1939 D_PDU1 (destination specific CEFF data frame) • SAE J1939 D_PDU2 (global broadcast CEFF data frame) • SAE J1939 CBFF data frame details
SAE J1939-22	• Data link layer specification for a CAN FD SAE J1939 network • SAE J1939 Request and Acknowledgement PGs (A_PDUs) and behavior requirements • SAE J1939 Multi-PG PGs (T_PDUs) and behavior requirements • SAE J1939 FD Transport Protocol PGs (CTS/RTS and BAM) (T_PDUs) and behavior requirements • SAE J1939 D_PDU1 (destination specific FEFF and CEFF data frames) • SAE J1939 D_PDU2 (global broadcast FEFF and CEFF data frames) • SAE J1939 D_PDU3 (global broadcast FBFF data frame) • SAE J1939 CEFF and CBFF data frame restrictions
SAE J1939-3X: Network layer documents	
SAE J1939-31	• Services for communication between different vehicle networks • Functionality for transferring non-SAE J1939 messages over SAE J1939 networks
SAE J1939-7X: Application layer documents	
SAE J1939DA	• All SAE J1939 PGN assignments • All SAE J1939 SPN assignments • SAE J1939 PG (A_PDUs) technical definition details (for most SAE J1939 PGs) • SAE J1939 SP technical definition details (for most SAE J1939 SPs) • Cross reference to documents containing PG and SP technical details • Other SAE J1939 identifier assignments, such as manufacturer IDs, NAME functions, NAME industry groups, preferred source addresses
SAE J1939-71	• SAE J1939 transmission rate descriptions • SAE J1939 SP position notation descriptions • SP data byte order • SP valid data and error indicator value ranges • Unused and unsupported SP data encoding in PG data • Character set for text data parameters • Refer to SAE J1939DA for PG and SP definitions
SAE J1939-73	• SAE J1939 diagnostics related PGs (A_PDUs) and behavior requirements, including active DTCs, previously active DTCs, clearing DTCs, and emissions related DTC reporting services • SAE J1939 diagnostic trouble code (DTC) format • SAE J1939 FMIs assignments and definitions
SAE J1939-74	• Technical details for configurable messages • Exchange information about parameters contained in configurable messages

Document	Content Summary
SAE J1939-75	• Summary of PGs and SPs for generator and utility parameters • Refer to SAE J1939DA for PG and SP definitions
SAE J1939-76	• Technical details for Functional Safety communications using SAE J1939-21 data link layer
SAE J1939-8X: Network Management and Compliance documents	
SAE J1939-81	• SAE J1939 Address Claim and Address Arbitration (method to acquire network address) • SAE J1939 Address Claimed PG definition • SAE J1939 NAME object definition • Behavior requirements when unable to claim address
SAE J1939-82	• Technical requirements for compliance self-assessment to SAE J1939 standards
SAE J1939-84	• Technical requirements for verifying vehicle compliance to OBD off-board diagnostic tool interface requirements using SAE J1939
SAE J1939-9X: Support documents	
SAE J1939-90	• Identifies SAE J1939 SPs and PGs that can be used to satisfy ARB OBD II and HD OBD requirements

SAE J1939 is structured into several parts based on the ISO/IEC 7498 Open System Interconnect (OSI) model. The OSI model provides guidance on organizing the documentation of fundamental functionality and services in one or more standards. Resulting standards, such as SAE J1939, are not required to be explicitly partitioned into these seven layers as long as the fundamental functionality is supported. SAE J1939 uses the OSI model for guidance on partitioning functionality and services among the subordinate standards.

SAE J1939 does not have dedicated documents for each OSI model layer. Additionally, some of the functionality and services commonly associated with a particular OSI layer is specified as part of SAE J1939 documents identified to other OSI layers. For example, Transport Layer functionality and services are specified in the SAE J1939 Data Link layer documents, i.e., SAE J1939-21 and SAE J1939-22.

This document, SAE J1939, is the top level of a hierarchy of related documents. The related documents are identified as “SAE J1939-NX,” where the first digit “N” designates an OSI model layer (one to seven) and the second digit “X” differentiates multiple documents designated to the same OSI model layer. One exception is the SAE J1939DA document which is an application layer (layer seven) document but does not use the “-7X” numbering standard for reasons not relevant to this introduction.

SAE J1939 documents associated with a specific OSI layer are not necessarily exclusive alternatives. In some instances, a single network can allow or can require implementation of multiple SAE J1939 documents associated with the same OSI layer. One example is application layer document for on-highway heavy-duty tractor that utilizes both SAE J1939-71 for the majority of communications and SAE J1939-73 for diagnostics communications, with both sets of messages carried over the exact same network. Another example is physical layer documents for a system that utilizes SAE J1939-13 for the diagnostic connector, SAE J1939-14 for the baud rate and cabling, and SAE J1939-16 for baud rate detection by off-board diagnostic tools. Similarly, a single vehicle/application can utilize different SAE J1939 physical layers for different SAE J1939 networks, such as an on-highway truck where the physical layer used to connect the tractor to the trailer can be different than the physical layer used on the tractor itself.

4. TECHNICAL REQUIREMENTS

This section provides general information about key aspects required for communicating over an SAE J1939 network. This section is offered as informative text for illustrating and clarifying SAE J1939 and providing guidance for the SAE J1939 documents that contain the technical specifications. This section is not a normative definition of an SAE J1939 network.

Refer to the individual SAE J1939 documents listed in 3.3 for the complete definition and specification of each aspect of the network. In 4.15, SAE J1939-1 is used as the basis for some of the examples and is not meant to infer that all SAE J1939 applications must follow SAE J1939-1. Applications can use alternative versions of one or more layers resulting in corresponding changes to the following discussion.

4.1 SAE J1939 Introduction

SAE J1939 defines a CAN communication solution designed to support real-time closed loop control functions and information exchange, such as diagnostic data, between ECUs distributed throughout a vehicle or system or connected to the vehicle or system.

Information is exchanged using standardized SAE J1939 Parameter Groups (PG). A parameter group (message) is a structured data object that contains the data for a predefined set of zero or more parameters. The PG data definition specifies the data parameters and the absolute or relative position of the data for each parameter within the data object. Parameter groups communicate operational data and commands, such as engine speed or valve actuator position, or diagnostic information, such as active diagnostic trouble codes (DTC), as well as fundamental communication services, such as PG requests, transport protocol, and address claim. A unique numeric value, known as the Parameter Group Number (PGN), is assigned to each defined SAE J1939 PG and is used to identify the PG and its PG data in SAE J1939 communications. The data definition for a data parameter specifies the data size and data encoding. An SAE J1939 Parameter Group is a Protocol Data Unit (PDU) at an OSI layer above the data link layer; as such, the size of the PG data for an SAE J1939 parameter group is not limited to the size of the data field of a single data link layer data frame. The PG definition specifies if the PG is transmitted in a continuous unsolicited manner or in a solicited (requested) manner. For a PG with continuous unsolicited transmit behavior, the PG is sent automatically and periodically by a transmitter. Parameter groups are not defined specific to any source address thus allowing any source to send any PG. Most SAE J1939 PGs are fully defined in SAE J1939DA or one of the other SAE J1939 documents. Some SAE J1939 PGs are assigned to other industry standards and the definition for those SAE J1939 Parameter Groups are maintained within the respective industry standard documents.

Data parameters and diagnosable components, events, and conditions are called Suspect Parameters (SP). SAE J1939 assigns a unique numeric value, known as the Suspect Parameter Number (SPN), to every defined data parameter and every diagnosable component, event, and condition. The SPN is communicated primarily as part of an SAE J1939 Diagnostic Trouble Code (DTC). An SAE J1939 DTC is a data structure used by SAE J1939 to describe a detected failure for a suspected parameter or system condition. The DTC consists of an SPN and an SAE J1939 Failure Mode Indicator (FMI), where the SPN identifies the parameter or condition being diagnosed and the FMI identifies the type of failure detected. SAE J1939 DTCs are communicated primarily in the PG data of SAE J1939 Diagnostic Messages defined within SAE J1939-73. SAE J1939 maintains the assignments of SPNs and FMIs; however, SAE J1939 does not specify the combinations SPN and FMI. For an SAE J1939 data parameter, the parameter definition identifies its assigned SPN and specifies the data size, data encoding, and operational definition of the parameter. Outside of its use within an SAE J1939 DTC, the SPN is primarily used in PG data definitions to cross-reference a specific data parameter as part the PG data content. With only a few exceptions, an SAE J1939 SP with a data definition is communicated within only one SAE J1939 PG.

