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SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) NETWORK LAYER

Foreword—This series of SAE Recommended Practices have been developed by the SAE Truck and Bus Control and Communications Network Subcommittee of the SAE 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 change to keep pace with experience and technical advances.

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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 the electronic devices (Network Interconnection ECUs) providing intercommunications between different segments of the SAE J1939 Vehicle Network. It also defines the various types of Network Interconnection ECUs and the functions they provide.

2. References

2.1 Applicable Publications—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—Serial Control and Communications Vehicle Network—(Class C)
SAE J1939-01 DRAFT—Serial Control and Communications Vehicle Network for Truck and Bus Applications
SAE J1939-02 DRAFT—Serial Control and Communications Vehicle Network for Construction and Agricultural Applications
SAE J1939-21—Data Link Layer
SAE J1939-71—Application Layer
SAE J1939-81—Network Management Protocol

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

ANSI/IEEE STD.802-1D-1993—Local Area Networks: Media Access Control (MAC) Bridges

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

3.1 Segment—This refers to the physical media of a given network and the ECUs attached to it. A single segment of a network is distinguished by all of the ECUs "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 Network Interconnection ECUs.

3.2 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, router, or gateway to help minimize bus traffic on each segment. Collectively the subnetworks are the SAE J1939 Vehicle Network.

3.3 Network Interconnection ECU—A device that exists primarily for the purpose of interconnecting networks or subnetworks. Specific implementations for “forwarding” messages include: Repeater, Bridge, Router, and Gateway.

3.4 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.

3.5 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.

3.6 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. This also permits a vehicle system like a tractor, trailer, or implement to appear as a single device to another portion of the vehicle.

3.7 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.

3.8 Port—The connection point from a controller to the network. Although most ECUs have only one port, a bridge may have two or more ports to connect various segments together.

4. Description of the Network Layer—This document defines the requirements and services for electronic devices providing intercommunications between different segments of vehicle wide SAE J1939 network. When multiple segments exist, a Network Interconnection ECU must provide for the transfer of messages from one segment to another. Functions a Network Interconnection ECU may provide include: message forwarding, message filtering, address translation of messages, and message repackaging. A Network Interconnection ECU may also support database management to permit access and configuration of the internal databases. Depending on the functions required, various types of Network Interconnection ECUs can provide these services. 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. Port number assignments associated with particular bus segments are industry specific.

