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

RATIONALE

This document has been updated to reflect the change to discontinue publishing the content of Table A2, Tables B1 through B12, and Table C1 in Appendix A, Appendix B, and Appendix C; instead, this information is now published in the SAE J1939DA Digital Annex spreadsheet. This document has also been updated to reference SAE J1939-14 and various text updates throughout the document, including several sections of the SAE J1939 Overview.

FOREWORD

The SAE J1939 communications network is defined using a collection of individual SAE J1939 documents based upon the layers of the Open System Interconnect (OSI) model for computer communications architecture. 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 network is the next generation successor to the SAE J1708 and SAE J1587 low speed networks. SAE J1708 and SAE J1587 are older, widely used networks intended to provide simple information exchange, including diagnostic data, between ECUs. SAE J1939 is capable of performing all of the functions of SAE J1708 and SAE J1587 networks as well as provides control system support.

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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TABLE OF CONTENTS

1. SCOPE ... 3
1.1 Degree of Openness ... 3
1.2 Proof of Compliance ... 3

2. REFERENCES ... 3
2.1 Applicable Documents ... 3
2.2 Related Publications ... 4

3. DEFINITIONS AND ABBREVIATIONS ... 5
3.1 Definitions ... 5
3.2 Abbreviations ... 10
3.3 References to the OSI Model ... 11
3.4 Documentation Structure and Guide ... 12

4. TECHNICAL REQUIREMENTS ... 13
4.1 SAE J1939 Overview ... 13
4.1.1 Introduction ... 14
4.1.2 Message Format and Usage ... 14
4.1.3 Addresses and NAME ... 15
4.1.4 Communication Methods ... 17
4.1.5 Transmitting Messages ... 18
4.1.6 Receiving Messages ... 18
4.1.7 ECU Design ... 18
4.1.8 Network Topology ... 19
4.2 Pre-assigned Values ... 19
4.2.1 Parameter Group Numbers ... 19
4.2.2 Data Field Grouping ... 20
4.2.3 NAME Systems and Functions ... 20
4.2.4 Industry Group ... 21
4.2.5 Manufacturer Code and Identity Number ... 21
4.2.6 Preferred Address ... 22
4.2.7 Suspect Parameter Number (SPN) ... 22
4.3 SAE J1939DA Spreadsheet ... 23
4.4 Requests for New Assignments ... 23
4.5 Application Examples ... 24
5. NOTES ... 25
5.1 Marginal Indicia ... 25

APPENDIX A PARAMETER GROUP ASSIGNMENTS ... 26
APPENDIX B ADDRESS AND IDENTITY ASSIGNMENTS ... 27
APPENDIX C FAULT REPORTING PARAMETERS ... 29

FIGURE 1 THE OSI SEVEN LAYER MODEL ... 11
FIGURE 2 SAE J1939 29 BIT IDENTIFIER ... 14
FIGURE 3 DEPENDENCIES IN THE NAME FIELDS ... 21

TABLE 1 29 BIT IDENTIFIER DATA PAGES ... 15
TABLE 2 NAME FIELDS ... 16
TABLE A1 SAE J1939 PARAMETER GROUP TEMPLATE (SEE SAE J1939-21) ... 26

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.

The SAE J1939DA Digital Annex spreadsheet replaces the Appendices of this document for the publication of the list of all SPN assignments, PGN assignments, NAME Function assignments, Manufacturer Code assignments, and Preferred Address assignments. This document has been updated to reflect the change to discontinue publishing the content of Table A2, Tables B1 through B12, and Table C1 in Appendix A, Appendix B, and Appendix C; instead, this content is now published in the SAE J1939DA Digital Annex spreadsheet.

1.1 Degree of Openness

An SAE J1939 network is open to the degree that any two ECUs which conform to the same SAE J1939-0*X* 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. ECUs which conform to a different SAE J1939-0*X* document may not be capable of communicating directly with one another and in some cases may 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 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 recommended practices for self-certifying compliance to several of the other SAE J1939 documents. In the future, additional procedures may be defined and implemented to test new products to ensure full compliance with all appropriate SAE J1939 documents. Until that time, compliance will be 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 shall 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 724-776-4970 (outside USA), www.sae.org.

SAE J1213 Glossary of Automotive Electronic Terms

SAE J1939DA Digital Annex of Serial Control and Communications Heavy Duty Vehicle Network Data

SAE J1939-01 On-Highway Control and Communication Network

SAE J1939-02 Agricultural and Forestry Off-Road Machinery Control and Communication Network

SAE J1939-03 On Board Diagnostics Implementation Guide

SAE J1939-05 Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide

SAE J1939-11 Physical Layer, 250K bits/s, Twisted Shielded Pair

SAE J1939-13 Off-Board Diagnostic Connector

SAE J1939-14 Physical Layer, 500 Kbps

SAE J1939-15 Reduced Physical Layer, 250K bits/sec, UN-Shielded Twisted Pair (UTP)

SAE J1939-21 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 J1939-81 Network Management

SAE J1939-82 Compliance - Truck and Bus

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

SAE CS1939 J1939 Companion Spreadsheet

2.1.2 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 7498 Information processing systems - Open systems interconnection (OSI) - Basic reference model

ISO 11898-1 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 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

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 11783 Tractors and machinery for agriculture and forestry — Serial control and communications data network (Part 1 through Part 13)

ISO 11992 Road vehicles - Electrical connections between towing and towed vehicles - Interchange of digital information (Parts 1, 2, 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 NMEA, 7 Riggs Ave., Severna Park, MD 21146, Tel: 410-975-9425, www.nmea.org.

NMEA 2000 NMEA 2000 interface standard

3. DEFINITIONS AND ABBREVIATIONS

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

3.1 Definitions

3.1.1 ACKNOWLEDGMENT (ACK)

Confirms that the requested action has been understood and performed.

3.1.2 ADDRESS

The 8 bit field (or fields) used to define the source (and destination when applicable) of a message (e.g. engine, transmission, etc.).

3.1.3 ARBITRATION

The process by which one or more ECUs resolve conflicts in obtaining access to a shared network bus.

3.1.4 BASE FORMAT

A CAN data frame using an 11 bit identifier as defined in the ISO 11898-1 specification. Formerly referred to as Standard Frame.

3.1.5 BIT STUFFING

A procedure used to assure the transmitted and received messages maintain a minimum number of dominant to recessive edges, and vice versa, to maintain the proper resynchronization within the string of bits in a CAN Data Frame. See CAN specification for a more detailed discussion.

3.1.6 BRIDGE

A device which stores and forwards messages between two SAE J1939 network segments. This permits changes in the media, the electrical interface, and data rate between segments. The protocol and address space remain the same on both sides of the bridge. Note that a bridge may selectively filter messages going across it so that the bus load is minimized on each segment.

3.1.7 BUS

See Segment.

3.1.8 CAN DATA FRAME

The ordered bit fields necessary to create a CAN frame used to convey data, beginning with an SOF and ending with an EOF.

3.1.9 CONTROLLER APPLICATION (CA)

The software within a particular controller is the “Controller Application” (CA). A controller is made up of the software and the hardware within an Electronic Control Unit (ECU) that performs a particular control function. An ECU may serve as one or more controllers and hence may contain one or more CAs. Each CA will have one address and an associated NAME in order to communicate on the SAE J1939 network.

3.1.10 CYCLIC REDUNDANCY CHECK (CRC)

An error control mechanism. A 15 bit cyclic redundancy check is performed for detecting transmission errors. Given a *k*-bit frame or message, the transmitter generates an *n*-bit sequence, known as a frame check sequence so that the resulting frame, consisting of $k + n$ bits is exactly divisible by some predefined number. The receiver then divides the incoming frame by the same number and, if there is no remainder, assumes that there was no error.

3.1.11 DATA FIELD

A 0 to 64-bit field normally placed in a CAN data frame which contains the data as defined in the Application Layer (document SAE J1939-7X).

3.1.12 DATA PAGE

A one-bit field in the Identifier portion of the CAN Arbitration Field that is combined with the Extended Data Page bit to select one of four pages of message definitions. The page selections for the Data Page and Extended Data Page bits are listed in Table 1. It also is one of the fields used to determine the Parameter Group Number which labels the data field of the CAN Data Frame.

3.1.13 DESTINATION ADDRESS (DA)

This is a Protocol Data Unit (PDU) specific field in the 29 bit CAN identifier used to indicate the address of the ECU intended to receive the SAE J1939 message.

3.1.14 DEVICE

A physical component with one or more ECUs and network connections.

3.1.15 ELECTRONIC CONTROL UNIT (ECU)

A computer based electronic assembly from which SAE J1939 messages may be sent or received.

3.1.16 END OF FRAME (EOF)

A 7 bit field marking the ending of a CAN data frame.

