Model-based systems engineering for automotive electronics and software

SIEMENS

White Paper

A plan to succeed

Model-based systems engineering as part of a PLM environment provides the right information so that the right people can make the right decisions as quickly and as accurately as possible. You will produce higher quality vehicles that get to market faster, while reducing defects and re-work, and saving warranty costs.

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Executive summary

Today's cars are better, safer, and more sustainable than ever. They are also increasingly complex, especially with respect to electronics and embedded software. Today's vehicles include dozens of electronic control units governed by tens of millions of lines of software code and are expected to have many more in the future. All of this product content must be carefully planned, manufactured, integrated and managed.

OEMs and their suppliers must work through this complexity and make thousands of informed decisions in order to build the right product and build it the right way. A system architect may choose to model and partition the functions in a system any number of ways, and that decision will affect downstream activities, as do "make or buy" decisions, decisions on how to manufacture the vehicle, and decisions on choice of supplier.

The challenge is that the information you need is spread out across globally distributed teams and, if domain specific, may not be readily available to or understood by others in the team. Model-based systems engineering as part of a PLM environment provides the right information so that the right people can make the right decisions as quickly and as accurately as possible. You will produce higher quality vehicles that get to market faster, while reducing defects and re-work, and saving warranty costs.

Business challenges in automotive electronics and software

Electronics and software play a key role in meeting the challenges in today's automotive industry. Automakers and their suppliers use software controlled electronics to:

- Meet strict regulatory requirements for reduced emissions and improved fuel economy as well as the overall efficiency of combustion engines and electric propulsion

- Provide the constant connectivity customers desire with their smart devices as well as communications between vehicles with features such as adaptive cruise control or with the infrastructure for smart grids and electric charging

- Deliver greater feature content at lower cost to meet the unique market needs in different countries from consumers and government regulations

- Improve overall safety performance for vehicle occupants and pedestrians through active safety features

Electronics and software in vehicles have become critical elements which must be managed effectively since they impact the overall value of the product, its perceived quality and complexity of use. In fact, since 2006, JD Powers' automotive customer satisfaction survey reports issues related to technology have increased 45 percent, and for the last two years, customers have downgraded the ratings of vehicles they perceive as too complicated to use.

Vehicles have thousands of product variations, delivered through multiple electronic control units and the associated code and parameters as well as communication networks and wiring systems; all of which is developed by a globally distributed team from the automaker and its supply chain. With the electrical and electronic systems comprising as much as 25 percent of the overall vehicle cost, this complexity needs to be effectively managed.

In addition, the printed circuit boards used to drive the performance of the electronic device can be almost one third of the total cost of the unit which represents a significant cost aspect to control. Yet at the same time, OEMs must ensure that all this technology is easy for drivers and passengers to use. If not, the quality of the vehicles will suffer, both in terms of actual software errors and in customer perception of the overall complexity of use,

Minimizing warranty costs and serviceability related to software is an increasing concern for automakers and suppliers. They also need to effectively manage the growing amount of software in vehicles and the escalating software development costs that can come with this growth. As a result, today's innovation trends require that the software development lifecycle is given equal importance to that of the mechanical lifecycle.

Product lifecycle management addresses the challenges in automotive electronics and software

The automotive industry has a rich history of driving process transformations and adopting new technology solutions to improve productivity and efficiency in developing vehicles.

With the greater variability in vehicle content, introduction of electric drive trains and tougher environmental guidelines, migrating to a systems-driven product development approach is the key to achieving significantly shorter development cycles and better compliance. This approach focuses on upfront definition of the system, its requirements and validation of the functions and behavior of the system and individual products it contains in the context of the given requirements.

The systems-driven product development approach works across all disciplines and increases engineering productivity, identifies issues earlier in the development process to reduce risks and rework at launch, manages the complexity across the domains and helps bring higher quality vehicles to market earlier.

Minimizing warranty costs

A major automotive OEM deployed an in-vehicle software data management solution on 57 worldwide vehicle programs. The system supports synchronized mechatronics design that helps the company track embedded software content associated with an electronic control unit (ECU). The solution enables the OEM to leverage its global innovation network by tracking content throughout the lifecycle of a vehicle and coordinating its use and function as part of the overall system.

In-vehicle software management capabilities enhance enterprise-wide collaboration and standardize product data management associated with the growing volume of embedded software that the company is building into its fleet of increasingly intelligent vehicles.

Using PLM technology to manage in-vehicle software, this OEM has greatly reduced repair work, saving more than $100 million in warranty cost savings and setting the stage for additional savings through software re-use.

Systems-driven product development helps to transform the business processes to a more cross-disciplined and collaborative approach supported by an information management transformation on a common virtual platform. For automotive electronics and software, this process also encompasses model-based systems engineering. The business process is supported for better analysis of the definition, design and behavior of the electronic board net and the related software, hardware and electrical components.

Model-based systems engineering supports the decision making process by providing complete information from requirements to validation and by making existing knowledge available across vehicle programs. The model-based approach connects electrical, electronics and software to the other disciplines and allows for driving cross-discipline simulation as part of the overall process. The benefits of this approach are profound, in that:

- Product development time is accelerated by reducing re-work, duplication of effort, and re-engineering of the implementation for an existing feature or function. For example, three different vehicle program teams no longer need to create three unique implementations of the same feature, such as a sunroof.

