BERYLLS STRATEGY ADVISORS

THE FUTURE OF AUTOMOTIVE R&D: LESSONS FOR OEMS FROM SYSTEMS ENGINEERING

AGENDA

1. How does a system-oriented approach work?
2. Within the R&D organization: Three approaches to take
3. The future R&D organization: Actions to take

Automakers' R&D organizations were not set up to work on the complex software that defines modern cars - but there is a tried and tested approach they can adopt

Carmakers are expected to increase their spending on electrics and electronics (E/E) by 64 percent over the next decade, from €58.7bn this year to €94.6bn by 2030, and the biggest share of this will be software. Berylls research shows it will account for €56.2bn by the end of the decade.

The reason for the steep increase is that the next generation of cars will be controlled by highly complex software and will need a high degree of connectivity, between different platforms within the vehicle as well as outside it. Cars will need to access software updates throughout the life of the vehicle, and autonomous driving systems will need to connect to real-time data on road conditions and hazards.

Automakers' established research and development (R&D) organizations have been built over time to deal with individual components in distinct domains – the drivetrain, the chassis or the electrics.

They were not designed to deal with today's complex functions, which work across the domains. OEMs have already spent a great deal of effort and time trying to align people and processes from each of the domains, in order to link the elements of software systems together after they were built.

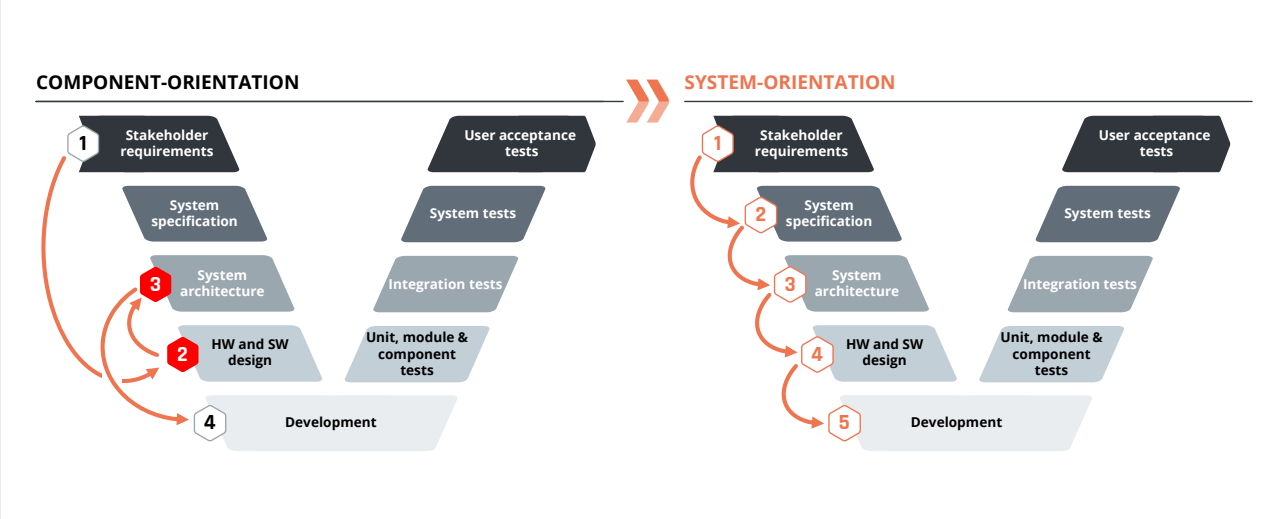
This way of working not only wastes time; there have also been quality issues during product development, and rapidly increasing costs. Such problems are likely to increase as the proportion of software in vehicles, and its value, increases. We believe the solution is for OEMs to adopt a systems engineering approach across their R&D organization. Carmakers are already doing so in individual pilot projects, but they need to go further, and this will require a radical change in developers' ways of working. The benefits are undeniable: shorter development cycles, more efficient use of resources, and higher quality results.

1

HOW DOES A SYSTEM-ORIENTED APPROACH WORK?

FIGURE 1:

COMPARISON OF PROCESS FLOWS ALONG THE V-MODEL



Source: Berylls Strategy Advisors

As the left side of the diagram above shows, using a development approach that focuses on single components creates a disjointed process with a lot of time spent doubling back when it comes to developing hardware and software for complex distributed functions such as ADAS.

Instead, the system-oriented approach shown on the right of the diagram defines the **overall system architecture before detailing the specific technology**, so that each piece of hardware and software contributes to optimizing the overall system rather than being retrofitted to it. Work flows logically from one stage to the next.

The good news for carmakers is the model on the right is already used successfully in software systems engineering in a range of industries including defense and avionics, and by automotive OEMs using the ASPICE framework to assess technology suppliers. System-oriented development aims to centralize responsibility and reduce the coordination efforts needed at interfaces, defined as the boundaries of responsibilities between teams.

The goal is to have as few interfaces as possible, and instead allocate all components and functions (hardware and software) to a system overseen by a system project manager with end-to-end responsibility.