3.1.17 EXTENDED DATA PAGE (EDP)

A one-bit field in the Identifier portion of the CAN Arbitration Field that is combined with the Data Page bit to select between multiple pages of decoding of the remaining sections of the Identifier field. The page selections for the Data Page and Extended Data Page bits are listed in Table 1.

3.1.18 EXTENDED FORMAT

A CAN data frame using a 29 bit identifier as defined in the ISO 11898-1 specification. Formerly known as Extended Frame.

3.1.19 EXTENDED FRAME

See Extended Format.

3.1.20 FRAME

A series of data bits making up a complete message. The frame is subdivided into a number of fields, each field containing a predefined type of data. See CAN Data Frame.

3.1.21 FUNCTION

A capability of a vehicle system having one or more ECUs that are connected to a SAE J1939 bus segment of a Vehicle System. The function value is used in the 8 bit Function field in the 64 bit NAME entity (See SAE J1939-81, Section 4.2).

3.1.22 GATEWAY

This device permits data to be transferred between two networks with different protocols or message sets. The gateway provides a means to repackage parameters into new message groups when transferring messages from one segment to another.

3.1.23 GROUP EXTENSION (GE)

This is a PDU specific field of a SAE J1939 CAN Data Frame that is used as part of the information necessary to determine the Parameter Group Number.

3.1.24 IDENTIFIER

The identifier portion of the CAN arbitration field.

3.1.25 IDLE

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

3.1.26 IMPLEMENT

A machine consisting of one or more ECUs which may be attached to or detached from the vehicle as a unit.

3.1.27 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.

3.1.28 MESSAGE

A “message” is equivalent to one or more “CAN Data Frames” that have the same Parameter Group Number. For instance the information related to a single Parameter Group Number to be transferred on the bus may take several CAN data frames.

3.1.29 MULTIPACKET MESSAGES

A type of SAE J1939 message which is used when more than one CAN data frame is required to transmit all data specific to a given Parameter Group Number. Each CAN data frame will have the same identifier but will contain different data in each packet.

3.1.30 NAME

An 8 byte value which uniquely identifies the primary function of an ECU and its instance on the network. A device's NAME must be unique, no two devices may share the same NAME value on a given vehicle network.

3.1.31 NODE

A specific hardware connection of an ECU to the physical media. A specific node may have more than one address claimed on the network.

3.1.32 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 ECU addresses or NAMEs, that are changed during use. Read Only Memory (ROM) is technically non-volatile, but is not changeable during use and thus not what is referred to in these documents.

3.1.33 NEGATIVE-ACKNOWLEDGMENT (NACK)

A response which indicates that a message has not been understood or a requested action could not be performed.

3.1.34 PACKET

A single CAN data frame. This can also be a message if the Parameter Group to be transferred can be expressed in one CAN data frame.

3.1.35 PARAMETER GROUP (PG)

A collection of parameters that are conveyed in a SAE J1939 message. Parameter Groups include commands, data, requests, acknowledgments, and negative-acknowledgments. The PG identifies the data in a message, regardless of whether it is a single packet or multipacket message. Parameter Groups are not dependent on the source address field thus allowing any source to send any Parameter Group.

3.1.36 PARAMETER GROUP NUMBER (PGN)

A three byte, 24 bit, representation of the Extended Data Page, Data Page, PDU Format, and GE fields. The Parameter Group Number uniquely identifies a particular Parameter Group.

3.1.37 PDU FORMAT (PF)

An 8 bit field in the 29 bit identifier that identifies the PDU format and is used in whole or in part to provide a label for a Parameter Group. It also is one of the fields used to determine the Parameter Group Number which labels the data field of the CAN Data Frame.

3.1.38 PDU SPECIFIC (PS)

An 8-bit field in the 29 bit identifier whose definition depends upon the value of the PDU Format field. It can be either a destination address (DA) or Group Extension (GE). It also is one of the fields used to determine the Parameter Group Number which labels the data field of the CAN Data Frame.

3.1.39 PDU1 FORMAT

A PDU format used for messages that are to be sent to a destination address (DA). The PS field contains the destination address (specific or global).

3.1.40 PDU2 FORMAT

A PDU format used to send information that has been labeled using the Group Extension technique. This PDU does not contain a destination address. The PS field contains the Group Extension in the case of PDU2 formats.

3.1.41 PREFERRED ADDRESS

The address that an ECU will attempt to use first when claiming an address. Preferred Addresses are assigned by the committee. The SAE Truck and Bus Control and Communications Committee is discontinuing most new assignments of Preferred Addresses, especially Industry Group specific Preferred Addresses. See SAE J1939DA for these assignments. These assignments were previously listed in Appendix B, Table B3 through Table B9 of this document.

3.1.42 PRIORITY

A 3-bit field in an identifier that establishes the arbitration priority of the information communicated. The highest priority is zero and the lowest priority is seven.

3.1.43 PROTOCOL DATA UNIT (PDU)

A PDU is a SAE J1939 specific CAN Data Frame format.

3.1.44 REMOTE TRANSMISSION REQUEST (RTR)

A feature of the CAN protocol allowing an ECU to request that another ECU or ECUs send a message. This feature of CAN is not used in SAE J1939. An alternate request mechanism is specified for SAE J1939.

3.1.45 REPEATER

An ECU which regenerates the bus signal onto another segment of media. This permits the network to connect more electrical loads (ECUs) onto the bus, or to connect to another type of media (Physical Layer Expansion). The speed (data rate), protocol (data link layer), and address space are the same on both sides of the repeater. For SAE J1939, any delays in regenerating the data signal must be kept to a very small fraction of one bit interval.

3.1.46 RESERVED BIT

An SAE J1939 term that became obsolete with the December 2006 revision of SAE J1939-21 when the 'Reserved' bit was redefined as the 'Extended Data Page' bit. Originally, this term referred to the 5th bit in the SAE J1939 29-bit identifier that was noted as ‘Reserved for future definition by SAE’.

3.1.47 ROUTER

An ECU which allows segments with independent address spaces, data rates, and media to exchange messages. A router may permit each segment to operate with minimum bus loading yet still obtain critical messages from remote segments. The protocol remains the same across all segments. Note that the router must have look up tables to permit the translation and routing of a message with ID X on segment 1 to ID Y on segment 2.

3.1.48 SEGMENT

The physical media and attached nodes of a network not interconnected by Network Interconnection ECUs. A single segment of a network is characterized by all of the ECUs “seeing” the signal at the same time (i.e., there is no intermediate ECU between electrical sections of the network). Multiple segments can be connected together by Network Interconnection ECUs including repeaters, bridges, and routers.

3.1.49 SOURCE ADDRESS (SA)

An 8-bit field in the 29 bit identifier which allows for the unique identification of the source of a message. The SA field contains the address of the ECU that is sending the message.

3.1.50 STANDARD FRAME

See Base Format.

3.1.51 START OF FRAME (SOF)

The initial bit in a CAN frame serving only to indicate the beginning of the frame.

3.1.52 SUSPECT PARAMETER NUMBER (SPN)

A 19 bit number used to identify a particular element, component, or parameter associated with an ECU. The primary use of the SPN is in an SAE J1939 Diagnostic Trouble Code (DTC), where the SPN identifies the element, component, or parameter suspected of exhibiting the diagnostic condition. Every assigned SPN has a text label which describes the particular element, component, parameter, or condition. A subset of SPNs are associated with SAE J1939 data parameters and those SPNs include a data encoding definition and an associated Parameter Group (PG). Each SAE J1939 data parameter has an SPN assignment to permit reporting any related diagnostics. The Parameter Group definitions use the SPN to identify or cross reference each data parameter in its data field.

3.1.53 SUBNETWORK

This refers to the network activity (message traffic) on a specific SAE J1939 segment when multiple segments are used. Subnetworks may include: Tractor; Trailer, Implement, and Braking System. Note that they may be separated by a bridge or router to minimize total bus loading. Collectively the subnetworks are the SAE J1939 Vehicle Network.

3.1.54 VEHICLE

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

3.1.55 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 may be connected or disconnected from the vehicle. A Vehicle System may be made up of one or more Functions, which have ECU's that are connected to a SAE J1939 segment of the Vehicle System.

