Hardware In the Loop (HIL) Simulator to Accelerate Innovation

The challenge:

Buhler Versatile is the largest Canadian manufacturer of agricultural tractors. They offer more than 20 configurations of tractors, each one supporting a large number of options. Due to this complex matrix of possibilities, validating new releases of the main computer's firmware is a challenging and time consuming task. Despite significant efforts to verify release candidates, bugs not detected on time can impact their customers.

Figure 1: Versatile Delta Track in operation

The solution:

With a virtual tractor capable of simulating different tractor configurations, Versatile's engineers can quickly and frequently test firmware changes in the office. The Automated Test System (ATS) replicates each of the components (engine, transmission, hydraulics, etc.) including their behaviour and CAN messages in order to make the controller think that it is interacting with a real tractor. This resulted in a **reduction of 75% in troubleshooting time** and a **30 fold increase in the frequency of testing** by taking advantage of automation. With such a flexible tool, Versatile increased the reliability and significantly shortened the development cycles of its controller's logic.

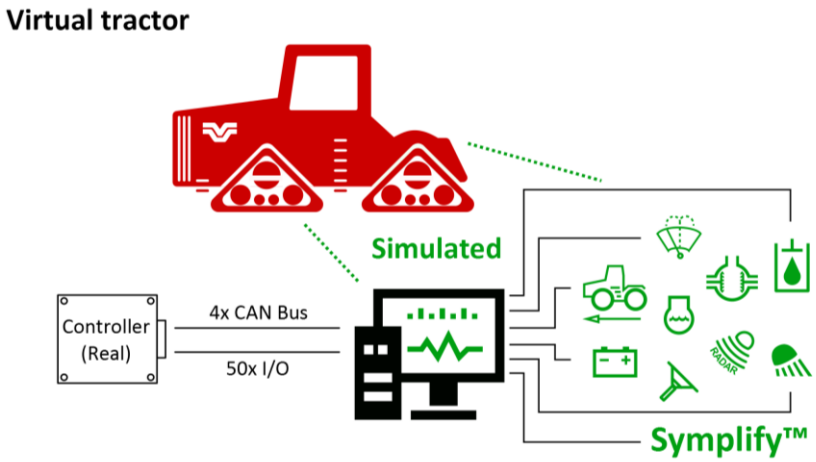

Figure 2: Virtualization of tractor

Introduction:

Synovus Solutions designs custom Automated Test Systems (ATS) with an expertise for creating complex, deterministic systems to support Research and Development (R&D) activities. When Versatile approached our team to assist them with their challenge, we knew that our skills and the CompactRIO and LabVIEW platforms from National Instruments would allow our engineers to create the right solution for them. The initial requirements included over 600 variables (which grew to more than 1100) to process and update deterministically. These variables represented the status of digital and analog electrical signals, variables used in the models as well as signals received and transmitted on multiple CAN buses.

