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Standards and

In the heavy-duty vehicle arena, adoption of standards for networking benefits everyone.

There is no better term than "coopetition" to describe how companies that produce today's heavy-duty vehicle network controllers, diagnostic applications, and protocol adapters are using standardization to maximize equipment up-time and decrease overall operating expenses. Coopetition can best be described as cooperation among competitors for the purpose of the common good of an industry, but limited to issues that do not impact competition. In actuality, standards in the heavy-duty-vehicle networking industry, produced as a result of coopetition, place every manufacturer on a level playing field, thereby increasing competition and providing customers with more features and functionality and better overall operator comfort.

Network standardization

In the heavy-duty industry, vehicle network standards are very open. For the most part, this fact can be attributed to the trucking industry, although there were some humble beginnings in the automotive sector that cannot be forgotten.

Today, it is common for fleet operations to custom-order equipment of "OEM Brand X," with an engine of "Brand W," a transmission of "Brand Y," and an ABS system of "Brand Z." This occurs even though OEM "Brand X" may have an intimate business affiliation with, or even own, the manufacturer of the engine, transmission, or brakes.

Regarding such customization in the automotive industry, the standards are open (such as **SAE** J1850 and **ISO**15765) but the actual implementations based on these standards are not quite as open. Automotive OEMs go to great lengths to keep their on-vehicle networks and component communication implementations close to the vest. In fact, in the automotive OEM world, there is no equivalent situation in which a customer can order OEM equipment and have the engine, transmission, and braking systems differ from the standard models offered. Automotive vehicle networks, therefore, may aid in simplifying selection alternatives available to the customer.

In the early 1980s, automotive companies—led by the Big 3 (**Chrysler**, **Ford**, and **General Motors**)—started development and utilization of networked electronic components in vehicles. Being networked, the components were physically connected to a common set of wires and could be addressed or interrogated for all types of information, including their "health status," or diagnostics, via vehicle network protocols. Automakers charged significant fees for disclosing their method of vehicle networking to third parties needing to obtain information and diagnostics data. The U.S. federal government also wanted standardized—and free—access to this type of vehicle network information, and so mandated it of the automakers.

In contrast, and perhaps from learning of the automotive industry's lesson, the heavy-duty truck and bus industries "voluntarily" (there was pressure from their customer bases) adopted standards that today still work to provide standardized vehicle network device support within tractors, trailers, engines, transmissions, and brake industry sectors. Additionally, standards allow for true multi-vendor, networked interoperability among these vehicle industry sectors (*e.g.*, **Freightliner** tractor, **Cummins** engine, **Allison** transmission, **Meritor-WABCO** brakes). In fact, one of the heavy-duty industry's voluntary standards, SAE J1939, has been accepted by the **U.S. EPA** and **California Air Resources Board** as an approved OBD protocol.

An evolution

The heavy-duty industry's first standardization move for network functionality and emissions compliance was the "physical layer" protocol SAE J1708 and a corresponding set of standardized messages defined in SAE J1587. They are commonly referred to as a single entity,

'coopetition'

J1708/J1587, and are the result of a joint effort between SAE and the Technology & Maintenance Council (TMC) of the **American Trucking Associations** (ATA). Besides solving some of the vehicle network challenges of the day, the joint effort was also a good learning experience that helped the heavy-duty industry realize what problems it would need to solve in future vehicle networks.

At the fairly nominal speed of 9.6 Kbps, J1708/J1587 is not a really good "control" network. The industry 10 years ago predicted a sunset for it by now, but it remains in use today as an information-sharing and diagnostics network. It most likely will be here for another 10 years, as it is slowly replaced by newer, faster—and in some cases, slower—specific-purpose network protocols.

The latest vehicle network standard, SAE J1939, comes directly from the automotive world's huge success with the **Bosch** Controller Area Network (CAN) "physical layer" protocol. The CAN protocol fixed many of the issues found in J1708/J1587, especially the problems of fairly taking turns using the bus to send a message, while providing the increased speed needed to serve as a vehicle control network. The message-layer standard developed is SAE J1939, which is very robust and runs at a much faster rate of 250 Kbps (25 times as fast as J1708/J1587).