3.2 Abbreviations

ABS Antilock Braking System
ACK Acknowledgment
AP Accelerator Pedal
ASR Acceleration Slip Regulation (Traction Control)
ASCII American Standard Code for Information Interchange
CA Controller Application
CAN Controller Area Network
Con-Ag Construction-Agriculture Industry
CRC Cyclic Redundancy Check
DA Destination Address
DLC Data Length Code
DP Data Page
ECM Engine Control Module
ECU Electronic Control Unit
EDP Extended Data Page
EOF End of Frame
GE Group Extension
ID Identifier
IDE Identifier Extension Bit
LLC Logical Link Control

LSB	Least Significant Byte or Least Significant Bit
MAC	Medium Access Control
MID	Message Identifier
MSB	Most Significant Byte or Most Significant Bit
NA	Not Allowed
NA	Not Available
NACK	Negative-Acknowledgment
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
PS_GE	PDU Specific - Group Extension
PS_DA	PDU Specific - Destination Address
PTO	Power Take-Off
R	Reserved
RTR	Remote Transmission Request
SA	Source Address
SID	Subsystem Identifier
SLOT	Scaling, Limits, Offset, and Transfer Function
SOF	Start of Frame
SPN	Suspect Parameter Number
SRR	Substitute Remote Request
un	Undefined

3.3 References to the OSI Model

SAE J1939 is structured into several parts based on the ISO 7498 Open System Interconnect (OSI) model. There are seven layers to the OSI model as shown in Figure 1. The intent is that protocols be developed to perform the functions of each layer as needed. While there is a SAE J1939 document allocated to each layer, not all of them are explicitly identified by having their own SAE J1939 document. Some of the layers not having their own documents are supported by functionality included within other documents.

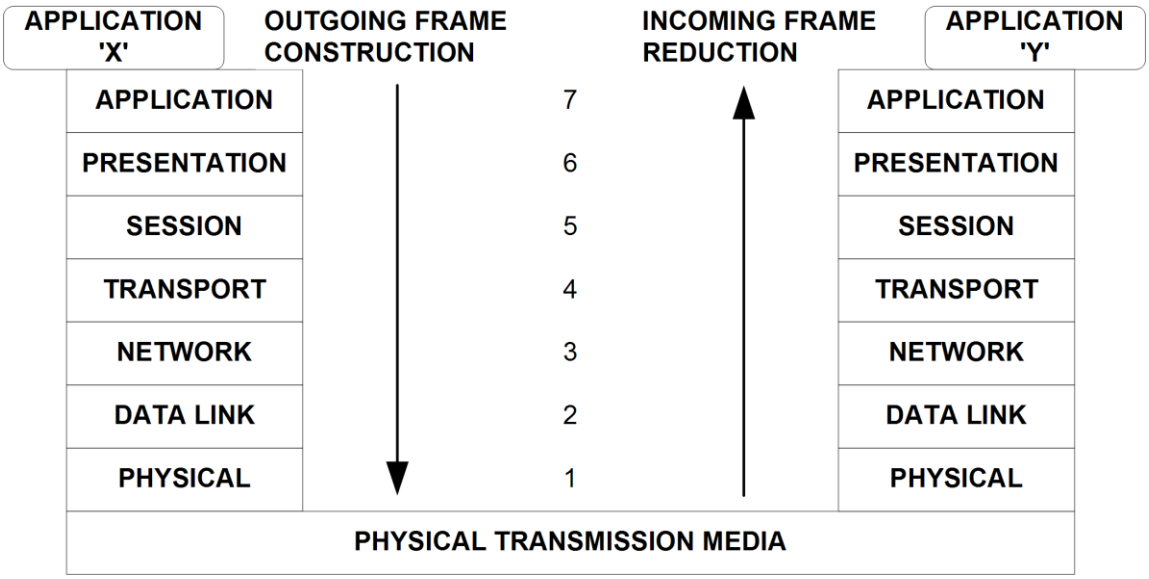

FIGURE 1 - THE OSI SEVEN LAYER MODEL

The functionality of each layer is:

1. Physical - Concerns the transmission of structured bit stream over physical media; deals with the mechanical, electrical, functional, and procedural characteristics to access the physical media

2. Data Link - Provides the reliable transfer of information across the physical layer; sends blocks of data (frames) with the necessary synchronization, error control, sequence control, and flow control;

3. Network - Provides upper layers with independence from the data transmission and switching technologies used to connect systems; responsible for establishing, maintaining, and terminating connections;

4. Transport - Provides reliable, transparent transfer of data between end points; provides end-to-end error recovery and flow control; provides segmentation and reassembly of very large messages;

5. Session - Provides the control structure for communication between applications; establishes, manages, and terminates connections (sessions) between cooperating applications;

6. Presentation - Provide independence to the application process from differences in data representation (syntax); and

7. Application - Provides access to the OSI environment for users and also provides distributed information services.

The purpose of the OSI model is to provide a common basis for coordinating standards development by placing them within the perspective of the overall model. Any resulting standard, such as SAE J1939, is not required to be explicitly partitioned into these seven layers as long as the fundamental functionality is supported. In addition, the hardware and software which perform the functions of each layer need not be rigidly defined such that each layer is recognizable within the system design. The distinction between layers can become totally obscured upon allocating these functions to a specific system design. In reviewing the SAE J1939 layer documents, it can be seen that some SAE J1939 layers include some functions normally associated with other OSI layers. This usually occurs when a layer may not require, or justify having, a standalone document of its own.

Since the SAE J1939 network is a specific communications system, supporting specific sets of applications and a specific industry, rather than being generalized, not all of the OSI layers are required. Only those layers which are required for the anticipated SAE J1939 uses will be defined, with a separate document being used for each of these layers.

3.4 Documentation Structure and Guide

This SAE J1939 document is merely the top level of a hierarchy of related documents. A separate document, identified as SAE J1939-*N*, has been defined for each application of the network and for each of the seven OSI model layers. To accommodate multiple versions of any one layer, a second digit (*X*) after the dash is used to identify the version of a document. Thus to determine the total network definition for a particular application, such as for North American agricultural equipment, one must obtain the top level application document, SAE J1939-02, which identifies all of the layer versions used, and then obtain each of these individual layer documents. The presently defined documents and numbering system are as follows:

J1939	Top Level Document for a Serial Control and Communications Vehicle Network.
J1939DA	Digital Annex of Serial Control and Communications Heavy Duty Vehicle Network Data
J1939-0*X*	An application document, where *X* refers to a specific network/application version of the network. This document will identify the industry or applications for which it pertains and will list the specific versions of each layer that makes up this network.
J1939-01	Recommended Practice for Control and Communications Network for On-Highway Equipment
J1939-02	Agricultural and Forestry Off-Road Machinery Control and Communication Network
J1939-03	On Board Diagnostics Implementation Guide
J1939-05	Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide
J1939-1*X*	A Physical Layer document, where *X* refers to a specific version of the Physical Layer.
J1939-11	Physical Layer, 250K bits/s, Twisted Shielded Pair
J1939-13	Off-Board Diagnostic Connector
J1939-14	Physical Layer, 500 Kbps
J1939-15	Reduced Physical Layer, 250K bits/sec, Un-Shielded Twisted Pair (UTP)

J1939-21 Data Link Layer (no alternative versions permitted)
J1939-3*X* Network Layer document, where *X* refers to a specific version of the Network Layer.
J1939-31 Network Layer
J1939-4*X* Transport Layer document, where *X* refers to a specific version of the Transport Layer. No Transport Layer documents are presently defined.
J1939-5*X* Session Layer document, where *X* refers to a specific version of the Session Layer. No Session Layer documents are presently defined.
J1939-6*X* Presentation Layer document, where *X* refers to a specific version of the Presentation Layer. No Presentation Layer documents are presently defined.
J1939-7*X* Applications Layer Document, where *X* refers to a specific version of the Application Layer.
J1939-71 Vehicle Application Layer
J1939-73 Application Layer - Diagnostics
J1939-74 Application - Configurable Messaging
J1939-75 Application Layer - Generator Sets and Industrial
J1939-81 Network Management (no alternative versions permitted)
J1939-82 Compliance - Truck and Bus
J1939-84 OBD Communications Compliance Test Cases for Heavy Duty Components and Vehicles

Document numbers have been assigned to all seven of the OSI model layers even though they are not all specifically defined within the present definition of SAE J1939. This was done in part to provide an easily recognizable relationship between the documents and the OSI model and also to provide growth capabilities should it be determined later that such documents are needed. Documents in the SAE J1939-8x sequence are kept separate as they represent a vertical slice through all of the layers and are thus best explained and understood as an individual subject.

Multiple application layer documents may be utilized simultaneously on the same network and thus must maintain compatibility. An example of such a system is an on-highway heavy duty tractor that utilizes both SAE J1939-71 for the majority of communications and SAE J1939-73 for diagnostics communications, both sets of messages being carried over the exact same network. A single vehicle/application may also utilize different physical layers within the same system but they need not be compatible if on different segments. An example is on-highway trucks where the physical layer used to connect the tractor to the trailer may be different than that used on the tractor itself.

4. TECHNICAL REQUIREMENTS

Beyond being an introduction to the full set of SAE J1939 documents, this document is meant to aid those unfamiliar with SAE J1939 by answering the most basic questions of:

- How SAE J1939 is intended to work
- How to construct and process messages (transmit and receive)
- How to design an ECU to support SAE J1939
- How typical control sequences are done (application examples)
- How a typical network is wired

4.1 SAE J1939 Overview

The following overview provides general information about many of the key aspects required for communicating over an SAE J1939 network. This section is offered as informative text for illustrating and clarifying the network and guidance for identifying 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 section 2.1.1 for the complete definition and specification of each aspect of the network. In section 4.1.8, SAE J1939-01 is used as the basis for some of the examples and not meant to infer that all SAE J1939 applications must follow SAE J1939-01. Applications may elect to utilize alternative versions of one or more layers resulting in corresponding changes to the following discussion.

