(R) Agricultural Forestry Off-Road Machinery Control and Communication Network

RATIONALE

This SAE Recommended Practice was reviewed and updated as part of the SAE Five-Year Review. Updates include clarifying messaging uses ISO 11898-1 CEFF data frames, replacing abbreviations A&F and T&B with full terms throughout document, and some wordsmithing regarding the interactions between ISO 11783 and SAE J1939 for item requests and assignments. Updated Table 1 to only include applicable SAE J1939 documents.

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. This document, SAE J1939-02, specifies a particular set of SAE J1939 documents which define an SAE J1939 network as it applies to agricultural and forestry equipment.

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

The SAE J1939 communications network is developed for use in heavy-duty environments and suitable for horizontally integrated vehicle industries. The SAE J1939 communications network is applicable for light-duty, medium-duty, and heavy-duty vehicles used on-road or off-road, and for appropriate stationary applications which use vehicle-derived components (e.g., generator sets). Vehicles of interest include, but are not limited to, on-highway and off-highway trucks and their trailers, construction equipment, and agricultural equipment and implements. The physical layer aspects of SAE J1939 reflect its design goal for use in heavy-duty environments. Horizontally integrated vehicles involve the integration of different combinations of loose package components, such as engines 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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1. SCOPE

This SAE Recommended Practice specifies the requirements for application of SAE J1939 in agricultural and forestry equipment. This document specifies the series of documents within the set of SAE J1939 documents that are applicable to agricultural and forestry equipment and provides further requirements for this industry.

The SAE and ISO groups have cooperated to define agricultural and forestry networks in a manner to allow compatibility of ECUs and messaging protocols between agricultural and forestry ISO 11783 networks and truck and bus SAE J1939 networks.

2. REFERENCES

2.1   Related Publications

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

2.1.1   SAE Publications

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

SAE J1939   Serial Control and Communications Heavy-Duty Vehicle Network - Top-Level Document

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

SAE J1939-11   Physical Layer, 250 kbps, Twisted Shielded Pair

SAE J1939-13   Off-Board Diagnostic Connector

SAE J1939-15   Physical Layer, 250 kbps, 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

2.1.2   ISO Publications

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

ISO 11783-1   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 1: General standard for mobile data communication

ISO 11783-2   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 2: Physical layer

ISO 11783-3   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 3: Data link layer

ISO 11783-4   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 4: Network layer

ISO 11783-5   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 5: Network management

ISO 11783-6   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 6: Virtual terminal

ISO 11783-7   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 7: Implement messages application layer

ISO 11783-8   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 8: Powertrain messages

ISO 11783-9   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 9: Tractor ECU

ISO 11783-10   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 10: Task controller and management information system data interchange

ISO 11783-11   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 11: Mobile data element dictionary

ISO 11783-12   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 12: Diagnostics services

ISO 11783-13   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 13: File server

ISO 11783-14   Tractors and machinery for agriculture and forestry - Serial control and communications data network -
Part 14: Sequence control

2.1.3   NMEA Publications

Available from National Marine Electronics Association, 7 Riggs Ave., Severna Park, MD 21146, 410-975-9425,
www.nmea.org.

NMEA 2000   National Marine Electronics Association Standard for Serial-Data Networking of Marine Electronic
Devices

3. DEFINITIONS

Terms and abbreviations are defined in the SAE J1939 top-level document for use in the context of this document. Additional terms are defined below.

3.1 CLASSICAL EXTENDED FRAME FORMAT (CEFF)

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

3.2 CONTROLLER APPLICATION (CA)

The software within an Electronic Control Unit (ECU) that performs a particular control function. More than one controller application can reside within an ECU. In ISO 11783, the term control function (CF) is synonymous with controller application.

3.3 CONFIGURABLE MESSAGES

A set of SAE J1939 PGs (messages) that can be configured to contain any desired combination of a set of parameters (SPs) that are designated to be configurable.

3.4 ELECTRONIC CONTROL UNIT (ECU)

Any of a number of electronic modules contained in a machine that communicates with other ECUs via an SAE J1939 network.

3.5 FARM MANAGEMENT INFORMATION SYSTEM (FMIS)

The office computer system for the farmer or contractor. It includes the software for farm management such as bookkeeping, payroll, resource management for machines, products, workers, field management, geographic information systems (GIS), decision support systems, and task management.

3.6 FAST PACKET

An NMEA 2000 transport protocol method employing multiple, broadcasted, and serialized data frames (packets) with no minimum separation between packets.

