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INNOVATION REPORT

Multidisciplinary modelling and simulation speeds development of automotive systems and software

EUREKA

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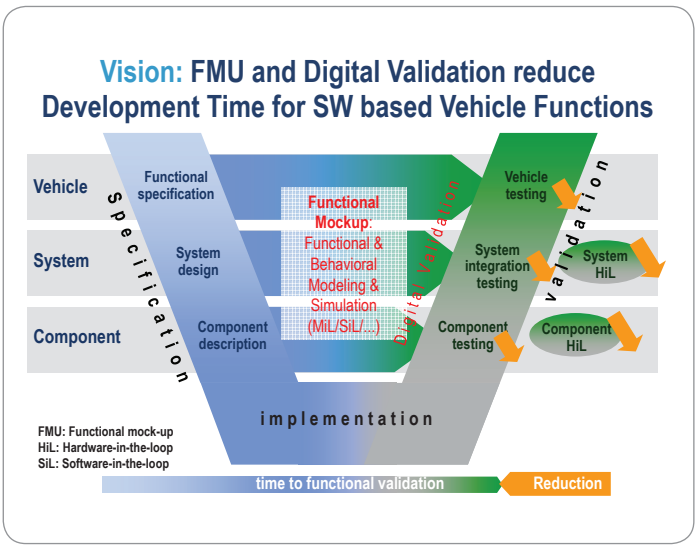
The ITEA 2 MODELISAR project has developed a Functional Mock-up Interface (FMI) for use in the design of the ever growing number of control systems now found in motor vehicles. This approach allows dynamic modelling of different software systems to be used together for software-, model- and hardware-in-the-loop simulation and for embedded software. Initial versions of the open FMI standard for model exchange, co-simulation and Product Lifecycle Management simulation data and process management can already be downloaded and a large range of tools are available incorporating the MODELISAR approach.

Microelectronics play an ever more important role in road vehicles and are at the heart of innovation with extensive use of functions dependent on electronic control units (ECUs). MODELISAR set out to improve the design of such systems and of the necessary embedded software in vehicles across the whole supply chain.

The project was intended to support the use of the automotive open system architecture (AUTOSAR) standard in the simulation environments of MODELISAR partners and to encourage use of the open Modelica language – although not limiting the approach to this single modelling language.



AUTOSAR is the open and standardised automotive software architecture jointly developed by carmakers, their suppliers and tool developers. It offers a full framework and platform upon which future vehicle applications can be implemented and helps minimise the barriers between functional domains. This architecture makes it possible to map functions and functional networks to different control nodes in the system, almost independently of the associated hardware.

Modelica is an open, non-proprietary, object-oriented, equation-based language intended to simplify the modelling of complex physical systems containing mechanical, electrical, electronic, hydraulic, thermal, control, electric power and/or process-oriented subcomponents. It is widely used by automotive manufacturers in the design of energy-efficient vehicles. Much of the recent development work in Modelica has been carried out through a series of ITEA 2 projects such as Eurosyslib and OpenProd.

Open interface standard

Modelling makes it possible to define the physical behaviour of a system from how a door opens to road handling as well as the parts around it early in the design process. In the case of a road-handling scenario, this could involve taking into account models of the road, driver behaviour and weather conditions as well as the vehicle itself.

Such digital validation saves both time and money. However, vehicles involve many different disciplines – electrical, mechanical, hydraulic, etc. – all of which have to be taken into account when programming an ECU. More of a problem is that, while modelling is now used widely, each discipline has its own approach and tools.

MODELISAR focused on the development of advanced *run-time interoperability interfaces* known as *Functional Mock-up Interfaces*. FMIs offer an open interface standard enabling models from different simulation environments, including the Modelica and non-Modelica tools of MODELISAR partners, to be used conveniently in other environments. This can be performed either by model importing – that is with no integrators

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embedded in the model – or in a co-simulation context at various levels (possibly containing the integrator). FMI specification can also be implemented with libraries of compiled embedded software and is the basis for AUTOSAR-based code generation for the targeted ECUs.

Flexible simulator integration

The FMI approach offers flexible and standardised simulator integration with production and exchange of functional mock-ups (FMUs) and co-operation between these FMUs via a master. Different types of simulator hardware and operating systems can continue to function independently while profiting from standardised services which enable the control of simulation, synchronisation, monitoring, parameter tuning and visualisation as part of one the simulation tools or in a dedicated FMU server.

As a result, different disciplines can now work on their models with the own modelling approach and tools while the FMI offers standardised application programming interfaces (APIs) into the software world. Effectively, the FMI offers a sort of plug-and-play approach for components in the simulation framework.

The proof of concept for the FMI standard and its support in both Modelica and non-Modelica tools, AUTOSAR editors and simulation editors and schedulers was carried out in a series of 25 industrial automotive scenarios. These covered a range of different areas including engine combustion, power-lift gate, cabriolet opening system, mechatronic gear change, chassis control and climate comfort.

Additionally, the data, models and software can now being incorporated into existing product life management (PLM) design systems to integrate tools and manage work flow, versions and variants over the product life.