4.1.1 Introduction

SAE J1939 is a high speed communications network designed to support real-time closed loop control functions between ECUs which may be physically distributed throughout the vehicle. SAE J1708/SAE J1587 is an older, widely used low speed network intended to provide simple information exchange, including diagnostic data, between ECUs. SAE J1939 is capable of performing all of the functions of SAE J1708/SAE J1587 as well as the control system support. Any one application may utilize one or the other or both of these networks.

SAE J1939 uses the CAN protocol which permits any ECU to transmit a message on the network when the bus is idle. Every message includes an identifier which defines the message priority, who sent it, and what data is contained within it. Collisions are resolved non-destructively due to the arbitration process that occurs while the identifier is transmitted. This permits high priority messages to get through with low latency (delay) times because there is equal access on the network for any ECU, but when multiple ECUs are simultaneously attempting to transmit, the highest priority message prevails.

4.1.2 Message Format and Usage

SAE J1939 provides a complete network definition using the 29 bit identifier (CAN Extended Format) defined within the CAN protocol shown in Figure 2. SAE J1939-21 describes the data link layer using the CAN protocol with 29-bit Identifiers and provisions on the use of 11-bit Identifiers. SAE J1939-21 enables 11 bit identifier (CAN Base Format) devices to be used within the same network, defining all messages as proprietary, permitting both device types to coexist without interference. The 11 bit identifier definition is not directly a part of SAE J1939 but is included to assure that users of it can coexist on the same network without conflict. SAE J1939 will not provide any further definition of the use of the 11 bit identifier. The CAN Data Frame Bits SOF, SRR, IDE, and RTR bits will not be discussed in the following description (see SAE J1939-21 and ISO 11898).

CAN EXTENDED FRAME FORMAT	SOF	IDENTIFIER 11 BITS											SRR	IDE	IDENTIFIER EXTENSION 18 BITS																RTR	...
J1939 FRAME FORMAT	SOF	PRIORITY			EDP	DP	PDU FORMAT (PF) 6 BITS (MSB)						SRR	IDE	PF (CONT.)		PDU SPECIFIC (PS) (DESTINATION ADDRESS, GROUP EXT. OR PROPRIETARY)								SOURCE ADDRESS								RTR	...
		3	2	1			8	7	6	5	4	3			2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1		
J1939 FRAME BIT POSITION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
CAN 29 BIT ID POSITION		28	27	26	25	24	23	22	21	20	19	18			17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		

FIGURE 2 - SAE J1939 29 BIT IDENTIFIER

The first 3 bits of the 29 bit identifier for an SAE J1939 message is the Priority field. The Priority field is used only for CAN bus arbitration to influence which message gets transmitted when two or more nodes are contending to send a message on the bus. The Priority field should be masked off and treated as "don't care" by the receiver. The Priority field is not part of the Parameter Group identifier that identifies the specific SAE J1939 message and should be ignored by the receiver to identify the message. A value of 000 has the highest priority. Higher priority messages would typically be used for high speed control messages. An example of this is the torque control message from the transmission to the engine (see SAE J1939-71). A lower priority would be used for data which is not time critical. An example of this is the engine configuration message. The priority field may be programmable for each message type so that network tuning can be performed by an OEM if necessary. Some messages may be defined to use a specific priority, such as the Transport Protocol messages which use the same priority regardless of the PGN being transported.

The next two bits in the identifier field, Extended Data Page and Data Page, are used to select from 4 separate pages of message definitions. The page selections are as noted in Table 1.

TABLE 1 - 29 BIT IDENTIFIER DATA PAGES

Extended Data Page	Data Page	Message Page Definition
0	0	Page 00 – Defined by SAE J1939
0	1	Page 01 – Defined by SAE J1939
1	0	Page 10 – Reserved for future definition by SAE J1939
1	1	Page 11 – Defined by ISO 15765-3

The next set of 8 bits in the identifier is the PDU Format (PF) field. PDU stands for Protocol Data Unit (i.e. Message Format). The PF field identifies one of two PDU formats able to be transmitted. PDU Formats are described in SAE J1939-21, Section 5.3. The SRR and IDE bits are entirely defined and controlled by CAN and therefore not described or modified by SAE J1939.

The next 8 bits of the identifier are PDU Specific (PS), meaning that they are dependent on the value of the PF. If the PF value is between 0 and 239 (PDU1), this PS field contains a destination address. If the PF field is between 240 and 255 (PDU2), the PS field contains a Group Extension (GE) to the PDU Format. The Group Extension provides a larger set of values to identify messages which can be broadcast to all ECUs on the network.

Most messages on SAE J1939 are intended to be broadcast using the PDU2 format. Data transmitted on the network using PDU2 format cannot be directed to a specific destination. When a message must be directed to a particular ECU, it must have been assigned a PGN in the PDU1 format range of numbers so a specific destination address can be included within the identifier of the message. An example of this is the transmission commanding a specific torque value from the engine or a specific torque value from a retarder. Requiring a destination must be considered when the Parameter Group is first defined and published by the SAE committee (see SAE J1939-21).

Collectively, the Extended Data Page bit, Data Page, PF, and PS values define the PG being transmitted. These PGs have definitions which include the parameter assignments within the 8 byte data field of each message as well as the transmission repetition rate and priority. The term "Parameter Group" is used because they are groups of specific parameters. Parameter Groups are identified by a Parameter Group Number (PGN), which uniquely identifies each Parameter Group. The PGN structure permits a total of up to 8672 different Parameter Groups to be defined per page. The concepts of Parameter Groups and Parameter Group Numbers are described in SAE J1939-21. See SAE J1939DA for the current list of PGN assignments. These assignments were previously listed in Appendix A of this document.

The last 8 bits of the identifier contain the address of the ECU transmitting the message (Source Address). For a given network, every address must be unique (254 available). Two different ECUs cannot use the same address at the same time. The PGNs are independent of the Source Address, thus any ECU can transmit any message.

4.1.3 Addresses and NAME

Each ECU on the network will have at least one NAME and one address associated with it. There are examples, such as an engine and engine retarder residing in a common ECU, wherein multiple NAMEs and multiple addresses may coexist within a single electronics unit. The address of an ECU defines a specific communications source or destination for messages, and the NAME includes identification of the primary function performed at that address and adds an indication of the instance of that functionality in the event that multiple ECUs with the same primary function coexist on the same network. As many as 254 different ECUs of the same function can coexist on the network, each identified by their own address and NAME.

To uniquely name each ECU, SAE J1939 defines a 64 bit NAME consisting of the fields shown in Table 2. The Function Instance, ECU Instance, and Identity Number fields permit multiple ECUs of the same make and model to coexist on the same network but still have unique NAMEs for each. See SAE J1939-81 for a full description of the NAME data object and the address claim process. See SAE J1939DA for the current list of committee assignments for the NAME field enumerations and source addresses. These assignments were previously listed in Appendix B of this document.

TABLE 2 - NAME FIELDS

Arbitrary Address Capable	Industry Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Manufacturer Code	Identity Number
1 bit	3 bit	4 bit	7 bit	1 bit	8 bit	5 bit	3 bit	11 bit	21 bit

NAMEs identify the primary vehicle function or functions which an ECU performs and uniquely identify each ECU, even when there are more than one of the same type on the network. But with a length of 64 bits, a NAME is inconvenient to use in normal communications. Therefore, once the network is fully initialized, each ECU utilizes an 8 bit address as its source identifier or "handle" to provide a way to uniquely access a given ECU on the network. For example, an engine may be assigned address 0, but if a second engine is present, it needs a separate, unique address (e.g. 1) and instance. ECUs that accept destination specific commands may require multiple addresses. This permits distinguishing which action is to occur. For example, if the transmission is commanding a specific torque value from the engine (address 0), this must be differentiated from commanding a specific torque value from the engine brake (retarder) (address 15). As can be seen by this example, a single ECU on the network may have multiple addresses and each address will have an associated NAME.