3.7 IMPLEMENT NETWORK

Network segment that connects agricultural implement ECUs, as well as some ECUs on a tractor, such as a virtual terminal and a tractor ECU.

3.8 ISOBUS

Standardization of the agricultural implement network defined in ISO 11783.

3.9 MANAGEMENT COMPUTER INTERFACE

The method of exchanging information between the FMIS and the vehicle task controllers using XML data format. A physical interface is not specified.

3.10 NETWORK INTERCONNECTION ECU

A device that exists primarily for interconnecting networks or sub networks. Specific implementations for "forwarding" messages include: repeater, bridge, router, and gateway.

3.11 PROCESS DATA

A message that is used for the transmission of measured data and/or set point commands to one or more controllers.

3.12 TASK CONTROLLER

An electronic unit on the mobile implement control system that is responsible for the sending, receiving, and logging of process data. A task controller can have an operator interface.

3.13 TERMINATION BIAS CIRCUIT

A circuit required at each end of a network segment that provides bias voltages for the CAN high and CAN low signals, and the common mode impedance termination for the respective conductors.

3.14 TRACTOR NETWORK

Network segment that connects mainly tractor mounted ECUs, including powertrain modules.

3.15 TRACTOR ECU

Standardized network interconnect device between tractor network and implement network.

3.16 VIRTUAL TERMINAL

An ECU, consisting of a graphical display and input functions, which provides the capability to display information to and retrieve data from an operator for a connected implement or working set.

4. ABBREVIATIONS

Abbreviations are defined in SAE J1939 for use in the context of this document.

CA	Controller Application
CEFF	Classical Extended Frame Format
ECU	Electronic Control Unit
ETP	Extended Transport Protocol
FMIS	Farm Management Information System
ISO	International Organization for Standardization
ISO/TC 23/SC 19/WG 1	International Organization for Standards, Technical Committee 23, Subcommittee 19, Working Group 1 (the group responsible for maintaining the ISOBUS protocol standard for agricultural and forestry networks)
NMEA	National Marine Electronics Association
PDU	Protocol Data Unit
PG	Parameter Group
PGN	Parameter Group Number
SLOT	Size, Length, Offset, and Transfer Function

SP   Suspect Parameter

SPN   Suspect Parameter Number

TBC   Termination Bias Circuit

TC   Task Controller

VT   Virtual Terminal

XML   eXtensible Markup Language

5.   DOCUMENTATION STRUCTURE

General information regarding this series of recommended practices is found in SAE J1939.

Agricultural and forestry CAN communication networks are defined and standardized based upon SAE J1939 and further elaborated in ISO 11783 to produce compatible networks. See Section 6 for details of the working process between SAE and ISO working groups.

A subset of SAE J1939 documents is applicable for agricultural and forestry equipment. A combination of SAE J1939 and ISO 11783 documents completely specifies the agricultural and forestry off-road control and communications networks. The series of documents applicable for agricultural and forestry equipment are listed in Table 1.

Some information relating to foundation principles on which the networks operate are contained in both sets of documents. Other information relating to agricultural and forestry application-specific features and services are contained only in the ISO documents.

Section 7 of this document summarizes the major points about each of the documents listed above. Additionally, Section 8 gives some guidance for those familiar with SAE J1939 who want to design ECUs that will also be compatible with the agricultural and forestry networks described here.