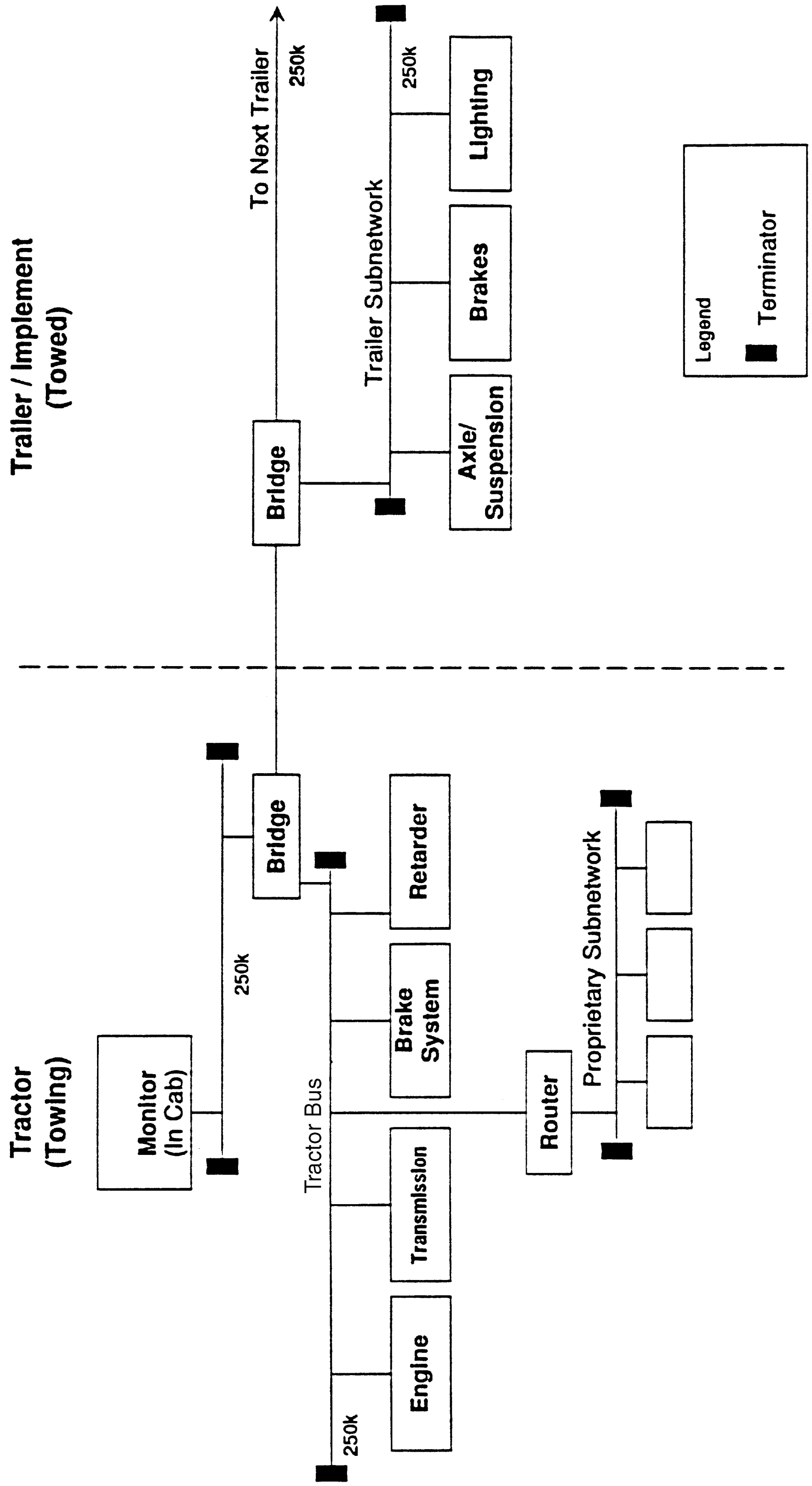

FIGURE 1—TYPICAL SAE J1939 VEHICLE NETWORK FOR TRUCK AND BUS

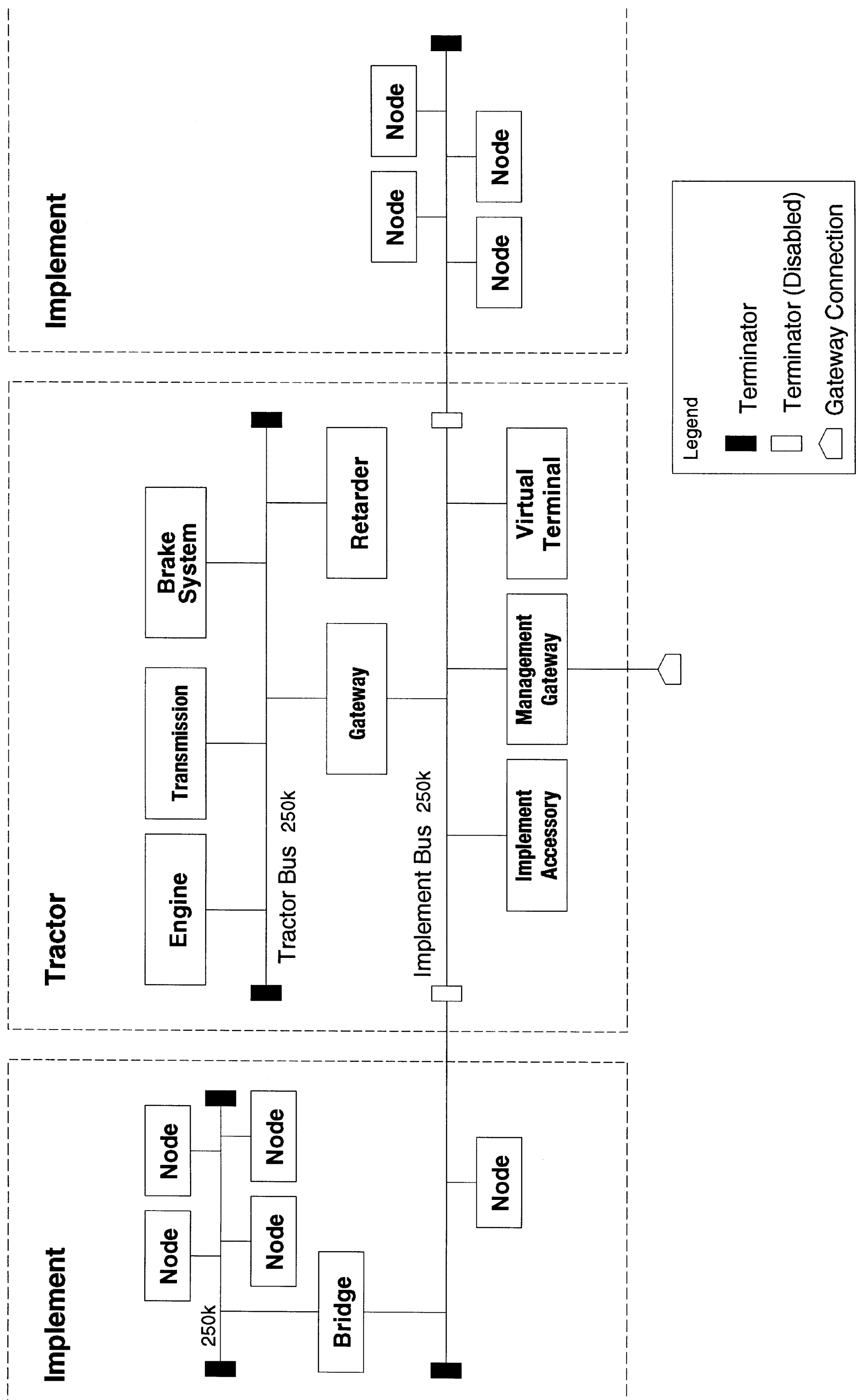

FIGURE 2—TYPICAL SAE J1939 VEHICLE NETWORK FOR AGRICULTURAL APPLICATIONS

4.1 Network Layer Functions —The major function provided by the network layer is the transfer of messages from one segment to another segment. The simplest functionality is to forward messages, see 5.1. This can be achieved with a repeater, see 6.1. A bridge type device, see 6.2, also has the capability to perform message filtering, see 5.2. A router permits a vehicle system like a tractor, trailer, or implement to appear as a single device to another portion of the vehicle. See 6.3, Router, for details. This is achieved by address translation, see 5.3. A gateway, see 6.4, permits parameters to be repackaged into different messages. See 5.4, Message repackaging, for details.

In addition to these Network Layer functions for message transfer, another Network Layer service is provided to access and configure the databases within a Network Interconnection ECU as defined in 5.5, Database Management. Note that Network Interconnection ECUs may perform other functions beyond those defined in this document as provided by the supplier or as dictated by the vehicle configuration. Examples include: integrated lighting control functions or sequential trailer initialization. Network Interconnection ECUs may also be required to participate in the address claim procedure on behalf of the other ECUs on a subnetwork, particularly if the Network Interconnection ECU is serving as the main controller for a trailer, implement, or subsystem (i.e., braking). Refer to SAE J1939-01 for specific requirements of a Network Interconnection ECU to handle sequential trailer initialization, or SAE J1939-02 for specific requirements of a Network Interconnection ECU to provide the interface to the implement bus. Refer to SAE J1939-81 Network Management for specific details on the address claim procedures for Network Interconnection ECUs and other ECUs on subnetworks.

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.

4.2 Network Interconnection ECU (NIECU) Types—A NIECU type is typically defined by the functions it provides. The four types are: Repeater (forwarding), Bridge (forwarding and filtering), Router (forward, filter, and address translation), and Gateway (forward, filter, address translation, and message repackaging).