Address Claim, defined in SAE J1939-81, is the process for claiming a network address and associating the NAME, or vehicle function, to that address. It also serves as the process for ECUs to determine the network address associated with other vehicle functions. To facilitate the initialization process of determining the address(es) for each ECU on the network, commonly used devices have Preferred Addresses assigned by the committee (See SAE J1939DA for the Preferred Addresses assignments. These assignments were previously listed in Appendix B, Table B2 through Table B9 of this document). Using the Preferred Addresses minimizes the frequency of multiple devices attempting to claim the same address. If there is no applicable Preferred Address assignment, then it is up to the supplier of a Controller Application (CA) to select the initial address to claim within the range of 128 to 247. The Address Claim process is used after power up to claim a network address and resolve any conflicts when multiple devices attempt to claim the same address. Each ECU must be capable of announcing which address(es) it intends to use. This is the address claim feature. Address Claim is detailed in SAE J1939-81. Two key aspects of Address Claim are:

1. Upon power-up and whenever requested, an ECU must send an Address Claimed message to claim an address. When an ECU sends the Address Claimed message, all ECUs must at least compare the newly claimed address with their own. Should multiple ECUs claim the same address, the one having the lowest value NAME uses this address and the other(s) must claim a different address or stop transmitting on the network. ECUs should record or compare this newly claimed address to their own table of addresses and associated NAMEs on the network. Not all ECUs are required to maintain such a table.

2. An ECU may send a request for Address Claimed message to determine addresses claimed by other ECUs. When an ECU sends a request for Address Claimed, all requested ECUs then send their Address Claimed messages. This permits transitional ECUs (tools, trailers, etc.) or ECUs powering up late to obtain the current address table so that an available address can be found and claimed or to determine which ECUs are currently on the network. This approach permits the option of self-configurable addresses for those ECUs which may need it, but does not make this a requirement for all ECUs. Self-configurable addressing is optional; those ECUs which might be expected to encounter address conflicts are recommended to support this capability.

When an address conflict has been detected, the following four options are available, depending upon the capabilities of the CA involved:

- Self-Configurable CAs - a self-configurable CA is capable of dynamically computing and claiming an unused address. Most service tools and bridges will have this capability.
- Command Configurable CAs - A network interconnection CA, such as a bridge, or a service tool, may command another ECU to use a given address. The CA targeted for the commanded address would then issue an Address Claimed message to acknowledge acceptance of this new commanded address. The CA may be commanded to accept a new address even though it has already claimed a valid address.

- Service Configurable CAs - CAs which are modifiable by service personnel, usually by the means of DIP switches or a service tool. When "commanded address" messages are used, this option differs from the Command Configurable in that a service tool is required and will often use proprietary techniques.
- Non-Configurable CAs - Those CAs that are neither self-configurable nor reprogrammable would have to cease transmitting if they fail to claim a valid address.

4.1.4 Communication Methods

Three primary communication methods exist within SAE J1939 and appropriate use of each type allows effective use of the available Parameter Group Numbers. Each of the communications methods has an appropriate use. The three communications methods are:

- Destination specific communications, using PDU1 (PF values 0 - 239) (includes the use of the global destination address - 255)
- Broadcast Communications using PDU2 (PF values 240 - 255)
- Proprietary Communications using either PDU1 or PDU2 format

4.1.4.1 Destination Specific Communications

Destination specific Parameter Group Numbers are needed where the message must be directed to one or another specific destination and not to both. SAE J1939 currently defines a torque control message which may be sent to an engine or retarder. In the case of more than one engine, this message must be sent only to the desired engine and a destination specific Parameter Group Number is needed and has been assigned.

4.1.4.2 Broadcast Communications

Broadcast Communications apply in several situations, including:

- Messages sent from a single or multiple sources to a single destination
- Messages sent from a single or multiple sources to multiple destinations

Broadcast Communications cannot be used where a message must be sent to one or another destination and not to both.

4.1.4.3 Proprietary Communications

Proprietary communications is provided by the use of three proprietary Parameter Group Numbers. A Parameter Group Number has been assigned for broadcast proprietary communications and two Parameter Group Numbers have been assigned for destination specific proprietary communications. This allows for two functions. One, a specific source can send its proprietary message in a PDU2 type format (broadcast). Two, it allows for situations where a service tool must direct its communication to a specific destination out of a possible group of ECUs. For instance this case arises when an engine uses more than one controller but the service tool must be able to perform calibration/reprogramming while all ECUs are connected to the same network. In this case the proprietary protocol needs to be destination specific. Note that the destination ECU must be capable of properly interpreting the proprietary data.

Proprietary communications are useful in two situations:

- Where it is unnecessary to have standardized communications
- Where it is important to communicate proprietary information

4.1.5 Transmitting Messages

The CAN Data Frame consists of the 29 bit identifier shown in Figure 2, a 6 bit control field, and a data field which is typically 8 bytes, and terminates with CRC, ACK, and EOF fields. To send a particular data item, a message must be constructed with the proper data placed in each of these fields. The data for the 6 bit control field and the CRC, ACK, and EOF fields is generally filled by the CAN controller. The SAE J1939 documents provide technical information for filling the 29 bit identifier and the data field. The SAE J1939 documents also specify behavior requirements for messages, such as transmission rate. The applicable SAE J1939 document needs to be referenced to get the technical information required to send a particular data item. For a particular data item, the SAE J1939 document will define the message's Parameter Group Number (PGN), the message update (transmission) rate, the message default priority, the encoding of the item's data, and the position of the item's data in the message's data field. In SAE J1939 multiple data items are typically packed together within a message (or PGN), and SAE J1939 defines the position of the data for each data item in the data field. For most SAE J1939 messages, the sending device is not required to support each data item carried in the data field. If the transmitting ECU does not have data available for a given parameter in the data field, then it sets those bits to "not available", as described in SAE J1939-71, so that a receiver knows that the data is not provided for that parameter. If an ECU receive SPN data in an PGN from the network segment and also transmits that same PGN onto the same network segment, then the ECU shall set the bits for that SPN's data as 'not available' instead of retransmitting the SPN data it received. Additionally, if bits in the data field are not defined by SAE, the transmitting ECU shall also set those bits to “not available”.

Parameter Groups which have more than eight bytes of data must be sent as multipacket messages using the Transport Protocol functions defined in SAE J1939-21 Section 5.10.

4.1.6 Receiving Messages

There are various techniques (and electronic ICs) available for capturing selected messages off the network. Several general observations from SAE J1939-21 can be made however regarding received messages.

1. If it is a destination specific request or command, the ECU must determine if there is an address match between itself and the incoming messages' destination address. If there is, it must process the message and provide some type of acknowledgment.

2. If a message is a global request, every ECU, even the originator, must process it and respond if the data is available.

3. If a message is broadcast, each ECU must determine if it is relevant or not.

4.1.7 ECU Design

Although every manufacturer will have different performance requirements for the ECU contained within their product, several observations should be made regarding the resources needed to support SAE J1939.

Even though not every message is relevant, the receiving processor must still be able to handle (or buffer) multiple back to back messages. As described in the Processing Requirements section in SAE J1939-21, devices must be designed so no messages will be lost due to ECU hardware or software design limitations. This requirement will require some RAM space as well as processor time for the memory transfers. SAE J1939-11 and SAE J1939-15 networks operate at 250 kbps so an ECU could receive a new message every 250 μs for the shortest SAE J1939 message with zero data bytes and an ECU could receive a new message every 500 μs for typical SAE J1939 messages with 8 data bytes. SAE J1939-14 networks operate at 500 kbps so an ECU could receive a new message every 125 μs for the shortest SAE J1939 message with zero data bytes and an ECU could receive a new message every 250 μs for typical SAE J1939 messages with 8 data bytes.

Additional resources will be needed to support other aspects of SAE J1939, such as Address Claim and NAME discussed in SAE J1939-81, Requests and Acknowledgements as described in SAE J1939-21, and any applicable data and diagnostics as described in the SAE J1939-7X documents.

4.1.8 Network Topology

SAE J1939-11, SAE J1939-14, and SAE J1939-15 specify the requirements for different physical layers which can be used for an SAE J1939 segment. An SAE J1939 network may consist of one SAE J1939 segment or multiple SAE J1939 segments connected by Network Interconnection ECUs. The SAE J1939-01 provides examples of a system consisting of one SAE J1939 segment and a system consisting of multiple SAE J1939 segments connected by Network Interconnection ECUs. Each SAE J1939 segment consists of a single, linear, twisted pair of wires running around a section of the vehicle to each ECU. A short stub is permitted to connect this “bus” to each ECU. This simplifies the routing of the main bus wiring by not requiring it to come in direct proximity with each ECU. The linear bus is necessary at a data rate of 250 Kbps and 500 Kbps in order to minimize reflections of the electrical signals. The termination resistor at each end of the bus also reduces reflections. To support a tractor pulling one or more trailers, and the frequent removal and addition of new trailers, a separate SAE J1939 segment (subnetwork) is used within the tractor and in each trailer or dolly.

The SAE J1939 network may thus be composed of multiple segments, with a Network Interconnection ECU (bridge) between them, as defined in SAE J1939-31. These segments need not be directly compatible with each other, as they may operate at different data rates or use different physical media. For example, a bridge provides electrical isolation between segments, provides initialization support for the subnetwork connected to it, and can provide message filtering to prevent unnecessary message traffic on the subnetworks. In the event of a bus failure on the wires exposed between the tractor and trailer, the main SAE J1939 subnetwork on the tractor will continue to function.