Table 1 - Agriculture and forestry applicable documents

SAE J1939 Document	ISO 11783 Document	Summary
SAE J1939 Serial Control and Communications Heavy-Duty Vehicle Network - Top-Level Document	N/A	This top-level document describes the network in general.
SAE J1939-02 Agricultural Forestry Off-Road Machinery Control and Communication Network	ISO 11783-1 General standard for mobile data communication	The application layer for off-road equipment being described in this document. A primary intent of this document is to describe the agricultural and forestry network and the harmonization of SAE and ISO standards that results in a complete network definition. This standard specifies a serial data network for control and communications on forestry or agricultural tractors, mounted, semi-mounted, towed, or self-propelled implements. Its purpose is to standardize the method and format of transfer of data between sensors, actuators, control elements, information storage, and display units (whether mounted on or part of the tractor), or any implements.
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-2 Physical layer	The agricultural implement network physical layer consists of a 250 kbit/s, twisted, non-shielded, quad-cable physical layer and active terminators or an alternative twisted pair physical layer with passive and weak termination. This physical layer is unique to agricultural and forestry. ECUs designed for SAE J1939-11 or SAE J1939-15 physical layers are compatible with this physical layer.
SAE J1939-13 Off-Board Diagnostic Connector	Included in ISO 11783-2	The off-board diagnostic connector used on the vehicle to get access to the vehicle communication links. Agricultural and forestry networks use the Type 1 connector for 250 kbit/s.
SAE J1939-21 Data Link Layer	ISO 11783-3 Data link layer	These documents describe the use of the ISO 11898-1 CEFF data frame (29-bit identifier) and the basic transport protocol mechanism.
SAE J1939-31 Network Layer	ISO 11783-4 Network layer	These documents describe the network layer, which defines the requirements and services needed for communication between electronic control units in different segments of the off-road network. The various types of network interconnection unit are defined. The ISO document includes a powerful capability allowing connections to be established between networks with separate address spaces.
SAE J1939-71 Vehicle Application Layer	ISO 11783-8 Powertrain messages	These particular standards defines data placement notation and parameter data value range notation.
SAE J1939DA Digital Annex of Serial Control and Communications Heavy-Duty Vehicle Network	ISO 11783-8 Powertrain messages	This top-level document includes the messages required by tractors and self-propelled implements on the powertrain or tractor network. It also includes pre-assigned NAMEs, preferred addresses, PGNs, and suspect parameters.
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-7 Implement messages application layer	This part of ISO 11783 describes the tractor-implement specific messages application layer of the network, specifying the message set and defining the messages used for communication with and between tractors and connected implements.
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-6 Virtual terminal	This part of ISO 11783 describes a universal virtual terminal that can be used by an operator to interface with both tractor and implement electronic control units.
SAE J1939-73 Application Layer - Diagnostics	ISO 11783-12 Diagnostic services	The diagnostics application layer.

SAE J1939 Document	ISO 11783 Document	Summary
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-9 Tractor ECU	This part of ISO 11783 describes the tractor ECU, the electronic control unit that provides the gateway between the network's tractor and implement networks, as well as performing other tractor functions.
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-10 Task controller and management information system data interchange	This part of ISO 11783 describes the task controller applications layer, which defines the requirements and services needed for communicating between a task controller in the system and electronic control units of one or more implements. The data format to communicate with the farm management computer, the calculations required for control, and the message format sent to the ECU are defined in this document.
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-11 Mobile data element dictionary	This part of ISO 11783 describes the data elements that are used by the process data messages as defined in Part 10 of this standard. This data dictionary information is available as an online data base, accessed at www.isobus.net.
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-13 File server	This part of ISO 11783 describes a file server capability for use by tractors and self-propelled implements, for storage of large amounts of data for other devices on the network.
No SAE J1939 equivalent; refer to ISO 11783 document	ISO 11783-14 Sequence control	This part of ISO 11783 describes a sequence control system, such as a headland management system, which includes tractor and implement functions in one system. The system allows recording of multiple sequences of operator-activated functions from a tractor or any other control function on the network and replaying them on operator command.
SAE J1939-74 Application - Configurable Messaging	No ISO 11783 equivalent; refer to SAE J1939 document	An application layer that allows users to use parameters that have previously been identified as configurable to be packed into messages in a proprietary manner for optimizing network performance. Parameters from other SAE J1939 documents are not to be sent via the configurable messages. Configurable messaging is not allowed on ISOBUS (implement network) but can potentially be used on the tractor network or on a closed system network.
SAE J1939-75 Application Layer - Generator Sets and Industrial	No ISO 11783 equivalent; refer to SAE J1939 document.	An application layer with messages dealing with stationary equipment and generator sets.
SAE J1939-81 Network Management	ISO 11783-5 Network management	These documents describe the management of source addresses for electronic control units, the association of addresses with the control functions, response to brief power outages, and minimum requirements for network-connected electronic control units.
SAE J1939-82 Compliance	No ISO 11783 equivalent. Refer to SAE J1939 document.	A testing plan and a set of requirements that need to be met for each SAE J1939 document or layer.

6. STANDARDIZATION PROCESS WITH REGARD TO AG AND FORESTRY NETWORKS

SAE J1939 and ISO 11783 Task Forces originally worked in parallel with overlapping memberships to ensure that agricultural and forestry networks were compatible with SAE J1939 networks. This allows the controller hardware and much of the software drivers for both networks to be the same. This section documents the process followed to maintain continued compatibility between truck and bus SAE J1939 networks and agricultural and forestry ISO 11783 networks.

