LIFECYCLE MANAGEMENT FOR MORE EFFICIENT ECU SOFTWARE DEVELOPMENT

Still today there is a hard break between development and testing processes of ECU software. Lifecycle Management (LCM) can make a contribution to close this process gap for a more efficient development. Berner & Mattner features an approach which includes all processes from the specification of an ECU function to its test at the test bench. In doing so, the company deals with projects that already exist in part at German premium OEMs and suppliers. Production vehicles launched in 2009 profit from the LCM methods for the first time.

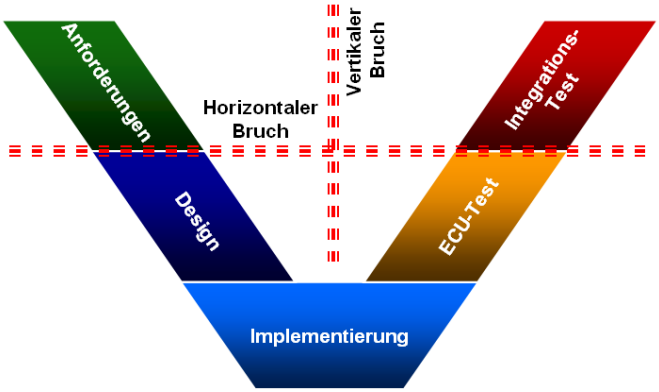
All OEMs with a wide range of car models have the following challenge: On the one hand they want to master the complexity of variants in combination with reuse across several car series. On the other hand they want to master the use of software, e.g. customer relevant infotainment and advanced driving assistance functions, as an essential distinguishing feature in competition.

These claims require high-quality software development processes, particularly at the interfaces between OEM and TIER1. The often used magic formula which promises improvement is the seamless consistency of processes, methods and tools. A closer examination of currently used ECU software development processes reveals two main weaknesses in the process chain.

a.)The **horizontal break of the development process or "When the implementation does not match the specification":** Many requirements are derived from the vehicle operation concepts and driver/passenger use cases. Therefore it is primarily the task of the OEM to specify these demands on a software component (SWC). The number of executable specifications at the OEMs was systematically increased in the last years, a positive and important trend. Mixed requirements specifications with prose descriptions (e.g. DOORS, IRQA, Word) and models (e.g. UML, Simulink/TargetLink function blocks, ASCET statecharts) reach a considerable quality and more often they are executable with a maturity level of a reference implementation. The transition from the requirements specification phase at the OEM to the software design phase at TIER1 usually leads to a strong horizontal break in the development process (Figure 1). Requirements models are not seamlessly used from the TIER1 as delivered by the OEM. Therefore requirement models and design models have to be synchronized manually after each change. In practice this is frequently impossible due to existing hard deadlines and budget constraints.

b.) The **vertical break in the development process or „When the left hand does not know what the right hand is doing":** A strong process gap in the development process exists between the left and the right V-branch of the V-model. This vertical break is revealed by the insufficient exchange of test cases between development, integration and test. Test specifications are linked to the requirements (e.g. DOORS) but high quality and automated test cases usually are built later in the integration and test departments at TIER1s and OEMs. Furthermore, test cases are often not useful in the left V-branch because the test-toolchain does not support tests in these early process steps.

Figure 1: Process breaks



Berner & Mattner supports OEMs and suppliers in model-based development and test of ECU software for many years. As a product and solution provider, B&M performed many analysis and process improvement projects for ECU development processes. Based on that, Berner & Mattner developed the concept of "Lifecycle Management for ECU Software" (LCM). The aims are: To cope with the permanently increasing requirements of ECU software while development budgets are decreasing, to avoid process breaks and to reduce the process cycle time.

The following key concepts are part of the LCM:

- Domain and function orientation with a expert-teams
- Single model principle
- MiL/SiL/HiL consistency

Domain and function orientation with expert-teams: To realize the LCM for ECU software (Figure 2) experts at different positions and organizational interfaces are required. It is very important to fulfill the following requirements:

a) The specialists must hold a primary discipline like modeling, Software/Hardware-in-the-Loop-Testing (SiL/HiL), review processes as well as high functional competence in the automotive domain. This is the base for a precise and complete specification (prose + model) which is readable and maintainable on a long-term basis – necessary to effectively reuse functions in new car series.