The SAE J1939-13 document specifies the requirements for the standard diagnostic connector used for connecting a diagnostic tool to the SAE J1939-11, SAE J1939-14, and SAE J1939-15 networks of a system.

4.2 Pre-assigned Values

Most identifiers and data elements for parameters, messages, diagnostic identifiers, SAE J1939 NAME identifiers, and network addressing are assigned by the SAE Truck and Bus Control and Communications Network Committee. Several such identifiers include the Suspect Parameter Numbers (SPNs) for parameter and diagnostic identification, Parameter Group Numbers (PGNs), and Preferred Addresses. For the SAE J1939 NAME object, the SAE Truck and Bus Control and Communications Committee assigns values for the Manufacturer Code, Industry Group, Function, and Vehicle System. Except as noted below, applications must use the actual values that have been assigned by the SAE Truck and Bus Control and Communications Committee. If new values are required that are not already assigned, developers may request new values to be assigned by the SAE Truck and Bus Control and Communications Committee.

The values for several identifiers and data element assignments are not assigned by the SAE Control and Communications Network Committee and the values are at the discretion of the application or developer. Several such identifiers include the data content of the three Proprietary PGNs, the description for the Manufacturer Specific Diagnostic SPNs, the Instance Number elements of the SAE J1939 NAME object, and the Identity Number of the SAE J1939 NAME object.

Application specific parameters and Parameter Groups are defined in the SAE J1939-7*X* documents. Parameter Groups that are used for control and management of the network are defined in SAE J1939-21, SAE J1939-31, and SAE J1939-81. Assignments for Preferred Addresses, NAME elements, and Parameter Group Numbers are published in SAE J1939DA, though they were previously published in the Appendices of this document. Each of these items is described in this section.

4.2.1 Parameter Group Numbers

Parameter Group Numbers are assigned specifically to use either PDU1 format or PDU2 format (PDU types are described in Section 4.1.2 and in SAE J1939-21, Section 5.3). Once assigned to a format the other PDU type is not available for that Parameter Group. The assignment of a Parameter Group Number should be done keeping in mind the following characteristics: priority, update rate, importance of the data in the packet to other ECUs, and length of the data associated with the Parameter Group.

The current Parameter Group Number assignments are published in SAE J1939DA, though previously they were listed in Appendix A Table A2 of this document. Parameter Group Numbers are assigned linearly to the various sections of the Parameter Group based on the order of request and other criteria, such as PDU type and update rate. See Appendix A, Table A1 of this document.

Much of the communications between ECUs constructed by a single manufacturer do not require standardization. The information that is communicated is not generally useful to other ECUs on the network. In this situation the proprietary Parameter Groups can be used. The use of standardized communications is preferred and should be used whenever practical, however the proprietary option is offered as a means of solving unique problems and situations.

If proprietary information is being communicated, or the information to be communicated is not of general interest, the proprietary method should be used. If the information is of general interest and does not require direction of the message to a particular ECU, a Parameter Group Number utilizing the PDU2 broadcast format should be sought. Finally, if the information is of general interest but requires direction to one or another ECUs then destination specific addressing is needed and a PDU1 format Parameter Group Number should be sought. Proprietary and PDU1 communications methods should be considered carefully and used sparingly.

4.2.2 Data Field Grouping

Minimizing message overhead with CAN based systems requires full use of the data fields of messages. Except in the case of very time critical messages, parameters should be grouped to fill the 8 byte data field. Following this principle conserves PGNs 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 needed to allow definition of Parameter Group Numbers that result in sparsely used data fields.

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.)

It should be recognized that, while these are guidelines, in most cases when parameters are grouped together they will end up violating one or more of the above rules. Since all parameters defined in SAE J1939 have a technique for identifying when they are not available it is not critical that all of the parameters in one Parameter Group come from the same ECU. If a new parameter is defined and there are spare bytes or bits in an existing Parameter Group, then it can be easily added there. When the update rate is fast, it is desirable to make sure that a Parameter Group is as fully utilized as possible (i.e. uses all 8 data bytes) before defining another PG and preferable that all parameters are normally coming from one specific ECU.

For the slower update rate data it is not as critical that all of the parameters in a Parameter Group come from the same ECU. Even though it is desirable to have parameters come from one ECU, the intention of SAE J1939 is to provide a means for communicating the data and not dictating which ECU is to send what data.

4.2.3 NAME Systems and Functions

A Function is a capability of a component or group of components served by one or more ECUs. The Function of each ECU is identified within an 8 bit field of that ECU's NAME. As there may be multiple ECUs which identify themselves with the same Function, the Function Instance field of NAME is used to distinguish between them. The same Function value (upper 128 only) may mean different things for different Industry Groups or Vehicle Systems, therefore the Function (upper 128 only) identification is dependent upon the Industry Group, and the Vehicle System as shown in Figure 3 (see SAE J1939-81 Section 4.2).

A Vehicle System is a subcomponent of a vehicle or an analogous component that includes one or more SAE J1939 network segments and may be connected or disconnected from the total vehicle. A Vehicle System may be made up of one or more Functions, which have ECUs that are connected to a SAE J1939 network segment of that Vehicle System. A typical on-highway Vehicle System is a tractor or trailer. Because the definition of Vehicle Systems will vary from one industry to another, the System definition is dependent upon the Industry Group as shown in Figure 3 (see SAE J1939-81 Section 4.2).

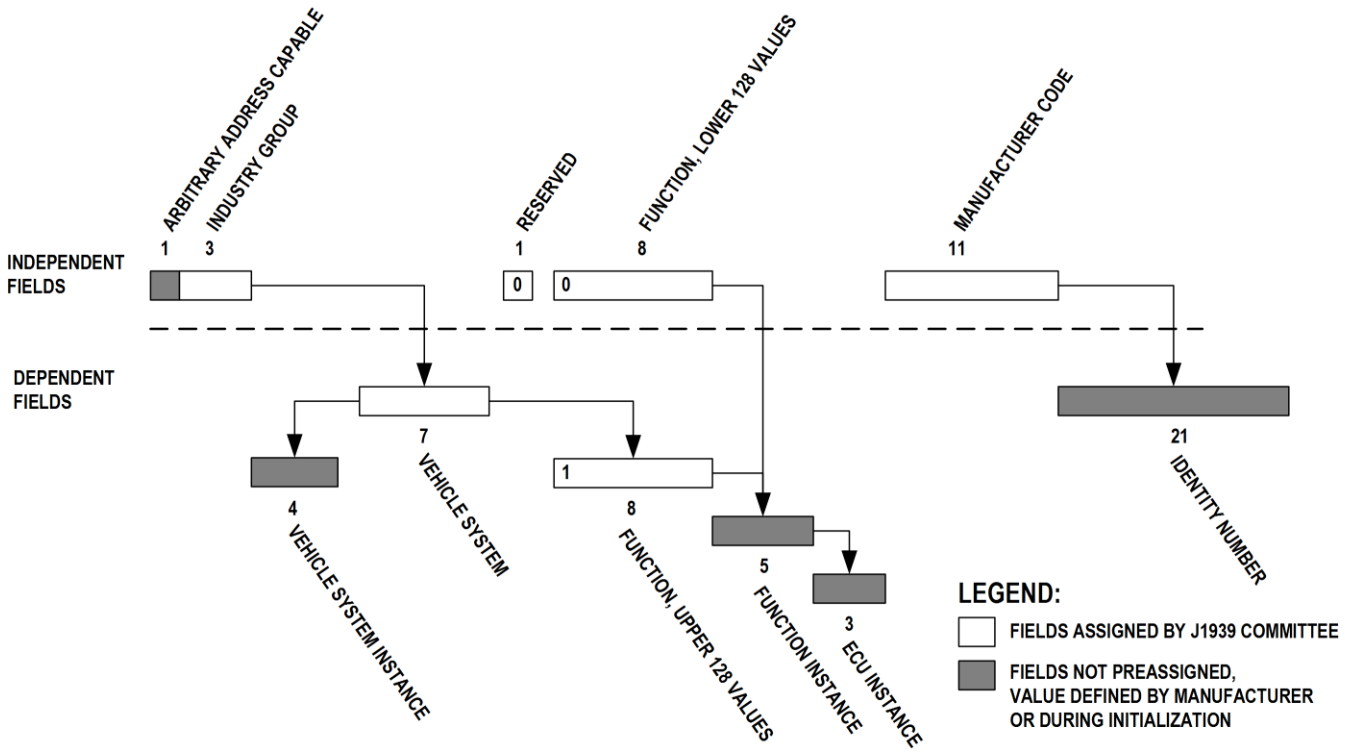

FIGURE 3 - DEPENDENCIES IN THE NAME FIELDS

A single ECU on the network may combine multiple Functions, and would then have the option to claim a separate address for each supported function. The assigned Vehicle System and Function values are published in SAE J1939DA. These assignments were previously listed in Appendix B, Tables B11 and B12 of this document.