The PG data for an SAE J1939 PG is communicated over an SAE J1939 data link using one or more SAE J1939 data frames. An SAE J1939 data frame is an ISO 11898-1 CAN data frame (CEFF, FEFF, CBFF, FBFF) where the 29-bit identifier or the 11-bit identifier is interpreted according to SAE J1939-21 (Classic CAN) or SAE J1939-22 (CAN FD). For the SAE J1939-21 data link, an SAE J1939 PG is communicated using ISO 11898-1 CEFF data frames, with the CBFF data frames permitted for proprietary communications. For the SAE J1939-22 data link, SAE J1939 PGs are communicated using ISO 11898-1 FEFF data frames and FBFF data frames, with limited use of CEFF and CBFF data frames. SAE J1939 data frames using CEFF and FEFF data frames use the 29-bit identifier to identify the PGN of the PG whose data is contained in the data field, the network address of the transmitter of the data frame, and possibly the network address of the intended recipient of the data frame. The two formats of SAE J1939 data frames using CEFF and FEFF data frames are D_PDU1 and D_PDU2. The D_PDU1 format, commonly known as the destination specific format, contains two addresses (transmitter, recipient) allowing the SAE J1939 data frame to be sent to a specific network device. The D_PDU2 format, commonly known as the broadcast format, contains only one address (transmitter) allowing the SAE J1939 data frame always be sent to all network devices. The D_PDU1 format is best suited for J1939 PGs with control or command data where it can be necessary to send the same message to multiple different controller applications with different data values to each controller application, such as actuator position command to different actuators. The D_PDU2 format is best suited to J1939 PGs with measured or status data, such as engine speed or oil temperature, where the reported data values are the same regardless of the receiver. The D_PDU format supported for an SAE J1939 PG is established when the PGN is assigned to the PG. Most SAE J1939 PGs are defined for using the D_PDU2 format. When the length of the PG data for an SAE J1939 PG exceeds the length of the data field of a single SAE J1939 data frame, then the respective transport protocol service is used to transfer the PG data using a serialized sequence of SAE J1939 data frames. The transport protocol service at the transmitter divides the PG data into serialized fragments and sends each of those fragments in separate SAE J1939 data frames. The transport protocol service at the receiver receives each of those SAE J1939 data frames and reassembles the serialized fragments into the PG data.

Any controller application (CA) that can transmit an SAE J1939 data frame on an SAE J1939 network is required to have an SAE J1939 source address. Every CA that communicates on an SAE J1939 network is required to have a unique SAE J1939 source address; the same source address cannot be used by two or more CAs on the same SAE J1939 network. The Address Claim protocol, specified in SAE J1939-81, is used by a CA to announce, arbitrate, and claim an SAE J1939 source address on the network. The Address Claim protocol also allows a CA to identify the source address and function of other CAs on the network. After a CA successfully claims an SAE J1939 source address, the CA uses that address as the source address for each SAE J1939 data frame it transmits and uses that address when determining if a destination specific SAE J1939 data frame is addressed to the CA. SAE J1939 source addresses are a 1-byte value divided into two classes: Global Preferred Addresses (or fixed function addresses) and Arbitrary Addresses (or dynamic function addresses). Global Preferred Addresses range from 0 to 127 and 248 to 253, and can only be claimed by a CA performing the function assigned to that address by SAE J1939. Arbitrary Addresses range from 128 to 247 and can be claimed by any CA performing any function. Source addresses 254 (NULL) and 255 (Global) are special SAE J1939 addresses with restricted usage.

An SAE J1939 network can consist of a single SAE J1939 segment or multiple SAE J1939 segments connected through network interconnection ECUs. An SAE J1939 segment is defined by a valid combination of an SAE J1939 physical layer and an SAE J1939 data link layer, e.g., SAE J1939-11 physical layer and SAE J1939-21 data link layer. Each of the SAE J1939 segments of an SAE J1939 network are not required to be of the same combination of physical and data link layers; however, a network interconnection ECU is required between SAE J1939 segments with different combination of physical and data link layers. The SAE J1939 physical layers, i.e., SAE J1939-11, SAE J1939-14, SAE J1939-15, and SAE J1939-17, each define the ECU characteristics, bit rate, bus length, node count, cabling, and other network topology requirements for a specific type of physical layer. The SAE J1939 data link layers, i.e., SAE J1939-21 and SAE J1939-22, each define the meaning of the identifier bits in the allowed CAN data frames as well as basic communication services, such as requests and transport protocols. Only certain combinations of SAE J1939 physical layers and SAE J1939 data link layers are valid combinations. SAE J1939-13 specifies the requirements for a standard diagnostic connector for connecting a diagnostic tool to an SAE J1939 network.

The SAE J1939 Committee is the data registration authority for all Parameter Groups (PG) and Suspect Parameter (SP) assignments for SAE J1939 networks. The collection of all assigned SAE J1939 Parameter Groups represents the available SAE J1939 messages for use on SAE J1939 networks. The actual SAE J1939 messages used on an SAE J1939 network is determined by the system integrators and component designers for that application. SAE J1939 does not specify the SAE J1939 messages to be supported by components, sub-systems, or systems. The SAE J1939 Committee meets regularly to review submitted requests to add new SAE J1939 PG and SP assignments to its dictionary, revise existing PG and SP definitions, and assign other standardized SAE J1939 identifiers, such as manufacturer codes and NAME functions.

4.2 Standard and Preassigned SAE J1939 Identifiers

Most of the identifiers used in SAE J1939 communications are standardized by the SAE J1939 Committee. SAE J1939 fully defines messages, parameters, diagnostic identifiers, and other identifiers to establish a well-known information interface that enables components and subsystems from different manufacturers to be integrated and able to interoperate. Communications on an SAE J1939 network is limited to these standardized identifiers.

The SAE J1939 Committee is the data registration authority for the assignments of SAE J1939 PGNs, SPNs, SAE J1939 global preferred source addresses, and several SAE J1939 NAME data components. Some of these identifiers are briefly discussed in 4.3, 4.4, 4.6, and 4.7. The technical definitions for most of these identifiers are documented in SAE J1939DA or one of the other SAE J1939 documents. However, some are assigned to other industry standards and the technical definition for those are maintained within the respective industry standard documents.

Four parameter groups (PropA, PropA2, PropB, and PropB2) and 8096 suspect parameters are assigned by the SAE J1939 Committee for proprietary or manufacturer specific message and diagnostic needs. The PG data definition, SP data definition, and diagnostic meaning of these proprietary identifiers are at the discretion of all application developers. The same PGNs and SPNs are assigned to these proprietary parameter groups and proprietary suspect parameters for all components and manufacturers so additional checks are needed when applications use these proprietary identifiers. See 4.10.6 for more details.

SAE J1939 maintains a dictionary of every Parameter Group and assigned PGN and every Suspect Parameter and assigned SPN. The lists of all assigned SAE J1939 PGs, PGNs, SPs, and SPNs are provided in SAE J1939DA. The industry document containing technical details for each defined SAE J1939 PG is indicated in the PG Document column on the “SPs & PGs” worksheet of SAE J1939DA. The industry document containing technical details for each defined SAE J1939 SP is indicated in the SP Document column on the “SPs & PGs” worksheet of SAE J1939DA.

Some identifiers, such as instance numbers in the SAE J1939 NAME and identity number in the SAE J1939 NAME, are not derived from SAE J1939 managed identifier assignments. The values for such identifiers are at the discretion of the application developer.

4.3 Parameter Groups (PG)

An SAE J1939 Parameter Group, or SAE J1939 message, is a standardized data object (PG Data) that contains data for a predefined group of zero or more data parameters. All data and information communicated over SAE J1939 is done using SAE J1939 PGs. The SAE J1939 Parameter Group Number (PGN) is the unique numeric identifier assigned to each SAE J1939 Parameter Group. The technical definition for an SAE J1939 PG specifies its identity characteristics (PGN, PG Name, Acronym), its PG data definition (data content, PG data length variability), and its transmit characteristics (transmission rate, addressing capability); see 4.3.1 through 4.3.5. Most SAE J1939 PGs are fully specified in SAE J1939DA or one of the other SAE J1939 documents. Some SAE J1939 PGs are assigned to other industry standards and the definition for those SAE J1939 Parameter Groups are maintained within the respective industry standard documents.

The majority of SAE J1939 PGs are Application Layer PDUs (A_PDU) that communicate operational data and commands, such as engine speed or valve actuator position, or diagnostic information, such as active diagnostic trouble codes (DTC). A few SAE J1939 PGs are defined for communication services, such as PG requests, transport protocols, and address claim, and can be associated to OSI layers between the application layer and the data link layer. SAE J1939 PGs are not defined specific to any source address thus allowing any source to send any PG.

