Fifth VDA Automotive SYS Conference

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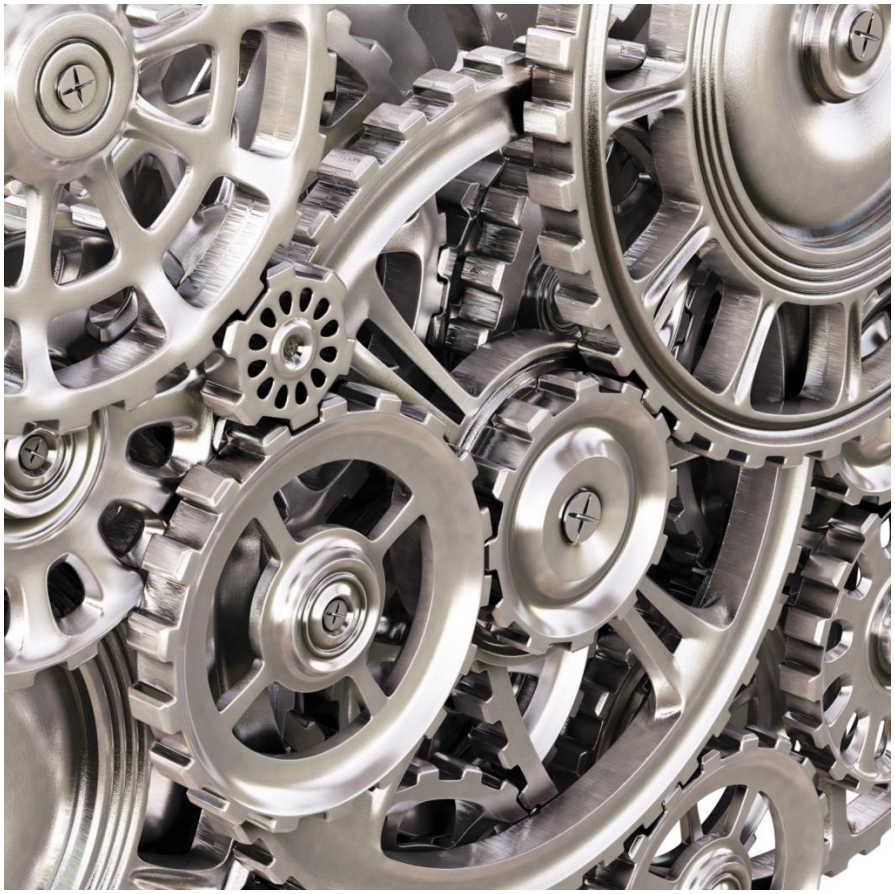
SPICE for Mechanical Systems

Presentation Handout



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1 Summary

The development of mechatronic systems is a challenging process. Software, mechanical components, and hardware must satisfy demanding requirements and be optimally attuned to each other. For this reason, the intacs working group Mechanical SPICE created an integrated development model based on SPICE.

2 Gate4SPICE: Advancing Together

intacs is the interest group of ISO 15504 (SPICE) assessors. One task of the non-profit organization is the training and continuing education of SPICE assessors.

The intacs working group "Assessor Support" organizes Gate4SPICE meetings in which SPICE assessors discuss current topics of importance. This improves the assessors' qualification and fosters a common understanding of responsibilities and appropriate solutions. This, in turn, leads to more uniformly conducted assessments to allow for better comparability of the processes assessed.

Every SPICE assessor may participate in Gate4SPICE meetings; intacs members are given priority if the number of interested parties exceeds available seats.

Gate4SPICE was created in 2003. Since 2011 Gate4SPICE meetings have been managed by Dr. Joachim Fleckner of F+S Fleckner and Simon Informationstechnik GmbH as head of the intacs working group "Assessor Support".

Since 2011, about 25 meetings with over 700 participants have been held – and with some success, according to the statements of participants: "Helpful in day-to-day work", "Very interesting lectures", "Interesting discussions", "Now I know what to do", "Exactly the right topic".

