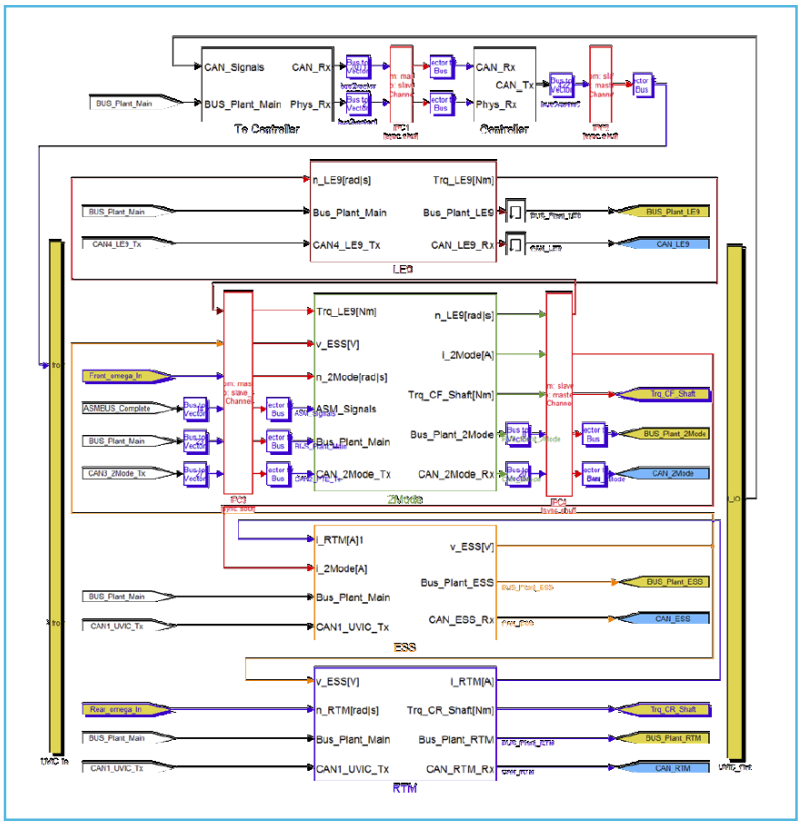
dSPACE Tools Help UVic Students Streamline Vehicle Development

The University of Victoria (UVic) is one of 16 student teams across North America participating in EcoCAR: The NeXt Challenge. An Advanced Vehicle Technology Competition (AVTC) organized by the US Department of Energy's Argonne National Labs, the EcoCAR Challenge, requires teams to re-engineer a General Motors donated vehicle to achieve improved fuel economy and reduced emissions while maintaining safety and consumer appeal.
UVic has been using dSPACE hardware and software through all phases of the three year challenge, from modeling and simulation to prototype development. Currently in the final year, which culminates in a competition in June of 2011, UVic has, with the help of dSPACE, implemented several modeling and hardware improvements that will help ensure a strong finish.

Model Based Design and HIL Simulation

The UVic Team is developing an extended-range electric vehicle (E-REV) with independent four-wheel drive propulsion that couples a GM 2-Mode transmission and 2.4L LE9 EcoTEC engine coupled to the front wheels, and a UQM PowerPhase 145kW electric motor to the rear wheels. Electric power is supplied by an A123 System's 21 kWh lithium-ion battery pack that provides up to 60 km (40 miles) of all-electric propulsion. With model-based design and HIL testing important components of the competition, UVic has been striving to develop a vehicle model that will accurately reflect the dynamic interactions of their complex powertrain, and the effects of added mass on performance and handling.



The UVic Team is currently running their HIL model on three HIL processors.

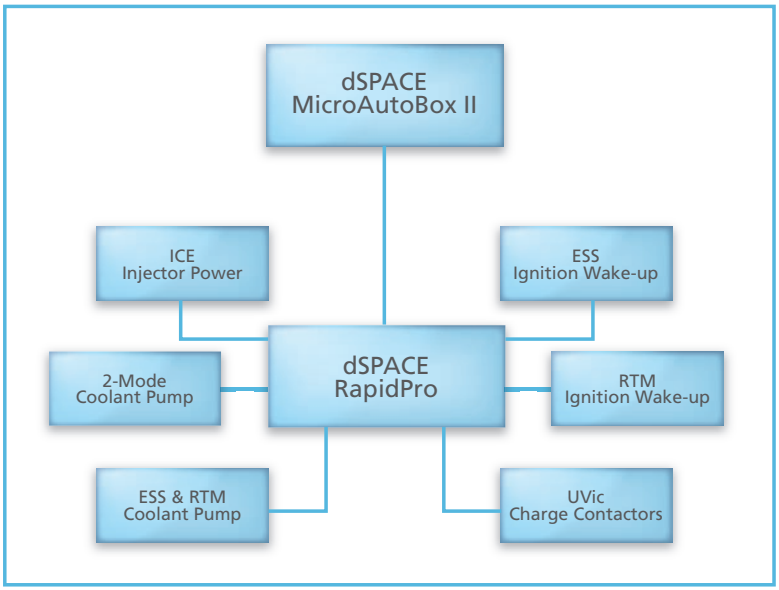
In the second year of the competition, the Team adapted and parameterized dSPACE's ASM Vehicle Dynamics (VD) model to reflect UVic's vehicle. The VD model gave the Team the ability to fully parameterize the vehicle's suspension and mass distribution characteristics, and contains compliant shafts, which made it an ideal platform for the development of the Team's traction and stability control systems, and front/rear axle torque distribution control system. The VD model has also helped the Team analyze the effects of suspension modifications on ride and handling.