2

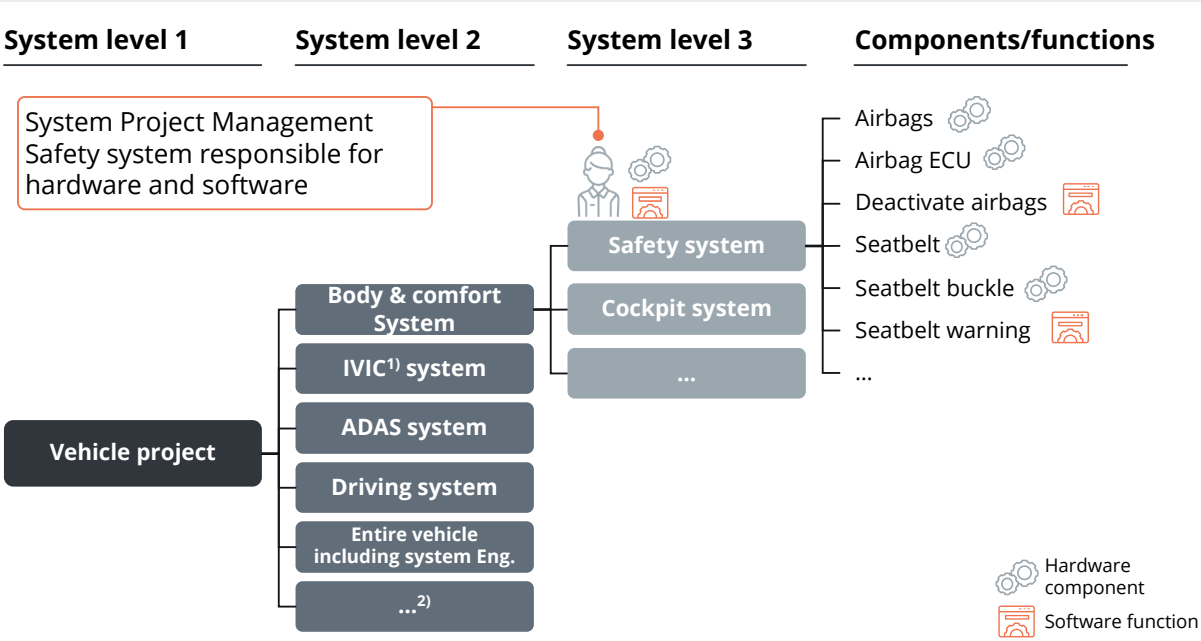
WITHIN THE R&D ORGANIZATION: THREE APPROACHES TO TAKE

OEM's R&D departments are made up of both vehicle project organizations and the line organizations the developers work within.

We recommend that **vehicle project organizations** use the system-oriented approach to produce, in the end, a holistic system. The diagram below shows how this would work with the example of the vehicle safety system, with one system project manager overseeing both hardware and software:

FIGURE 2:

EXEMPLARY SYSTEM-ORIENTED VEHICLE PROJECT ORGANIZATION



1) In-vehicle infotainment and communication 2) e.g., Project manager for Production, Finance, Sales, Quality, Purchasing and Project Mgmt.

Source: Berylls Strategy Advisors

However, when it comes to **line organizations**, we see three possible approaches: system-oriented, function-oriented or a hybrid of the two:

» A **system-oriented approach** works best when the OEM is bringing in software from outside suppliers rather than developing it in-house. The priority is building a system that successfully integrates all the different suppliers.

» For in-house software development, a **function-oriented** approach works better as it allows greater flexibility in design, enabling more focus on the features valued by that particular OEM's customers. A function-oriented line organization treats software functions as distinct components: it develops complex, networked software functions and connects them via generic APIs.

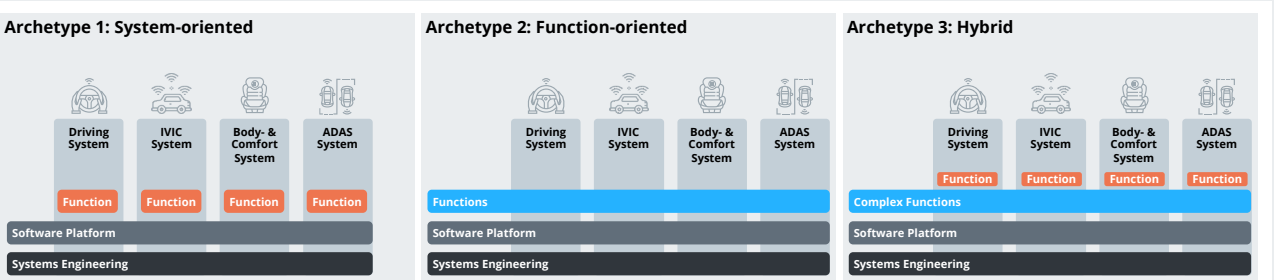
» A **hybrid line organization** allows OEMs to simultaneously give special focus to complex functions, and to maintain their legacy architectures in a system-oriented way. However, there is a risk that the line organization becomes stuck in the middle of two different ways of working.