Some of the topics which drew a great deal of interest were:

- "SPICE for Beginners" – practiced assessors shared some of their experiences with newcomers, discussed and answered questions.
- "SPICE and Agile" – these meetings addressed how SPICE requirements can be integrated into Agile development.

3 The Challenge of Mechatronics

One interesting topic of the Gate4SPICE meetings which received positive feedback is the definition of processes for the development of mechatronic systems.

The challenge of developing software, mechanical components, and hardware in parallel, coordinating them with each other, and integrating them is immense. Mechatronic systems are extremely complex. Often they must satisfy high safety standards and be developed affordably and increasingly faster. Many systems in cars are mechatronic systems.

Thanks to Automotive SPICE we know how to organize software engineering to be successful. What is missing are similar process models for hardware and mechanical component development. Combined with the software development process this would allow us to create harmonious overall systems. The usual development processes are insufficient - to this statement all Gate4SPICE participants who worked on the topic of "Mechanical SPICE and mechatronics" quickly agreed.

3.1 Clock Example

To illustrate a simple example from a different area: imagine a watch manufacturer. For generations they have produced mechanical watches and have also had long-term success with electric quartz watches and electronic radio watches that automatically adjust their time. Then the company wants to manufacture a mechanical radio watch; after all, they are skilled with mechanical components and with software and electronics.

At first, the innovative watch works very well. However, after changing the time to daylight savings time and back again several times, the watch became defective. The delicate mechanical components were not designed to move very quickly for a relatively long time, like advancing quickly 1 or 11 hours. So, over the course of three years the gears wear down and the watch stops working. The manufacturer had not considered the system "watch" as an overall integrated system and overlooked the "daylight savings time" use case.

3.2 Combining Relative Perspectives

In order to avoid such mistakes with mechatronic systems in the automotive sector, the Gate4SPICE meetings followed this basic thought: In the scope of SPICE, we want to view software development and the mechatronic development as one undivided entity and expand SPICE with the mechanical components for this purpose.

Expert mechanical engineers together with experienced assessors familiar with the SPICE model, software development, and an understanding of hardware and mechanical components contributed to these Gate4SPICE meetings.

Since we did not want to reinvent the wheel we utilized everything that is good about SPICE, for example the consistent breakdown from a complex system view into "atomic" units.

Mostly, with an initial focus on the engineering processes, the contributors worked on these questions:

- What can we adopt directly from SPICE? Where in the descriptions can we simply replace "software" with "mechanical"?
- Where must the descriptions be adapted?
- What may be omitted (because it is irrelevant for mechanical components)?
- And what must be added?