4.3 Network Topology—The topology of the vehicle network must be constructed so that there is at most one path between any two ECUs. The OEM should therefore assure that no network loops exist on the vehicle. No special provisions are made for Network Interconnection ECUs to detect network loops or to prevent duplicate messages from being generated or replicated indefinitely. Redundant bus segments can be provided for fault tolerance, but the mechanism to detect, select, and autoreconfigure the message routing path is the responsibility of the Network Interconnection ECU supplier and is not defined within this document.

4.4 Conformance (Minimum Requirements)—A SAE J1939 Network Interconnection ECU that claims conformance to this document:

a. Shall forward messages as described in this document based on NIECU type.
b. Shall forward messages with a higher priority before those with a lower priority.
c. Shall forward messages for a given priority in the same order as received.
d. Shall not go bus off due to the forwarding and contention of an Address Claimed message.
e. May support Network Interconnection ECU database management (highly recommended).
f. Shall specify a guaranteed filtering rate and forwarding rate.
g. Shall not exceed the values for the following parameters:

    1. Maximum transit delay (see Section 6 for NIECU specific values)

4.5 Network Interconnection ECU Performance Criteria—Three performance criteria are typically associated with a Network Interconnection ECU to determine its suitability for a given application. The first is the maximum number of messages guaranteed to be forwarded per second. If this rate is exceeded due to average or peak bus loads, it is possible that the Network Interconnection ECU may lose messages. The second parameter is the maximum number of messages guaranteed to be filtered per second. If this rate is exceeded due to the number of entries in the database, it is possible that messages will be excessively delayed across the Network Interconnection ECU. The third is the maximum transit delay. This parameter is used to determine what the worst case latency could be for a message to be transmitted by an ECU and received by another ECU on a different bus segment.

