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System Architecture: Applying the Lessons Learned in the Early Design Stages of Visteon Engineering Process

System Architecture: Applying the Lessons Learned in the Early Design Stages of Visteon Engineering Processes

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Abstract
Many of the critical issues, which appear in the later stages of the engineering process, are of multidisciplinary nature. They are usually sporadic and remain undiscovered for an extended period, due to the local defects of the less mature work products of electrical engineering (EE), mechanical engineering (ME) and software covering them. Disclosed is a simple methodology which, when correctly maintained, may flag up issues early or prevent them entirely on the system level.

Introduction
During the execution of the latest large-scale programs, we found that the top impact issues, which we face in the later stages of development, are almost entirely on a system level (shared between at least two disciplines). Of course, we have processes that require several engineering reviews, sign-offs and gates, but some issues can still slip through. On the other hand, the complexity of the new developments has increased so much that the manual reviews and checks are increasingly prone to mistakes and misses. There is an obvious need to improve this, by introducing some kind of automation to assist the architect, designers and technical experts, in both design and verification of these new complex systems.

Example
Let's take the following real example: The housing of the final part is a magnesium box. The box, except housing functions, is used as a heatsink, electrical grounding and electromagnetic compatibility (EMC) shield. To make the EMC shielding more efficient, we have increased the ground contact points between the board and the housing, by populating EMC gaskets on the printed circuit board (PCB), and respectively adding domes to contact those gaskets on the housing. The gasket-dome is an EE/ME interface.

The first emission measurements with a number of sample parts, showed significant deviations in the EMC performance. When we removed the gaskets on those parts (and the EMC generally worsened) – all the parts performed comparably. The conclusion was that the gasket-dome interface was not reliable. The rootcause analysis found the finishing process after the magnesium molding (where remaining burrs should be removed) adds a thin film of solvent material, which causes some electrical resistance on the surface of the housing. This resistance varies significantly (from 0 OHM to a few hundred OHM). This thin film result of a supplier process is not part of the intended design.

This was a lessons learned – to not oversee the conductive characteristics of the real part and not rely solely on the theoretical characteristics of the raw material specified in the drawing by the ME designer. Define the electrical resistance of the surface as a special characteristic in the drawing explicitly, and plan adequate verification of the performance of this interface when representatives samples are available. The special characteristic will also require process control during production from the supplier.

Challenge
But how do we "force" every project in the organization to consider this lesson? The lessons learned are normally browsed and not automatically propagated in the design. Process improvement incorporates:

- Propagation of all the relevant best practices (BP) and lessons learned (LL) in the system architecture, in the moment the architect decides to use specific system interface or element. This includes "design recommendation" to each affected discipline for their detailed design *and* "verification criteria" to make sure the actual implementation works as expected in system level. This indirectly defines most of the system integration test plan – collecting the entries from the "verification" column.

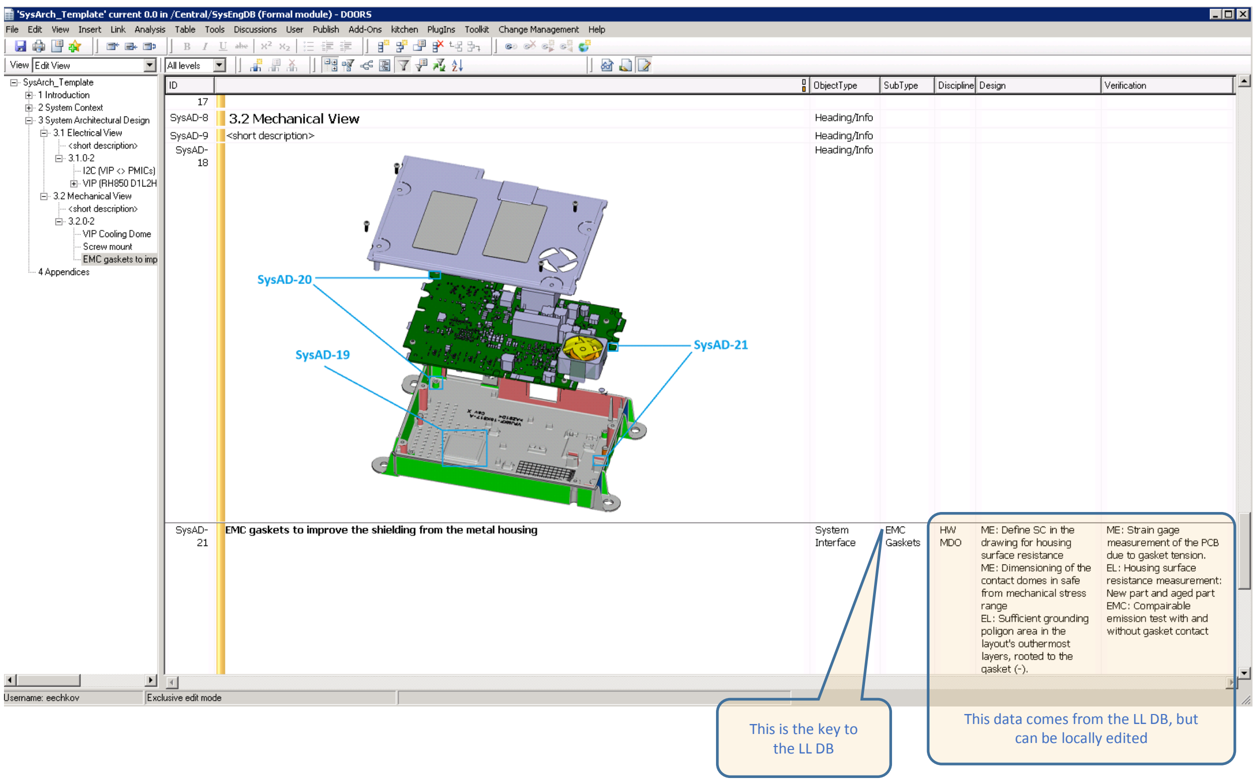
Implementation example
The system architecture can use many formalisms, but at the end a System Architecture Document (SysAD) is required to be consolidated in DOORS[1,2]. Every power line, communication line, contact point with the housing, etc. should be identified and described. For example, what is it and what purpose does it serve? The architect identifies these items as a "system interface"

