SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1939/31

Issued 1994-12

Submitted for recognition as an American National Standard

RECOMMENDED PRACTICE FOR SERIAL CONTROL AND COMMUNICATIONS VEHICLE NETWORK—PART 31—NETWORK LAYER

Foreword—This series of SAE Recommended Practices have been developed by the Truck and Bus Control and Communications Network Subcommittee of the Truck and Bus Electrical and Electronics Committee. The objectives of the subcommittee are to develop information reports, recommended practices, and standards concerned with the requirements design and usage of devices which transmit electronic signals and control information among vehicle components. The usage of these recommended practices is not limited to truck and bus applications, but also includes applications for construction/agricultural equipment and stationary power systems.

These SAE Recommended Practices are intended as a guide toward standard practice and are subject to changes to keep pace with experience and technical advances.

1. Scope—This series of SAE Recommended Practices was developed to provide an open interconnect system for on-board electronic systems. It is the intention of these documents to allow electronic devices to communicate with each other by providing a standard architecture. This particular document describes the Network Layer which defines the requirements and services needed for communicating between devices that are on different segments of the SAE J1939 Vehicle Network.

2. References

2.1 Applicable Documents—General information regarding this series of documents is found in SAE J1939. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1587—Joint SAE/TMC Electronic Data Interchange 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
SAE J1939 DRAFT—Serial Control and Communications Vehicle Network—(Class C)
SAE J1939/81 DRAFT—Network Management Protocol

2.1.2 IEEE PUBLICATION—Available from IEEE, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

IEEE STD.802-1D-1990 Local Area Networks: Media Access Control (MAC) Bridges

2.2 Definitions—See SAE J1939 for definitions that are not defined in this document.

2.2.1 SEGMENT—This refers to the physical media of a given network and the devices attached to it. A single segment of a network is distinguished by all of the devices "seeing" the signal at the same time (i.e., there is no intermediate device between different sections of the network). Multiple segments can be connected together by devices including repeaters, bridges, and routers.

2.2.2 SUBNETWORK—This refers to the network activity (message traffic) on a specific SAE J1939 segment. Subnetworks may include: Tractor, Trailer, Implement, and Braking System. Note that subnetworks are typically separated by a bridge or router to help minimize bus traffic on each segment. Collectively the subnetworks are the SAE J1939 Vehicle Network.

2.2.3 REPEATER—A device which regenerates the data signal to and from another segment of media. This permits the network to cover a greater distance (area), to connect more electrical loads (devices) onto the bus, or to connect to another type of media (physical layer expansion). The data rate, protocol (data link layer), and address space are the same on both sides of the repeater.

2.2.4 Bridge—A device which stores and forwards messages between two or more 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 both segments.

2.2.5 ROUTER—A device which allows segments with independent address spaces, data rates, and media to exchange messages. This permits 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 address X on segment 1 to address Y on segment 2.

2.2.6 GATEWAY—This device permits data to be transferred between two networks with different protocols.

2.2.7 PORT—The connection point from a controller to the network. Although most devices have only one port, a bridge or router may have two or more ports to connect various subnetworks together.

3. Description of the Network Layer—This section defines the requirements and services for communicating between devices when they are on different segments of the SAE J1939 network. SAE J1939 is a vehicle wide network with a single set of identifiers and addresses. When multiple segments exist, a specific device must provide for the transfer of messages from one segment to another. For example, a bridge may isolate two segments of media and the bus traffic on each, but the network is still considered "one" network in terms of address space and identifiers. See Figures 1 and 2 for typical network topologies.

3.1 Network Layer Services—The major service provided by the network layer is the transfer of messages from one segment to another segment. The minimum functionality is to forward all messages. This can be achieved with a repeater. With a bridge type device, there is also the capability to perform message filtering, and to manage the message filter database. See Section 4 on Bridge Functions for details.

The use of a router or gateway to interface to a proprietary subnetwork is beyond the scope of SAE J1939 because it is application dependent. Specific implementations may be developed by the component manufacturer, subsystem supplier, or OEM to perform needed functions.