What J1939/CAN did was solve most, if not all, problems encountered with SAE J1708/J1587. It also introduced many new features, including:

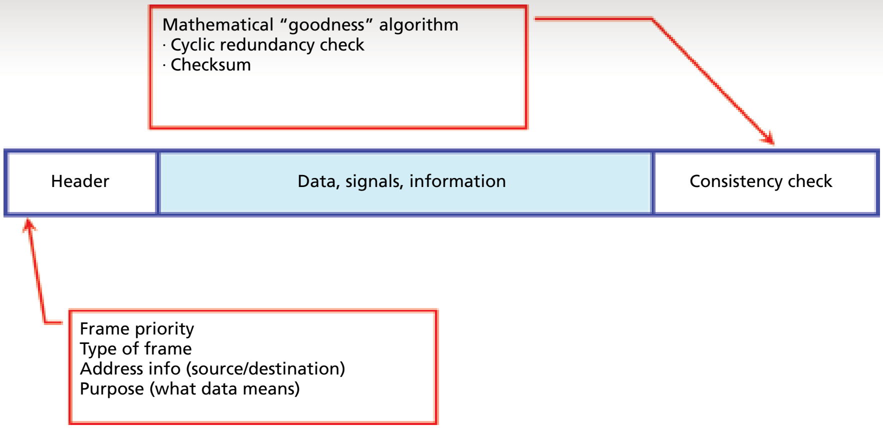
• Device-to-device messaging. There were "source addresses" defined in J1708/J1587, but there were no messages specifically designed for "destination addresses" except for proprietary messages. J1939 includes destination-specific messages called Protocol Data Unit 1 (PDU1) types, as well as general-purpose broadcast messages called PDU2 types. The PDU1 types allow controllers on the data bus, such as a hydraulics pump controller on a mining truck, to easily ignore messages not specifically destined for it. This allows controllers more time for their own sensor monitoring and control.

• Good "large message" support. Underlying CAN messages are limited to eight bytes, whereas J1708/J1587 messages were 21 bytes. However, the J1939 committee used those eight bytes to their maximum potential, breaking them into "parameter group numbers" (PGNs). PGNs are simply groupings of related types of messages, such as engine messages. For messages greater than eight bytes, the J1939 committee created a good

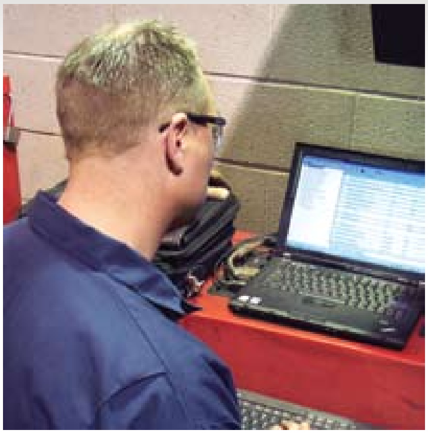
Open Systems Interconnection Basic Reference Model

Sequence	Layer	Function
7	Application	Diagnostic applications, transfers files, sends messages
6	Presentation	Handles file format differences
5	Session	Provides synchronization of data flow
4	Transport	Provides end-to-end delivery
3	Network	Switches and routes information (*e.g.*, router)
2	Data link	Delivers information to the next node
1	Physical	Transmits bit stream on physical medium

Note: Highlighted in yellow are the specific Open Systems Interconnection layers commonly used in heavy-duty vehicle networks.



J1939 and J1587 messaging standards follow this general format for a vehicle network protocol data unit.



A technician performs vehicle network diagnostics via a PC and protocol adapter.

method, the "transport layer," for getting those messages where they needed to go. The transport layer offers both flow-controlled messaging with handshaking called Ready-To-Send/Clear-To-Send (RTS/CTS), as well as a faster approach without handshaking called Broadcast Announce Message (BAM).

• Industry-specific messages. Not only were problems solved and new "protocol" features added, but J1939/CAN also opened up a new arena in messaging, as the construction, agriculture, military, and industrial-stationary OEMs added their own messages and processes for dynamically figuring out which address to claim on the bus.

Overburdened

No good deed goes unpunished, and some heavy network traffic is appearing on the J1939/CAN bus. There are a couple of architectural solutions that can be used to keep J1939 rolling for quite some time. Some OEMs are splitting the data bus into two separate networks, one for control and one for noncritical items such as air-conditioning controls. A "gateway" device connects these two buses and passes information back and forth as needed (currently the engine controller and/or a body controller performs this function, saving an extra ECM on the network). The second option is to pump up the speed by sending network traffic at a higher bit rate, such as 500 Kbps or even 1.0 Mbps, which is the CAN protocol limit.

