CIMdata eBook

Sponsored by Siemens Digital Industries Software

Driving the Change for the Future of Automotive Development

An Integrated Model-Based Systems Engineering Approach

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Image courtesy of Siemens

Takeaways

A fully integrated approach is required to move and sustain an automaker into a leadership position

Takeaway #1
Today's traditional automakers (i.e., OEMs and their suppliers) not only have to outmaneuver each other, but they also must outmaneuver new market disruptors who are more agile and able to rapidly take advantage of the latest digital engineering and manufacturing technologies and best practices.

Takeaway #2
The exponential growth of vehicle-related electronics and software has elevated the importance of integrated software development within the overall context of a sound model-based systems engineering (MBSE) practice. This requires bringing software development out of the backroom to the forefront of vehicle differentiation, development, and lifecycle support.

Takeaway #3
Only a fully integrated approach can move and sustain an automaker into a leadership position for tomorrow—one that starts integrated and stays integrated.

Takeaway #4
A closed-loop approach across all phases of the vehicle lifecycle—from ideation to design to manufacturing, and through service—is critical. It is throughout the entire vehicle lifecycle where the automaker must continually learn, adapt, and adjust to stay ahead of its competition.

Takeaway #5
Siemens Digital Industries Software's integrated cross-domain MBSE approach has been designed to keep teams integrated, improving decision-making across an extended enterprise and throughout the entire lifecycle. This comprehensive solution, Software & Systems Engineering, is based on five pillars that enable an automaker to manage, define, connect, validate, and ensure compliance throughout the end-to-end vehicle lifecycle and across multiple business domains.

Introduction

New approaches to engineering are required—supported by new solutions

While today's automotive industry may look like yesterday's, and decade's prior, it is significantly different. Change is visible in many facets, including major shifts in global competition and production, enhanced and evolving regulatory requirements, the emergence of rideshare services, and semi- to fully-autonomous capabilities. In addition, there are significant increases in product and manufacturing complexity, durability, reliability, and safety. Traditional automakers are still innovating. But new, and perhaps more agile, disrupters are entering the automotive market from all sides, often looking to topple the status-quo. To address this, many have tried to apply yesterday's process thinking and enabling technologies to address these evolving challenges. Unfortunately, they fall far short of reaching the new level of business support required to be successful. This is forcing automotive original equipment manufacturers (OEMs) and supply chain participants (i.e., automakers) to reimagine and rethink how they design, manufacture, deliver, and support their products.

Vehicles now consist of far more systems of systems as engineers consider IoT-enabled and connected vehicle systems that are aware of their surroundings to make safe, quick, and robust decisions. The role of automotive software, both in-vehicle and off-vehicle, is where significant innovation is taking place. Providing operational services within an automotive product is occurring more often, oftentimes, after it is manufactured. Siloed product development and systems integration as a final step is too risky—at least for those who want to stay successful. Only a more end-to-end and integrated approach is going to get the job done. Albert Einstein defined insanity as "…doing the same thing over and over again and expecting different results." To stay competitive, from new competitors willing and able, to disrupt the market, to vehicle-related software innovations, a new approach and supporting solutions are required.

In this eBook we will discuss the need automakers and their supplier network have for a modern systems engineering approach, and show how Siemens, a proven provider for the automotive industry, is enabling a highly integrated MBSE approach, Software & Systems Engineering (SSE). This approach has been designed to address evolving challenges in new and innovative ways.

According to Siemens, "…complexity in the automotive industry demands continuous engineering across domains, and to be successful, a company must start integrated and stay integrated." It is with this in mind, that CIMdata provides its view of Siemens' approach.

Image courtesy of Siemens

The Increasing Complexity in the Automotive Industry

Comprehending Smart Products Across Lifecycles

In the Automotive industry, the design, manufacture, delivery, and support of driver assisted, autonomous, and electrified mobility products are at a critical inflection point. Vehicle development has always been challenging. That would be true as compared to many other products, but this pales in comparison to tomorrow's anticipated complexities. Automotive software is enabling broader connectivity (both inside and outside the vehicle), improved sensing on and around vehicles, and increased "thinking." This "thinking" will expand as computing horsepower for input processing and control actuation becomes less expensive. Additionally, we at CIMdata recently stated our belief that this is an untapped capability. To properly address this, it will take an integrated MBSE process and technology revolution focused on SSE.