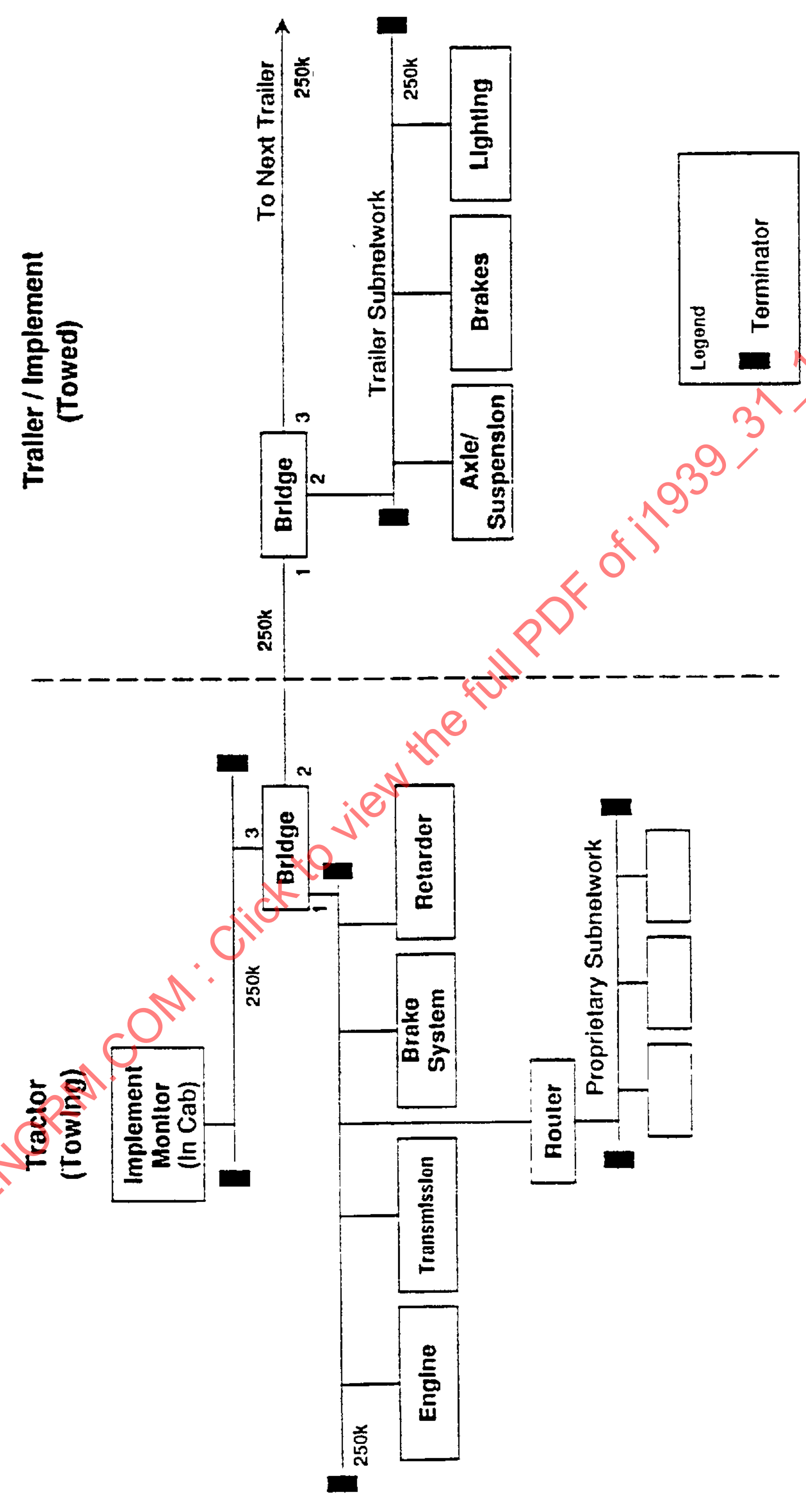

FIGURE 1—TYPICAL SAE J1939 VEHICLE NETWORK FOR TRUCK AND BUS

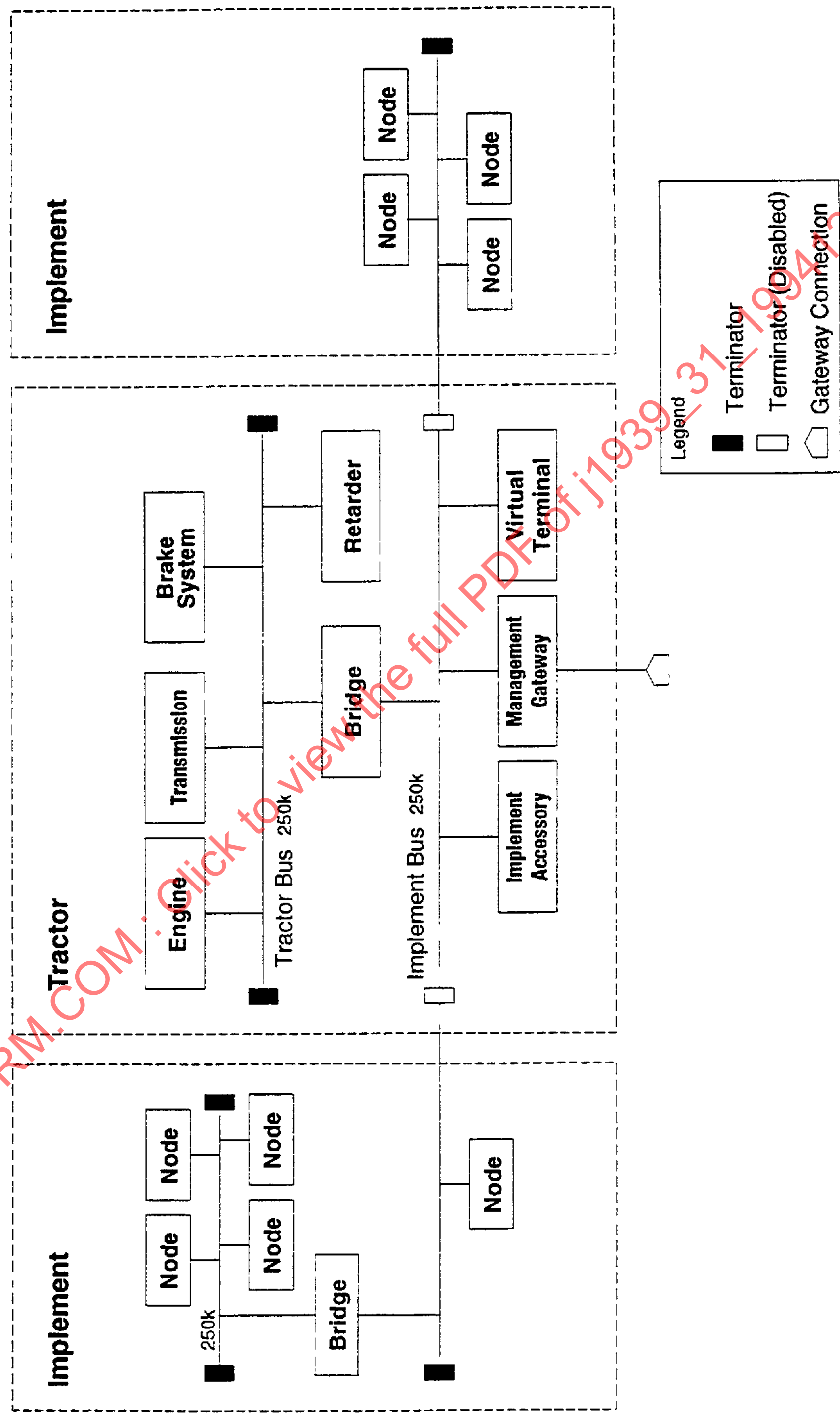

FIGURE 2—TYPICAL SAE J1939 VEHICLE NETWORK FOR AGRICULTURAL APPLICATIONS

3.2 Network Addressing—The Data Link Layer defines 256 Source Addresses. This is the maximum number of "devices" permitted on the network. Note that the electrical loading on the bus from each device may restrict this number if a repeater or bridge is not present. The use of a Router does permit the number of "devices" to be further increased by creating another address space on a separate subnetwork. This subnetwork may contain devices and messages related to a specific function (Braking, Suspension, Trailer, etc.) with a main controller also serving as the router of selected messages to the main SAE J1939 network.

3.3 Off-Tractor Segment (Trailer or Implements)—In order to isolate and protect the main tractor segment, a device must exist between it and any off-tractor segment. In the simplest form this would consist of a Repeater for regenerating the signal. A Bridge permits the off-tractor segment to run at a different data rate and with reduced traffic. A Router permits the off-tractor segment to be developed independently, and optimized for specific functions.

