

Systems Engineering

DEVELOPMENT OF MECHATRONICS AND SOFTWARE NEED TO BE INTEGRATED CLOSELY

Products from automobiles to mobile phones contain an increasing amount of software providing various functionality, including the control of mechatronic systems. In order to ensure optimal design in these Embedded Systems, the development of mechatronics and software need to be integrated more closely across all phases of the product lifecycle.

The integration of tools to control the software lifecycle within the PLM environment is a crucial prerequisite in this context. Continental Automotive provides a best practice example for the successful realization of such an integration.

To tune a car's performance these days, you no longer need to be a traditional mechanic, but rather a software engineer. Horsepower is not determined only by the engine's mechanical characteristics, but also on the software controlling it. With different control algorithms, the same engine can provide different ranges of horsepower. Andre Radon, Vice President Product Lifecycle Management at tier 1 automotive supplier Continental Automotive recently explained to attendees at the International PTC User Conference in Las Vegas that a key differentiator between a car of 300 and 400 hp is the software. Cars are increasingly becoming computers – with millions of lines of software – on wheels. Some luxury vehicles are now home to more lines of software code than a complex IT solution. The software not only controls the complex infotainment applications, but also works together with mechanical and electronic system components to control basic functions which affect driving behavior and safety. This sets very high standards in terms of the quality and reliability of the embedded programs, as any bugs could be life-threatening.

Software Drives Innovation

According to estimates, software contributes between 60 and 80 percent of the innovations in a car. The contribution of Embedded Systems to innovations in the automotive industry is even higher. However, at the same time software has also become one of the biggest potential sources of problems. Embedded Systems are hardware and software components integrated into a more comprehensive solution in order to fulfill product-specific functionalities. The end users either see nothing of the software or they only get to see the user interface without being able to influence the actual behavior of the system.



These days, Embedded Systems are not only found in cars and aircraft, but also in industrial plants, automation technology, in medical devices and in environmental and energy technology. Many economies worldwide are significantly influenced by embedded systems development. Research suggests that the U.S., Japan, and Germany are at the top of this market. Embedded systems allow faster reactions to new market requirements, more cost-effective implementation of innovations to make market-ready products and stronger differentiation of these products in terms of functionality without having to alter the hardware (e.g., mechanics and electronics).

The rise of Embedded Systems has led to a steadily increasing value contribution of electric and electronic components to motor vehicles. Over 50 percent of the costs of new systems stem from embedded software. This shifts the importance of various professional groups in automotive development – traditional mechanical developers are increasingly being dominated by system and software developers. At Continental Automotive, for example, two thirds of the engineers now work in systems and software engineering. According to Radon, Continental Automotive has more software programmers than many leading IT companies.

Dynamic Change Process

The development of Embedded Systems is a complex process involving a broad range specialized engineering disciplines which use different systems, have different processes, and communicate in different technical language. So, traditionally, mechatronics and software components are developed separately and in parallel to one another. They are only brought together at a relatively late point in the development process. This has several disadvantages including significant risk that

the software and hardware do not function properly together, creating expensive rework. At the same time, it makes multidisciplinary optimization more difficult, where the aim is to optimize the functionality of the system as a whole, possibly taking into consideration less than optimum results from individual

When challenges do arise, in many cases, the software developers can solve the problem more quickly and easily than the mechanics developers. After all, it is not only much faster to change software, it is also a lot more cost-effective than altering mechanical components. At Continental Automotive, for example, there is an average of 100 software changes and around ten electronics alterations for every hardware change. However, it is this dynamic of software development which needs to be controlled and coordinated for the development of Embedded Systems. Unlike pure software applications, Embedded Systems require close interaction between software, electronics and hardware, which means that a software change which is not controlled and coordinated can lead to a complete breakdown or major functionality issue for the whole system. It is no coincidence that some 50 percent of guarantee costs go towards Embedded Systems these days.

When analyzing error causes and potential efficiency improvements in embedded systems, quality assurance across system boundaries turns out to be the biggest potential for optimization. In order to guarantee high levels of quality, it is necessary to produce an integral overview of the system to be developed and all its configurations and variants as early as possible and continue to maintain it on a consistent basis. The approach to application must be holistic and system-oriented in order to ascertain the influence that the software has on the hardware and vice versa at any stage.

Integrated Development Approach

The central challenge during the development of Embedded Systems is process integration. This begins with requirements management, which is the capturing and representation of functional (and non-functional) requirements at the system level. The individual system components (e.g., hardware, electronics, software, etc.) and the relations among each other need to be reflected in an integral architecture strategy. By doing so interdependencies can be recognized and the impact of changes can be evaluated. Accordingly, a model based development process facilitates the virtual validation of the Embedded Systems. Early analysis and validation of Embedded Systems require comprehensive configuration management and a powerful management of versions. Such configuration management also needs to reflect the different dynamics of changes that occur during the development of software as opposed to the development of mechatronics.

Product configurations from software, electronics and mechanics with their different lifecycles must be traceable throughout the design and development processes in order to avoid product liability issues and to ensure a high level of product quality.