Software has become a significant differentiator, and at times, the most prominent detail in a new vehicle. Software is used to control the vehicle, connect the vehicle to the owner and service organization, as well as sense what is happening around the vehicle. Many functional driving features that were predominantly mechanical are now accomplished using electronics and software. And many user-convenience features that did not even exist a decade ago (e.g., Automated Driver Assist Systems (ADAS)) are now possible thanks to on vehicle electronics and software. Automotive software has expanded as connectivity technology has become ubiquitous. It is everywhere from a chip in the vehicle to a city's infrastructure in which the vehicle must be integrated. Making things more challenging, the amount of software within a vehicle's complex systems is constantly increasing. What started with improved mechanical controls and their reliability, has expanded over the years to also improve areas such as safety and durability.

Other automotive factors driving increased technological complexity include the electrification of propulsion systems. This requires innovation in battery management to provide competitive travel range, and motion sensors requiring synthesis of images to enable an autonomous transportation service. The continued effects of Moore's Law (cheaper and cheaper computing power) and vastly improved network speeds, have provided much greater capacity both for an individual vehicle or a fleet of vehicles. This trend will no doubt accelerate with the adoption and rollout of 5G wireless communications.

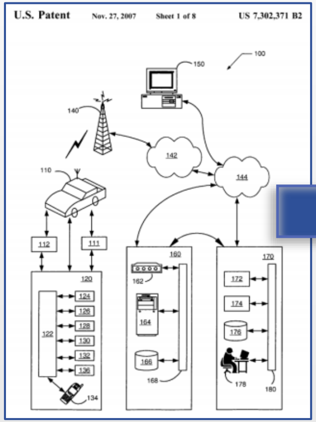
Image courtesy of Siemens

Pervasive Sensing Connected by Clouds

The Problem Transcends the Product

Technology complexity is running head long into consumer expectation complexity

An additional challenge deals with new connected transportation systems. These systems go beyond the boundary of an individual vehicle. Complexity is caused from connecting vehicles to infrastructure—starting with service and moving quickly toward travel efficiency. A systems engineering view of the boundary diagram of these different systems shows that the vehicle is now a sub-system of a connected transportation service. And the services provided are changing as quickly as the pace of technology advances coming from Silicon Valley. In essence, technology complexity is running head long into consumer expectation complexity. Tackling this requires Systems Design Thinking, making sure your solution is robust enough in all its delivered capabilities. This includes those you may not be able to foresee, and an increased vigilance of the competition. Even forces outside the industry are changing customer expectations, for example: music playlists from your phone are available in your vehicle; and Alexa can pay at the gas station (via telematics in the car). Leading and managing this complexity requires MBSE processes and tools like those being brought to market by Siemens.



2005 - Diagnostics To Email

Image courtesy of Siemens

2020+ Emerging Transportation Systems

Vehicles are becoming a subsystems in interconnected transportation systems

MBSE's Impact

MBSE is essential due to the design complexity of today's vehicles and the associated ecosystem

Systems engineering (SE) has been used by experts in the aerospace and defense industries for decades, originally developed in the era of space exploration in the 1950s and 1960s. It is a proven practice for one of a kind, mission critical systems development. Over the past decade, the movement has been towards replacing a document-centric SE approach with a process based on broad, varied digital models. Doing so allows them to be used to perform all types of vehicle performance simulations and be continuously updated, shared, and managed across the various organizational domains and throughout the end-to-end product lifecycle. These functional, logical, and physical models comprise the systems architecture that describe the system's intent. Such models can then be linked with system-level physics-based behavioral models, as well as subsystem and component models, including 3D views and assemblies. Requirements verification and validation can begin early in the design process, leveraging digital models to ensure the systems design will meet customers' expectations and "best design alternatives" from a cost and manufacturing perspective. Alternatives can also be identified and ranked prior to committing to a detailed design and build. This cross-domain integrated process is commonly referred to as MBSE.

