The SAE J1939 Communications Network

An overview of the J1939 family of standards and how they are used

An SAE White Paper

Since its publication more than a decade ago, SAE J1939 has become widely accepted as the Controller Area Network (CAN) for on-highway trucks, off-highway equipment, agricultural equipment, construction equipment, and other vehicles.

What is J1939?

> ***From the Foreword to J1939 (Serial Control and Communications Heavy Duty Vehicle Network)...***
> *"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 common communication architecture strives to offer an open interconnect system that allows ECUs associated with different component manufacturers to communicate with each other."*

J1939 covers the design and use of devices that transmit electronic signals and control information among vehicle components. Used as an application layer, J1939 provides communication between the engine control, transmission control, vehicle body control, and other applicable sub-control systems.

J1939 also defines message timeouts, how large messages are fragmented and reassembled, the network speed, the physical layer, and how applications acquire network addresses.

The 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.

SAE International

A "Family" of Documents

The J1939 standards "family" consists of the top level document (J1939 itself) and 16 companion documents.

J1939 is the master control for definitions common to many applications. This document provides the comprehensive list of all assigned data parameter and diagnostic identifiers (SPNs), all assigned messages (PGNs), and all assignments for NAME and Address identifiers.


SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

J1939 REV. FEB2007

Issued 2000-04
Revised 2007-02
Superseding J1939 JAN2005

(R) Recommended Practice for a Serial Control and Communications Vehicle Network

RATIONALE

New parameters, parameter groups and other assignments are reviewed and discussed by the Subcommittee on a regular basis. This SAE Recommended Practice has been updated to reflect all changes and additions approved and balloted through May 2006.

FOREWORD

This series of SAE Recommended Practices has been developed by the Truck & Bus Control and Communications Network Subcommittee of the Truck & Bus Electrical & Electronics Committee. The objectives of the subcommittee are to develop information reports, recommended practices and standards concerned with the requirements, design, and usage of ECUs which transmit electrical signals and control information among vehicle components. The usage of these Recommended Practices is not limited to truck and bus applications; other applications may be accommodated with

The top level document serves as the central registry for these assignments even though the technical details for most SPNs and PGNs are specified throughout the other documents in the J1939 family.

The top level document describes the network in general, the OSI layering structure, and the subordinate document structure, as well as providing control for all preassigned values and names.

J1939 is:

- Developed for use in heavy-duty environments
- Suitable for horizontally-integrated vehicle industries

The physical layer aspects of SAE J1939 reflect its design goal for use in heavy-duty environments. But the J1939 communications network is applicable for light-duty, medium-duty, and heavy-duty vehicles used on-road or off-road, and appropriate stationary applications which use vehicle-derived components (such as generator sets).

The companion documents explain component rationalization and product standardization for a particular application or industry. Specific documents in the J1939 family describe the recommended practices for networks in:

- Heavy-Duty On-Highway Vehicles
- Agricultural and Forestry Off-Road Machinery
- Marine Stern Drive and Inboard Spark-Ignition Engines

Companion documents also describe layers used in the OSI network architecture, such as:

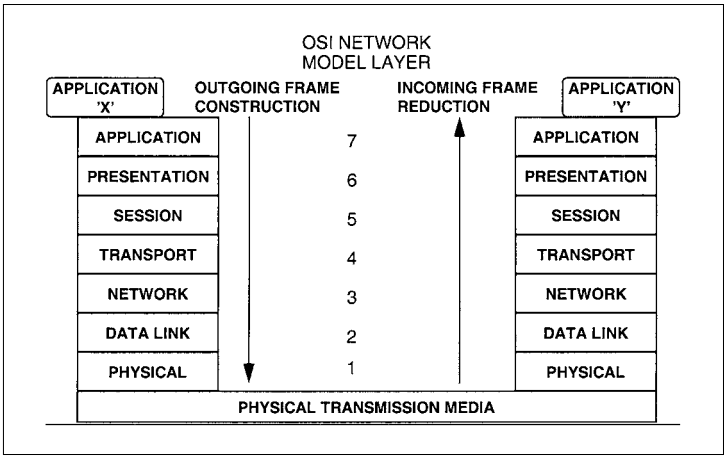
- Physical Layer
- Data Link Layer
- Network Layer
- Vehicle Application Layer

J1939 Compliance

There is no procedure presently in place to test, validate or provide formal approval for ECUs utilizing the SAE J1939 network. Developers are expected to design their products in the spirit of, as well as the specific content of, the recommended practice. In the future, procedures may be defined for the testing of products to ensure compliance. Until then, compliance is determined by the manufacturer of the component. J1939 gives OEMs the ability for customized communication.

