SAE J1939: 25th anniversary

Figure 1: Originally J1939-compliant networks were used in heavy-duty road vehicles for the U.S. market, today most commercial trucks are equipped with multiple J1939 networks (Source: Adobe Stock)

In 1994, the nonprofit SAE association released the first J1939 documents. In the meantime, application-specific network solutions have been developed, which are based on the J1939-21 application layer.

Originally, it was not intended to map J1939 messages to the CAN data link layer. But the introduction of the CAN extended frame format enabled the mapping of the 8-bit source and the 8-bit destination addresses into the 29-bit identifiers. Even today, the 29-bit CAN-ID data frame format option is often named as CAN 2.0B; although, it was already internationally standardized in ISO 11898:1993 and named Extended Data Frame. In the last revision of ISO 11898-1, it is called Classical Extended Data Frame Format (CEFF). This term should be used; CAN 2.0B is outdated since 1993.

In 1994, SAE released the J1939-11 high-speed physical layer, the J1939-21 application layer (unfortunately, titled wrongly as data link layer), and the J1939-31 network layer specifications. The J1939-21 document also specified the BAM (Broadcast Announcement Message) and the RTS/CTS (Request-To-Send/Clear-To-Send) transport layer protocols, which enabled the transmission of messages with more than 8 byte. In order to provide ECU (electronic control unit) interoperability, the J1939-71 document specified the content of the PDUs (protocol data units). Most of the specified parameter groups (PGs) have a length of 8 byte fitting into Classical CAN data frames. Today most of them are specified in the J1939 digital annex. The PGs are identified by the uniquely assigned PGN (parameter group number). Standardized PGs are not configurable, but user-specific PGs as specified in J1939-74 are configurable. They were introduced in 2004.

J1939 networks were first used in trucks and bus to link powertrain electronic control units (ECUs). Nowadays, nearly all commercial vehicles are equipped with J1939 networks. In the last 25 years, additional J1939 specifications have been developed (see Table 1).

The J1939 application layer was also adapted by other industries. The first one was the stationary generator sets, which used the J1939 recommended practices. Some specific functions are specified in J1939-75 (2002). However, this industry is not very transparent. This means, the SAE J1939 committee, which meets quarterly, has no detailed information about generator set applications.

The agriculture and forestry machine industry makes also use of the J1939 communication technology. The ISO 11783 series, released in 2007, references the SAE specifications and adds some specific functions. Also the transport layer protocol has been adjusted to the specific needs of this industry. ISO 11783 compatible networks are also known as Isobus. They link tractors to so-called implements. Implements comprise tractor add-on devices such as sprayers as well as attachable harvesting machinery. There have been published some Isobus-related articles by this magazine. Interesting is that this industry is well organized in the nonprofit AEF association, which organizes bi-annually so-called plugfest. These events are used to proof the interoperability of Isobus devices. AEF has also developed conformance test tools. Conformance testing is mandatory for Isobus implementations. ▷

Table 1: SAE J1939 documents

Number	Title	First issue	Current issue
J1939	Serial control and communications heavy duty vehicle network – Top level	2000	2019
J1939/1	On highway equipment control and communication network	2000	2011
J1939/2	Agriculture and forestry off-road machinery control and communication network	2006	2019
J1939/3	On-board diagnostics implementation guide	2008	2015
J1939/05	Marine stern drive and inboard spark-ignition engine on-board diagnostics implementation guide	2008	2017
J1939/11	Physical layer, 250 kbps, twisted shielded pair	1994	2016
J1939/13	Off-board diagnostic connector	1999	2016
J1939/14	Physical layer, 500 kbps	2011	2016
J1939/15	Physical layer, 250 kbps, un-shielded twisted pair	2003	2018
J1939/16	Automatic baud rate detection process	2015	2018
J1939/17	CAN FD physical layer – 500 kbps/2 Mbps	*	*
J1939/21	Data link layer	1994	2018
J1939/22	CAN FD data link layer	*	*
J1939/31	Network layer	1994	2018
J1939/71	Vehicle application layer	1994	2016
J1939/73	Application layer – Diagnostics	1996	2019
J1939/74	Application – Configurable messaging	2004	2015
J1939/75	Application layer – Generator sets	2002	2015
J1939/76	SAE J1939 functional safety communications protocol	2018	2018
J1939/81	Network management	1997	2017
J1939/82	Compliance	2008	2015
J1939/84	OBD communications compliance test cases for heavy duty components and vehicles	2008	2017
J1939/90	OBD traceability matrix	2019	2019
J1939/91	Network security	*	*
J1939DA	Digital annex (SP and PG specification)	2013	2019
* under development			

Another industry, which makes use of J1939 technology, is the marine industry. The nonprofit NMEA association developed already in the late 90ties the NMEA 2000 specification. It is since 2008 internationally standardized in IEC 61162-3. This standard is widely used for navigation purpose in small boats as well as ocean vessels. It has been amended several times. Last amendment was released in 2014.