4.2.4 Industry Group

To permit multiple industries to use SAE J1939, an Industry Group code is used to identify the industry to which the ECU is associated. Industry Group Code 0 is a special category of Industry Group in that it identifies Preferred Addresses and NAME Functions that are common to all industries. Any ECU which may be used in more than one industry application, such as diesel engines, should use NAME Functions and Preferred Addresses within this global group. It is the responsibility of those requesting new definitions to consider if this may be the case, and to request the new definition in the correct group. To avoid running out of NAME Function or address values, it is requested that global values be used only when truly applicable. If an ECU may exist in only one group, such as agricultural equipment, it is preferable to add the definition to the applicable group rather than to use a global value. Industry Group codes are listed in SAE J1939DA. These assignments were previously listed in Appendix B, Table B1 of this document.

4.2.5 Manufacturer Code and Identity Number

As defined in SAE J1939-81, the SAE J1939 NAME must be unique for all ECUs communicating on a particular network. The SAE J1939 NAME object includes a Manufacturer Code element and the Identity Number element for establishing unique SAE J1939 NAME values. The Manufacturer Code, assigned by the SAE Truck and Bus Control and Communications Committee, permits NAME uniqueness between manufacturers of similar Controller Applications where the Industry Group, Vehicle System, Functions, and Instance elements would likely use the same values. The Identity Number is assigned by the manufacturer and permits NAME uniqueness between individual products for a manufacturer where all of the other SAE J1939 NAME elements are identical.

The Manufacturer Code assignments are listed in SAE J1939DA. These assignments were previously listed in Appendix B, Table B10 of this document. A manufacturer is permitted to have multiple codes, such as when there are multiple divisions or major product lines. Having a unique Manufacturer Code for each individual product is discouraged as this would quickly exhaust the range of available codes. There are 21 bits available in the Identity Number field of NAME, permitting the manufacturer to include a reference to each particular product if desired.

4.2.6 Preferred Address

The SAE Truck and Bus Control and Communications Committee is discontinuing most new assignments of Preferred Addresses, particularly for Industry Group specific Preferred Addresses (See SAE J1939DA for these assignments. These assignments were previously listed in Appendix B, Table B3 through Table B9 of this document). The SAE Truck and Bus Control and Communications Committee may assign new Global Preferred Addresses (See SAE J1939DA for these assignments. These assignments were previously listed in Appendix B Table B2 of this document) for system functions that warrant the assignment. Preferred address assignments serve to establish the first address to claim by a CA and minimize the frequency of multiple devices attempting to claim the same address. However, too many devices have been designed to be Single Address Capable on the expectation of having an assigned preferred address and hard coded to expect use of specific preferred addresses by other devices on the network. As a result, these design practices have depleted the ability to make unique preferred address assignments within some Industry Groups. Preferred address assignments weren't intended as a means for the vast majority of devices to avoid having to support Address Arbitration. New devices should be designed to be Arbitrary Address Capable and rely upon Address Claim to determine the network address of other system functions.

As defined in SAE J1939-81, a CA claiming a preferred address in the Global Preferred Addresses range of 0 to 127 and 248 to 253 must perform the described function for that preferred address and specify the associated function within its NAME. With less than 40 unassigned Global Preferred Addresses remaining, the SAE Truck and Bus Control and Communications Committee must limit new assignments within this range to functions that warrant the assignment.

If a CA does not have an assigned preferred address, then the CA should initially claim an address in the range of 128 to 247. Such devices should be arbitrary address capable in order to claim an address through Address Arbitration. The discontinuation of preferred address assignments means more devices will not have an assigned preferred address and will need to rely upon Address Arbitration in the range of 128 to 247 to claim an address. The supplier of a CA may provide any strategy for selecting the initial address to claim within the range of 128 to 247.

The number of addresses within a given system cannot exceed 254 (null and global cannot be claimed by devices). Many ECUs that operate on a SAE J1939 network will have an assigned Preferred Address that the ECU may use. If a Preferred Address is not available, then the ECU should perform address arbitration. If the ECU's Preferred Address has been claimed or is in use by another ECU on the network, the conflict will be resolved using the procedures outlined in Section 4.1.3 and detailed in SAE J1939-81. There may be additional constraints or procedures defined in the applicable SAE J1939-0X document. For instance, on-highway trailer bridges and devices have address claiming constraints that differ from Con-Ag systems. A supplier of a Self-Configurable ECU may provide any strategy for selecting an address to attempt to claim. However, if an alternative approach is not defined, it should attempt to claim an address in the range 128 - 247, starting at 128. Individual reserved Preferred Address assignments begin at zero and are assigned in a linear fashion as follows:

0 to 127	Reserved for most conventional ECUs in Industry Group 0 - Global
128 to 247	Reserved for Industry Specific assignments
248 to 253	Reserved for special ECUs
254	Null Address
255	Global Address

The current Preferred Address assignments are published in SAE J1939DA. These assignments were previously listed in Appendix B of this document. For further information, see SAE J1939-81.

4.2.7 Suspect Parameter Number (SPN)

A Suspect Parameter Number (SPN) is a 19 bit number used to identify a particular element, component, or parameter associated with an ECU. This capability is especially useful for diagnostics, permitting an ECU which has detected a fault associated with a particular component, such as a sensor, to transmit a fault message identifying the faulty component. SPNs are assigned by the SAE Truck and Bus Control and Communications Committee and are published in SAE J1939DA. These assignments were previously listed in Appendix C. The first 511 SPNs are reserved and will be assigned, when possible, to the exact same number as the Parameter Identifier (PID) of SAE J1587. For example, SAE J1587 PID 91 is "Percent Accelerator Pedal Position" and an accelerator pedal position parameter fault could be reported in SAE J1939 by using SPN 91. All other SPNs will be assigned in sequential order as SPN requests are processed.

4.3 SAE J1939DA Spreadsheet

The SAE J1939DA Digital Annex is an electronic spreadsheet document used to publish SPNs, PGNs, SLOTs, NAME field enumerations, and Preferred Address assignments made by the SAE Truck and Bus Control and Communications Committee. The SAE J1939DA is the only publication for

- the NAME field enumerations and Preferred Address assignments previously published in Table B1 through Table B12 of Appendix B of this document
- the listing all SAE J1939 SPN assignments, which were previously published in Appendix C, Table C1 of this document
- the full definition details for the SPNs previously published in the SAE J1939-71 document
- the list of SPNs that are available for use only in diagnostic trouble codes
- the list of SPNs assigned for use by other industry standards documents
- the listing all SAE J1939 PGN assignments, which were previously published in Appendix A, Table A2 of this document
- the full definition details for the PGNs previously published in the SAE J1939-71 document
- the list of PGNs assigned for use by other industry standards documents

The SAE J1939DA replaces the SAE CS1939 Companion Spreadsheet. The content in SAE J1939DA is fully approved and balloted by the SAE Truck and Bus Control and Communications Committee. The CS1939 spreadsheet contained only a fraction of the SPN and PGN technical details and did not include most of the SAE J1939 Appendix B tables. SAE CS1939 contained some data that was approved but not yet balloted by the SAE Truck and Bus Control and Communications Committee.

The SAE J1939DA supports easier sorts and searches of the large amount of data published for the SPNs, PGNs, SLOTs, and other Identifiers.

4.4 Requests for New Assignments

If new values are required that are not already assigned, developers may request new values to be assigned by the SAE Truck and Bus Control and Communications Network Committee. Requests for new values must use the SAE Truck and Bus Control and Communications Committee 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 Truck and Bus Control and Communications 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 requester should assure they are using and referencing the latest version of the SAE J1939 document, the particular SAE J1939-XX application document, and/or SAE J1939DA to avoid making requests for existing assignments at the time of request submittal.

The SAE J1939 Request Form contains sections for requesting Parameter Group Numbers (PGNs), Suspect Parameter Numbers (SPNs) for data parameter and diagnostics, Manufacturer Codes, NAME Functions, NAME Vehicle Systems, and Preferred Source Addresses. When requesting multiple new assignments, the individual item requests can be included within a single Request Form document or submitted in multiple separate Request Form documents. When requesting a new PGN, the request for the PGN and request for the parameters (SPNs) to be contained within the new PGN should be submitted together within the same Request Form document. When requesting several diagnostic SPNs, it is acceptable to include all of them within the same Request Form document. When requesting multiple new PGNs, it is often easier to submit each PGN request in a separate Request Form document; however, this is not required.