or “system element.” A drop-down list allows them to select what type of system item this is (like I2C, Ethernet, CAN, power supply, heat sink, or screwing point), and extracts from a centralized DOORS database (LL DB) everything important that needs to be considered for this interface, based on the accumulated BP and LL:

- Between which disciplines the system interface is shared, and need to be considered in its detailed design and implementation
- Design recommendations
- Verification criteria

This data is filled in the SysAD from the LL DB. The entries in the SysAD are not a link but copy, which allows the system architect to tailor the generic entries to their specific project further, if needed (reduce/extend/modify). If an interface type does not exist in the LL DB but the architect wants to use it, first the entry is created in the LL DB, and then is used in the system architecture.

Below is a simplified example of what SysAD looks like in DOORS:



As the LL DB is a live document, continuous contribution from the engineering teams is needed. The “old” system architectures cannot directly profit from this change, but once SysAD is created with the new template, regular checks against the latest LL is a matter of automation even at a later stage.

Further potential impact of this method

With the consideration of the “Design Recommendation” and “Verification Criteria” introduced in the early design stage, the balance between the system architecture and related documents and activities can also change, providing more optimization opportunities in the future:

- Technical Design Reviews
  - Technical design reviews are on a system- and uni-disciplinary level. They are required engineering sign-offs to ensure the quality and compliance of the engineering work products. They are performed by a Technical Fellow following a checklist with design rules and BP. The checklist is a superset over the project portfolio, which is manually tailored by the Technical Fellow for the review needs of the specific project. The “super-checklists” are some of the inputs for the LL DB, which means the relevant BP will appear in the SysAD during the design. During the design review, an export from the SysAD filtered by the discipline, could be used as a checklist to verify against. If the result of the review is further stored in DOORS as well, the review could be baselined, traced and can report coverage over the product definition.

- Design Failure Mode and Effect Analysis

- The current design failure mode and effect analysis (DFMEA) is a comprehensive document with many layers of detail – from functional failure modes on product level, through process failure modes, down to single discipline implementation specifics (like critical electrical components). The future DFMEA could be reduced by excluding failure modes, which are prevented and justified by design, propagated to the detailed design and assured via the system verification. In some cases "design recommendation" could be linked to "prevention", and "verification" to "detection" of the failure mode of the interface.

- Engineering Gates
  - The different engineering gates require different work products to be completed and verified. When the design and verification details are introduced in the early design stage, they can be propagated to the following work products as detailed design and implementation of the single disciplines (at the left side of the standard V-cycle), but also the different verification steps (at the right V-cycle side). When traceability to those is established, the engineering gates may rely on reporting like:
    - System engineering design solutions propagated downstream to the single disciplines and the design recommendations considered in their detailed designs
    - System interfaces and elements considered to be tested during the engineering tests of the different disciplines
    - System interfaces and elements considered to be tested during the system integration test on product level
    - Results of the tests or "how much of the system is performing as expected"

- System Integration and Testing
  - As mentioned above, the system integration test plan (as defined in the ASPICE SYS.4 process) will be automated by extracting the verification criteria entries from the SysAD. The test coverage over the complete system can be automatically established as soon as the system test plan and test reports are maintained in DOORS.

1) *in the examples, the focus is on the physical technical solution of the system, the SysAD is much more extensive document*
2) *DOORS can be any other requirement management system*