3.3 Mastering Complexity

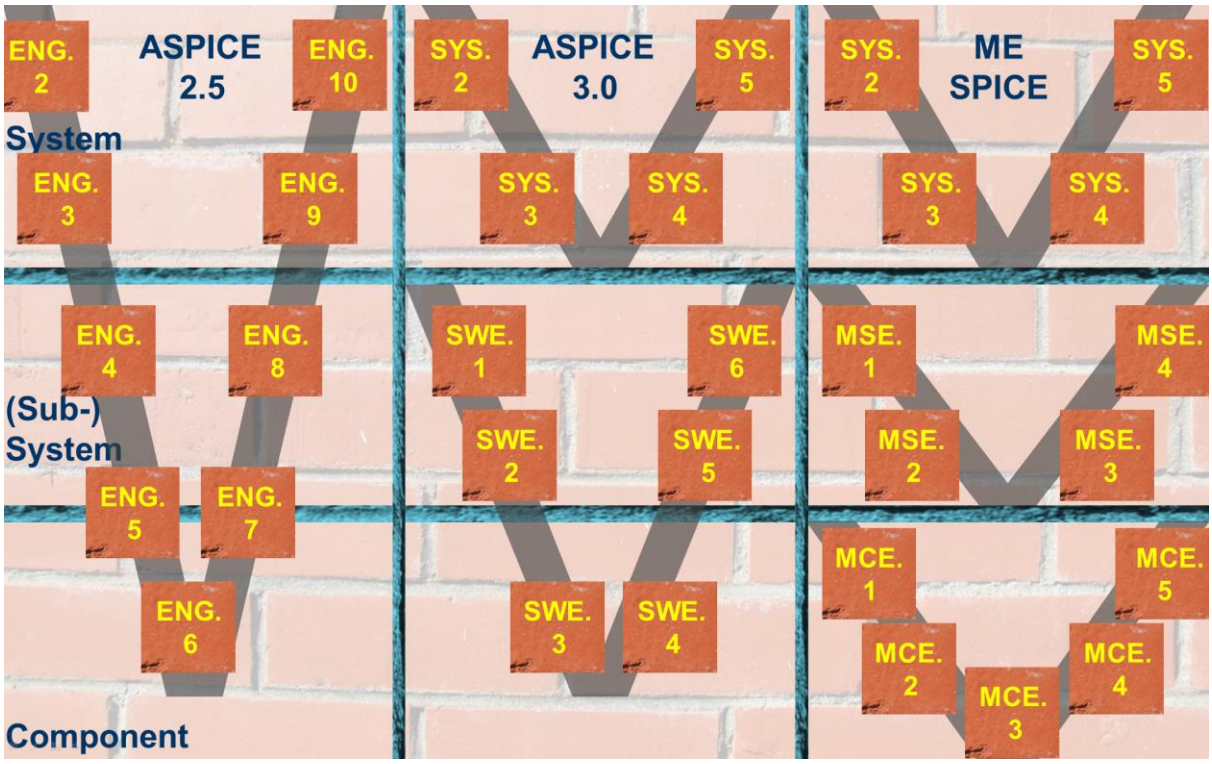
The starting point was the well-known V-model from Automotive SPICE Version 2.5. We started with the overall system, a control unit (ECU), which should be developed. The "downstream" software system level which follows the requirement analysis and software design steps is broken down into increasingly smaller units.

At the bottom level, at the tip of the V, are the "atomic" units, i.e. the software components are implemented, then integrated incrementally and then tested.

In Automotive SPICE 3.0, soon to be released, the software system level and the software component level are clearly separated, unlike in Automotive SPICE 2.5.