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 Truck and Bus Control and Communications 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 may 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 Web Site is used by the SAE Truck and Bus Control and Communications Committee for working through most of the technical issues and questions related to a 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 Truck and Bus Control and Communications 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 at the SAE Truck and Bus Control and Communications Committee 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, it will be necessary to table the request until the committee's questions are answered by the requester, resulting in months of delay before the request can be resolved. All too often, requests have been tabled so that questions arising from committee discussion can be resolved. Once an assignment has been made, it cannot be deleted or significantly altered because systems using this definition may have already been fielded. Consequently, this forces the committee to seriously challenge any request that is not fully understood or which might result in a future request that is very similar.

4.5 Application Examples

A typical shift sequence consists of a series of commands from the transmission to the engine 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 may also be sent regularly to disable the engine retarder at the proper time interval, or to inhibit ASR functions which might affect engine demand during portions of the shift sequence.

Parameter Group	Msg. Type	Sender	Using ECU	Action/Function
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

A typical ABS sequence will cause a message to be transmitted which indicates that the engine should reduce torque and the driveline (transmission) to remain in its existing (stable) state. If the ABS condition is "significant" (i.e. not just bouncing tires), it may 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 may return to "normal" operation.

Parameter Group	Msg. Type	Sender	Using ECU	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

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 may be requested in order to achieve acceptable torque values. Note that the transmission takes over engine control during the shift.

Parameter Group	Msg. Type	Sender	Using	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 reque 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 Marginal Indicia

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.

PREPARED BY THE SAE TRUCK AND BUS CONTROL AND COMMUNICATIONS COMMITTEE
OF THE SAE TRUCK AND BUS ELECTRICAL/ELECTRONICS STEERING COMMITTEE

APPENDIX A - PARAMETER GROUP ASSIGNMENTS

TABLE A1 - SAE J1939 PARAMETER GROUP TEMPLATE (SEE SAE J1939-21)

Legend:

EDP	= Extended Data Page	(1 bit)			
DP	= Data Page	(1 bit)	GE	= Group Extension	(8 bits)
PF	= PDU Format	(8 bits)	P	= Priority	(1 bit)
PS	= PDU Specific Field	(8 bits)	NA	= Not Allowed	
DA	= Destination Address	(8 bits)	Un	= Undefined	
PGN	= Parameter Group Number	(3 bytes)			

EDP	DP	PF	PS	Parameter Group Definition	Multipacket	PGN
0	0	0	DA	PDU1 Format - 100 mS or less	NA	000
0	0	1	DA			256
	.					
	Boundary x					
0	0	238	DA	PDU1 Format - Greater than 100 mS	Allowed	60928
0	0	239	DA	PDU1 Format - Proprietary A	Allowed	61184
0	0	240	0	PDU2 Format - 100 mS or less	NA	61440
0	0	240	1			61441
	.					
	Boundary y					
	.					
0	0	254	254			65278
0	0	254	255	PDU2 Format - Greater than 100 mS	Allowed	65279
0	0	255	un	PDU2 Format - Proprietary B	Allowed	65280-65535
0	1	0	DA	PDU1 format - 100 mS or less	NA	65536
0	1	1	DA			65792
	.					
	Boundary x1					
	.					
0	1	238	DA	PDU1 Format - Greater than 100 mS	Allowed	126464
0	1	239	DA	PDU1 Format - Proprietary A2	Allowed	126720
0	1	240	0	PDU2 format - 100 mS or less	NA	126976
0	1	240	1			126977
	.					
	Boundary y1					
	.					
0	1	254	254			130814
0	1	254	255	PDU2 Format - Greater than 100 mS	Allowed	130815
0	1	255	un	PDU2 Format - Proprietary B	Allowed	130816 -131071

Note 1: Refer to Table 1, page 15, regarding 29-bit CAN Identifiers with EDP = 1.

TABLE A2 - PARAMETER GROUPS (PGN)

See 'SPNs & PGNs' worksheet in SAE J1939DA for current listing of PGN assignments

APPENDIX B - ADDRESS AND IDENTITY ASSIGNMENTS

TABLE B1 - INDUSTRY GROUPS

See 'Industry Groups (B1)' worksheet in SAE J1939DA for assignments formerly listed in Table B1

TABLE B2 - PREFERRED ADDRESSES - INDUSTRY GROUP 0 - GLOBAL

NOTE: Preferred Addresses 128 thru 247 are Industry Group specific. See Tables B3 thru B9. The SAE Truck and Bus Control and Communications Committee is discontinuing most assignments of Preferred Addresses. The SAE Truck and Bus Control and Communications Committee may assign new Global Preferred Addresses for system functions that warrant the assignment. Applications should be developed to be Arbitrary Address Capable and use Address Claim to claim addresses in the 128 to 247 range.

See 'Global Source Addresses (B2)' worksheet in SAE J1939DA for assignments formerly listed in Table B2

TABLE B3 - PREFERRED ADDRESSES - INDUSTRY GROUP 1 - ON-HIGHWAY EQUIPMENT

The SAE Truck and Bus Control and Communications Committee is discontinuing the assignment of Industry Group Preferred Addresses. Applications should be developed to be Arbitrary Address Capable and use Address Claim to claim addresses in the 128 to 247 range.

See 'IG1 Source Addresses (B3)' worksheet in SAE J1939DA for assignments formerly listed in Table B3

TABLE B4 - PREFERRED ADDRESSES - INDUSTRY GROUP 2 - AGRICULTURAL AND FORESTRY EQUIPMENT

The SAE Truck and Bus Control and Communications Committee is discontinuing the assignment of Industry Group Preferred Addresses. Applications should be developed to be Arbitrary Address Capable and use Address Claim to claim addresses in the 128 to 247 range.

See 'IG2 Source Addresses (B4)' worksheet in SAE J1939DA for assignments formerly listed in Table B4

TABLE B5 - PREFERRED ADDRESSES - INDUSTRY GROUP 3 - CONSTRUCTION EQUIPMENT

The SAE Truck and Bus Control and Communications Committee is discontinuing the assignment of Industry Group Preferred Addresses. Applications should be developed to be Arbitrary Address Capable and use Address Claim to claim addresses in the 128 to 247 range.

See 'IG3 Source Addresses (B5)' worksheet in SAE J1939DA for assignments formerly listed in Table B5

TABLE B6 - PREFERRED ADDRESSES - INDUSTRY GROUP 4 - MARINE EQUIPMENT

The SAE Truck and Bus Control and Communications Committee is discontinuing the assignment of Industry Group Preferred Addresses. Applications should be developed to be Arbitrary Address Capable and use Address Claim to claim addresses in the 128 to 247 range.

See 'IG4 Source Addresses (B6)' worksheet in SAE J1939DA for assignments formerly listed in Table B6

TABLE B7 - PREFERRED ADDRESSES -
INDUSTRY GROUP 5 - INDUSTRIAL, PROCESS CONTROL, STATIONARY EQUIPMENT

The SAE Truck and Bus Control and Communications Committee is discontinuing the assignment of Industry Group Preferred Addresses. Applications should be developed to be Arbitrary Address Capable and use Address Claim to claim addresses in the 128 to 247 range.

See 'IG5 Source Addresses (B7)' worksheet in SAE J1939DA for assignments formerly listed in Table B7

TABLE B8 - PREFERRED ADDRESSES - INDUSTRY GROUP 6 - RESERVED FOR FUTURE ASSIGNMENT

TABLE B9 - PREFERRED ADDRESSES - INDUSTRY GROUP 7 - RESERVED FOR FUTURE ASSIGNMENT

TABLE B10 - MANUFACTURER CODES

See 'Manufacturer IDs (B10)' worksheet in SAE J1939DA for assignments formerly listed in Table B10

TABLE B11 - ALL INDUSTRY INCLUSIVE NAME FUNCTIONS

The NAME fields are described in Section 4.1.3 and in SAE J1939-81, Section 4.2. This table defines the Lower 128 Functions which are independent of the Vehicle System or Industry Group. These functions are used with all 8 Industry Groups, which is a distinction from Industry Group 0 which is an Industry Group itself but applicable to all industries.

See 'Global NAME Functions (B11)' worksheet in SAE J1939DA for assignments formerly listed in Table B11

TABLE B12 - INDUSTRY GROUP AND VEHICLE SYSTEM DEPENDENT NAME FUNCTIONS

The NAME fields are described in Section 4.1.3 and in SAE J1939-81, Section 4.2. This table defines the Upper 128 Functions which are dependent on the Industry Group and Vehicle System. Due to the dependencies of Vehicle System on Industry Group, and of Function on Vehicle System, the following table is used to define both Vehicle System and Function.

See 'IG Specific NAME Function (B12)' worksheet in SAE J1939DA for assignments formerly listed in Table B12

APPENDIX C - FAULT REPORTING PARAMETERS

TABLE C1 - SUSPECT PARAMETER NUMBERS (SPN)

See 'SPNs & PGNs' worksheet in SAE J1939DA for current listing of SPN assignments