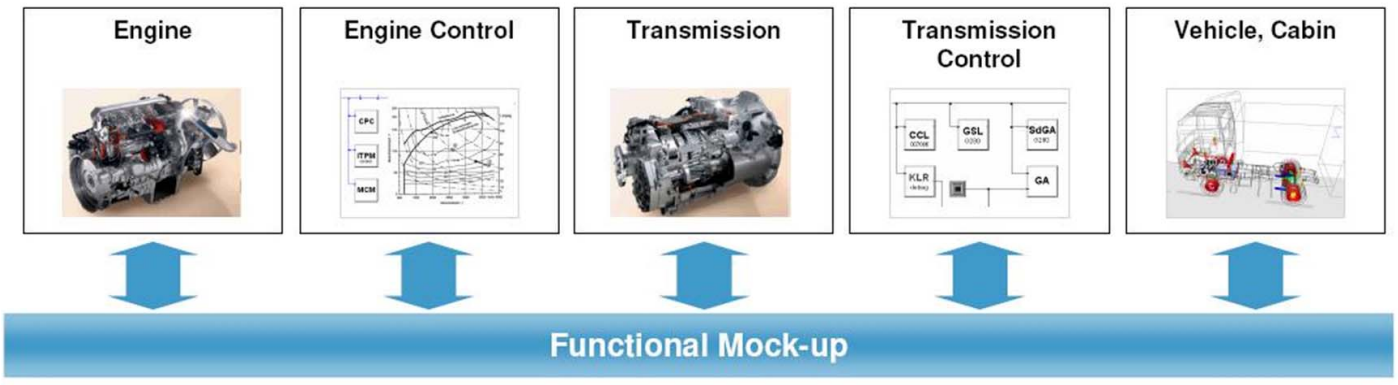
Taking an international lead

A key achievement of this ITEA 2 project is the consortium decision to make future FMI developments as an *open international standard* through the Modelica Association. It was foreseen that the very early adoption of FMI tools would not be worthwhile unless there was continuity and so the project consortium has developed such an approach. This involves the Creative Commons IP rules to handle the intellectual property in a single group with a trademark.

Bylaws of the Modelica association have been drawn up for an open organisation to provide support both for FMI and to extend the scope beyond the Modelica language itself, that is to other modelling- and simulation-related topics.. New FMI organisation partners now include many Modelisar partners, as well as several ITEA 2 OpenProd project partners. The new association (FMI MAP) has already started officially in March 2012.

Main Modelisar outcomes are:

- High quality and mature FMI specifications for model exchange, co-simulation and product lifecycle management, with work continuing on application coupling – FMI open specifications are available on http:/www.modelisar.com;
- 10 FMI prototypes – for model exchange, co-simulation and PLM – for the industrial use cases;
- 10 supporting scientific studies including AUTOSAR, co-simulation, timing and bus;
- Modelica evolution proposals for the benefit of FMI and AUTOSAR;
- 24 FMI industrial use-case proofs of concept; and
- Interoperability with deliverables of other relevant European projects, including ITEA 2 Eurosyslib, ARTEMIS Cesar, ASAM and ITEA 2 Modrio.



Cosimulation of the behavioral models and the embedded controller software

MODELISAR vision

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Tool vendors on board

The impact of MODELISAR is already important. Some 34 FMI-compatible tools have been announced with 25 of them available commercially. Moreover, nearly half of these products – 15 tools come from 11 suppliers not involved in this ITEA 2 project. One of the outcomes of the project is a reference book of these FMI-compatible tools including a list of demonstrations and a FMI summary.

FMI is being used for commercial software with potential applications in the automotive industry – model, software and hardware in the loop. Since, FMI has been technically defined *independently of the industry domain*, attention can also being given to other domains, such as aerospace, rail transport, wind turbines, industrial machinery and construction equipment.

Research institutes are working on FMI implementation to handle multi-platform models as well as easy exchange of scientific-technical software libraries for modelling and simulation. They are also promoting use of FMI to non-MODELISAR tool vendors.

Finally, the industrial partners are starting to exploit FMI as a fast and efficient way to exchange virtual prototypes between teams. FMI makes possible efficient frontloading and early integration of suppliers and development partners into cross-domain co-simulation as well as extending to model-based development of cross-domain vehicle systems.

Daimler intends to use FMI in future gearbox projects for Mercedes-Benz cars. And FMI should become the standard interface for model exchange and simulation tool coupling in software-in-the-loop simulations at Daimler Trucks Customer Application Engineering, especially for power-train dynamics.

Dassault Systèmes is integrating MODELISAR developments in the CESAR project: the Enovia Reference Technology Platform for CESAR leverages MODELISAR results, particularly the capability to handle AUTOSAR models, C Code and FMU description files. The consolidated results of CESAR and MODELISAR will offer a larger scope for systems engineering activities.

TWT is focusing on shared simulation incorporating FMI in the iSSE CleanSky project. By co-simulating static and dynamic performance of on-board aircraft systems, the concept of an all-electric aircraft can be comprehensively assessed with particular focus on electrical power absorption and thermal energy production.

More information:
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