3.4 Proprietary Messages and Networks—The network has provisions for proprietary messages to reside directly on the main tractor segment. If Bus traffic and latency become an issue, a separate segment can be used to handle the proprietary messages. The supplier of this separate segment and its related devices must provide the router function within one of these devices.

3.4.1 CAN 11-BIT IDENTIFIER INTERFACING—All devices on the main tractor segment must support CAN 2.0B which defines 29-bit identifiers. Subnetworks may support CAN 2.0A or CAN 2.0B with 11-bit identifiers, but a router or gateway must exist to selectively permit the transfer of messages between the two segments. This device must also be responsible for any diagnostics of the subnetwork as SAE J1939 does not utilize 11-bit identifiers. Component suppliers and OEMs must assume responsibility when using 11-bit identifiers since there is no means to assure the assignment of unique IDs. Note that a CAN 2.0B 11-bit subnetwork could actually reside on the same two-wire segment as the J1939 main tractor network, but bus loading and reliability issues must be considered.

3.5 J1587 Interface—Devices requiring SAE J1587 for information or diagnostics must have a separate port to access this link. No provisions for defining a gateway to SAE J1587 are planned.

3.6 J1922 Interface—Since SAE J1922 is intended to be an interim standard for drivetrain control, no specific support or gateway will be provided since SAE J1939 is to supersede it.

4. Bridge Functions—The principle operations provided within a bridge are: message forwarding, message filtering, and bridge management. Once operational, the bridge should be essentially transparent to any devices on the vehicle network. Note that the topology of the vehicle network must be constructed so that there is at most one path between any two devices, thus preventing any loops and therefore the possibility of messages being duplicated on the same segment.

4.1 Forwarding—A bridge transfers individual message frames between two or more ports (one port for each network segment). The order of frames received on one port and transmitted on another shall be preserved for a given priority level. Note that when a bridge retransmits a message on another segment, it uses the identical source address of the originator. This does not cause arbitration problems since the bridge does not retransmit on the segment the message originally came from and addresses are unique on a given SAE J1939 network.

A bridge will not begin to forward messages from one subnetwork to another until it has claimed an address.. Note that the subnetwork was initially "isolated" and devices on it would not see other messages until it was "connected" to the vehicle network. See SAE J1939/81, Network Management, for specific details on address claim procedures for bridges and devices on subnetworks.

4.2 Filtering—There are two basic modes of operation for the filtering process within the bridge. In the first mode (0), the bridge will default to forwarding all messages. Bus utilization (traffic) may be higher on each bus segment, but if this is within acceptable limits, the message filtering algorithm is nonexistent. If necessary, the filter database within the bridge may contain entries of the identifiers (PGN values) for messages which should not be forwarded. This method can be used to reduce the overall bus traffic on a given segment. This is the preferred mode of operation for SAE J1939 bridges. Entries to the filter database are typically entered during configuration and retained in nonvolatile memory.

The second mode (1) of filtering requires the database to contain entries for any identifiers (PGN values) which are to be forwarded. This mode is best used for the ports on bridges going to/from proprietary subnetworks or to networks performing a specific function (braking, suspension, etc.). It requires prior knowledge of the devices and functions present on the network, or requires the ability for devices to dynamically add entries to the filter database. This method may require more memory and processing power to exist within the bridge if it is to accommodate and handle a potentially large filter database.

Some entries within the database will be static (configured to always be present) so that the corresponding messages will always be forwarded across the whole network. Typical functions would include network management, diagnostics, and global requests.

The dynamic entries within the filter database can be modified by any device on the network, however a source address is also appended to each entry. This address represents the device which placed the entry, since it is also the only device which should remove it. Although this does not prevent devices from entering conflicting requests, it does prevent them from deleting entries within the filter database unexpectedly.

Note that a filter database must exist for each pair of ports and for each direction. This is necessary in order to restrict traffic to a specific subnetwork, but also allows specific messages to be forwarded from it. For example, the bridge on a tractor may filter out the engine data so it does not go back to the trailer, but any request from the trailer should be forwarded to the tractor.

4.3 Bridge Management—This management function is used to configure the message filter database, access bridge parametrics (status and statistics) and perform the address block claim procedure for subnetworks. All these functions preferably use nonvolatile memory to retain data values through power loss.