6.1 Communication and Administration

Any person can make requests to the SAE J1939 committee. When possible, SAE J1939 identifies requests that are agricultural and forestry-related and asks that those requests be reviewed by ISO/TC 23/SC 19/WG 1 first. After ISO/TC 23/SC 19/WG 1 review, any needed requests are then submitted to SAE J1939 for numerical assignments.

ISO/TC 23/SC 19/WG 1 confines its work to the agricultural and forestry applications and, whenever possible, directs requests for powertrain or other general purpose usage to SAE J1939. However, this does not limit ISO/TC 23/SC 19/WG 1 from considering those requests and passing along its recommendations to SAE.

Overlapping membership between groups periodically reviews documents with the goal of harmonizing items of shared interest.

Typical processes for creating compatibility between networks are described in the following sections.

6.2   Messages

The CEFF data frames, with a 29-bit CAN identifier, are used for SAE J1939 messages. SAE J1939-21 specifies the function assignment to the CEFF CAN identifier bits. SAE J1939 and ISO 11783 have common bit field assignments for priority, data page, PDU Format, PDU Specific, and source address.

The PGN assignments for SAE J1939 and ISO 11783 messages are made from a common numbering space administered by SAE J1939. A common assignment space for all PGNs, SPNs, NAME fields, FMIs, etc., is used so there are no duplicate or conflicting assignments. The shared goal is that ECUs that are connected to either an SAE J1939 network or an ISO 11783 network will not behave unpredictably due to misinterpretation of messages.

The request to SAE J1939 for PGN assignment for an agricultural and forestry-related message is made by ISO/TC 23/SC 19/WG 1 after ISO/TC 23/SC 19/WG 1 has completed its own vetting and approval process. The request is usually accepted without modification. If a message is deemed to be agricultural and forestry specific and not applicable to truck and bus applications, then the SAE J1939DA only documents the message name, its PGN assignment, and its ISO 11783 document, and the full description and behavior is fully documented in the corresponding ISO 11783 document.

Many of the messages defined in SAE J1939DA are intended to be used unchanged in agricultural and forestry networks. These include powertrain control messages, vehicle lighting control messages, joystick and other human machine interface messages, hydraulic control messages, and diagnostic messages.

6.3   Parameters

SAE J1939 and ISO 11783 use common SLOT definitions for the encoding of parameter data in the PG data. The SLOT definitions include the use of error-bit regions and "not available" codes for each SLOT size and type.

The SPN assignments for SAE J1939 and ISO 11783 parameters are made from a common numbering space administered by SAE J1939. Similar to messages, ISO/TC 23/SC 19/WG 1 approves parameter definitions for agricultural and forestry applications. These are submitted to SAE J1939 and usually accepted without modification. If a parameter is deemed to be agricultural and forestry specific and not applicable to truck and bus applications, then the SAE J1939DA only documents the parameter name, its SPN assignment, and its ISO 11783 document, and the full parameter definition is fully documented in the corresponding ISO 11783 document.

6.4   Additional Items

Use of NAMEs for address arbitration follow the same rules so controllers can exist cooperatively on the same network. ISO/TC 23/SC 19/WG 1 assigns numerical values for NAME functions in Industry Group 2 - Agriculture. The lower 128 NAME functions values are shared and common among all industry groups and are harmonized with SAE J1939. The upper 128 functions are specific to the industry group and vehicle system. For Industry Group 2, these upper functions are assigned by ISO/TC 23/SC 19/WG 1 for each of its vehicle systems. These assignments are communicated to SAE J1939 and included in the SAE J1939 database periodically.

SAE J1939 contains assigned values from ISO 11783 in a summary form but does not contain detail and usage rules for those items.

7. TECHNICAL REQUIREMENTS

7.1 Network Description

Networks can consist of one or more connected network segments based on the SAE J1939 component documents specified in Table 1.

Figure 1 depicts a typical network found on a tractor and connected implements. This particular network has three network segments: the tractor network segment interconnecting components on the tractor, the implement network segment interconnecting the implement and tractor, and an implement sub-network segment connected to the implement network by a bridge. At least one of the network segments shown is required to form a network, but, in most systems, at least the tractor and implement network will exist.