J1939 Benefits

Because a vehicle's electronic systems are connected to one central network, vehicle monitoring and management is enhanced. Vehicle systems become more serviceable because they are all connected to one network.



Thus, J1939 results in improvements in:

- Vehicle flexibility and reliability
- Product standardization
- Parts economy
- Self-diagnostics
- Log and record capabilities
- Calibration of individual components
- Reading or deleting the diagnostics data of individual components
- Transmitting measurement values and control data to configure components

History

The J1939 family of standards is developed by SAE's Truck and Bus Control and Communications Network Committee, which reports to the Electrical and Electronics Steering Committee of the Truck and Bus Council. Participants in the Control and Communications Network Committee include personnel from OEMs, suppliers, consulting firms, governmental agencies, and others involved in the truck and bus industry.

The top-level document, J1939, was originally published in April 2000. It has since been revised in 2003, 2005, 2007, 2009, 2010, and most recently, in April 2011.

As stated in the original publication of J1939, the purpose of the recommended practices was to "provide an open interconnect system for electronic systems. It is the intention of these recommended practices to allow Electronic Control Units to communicate with each other by providing a standard architecture."

The J1939 network was the next generation successor to the SAE J1708 and SAE J1587 low speed networks. Those earlier standards provided simple information exchange, including diagnostic data, between ECUs. J1939 was capable of performing all of the functions of those earlier networks. It enhanced previous capabilities and added new ones to better support controls and multiplexing on a single network.

The J1939 Standards Collection on the Web

The most convenient and comprehensive way to access everything related to the SAE J1939 family of standards is through the SAE J1939 Standards Collection on the Web. This web-based subscription service provides access to the top level document (J1939), as well as the 16 core companion documents. Whenever any of these documents is revised, or if a new standard is added, the subscription is updated automatically.

In addition, the subscription includes more than 20 related standards and technical papers, and the Companion Spreadsheet for 1939, a supplementary Excel document consisting of the parameters and parameter groups contained in J1939 standards.

Single user, one-year subscription: $650
To order, or for more information:
sae.org/j1939
1-888-875-3976
CustomerSales@sae.org

Technology had advanced to the point where a high speed communication network was feasible. It was needed to secure higher bandwidth capabilities for more demanding control needs, so that component suppliers could integrate subsystems for improved performance, and to meet customer expectations and government regulations.

A number of documents in the J1939 family preceded the publication of the top level document. For example, these recommended practices were available in 1994:

- J1939-11: Physical Layer, 250K bits/s, Twisted Shielded Pair
- J1939-21: Data Link Layer
- J1939-31: Network Layer

Revision, expansion and updating of all standards in the J1939 family is ongoing. The following four documents in the J1939 family have been revised in 2011:

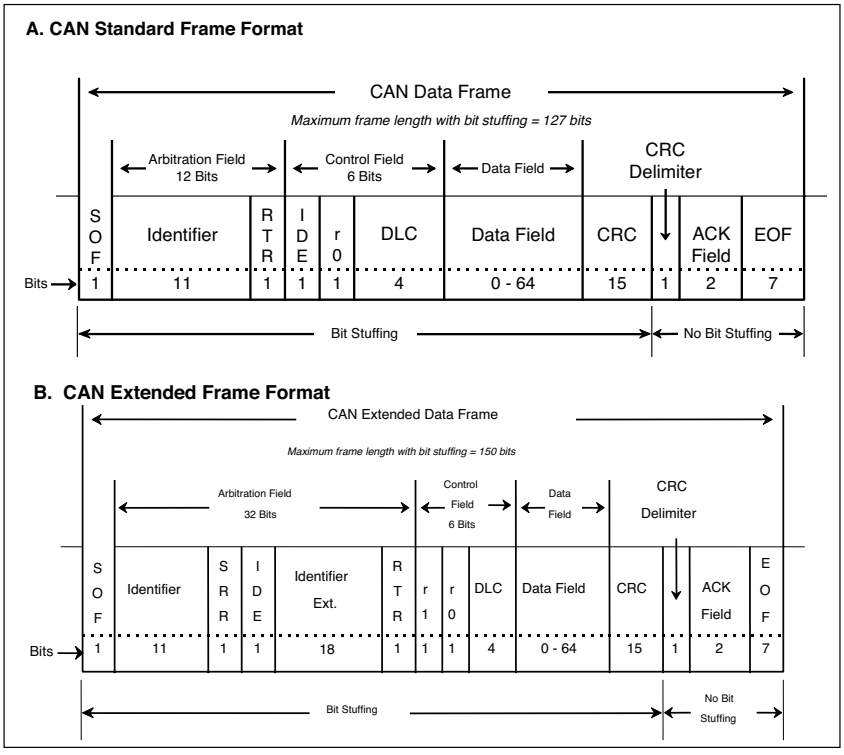
- J1939-01: Recommended Practice for Control and Communications Network for On-Highway Equipment
- J1939-71: Vehicle Applications Layer
- J1939-75: Application Layer – General Sets and Industrial
- J1939-81: Network Management