SAE J1939 fully defines the Parameter Groups and parameters, establishing a well-known information interface that enables components and subsystems from different manufacturers to be integrated and to interoperate. All transmitted SAE J1939 PG on an SAE J1939 network shall only be standardized SAE J1939 PG and shall conform to the SAE J1939 specified characteristics including, but not limited to, transmission rate, data content, data placement, and data encoding. The PG data for each transmitted SAE J1939 PG shall only contain data for the parameters specified for that SAE J1939 PG and encoded as specified for each parameter. The only exception is the data communicated using SAE J1939 PG defined as proprietary messages, i.e., PropA, PropA1, PropB, and PropB1 PGs, where the parameter data and its placement in the PG data is defined by the transmitter of the proprietary messages.

4.3.1 Parameter Group Number (PGN)

The Parameter Group Number (PGN) is a numeric value that uniquely identifies a SAE J1939 PG. The PGN is most commonly used in SAE J1939 communications to identify the PG associated to the PG data being communicated. The PGN can be communicated as part of the PG Data to identify or reference a specific PG. The PGN can be cited in documentation, specifications, and dialog to refer to a specific PG. SAE J1939 Committee is the data registration authority for all PGN assignments (see 4.2).

There are four numeric components derived from the PGN value - the Extended Data Page (EDP), Data Page (DP), PDU Format (PF), and PDU Specific (PS) values. These numeric components are used in the CAN identifier of a SAE J1939 data frame (CEFF or FEFF data frame) to identify the PGN associated to the PG data in the data frame’s data field. The PF value indicates if the SAE J1939 data frame CAN identifier contains destination addressing.

For PDU1 type PGs, there is only one PG with a specific combination of EDP, DP, and PF values and the PS value is always and only 0. For PDU2 type PGs, there is only one PG uniquely identified by the combination of EDP, DP, PF, and PS value.

4.3.2 PG Name and Acronym

A unique PG Name and unique Acronym are assigned to each Parameter Group to aid in referring to the PG in documentation, specifications, and dialog. The PG Name is a title meant only to provide a general description of the parameter data content, e.g., Transmission Control 1, or the function of the PG; e.g., Request. The Acronym for a PG is generally derived from the PG Name, e.g., TC1 for the Transmission Control 1.

Within SAE J1939 documents, a reference to a specific PG is commonly done using either the PG Name or Acronym, followed by the PGN in parenthesis. For example, Diagnostic Message 1 PG (PGN 65225) or DM1 (PGN 65225).

4.3.3 PG PDU Type (PDU Format) and Destination Addressing

The PDU Type describes the destination addressing capability of the PG. There are two PDU types assigned to SAE J1939 PGs – PDU1 or PDU2.

A PDU1 type PG is commonly referred to as a destination specific PG. Each instance of an PDU1 type PG can be addressed (sent) to a different network device. PDU1 type is best suited for an SAE J1939 PG with control or command information in its PG data, where it can be necessary to send the PG with different parameter data values to different CAs. For example, sending actuator position commands to different actuators. PDU1 type PG can be addressed to a single device or globally to all devices (using the Global Destination Address). Some PDU1 type SAE J1939 PGs have special destination address requirements. For example, the Address Claimed PG and the Acknowledgement PG, both PDU1 type SAE J1939 PGs, each require using the global address (255) as the destination address.

A PDU2 type PG is commonly referred to as a broadcast PG and does not support destination addressing. PDU2 type is best suited for an SAE J1939 PG with measured or status data, such as engine speed or oil temperature, where the reported PG data values are the same regardless of the receiver. A PDU2 type PG can only be sent globally to all devices on the network. A PDU2 type PG cannot be directed only to a specific receiver.

There is a direct correlation between the PDU Format (PF) of the assigned PGN and the PDU Type of the PG. For a PDU1 PG the PDU Format value is from 0 to 239, inclusively, and for a PDU2 PG the PDU Format value is from 240 to 255, inclusively.

4.3.4 PG Data Definition and PG Data Length

The PG data definition for an SAE J1939 PG species the parameters whose data are contained within the structured data (PG Data) and the position of each parameter's data within that structured data object. For each data parameter (SP) communicated within the PG data, the PG data definition references the data parameter (SP) and its data definition by its assigned SPN and specifies the position of the parameter’s encoded data in the PG data structure. The data definition for a data parameter SP provides the technical details such as parameter name, data size, and data encoding (e.g., scaling, offset, units, state value enumerations), as discussed in 4.4. The PG data position of the data for a parameter is specified using in the PG data definition as an absolute position (e.g., bytes 4 to 5) or a relative position (subsequent placement following data for another parameter). Relative position of parameter data is required when the PG data contains at least one parameter with variable length data or contains repeated groups of parameters. SAE J1939-71 discusses the parameter position notation used in SAE J1939 documents. SAE J1939-71 also specifies the byte ordering of parameter data in the PG data for parameters with more than 1 byte of data. The standard byte ordering of parameter in the PG data structure is least significant byte first for parameter data longer than 1 byte. There are byte ordering alternatives for parameters with textual data and parameters with data length of 1 byte or shorter.

The transmitter of an SAE J1939 PG is not required to provide actual parameter data for every SP that is contained in the PG data. SAE J1939 employs the “SAE J1939 not available bit encoding” technique for encoding PG data bits that are not supported by the transmitter. Per this data encoding practice, such PG data bits are encoded with a “1.” This practice allows a recipient of the PG data to determine if data is provided for any data parameter assigned to those PG data bits.

PG data definitions can have PG data bits that are not yet assigned to any parameter. SAE J1939 refers to these bits as unassigned, unspecified, or SAE J1939 reserved bits. These unassigned bits are strictly reserved for future assignment by SAE J1939 and cannot be used at the discretion of component and system designers. The “SAE J1939 not available bit encoding” technique is used to encode PG data bits not yet assigned to a data parameter. This unused PG data bit encoding practice allows SAE J1939 to assign additional data parameters to the unused bits at some future date in order to maximum the data content of the PG data. This special encoding technique allows a recipient of the PG data to determine if data is provided for data parameters assigned to those PG data bits even when a data parameter is assigned to those PG data bits in the future.

Parsing parameter data from PG data for a specific PG requires knowing the position of the parameter's data according to the PG data definition for that PG and the data parameter’s (SP) data definition for the data size and its encoding. For PG data parameters with relative position, parsing the parameter data can require evaluating or parsing other data parameters.

The PG Data Length property of a PG specifies the length characteristic of the PG data. The length of the PG data can be defined as being a fixed (non-variable) length data object or a variable length data object. For a PG defined with a fixed length PG data, the length of the PG data is the specified byte length for every instance of that PG. For a PG defined with variable length PG Data, the length of the PG data can vary between instances for that PG. A PG is defined with variable length PG data when its PG data definition contains parameters with variable length data, contains repeating groups of parameters, and/or its PG data definition can be modified and extended to accommodate additional parameters.

An SAE J1939 PG describes a PDU above the data link layer; therefore, the length of the PG data for a PG can be longer than the maximum length of the data field of a single CAN data frame, e.g., 8 bytes for a CEFF data frame or 64 bytes for a FEFF data frame. SAE J1939-21 and SAE J1939-22 (SAE J1939 data link layers) define transport protocols that are used to transfer PG data when the PG data cannot be sent in its entirety in the data field of a single SAE J1939 data frame. The SAE J1939 Transport Protocol is discussed in more detail in 4.10.

4.3.5 PG Transmission Rate

The PG transmission rate specifies the required transmit behavior and timing requirements for the PG. Most SAE J1939 PGs are transmitted in either a continuous unsolicited behavior or a solicited (requested) behavior. While there are numerous transmission rate models, the most common transmission rate models are continuous unsolicited transmit (e.g., fixed interval period and fixed interval period with event-driven updates) and solicited transmit (e.g., on request). For a PG with continuous unsolicited transmit behavior, the PG is sent automatically and periodically by a transmitter (producer) of the PG. For a PG with solicited transmit behavior, the PG is only sent when requested or prompted. The Request PG (PGN 59904) (refer to SAE J1939-21 or SAE J1939-22) provides the service for requesting (soliciting) another device to transmit a specific PG. The PG data for the Request PG contains the PGN of the PG being requested to be transmitted.

In some instances, the PG transmission rate can also describe required response behavior. For example, the DM3 PG requires an Acknowledgement PG as its response.

4.4 Suspect Parameter (SP) and SPN

The SAE J1939 Suspect Parameter (SP) refers to a diagnosable data parameter, component, event, or condition. Every J1939 SP has an SP Name that describes diagnosable data parameter, component, event, or condition. SAE J1939 assigns a unique numeric value, called the Suspect Parameter Number (SPN), to every defined SAE J1939 SP. The SPN is primarily used as part of an SAE J1939 Diagnostic Trouble Code (DTC) (see 4.9) to identify the system parameter, component, event, or condition that is suspected as having a detected failure or issue. Many J1939 SPs include an SP description that provides an operational definition of the data parameter, component, event, or condition.