Source: Tech-Clarity 2011

Interdisciplinary lifecycle management for mechatronics and embedded systems, accordingly, is a prerequisite for process integration. An integral product development platform should be able to:

- document complete product configurations, its variants and its dynamics of change so that they can be traced at early stage
- provide a virtual overall model for reference and validation at all phases of the lifecycle
- represent interdependencies between requirements, functions, product and tests in different views and synchronize them in case of changes
- incorporate the individual tools of the engineering disciplines involved and support their specific requirements for the process

In analogy to the V-Model approach of software development, the system is first considered on an integral basis across all disciplines. Only then it is broken down into system components and working packages for the different disciplines, which are then implemented and finally integrated back again. Discipline-related activities are still being processed separately, but they are held together in structured form by a shared system configuration layer within of the PLM solution. The goal of such a procedure is to carry out tests at a system level within the process as early and reliably as possible. In order to provide better support for integrated lifecycle management for mechatronics and software, PTC has recently added the Integrity solution from MKS, one of the leading manufacturers in the field of embedded software development, to its product development system (PDS) based on the PTC Windchill PLM platform. With its integral approach from requirements management through to test management, the PTC Integrity solution is a perfect complement to the existing PTC Windchill solution. The modern architecture of the two systems also means that the PTC Integrity solution can be made available both as a standalone package as well as integrated with PTC Windchill to provide an overall solution.

PLM Architecture in Real Life

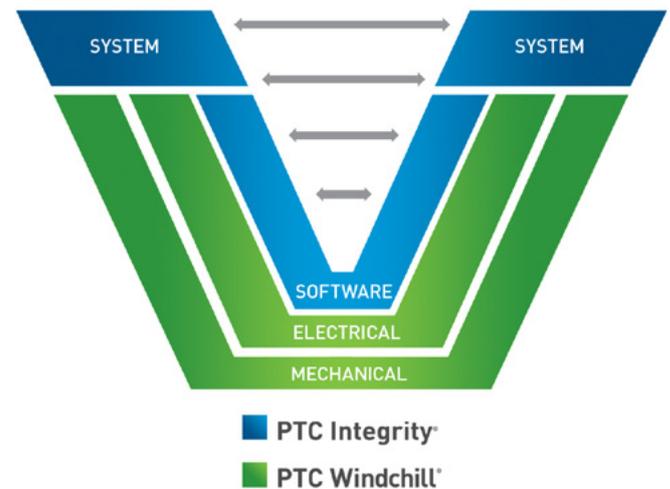
The example of Continental Automotive is a great use case how such an integrated solution can be implemented. In a first step, the automotive supplier consolidated its heterogeneous system architecture in order to support the system-oriented development approach. Beforehand, the IT landscape consisted of a broad range of different authoring systems and data management tools. Some of them were not integrated at all or, if integrated, then only partially. The IT consolidation resulted in a consistent PLM architecture for the entire engineering process (mechanics, electronics/electronics, software and system development).

PTC's Windchill and PTC Integrity solutions are mission-critical elements of this architecture. They are seamlessly integrated by means of SOA-based services (service-oriented architecture) that core processes such as configuration and change management can be supported throughout the entire processes and across the entire system. Thanks to the consistent, web-based interface all specific information can be easily accessed to in-house users and Continental Automotive customers. While all system level changes to the software are controlled by PTC Integrity, PTC Windchill supports the change process for mechanical and electronic development.

Every time a software developer makes a change request to the system, it first analyses which mechanical and electronic development functions are affected. Once the effects of the software change on the mechanics and electronics systems and related costs have been reported back, the proposed change is accepted by the Change Control Board. Afterwards, the relevant change requests are communicated to the mechanical, electronics and software developers.

The software components affected by this change belong to the product configuration which is maintained across the system in PTC Windchill and PTC Integrity.

The new PLM architecture at Continental Automotive is projected to make a significant contribution to improving transparency and facilitate interdisciplinary, globally dispersed cooperation by means of seamlessly integrated processes. Data quality shall be improved by virtue of the fact that the development history is clearly traceable for stakeholders of all disciplines and locations. The SOA-based architecture allows fast adaptation and expansion of the solution and provides the users with the applications required from anywhere through a web portal.



Strong Support For Change Processes

Embedded Systems are the most important driver of innovation in the automotive industry and in other sectors of the manufacturing industry. Developing them is a complex process that requires a seamless integration of the different engineering disciplines to guarantee the quality and reliability of these systems. Interdisciplinary product lifecycle management provides the framework required to make the increasing complexity of this process manageable. However, creating an integrated development environment on its own is not yet enough: cooperation needs to be practiced, and this requires a change in the way people think and it requires compromises along the way. The implementation of the system-oriented development approach has its challenges, to be certain. This is why Continental Automotive defined a comprehensive program of information, integration of specialist departments and qualification to create a roadmap documenting the transition to an integrated approach over a period of several years. The added value of the company and its performance is reflected in the increased integration and flexibility and in transparency and traceability. All factors are crucial for global manufacturers of complex systems.

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J000-Systems-Engineering-WP-EN-0912