UVic's dSPACE Simulator Mid-Size.

At the beginning of Year 3, however, the Team encountered challenges when attempting to increase the complexity of several of its models, especially its 2-mode transmission model: The single-processor board in the Team's HIL system, dSPACE Simulator Mid-Size, could not simultaneously run all of UVic's new models and the VD model in real-time. This prompted the Team to acquire a four-processor board for its HIL system, and divide its model to run on separate processors. The implementation of a multiple-processor HIL system has given the Team great flexibility to continue to improve and expand their HIL model further, and in the process, Team members have gained invaluable ex-

perience. "Going through the entire modeling process and encountering real-world challenges such as this is what makes EcoCAR such a great experience for engineering students," says Jeff Waldner, UVic EcoCAR's Team leader. "None of this would be possible, though, without the support and resources provided by dSPACE and our other tremendous competition sponsors."

Since implementing this HIL solution, the Team has gone through a successful model validation process, and has submitted a technical paper for publication which, in part, details the transition from HIL to in-vehicle testing and demonstrates the close linkages between the Team's HIL model and vehicle.



Functions of the RapidPro System in UVic's vehicle.

Control System Implementation

The Team made significant strides not only in modeling and simulation, but also in control system implementation through the integration of a dSPACE RapidPro Power Unit. In the first year of the EcoCAR Challenge, UVic selected a dSPACE MicroAutoBox as the vehicle's primary supervisory controller. A secondary controller and in-house custom electronics, which communicated with the MicroAutoBox, were chosen to provide ignition power to several UVic-added vehicle components, and drive several pumps and other auxiliary systems.

dSPACE RapidPro.

Throughout Year 2, the Team implemented this initial solution, but encountered several challenges in doing so. The continued support of the custom electronics solution developed by the Team was difficult, and several issues were encountered. For example, the in-house solution possessed no diagnostic feedback and no overload protection, features that are difficult to implement without significant time and electronics knowledge. Reliably achieving appropriate power levels in the custom electronics necessary for powering some loads, such as large coolant pumps, was also difficult. Additionally, the secondary controller used by the Team required an alternate software package and independent code, which made updating the sys-

tem cumbersome and time-consuming. Finally, an analysis of potential vehicle failure modes exposed UVic's custom electronics solution as a potential source of system errors due to lack of diagnostic capabilities and possible robustness issues.

In order to improve system robustness and ease of use, the Team acquired and installed a dSPACE RapidPro Power Unit that contains 4 full-bridge drivers for driving large loads, 12 high-side drivers for powering smaller loads and relays, and 6 low-side drivers. Implementing this system allowed the Team to replace not only its custom electronics, but also its secondary controller, which provides several key benefits:

- The robustness of the system has increased significantly, as the RapidPro possesses current feedback capabilities, overload and short circuit protection, and additional diagnostic features through a PC link and dSPACE's ConfigurationDesk software. These benefits also made troubleshooting during the initial installation process much simpler and faster, allowing the Team to roll out these changes in a relatively short period of time.
- Code development and deployment has been streamlined, as all relevant code has now been consolidated on the Team's MicroAutoBox. This makes applying changes to the system much simpler and less time-consuming.
- The total amount of low voltage wiring required to complete the necessary tasks was significantly reduced with the removal of the original secondary controller and custom electronics.
- The RapidPro system is expandable and flexible, should the Team require additional power circuits in the future.

Tackling these challenging problems with the initial solution and the subsequent upgrade to the RapidPro system has given the Team a better understanding of what is necessary in order to develop a safe and reliable vehicle. Team members will move forward in their careers more likely to fully understand the implications of certain design choices, and the makings of a 'good' solution to such problems.

The Road Ahead

With a strong HIL model and a more robust vehicle, the UVic EcoCAR Team is looking forward to a strong showing at EcoCAR's Year 3 competition. The Team is also hoping for a berth into EcoCAR 2: Plugging in to the Future, the next AVTC which is set to start in September 2011, to go through another vehicle development process and continue to build a relationship with dSPACE.