SAE J1939 SPs are classified as either a diagnostic-only SP or a parametric SP (data parameter SP). A diagnostic-only SP is an SP whose SPN can only be used in diagnostic reporting with an SAE J1939 DTC. A parametric SP is an SP whose SPN can be used in diagnostic reporting with an SAE J1939 DTC; however, the SP also has a SP data definition whereby related quantifiable data can be communicated within the PG data of an SAE J1939 PG. See 4.4.1 for more details about parametric SP. A diagnostic-only SP can be changed to data parameter SP by adding a data parameter definition and associating the parameter to an SAE J1939 PG.

The SAE J1939 Committee is the data registration authority for all SPN assignments (see 4.2).

4.4.1 Parametric SP (Data Parameter SP)

A parametric SP is a specific type of SAE J1939 SP that includes a data definition whereby related quantifiable data can be communicated within the PG data of an SAE J1939 PG. The SP data definitions for most SAE J1939 parametric SPs are documented in SAE J1939DA or in one of the other SAE J1939 documents, such as SAE J1939-21, SAE J1939-73, and SAE J1939-81. SAE J1939 PG data definitions use the SPN to cross-reference a specific data parameter SP. The SP data definition of the associated parametric SP specifies the encoding used for the parameter data in the PG data. The SP data definition establishes a well-defined interface and strict compliance to the specified characteristics is mandatory.

The technical details of the SP data definition specify the data size and data encoding (e.g., scaling and offset, units, state value enumerations). The data encoding specifies how real world data is strictly encoded for representation in the PG data and vice versa. For parametric SPs with technical details specified in an SAE J1939 document, the data encoding is derived from a standard data encoding called a SLOT (scaling, length, offset, transfer function). A SLOT defines the data bit size, bit value scaling factor, conversion offset, engineering data units, and range of valid engineering values. SLOTs are used to manage and minimize the number of different data encodings used by SAE J1939 data parameters. When assigning a new SAE J1939 parametric SP, SAE J1939 uses an existing SLOT when the scaling factor, units, and engineering data range satisfies the needs for the data parameter. The definition of all defined SLOTs is documented in SAE J1939DA.

For parametric SPs with scaled data, the SLOT used by the SP data definition specifies the data bit length, the bit scaling factor, offset value, and engineering data units. SAE J1939 uses a linear equation (scaled with offset) model for converting between engineering data and the encoded data. The SLOT scaling factor only specifies the finest resolution that can be reported for the data; the scaling factor does not impose a requirement on the measurement capability of the reporting device.

For parametric SPs with state value data, the SLOT used by SP parameter definition specifies the data bit size and the SP data definition specifies the assigned meaning for each value state. For example, the SP data definition can specify the data value 0 indicates “off” and the data value 1 indicates “on.”

Most SAE J1939 SLOTs allocate some of the possible encoded data values for reporting data validity indicators. Data validity indicators are specific encoded values typically used to indicate that valid data is not provided in the PG data for a parameter. Data validity indicators can be used when the parameter is not supported or when valid parameter data is not available due to some condition, like a detected sensor failure, and are compatible with the SAE J1939 Not Available Data Encoding technique. Because of data validity indicators, the number of encoded data values available for encoding valid parameter data is less than the total number of encoded data values per the data size. For example, a 1-byte SLOT allocate 250 encoded data values for valid parameter data and 5 values for data validity; whereas a 2-byte SLOT can allocate 64 255 encoded data values for valid parameter data and 1280 values for data validity. The use of data validity indicators means some data parameters need to use a SLOT with a larger data size. For example, a simple two state data parameter that supports data validity indicators needs to use a 2-bit state value SLOT, where two of the four values (00b and 01b) report operational values, such as “on” and “off,” one value (10b) indicates data error, and one value (11b) indicates parameter not available or unsupported.

As general policy, SAE J1939 only defines one data parameter SP for a specific piece of system data, and the data for that parametric SP is communicated in only one PG. This policy supports interoperability between CAs and subsystems from different manufacturers. In some situations, SAE J1939 has defined a second parametric SP for a piece of system data, but this is usually done only where technical and system design advances warrant reporting the parameter data with better resolution and/or a larger range of valid values.

4.5 SAE J1939 Data Frames

An SAE J1939 data frame is an ISO 11898-1 CAN data frame (CEFF, CBFF, FEFF, FBFF) used to communicate the entire PG data or a fragment of the PG data for an SAE J1939 PG. Specifically, an SAE J1939 data frame is a ISO 11898-1 CEFF, FEFF, CBFF or FBFF CAN data frame where the bits in the 29-bit identifier or 11-bit identifier, respectively, of the CAN data frame arbitration field are interpreted according to their meaning as assigned according to SAE J1939-21 or SAE J1939-22. SAE J1939-21 communicates SAE J1939 PGs using ISO 11898-1 CEFF data frames, with CBFF data frames permitted for proprietary communications. SAE J1939-22 communicates SAE J1939 PGs using both ISO 11898-1 FEFF data frames and FBFF data frames, with limited use of CEFF and CBFF data frames.

SAE J1939 defines two data link layer PDUs, D_PDU1 and D_PDU2, that use the CEFF and FEFF data frames, and one data link layer PDU, D_PDU3, that uses the CBFF and FBFF data frames. CEFF and FEFF data frames are interpreted as SAE J1939 D_PDU1 and D_PDU2 data frames only when the EDP field of the 29-bit identifier contains the value 0. SAE J1939 has not defined data link layer PDUs for CEFF and FEFF data frames with an EDP field value of 1; therefore, the 29-bit identifier for such data frames cannot be interpreted as D_PDU1 and D_PDU2 data frames. SAE J1939-21 and SAE J1939-22 describe the designation of the CEFF and FEFF data frames with an EDP field value of 1.

4.5.1 D_PDU1 (Destination Specific) and D_PDU2 (Broadcast) Data Frames

SAE J1939 defines two data frame PDUs, D_PDU1 and D_PDU2, that use the CEFF and FEFF data frames. D_PDU1 is commonly known as the destination specific data frame and D_PDU2 is commonly known as the broadcast data frame. SAE J1939-21 and SAE J1939-22 have matching functional assignments for the 29-bit identifier bits for the D_PDU1 and D_PDU2 data frames. In general, the type of data frame PDU used for a PG correlates to the PG's PGN Type; more specifically, D_PDU1 data frames are generally used with PDU1 Type PGs and D_PDU2 data frames are generally used with PDU2 Type PGs, though there can be exceptions.

The 29-bit identifier of the D_PDU1 data frame contains two SAE J1939 addresses, one identifying the transmitter and one identifying the destination, allowing the D_PDU1 data frame to be sent to a specific node on the network. The 29-bit identifier of the D_PDU2 data frame contains only one SAE J1939 address, identifying the transmitter, so the D_PDU2 data frame is sent broadcast on the network.

The interpretation of 21 bits of the 29-bit identifier is identical for both D_PDU1 and D_PDU2 data frames, where those 21 bits consist of a 3-bit Priority field, a 1-bit EDP field, a 1-bit DP field, an 8-bit PF field, and an 8-bit transmitter address. The interpretation of the remaining 8 bits of the 29-bit identifier differs between D_PDU1 and D_PDU2 data frames, where those 8 bits identify the destination address in a D_PDU1 data frame and those 8 bits identify the PS value of the PGN in a D_PDU2 data frame. The value in the PF field indicates the data frame as either a D_PDU1 or a D_PDU2 data frame. A D_PDU1 data frame has a PF field value that is less than 240, while a D_PDU2 data frame has a PF field value is greater than or equal to 240.

With a D_PDU1 data frame, 10 bits in the 29-bit identifier indicate the PGN of the PG whose data is contained in the data frame's data field, 8 bits indicate the SAE J1939 address of the transmitter of the data frame, and 8 bits indicate the SAE J1939 address of the intended recipient of the data frame. The D_PDU1 data frame is used only with PDU1 type PGs because the 29-bit identifier omits the PS value of the PGN. For PDU1 type PGs, there is only one PG with a specific combination of EDP, DP, and PF values and the PS value is always and only 0. Because of this, the 29-bit identifier of a D_PDU1 data frame can precisely indicate the PGN of a PDU1 type PG using only EDP, DP, and PF values as the PS value can be unequivocally inferred as 0. Omitting the PS value in the 29-bit identifier frees up 8 bits in a D_PDU1 data frame to indicate the SAE J1939 address of the intended recipient of the data frame. When the Global Destination Address (FFh) is the SAE J1939 address of the intended recipient of the data frame, the data frame is directed to all devices on the network.

With a D_PDU2 data frame, 18 bits in the 29-bit identifier indicate the PGN of the PG whose data is contained in the data frame's data field and 8 bits indicate the SAE J1939 address of the transmitter of the data frame. The D_PDU2 data frame is used only with PDU2 type PGs. For PDU2 type PGs, a PG is uniquely identified by the combination of EDP, DP, PF, and PS value. Because of this, the 29-bit identifier for D_PDU2 can precisely indicate the PGN only by providing the EDP, DP, PF, and PS values.

