Early Software Validation on the PC

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Validation of ECU software in virtual test drives with AUTOSAR and FMI

Hardware-independent validation of ECU software with virtual electronic control units and virtual test drives offers many advantages. ETAS and IPG Automotive GmbH make the most of them with a new solution.

The complexity of vehicle development is continually increasing. The driving forces are shorter development cycles, more model versions, cost pressure, cooperation between regionally distributed teams of car manufacturers and suppliers, as well as trends such as "semi-automatic or autonomous driving". These are compelling reasons to integrate an increasing number of ECUs and software functions into vehicles – and of course to validate in advance. The sooner manufacturers and suppliers can test ECU controller software, and the earlier they can detect possible software errors, the more cost-efficient development can be. A general rule of thumb applies: for every development stage in which a fault remains undetected, the resolution costs increase by a factor 10. Making corrections early on also saves valuable time in the tightly scheduled development process and early software testing helps to master the growing complexity.

Limited test options with hardware prototypes

Up to now, prototypes of the electronic control unit and the vehicle were required for realistic testing of ECU software. For the most part, however, they are only available in later development stages – and are limited in number due to cost reasons. Result: in around 60 percent of the development time, no prototype is available and barely 10 percent of the engineers get the chance to perform tests in a real vehicle. The limited hardware availability makes software testing more difficult, and even more so if distributed teams in different locations need to have access. Costly and time-consuming transport, fraught with uncertainties, such as customs delays, are par for the course. Despite all the effort, a crucial disadvantage remains: dangerous situations and complex environmental conditions can hardly be simulated with hardware – and are even harder to reproduce. But testing in critical situations is exactly what is needed to assess the operability of driver assistance systems.

Requirements for efficient software validation

It is clear in order to make early ECU software validation possible, the current hardware dependency must be overcome. On top of time and cost savings, there are also convincing organizational reasons. If ECU software is validated in advance without hardware prototypes, this relieves the demand for using scarce resources in further development processes – such as Hardware-in-the-Loop systems or test vehicles. Furthermore, hardware-independent tests can be performed and reproduced in parallel at different locations. A prerequisite for this, however, is that the solution for software validation has been prepared for the heterogeneous toolscapes of the stakeholders involved in the distributed development process.

Models and components created with different domain-specific tools must be taken into account, just as well as the easy integration of the solution into the existing tool chain. For an efficient end-to-end development process, it is also important that existing models, test cases, and test data are reusable. Individual driving maneuvers or existing test catalogs should also be easy to integrate, so that potentially dangerous situations can be run through without any risk to the driver or vehicle. And, last but not least, the performing of realistic tests requires that the application software can be observed in interoperation with the operating system or basic software.

Creation of a virtual road test by integrating vehicle components, virtual ECUs, and simulation models.

Realistic software validation on a PC by using EVE, the virtual ECU from ETAS, and the open integration and test platform CarMaker from IPG Automotive.

Main components of potential solutions

To sum it up, we can deduce two main elements of potential solutions:

1. Use of virtual ECUs in virtual test drives

Virtual electronic control units can be created at an early stage of development, independent of the hardware. Compared to prototypes, virtual ECUs are inexpensive and easy to reproduce. They can be seamlessly integrated into existing development processes and enable the reuse of existing methods and artifacts. The ECU software can also be tested in the system context and validated in interoperation with environment and component models, long before hardware prototypes are available. This way ECU software achieves a high level of maturity earlier on, which provides developers with time to develop new functions. Trials in virtual test drives are possible; the virtual

vehicle – as with its real counterpart – has all the components such as the engine, powertrain, driver assistance systems, etc. Nearly every one of these components has one or several integral ECUs. Validation is possible in virtual traffic scenarios in the virtual system.

2. Taking standards into account

If vehicle manufacturers and suppliers work together in teams, standards are the basis for efficient software validation. They allow the exchange of artifacts and lay the foundation for end-to-end processes, despite heterogeneous toolscapes. The automotive software standard AUTOSAR facilitates the exchange of software on different ECUs and ensures that software components can be reused, replaced, and integrated by defining methods to describe software in vehicles. Of similarly high relevance is the Functional Mock-up Interface (FMI) standard. As a tool-independent standard, it supports the exchange of models and the co-simulation of dynamic models, making virtual validation much easier.

Shared problem-solving approach of ETAS and IPG Automotive

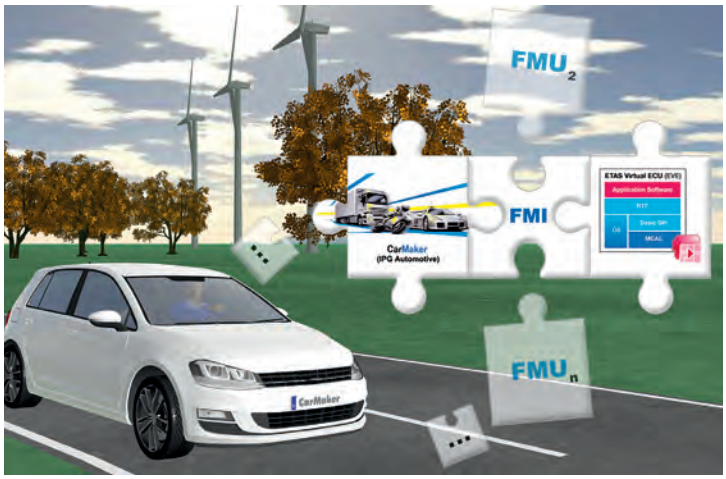
Together with IPG Automotive GmbH, ETAS has developed a specific solution that overcomes the described challenges. It is based on the virtual electronic control unit EVE (ETAS Virtual ECU) and the open integration and test platform CarMaker from IPG Automotive.

The EVE platform for virtual software integration and validation on the PC allows you to virtualize individual ECUs or an entire ECU network. In contrast to previous solutions, it allows for the integration of functional models, application software components, and basic software modules from various sources in virtual electronic control units. On the PC, the application software is integrated with the embedded operating system RTA-OS, with the AUTOSAR Runtime Environment (RTE), and with the basic software to be used. Independent of the ECU hardware, you are able to validate and calibrate, in real-time and non-real-time, under realistic conditions, and in a wide variety of use cases.

CarMaker is used as a simulation environment for virtual test drives. The integration and test platform is open to models of different modeling tools. Precise non-linear vehicle and trailer models form the basis for high-quality simulations, in which complex driving maneuvers can be easily set up and reproducibly performed – including the behavior of driver assistance systems in situations with many road users. CarMaker covers a wide range of application areas and allows for ensuring features through Model-, Software-, Hardware- and Vehicle-in-the-Loop testing.

To start with, the software to be tested is integrated in EVE, the virtual ECU. It can be exported as a Functional Mock-up Unit (FMU) and then integrated in CarMaker via the standardized FMI interface. In CarMaker the software is tested and released following virtual test drives. For the interactive operation, the solution from ETAS and IPG Automotive also allows for the debugging of the software code during testing.

This shared problem-solving approach clears the way for early software validation on the PC and a more efficient development of ECUs for vehicle manufacturers and suppliers. Thanks to its open design and standardization, developers can work using familiar tools and access existing artifacts at any time.



Connection of the virtual ECU (EVE) to the integration and test platform CarMaker via the "Functional Mock-up Interface" (FMI) standard.