4.3.1 NETWORK MESSAGE—This message provides a means to access the filter database and bridge parametrics. See Figure 3.

Parameter Group Name:	Network
Definition:	Used to access bridge parametrics and database.
Transmission repetition rate:	Per user requirements, not to exceed 5 times per second.
Data Length:	8 bytes
Data Page:	0
PDU Format:	237
PDU Specific Field:	Destination Address
Default Priority:	6
Parameter Group Number:	60672 (00ED00h)
Byte 1:	Function Code (see 4.3.2 and 4.3.3)
Bytes 2 to 8:	Data (unused bytes filled with FFh)

FIGURE 3—NETWORK MESSAGE

4.3.2 MESSAGE FILTER DATABASE (MFDB) CONFIGURATION—The filter database within a bridge can be configured in several ways. The first method is to have it preprogrammed off line. This "static" database requires prior knowledge of the whole vehicle network including the devices and messages present. This may not adequately handle additions or changes to the vehicle network unless it can be reprogrammed.

The second method permits any device on the network to request additions or changes to the message filter database. The functions required to support this are defined in Figure 4. The first byte in the data field is the function code, the second byte is the port pair (x/y), and all the bytes which follow contain the filter mode and/or the PGNs of interest. Mode is set to 0 to filter out messages with specific PGNs. Mode is set to 1 to permit messages to be forwarded with specific PGNs. The port pair (x/y) is represented by a nibble for each numbered port.

TABLE 1—PORT NUMBERS

Port #	Definition
0	Null
1-14	Assignable
15	Global

Each device on the network may need to transmit one or more network layer messages to indicate the PGNs it is interested in receiving. This is stored in the "dynamic" filter database. The transport protocol is used whenever the message length is greater than 8 bytes. See Figure 4.

Message	PF	Function Code	Port (from/to)	Data
N.MFDB_Request	237	0	x/y	
N.MFDB_Response	237	1	x/y	Mode, PGNs
N.MFDB_Add2	237	2	x/y	PGNs
N.MFDB_Delete	237	3	x/y	PGNs
N.MFDB_Clear	237	4	x/y	
N-MFDB_Set_Mode	237	5	x/y	Mode

FIGURE 4—MESSAGE FILTER DATABASE CONFIGURATION FUNCTIONS

NOTE—The Add, Delete, Clear, and Set_Mode functions may also require a separate, proprietary security procedure to enable the modification of the database.

EXAMPLE—The messages in Figure 5 would be transmitted to obtain the entries of the filter database within the tractor bridge (SA = 032). The request is initiated from an off board diagnostic tool (SA = 248). Note that the request is only for the list of PGNs that are being filtered when going to the trailer (port 1 to port 2). The response indicates that the only message being filtered out (Mode 0) is engine configuration (3EE3h).

Identifier PRI R P PF DA SA	Data Function	Port	Mode	PGNs	
110 0 0 237 032 248	0	12H			;Request
110 0 0 237 255 032	1	12H	0	3EE3h	;Response

FIGURE 5—EXAMPLE OF MESSAGE FILTER DATABASE ACCESS

4.3.3 BRIDGE PARAMETRICS (BP)—STATUS AND STATISTICS—The functions required to support accessing of the bridge parametrics are defined in Figure 6. A list of available parameters is provided in Figure 7.

Message	PF	Function	Data
N.BP_Request	237	128 (80H)	Parameter #s (up to 7)
N.BP_Response	237	129 (81H)	Parameters
N.BP_Reset_Statistics	237	130 (82H)	

FIGURE 6—FUNCTIONS USED TO ACCESS BRIDGE PARAMETERS

Parameter #	# Bytes	Parameter
1	2	Buffer Size (bytes)
2	2	Filter Database Size (bytes)
*3	2	# Database Entries
4	2	Max. Messages Received/Sec
5	2	Max. Messages Forwarded/Sec
6	2	Max. Messages Filtered/Sec
7	2	Max. Delay Time Allowed (mS)
*8	2	Ave. Delay Time (mS)
*9	2	# Messages Lost due to buffer overflow
*10	2	# Messages with Excess Delay Time
*11	2	Ave. Messages Received/Sec
*12	2	Ave. Messages Forwarded/Sec
*13	2	Ave. Messages Filtered/Sec

• Statistical parameters which are not fixed and can be reset.

Note that a request of Parameter 0 returns the whole list of parameters.

FIGURE 7—BRIDGE PARAMETRICS (BP)