The data field of D_PDU1 and D_PDU2 data frames contains the PG data for the PG identified by the PGN specified in the 29-bit identifier of the CAN data frame.

Three bits in the 29-bit identifier of D_PDU1 and D_PDU2 data frames make up the priority field. The priority field provides a means to influence which CEFF or FEFF data frame gets transmitted in the situation where two or more nodes are contending to send data frames on the bus at the same time. The priority is not used by receivers for any purpose.

4.5.2 D_PDU3 (Broadcast) Data Frames

SAE J1939 defines one data frame PDU, D_PDU3, that uses the CBFF and FBFF data frames. The D_PDU3 data frame is only sent broadcast because the 11-bit identifier contains only one SAE J1939 address to identify the originator of the data frame.

SAE J1939-21 and SAE J1939-22 designate the same 8 bits in the 11-bit identifier to indicate the SAE J1939 address of the transmitter of the data frame. However, SAE J1939-21 and SAE J1939-22 have different functional assignments for the other 3 bits of the 11-bit identifier for D_PDU3 data frames. As a result of this difference, D_PDU3 data frames from an SAE J1939-21 network cannot be communicated on an SAE J1939-22 network unless routed through a gateway (i.e., protocol translation). For SAE J1939-21 the other 3 bits are a Priority field, while for SAE J1939-22 these same 3 bits are a Type of Service field.

For D_PDU3 data frames, the 11-bit identifier does not explicitly identify the data field content, unlike the PGN identified in the 29-bit identifier of D_PDU1 and D_PDU2 data frames. For the D_PDU3 per SAE J1939-22, the Type of Service bits in the 11-bit identifier indicates the service associated with the data field content, which does not sufficiently indicate interpretation of the data field content. Interpretation of the data field content can be a function of the transmitter address and/or it can rely upon some identification data within data field content itself.

4.6 Source Addresses

The SAE J1939 source address (SA) is the numeric value used to identify a controller application (CA), as part of an ECU, communicating on an SAE J1939 network. SAs are used in SAE J1939 data frames to identify the originator of an SAE J1939 data frame and the intended recipient

The source address (address) is used in SAE J1939 data frames to indicate the CA that originated the SAE J1939 data frame and to indicate the CA that is the intended destination of a D_PDU1 data frame.

Technically, an SAE J1939 source address is associated to each controller application (CA) and not with a physical ECU. A controller application describes the software within an ECU that performs a particular control function, like controlling the engine or monitoring operator cab controls. In some instances, the ECU software performs only one primary control function, such as transmission control, so there is only one SAE J1939 source address for the only CA in the ECU; in this case the source address is informally stated as being the address of the ECU. In other instances, ECU software performs multiple controller applications, such as engine control and engine retarder control, and there can be the need for each CA to have its own address on the SAE J1939 network; in this case there are multiple source addresses associated with the ECU.

An SAE J1939 source address is to be used by only one CA on an SAE J1939 network. An SAE J1939 source address can be used by two or more CAs as long as the CAs are connected to separate SAE J1939 segments that are separated by at least a router.

A controller application claims an SAE J1939 source address if the CA can transmit any SAE J1939 PG onto the SAE J1939 network; this includes sending the Request PG to solicit an SAE J1939 PG from another device. A controller application is required to successfully claim an SAE J1939 address before using that address to transmit any SAE J1939 PG. See 4.8 for discussion of the address claim protocol. There are two exceptions where a controller application can send an SAE J1939 PG without having a claimed address; a controller application can send the Address Claimed PG and can send a globally addressed Request PG soliciting the Address Claimed PG.

SAE J1939 source addresses are divided into two ranges. The SAE J1939 addresses from 0 to 127 and 248 to 253 are known as global preferred addresses. The SAE J1939 addresses from 128 to 247 are known as dynamic addresses. The SAE J1939 addresses 254 and 255 serve special addressing needs. SAE J1939DA provides the preferred source address lists.

4.6.1 Global Preferred Addresses (0 to 127 and 248 to 253)

The SAE J1939 source addresses from 0 to 127 and 248 to 253 are known as global preferred addresses. A global preferred address is only to be claimed and used by a CA that performs the described function and function instance, if applicable, that is assigned to that address by SAE J1939. Global preferred addresses are assigned for system functions that are fairly common across most industries, such as engine, transmission, service tool, or display.

Since there is a small finite set of global preferred addresses, SAE J1939 only assigns these addresses to system functions that are considered common across most industries and usually only for the first instance of such a function.

4.6.2 Dynamic Addresses (128 to 247)

The SAE J1939 source addresses from 128 to 247 are known as dynamic addresses. SAE J1939 addresses in this range can be claimed and used by any CA performing any system function. The supplier of a CA can use any strategy for selecting the initial address to claim within the range of 128 to 247.

Historically, SAE J1939 had made industry group specific preferred address assignments to addresses in the dynamic address range. This practice was abandoned around 2003. The industry group specific preferred addresses are intended as a means to minimize address arbitration on the SAE J1939 network by suggesting an initial (first) SAE J1939 address to claim for certain functions and instances. However, it became obvious it was not sustainable to uniquely issue preferred address assignments within most industry groups. In addition, too many components and systems had incorrectly treated these as fixed or absolute address assignments, often hard coding these addresses as the required address for certain system functions on the network.

4.6.3 Global Destination Address (255)

The SAE J1939 source address 255 is the global destination address. The global destination address is only used as the destination address in a D_PDU1 data frame to indicate the SAE J1939 data frame is directed to all CAs on the network.

4.6.4 Null Address (254)

The SAE J1939 source addresses 254 is the Null address. The Null address is only used as the source (transmitter) address within a D_PDU1 or D_PDU2 data frame. There are only two permitted uses of the Null address. The Null address can be used with an Address Claimed PG when a CA is reporting it is unable to claim an SAE J1939 Address. The Null address also can be used with an Request PG soliciting the Address Claimed PG when the Request PG is transmitted by a CA before it has claimed a source address.

4.7 SAE J1939 NAME

The SAE J1939 NAME (NAME) is an 8-byte object that identifies the primary system function of a controller application (CA). NAME is to be unique among all CAs on an SAE J1939 network. NAME is primarily communicated in the PG data of the Address Claimed PG, serving to describe the system function associated to a claimed address. Cohesively reporting the CA's NAME with its address claim allows other CAs on the network to catalog the NAME associated with each claimed SA. The association of NAME to a source address allows a CA to fully identify the source of an SAE J1939 data frame or an SAE J1939 PG. The association of NAME to a source address also enables a CA to determine the SA to use in order to send an SAE J1939 PG to a CA performing a specific system function.

NAME is comprised of 10 data parameters. The values for the NAME Function, Vehicle System, Industry Group, and Manufacturer Code elements are populated from the lists of standardized SAE J1939 values published in SAE J1939DA. Values for the remaining elements are specified by the component or system designer as appropriate for component or system. The NAME for a CA is typically configured or established during software design, but the value for some fields can be determined at run time. There are several "instance" data parameters in the NAME object for differentiating multiple instances of a control function within a system, such as differentiating between two separate engine ECUs where each ECU controls a different engine in a system with two engines.

NAME is an attribute of a CA executing within the ECU. Consequently, the NAME reported from an ECU can change when different CA software is loaded onto the ECU. It is common for a blank ECU, i.e., an ECU running only basic operating system application, to have a NAME so the CA can claim a network address in order for application software to be loaded at the factory or in the field. The NAME used by a blank ECU, i.e., an ECU running only basic operating system application, can be different than the NAME used when application software is loaded and executing on that same ECU.

The Manufacturer Code element in NAME permits NAME uniqueness between manufacturers of similar controller applications where the values for the other NAME elements are the same. Manufacturer Code typically is an attribute of the CA executing within the ECU. In general, the Manufacturer Code should identify the OEM or the final product company owning the CA application, even if the software is actually written by a different company. In some instances, manufacturer code is implemented as an attribute of the ECU; in which case, it generally identifies the OEM or the final product company owning or marketing the ECU rather than the supplier that manufactured the ECU. The manufacturer code value reported from an ECU can change as different application software loaded onto the ECU.

SAE J1939-81 provides the technical specifications on SAE J1939 NAME object. SAE J1939DA provides the assignments for the standardized values used in several of the fields in the SAE J1939 NAME object.

4.8 Address Claim

Address Claim is SAE J1939 protocol used by controller applications to announce and claim an SAE J1939 address on the SAE J1939 network. The SAE J1939 Address Claim protocol includes behaviors to resolve conflicts when multiple CAs attempt to claim the same SAE J1939 address. Address Claim is required to be performed by all controller applications, regardless if the CA is attempting to claim a global preferred address or a dynamic address. A CA must successfully claim an SAE J1939 address before using that address to transmit any SAE J1939 PGs. Prior to successfully claiming an address, a CA can send a globally addressed Request PG requesting the Address Claim PG in order to determine that addresses already claimed by other CAs.