Each of the boxes depicted in Figure 1 represents an ECU. Several of the ECUs in Figure 1 require significant standardization and are described further in documents that are a part of this series. Those ECUs include:

1. The virtual terminal described in ISO 11783-6.

2. The tractor ECU described in ISO 11783-9.

3. The task controller described in ISO 11783-10.

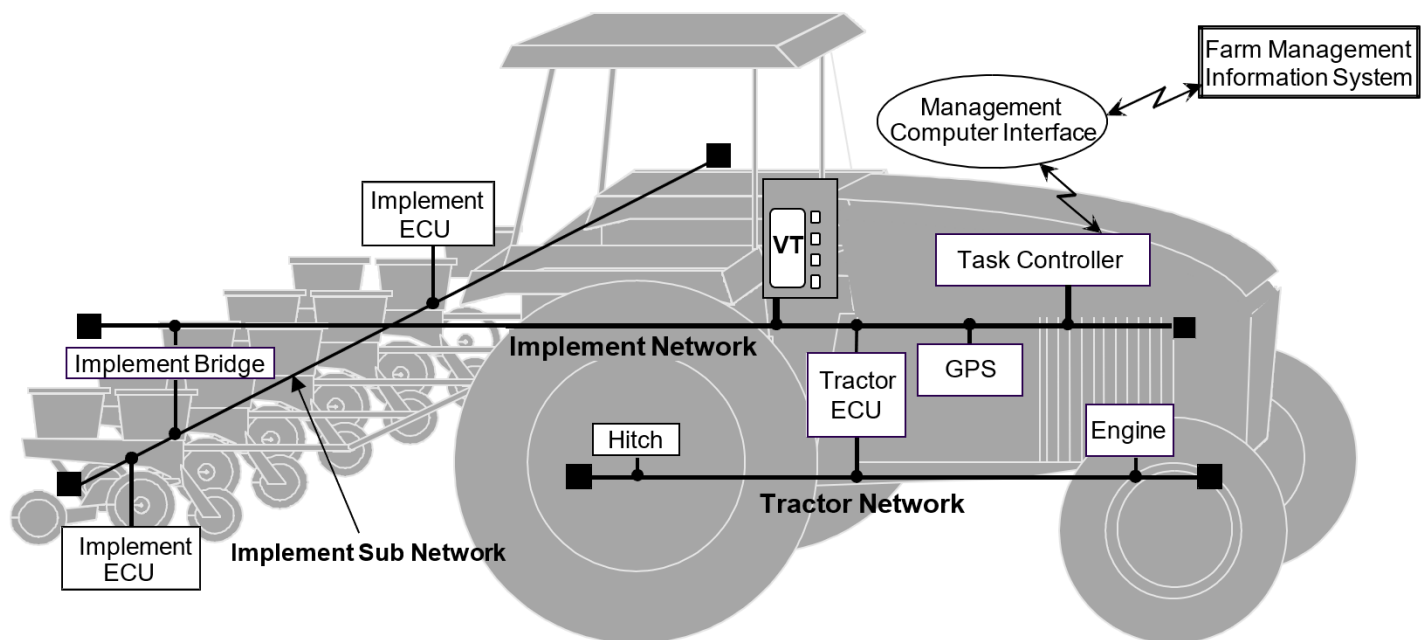4. The engine controller described in SAE J1939-71.

Figure 1 - Example of a typical network with tractor network, implement network, and implement sub-network

7.2 Physical Layer

ISO 11783-2 describes the physical layer intended for use in this network. The document identifies the media as an unshielded, twisted quad cable with characteristic impedance of 75 Ω, as well as the connectors and signaling for the network. The third edition of ISO 11783-2 adds an alternative cable and architecture named "twisted pair physical layer" based on a 250 kbit/s, un-shielded, twisted pair cable network layer which is fully backward compatible to twisted quad based machines and devices. Users should refer to ISO 11783-2 for required connectors and placement. A diagnostic connector is required as a part of the network. The required diagnostic connector is defined in SAE J1939-13. Required placement for the diagnostic connector is provided in ISO 11783-2. Both tractor network and implement network segments are present in the diagnostic connector.

This physical layer design requires that signal transition times on the CAN lines be controlled to limit radiated emissions. The slope on bit rise and fall times of 500 ns maximum is the same as specified for SAE J1939-11.

The twisted quad physical layer network requires active termination. These termination bias circuits (TBCs) are required at each physical end of the network to provide the electrical bias and common mode termination needed to suppress reflections. The twisted pair physical network is terminated by passive termination with the option for weak termination for network stubs.

The CAN bit sample point for ISO 11783 is 80% ± 3% of the bit time, referenced to the start of the bit time. This differs from SAE J1939-11 and SAE J1939-15, whose sample point is, "As close to, but not greater than, 7/8 (87.5%) of a bit time."