J1939 and CAN

J1939 uses the CAN protocol which permits any ECU to transmit a message on the network when the bus is idle. Every message uses an identifier that defines:

- The message priority
- From whom it was sent
- The data that is contained within it

Collisions are resolved non-destructively as a result of the arbitration process that occurs while the identifier is transmitted.



This permits high priority messages to get through with low latency (delay) times because there is equal access on the network for any ECU. When multiple ECUs are simultaneously attempting to transmit, the highest priority message prevails. This results in maximum reliability, combined with maximum possible performance, leading to better vehicle performance, and reduced production costs.

CAN systems enable use of a single command station to control diagnostic systems and receive information such as:

- Brake and transmission temperature
- Tire pressure
- Fuel efficiency
- Emission levels

J1939 uses the 29-Bit identifier to identify the source, and in some cases, the destination of data on the bus. J1939 extends the use of the 29-Bit CAN identifier beyond the standard CAN message identification.

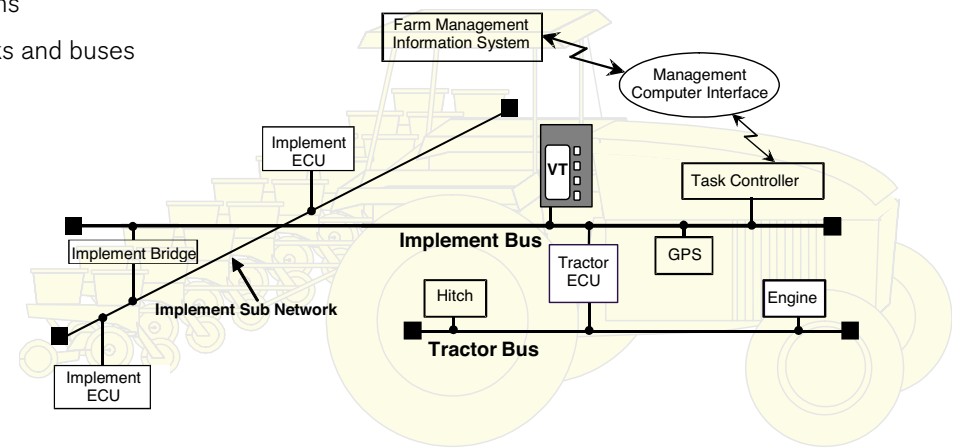
J1939 takes advantage of these features of CAN:

- Reduced wiring (CAN requires only two wires between nodes)
- Reliable communication
- Easy implementation
- Improved maintenance and service capabilities
- Error detection and fault confinement
- Collision-free bus arbitration

J1939 Applications in Industry

J1939 has been widely adopted by diesel engine manufacturers and in the commercial vehicle sector. J1939 is heavily used in the following vehicle applications:

- Diesel powertrain applications
- In-vehicle networks for trucks and buses
- Agricultural machinery
- Forestry machinery
- Truck-trailer connections
- Mining equipment
- Military vehicles
- Fleet management systems
- Recreational vehicles
- Marine navigation systems



J1939 has been used as the basis for the development of other industry-specific standards, including ISO 11783 for agricultural machinery, MilCAN for military applications, and NMEA 2000 for marine applications. Recently, six major European truck manufacturers developed the FMS (Fleet Management System), a common standard for trucks based on J1939.

Companies using J1939 include Volvo, MACK, John Deere, Caterpillar, Nissan Diesel, and Navistar.

The J1939 Family of Standards

In addition to J1939 (Recommended Practice for a Serial Control and Communications Vehicle Network), the J1939 family of documents consists of:

J1939-01
On-Highway Equipment Control and Communications Network

This document was updated in May 2011 to more accurately describe the J1939 network as typically used in heavy duty on-highway vehicle applications.

J1939-02
Agricultural and Forestry Off-Road Machinery Control and Communications Network

This document is intended to specify the requirements for application of J1939 in construction and agricultural equipment. This document specifies the series of documents within the set of J1939 documents that are applicable to construction and agricultural equipment and provides further requirements for this industry.