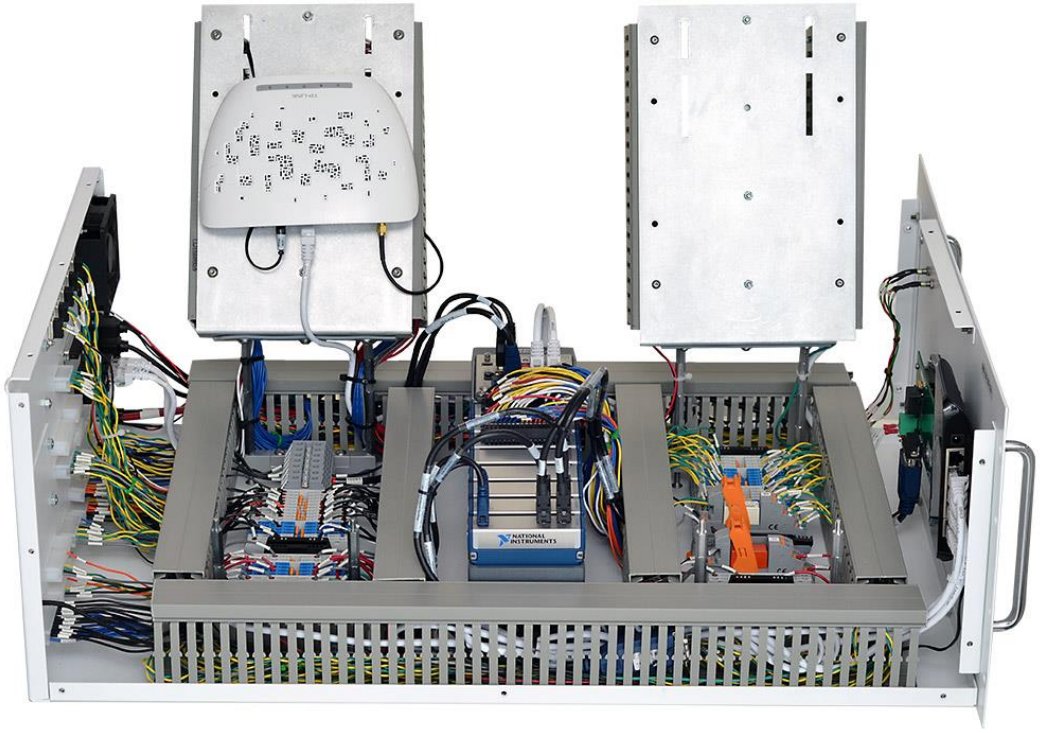

Figure 3: Integration of electrical components inside SBX enclosure

Application Details:

The ATS designed for Versatile includes a virtual copy of every component that the controller interacts with in a tractor (engine, wheels, etc.) Each of the models created in LabVIEW execute at fast loop rates in order to continuously update and read 500 CAN signals exchanged with the tractor's controller. Custom logic, such as variable PWM signals, are implemented directly into the FPGA of the CompactRIO to mimic real components with micro-seconds (µs) accuracy. To support all of the configurations and options, some of the variables are used by the models to know which behavior should be replicated and which CAN messages should be transmitted.

The ATS' code was developed using Synovus' proprietary Symplify™ platform. With flexible templates offering deterministic communication methods and multiple diagnostic tools, the development remained on schedule despite all the technical challenges associated with such a complex simulator. Because Symplify™ can run on different targets, Synovus saved a significant amount of time by developing the software on a standard computer to take advantage of more flexible debugging tools

and later deploying the same code on a CompactRIO (RT computer) for the guaranteed deterministic behaviors required from the simulator.

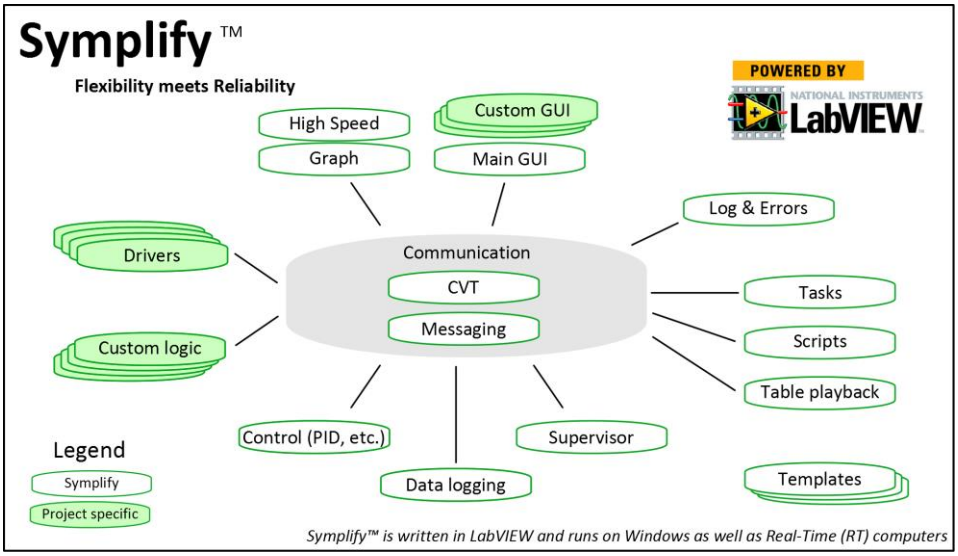

Figure 4: Core modules of a solution built around the platform

The code for each model runs independently, executing in parallel threads to take advantage of multi-core processors. Each user interface is completely decoupled from the model and offers the flexibility to create User Interfaces (UI) which closely replicate the real controls and indicators in the tractor. This allows Versatile's employees to control and to monitor the test execution and to quickly identify abnormal behaviour.