The automotive industry uses MBSE to organize new ways of work (e.g., simulation replacing and/or augmenting physical testing), taking advantage of new technologies in support of obstacle detection, learned performance, and new materials or subsystems. MBSE is becoming more valuable, even mission critical as the benefits of reuse, model partitioning, and other linking technologies are realized. MBSE is now essential due to the design complexity of today's vehicles and the associated ecosystem required for developing automotive software systems. SSE starts with a domain-agnostic understanding of the system intent for all domains, while the logical and physical implementation tradeoffs, including automotive software considerations, are examined. This enables innovative disruptions without compromising the existing domains of mechanical, software, and electrical engineering.

It is important to note that MBSE applies well outside of the vehicle that one might own. When it is a subsystem within a transportation system, a fleet, or a sensor for contact tracing, the boundary of the system keeps expanding. In fact, different solutions and services will have common elements or subsystems, the customer's vehicle being just one element of a much larger ecosystem.

Image courtesy of Siemens

Complexity Drives the Digital Twin

A comprehensive digital twin is required to continuously evaluate new capabilities throughout the lifecycle

Customer use data has always been collected and summarized to make future product development actionable, and often to deliver critical insights. MBSE can provide a platform to organize and learn from field experiences. Historically, when a quality issue occurred, recalls and repairs proceeded as quickly as possible, but often products were delivered to customers before corrective action could be applied. Today's connected technologies allow faster monitoring and, one would expect, faster problem resolutions for services in the field. This leads to much lower warranty costs by simply shortening the collection and investigation time and effort. As system complexities evolve, faster response to customer demands and improvements in quality will occur.

A comprehensive digital twin to continuously evaluate new capabilities throughout the product lifecycle is now required. Many instances of the comprehensive digital twin will be used for the purpose of predicting and optimizing the range of performance characteristics required to satisfy consumer wants and safety requirements. These digital twin instances must all be based on the most up to date product data as systems progress from development to manufacturing, and finally into service. The digital thread is the glue that enables rationalization, configuration management, and traceability of information throughout the virtual enterprise and across the entire product lifecycle.

Image courtesy of Siemens

Complexity in vehicle development is greater than ever imagined.

Solving Automotive Challenges

Leveraging MBSE to start integrated and stay integrated

Additionally, industry leaders are now using artificial intelligence (AI) / machine learning (ML) to understand, predict, and resolve field issues as they happen. ML applied to fleet management, especially for shared vehicles, is becoming a common practice for delivery companies. Another key element is gathering unstructured data from multiple sources (i.e., marketing, take-rates, consumer-insights, service-issues, vehicle-downtimes, regional use patterns, etc.) and making it available to engineers with meaningful business-intelligence for product enhancements thus accelerating and enhancing product designs. As transportation becomes a service as opposed to vehicle ownership, the data collected gets used increasingly to improve the overall efficiency for systems of systems. The embedded computers are located onboard and in the cloud that greatly benefits consumers and service providers. Yes, IT departments managing cloud installations will be part of the future transportation services leveraging MBSE. They need a framework that allows dynamic configurations of services using proven and new components with known performance capabilities. The framework will help manage the development, testing, and packaging of future transportation services.

Change is necessary, that is clear. Change or become irrelevant, or perhaps go out of business. That is the concern for many. But what can be done? What approach should be taken? One proven approach is to look to and work with the leaders in the market. These leaders, including Siemens, must have the experience solving automotive challenges of the past and present, and the vision for how future problems will be solved. Additionally, they must provide a comprehensive, flexible, and open solution framework that addresses the industry's complexities. This is where Siemens' Automotive MBSE approach is positioned.

Image courtesy of Siemens

"What is needed, are refined and new processes that allow Automakers to move as fast as these technology disruptors and use their 100+ years of expertise to remain competitive. A way in which they can start integrated and stay integrated. For example, leveraging processes such as design verification in real time, product verification across all engineering disciplines, electrical system automation, and vehicle performance validation and feedback into future designs."—Siemens Digital Industries Software

Siemens' MBSE Approach

Siemens' MBSE approach for Software & Systems Engineering is comprised of five pillars

Siemens' MBSE approach for Software & Systems Engineering, which enables cross-domain model-based dataflows, is comprised of five pillars that support an integrated environment for the management, definition, connection, validation, and compliance of complex vehicle systems and their end-to-end lifecycles. These five pillars are:

- Integrated Program Planning—manages all of the interconnected digital information that defines the systems of systems
- Product Definition—ensures that the "right product" has been defined before it goes to engineering
- Connected Engineering—productive and efficient engineering for concurrency and collaboration within and across domains
- Product Validation—the virtual verification and validation of the intended product combining functional and physical behaviors
- Quality Engineering—ensures compliance in an ever more regulated world where delivering a safe, reliable, and secure vehicle is the goal

Each of these pillars is described below.