The Address Claim protocol consists of Address Claimed PG exchanges together with CA behaviors to resolve address claim conflicts. A CA sends the Address Claim PG under several situations. A CA sends the Address Claimed PG when it first connects to an SAE J1939 network as it attempts to claim its initial SA. A CA sends an Address Claimed PG when it receives the Request PG requesting the Address Claimed PG. A CA sends an Address Claimed PG for the same SA (to defend its claimed address) when it receives an Address Claimed PG from another CA and its NAME value is numerically lower than the NAME reported by the other CA. A CA sends an Address Claim PG for a different SA (since it lost arbitration to another CA) when it receives an Address Claim PG from another CA and its NAME is numerically higher compared to the NAME reported by the other CA. A CA successfully claims a source address when a specified period of time lapses with no other Address Claimed PG for that same source address. On a subsequent power up, SAE J13939 recommends a CA first attempt to claim the last source it successfully claimed.

SAE J1939-81 provides the technical specifications on the SAE J1939 address claim protocol.

4.9 Diagnostic Trouble Code (DTC)

The SAE J1939 diagnostic trouble code (DTC) is the data structure used to describe a detected failure for a parameter, component, event, or system condition. A DTC consists of a suspect parameter number (SPN) and a failure mode indicator (FMI), where the SPN identifies the item associated to the diagnostic is being reported and the FMI identifies the type of failure detected in the subsystem identified by the SPN. SAE J1939 maintains standard assignments of both SPNs and FMIs; however, SAE J1939 does not specify standard combinations SPN and FMI.

SAE J1939 DTCs are communicated in the PG data of SAE J1939 PGs that report diagnostic details, such as a list of DTCs, rather than operational data, like temperatures or pressures. For example, Diagnostic Message 1 (DM1) is an SAE J1939 PG for reporting the list of active DTCs. Refer to SAE J1939-73 for technical details on the SAE J1939 DTC structure and definitions of SAE J1939 PGs for communicating DTCs. The list and description of all assigned FMIs is provided in SAE J1939-73.

4.10 Communication Methods

The section discusses the basic communication methods for SAE J1939 PG exchanges. Refer to SAE J1939-21, SAE J1939-22 and SAE J1939-71 for the technical requirements and documentation.

4.10.1 Transmitting Messages

The following is a simplified description of the transmit an SAE J1939 PG using D_PDU1 or D_PDU2 data frames on an SAE J1939-21 data link layer. The general concept is the same for SAE J1939-22, though SAE J1939-22 has some additional services for communicating multiple PGs in the data field of a single SAE J1939 data frame.

At the originating CA's application layer, the CA prepares the A_PDU for the PG to be transmitted. At a minimum, the A_PDU includes the PGN of the PG, the PG data, and the identity of the recipient for a PDU1 type PG. The application layer passes the A_PDU down the OSI stack. At the transport layer of the OSI stack, the length of the PG data is evaluated to determine if the PG data can be transmitted in its entirety using a single SAE J1939 data frame. If the length of the PG data prevents it from being transmitted in a single SAE J1939 data frame, then the A_PDU is passed to the Transport Protocol (TP) service (see 4.10.3). Otherwise, the A_PDU is passed to the data link layer and the appropriate D_PDU is prepared for the A_PDU.

For a PDU1 type PG, a D_PDU1 data frame is prepared according to the A_PDU. For the D_PDU1 data frame, the EDP, DP and PF fields are populated using the EDP, DP, and PF values, respectively, of the PGN identified in the A_PDU; the PS field is populated with the source address of the intended recipient; the SA field is populated using the address of the originating CA; the Priority field is populated accordingly; and the PG data is placed into the data field of the D_PDU1 data frame. The prepared data frame is then transmitted over the physical layer.

For a PDU2 type PG, a D_PDU2 data frame is prepared according to the A_PDU. For the D_PDU2 data frame, the EDP, DP, PF, and PS fields are populated using the EDP, DP, PF, and PS values, respectively, of the PGN identified in the A_PDU; the SA field is populated using the address of the originating CA; the Priority field is populated accordingly; and the PG data is placed into the data field of the D_PDU2 data frame. The prepared data frame is then transmitted over the physical layer.

4.10.2 Receiving Messages

The following is a simplified overview of the reception of an SAE J1939 PG using D_PDU1 or D_PDU2 data frames on an SAE J1939-21 data link layer. This overview excludes any address or PG filtering. The general concept is the same for SAE J1939-22, though SAE J1939-22 has some additional services for communicating multiple PGs in the data field of a single SAE J1939 data frame.

At the receiving ECU, the ECU's data link layer receives the CAN data frame transmitted over the physical layer. The data link layer evaluates the PF field of the SAE J1939 data frame to determine if it is a D_PDU1 or D_PDU2 data frame and parses the PGN and addressing out of the CAN identifier and the PG data from the data field. If the PGN isn't one of the TP PGs, then the data link layer assembles an A_PDU containing the parsed PGN, addresses, and the PG data and passes the A_PDU to the recipient CA's application layer. If the PGN is one of the TP PGs, then the data link layer puts that information into a T_PDU and passes it to the TP service. The TP service reassembles the PG data from the serialized fragments from the T_PDUs for TP.DT. Once all fragments are received and the PG data is assembled, then the TP service assembles an A_PDU containing the PGN, addresses, and the reassembled PG data, and passes the A_PDU up to the recipient CA's application layer. At the recipient CA's application layer, the PG data from the A_PDU can be parsed according to the PG data definition of the PG associated to the PGN.

prepares and A_PDU to be passed up the OSI stack. If the value in the PF field is less than 240, then it is a D_PDU1 data frame, and if the value in the PF field is greater than or equal to 240, then it is a D_PDU2 data frame. At a minimum, the prepared A_PDU includes the PGN of the PG, the PG data, the source address, and the destination address recipient for a D_PDU1 data frame.

A received SAE J1939 data frame is identified as a D_PDU1 frame when the PF field in the 29-bit identifier is less than 240. For a D_PDU1 data frame, the PGN is identified using the EDP, DP, and PF values from the EDP, DP and PF fields from the D_PDU1 data frame, and 0 as the PS value of the PGN. The A_PDU originator source address is populated from the D_PDU1 data frame source address and the A_PDU recipient (destination) address is populated from the value in the PS field of D_PDU1 data frame. The A_PDU PG data is populated from the data field of the D_PDU1 data frame.

A received SAE J1939 data frame is identified as a D_PDU2 frame when the PF field in the 29-bit identifier is greater than or equal to 240. For a D_PDU2 data frame, the PGN is identified using the EDP, DP, PF, and PS values from the EDP, DP, PF, and PS fields from the D_PDU2 data frame. The A_PDU originator source address is populated from the D_PDU2 data frame source address. The A_PDU PG data is populated from the data field of the D_PDU2 data frame.

4.10.3 Transport Protocol

The SAE J1939 transport protocol (TP) is a communication service used to transport PG data when the PG data, because of its length, cannot be sent in its entirety in the data field of a single SAE J1939 data frame. TP essentially transports the PG data using a series of SAE J1939 data frames, each containing a fragment of the PG data. There are two TP transport modes: RTS/CTS (connection oriented) and BAM (connectionless). The RTS/CTS (ready to send/clear to send) mode allows a connection-oriented transfer of the PG data between two CAs, which includes flow control and lost data frame and data fragment recovery capabilities. The BAM (broadcast announce message) mode only allows transfer of the PG data to all CAs and has no flow control and no lost data frame nor data fragment recovery capabilities. The transport protocol mode used for a PG and its PG data depends upon the PG's PDU type and any addressing specified for the PG (refer to Request PG in SAE J1939-21 and SAE J1939-22 for more details). The RTS/CTS mode is used with a PDU1 type PG being sent to a specific address, and the BAM mode is used with a PDU2 type PG or a PDU1 type PG being sent globally.

The SAE J1939 Transport Protocol (TP) operations and messages are data link layer specific. SAE J1939-21 and SAE J1939-22 each specify the Transport Protocol messages and operations. Each transport protocol service uses two SAE J1939 PGs with similar functionality to perform the data exchange operations; however, different SAE J1939 PGs are used by the SAE J1939-21 TP and the SAE J1939-22 FD.TP. The Connection Management PG (TP.CM, FD.TP.CM) is the TP message used to manage the fragmented data exchange and the Data Transfer PG (TP.DT, FD.TP.DT) is the TP message used to transmit the serialized data fragments. The PG data definitions for these PGs are such that these PGs are sent using a single SAE J1939 data frame.

