Integration of J1939 Systems in Practice

Commercial vehicle producers are continually being confronted with problems in integrating networked systems with the J1939 protocol. Weaknesses include information exchange between OEM and supplier and different variants of the J1939 standard. Initial approaches to improvement: establish a uniform data exchange format for the CAN communication, introduce a tool for conformity testing and define mandatory device profiles.

At the suggestion of key American truck manufacturers, the Vector US subsidiary hosted a conference to discuss improvement options for J1939 networking. At this conference, a number of presenters described their concepts and experience in integrating J1939 components. In addition, weaknesses were identified, and specific optimization potentials were discussed.

J1939 is not always J1939

The presentation by Vector showed how the SAE J1939 protocol takes on a different meaning in the USA, than it does in Europe [1]. The market structures that have evolved and the different technical requirements both play a role here. For example, the relationship between customer and OEM differs; a US customer not only selects the vehicle functions but the customer can also choose whether an installed ECU – a brake ECU for example – comes from supplier A or B. Therefore, the E/E design and communication protocol used must be as flexible as possible and must be based on standards. Typically, individual components are used across OEMs. This means that the OEM in the US has less influence on functionalities or the component manufacturer’s development processes. The role of the OEM is often limited to that of an integrator.

In Europe, on the other hand, OEMs offer the vehicles in different variants. Therefore, European customers do not have the option of selecting components like their counterparts in the USA. European OEMs typically use their own chain of fixed suppliers who individually develop or intensively modify ECUs for them. The OEM specifies the entire E/E design and sometimes the development process as well, and they are structured so that individual components can be used in different model series or brands/markets. Standards or open protocols are only needed where external interfaces are provided, e.g. in emissions-related diagnostics (OBD), fleet management (FMS), Toll Collect Modules (OBU) or trailers (ISO11992). This is also the case when components, e.g. the engine, is supplied to other industries such as agricultural or construction equipment. In practice, European OEMs tend to view J1939 more as a "toolbox" and they only use those properties actually needed in the vehicle. A J1939 conformity test would be inadequate for these implementations – but the OEMs do not consider this a disadvantage.

Reducing development costs with standard software components

The presentation by Ford [2] indicates that the network architecture is not viewed as a crucial competitive advantage. So, in this area it makes sense to use standardized and largely generated software components. In its FNOS (Ford Network Operating System) initiative in the automotive area, for example, Ford took up the idea of making an implementation available to all of its suppliers. This reduced quality problems and their propagation to a minimum. The commonality between this approach and J1939 is that FNOS is like a standard for the suppliers. In contrast to FNOS, however, many J1939 users implement the standard quite differently. Participants report that this situation always leads to problems in integration. For example, messages might not be received, because sender and receiver priorities do not match, specific ECU addresses are assumed or signals are not fully implemented. Navistar [3] noted that even the exchange of information between OEM and suppliers on which signals are available is a recurring source of errors due to outdated information and incomplete information. Instead of using an available quasi-standard – such as the DBC data format – to describe the CAN communication, text documents are often used.

Ford's experience with FNOS demonstrates that de-facto compatibility increases the availability of products and significantly reduces integration effort. For OEMs, advantages are realized if they do not develop the reference implementation for different hardware platforms themselves. By outsourcing this work to a specialized company – in this case Vector – savings were attained on the order of about 800,000 US-dollars at Ford.

Vector CANtech [4] discussed the use of standard software components versus in-house solutions. In particular, the use of off-the-shelf components offers a number of advantages in areas that are not competition-relevant and are not typically core competencies. Purchased and in some cases pre-certified components, such as the J1939 CAN communication software or the operating system, lead to greater assurance in the development process and increase interoperability. Model-based development also contributes toward reducing sources of errors **(Figure 1)**.

Optimizing J1939 integration

In its presentation, Navistar showed just how all US commercial vehicle OEMs might realize such savings potential [3]. In the context of its "Blue Diamond Program," Navistar acquired experience with both J1939 and FNOS. This involved marrying a Ford cab to a Navistar chassis. A gateway (Blue Diamond Gateway) had to be developed that would act as a link between the FNOS cab and the J1939 chassis. It became evident that the advantages of FNOS could not simply be transferred one-to-one to J1939, but that the underlying principles could. Navistar has identified a number of items that could be improved for future J1939 integration:

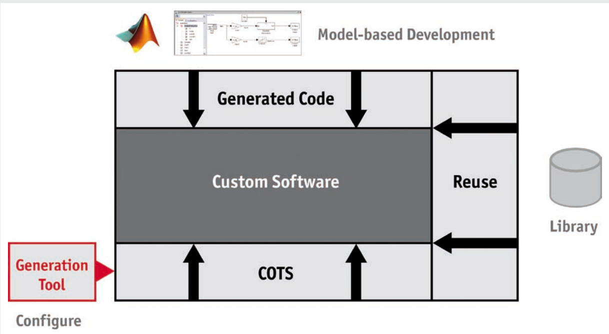

Figure 1:
development models in contrast (green, blue) and a potential merging (red).