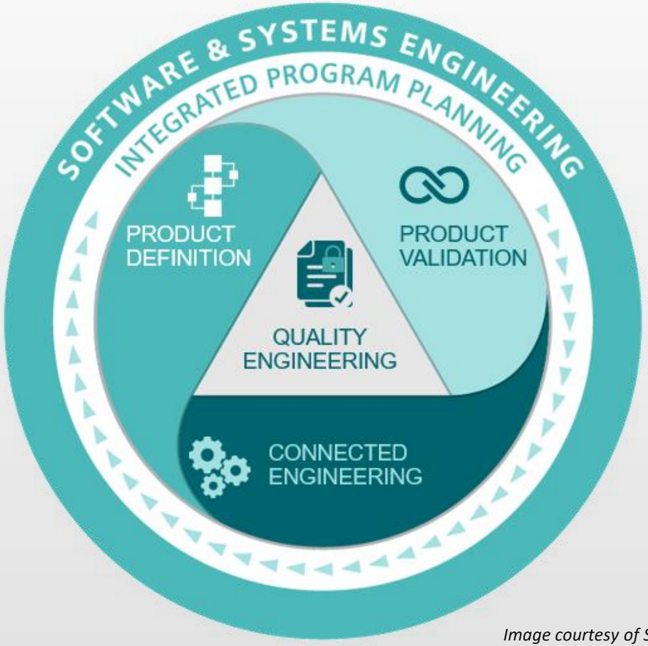


Image courtesy of Siemens

Software & Systems Engineering: An Integrated MBSE Approach

Siemens' MBSE Approach

The pillars that support SSE

Integrated Program Planning

This pillar enables simultaneous development across an extended enterprise. For far too long, planning and project managers have used spreadsheets or other personal computer-based project management tools for their projects. Typical output from these is often of little value to the engineers and is usually out of date until the next project review, which is too often focused on data collection and finding configuration mismatches.

Product Definition

The enablement of today's vehicle definition that has mechanical, electrical, and software needs to be more integrated than ever. Seeing each discipline's development progress in the context of the virtual 3D assembly in motion greatly improves understanding and thus quality. The ability to integrate parameter and requirements management with functional and systems modeling in a multi-domain architecture supports better decision making. This allows everyone to be on the same page to influence downstream development for compliant design of vehicles. Physical testing is significantly reduced as confidence and discipline grow. Designers execute component analyses and simulation experts become data and robustness engineers of complex and integrated systems. The best simulation engineers then use ML to continuously groom managed data from across hundreds of different scenarios to make better decisions. This ensures all stakeholders have a common understanding of the "right product" with realistic models of the system, product, and process intent before engaging engineering for detailed implementations.

Connected Engineering

Connected Engineering is at the center of the complete transportation system of systems, where an individual vehicle is only one of many moving parts. Today, engineers must develop parts and services that address today's requirements and also understand the performance envelope their solution can be used in for tomorrow's products. They need to be connected in a network of developers that allow them to explore uses of any design and/or process element. Whether this is a mechanical part, some embedded software, or even the flow of information between the disciplines being connected with accurate configurations—all of which are crucial.