4.6 Network Addressing—The Data Link Layer provides for the potential of up to 254 unique Source Addresses on the network. Note that the electrical loading on the bus from each ECU may restrict the total number of ECUs permitted on a given segment if a Network Interconnection ECU is not present. In addition, the use of a Router permits the number of ECUs to be further increased by creating another address space on a separate subnetwork. This subnetwork may contain ECUs and messages related to a specific function (Braking, Suspension, Trailer, Implement, etc.) with a main controller also serving as the router of selected messages to and from the main SAE J1939 network.

4.7 Off-Tractor Segment (Trailer or Implements)—In order to isolate and protect the tractor segment, a Network Interconnection ECU must exist between the tractor segment 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 by performing message filtering. A Router permits the off-tractor segment to be developed independently, and optimized for specific functions.

4.8 Proprietary Messages and Networks—The network has provisions for proprietary messages to reside directly on the 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 also provide the router/gateway function.

4.8.1 CAN 11-BIT IDENTIFIER INTERFACING—All ECUs on the tractor segment must support 'the 29 bit extended frame identifier of' CAN 2.0B. Separate subnetworks that use 11 bit standard frame identifiers (CAN 2.0A or CAN 2.0B) will require a router or gateway 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.

4.9 SAE 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.

4.10 SAE 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.

5. Network Interconnection ECU Functions—The principle functions that can be provided by a Network Interconnection ECU are: message forwarding, message filtering, address translation, and message repackaging. Database management can also be performed to access and configure the Network Interconnection ECU. Once operational, the Network Interconnection ECU should be essentially transparent to any ECUs on the vehicle network.

5.1 Forwarding—A Network Interconnection ECU 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. A Network Interconnection ECU shall forward any queued messages of a higher priority before those of a lower priority. Otherwise all messages being forwarded to a specific port could be excessively delayed. This requirement therefore does not permit a simple First-In-First-Out (FIFO) queue to exist.

When a Network Interconnection ECU forwards a message onto another segment, it uses the identical source address of the originator. For standard messages this will not cause arbitration problems since the Network Interconnection ECU does not retransmit onto the segment the message originally came from, and the addresses on a given SAE J1939 network are unique. The only exception to this is when an Address Claim message is forwarded onto a segment where another ECU is simultaneously claiming the same address. In this very low probability case, the Network Interconnection ECU must have the ability to detect a bus error when transmitting this message, and should stop the automatic retransmission sequence within the CAN controller chip. Otherwise the Network Interconnection ECU will experience multiple collisions and go Bus Off, thereby preventing other messages from being forwarded until the Network Interconnection ECU is able to recover from the bus off condition. An alternative method is to have a second CAN controller which can be immediately enabled and utilized when the first one goes bus off.

A Network Interconnection ECU may begin to forward messages from one segment to another before it has claimed an address if it is simply acting as a repeater or bridge, (i.e., no address translation). Note that until a Network Interconnection ECU has completed a Power Up and Self Test (POST) sequence, that each subnetwork is "isolated" from the others and ECUs will not see messages from other subnetworks until the vehicle network becomes “connected” via the Network Interconnection ECU.

5.2 Filtering—There are two basic modes of operation for the filtering process within a Network Interconnection ECU: Block or Pass. These modes apply to a particular Port_Pair on the NIECU. In the Block filter mode (0), the Network Interconnection ECU 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 Network Interconnection ECU may contain entries of the identifiers (PGN values) for messages which should not be forwarded (blocked). 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 initial vehicle build/configuration and retained in nonvolatile memory.

In the Pass filter mode (1), the Network Interconnection ECU will default to not forwarding any messages. An entry must exist with a specific identifier (PGN value) for each particular message to be forwarded. This filter mode is best used for the Port_Pairs on Network Interconnection ECUs going to/from subnetworks performing a specific function (braking, suspension, etc.). It requires prior knowledge of the ECUs and functions present on the whole network, or requires the ability for ECUs to add entries to the filter database. This method may require more memory and processing power to exist within the Network Interconnection ECU if it is to accommodate and handle a potentially large filter database.

For Pass filter mode (1), some entries within the database will need to be permanent (configured to always be present) so that the corresponding messages will always be forwarded across the whole network. Typical messages would include network management, diagnostics, and global requests.

a. The filter database that exists within a Network Interconnection ECU may be configurable in several different ways:
b. A supplier of a Network Interconnection ECU may provide it with a fixed filter database.

c. A Network Interconnection ECU may be designed that permits the vehicle OEM to preconfigure the filter database at the time of manufacture. This requires prior knowledge of the whole vehicle network including the ECUs and messages present. This method may not adequately handle additions or changes to the vehicle network over time unless the Network Interconnection ECU can be reconfigured during a service procedure.
d. Configuration over the network during a service procedure by a diagnostic tool. Section 5.5 defines the messages required to access the filter database.
e. Network Interconnection ECU reconfiguration at any time by any ECU on the network. Note that a separate security procedure to enable the modification of the database may also have to exist. Restrictions on which ECUs may reconfigure the filter database is application/implementation dependent.

