

CASE STUDY – Toyota Motor Corporation, Control Logic Verification

<<In Red below title>>: Veltronix Accelerate was introduced to all divisions in Toyota as an effective verification tool for control logic. We provided technical consultation services related to Model Based Development (MBD).

<<Overview>>:

Vehicle development today is a complex and advanced process involving the integration of software, hardware, electronics and mechanics at every stage of manufacturing. New development processes are required to maintain the highest safety and quality standards while implementing new features. Development infrastructure, which supports the prompt testing of engineering ideas, is crucial for innovation and research to continue amidst existing complexity.

Toyota Motor Corporation decided to use Veltronix Accelerate to support innovation and research within the company. Our in-house product, Veltronix Accelerate was introduced across all Toyota divisions to enable all engineers within Toyota to reliably test their prototypes. Veltronix automates hardware generation, giving accurate, swift and optimal results. Toyota's engineers can convert their control ideas into hardware with no risk and at a fraction of the cost.

Toyota also called in technical experts from Veltronix to support their engineers in establishing new development processes. Our technical consultation enabled Toyota to transition smoothly into a more agile company with development infrastructure that balances the modern requirements of the automotive industry with comprehensive testing and research.

<<Results and Future Use>>

Veltronix Accelerate is currently being used by Toyota for the advanced development of HV motor control. The usage of this tool has significantly reduced the time needed to implement control ideas from weeks to days. In the past, work that needed 3-4 weeks for completion is now done within a day.

Toyota and other leaders within the Automotive Industry now recognise Veltronix as the technical consultation expert for electronic software development processes like Electronic Control Unit (ECU) shared architecture suitable to MBD development, cooperative control between multiple ECUs and acceleration of evaluation environment.

<<Main>>

The problem till now: The main requirement in electronic vehicle development is to establish innovative development methods and an evolving development environment. But given the complexity of car electronic systems, trying out and testing new hardware ideas is time-consuming and expensive. In order to meet these new challenges in the automotive industry, Toyota required different methods that would allow engineers to test new theories and convert their control ideas into hardware. Toyota needed not just better development

infrastructure, but also technical consulting so as to assist staff with setting up and using the new infrastructure.

Solution provided: Toyota decided to adopt Veltronix Accelerate because it could generate software prototypes of electronic control ideas efficiently and rapidly, while minimising errors and giving accurate output. Toyota heads appreciated the innovation that Accelerate could bring into the company, but they also recognised that staff needed mentoring on how to use Accelerate in their regular development processes. The Veltronix team was called in to provide consultation on Model Based Development and other methodologies that were needed in order to use the tool properly. This combination of methodologies and tools has now been adopted in all divisions of Toyota, and has greatly improved their complex automotive development processes.

Quality, Cost and Delivery are the key factors driving automotive industry growth. <<This could be in the orange box on last page>>

Mr. Keiji Naruto, Senior Manager at Toyota Motor Corporation is responsible for the internal promotion and standardisation of development methods and infrastructure for electronic control units. He says, “Testing out new functions such as automated driving or safe driving support has now become practical, thanks to Veltronix Accelerate and the team’s support. How we improve the development QCD (Quality, Cost & Delivery) is key in our industry and Toyota is grateful to partner with Veltronix for the same.”

The establishment of standardised development infrastructure is important not only for manufacturing production ready vehicles but also to further technical research in the cutting-edge automotive industry. Various ideas from engineers have to be promptly implemented and verified. Continuous modification and testing have to be supported in order to upgrade existing systems. The feasibility and effectiveness of upgrades needs to be tested to ensure the technology is production ready. Hence, Toyota was seeking an infrastructure and environment that permitted engineers’ ideas to take shape.

Prototyping tool for the early stages of development

Among the various tools that support prototyping, Veltronix Accelerate was selected as the best quality prototyping tool for early stages of development and research.

“When new control algorithms in electronics development need to be verified, they have to be converted to hardware by using FPGA. However, the usage of generic high-level synthesis tools that convert C language to HDL (hardware language) requires HDL or FPGA knowledge. This was the main difficulty for our control system engineers who usually do not have hardware expertise”, says Mr. Naruto.

“With Veltronix Accelerate, algorithms written in C can directly be converted to Verilog HDL without the need for any hardware expertise or rewriting of source codes. We could see that Veltronix Accelerate would greatly reduce our prototyping cycle using FPGA. That is why we decided to introduce it in all our

advanced development departments. The results have exceeded all our expectations and we highly recommend it to anyone interested in hardware prototyping.” (Mr. Naruto)

Veltronix Accelerate was introduced to other departments after verification and performance benchmarking were conducted.

Toyota Motor Corporation conducted “Back-to-Back” tests verifying the control algorithm written in C and synthesised manually by their engineers against Verilog HDL synthesised by Veltronix Accelerate. Results revealed that the execution time of Accelerate’s code was 141 times faster than manually generated code. Also development time dropped from 200 hours to 8 hours. Veltronix Accelerate was benchmarked for generating higher quality code in much lesser time.

Further testing was done to compare the performance when C source codes were operated by a micro- computer (Renesa’s architecture) on a vehicle against the performance when the same codes were converted onto FPGA by Veltronix Accelerate. “We confirmed that Veltronix Accelerate accelerated the execution time by 30 times compared to the micro-computer. We determined that Veltronix Accelerate allowed us to verify operations under no performance restrictions in an advanced control development.” (Mr. Naruto)

Please refer to our case study on “Efficiency improvement on the advanced development of HV motor controls / Time reduction to implement ideas from the existing 200 hours to 8 hours” to see how Veltronix Accelerate was used for the advanced development of HV motor control.

Veltronix provides technical consultation for development methods and development infrastructures.

Mr. Naruto recommends Veltronix’s technical consulting service for cooperative control simulation between multiple ECUs, acceleration of model evaluation environment and ECU software. He says, “In order to internally roll out new development methods such as MBD, we required Veltronix’s expertise and technology. I highly recommend the Veltronix team for their in-depth knowledge, mentoring skills and guidance that benefited our entire team.”

Toyota Motor Corporation has been promoting Model Based Development (MBD) and Model Based Systems Engineering (MBSE) within the organisation. MBD and MBSE eliminate the need for excessive development rework even while optimising overall system development. **Toyota applied MBD principles on the 4th Generation “Toyota Prius” model that was launched in December 2015.**

It is expected that MBD will be applied to more types of vehicles in the future. Veltronix technology will definitely be utilised by Toyota in searching new development methods and establishing development infrastructure.

Toyota recommends Veltronix. <<or this can be in orange box>>

“Veltronix Accelerate is a type of high-level synthesis tool converting C source code to Verilog HDL. It can be used for optimising Stratix IV and Arria V of Intel FPGA (ex-Altera) as well as for general purposes (as of March 2017). It is convenient for control system engineers and software engineers to use as it doesn’t require the rewrite of C source code or detailed settings for circuit delay or logic cells.

I recommend that this tool be used in every industry where control logic is written in C such as construction machineries, industrial machineries, railroads and aviation. It is suitable for image processing and is the ideal tool for highly advanced Research and Development.” Mr. Keiji Naruto, Senior Manager at Toyota Motor Corporation