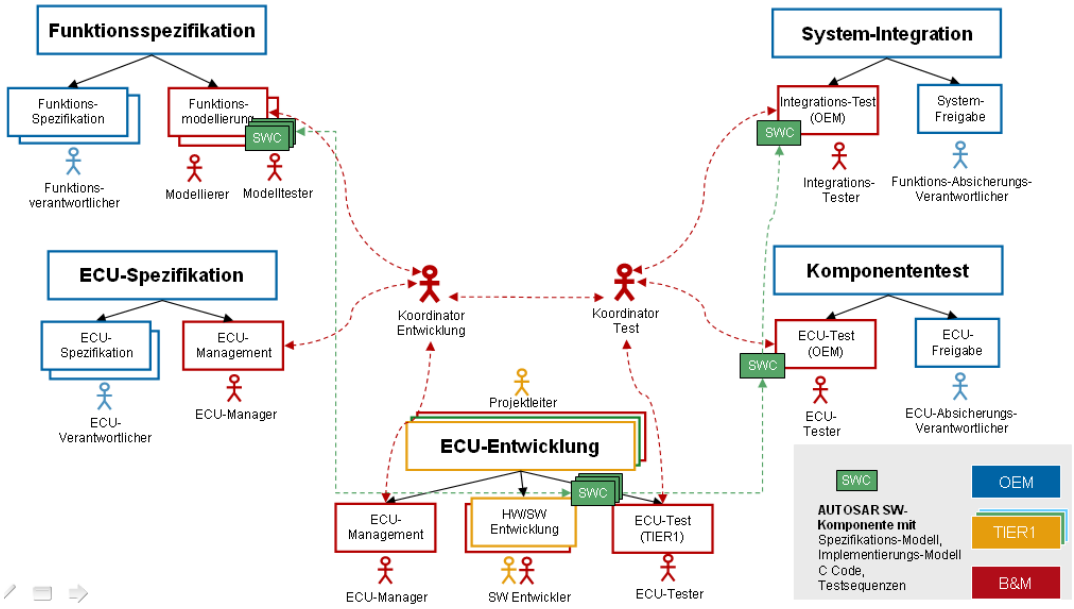
b.) Development and test coordinators have to perform e.g. project planning, progress monitoring, test management, fault management and “department linking”. But basically, the coordinators must have extensive soft skills to integrate the responsible parties (e.g. functional owners, ECU-managers, project managers at suppliers).

The involved development engineers at the OEM often work in different departments, divisions and systems engineering disciplines as well. Different interfaces to development and test departments at the TIER1 have to be managed additionally. The development and test coordinators in the LCM handle this integration job in the OEM-TIER1 processes. The horizontal break in the development process is reduced by linking involved teams and persons at OEM and TIER1. These two roles take care about objectives, interests and schedules at OEM and TIER1 as well. The close collaboration of development and test coordinators reduces the vertical process break enormously. Thus, existing faults in a function are located faster and are eliminated earlier in comparison to traditional, separately managed processes at OEMs and TIER1s.

c.) The specifically needed functional competence can only be built up when the business units of the development partner are organized according to the specific domains and functions. E.g. Berner & Mattner supports the domains infotainment, body, advanced driver

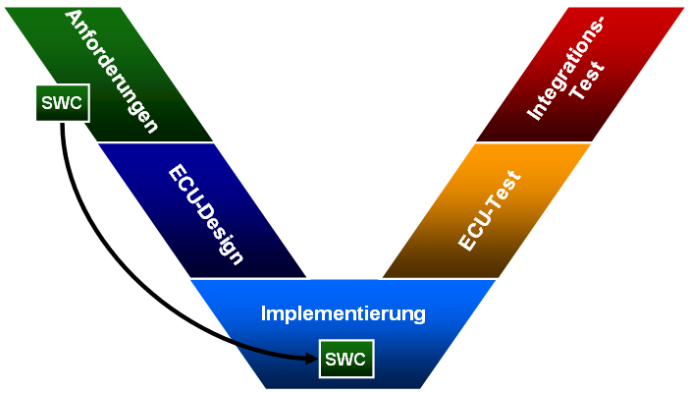
assistance systems (ADAS) and domain functions like Bluetooth connectivity, comfort access, camera based ADAS. It is also significant that domains and functions in these business units are completely managed by one department, from requirements to tests. It takes at least three years and needs a high continuity of the functional experts to build up this specific competence.

Figure 2: LCM with roles and responsibilities



Single model principle: An easy but highly effective concept - the single model principle - is used to avoid the horizontal break. Requirements, design and implementation models are not distinguished any more. The requirements model is also used as implementation model (Figure 3). A mandatory precondition for this simplification (in the opinion of modern software engineering this is called “impossible”, without any systematic and dilettante) is the availability of a precise ECU software architecture at TIER1, with well defined software interfaces. Easy to understand, that the AUTOSAR standardization is especially helpful for successfully realization of this concept. The LCM of Berner & Mattner designates the support of TIER1s at the function integration to organize a smooth integration of software components ([1]).