For filter database entries created using the database management functions described in 5.5, a source address and/or name is also associated with each entry. This address/name represents the ECU which placed the entry, since it is also the only ECU which should remove it. Although this does not prevent ECUs from entering conflicting requests, it does prevent them from deleting entries within the filter database unexpectedly. A provision should also exist for diagnostic tools to override this address/name match requirement in order to remove entries.

NOTE—Each entry within the filter database identifies the PGN to be filtered, whether it is to be Passed or Blocked, as well as the Port_Pair (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 Network Interconnection ECU on a tractor may filter out the engine data so it does not go back to the trailer, but requests from the trailer should be forwarded to the tractor.

5.3 Address Translation—A Network Interconnection ECU may provide Address Translation for particular messages. This permits a single address to be used to reference a particular vehicle system (i.e., trailer or implement) without knowing the specific address of a particular function on the vehicle system (i.e., lighting). An address translation database must then exist which identifies through a look-up table the associated source/destination addresses. Note that the Network Interconnection ECU must have a valid address claimed before it can provide this address translation service.

5.4 Message Repackaging—A Network Interconnection ECU may provide Message Repackaging when transferring messages from one segment to another. This provides a potential reduction in bus traffic by improving the amount of useful parameters per message, as well as reducing the number of different messages required to be received by a particular ECU. A message repackaging database or processing routine must then exist to identify how messages are to be repackaged.

5.5 Database Management—This optional but highly recommended service is used to provide a standard method for access and configuration of the various databases within a Network Interconnection ECU. This also includes the Network Interconnection ECU parametrics (status and statistics) and network topology. All of these functions preferably use nonvolatile memory to retain the database values through power loss. This is particularly important in order to maintain a static filter database. Provisions for a separate dynamic filter database which is cleared upon power loss to permit easy reconfiguration as ECUs are added and removed from the network is not presently defined.

5.5.1 NETWORK MESSAGE DEFINITION—This message provides a means to access and configure the database and bridge parametrics within a Network Interconnection ECU. See Figure 3. A response is always required if a request or command is made to a specific destination (not global), even if it is an acknowledgment indicating that the particular Control function is not supported or could not be performed. Refer to SAE J1939-21 Data Link Layer for details on Acknowledgment. Note that some PGNs are multipacket, so several CAN data frames can occur as a result of a single request. An ECU should always wait for a response from it’s request or command, or the “no response” time-out before sending another request or command.

Parameter Group Name:	Network
Definition:	Used to access Network Interconnection ECU parametrics and databases
Transmission Repetition Rate:	Per user requirements, not recommended 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)

Data ranges for parameters used by this group function:

Control Byte:	0-6, 64-65, 128-133	See Sections within 5.5 for definitions
	7-63, 66-127, 134-250	Reserved for future assignment by SAE
	251-255	Defined per SAE J1939-71, Table 1

FIGURE 3—NETWORK MESSAGE

5.5.2 MESSAGE FILTER (AND FORWARD) DATABASE (MFDB)—The functions needed to support filter database access and configuration are defined in Figure 4. The first byte in the data field is the Control code which identifies the function performed. The data bytes which follow are dependent on the function. The Port_Pair is a one byte field. The upper nibble represents the “From” port, the lower nibble represents the “To” port. See Table 1 for the port parameter values. The port number 0 (local) is used to facilitate the directing of a message by an ECU to and from a Network Interconnection ECU without requiring the ECU to know what port of the Network Interconnection ECU it is connected to. Port “0” indicates the “local” port the message is received at. Port number 15 (global) is used to facilitate the directing of a message by an ECU to a Network Interconnection ECU without requiring the ECU to know how many ports the Network Interconnection ECU has. If either of the port numbers within a message (From/To) is set to global, multiple responses from the Network Interconnection ECU for each Port_Pair may be provided. The Network Interconnection ECU should be capable of configuring the filter database properly with these port values also. The Filter_Mode byte is defined in Table 2. The [PGN-list] contains zero, one, or more 3 byte PGNs. If there are no PGNs in the list, the unused data bytes are set to all “1”s. Note that the transport protocol as defined ins SAE J1939-21 is used whenever a message length is greater than 8 bytes.