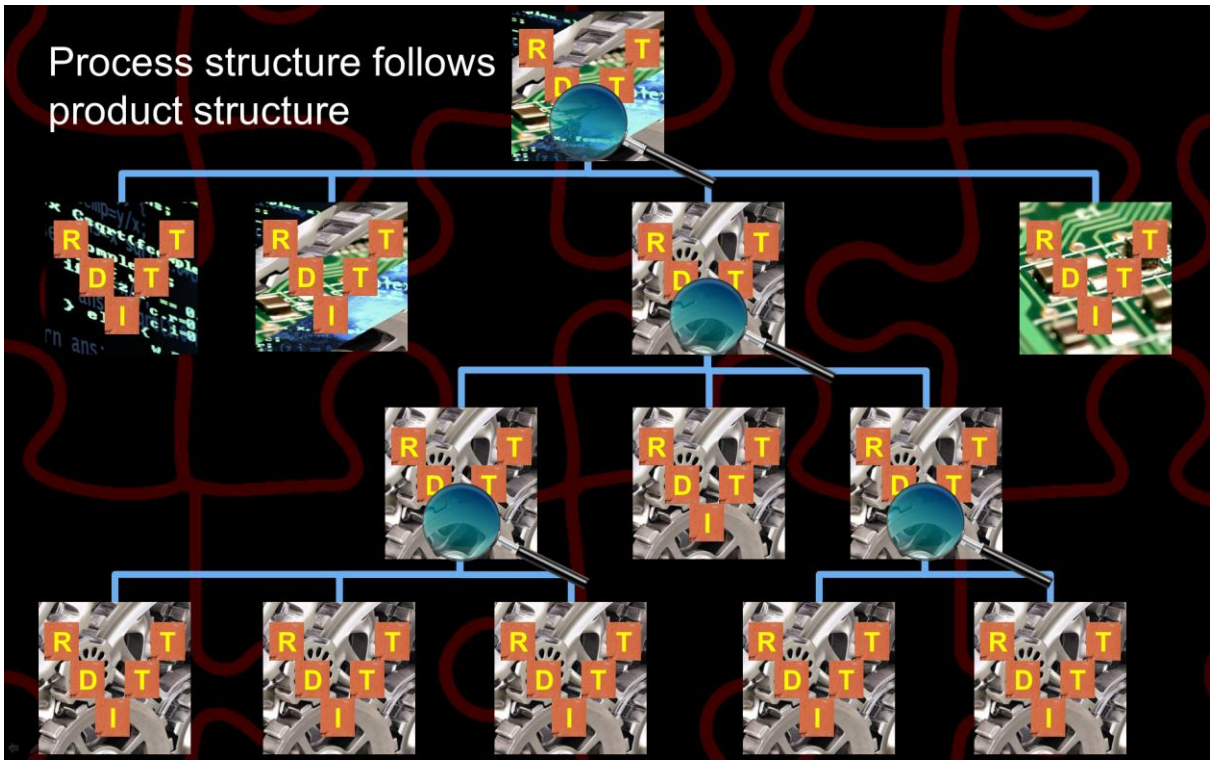
Therefore, the working group used a preliminary version of Automotive SPICE 3.0 in order to define Mechanical SPICE. We broke down the overall system level into subsystems of different "disciplines": now, there can be mechanical and software subsystems.

In addition, the mechanical subsystems were broken down into smaller subsystems; this break down is well known from exploded diagrams of complex mechanical systems.



There is only an implementation process on the component level; the system is initially modelled on the subsystem level by use of further subsystems. In the mechanical area the "implementation" is the "creation of components". What a component actually is depends on several factors, like the production depth of the supplier, e.g. a component may be a gear wheel or an entire transmission.

For example, we can break down a complex complete system into four subsystems: a software subsystem, another mechatronic subsystem which we buy from a supplier, a mechanical and an electrical subsystem. The mechanical subsystem, again, consists of several mechanical components and subsystems, which, in turn, comprise several additional mechanical components.