Figure 3: Single model principle



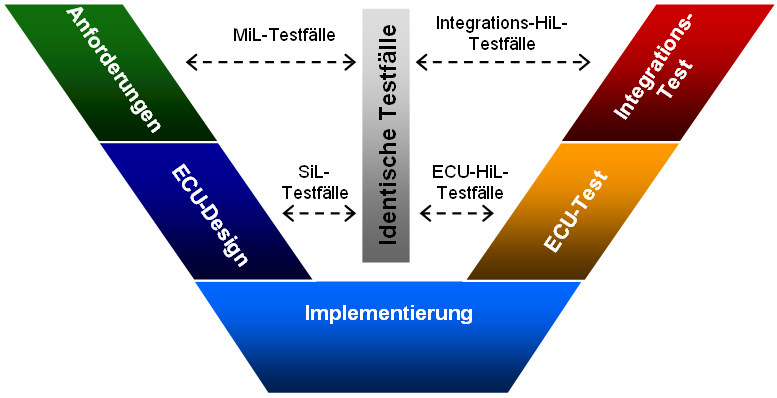
MiL/SiL/HiL consistency: A seamless process without critical breaks demands corresponding tools and products. Beside the modeling tools, software platforms like MESSINA (Figure 4) from Berner & Mattner can serve as central development tool.

Figure 4: MESSINA and scalable modularHiL

In MESSINA MiL and SiL tests for MATLAB/Simulink, ASCET and AUTOSAR compatible software components (SWCs) as well as HiL tests are specified and executed in real-time. In the next iteration, UML models are smoothly integrated and supported in the same way. Environmental models for simulation of the ECU environment (sensors, actuators) are integrated e.g. via MATLAB/Simulink models like veDyna from TESIS.

The outstanding feature of MESSINA lies in the consistent reuse of test sequences in all phases of development. This key concept avoids the vertical break in the process. Models and MiL/SiL-testcases are executed identically also on HiL test benches on basis of the high scalable test system modularHiL (Figure 5). Reuse of test sequences is guaranteed by the signal abstraction concept in MESSINA.

Figure 5: Consequent reuse of test cases in MESSINA



Thus, hardware changes are performed by a simply reconfiguration of the system. Neither the simulation models nor the test cases must be adapted. Therefore, test cases and simulation models can be reused without any change in different test scenarios and development phases. Test cases can be exchanged between OEM and supplier easily, followed by a higher consistency in the process and a strongly reduced defect rate.

Leading edge MESSINA expansions like the Classification Tree Method (CTM/CTE) [2] and Time Partition Testing (TPT) allow systematic verification of very complex SWCs in next generation ECUs. The Classification Tree Method (CTM) enables the systematic

specification of test campaigns based on the requirements specification. The method CTM enables test specifications free of redundancy. The Classification Tree Editor (CTE) serves as application tool to create test cases in compliance to CTM.

Additionally to its graphical user interface, TPT ensures a consistent model-based description of test cases for all development phases. At the moment, TPT is the only tool on the market with a systematic process for reactive tests of embedded systems that natively supports the modeling of test cases with continuous signals.

The MiL/SiL/HiL consistency reached by MESSINA, modularHiL and MESSINA expansions, significantly reduces the horizontal and vertical break and increases the process security, at OEMs and TIER1s.

Prospect:

Lifecycle Management for ECU software represents a promising basis to steadily master the complexity of future ECU developments from the requirements specification up to the HiL test bench. The development processes across companies with regard to quality and costs are also optimized.

Berner & Mattner will consequently rollout and optimize the LCM-Methods with further OEMs and suppliers. In the next steps, the following key areas will be in the scope of work:

a.) Implementation a clear understanding for role definition and allocation at OEM, TIER1 and engineering partners to achieve an effective collaboration between involved partner companies (e.g. for function modeling, test house operation).

b.) Mapping of standardization results, e.g. RIF (Requirements Interchange Format), test exchange formats (EXAM, etc.) and HiL-API, in the LCM-Method. Existing test systems at OEMs and TIER1s can be integrated more smoothly with standard like this, process interfaces are simplified by these standardization activities.

c.) Consequent support of AUTOSAR in the used modeling and test systems to reach a high degree of reusability of software components and interoperability between tool suppliers.

d.) LCM process integration into already existing car development processes to reach CMMI/A-SPICE level 3, comprehensively between OEM and supplier.

In a further step Berner & Mattner will follow the plan to extend the reuse of models and software components across several OEMs. This approach is especially interesting for non competitive relevant functions of course. This innovative concept will reduce time and costs for integration of functions in new car series dramatically.

References

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