TABLE 1—PORT NUMBERS

Port Number	Definition
0	Local
1-14	Assignable
15	Global (All ports)

TABLE 2—FILTER MODE

Filter Mode	Definition
0	Block specific PGNs (Default = pass all)
1	Pass specific PGNs (Default = block all)
2-255	reserved

Function	PGN	Control Code	Other Data Fields
N.MFDB_Request	60672	0	Port _Pair
N.MFDB_Response	60672	1	Port_Pair, Filter Mode, [PGN-list]
N.MFDB_Add	60672	2	Port_Pair, [PGN-list]
N.MFDB_Delete	60672	3	Port_Pair, [PGN-list]
N.MFDB_Clear	60672	4	Port_Pair
N.MFDB_Set_Mode	60672	5	Port_Pair, Filter Mode
N.MFDB Create Entry	60672	6	Port_Pair, Filter Mode, [PGN-list]

FIGURE 4—FUNCTIONS FOR MESSAGE FILTER DATABASE ACCESS

5.5.2.1 *N.MFDB_Request*—Used to request a copy of a filter database.

5.5.2.2 *N.MFDB_Response*—The response to a N.MFDB_Request which contains the filter database entries.

5.5.2.3 *N.MFDB_Add*—A command used to add one or more entries within the filter database. If the “To” port is set to global, multiple entries are made in the filter database, one for each Port_Pair containing the “From” port. Acknowledgment of the command is provided with the Acknowledgment Message (PGN = 59392). Note that any ECU using this function must already know the Filter Mode of the particular filter database before making an entry as the Filter_Mode is not included with this command. See 5.5.2.7 N.MFDB_Create_Entry for comparison.

5.5.2.4 *N.MFDB_Delete*—A command used to delete one or more entries within the filter database. Acknowledgment of the command is provided with the Acknowledgment Message (PGN = 59392).

5.5.2.5 *N.MFDB_Clear*—A command used to clear one or more of the filter databases based on the Port_Pair (and direction). Acknowledgment of the command is provided with the Acknowledgment Message (PGN = 59392).

5.5.2.6 *N.MFDB_Set_Mode*—A command used to set the filter mode of one or more of the filter databases based on the Port_Pair (and direction). Acknowledgment of the command is provided with the Acknowledgment Message (PGN = 59392). The Filter_Mode should not be changed without first clearing the filter database.

5.5.2.7 *N.MFDB_Create_Entry*—A command used to create one or more entries within the filter database. If the “To” port is set to global, multiple entries are made in the filter database, one for each Port_Pair containing the “From” port. Acknowledgment of the command is provided with the Acknowledgment Message (PGN = 59392). Note that the filter mode is included with this command so an ECU can explicitly indicate whether that specific new entry is for block or pass and lets the Network Interconnection ECU determine how to add the entry to the existing filter database. The filter mode included with the message does not change the filter mode of the Port_Pair.

EXAMPLE— The messages in Figure 5 would be transmitted to obtain the entries of the filter database within the tractor bridge (SA = 032). The destination specific 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 (From port 1 to port 2). The destination specific response indicates that the only message being blocked (Filter_Mode = 0) is engine configuration (003EE3h).

Function	Identifier PRI R P PF DA SA	Data Control Code	Port_Pair	Filter Mode	PGNs
N.MFDB_Request	110 0 0 237 032 248	0	12H		
N.MFDB_Response	110 0 0 237 248 032	1	12H	0	03EE3h

FIGURE 5—EXAMPLE OF MESSAGE FILTER DATABASE ACCESS

5.5.3 ADDRESS TRANSLATION (AT) DATABASE—TBD in future revisions of this document.

5.5.4 MESSAGE REPACKAGING (MR) DATABASE—TBD in future revisions of this document.

5.5.5 NETWORK INTERCONNECTION ECU PARAMETRICS (GP)—GENERAL—The functions required to support accessing of the Network Interconnection ECU general parametrics (status and statistics) are defined in Figure 6. A list of available parameters is defined in Figure 7. (Note that some of these parametrics may be applicable for a given NIECU, for a specific Port_Pair, or for both. These parameters can also be accessed through a Port_Pair specific parametric request. See 5.5.6). The parameter values sent within the response must be sent in the same order as the parameter numbers in the request. Valid parameter value ranges are per SAE J1939-71, with all bits within a parameter value set to "1" for indicating "Not Available". Note that the transport protocol as defined in SAE J1939-21 is used whenever a message length is greater than 8 bytes.

