



Productivity is key when Ford engineers bring their new battery management system to production level

# Fusion Hybrid Energized

The control software for the battery management system of the 2010 Ford Fusion Hybrid was developed completely using model-based design and automatic production code generation. Jim Swish, who is in charge of this project, explains how the development was performed and what was achieved.



*Jim Swoish is HEV HV Battery Controls & Software Supervisor at Ford in Dearborn, USA.*



**“Using TargetLink, we have had no model-based autocode issues in the field.”**

*Jim Swoish, Ford*

***Could you briefly describe your battery software development project?***

Our main goal was to develop an in-house battery control system for the 2010 Fusion Hybrid. We wanted to develop and retain the key intellectual property of the control system. This enabled us to source the battery cells and other components separately and gave Ford a significant strategic advantage. It also gave us the ability to optimize the battery control system with the vehicle control system in order to reduce energy consumption. This was one factor in the Fusion Hybrid achieving the official 41 miles-per-gallon rating (~5.75 l / 100 km), making it the most fuel-efficient mid-size sedan in America at that time.

***What were the innovations in this project?***

We had two Ford Motor Company firsts. These were the first in-house development of software for a Hybrid Battery Energy Control Module –

where functional safety is crucial – and the first use of model-based development to autocode software for a production program.

***What did the actual development process look like?***

We completely relied on model-based design (MBD) and autocoding. This allowed the engineers to focus on developing and testing the correct behavior of the safety-critical system without laborious hours of handcoding. This, in turn, sped up the overall development and saved resources. We developed the code from the ground up, so all aspects of the battery control system had to be developed from scratch. There was no legacy code. Most of the code – about 80 to 85 % – was autcoded, with the exception of lower-level routines. Our target hardware utilized a 32-bit floating-point microprocessor that proved to be more than adequate for the task.



HEV HV Battery Controls & Software Supervisor Jim Swoish and his project team received the esteemed Henry Ford Award in recognition of the battery software they developed for the 2010 Ford Fusion.

“We chose model-based design and autocoding with TargetLink to do more development in less time. Mission accomplished!”

*Jim Swoish, Ford*

*What size team did you have, and how long did the development take?*

On average we had 4 people doing model-based design and 10 other team members working on requirements, handcoding, and hardware-in-the-loop (HIL) systems, and on developing model-based processes and best practices.

The project started in early 2006 and went into production on the 2010 Ford Fusion Hybrid in early 2009. The Fusion was named Motor Trend's 2010 Car of The Year and has received dozens of other awards. Our project team received the Henry Ford Excellence Award.

*This was all with TargetLink?*

Yes, the battery team used TargetLink for the whole process from function design to software implementation. One of the advantages of model-based development was that we could use simulation for early verification. TargetLink also greatly sim-

plified our testing process by providing a seamless simulation environment for both model-in-the-loop (MIL) and software-in-the-loop (SIL) testing. Especially switching between the modes and comparing results is very convenient and helps to understand if the generated code behaves as desired.

*What modeling guidelines did you use?*

We used some early guideline documents to start off with, but then continued to develop our own. This helps the modelers maintain common structures for similar functionality. It also drives the organization and structure of even unique features to the point that it is difficult to tell that different people worked on the various parts.

*Did you utilize the capabilities of the dSPACE Data Dictionary?*

Yes, a lot! Maintaining the data

dictionary and practicing proper check-out and check-in procedures is critical. We also established strict naming conventions and a formal change control process.

*What major challenges did you face?*

Some of the biggest challenges were in software management and archive database applications. Most such tools are designed for text file merging and branching. Using the model as the master presented some challenges initially. After that, it was a challenge to develop an automated build tool that would handle all the steps involved in autocoding, compiling, linking, etc. We now can go from a complete set of models to a hex file in 30 minutes just by pressing one button.

*What was your experience with TargetLink?*

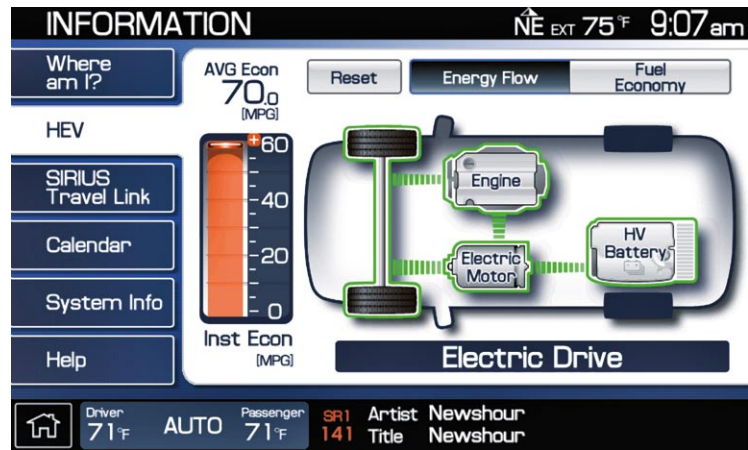
Very good. We did have only a few minor issues with the tool during

*With TargetLink, Ford employee Michael Schamber stays on top of things.*



## Profile of Ford Fusion Hybrid

- 2.5 L /152 hp gasoline engine
- Permanent magnet AC synchronous motor, 106 hp
- 275-volt sealed nickel-metal-hydride (NiMH) battery
- Full hybrid
- Regenerative braking



Instrument panel with energy flow display in the Ford Fusion Hybrid.

development, but none of them were job stoppers. The support we received was very good and the issues were resolved quickly. Thanks to a proper model structure and variable naming, the code is highly readable and well structured. Code efficiency is good, and with attention to best practices we have been able to continue increasing it.

The main reason we chose model-based development with autocoding was to do more development in less time. Mission accomplished! To date we have had no model-based autocode issues in the field.

### *Do you have plans to use TargetLink in any future projects?*

Yes, our next generation of batteries and control systems are already well along – all done with TargetLink. We continue to work toward more automation and test coverage as far ahead in the process as possible. We have efforts in progress to further develop MIL and SIL testing capability. Our goal is to reduce the defects found at the HIL level to zero early on. A high bar to set, but we have seen tremendous improvement over the last 4 years.

*Many thanks for talking to us, Mr. Swish!*



The Ford Fusion is based on second-generation hybrid technology.