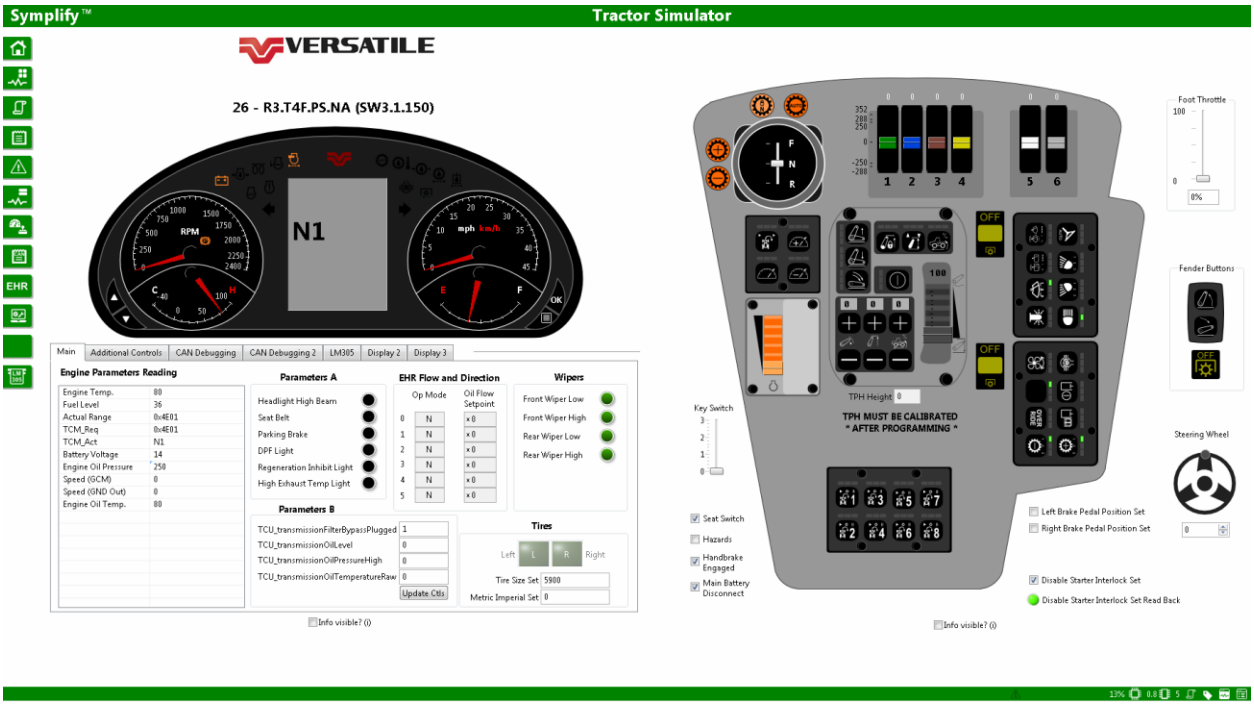

Figure 5: User interface mimicking real tractor components

Automating complex test procedures

Manual controls are useful to perform initial tests and rapid troubleshooting but scripts offer a way to automatically update variables (e.g. to simulate pressing a button) or read a variable to verify the controller's behavior is correct (e.g. a specific CAN signal value). Such automated test procedures can be repeated every day without human interaction, saving thousands of man-hours and providing a reliable confirmation that issues have been resolved. Those scripts can be written directly by Versatile's team without having to modify the code of the simulator.

F*aster troubleshooting*

One of the big challenges Versatile engineers face is to quickly understand the states and transitions of multiple variable/CAN signals at runtime. Synovus wants its clients to come up with questions and let the ATS provide the answer. In order to do that, all the variables coming from models, instruments and CAN bus are stored and can be displayed on multiple graph windows. This makes rapidly changing signals from different sources easy to analyze side by side.