When a network is extended (for instance, by connecting an implement to a tractor), the termination in the breakaway (implement) connector is removed since the connector is no longer the physical end of the network. The implement now provides the termination at the end of the network.

7.3   Data Link Layer

SAE J1939-21 describes the data link layer intended for use in this network. Major items include:

- The use of the ISO 11898-1 CEFF data frame (CAN data frame with a 29-bit identifier) for SAE J1939 PG communications. Includes specification of the D_PDU1 and D_PDU2 PDUs and the 29-bit identifier bits for PG identification, message priority, and data frame addressing.

- The transport protocol method for handling communication of SAE J1939 PGs (messages) with PG data longer than 8 bytes. Both broadcast (BAM) and connection management (RTS/CTS) forms of transport protocol are supported. These mechanisms are limited to transporting PGs with PG data up to 1785 bytes.

SAE J1939-21 specifies the Acknowledgement PG (ACK) in response to a Request PG (RQST) always uses the global response, regardless of how the request was made. Additional data link features supported in this off-road machinery control and communications network are:

- NMEA 2000 messages that carry GPS information are used in some off-road machines to enable navigation features. For NMEA 2000 navigation messages on the implement network, the fast packet method can be used so as to reduce the inter-frame time. The definition of fast packet is found in the NMEA 2000 standard. This mechanism is limited to transporting data objects between 9 and 223 bytes.

- An additional "extended" transport protocol (ETP) mechanism is prescribed in ISO 11783-3. This ETP allows ECUs to transport data objects up to 117 MB in size. This capability is often needed to handle the virtual terminal data objects.

- ISO 11783-3 does not require the ACK in response to a REQUEST message to be global but provides rules for response to requests based on request type.

ISO 11783-3 is harmonized with SAE J1939-21.

7.4   Network Layer

SAE J1939-31 and ISO 11783-4 are harmonized and describe the network layer intended for use in this network. Various types of network interconnect units are possible. Filtering, forwarding, and repackaging of messages are possible. There is also a means of node identification for units connected on another port of the network interconnect unit.

Messages exist to allow the filter database for a network interconnect unit to be configured for different types of message passing and for performance metrics to be accessed.

The physical layer timing requirements of ISO 11783-2 prevent the effective use of repeaters. Since the ISO 11783 network has a sample point of 80% of the bit time and allows a transition time equal to 1/4 bit time, true repeaters cannot be used. Repeaters should not be used to extend the implement network.

ISO 11783-4 has an added capability that allows diagnostic tools or controller applications to communicate across gateways to network segments with different address spaces. It does this through a mechanism for establishing connections to the desired controller application in the other address space. The connections use a virtual address on the local network to "map" to the appropriate address in the other address space. The gateway forwards messages to or from these virtual addresses. This allows systems to be designed with more than 250 network nodes. It also allows subsystems to exist in near isolation of other subsystems, yet allow diagnostic or other communication when needed.

7.5   Application Layers

Several application layers are defined for use in this network.

SAE J1939-71 describes messages for general-purpose use and messages for use on the tractor network, by reference to SAE J1939DA.

SAE J1939-73 defines diagnostic messages for the network.

ISO 11783-6 defines messages and behavior for virtual terminal. See 7.7.

ISO 11783-10 defines messages and behavior for task controller. See 7.9.

ISO 11783-7, -10, and -11 define messages and behavior for management computer interface. See 7.10.

Additionally, any of the other SAE J1939 application layers can be potentially useful and can be used in agricultural and forestry networks as needed.

SAE J1939-74 describes messages for configurable messaging.

SAE J1939-75 describes messages for generator sets and industrial use, by reference to SAE J1939DA.

7.6   Network Management

SAE J1939-81 describes the management layer intended for use in these networks. A more rigorous requirement for survival of power glitches is imposed for agricultural and forestry machines and implements beyond that existing in SAE J1939-81. These requirements are defined in ISO 11783-5 and summarized in the following paragraphs.

7.6.1   Power Supply Disturbances

ECUs on an ISO 11783 network should be able to handle voltage transients and interruptions. Reactions to voltage disturbances of different durations should be processed as detailed in the following clauses. The times are defined for transients and interruptions that occur from the nominal specified supply voltage for the ECU.

7.6.1.1   2 ms or Less Transients and Interruptions

If normal power (ECU_PWR) is restored within 2 ms and if interruptions are spaced at least 100 ms apart, then the ECU should have no occurrences of:

•   Loss of normal network communications or loss of in-process messages

•   Processor reset

•   Loss of data in volatile memory, including network configuration information and/or messages in progress over the network

7.6.1.2   Greater Than 1 Second Transients and Interruptions

If normal power is not restored within 1 second, then the ECU must reset and complete a power-on self-test (POST).