The following is a simplified explanation of the transport protocol service. At the originating device, the TP service evaluates the PG data passed in the A_PDU to determine the number of smaller serialized pieces (PG data fragments) required to transfer the PG data. The originating TP service sends the first CM PG (TP.CM or FD.TP.CM) to the recipient(s) to initiate/announce the transfer session by identifying the PGN (as specified by the A_PDU), the length of the PG data, and the number of PG data fragments in the transfer. Next the originating TP service sends a series of DT PGs (TP.DT or FD.TP.DT) to the recipient(s) where the PG data of each DT PG contains a serialized fragment PG data. After sending all of the PG data fragments, the originating TP service sends a CM PG to the recipient(s) to indicate it has transmitted all fragments, again identifying the PGN (as specified by the A_PDU), the length of the PG data, and number of PG data fragments in the transfer. At the receiving device, received SAE J1939 data frames for the Connection Management PG and Data Transfer PG are passed to the Transport service for handling. When the receiving TP service gets the CM PG initiating/announcing the TP transfer session, the service can get the PGN for the PG data to be transferred and makes any allocation for reassembling the PG data fragments. As the receiving TP service gets each DT PG, the service extracts the PG data fragment and adds it to the reassembled content according to its sequential position. When the receiving TP service receives the CM PG indicating the originator has sent all fragments, the receiving TP service verifies it has received all segments and the assembled data size is correct. Once validated, the receiving TP service assembles an A_PDU containing the PGN, the addressing information, any assurance data, and the reassembled PG data and passes it up to the CA's application layer. For a transfer using the RTS/CTS mode, there can be additional instances of the CM PG sent back between the recipient device and the originating device to control the transfer of the serialized fragments of the PG data.

4.10.4 Periodic Messaging

Periodic messaging describes the communications method where an SAE J1939 PG is transmitted automatically and continuously without the need for a request or solicitation to initiate the transmits. Periodic messaging applies to any SAE J1939 PG where its transmission rate specifies some type of periodic transmission rate, such as “100 ms” or “every 100 ms and on change not to exceed 20 ms.” When a CA is a transmitter of SAE J1939 PG with a periodic transmission rate, the CA automatically transmits the PG when connected to the network and continues to transmit the PG according to the specific transmission rate. When a CA is designed to receive an SAE J1939 PG with a periodic transmission rate, then that CA should not send out a request or solicitation for the PG.

4.10.5 Requests and Acknowledgement

The Request PG (PGN 59904) is the SAE J1939 PG for requesting or soliciting the transmit of an SAE J1939 PG by one or more devices on an SAE J1939 network. The Request PG should only be used to request SAE J1939 PG with a transmission rate that describes some type of transmit on request behavior, such as “on request.” The PG data for the Request PG contains the PGN of the PG being requested or solicited. When requesting a PDU1 type PG, the PS value is reported as zero when specifying the PGN number in PG data of the Request PG. The Request PG is a PDU1 type PG which enables the PG to be sent to a single CA or to be sent to all CAs.

The Acknowledgement PG (ACKM) (PGN 59392) is the SAE J1939 PG for providing positive or negative responses to a received message or a requested action. The PG data for the ACKM contains a specific type of positive or negative acknowledgment, the PGN of the PG being acknowledged, and the address of the CA whose message or requested action prompted the acknowledgement.

The Request PG response behaviors are notably different between a Request PG sent to a specific source address (destination specific request) and a Request PG sent to the global destination address. For a destination specific Request PG instance, the response from a recipient CA can be either the requested PG and its PG data or the Acknowledgement PG. For a globally addressed Request PG instance, the response from a recipient CA can be the requested PG and its PG data, the Acknowledgement PG, or no response at all. For a globally addressed Request PG instance, there can be multiple responses from different CAs in any combination of responses.

SAE J1939-21 and SAE J1939-22 specify the technical details for the Request PG as well as the response behaviors to the Request PG.

4.10.6 Proprietary Messages

SAE J1939 has defined 514 SAE J1939 PGs for communicating proprietary information over an SAE J1939 network. The SAE J1939 proprietary PGs are denoted with the acronyms PropA, PropA2, PropB, and PropB1. The PropA and PropA2 PGs are PDU1 type PGs and PropB and PropB1 PGs are PDU2 type PGs. SAE J1939 only defines the PGN assignment and acronym for the proprietary PGs. All other technical details for the proprietary PGs – PG data length, PG data definition, transmission rate – are at the discretion of every manufacturer that chooses to use those PGs. The same 514 SAE J1939 PG are assigned for use by all manufacturers. The interpretation of the data field of a proprietary PG is dependent on the manufacturer associated with source address sending the message and, for PDU1 format PG, possibly by manufacturer associated with the destination source address. Proprietary PG use should be considered carefully and they should be used sparingly. Additionally, software safeguards are strongly suggested when receiving proprietary PG, such as source address filtering or restrictions.

The use of standardized SAE J1939 Parameter Groups is preferred and should be used whenever practical; however, the proprietary PGs offer a means of solving unique problems and situations. If the information is not proprietary and is of general interest or generally applicable to similar system functions, then a standardized SAE J1939 Parameter Group should be sought. The proprietary PGs are intended for communicating truly proprietary information or communicating information that is not of general interest. For example, if the communications between CAs of a single manufacturer exchange information that is very specific to their solution and not generally useful to other CAs on the network, then proprietary Parameter Groups provide a reasonable solution.

4.11 Network Topology

An SAE J1939 network refers to a communications network consisting of a single SAE J1939 network segment or multiple SAE J1939 network segments connected through network interconnection ECUs (NIECU). An SAE J1939 network segment is defined by a valid combination of an SAE J1939 physical layer and an SAE J1939 data link layer; e.g., SAE J1939-11 physical layer and SAE J1939-21 data link layer. Only certain combinations of SAE J1939 physical layers and SAE J1939 data link layers are valid combinations. SAE J1939 network segments of an SAE J1939 network are not required to be of the same combination of physical and data link layers. An NIECU is required between SAE J1939 segments with different combinations of physical and data link layers. SAE J1939-1 provides examples of systems with a single SAE J1939 network segment and systems with multiple SAE J1939 network segments connected by network interconnection ECUs.

The SAE J1939 physical layers, i.e., SAE J1939-11, SAE J1939-14, SAE J1939-15, and SAE J1939-17, each define the ECU characteristics, bit rate, bus length, node count, cabling, and other network topology requirements for a specific type of physical layer.

The SAE J1939 data link layers, i.e., SAE J1939-21 and SAE J1939-22, each define the meaning of the identifier bits CAN data frames as well as basic communication services, such as requests and transport protocols.

SAE J1939-31 describes the different types of NIECUs and the SAE J1939 PGs for configuring and monitoring the NIECUs.

SAE J1939-13 specifies the requirements for a standard diagnostic connector for connecting a diagnostic tool to an SAE J1939 network.

4.12 ECU Design

Although every manufacturer will have different performance requirements for the ECU contained within their product, several observations can be made regarding the resources needed to support SAE J1939. ECU design considerations can impact hardware and software resources. SAE J1939 requirements impacting ECU design are not specified in any single SAE J1939 document.

An ECU processor needs to be able to handle (or buffer) multiple back-to-back SAE J1939 messages. As described in in SAE J1939-21 and SAE J1939-22, a device needs to have appropriate CAN receive buffer management so no SAE J1939 data frames or SAE J1939 PGs are lost due to ECU hardware or software design limitations. Depending on the SAE J1939 physical layer of an SAE J1939 network segment, an ECU can potentially receive CAN data frames every 200 to 500 µs during periods of 100% bus utilization.

ECU software resources, beyond the CA application, can be necessary to support other aspects of SAE J1939, such as address claim protocol and NAME/SA management, request and acknowledgement services, transport protocols, and applicable data, messages, and diagnostic services. For example, non-volatile memory can be needed in order to retain the last successfully claimed source address. The requirements for any ECU design are the responsibility of the ECU designers.

4.13 SAE J1939DA Spreadsheet

The SAE J1939DA digital annex is an electronic spreadsheet document used to publish SPs, PGs, SLOTs, NAME field enumerations, and preferred address assignments made by the SAE J1939 Committee. The content in SAE J1939DA is fully approved and balloted by the SAE J1939 Committee. The SAE J1939DA is the only publication for

- Comprehensive list of all SPN assignments
- SP definition details for most SAE J1939 data parameters
- SPNs assigned for use by other industry standards documents
- Comprehensive list of all SAE J1939 PG and PGN assignments
- PG definition details for most SAE J1939 PG
- PGNs assigned to and specified by other industry standards documents
- NAME standardized values (functions, vehicle systems, industry groups, manufacturer codes)
- Preferred address

4.14 Requests for Parameter Groups (PG), Suspect Parameters (SP), and other J1939 ID Assignments

The SAE J1939 Committee is the registration authority for all SAE J1939 based identifier assignments, including, but not limited to, PGNs, SPNs, SAE J1939 NAME standardized values, SAE J1939 NAME manufacturer codes, SAE J1939 global source addresses, and SAE J1939 preferred source addresses, as discussed in 4.2.

