

Streamlining Complex Product Development: Integrating Systems Engineering and SDM in One Platform

M. van den Hove, R. Luijkx
(AUDI AG, Germany)

Dr. M. Liebscher, Dipl.-Ing. M. Thiele
(SCALE GmbH, Germany)

Abstract

Efficient product development, particularly for complex systems like vehicles, increasingly relies on a seamless integration of digital tools and processes. In today's automotive industry, virtual product development is essential for reducing costs and accelerating time-to-market. However, managing Computer-Aided Engineering (CAE)-related work across a large automotive group with multiple brands presents significant challenges. Effective collaboration on CAE data, methods, and processes becomes crucial.

Simulation Data Management (SDM) plays a pivotal role in addressing these challenges by providing a centralized platform for managing, sharing, and automating key aspects of the development cycle. SDM ensures that all relevant data—including simulation models, results, and physical testing outcomes—are consistently available, fostering collaboration and enabling faster, more reliable decision-making across teams and locations.

This paper explores how a Systems Engineering approach, combined with a Simulation Data Management (SDM) platform and Model-Based Systems Engineering (MBSE), supports the efficient development of complex products such as vehicles. It focuses on organizing collaboration within the domain of crash and structural stiffness analysis among numerous CAE engineers across different locations and brands within a large automotive group.

1. Project requirements as Basis for MBSE

The implemented SDM solution provides a comprehensive approach for defining and verifying requirements to enhance development processes and ensure seamless traceability. The entire workflow—from managing technical requirements through verification to final evaluation—is supported, ensuring transparency and consistency at all times.

Requirements management is handled within the Master Data Management (MDM) module of the SDM system. MDM allows test cases and requirements to be systematically organized and later made available as project templates. These requirement templates can then be imported into new or existing projects and adapted and extended to specific project goals. The software supports versioning, updating, and change tracking within that process, which ensures full traceability of the entire workflow.

Additionally, requirements can be enriched with extended attributes such as target market, stakeholder, component, or product features. This enables targeted filtering and flexible adaptation to various project scenarios. Furthermore, target values can be defined at multiple levels, allowing for more granular evaluation beyond the traditional "fulfilled" and "not fulfilled" categories. This enables differentiated assessments, for example, using rating scales like EuroNCAP with color and star scales.

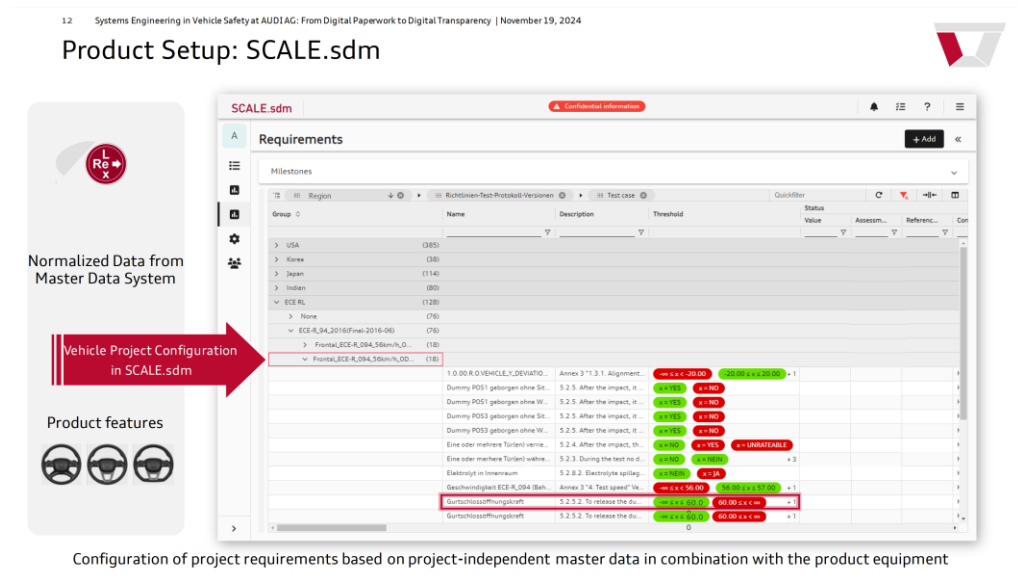


Figure 1: Example project configuration for multiple markets, regulations and test cases[1]

Streamlining Product Development: Integrating Systems Engineering and SDM in One Platform

The SDM solution ensures that all relevant information is readily available and efficiently utilized to optimally manage development processes.