The decision for R&D teams is whether to reduce the interfaces between the project and line organization as much as possible by having them work in a system-oriented way, or whether to decouple hardware and software development in the line organization and leave the task of joining the two to the project organization. Taking the second, function-oriented approach, inevitably involves a trade-off: a stronger focus on building bespoke software with all the right capabilities comes at the cost of having to integrate hardware and software at a later stage.

With a hybrid approach, only complex functions that cross multiple domains would be decoupled, while simpler areas of work follow the system-oriented approach.

FIGURE 3:

THREE ARCHETYPES FOR THE LINE ORGANIZATION



» **Organizational bundling** of components and functions in the line organization
» **1:1 mapping** of the system-oriented **vehicle project organization**
» Highly interconnected and complex functions can only be mapped **with difficulty**
» Changing assignment of functions to components, makes it **difficult to define clear system boundaries**
» Advantageous with **low internal value-add**

» **Organizational separation** of components and functions in the line organization
» **Dedicated organization** for customer functions facilitates **content and process focus** as well as **specific staffing** of management
» **Greater flexibility** in the design of customer functions
» **Increased coordination effort** between functions and components

» **Organizational separation** of components and complex, distributed functions in the line organization
» **Dedicated organization** for complex functions facilitates **content and process focus** as well as **specific staffing** of management
» **Reduction of coordination efforts** by assigning simple functions to systems
» Advantageous in **transition phase** between legacy architectures and decoupled HW/SW platforms

Source: Berylls Strategy Advisors

3

THE FUTURE R&D ORGANIZATION: ACTIONS TO TAKE

With vehicles increasingly defined and differentiated by their software, the complexity of systems consisting of hardware and software is constantly increasing.

As described above, traditional component-oriented ways of working in R&D departments' project and line organizations are not designed to deal with this level of complexity.

As a result, development costs are rapidly increasing, threatening OEMs' profitability.

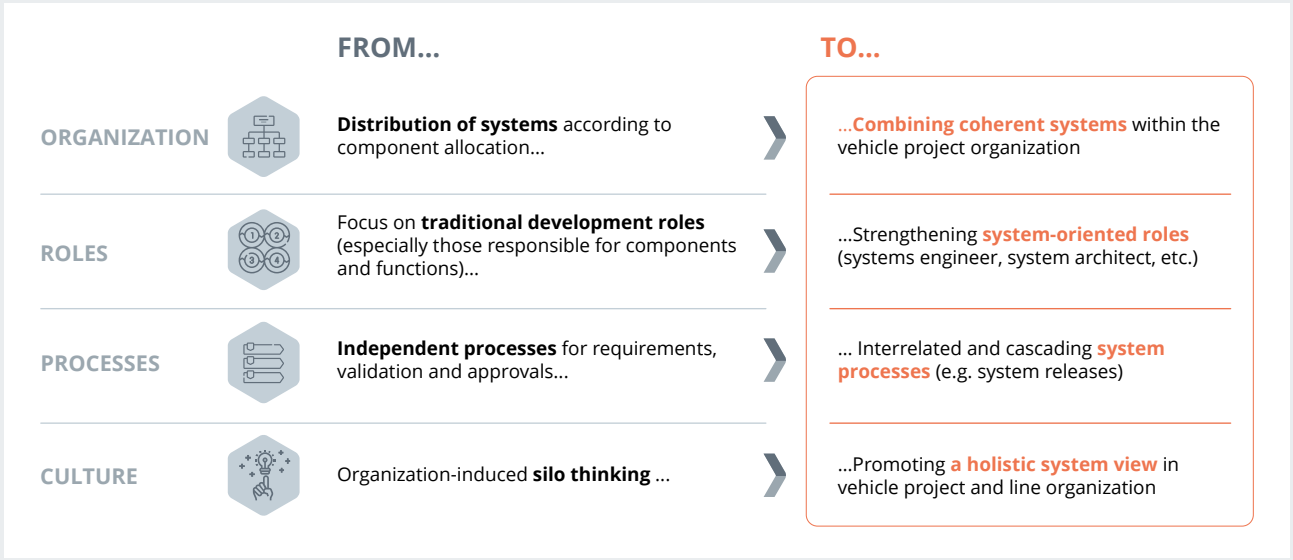
We recommend five key actions to address these challenges:

1. Consistently align development processes with systems engineering practices and the ASPICE framework.
2. Create a technology-independent functional view of the product based on the requirements of all stakeholders (customers, manufacturing, technology partners).
3. Assign functions and requirements to systems, and then translate those into an overarching vehicle project system structure.
4. Alongside vehicle projects, line organizations should be established as system-oriented or function-oriented, depending on the nature of the development task.
5. Ensure end-to-end responsibility for systems by realigning management roles to fit the new working model.

By making these changes, OEMs will transform their R&D department in the following ways:

FIGURE 4:

NECESSARY TRANSFORMATION TOWARDS A SYSTEM ENGINEERING ORGANIZATION



Source: Berylls Strategy Advisors

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