J1939-03
On-Board Diagnostics Implementation Guide

This document provides requirements and guidelines for the implementation of On-Board Diagnostics (OBD) on heavy-duty vehicles (HDV) using the SAE J1939 family of standards. The guidelines identify where the necessary information to meet OBD regulations may be found among the SAE J1939 document set. Key requirements are identified to insure the interoperability of OBD scan tools across individual OBD compliant vehicles.

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

This document describes the application of the SAE J1939 recommended practices for compliance with on-board diagnostic malfunction detection system requirements for marine stern drive and inboard spark ignition engines, as mandated by the California Air Resources Board.

J1939-11
Physical Layer – 250k bits/s, Twisted Shielded Pair

The physical layer is a realization of an electrical connection of a number of ECUs to a network. The total number of ECUs will be limited by electrical loads on the bus line. This document defines a physical median of shielded twisted pair.

J1939-13
Off-Board Diagnostics Connector

This document describes the off-board diagnostic connector used on the vehicle to get access to the vehicle communication links.

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

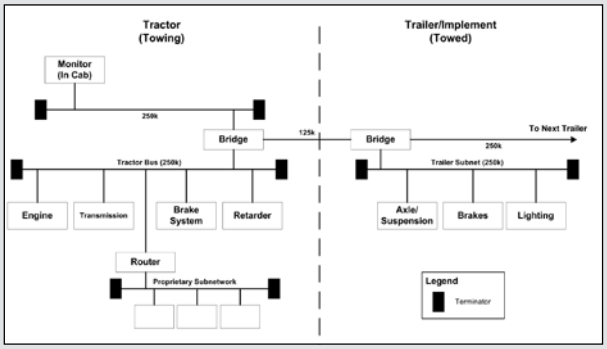
This document describes a physical layer utilizing Unshielded Twisted Pair (UTP) cable.

J1939-21
Data Link Layer

This document describes the data link layer using the CAN protocol with 29-bit identifiers. For SAE J1939 no alternative data link layers are permitted.

J1939-31
Network Layer

This 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.



J1939-71
Vehicle Application Layer

This recommended practice describes an Application Layer for vehicle use.

J1939-73
Application Layer – Diagnostics

This document identifies the diagnostic connector to be used for the vehicle service tool interface and defines messages to accomplish diagnostic services. California-regulated OBD II requirements are satisfied with a subset of the specified connector and the defined messages. Diagnostic messages (DMs) provide the utility needed when the vehicle is being repaired. Diagnostic messages are also used during vehicle operation by the networked electronic control modules to allow them to report diagnostic information and self-compensate as appropriate, based on information received. Diagnostic messages include services such as periodically broadcasting active diagnostic trouble codes, identifying operator diagnostic lamp status, reading or clearing diagnostic trouble codes, reading or writing control module memory, providing a security function, stopping/starting message broadcasts, reporting diagnostic readiness, and monitoring engine parametric data.

J1939-74
Application – Configurable Messaging

This document describes the message structure for a set of messages that enable the user to determine and announce to others on the network, the parameter placement within a particular message from the special set of messages defined within this document.

J1939-75
Application Layer – Generator Sets and Industrial

This document defines the set of data parameters (SPNs) and messages (PGNs) for information predominantly associated with monitoring and control generators and driven equipment in electric power generation and industrial applications.

J1939-81
Network Management

Network management in the SAE J1939 network is concerned with the management of source addresses and the association of those addresses with an actual function and with the detection and reporting of network related errors. Due to the nature of management of source addresses, network management also specifies initialization processes, requirements for reaction to brief power outages and minimum requirements for ECUs on the network.

J1939-82
Compliance – Truck and Bus

The purpose of these compliance procedures is to generate one or more test documents that outline the tests needed to assure that an ECU that is designed to operate as a node on an SAE J1939 network would do so correctly. These tests are presented to allow testing of a device to determine self-compliance by the manufacturer. The manufacturer can use its record of what procedures were run successfully to show the level of compliance with SAE J1939.

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

The purpose of this recommended practice is to verify that vehicles and/or components are capable of communicating a required set of information, in accordance with the diagnostic test messages specified in SAE J1939-73, to fulfill the off-board diagnostic tool interface requirements contained in government regulations. This document describes the tests, test methods, and results for verifying diagnostics communication from an off board diagnostic tool (i.e., scan tool) to a vehicle and/or component. This document serves as a guide for testing vehicles for compliance with ARB and other requirements for emissions-related on-board diagnostic (OBD) functions for heavy duty engines used in medium and heavy duty vehicles.