7.6.1.3   Greater Than 2 ms and Less Than 1 Second Transients and Interruptions

If power is disrupted for greater than 2 ms, but less than 1 second, internal requirements of the ECU will determine if a reset is required or is not required.

7.6.2   Working Sets

Groupings of ECUs, called working sets, as described in SAE J1939-81, can only be used in the virtual terminal application on agricultural networks in order to create distributed control over agricultural implements connected to tractors.

7.6.3   NAME Assignment

The use of NAMEs and source addresses described in SAE J1939-81 applies to SAE J1939-02 networks.

On the implement network (ISOBUS), arbitrary address capability is required. Implement control functions are required to be self-configuring because they can be attached to an already operating network. Presently, the agricultural and forestry preferred source address table (refer to SAE J1939DA, IG2 Source Addresses (B4) worksheet) is controlled by ISO 11783, and additions are allowed. Although a control function on an implement network can lose a preferred address due to occurrence of a higher priority NAME address claim, the preferred address definitions are maintained to define common default and initial factory setup network configuration for select control functions.

The NAMEs for agricultural and forestry devices are selected from tables maintained by ISO 11783 in an appendix and are referred to as the B tables. These names are mirrored in SAE J1939DA, IG Specific NAME Function (B12) worksheet designated with Industry Group 2.

7.6.4   Initialization Processes

Due to the potentially high number of ECUs present on agricultural systems, two initialization items are emphasized here:

1.   Multiple identical CAs are possible on an implement; for instance, for "per row" monitors or controllers. This possibility creates the potential for destructive message collisions during the address-claim process. To remedy this situation, special processing rules during power-up initialization are outlined in SAE J1939-81 discussion of Address Claim data frame bus collision management. The processing includes delaying any retries of any failed address claim messages by a pseudorandom delay of between 0 and 153 ms.

2.   Since arbitrary address capability is required on the implement network, it is also a requirement for the CAs to maintain a table correlating NAMEs to source addresses, and to use this table to associate transmitted and received messages with the correct CA. Refer to SAE J1939-81 discussion of Address to NAME association.

7.6.5   Implement Instance Initialization Processes

When assigning instances to implements to precisely specify an implement location, the rule is to number from left to right, followed by front to rear, followed by bottom to top. Refer to ISO 11783-6 discussion of multiple similar working sets.

7.7   Virtual Terminal

A standard for a virtual terminal is provided in ISO 11783-6. The VT is an electronic unit that provides a standardized operator interface to a system. The VT provides operator input and output capabilities in a single electronic unit. The VT is shown in Figure 1 attached to the implement network. Tractor ECUs or other ECUs within the tractor connected to the implement network can utilize the VT by the same method as an implement ECU.

7.8   Tractor ECU

The tractor ECU provides a communications link between the implement network and the tractor network and acts as a network interconnection unit to assure both electrical and message isolation.

This ECU is used to represent the tractor in communications on the implement network. Messages sent from any ECU on the implement network that can be directed to an ECU residing on the tractor should be sent to the tractor ECU, and any messages sent to ECUs on the implement network from tractor ECUs must use the source address of the tractor ECU. The network interconnection unit must provide appropriate acknowledgments or responses to the requesting or commanding ECU.

Three classes of tractor ECU capability have been defined. Each class must support a minimum set of messages, including all the messages of the next lower class. Details of the tractor ECU and lists of the required messages for each class are found in ISO 11783-9. The required messages are described in detail in ISO 11783-7.

7.9   Task Controller

Task controllers provide control via the ISO 11783 network. Task data received via the management computer interface is stored in the task controllers. These tasks are scheduled by the task controller, which sends control messages to the appropriate ECUs for execution. The task controllers can also record data received from ECU as tasks are being completed. This data can be transferred to the management computer through the management computer interface. The operation of the task controller and the format of messages sent and received from ECUs is detailed in ISO 11783-10.

7.9.1   Object Reference Structure

The object reference structure describes the method that a task controller uses to refer to a particular controlled section of an implement. This structure is used not only to allow set points to be sent to objects on an implement but also to allow objects to send actual values back to the task controller.

