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A guide to model-based systems engineering

Why now?

The automotive industry is changing fast and OEMs are under intense pressure to meet evolving customer expectations and stay ahead of the competition. However, current deficiencies in product development are posing a real obstacle to their profitability, innovation, and growth. The extreme complexity of the process and the associated data and information management present a need for higher levels of transparency, agility, and compliance. As development cycles across the automotive landscape become shorter, all players are moving to innovate faster.

To tackle these challenges, highly integrated tools and automated processes are key. Organizations must shift from document-based to data-driven and model-based systems engineering (MBSE). This approach includes connected data layers for requirements, functions, logical, and physical (RFLP) to manage traceability throughout the development process, developed on data-driven, model-based innovation platforms with advanced design, engineering, and manufacturing

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capabilities as well as enabling third-party tool integration, supplier authentication, and authorization management on a need-to-know principle.

The shift from document-based to model-based development

The move from document-based to MBSE is a move from decentral data pieces to a central interactive model, a scattered application landscape to a fully integrated environment, and limited engineering tool integration to full product life cycle management (PLM), virtual validation, and simulation orchestration. Switching to MBSE is not merely a technical or organizational transformation, but requires a comprehensive mindset change across all teams. Organizations only reap the rewards of the approach when they embrace customer-centricity over technology-centricity and deploy function-oriented rather than hardware-oriented system thinking.

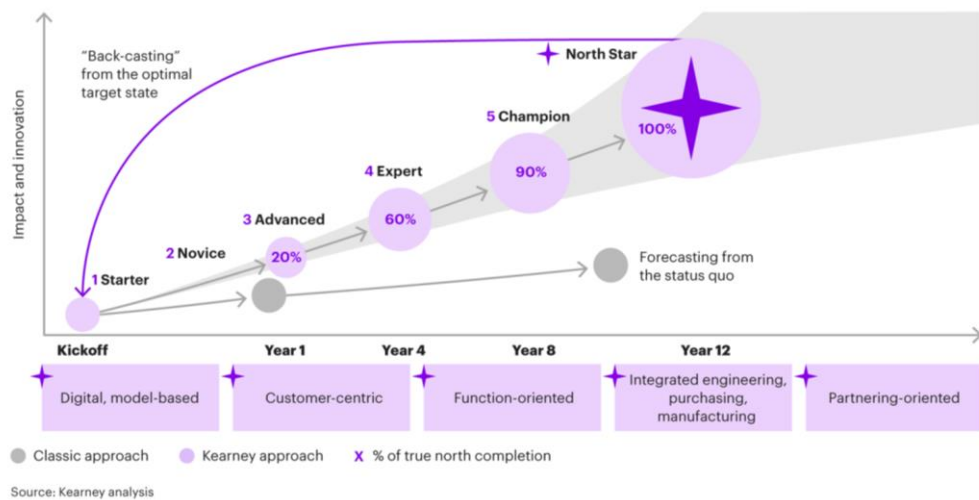
According to research for Kearney's Automotive Software Benchmark Index, MBSE can reduce prototyping hardware costs by 50 percent, shifting from real-world to stimulated testing. This major benefit sits alongside a 20 to 30 percent reduction in time to market by enabling continuous integration and testing, and a 10 to 20 percent reduction in development costs through collaborative teamwork and model reuse.

Assess your current progress to define the steps ahead on the MBSE transformation

The five stages of excellence below describe organizations at different stages of the journey toward an optimal target state, from “Starter” at the kick-off phase to “Champion” from year 8 onward (see figure).

Figure
An aspirational North Star is defined to push the boundaries and avoid incremental thinking

North Star for MBSE product creation



Stage 1: Starter

At this stage, organizations are at the beginning of their MBSE journey. They have investigated and identified the need for new ways of working and are willing to transform. The initial



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assessment is conducted along the V-model process covering requirements engineering, development, testing, and integration of the product including the underlying toolchain.

Based on these insights, an initial road map and target KPIs are defined for the key research and development (R&D) domains. This stage is especially relevant for traditional players with matured development processes looking for change. It will not just provide an overview of the status quo, but also a first indication of whether a green- or brown-field transformation is the better option.

Stage 2: Novice

The case for change is set and the transformation road map needs to be defined. To gain know-how and verify a company-specific hypothesis, a proof of concept (PoC) is initiated. Ideally, this involves the implementation of a system or sub-system with MBSE methodology and tools. These systems provide sufficient modeling complexity while not interfering too much with the overall vehicle development.

Again, this stage is highly relevant for traditional players looking into the approach before committing to the full transformation journey. For start-ups, the PoC is framed as the development of their first minimum viable product (MVP). It's crucial to gain hands-on experience with MBSE to embed new ways of working within the company.



Stage 3: Advanced

Advanced users have successfully analyzed the status quo and gained the first insights from one or multiple PoCs. They have used best practices and learnings to define their systems engineering methodology regarding requirements engineering (RE) and traceability throughout the development process. Based on the newly defined methods and process the R&D toolchain simplification and transformation is approached.

This level of implementation is typically found within traditional OEMs and tier 1 suppliers. It is driven by recent compliance challenges with a strong focus on the systems engineering process.

Stage 4: Expert

Expert players have successfully implemented MBSE methods and tools for parts of the R&D business (for example, hardware development). They already realize substantial savings in the region of a 20 to 30 percent reduction in development costs. The digital representation of the product, as in the example of hardware, is modeled in a central CAD database as an interactive digital twin. Internal and external engineers have access to the collaboration platform, enabling real-time simulation and analysis of committed changes.



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We observe the entry into this level at large-volume OEMs. These changes are driven by pricing challenges and realize savings by extending simulation capabilities, reducing physical prototyping, and fostering early conflict detection within the development process.

Stage 5: Champion

The champions and forerunners in this space have fully adopted the method and harmonized the toolchain over all R&D domains. They have implemented a fully fledged MBSE suite covering the complete PLM process. The organization itself has transformed its mindset to become customer-centric and function-oriented, alongside the defined systems engineering methodology.

Organizations at this stage are typically battery electric vehicle (BEV) start-ups with a limited budget and enormous pressure regarding time to market and innovation. As an example, NIO managed to launch the ES8 SUV within three years of development, rather than the common automotive 5-to-6-year phases. This was thanks to simulation, seamless collaboration, and virtual production planning.

Three key areas define your road to success

1. Processes and methods

When it comes to processes, taking an end-to-end, function-oriented perspective is key. Continuous interaction with customers requires new forms of prototyping, while the model-based approach needs new, digital ways of developing the product.

What are the benefits?

- Decreased risk of not meeting customers' expectations
- Improved quality and maturity of increasingly complex products
- Improved compliance with internal and external regulations
- Decreased vulnerability of data and unauthorized access to IP
- Increased product value through innovation
- Accelerated development time

2. Governance

This approach requires new steering methods that enable cross-functional collaboration. Defining the standards of

governance across the organization and RFLP data model dramatically increases transparency.

What are the benefits?

- Improved transparency regarding maturity through automated reporting
- Fewer interfaces and complexity through harmonized tools
- Higher level of collaboration and resource efficiency
- Higher organizational efficiency and improved product compliance

3. IT and toolchain

To create a seamless toolchain across all disciplines a simplified IT infrastructure, built on highly integrable solutions, is needed.

What are the benefits?

- Reduced cost compared to current complex and heterogenous IT landscapes
- Reduced lock-in risk through standardization of solutions
- High level of automation and real-time data availability
- Improved collaborative capabilities within and outside the organization



At the start of your MBSE journey?

To talk more about how we can help or to discuss access to our software features database, please email

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