While J1939/CAN works well for vehicle control, it is not fast enough for future developments such as brake-by-wire, steer-by-wire, and "infotainment" applications. The bottom line is that J1939/CAN is serving heavy-duty industries exceptionally well, and it is expected to be in place for many years to come. However, future needs are being considered, and the automotive industry is being eyeballed. For example, there is a need for high-speed wired protocols such as Ethernet and FlexRay, along with fiber-optic networks such as Media Oriented Systems Transport (MOST) and ByteFlight. Even some of the lower-cost/lower-speed networks—such as Local Interconnect Network, or LIN, which reduces vehicle wire count and offers simple messages for items such as heated mirrors, adjustable seats, and timer-based automatic-start irrigation pumps—are being examined.

The coopetition standard

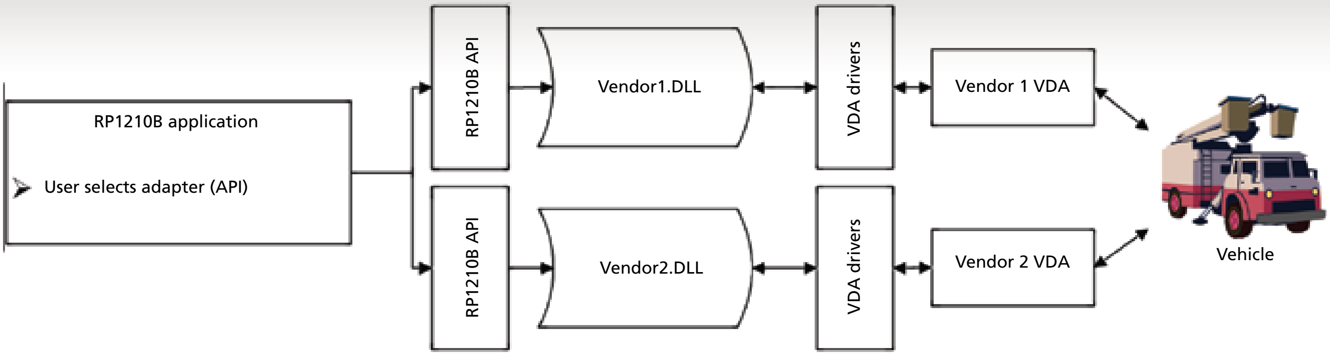
While vehicle network standards help provide a common framework for exchanging information on the vehicle, it is the application programming interface (API) that allows for the offboard diagnosis and reprogramming of vehicle components via personal computers. For the vehicle networks that apply to the heavy-duty industry, the API of common interest and standardization is TMC's Recommended Practice (RP) 1210. RP1210 supports the standards J1708/J1587, CAN, J1939, as well as these other critical heavy-duty vehicle network standards: ISO15765, J1850, PLC4TRUCKS, and ISO9141 (coming soon).

RP1210 allows one diagnostic/reprogramming protocol adapter to be used for many OEM/component applications, and is a parallel to the SAE J2534 standard the automotive industry is using. Third-party providers of vehicle datalink adapters can compete against each other in the areas of speed, protocols supported, and customer service before and after the sale. The standard also allows OEMs and component suppliers to compete against each other from a software features and functionality perspective.