Siemens' MBSE Approach

The pillars that support SSE

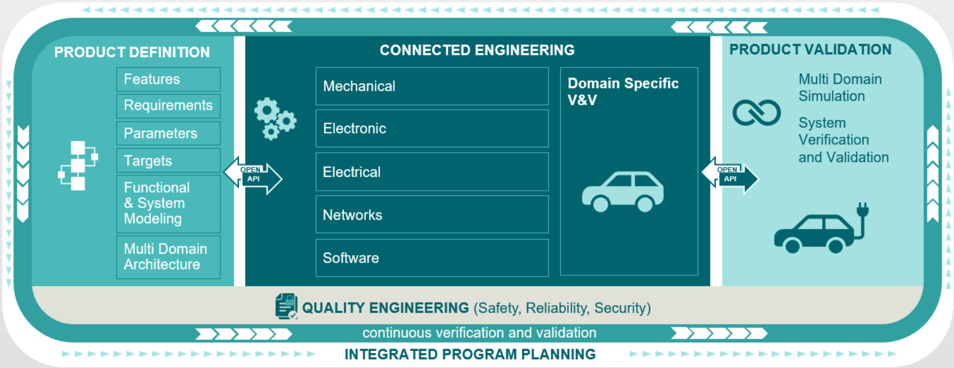
Product Validation

The Product Validation (also known as Verification & Validation) pillar provides proven 0D through 3D multi-physics performance simulation and testing capabilities, traditionally used to verify product designs versus physical prototypes. These same capabilities can now be applied up front to predict overall system behavior and to optimize system, sub-system, and component designs versus end user requirements based on key performance indicators. In-house systems and practices at automakers have often managed these simulation activities and related data in custom IT solutions and semi-manual processes for years. But the complexity of today's cyber-physical systems, such as hybrid and electric powertrains and autonomously operated vehicles, now require an elevated level of multi-domain systems modeling and simulation that spans software, mechanical, sensor, and electrical engineering domains and even includes the end user interaction with both the vehicle and its operating environment. The volume and complexity of both simulation and empirical data requires a platform that can capture, manage, and share.

Quality Engineering

Compliance is an ever more regulated field where delivering a safe, reliable, and secure transportation mechanism is the ultimate goal for all automakers. Quality Engineering can no longer be a separate silo of experts who arrive after there is a problem. Rather, they need to monitor and influence designs and services from the beginning, assuring lessons learned are applied to all products. This drives the need for well-integrated Quality Engineering (i.e., safety, reliability, and security) tools and databases.

Image courtesy of Siemens



Integrated MBSE supported across all phases of development and disciplines

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Conclusion

Siemens' SSE is an MBSE-enabling solution designed to keep teams integrated from start to finish

The challenges facing many of today's leading automotive companies can no longer be solved with yesterday's solutions, or by throwing more people at them. Today's automakers not only have to outmaneuver each other, but they also must outmaneuver new, more agile, and technologically savvy disruptors. Increased complexity exists on multiple fronts, especially in the areas of autonomy electrification, and mobility (e.g., the integration of vehicles within a managed transportation network). This has driven an exponential growth of vehicle-related electronics and software, which in turn has pushed software and systems engineering (e.g., MBSE) out of the backroom to the forefront of vehicle differentiation, development, and lifecycle support. To strive and thrive, a fully integrated enterprise solution approach must be taken that can move and sustain an automaker into a leadership position for tomorrow—one that starts integrated and stays integrated. It is critical that such a solution provide a closed-loop view throughout all phases of the vehicle lifecycle—from design to manufacturing, and finally to service. It is throughout the entire vehicle lifecycle where the automaker must learn, adapt, and adjust continually to stay ahead of its competition. Delivering vehicles that stay fresh even after sale is a growing necessity.

Siemens' SSE is an MBSE-enabling solution designed to keep teams integrated from start to finish, while improving decision-making across an extended enterprise and throughout the entire lifecycle. This comprehensive solution is based on five pillars that enable an automaker to manage, define, connect, validate, and ensure compliance throughout the end-to-end vehicle lifecycle and across multiple business domains. Leading automotive companies have used Siemens' various solutions for more than 30 years, starting with drawings, moving to geometric models for both products and their factories, then managing simulations to replace physical prototype evaluations.

Product Configurators are being used across their applications to provide consistent, on demand configuration management. CIMdata recently summarized a specific example—E/E Systems Development solution for wiring harness configuration and software systems.* Comprehensive configuration management is a keystone to an effective and comprehensive MBSE approach for the expanding complexity of transportation systems. That expanding complexity is in the interaction of all the systems of systems throughout today's rapidly evolving transportation networks, especially those that have not yet been predicted. Ultimately, Siemens is enabling a holistic Digital Thread that is meant to future proof an automaker's transportation products and services.

* See: Capital Expansion Addressing E/E Systems Complexity Commentary