The FMS (fleet management system) mainly developed by European truck makers is also based on J1939. It is developed under the umbrella of the nonprofit ACEA European vehicle makers association. Since 2004, it is used to read in-vehicle network and provide this by means of telecom services to manage a fleet of commercial trucks. The ISO 16844 standard, released already in 2001, specifies a J1939-based communication between tachograph and dashboard.

Table 2: ISO 11783 (Tractors and machinery for agriculture and forestry – Serial control and communications data network) documents

Part-no.	Title	First issue	Current issue
1	General standard for mobile data communication	2007	2017
2	Physical layer	2002	2019
3	Data link layer	1998	2018
4	Network layer	2001	2017
5	Network management	2001	2011[a]
6	Virtual terminal	2004	2018
7	Implement messages application layer	2002	2018
8	Power train messages	2006	2015
9	Tractor ECU	2002	2012[a]
10	Task controller and management information system data interchange	2009	2015
11	Mobile data element dictionary	2007	2016
12	Diagnostics services	2009	2019
13	File server	2007	2016
14	Sequence control	2013	2018
[a] under systematic review			

Figure 2: The J1939-based network for agriculture tractors and implements is standardized in the ISO 11783 series (Source: Adobe Stock)

In another ISO standard, the communication between truck and trailer is specified. There are two point-to-point links standardized: one for brake and running gear (ISO 11992-2) another one for other devices including lane departure functions (ISO 11992-3). These ISO standard series was published first in 1998. Both mentioned networks are based on J1939, but use the dedicated physical layer as specified in ISO 11992-1. Unfortunately, just one transceiver IC has been implemented, which is not available openly on the market. If several trailers or dollies are connected, you need multiple ISO 11992 network-segments. In Europe, the brake and running gear network as specified in ISO 11992-2 is required by an ECE (Economic Commission for Europe) regulation.

Under development is a network linking commercial vehicle body control systems such as tail lifts, truck-mounted cranes, cooling systems as well as complex body applications for refuse-collecting vehicles or fire-fighting trucks to telematics gateways. This DIN 4630 standard links also in-vehicle network gateways and FMS gateways. This German standard is written in English language and is mainly developed by body system suppliers in co-operation with some truck and trailer OEMs (original equipment manufacturers).

Other standards and specifications make also use of the J1939 application layer. Currently, the earth-moving machine manufacturers are standardizing autonomous driving vehicles using J1939-based networks to detect and avoid collisions. The Chinese e-vehicle charging standard (GB/T 27930) is also based on J1939.

J1939 and CAN FD

In 2016, CiA started to develop a J1939 application layer using CAN FD. CAN FD is a data link layer option providing data fields with up to 64 byte. The related CiA 602-2 specification introduced a multi-PDU concept allowing the mapping of multiple PGs into one CAN FD data frame. The CiA 602-2 specification was given to SAE for further extension and integration into the new J1939-22 application layer. This specification also introduces a new transport layer and is still under development. It is expected that J1939-22 will be released in 2020. SAE is also developing the J1939-17 physical layer specifying a 500 kbit/s arbitration speed and a 2-Mbit/s dataphase bit-rate. Also this SAE document will be released beginning of next year. ◀

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Hard to read for newcomers

The different standards based on J1939 are developed independently. There is no harmonization, so far, regarding terminology and description. Sometimes, the same functions are specified in two standards. I think, it would be better to make reference to avoid differences in the descriptions. It would be also more than nice to harmonize terms. This would decrease the chance of misunderstanding and misinterpretations. These problems are addressed and need to be fixed in the next revision of J1939-related specifications and standards. As the convener of an ISO working group responsible for the ISO 11992 and ISO 16844 series, I am working on the avoidance of double-specifications. I am doing the same as liaison officer for the ISO 11783 series. To improve all J1939-related documents is a giant task, which I cannot do alone. Everyone can do one simple thing: Use terminology consistently and correctly. For example, the PGN (parameter group number) is just a number and not the PG (parameter group). A J1939 message comprises the PGN and the PG. The PG is the assembly of suspect parameters (SPs). Do not use PGN as synonym for PG. Let us make the documents easier to read and to understand. Newcomers should not be challenged.

Holger Zeltwanger

Author

Holger Zeltwanger
CAN Newsletter
pr@can-cia.org
www.can-newsletter.org

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