2. Sharing Data and Enhancing Collaboration

When it comes to implementing the required virtual testing of the defined test cases, it is necessary to deal with a vast multitude of different simulation domains and all the data involved in setting up such simulations. Managing all this data and the related processes is at the very core of simulation data management and brings its own unique challenges—especially when it is required to share this data and the related processes among many engineers throughout different departments and even among group brands within the entire group.

Collaborative CAE Model Development

To facilitate collaboration, it is vital to organize simulation data so that common components—such as materials, impactors, barriers, and dummies—as well as process scripts or simulation methods in general, can be shared across the group's various brands. Within the Volkswagen Group, libraries of common CAE models and all types of process scripts are created and maintained by a small number of experts. These are then made available for use by all CAE users across the different group brands and partners.

By centralizing the development and maintenance of these models and scripts, the SDM system ensures consistency and standardization across the group. This not only improves efficiency but also reduces errors and rework caused by discrepancies in models or methods used by different teams.

Management of Product Variants

In vehicle development, manufacturers must manage countless product variants, ranging from specialized sports configurations to family-oriented models and special-purpose vehicles. Additionally, different regulations and market-specific requirements necessitate a multitude of load cases for testing. These dimensions of complexity result in an ever-increasing matrix of simulation variants that need to be created based on the same base model.

To manage this complexity, the SDM system employs an attribute-based approach. Individual components required to build a simulation deck are automatically associated with test cases (in the context of simulations called run-configurations) based on their attributes. This approach allows a single change to the base model to be propagated instantly to all relevant test cases, enabling the change to be effectively evaluated against all defined requirements.

Motivation

rising dimensions of complexity

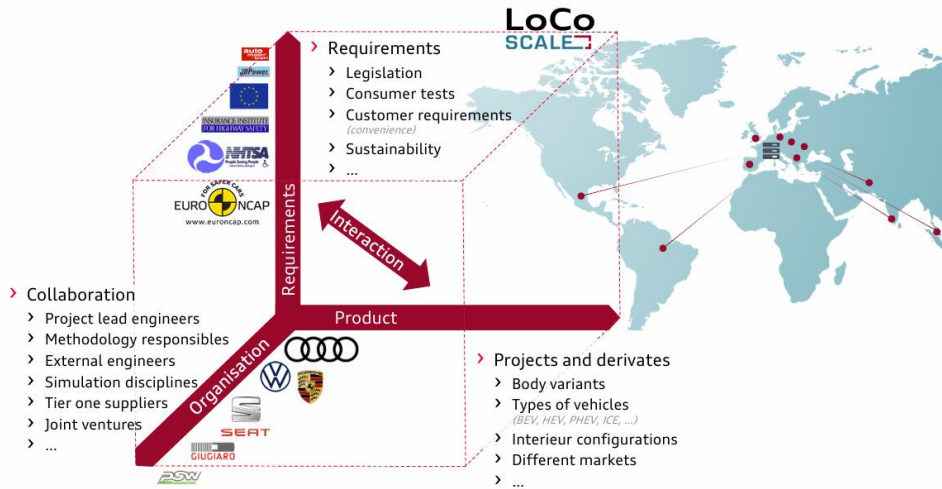


Figure 2: The ad-hoc evaluation of key-results against project requirements for selected simulations or physical test. A context menu action allows the reporting of a test as project status. [2]

Standardizing CAE Processes

The standardization of CAE processes is critical to ensure that they are applicable to everyone in the organization. The SDM platform supports this by providing a system where CAE methods and processes can be defined, managed, and distributed. The platform enables the configuration of simulation workflows that align with standardized practices, which are then accessible to engineers across all brands and locations.

In the past, CAE methods and processes varied among the group's brands, and sharing common CAE models was limited. Overcoming these limitations has been a focus in recent years, with the SDM system playing a pivotal role in facilitating this shift toward standardized, collaborative CAE model development.

Data Exchange and Collaboration Across Locations

To ensure effective collaboration regardless of the engineers' locations, a dedicated IT solution is required to exchange data between all locations within the group and with its various partners. The implemented SDM solution provides such capabilities, supporting the distribution and synchronization of data across different sites.

The platform's robust data management capabilities enable the sharing of simulation models, results, and associated data securely and efficiently. Engineers can work collaboratively on projects, with real-time access to the

To further streamline the development workflow, the SDM solution supports the automated evaluation of actual values against predefined project requirements.