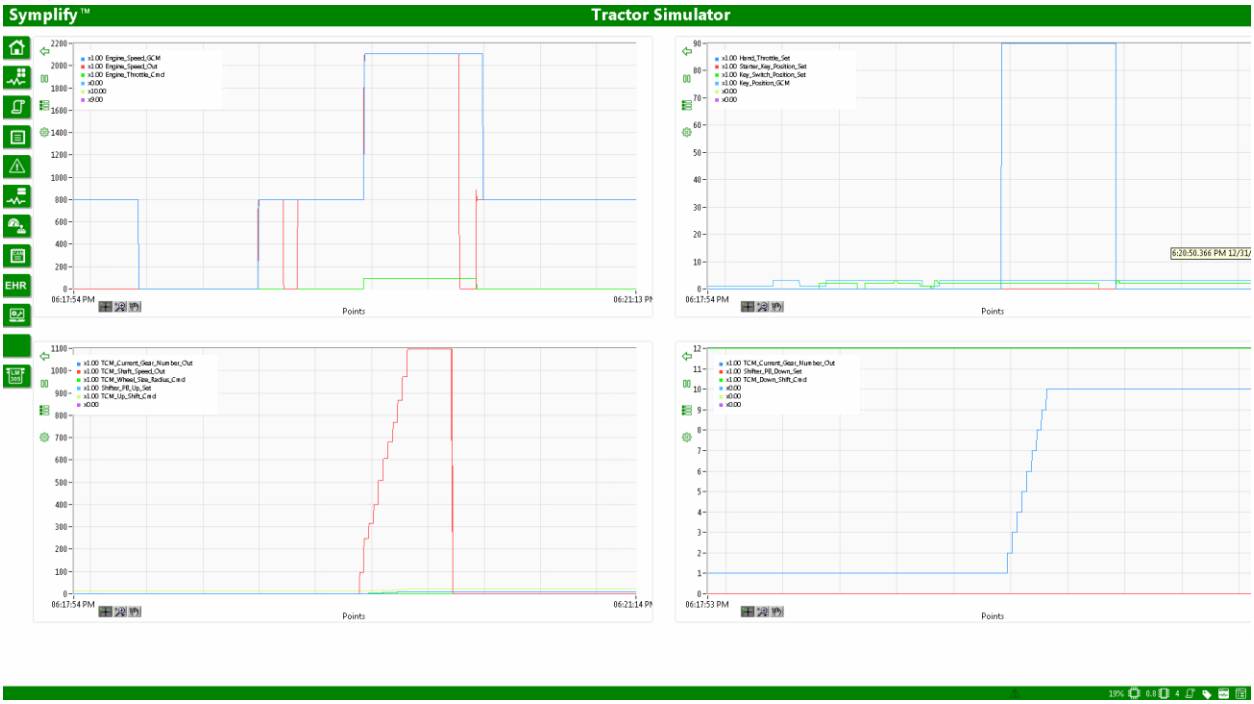

Figure 6: Visualization of a large number of variables

Benefits of the application:

The ATS offers Versatile a productivity gain of 75% over their traditional test and troubleshooting methods. By being able to validate all the code changes in the office rather than on a real tractor, the development activities are streamlined while saving a lot of fuel and reducing pollution.

With the daily regression, Versatile acquired three huge advantages over its previous way of testing its software:

1. Catch bugs within 24 hours of their insertion in the code
2. Reduced time validating fixes
3. Increasing test coverage takes additional time only once

New product development support

The ATS offers Versatile new opportunities during the development of new products. Simply by creating models for new components and integrating them in the ATS, the software engineering team can begin testing their code in this virtual environment as soon as the components are selected and months before the first prototype is ever assembled. Leveraging this during the design of the next generations of products would allow them to reduce development time and deliver more reliable products.

Figure 7: Versatile MFWD tractor

Conclusion:

Synovus was able to deliver a functional system to Versatile in less than 8 months. The use of LabVIEW and its Symplify™ platform was instrumental in achieving that objective and offering a very high level of flexibility to Versatile while handling more than 1,000 variables in the system in real-time.

Versatile was able to increase its test coverage by 750% and detect bugs within hours rather than weeks. Another key benefit of the automated validation is that new tests can quickly be added to the existing suite of tests to increase coverage without increasing the workload of the validation process. Overall, Versatile expects the release process of new firmware to be 50% faster by taking advantage of the ATS features.

Versatile will continue to expand the list of models and options supported by the ATS to release new products earlier, with greater confidence that they will experience a lower number of warranty service calls. With the right testing and diagnostic tools, Synovus meets its purpose of *"Accelerating Innovation"* for its clients.

-- Synovus Solutions and Versatile acknowledge the financial support from the Government of Canada through the NRC-IRAP program. --