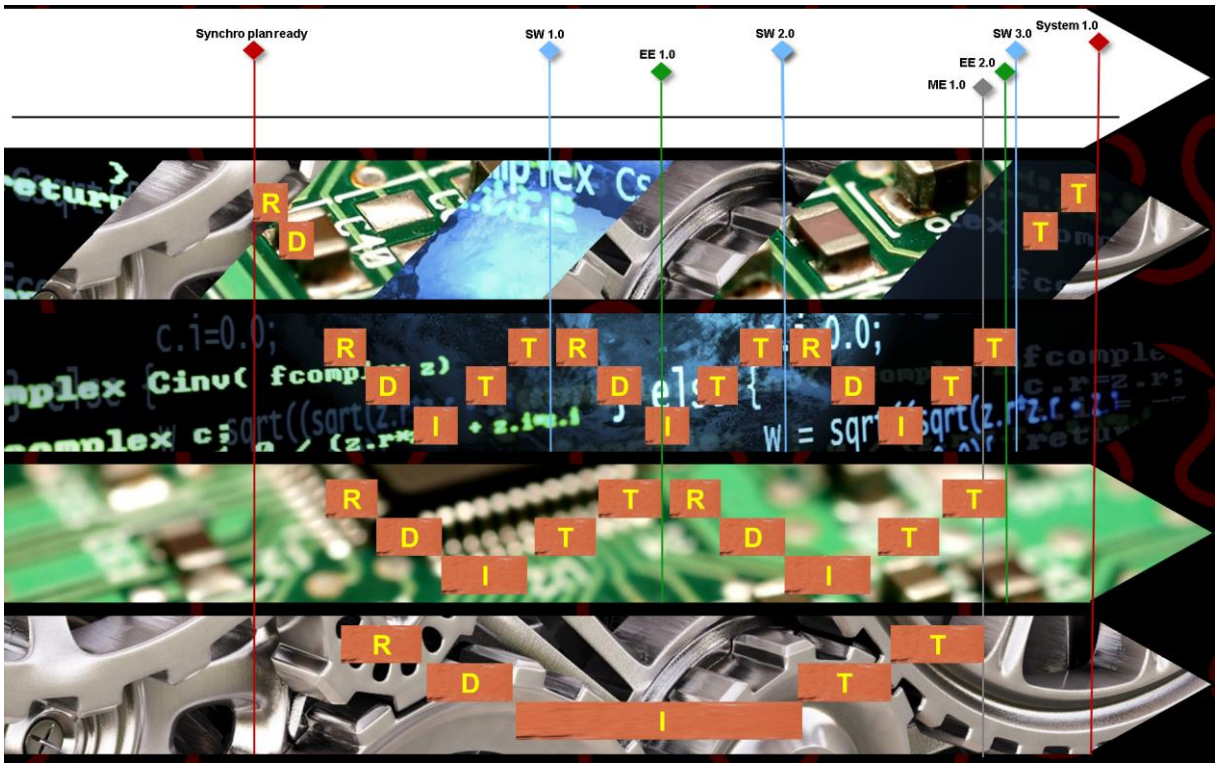


In general, a separate V-model can be added for each subsystem and for each component of the complete system. In other words: The complete system can be divided into any number of subsystems which, in turn, may contain several subsystems or components. With this, highly complex mechanical systems can be described, designed, and tested with Mechanical SPICE!

3.4 Synchronising Development Cycles

Software, mechanical, and hardware each have different development cycles - a new software release is developed significantly faster than new hardware, which is developed more quickly than new mechanical components and subsystems. Therefore, a synchronization plan is required on the system level. It must provide transparency with respect to the steps in which supplied components are integrated at specific times (milestones).

The synchronization plan allows overlapping processes: For instance, the initial software release works with the old hardware and the old mechanical components. The second software release will then only have to run on the new hardware, but still with the old mechanical components. The third software release is the first to run at the desired level, entirely based on the new hardware and the new mechanical components - now everything can work together.



3.5 Base Practices in Focus

The Mechanical SPICE group defined the structure of the description of complex systems on the overall level but considered also the details.

The engineering processes on system level remain unchanged. The engineering processes and their Base Practices for the subsystem and SW components level of SPICE 3.0 were inspected closely.

The central question: which Base Practices can be adopted, which should be adapted, and which must be redefined? Here are two examples how Automotive SPICE compares to Mechanical SPICE:

1. Based on ENG.4.BP1 from Automotive SPICE 2.5...

   ENG.4.BP1: Identify software requirements.

   Use the system requirements and the system architectural design as the basis for identifying the functional and non-functional requirements of the software and document the software requirements in a software requirements specification.

   ...we defined the corresponding Base Practice for Mechanical SPICE:

   MSE.1.BP1: Identify ME system requirements

   Use the upper system requirements and the upper system architectural design as the basis for identifying the functional and non-functional requirements of the ~~software~~ ME system and document the ~~software~~ ME system requirements in a ~~software~~ ME system requirements specification.

2. Out of the 10 base practices in the process ENG.6 Software Construction, only three remain in Mechanical SPICE, because the others in ENG.6 address activities which are either irrelevant for mechanical components or were moved to other processes (Design and Test):

   MCE.3 Mechanic component production

   The purpose of the Mechanic component production process is to produce a mechanic component that properly reflects the mechanic component design.

   MCE.3.BP1: Develop mechanic component production strategy.