Furthermore, by linking source tests and simulations, the SDM system ensures full traceability across all stages of development. The seamless integration within the platform allows every stakeholder direct access to all relevant information, enabling a consistent overview and in-depth analysis. This comprehensive connectivity enhances transparency and facilitates well-founded decision-making throughout the entire project lifecycle.

The flexible reporting options for both simulation and physical test results significantly increase productivity. The ability to aggregate data based on attributes such as target market, component, or requester provides clear and meaningful insights that support better analysis and decision-making.

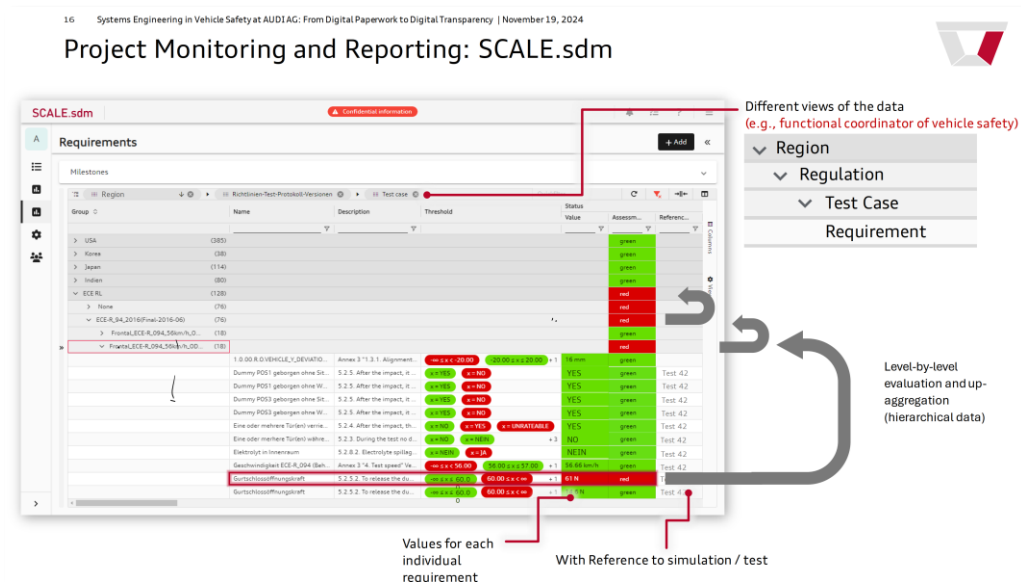


Figure 4: An example of an aggregated rating for Region, Regulation and Test case. The level order and the underlying attributes of aggregation are user-defined.[1]

4. Conclusions

Integrating Systems Engineering and Simulation Data Management within a unified platform offers significant advantages in the development of complex products such as vehicles. By providing robust tools for requirements management, enhancing collaboration across teams and locations, and streamlining validation and monitoring processes, the SDM solution enables organizations to optimize their development workflows.

Streamlining Product Development: Integrating Systems Engineering and SDM in One Platform

The standardized and collaborative approach to CAE processes and data management not only improves efficiency but also fosters innovation by allowing engineers to focus on value-added activities. As the automotive industry continues to evolve, such integrated platforms will be essential in maintaining competitiveness and meeting the increasing demands of the market.

5. References

[1] M. van den Hove and M. Liebscher, "Systems Engineering im Bereich Fahrzeugsicherheit der AUDI AG: Von digitaler Zettelwirtschaft zu digitaler Transparenz," in Proceedings of the 21st VDI-Tagung SIMVEC – Auslegung und Absicherung von Fahrzeugsystemen, Baden-Baden, Germany, Nov. 2024. Available: [Online]. Available: https://www.scale.eu/wp-content/uploads/2024/11/Systems-Engineering-im-Bereich-Fahrzeugsicherheit-der-AUDI-AG_DE.pdf

[2] R. Luijkx and M. Thiele, "Collaborating with CAE Processes and Data Across Several Brands of the VW Group," in Proceedings of the 7th NAFEMS DACH Conference, Bamberg, Germany, Jun. 2024. Available: [Online]. Available: https://www.scale.eu/wp-content/uploads/2024/11/2024-06-10_-_NAFEMS_DACH_-_Collaborating_with_CAE-processes_and_-_data_across_several_brands_of_the_VW-group_-_EN.final-static.pdf