Applications can use existing SAE J1939 Parameter Groups, data parameters, diagnostic IDs, and other standardized identifiers whenever available. If a new standardized identifier assignment is required for data that is not already assigned, then a developer can request the SAE J1939 Committee to assign new values. If changes to an existing standardized identifier assignment is desired, then a developer can request changes to an existing assignment. The SAE J1939 Committee can approve the additions/changes as requested, approve them with modification, or reject them altogether. Requested additions/changes are official only when they are reflected in a published version of the SAE J1939 standard.

New requests and changes are submitted using the SAE J1939 request form. The latest version of the SAE J1939 request form is available from SAE International or on the SAE J1939 discussion forum portion of the SAE web site (www.sae.org). In addition, the SAE J1939 Committee also publishes a guidelines document, “J1939_Request_Processing_Guidelines,” to help new requesters with the request process. The latest version of this guideline document is also available from SAE or on the SAE J1939 discussion forum portion of the SAE web site (www.sae.org).

The SAE J1939 request form contains sections for requesting new Parameter Groups (PGs), Suspect Parameters (SPs) for data parameter and diagnostics, manufacturer codes, NAME functions, NAME vehicle systems, and preferred source addresses. When requesting multiple new assignments, the individual requests can be included in a single request form document or submitted in multiple separate request form documents. When requesting a new Parameter Group, the request for the PG and request for the parameters (SPs) to be contained within the PG data of the new PG are submitted together in the same request form document. When requesting several diagnostic SPs, it is acceptable to include all of them in the same request form document. When requesting multiple new PGs, it can be easier to submit each PG request in a separate request form document.

The SAE J1939 request form is the only document that is required to be submitted for a request. For some requests, the SAE J1939 request form is sufficient. For other requests, the SAE J1939 Committee encourages requesters to provide supplemental documentation to help the committee fully understand what is being requested. Requesters should take care to avoid disclosing any trade secret or intellectual property information when they construct their SAE J1939 Request Form and any supplemental documents. Supplemental documents provide a means for the requester to explain the request and provide any relevant technical explanations or illustrations. Supplemental documentation also provides a means for the requester to present their justification for the new assignment, such as when the requester is aware of existing assignments that can appear to be similar to the new requests but the requester has reasons explaining the technical difference between the existing assignment and the requested item.

The SAE J1939 discussion forum portion of the SAE website is used by the SAE J1939 Committee for working through most of the technical issues and questions related to an SAE J1939 request. Requesters are encouraged to be active in leading technical review discussions of their request, usually via teleconference calls. Requesters are also invited to attend SAE J1939 Committee meetings should they wish to make a personal presentation of their request and answer questions about it. Experience has shown that supporting a request in person or by teleconference at the SAE J1939 Committee request review meeting often results in committee questions being resolved immediately with an approval at that time rather than waiting three to four months for the next committee meeting to take place. If the committee cannot fully understand the request or resolve their issues and questions, the request is tabled until the committee's questions are answered by the requester, resulting in months of delay before the request can be resolved. Once an assignment is made, it cannot be deleted or significantly altered because there can be systems using this definition. Consequently, this forces the committee to seriously challenge any request that is not fully understood or which can result in a future request that is very similar.

4.14.1 PG Data Parameter Grouping

The data efficiency of an SAE J1939 network is maximized when the PG data definition for a PG has parameter data assigned to every PG data bit. When possible and practical, data parameters should be grouped together to fully occupy every bit in the PG data for a PG. This principle conserves PGN values for future assignment and allows for minimum network loading when all data bytes are known by and sent from the same address. Strong justification is usually needed when requesting a new Parameter Group where data parameters in the initial PG definition occupy very few PG data bits.

When requesting a new data parameter, requesters should consider requesting the parameter data be assigned to unassigned bytes or bits in the PG data definition of an existing SAE J1939 Parameter Group. The "SAE J1939 not available bit encoding" technique makes it possible to assign a new data parameter to unassigned bits and bytes without issue. This special data encoding technique also means that it is not critical that all of the parameters in a Parameter Group come from the same CA.

When a new data parameter needs to be transmitted at a fast update rate, SAE J1939 Committee prefers to update an existing PG with new data parameters until its PG data is fully utilized (i.e., parameters assigned to all PG data bytes) before defining a new PG, provided the new data parameter and the existing data parameters in the PG are typically sent from the same CA function. For a new data parameter with a slower update rate, it is not as critical that the new data parameter and existing data parameters in the PG are sent from the same CA. Even though it is desirable to have parameters come from one CA, the intention of SAE J1939 is to provide a means for communicating the data and not dictate which CA is to send what data.

The following guidelines should be considered when grouping parameters together into an existing SAE J1939 PG or a new SAE J1939 PG. In most cases, grouping parameters based upon any one of these guidelines can end up violating one or more of the other parameter grouping guidelines. Parameters should be grouped as follows:

1. By common subsystem (the ECU likely to measure and send the data)

2. With similar update rates (to minimize unnecessary overhead)

3. By function (oil, coolant, fuel, etc.)

4. Limit groups to 8 bytes of parameter data for PGs with transmission rates less than 200 ms. (This is to avoid Transport Protocol services when transmitted over SAE J1939-21 data link.)

4.15 Application Examples

Table 2 illustrates a typical message sequence between the transmission and the engine during a transmission shift. Messages from the transmission to the engine consists of a series of commands for controlling engine RPM and torque. Messages from the engine provide status and information which is used to determine when a particular condition has occurred. Other messages can also be sent regularly to disable the engine retarder at the proper time interval, or to inhibit Acceleration Slip Regulation (ASR) functions which can affect engine demand during portions of the shift sequence.

Table 2 - Transmission shift messaging sequence example

Parameter Group	Msg Type	Transmitter	Using CA	Action/Function (per PG data)
ETC1	Info	Trans	Eng, ASR	Transmission decision to shift (shift in progress)
TSC1	Cmd	Trans	Eng	Override priority bits set for trans (01 priority)
				Torque control, torque = 0
TSC1	Cmd	Trans	Retarder (Eng)	Disable mode, torque = 0
EEC1	Info	Eng	Trans	Torque = 0 (Clutch may be disengaged)
TSC1	Cmd	Trans	Eng	Speed control mode, requested speed = X
EEC1	Info	Eng	Trans	Speed = X (Clutch may be engaged)
TSC1	Cmd	Trans	Eng	Speed/torque limit mode (11 priority)
ETC1	Info	Trans	ASR	Allow ASR (11 priority)
TSC1	Cmd	Trans	Ret (Eng)	Enable mode
TSC1	Cmd	Trans	Eng	Override disable
ETC1	Info	Trans	Eng, ASR	Shift complete

Table 3 illustrates a typical message sequence during an ABS sequence. A typical ABS sequence contains messages to be transmitted indicating the engine should reduce torque and the driveline (transmission) should remain in its existing (stable) state. If the ABS condition is “significant” (i.e., not just bouncing tires), it can request that the driveline also be disengaged. Note that this message must be sent at regular intervals to maintain the condition. Once the event is over, the ABS inactive indicates that the transmission and engine can return to “normal” operation.

Table 3 - ABS messaging sequence example

Parameter Group	Msg Type	Transmitter	Using CA	Action/Function
				ABS decision to modulate brakes
EBC1	Info	ABS	Eng, Trans	ABS active
TSC1	Cmd	ABS	Retarder (Eng)	Disable mode, torque = 0 (prevent engine stall)
TC1	Cmd	ABS	Trans	Disengage driveline
				ABS event over
EBC1	Info	ABS	Eng, Trans	ABS inactive

Table 4 illustrates a typical message sequence during an ASR sequence. A typical ASR sequence will attempt to reduce torque by sending torque limit messages to the engine. Torque can also be reduced by requesting more driveline retardation or permitting some clutch slip. Ultimately, an upshift can be requested in order to achieve acceptable torque values. Note that the transmission takes over engine control during the shift.

Table 4 - ASR messaging sequence example

Parameter Group	Msg Type	Transmitter	Using CA	Action/Function
				ASR torque reduction decision
EBC1	Info	ASR	Eng, Trans, Retarder (Drvl)	ASR torque control active
TSC1	Cmd	ASR	Eng	Torque limit
TSC1	Cmd	ASR	Retarder (Drvl)	Request more retardation
TC1	Cmd	ASR	Trans	Request more clutch slip
TC1	Cmd	ASR	Trans	Request new gear selection, no clutch slip requested
				Shift if possible
				Shift complete, ASR continues torque limit
				ASR event over
EBC1	Info	ASR	Eng, Trans, Retarder (Drvl)	ASR inactive, disable override

5. NOTES

5.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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