Developing a Fully X-by-Wire Vehicle

- **Full x-by-wire fuel cell application featuring FlexRay and CAN**
- **GM uses several dSPACE MicroAutoBoxes for x-by-wire application**

FlexRay is a high-speed and fault-tolerant bus system for use in automotive applications. General Motors (GM) uses a FlexRay network to control the Sequel, a fully x-by-wire fuel cell vehicle. Several dSPACE MicroAutoBoxes with FlexRay and CAN interfaces form the distributed control system for the vehicle.

We developed Sequel as the next stage after Hy-Wire in the reinvention of the automobile, based on the AUTOnomy concept. It features x-by-wire in several control applications:

- 4-wheel steering
- Braking
- Propulsion/drive

Distributed Control System

The functions in the vehicle are controlled by a distributed control system. One challenge is to realize an x-by-wire vehicle which is as safe as a vehicle with mechanical brakes and drivetrain.

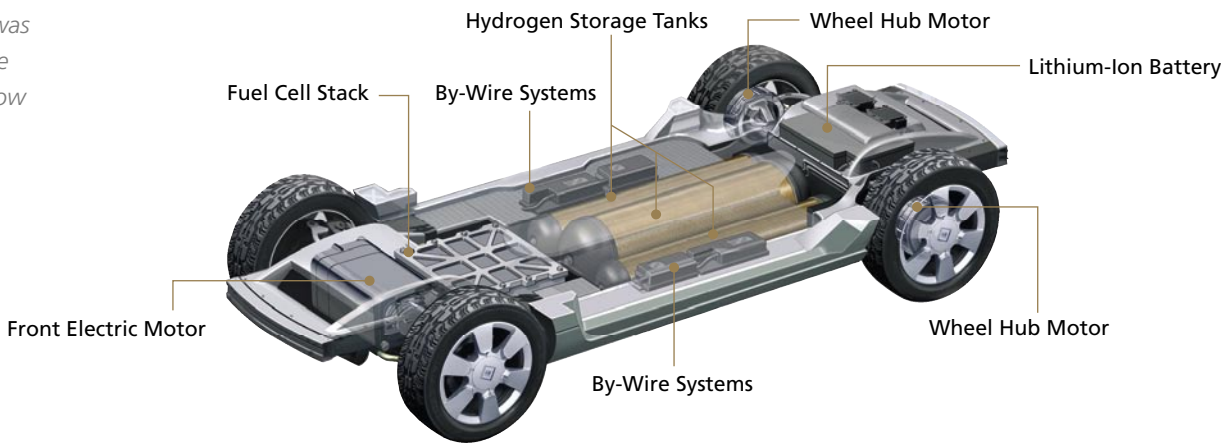
The control system consists of several dSPACE MicroAutoBoxes, linked by a DS830 MultiLink Panel from one host PC for master control, and integrates the multiple hardware platforms and software modules that were developed by different teams. Some model-based subsystems, for example, were developed by suppliers. The control system has FlexRay and multiple CAN busses. The MicroAutoBoxes have been equipped with FlexRay IP modules and act as host and gateway for the network. We used controllers, actuators, and sensors with dual/triple redundancy. We defined the process and interfaces for the models and control system, as well as the system naming conventions.

To implement the models on the control system, we used the RTI CAN Blockset and RTI FlexRay Blockset. Various third-party tools from DECOMSYS and Vector Informatik were also needed to set up the FlexRay and CAN environment.

Work Process

FlexRay requires an overall, agreed schedule, in which the following sequence of process steps is repeated:

- Developing physical and functional architecture
- Defining application task requirements and task schedules.
- Deriving communication tasks that create the communication schedule



The Sequel was modeled on the AUTOnomy show vehicle.

Improvements from Using FlexRay

Before FlexRay, all we could use was the CAN bus. A great disadvantage of CAN is that faulty nodes can bring down the whole network, because it is a nondeterministic protocol and has no redundancy. The overall benefits of using FlexRay are:

- Increased safety due to redundancy
- Higher performance due to better coordination between distributed controllers

The dSPACE tools worked as promised. Many other tools required much more effort on our part. The initial start up of the MicroAutoBoxes was very smooth and few problems were encountered.

▲ *GM Sequel.*

The FlexRay Challenge

The FlexRay concept is well thought-out. At first, tools for FlexRay were not very mature, which has been the biggest challenge, but this has greatly improved. To fully meet application requirements, integration methodologies had to be developed for FlexRay, and some software had to be integrated manually. Some manual work also had to be done to make all the tools work in the process.

Since we started the project, the FlexRay specifications and hardware have changed greatly. New releases fix minor problems and open up new possibilities.

FlexRay Consortium	
Foundation	September 2000
Aim	To develop a communication system for the tough requirements of future automotive applications, such as x-by-wire.
Role of General Motors	General Motors became a Core Member of the FlexRay Consortium in October 2001. With its experience in all areas of automotive research and developments, as well as its interest in the x-by-wire technology, GM helps to further develop the FlexRay standard.
GM about FlexRay	"FlexRay has many advantages to offer, such as fault tolerance and replicated dual channels for triple redundancy. This is especially important for safety-critical applications. FlexRay also supports high-performance computing and has a high communication bandwidth (10 Mbit/s). It is a time-triggered protocol for coordinated, distributed control systems throughout the vehicle."
Further information	www.flexray.com

Future Outlook

The future of FlexRay looks very promising – with smart actuators and fully distributed systems. FlexRay provides the right infrastructure, high bandwidth, fault tolerance, and determinism. Multiple CAN networks can be replaced by one FlexRay network. FlexRay offers increased safety, better performance, redundancy, and the ability to share more information. Initially the costs for FlexRay networks are higher, but as was the case with CAN, we expect that costs will drop to acceptable levels as the technology matures and volumes build up.

FlexRay is an enabler for the future to happen. It involves a process change for developers. FlexRay is time-triggered and we must think about the network architecture. We can't have both – a deterministic system and Plug & Play.

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