Function	PGN	Control Code	Other Data Fields
N.GP_Request	60672	128 (80H)	Parameter numbers
N.GP_Response	60672	129 (81H)	Parameter values
N.GP_Reset_Statistics	60672	130 (82H)	

FIGURE 6—FUNCTIONS USED TO ACCESS NETWORK INTERCONNECTION ECU PARAMETERS (GENERAL)

Resetable	Parameter Number	Number of Bytes	Parameter Values
	1	2	Buffer Size (bytes)
	2	2	Max. Filter Database Size (bytes)
	3	2	# Filter Database Entries
	4	2	Max. Messages Received/Sec
	5	2	Max. Messages Forwarded/Sec (Guaranteed Min.)
	6	2	Max. Messages Filtered/Sec (Guaranteed Min.)
	7	2	Max. Transit Delay Time (mS)
*	8	2	Ave. Transit Delay Time (mS)
*	9	2	# Messages Lost due to buffer overflow
*	10	2	# Messages with Excess Transit Delay Time
*	11	2	Ave. Messages Received/Sec
*	12	2	Ave. Messages Forwarded/Sec
*	13	2	Ave. Messages Filtered/Sec
	14	4	Uptime since last power on reset (Seconds)
	15	1	Number of ports
	16-250	n.a.	Reserved for future assignment by SAE

FIGURE 7—NETWORK INTERCONNECTION ECU PARAMETRICS

5.5.5.1 *N.GP Request*—Used to request Network Interconnection ECU parametrics. Note that a request of Parameter 0 returns the whole list of parameters. Each parameter number is one byte long.

5.5.5.2 *N.GP Response*—The response to a N.GP_Request contains the Network Interconnection ECU parametrics requested, in the order they were requested.

5.5.5.3 *N.GP Reset Statistics*—A command used to clear any of the statistical parameters which are resetable (*).Acknowledgment of the command is provided with the Acknowledgment Message (PGN = 59392).

5.5.6 NETWORK INTERCONNECTION ECU PARAMETRICS (SP)—SPECIFIC PORT_PAIR—The functions required to support accessing of specific Parametrics (status and statistics) for a given Network Interconnection ECU Port_Pair are defined in Figure 8. A list of available parameters is defined in Figure 7. The parameter values sent within the response must be sent in the same order as the parameter numbers in the request. Valid parameter value ranges are per SAE J1939-71, with all bits within a parameter value set to “1” for indicating “Not Available”. Note that the transport protocol as defined in SAE J1939-21 is used whenever a message length is greater than 8 bytes.

Function	PGN	Control Code	Other Data Fields
N.SP_Request	60672	131 (83H)	Port_Pair, Parameter #s
N.SP_Response	60672	132 (84H)	Port_Pair, Parameter values
N.SP_Reset Statistics	60672	133 (85H)	Port_Pair

FIGURE 8—FUNCTIONS USED TO ACCESS NETWORK INTERCONNECTION ECU PARAMETERS (PORT_PAIR SPECIFIC)

5.5.6.1 *N.SP Request*—Used to request one or more Network Interconnection ECU parametrics. Note that a request of Parameter 0 returns the whole list of parameters. Each parameter number is one byte long.

5.5.6.2 *N.SP Response*—The response to a N.SP_Request contains the Network Interconnection ECU parametrics requested, in the order they were requested.

5.5.6.3 *N.SP Reset Statistics*—A command used to clear any of the statistical parameters which are resetable (*).Acknowledgment of the command is provided with the Acknowledgment Message (PGN = 59392).

5.5.7 NETWORK TOPOLOGY (NT) INFORMATION—Although Bridges are essentially transparent to other ECUs on the network, it may be necessary to know the actual topology of the network in order to properly set up the databases. Two control functions are defined in Figure 9 to obtain this information. The Port number defined in Table 1 (contained in the lower nibble of the data byte with upper nibble set to “1”s) is used to help identify which source addresses are associated with each port on the Bridge. Note that if there are multiple bridges present on a given vehicle network, a bridge can only identify what port a source address is located on. A given source address may actually reside on a remote bus segment, so responses from each bridge must be compared to determine which local bus segment actually contains the given source address. A bridge may also have to perform a Request for Address Claim first in order to construct the list of source addresses associated with each port. Obtaining the topology of a network which contains routers and gateways is beyond the scope of this document.

Message	PGN	Control Code	Data
N.NT_Request	60672	64 (40h)	Port
N.NT_Response	60672	65 (41h)	Port, SA(s)...

FIGURE 9—NETWORK TOPOLOGY (NT)

5.5.7.1 *N.NT Request*—Used to request the list of source addresses found on a given Network Interconnection ECU port.

5.5.7.2 *N.NT Response*—The response to a N.NT_Request contains the Port number and then the list of source addresses found on that port.

6. Network Interconnection ECU Types—There are currently four Network Interconnection ECU types defined based on the functionality they provide. They are Repeater, Bridge, Router, and Gateway.

6.1 Repeater—The principle function provided by a repeater is: message forwarding between bus segments which are all running at the same data rate. This is achieved by regenerating the signal from one segment onto another at the physical layer of the network. Repeaters should incorporate an anti-loopback/lockout function. Bitwise arbitration is also achieved across the repeater. The repeater is essentially transparent to any ECU on the vehicle network. All messages are forwarded as there is no message filtering capability. If fault isolation is provided, the repeater has the ability however to disable one or more of it's transmitters if a bus fault is detected on one of the segments. No management function is defined for a repeater, so an address is not required.