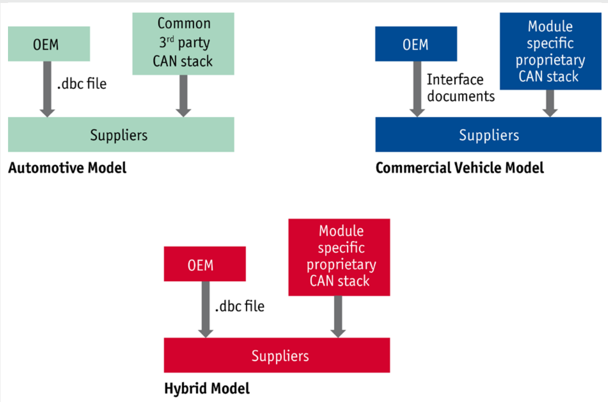

Figure 2:
Use of standard software components can reduce the share of application-specific software.

- The communication description should be made with an OEM-independent data format such as the DBC format. This enables automatic detection of incompatibilities or missing signals **(Figure 2)**.
- The OEM should have more influence in selecting the number of communicated parameter groups and signals. This offers a better way to avoid or entirely eliminate potentially critical latency times or excessively high bus loads.
- Suppliers can continue to write their own communications software. A DBC database is used for improved knowledge transfer related to the communication behavior and monitoring of communication.
- Exchange of simulation models between OEM and suppliers for all communication modules enables simulation and testing of the entire network.

Vector CANtech [5] has analyzed these items from a cost-benefit perspective and with regard to a timeline for their introduction. The use of a common existing data exchange format between OEM and suppliers is highly recommended, since it requires little implementation effort, and the benefits are realized immediately. The use of a conformity test offers additional advantages. It supports the user at various points in the development process, e.g. in implementation, verification and system integration, and it improves both product quality and process effectiveness. Development tools such as Vector's CANoe.J1939 support automatic generation of conformity tests utilizing DBC databases. This addresses critical paths in development much earlier in the process, so that they do not first appear in system integration **(Figure 3)**.

Conclusion

The conference showed that all of the US-OEMs in attendance were working on the same problems, although at different levels of intensity. This fuels the hope that these issues might be addressed as a group. The most obvious and promising approach can be implemented with little effort: "Use of a uniform data exchange format for CAN communication." This offers direct benefits to both OEMs and the suppliers. A reference implementation or official conformity test tool could be defined and implemented in coordination with the SAE organization. Mandatory device profiles could also be established in this framework.

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Figures:
Figures 0, 2 and 3: Vector Informatik GmbH
Figure 1: Vector Informatik GmbH based on documents from Navistar [3]

Literature:

[1] Fellmeth, P.; Vector Informatik GmbH: "E/E Development and J1939 in Europe, Overview about Current Status". JEIM Congress 2010.
[2] Paton, E.; Ford Motor Company: "Ford Network Operation System, The OEM Perspective." JEIM Congress 2010.
[3] Venkateswaran, S.; Navistar, Inc: "Blending Automotive and Commercial Vehicle Network Technologies." JEIM Congress 2010.
[4] Stevens, S.; Vector CANtech, Inc.: "Evolution of Vehicle Embedded Software – COTs". JEIM Congress 2010.
[5] Craig, J.; Vector CANtech, Inc: "In-Vehicle Network Development, Best Practices". JEIM Congress 2010.

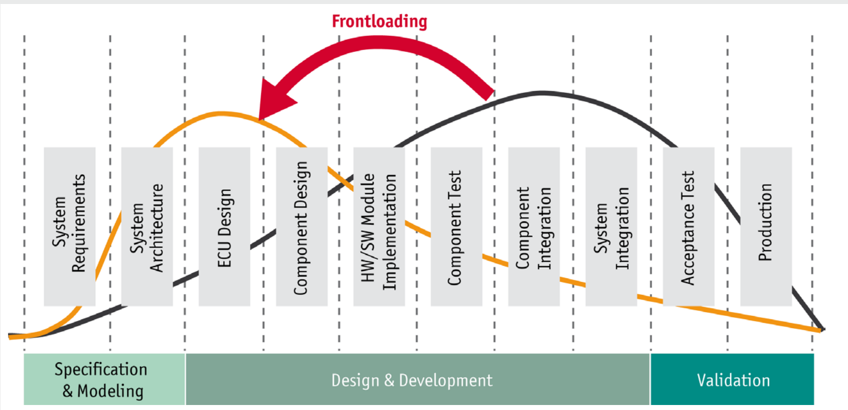

Figure 3:
Shifting effort to the beginning of the development process reduces risks and integration effort.

Links:
Homepage Vector: www.vector.com
Product Information Vector's solutions for J1939: www.vector.com/j1939

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