   MCE.3.BP.2: Produce ME components.

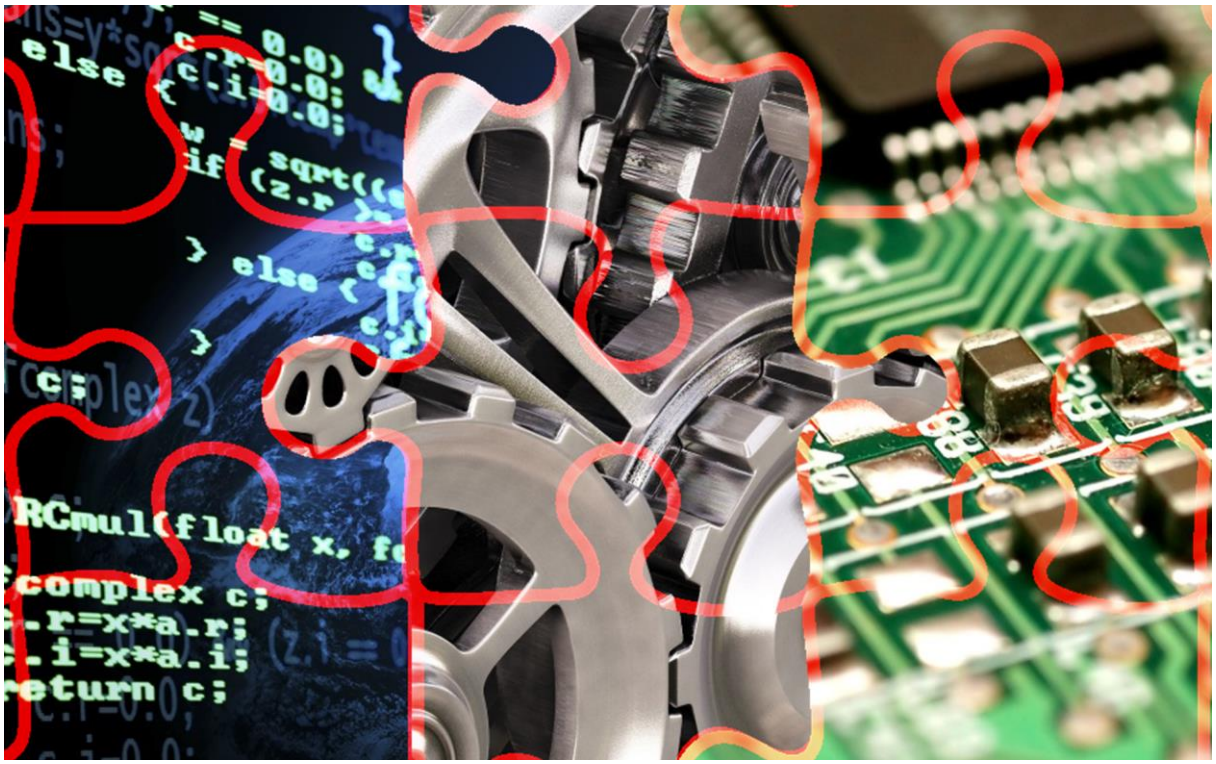
   MCE.3.BP.3: Provide feedback to mechanic development.

3.6 Summary and Outlook

Individual components of mechatronic systems must fit together like pieces of a puzzle. Only then a functioning system can be created successfully.

The "Mechanical SPICE" model was defined in the Gate4SPICE meetings. It contains processes that fit seamlessly together with the processes of Automotive SPICE like puzzle pieces: now, complex mechatronic systems can be developed quickly, affordably, and reliably.

Upcoming meetings will address the coordination of details in Mechanical SPICE with the version of SPICE 3.0. In order to be able to work as efficiently as possible with a consistent group of participants, the intacs "Mechanical SPICE" working group was created. We will continue to keep the community informed with our additional informational Gate4SPICE meetings.



Handout V2.0