6.1.1 FORWARDING—A repeater forwards all messages with only sub-bit-time delay. The maximum transit delay therefore should be less than 10% of a bit time (400 nS at 250 kbps) to permit bitwise arbitration to occur properly across the repeater, while still permitting reasonable propagation delay (cable distance).

6.2 Bridge—The principle function provided by a bridge is: message forwarding and filtering between bus segments. This is achieved by storing, filtering, and forwarding messages at the data link layer of the network. By filtering messages, the bridge can effectively reduce the amount of bus traffic present on each segment of the network. The bridge is essentially transparent to any ECU on the vehicle network. Note that there is some transit delay through the bridge. If no database management function is provided, an address is not required for the bridge.

6.2.1 FORWARDING—The maximum transit delay permitted will be application dependent. A recommended value is 50 mS. See J1939-21.

6.2.2 FILTERING—A bridge may filter any, all, or none of the messages it receives. This will be dependent on the application.

6.2.3 BRIDGE DATABASE MANAGEMENT—Although not required, it is recommended that the Database Management function be supported to provide a standard access to configure the forward and filter databases.

6.3 Router—The principle operation provided by a router in addition to those provided by a bridge is: address remapping (message routing). This permits a given vehicle subsystem to appear as a single address to another portion of the vehicle. This can potentially simplify the development of ECUs because they do not require specific knowledge of other individual ECUs (addresses) on the vehicle subsystem. Note that Address claim messages do not cross through a router.

Once operational, the router should be essentially transparent to any ECUs on the vehicle network. Note that there is some translation and forwarding delay through the router.

6.3.1 ADDRESS TRANSLATION—In addition to forward and filter functions, a Router may remap addresses from one port (bus segment) to another port (bus segment). The Message Filter Database is typically configured for Pass mode (1). All messages are then blocked unless a specific entry exists to pass a message through. In addition, a lookup table must exist which provides the address translation map.

6.3.2 ROUTER DATABASE MANAGEMENT—Although not required, it is recommended that the Database Management function be supported to provide a standard access to configure the forward, filter, and address translation databases.

6.4 Gateway—The principle operations provided by a gateway in addition to those provided by a router are: message repackaging. This permits a given vehicle subsystem containing several ECUs to appear as a single device to another portion of the vehicle by regrouping parameters to and from a single message. This can potentially simplify the development of ECUs because they do not require specific knowledge of other individual ECUs (addresses) on the vehicle subsystem.

Once operational, the gateway should be essentially transparent to any ECUs on the vehicle network. Note that there is some translation, repackaging, and forwarding delay through the gateway.

6.4.1 MESSAGE REPACKAGING—In addition to forward, filter, and address translation functions, a gateway may take parameters from one or more messages and repackage them into one or more "new" messages. This permits parameters to be grouped for easier transfer, reception, and interpretation by another ECU. The Message Filter Database is typically configured for Pass mode (1). All messages are blocked unless a specific entry exists to pass a message through. In addition, a message building function must exist which contains a database for repackaging messages.

6.4.2 GATEWAY DATABASE MANAGEMENT—Although not required, it is recommended that the Database Management function be supported to provide a standard access to configure the forward, filter, address translation, and message repackaging databases.

7. Notes

7.1 Marginal Indicia—The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE TRUCK AND BUS CONTROL AND COMMUNICATIONS
NETWORK SUBCOMMITTEE OF THE SAE TRUCK AND BUS
ELECTRICAL AND ELECTRONICS COMMITTEE

Rationale—Changes from December 1994 document:

Additions—Definition of Network Interconnection ECU, Router Functions, Gateway Functions, Repeater Functions, Network Topology Control Function, N.MFDB_Create_Entry Control Function, Address Translation, Message Repackaging, Conformance (Minimum Requirements).
Deletions—Address Claim Procedures (reference J1939-81 instead).
Clarifications—Filtering Modes, Port Numbers, Acknowledgment of Network Messages, Control Function Definitions, Document restructured.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—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 recommended practices 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 J1939 Vehicle Network.

Reference Section

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—Serial Control and Communications Vehicle Network—(Class C)

SAE J1939-01 DRAFT—Serial Control and Communications Vehicle Network for Truck and Bus Applications

SAE J1939-02 DRAFT—Serial Control and Communications Vehicle Network for Construction and Agricultural Applications

SAE J1939-21—Data Link Layer

SAE J1939-71—Application Layer

SAE J1939-81—Network Management Protocol

Developed by the SAE Truck and Bus Control and Communications Network Subcommittee

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