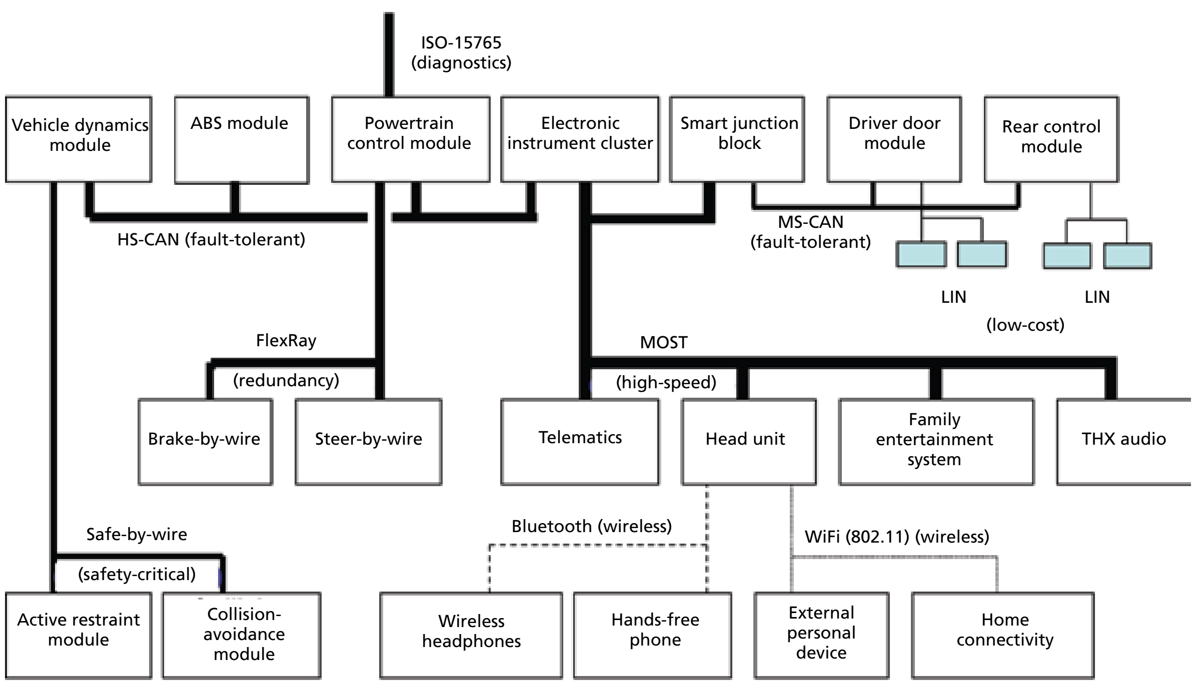
A poll taken about three years ago showed that there were over 150 commercially used RP1210-compliant software applications in the field. Some OEMs—mainly European "vertically integrated" ones—initially resisted adopting the standard. But due to fleet pressure, today all heavy-duty vehicle OEMs—as well as engine, transmission, and ABS component suppliers—now support it.

RP1210 was born from fleet frustrations of the late 1980s and early 1990s. As electronic vehicle components came on the scene, every engine, transmission, and ABS manufacturer came out with their own PC diagnostics programs. Not only did they write software, they also created or sourced their own "personalized" J1708/J1587 adapters and cabling. The problem was that with no standards in place, their software would seldom work with other adapters. To add complexity, writing device drivers for a fledgling operating system (Windows 3.1/95) was very difficult, tedious, and often turned up operating system bugs and forced "work-arounds."

Although they were not really electronically complex, the adapters were expensive, and a service bay often was a spider web of cables and adapters filling the tool crib wall. Servicing three truck OEMs, four brands of engines, three brands of transmissions, and two brands of ABS units in a shop having 10 bays would require the purchase of 120



An RP1210-compliant application can use any vendor's vehicle datalink adapter. Shown is the RP1210 functional diagram.



The number of vehicle networks to handle emerging heavy-duty applications is ever-increasing.

adapter/cable sets at more than $500 each. The cost to equip a shop easily could exceed $100,000, including software updates and new adapters that were designed to support the "new" protocol on the block, J1939, as well as support of legacy protocols. The irritant was not only cost, but also usability: one had to unhook the old adapter and cable—and possibly reboot the PC—to switch between applications.

While the heavy-duty OEMs had a very good thing going, fleet owners quickly approached the TMC S.12 Offboard Vehicle Electronics Study Group with the problem. Soon afterward, RP1210 and "coopetition in diagnostics" was born. The standard currently in the field is "RP1210A" and is being slowly migrated to the new "RP1210B" version, which plugs a lot of "holes" and adds features while staying 99% backwards-compatible with RP1210A. RP1210C, which will include the legacy protocol ISO9141, is scheduled for release in the 2009-2010 time frame.

While a standard has been quoted as being something that everyone is equally unhappy with, the TMC RP1210 standard seems to be different in that everyone involved seemed to enjoy taking off their corporate hat and to solve real industry problems and concerns. There are many emerging heavy-duty vehicle network application needs, and an ever-increasing number of active vehicle and trailer components are being added with each new architectural design. With the help of the many standards volunteers from industry players populating both SAE and ATA's TMC, vehicle network standards such as RP1210 and others will continuously be capable of meeting industry's demands, including lower overall operating expenses.

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