7.10   Management Computer Interface

Though the physical interface between the farm management information system and the vehicle is not specified in this standard, the messaging is defined in ISO 11783-10. Information about tasks to be performed by the vehicle's ECUs is transferred in XML format from the farm management system to the task controllers. The task controllers then parse the information using the process data message described in ISO 11783-7 and whose elements are described in ISO 11783-11. Figure 2 illustrates an example management computer interface.
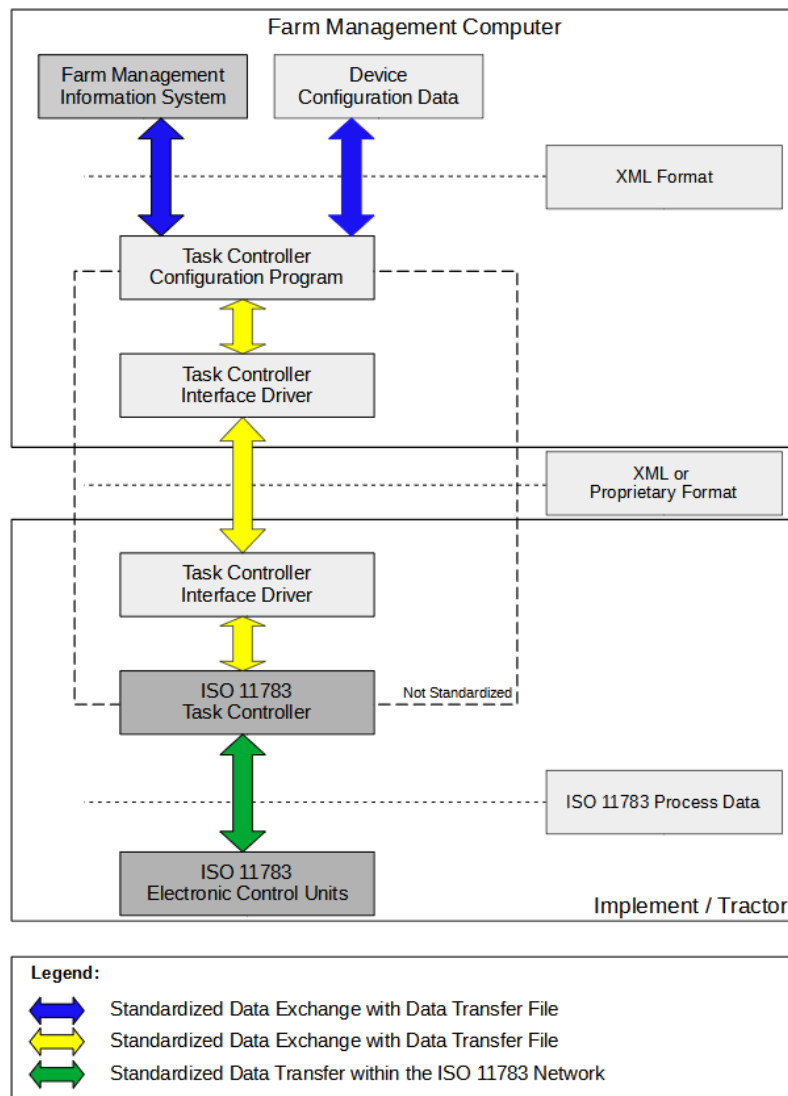
Figure 2 - Management computer interface example

8.   DESIGNING AGRICULTURAL AND FORESTRY NETWORKS

For those familiar with SAE J1939 networks, this section summarizes some of the key points made in this document that should be kept in mind when creating ECUs and networks that will comply with this agricultural and forestry application network standard.

8.1   Network Interface

The electronic circuit design for an ECU designed to meet SAE J1939-11 or SAE J1939-15 requirements will also work in an agricultural and forestry network. This includes rise and fall times. The agricultural and forestry network media has a characteristic impedance of 75 Ω, instead of the 120 Ω specified for SAE J1939 physical layers. Many modern CAN transceivers work over this range of impedances.

8.2   Low-Level CAN Drivers

A small but important difference exists in the sample time specification of the bits. SAE J1939 specifies the sample point to be as close to, but no greater than, 87.5% of the bit time. The agricultural and forestry specification is as close to, but no greater than, 80% of the bit time. This requires calculating the clocking and timing parameters and setting the bit timing registers appropriately.

8.3   High-Level Protocol Items

Use of arbitrary address capability is mandatory on the agricultural and forestry network. This requirement simplifies the integration of multiple implements and implement subsystems. It also eliminates the need to assign and maintain preferred address tables. However, this requirement implies that the NAME address table must be built and maintained by each ECU.

9.   NOTES

9.1   Revision Indicator

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

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