- Quality and reliability improves because system and product interfaces can be standardized and integration issues are found and resolved early in the development process prior to physical build events.

- Reuse of best-in-class carryover content in a vehicle and ready access to corporate knowledge (product information, specifications, lessons learned) from previous development programs allows new product teams to ramp up quickly and requires less development time and testing, lowering the final product investment required.

- Information barriers are brought down by sharing everyone's data simultaneously across domains and maintaining the voice of the customer throughout the value chain.

Effectively tying this globally complex environment together for success in model-based systems engineering requires an integrated solution that:

• Provides a shared semantics model for automotive electrical, electronics and software. This model enables the fundamental implementation of the elements of model-based systems engineering into the global information backbone.

• Contains the end-to-end solution for the design and manufacturing of software-driven electronics-based products to address the unique needs of each domain such as vehicle architecture definition or design of the mechanical, electrical, electronics and software product elements while also integrating and validating the resulting products, subsystems and systems in the vehicle. This solution also allows the business to take advantage of best of breed applications to define the best electrical and electronics solution in the context of the overall systems driven product development process, and

• Enables unified lifecycle execution and management for better decision making as OEMs and suppliers support the speed and complexity of change in products and processes from a usability, integration and deployment perspective.

Why is a shared semantic electrical, electronics and software model important?

OEMs and suppliers develop and integrate systems (such as driver assistance systems) as part of a complete vehicle board net. These systems need to interact together according to the defined requirements and are composed of many electrical, electronic and software components. It is crucial for you to be able to define and develop the best solution across these elements, to ensure their proper integration and to best leverage the organization's resources. Therefore, it is important to have the interfaces and semantics between these elements well defined.

Understanding the functions each subsystem and component needs to perform in relation to the complete system or vehicle operation ensures that better decisions are made during the development process. Capturing the interfaces between components and systems is critical to make certain that the vehicle will operate properly under all customer conditions. Understanding the physical and logical architectures ensures that parts will physically and electrically interact correctly. Making this full context or complete definition available allows all members of product development teams to design their products effectively while ensuring that they do not compromise overall vehicle performance.

Even with the resurgence of the automotive industry, cost pressures remain high for OEMs and suppliers as they strive to provide the desired vehicle variations as well as the introduction of new technologies and features for world markets. They increasingly look to reduce their development costs through improving commonality and re-use across a reduced number of global vehicle platforms. Through the semantic model, all relevant information is connected, which means that changes can be driven with high accuracy in terms of forecast predictability of expected development cost and timing.

OEMs and suppliers must meet stringent government and regulatory requirements covering safety, emissions, fuel efficiency, material usage and disposal at the end-of-life of the vehicle. The new ISO functional safety standard (ISO 26262) for electrical and electronic systems in vehicles addresses possible hazards caused by malfunctioning safety systems, including the interaction between them. Compliance to standards is the key to ensuring the ability to sell the vehicle in each market and to avoid recalls and warranty issues. Being able to completely document and predictably simulate the defined behavior according to those regulations is also of key importance to OEMs and suppliers. The shared semantic model helps to manage and relate all of this information.
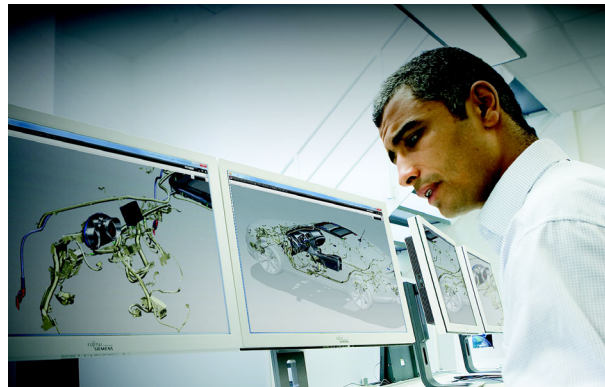
Siemens PLM Software's shared semantic model understands the needs of each domain and supports the integration of the multiple tools and datasets used in each domain. It provides the ability to capture and manage all of the functional, logical and physical implementation information generated in each domain and to create the appropriate allocation and associations between design objects. It also leverages industry standard formats to develop and support integrations to industry leading applications in each domain.

Associativity improves overall efficiency and quality

Siemens PLM Software's solution enables you to create a cross-domain systems definition that can be used as a logical system for a whole vehicle or product platform. In turn, you can decompose key product requirements to these systems and use these connected requirements to understand how key characteristics such as performance, maintainability and ergonomics are affected by given requirements. This shared semantic understanding helps you

capture and manage all the requirements, functional, logical and physical implementation information generated in each vehicle domain and creates the appropriate associations between design objects. This common context helps break down the walls between groups and increases the potential for design re-use.

As the various subsystems are being defined, a key aspect of the process is capturing detailed information, including the messages being shared through the connections and ports – basically, the detailed definition of each function's inputs and outputs. The information provides a common understanding across the supply chain of what messages each subsystem will communicate, its format, description and more. Our solutions can capture these models as part of the product structure, organizing and storing the messages using Teamcenter® software from Siemens PLM Software. This single source signal library can be created and used on a single project or leveraged across multiple programs and platforms. Software functions are embedded into system models to facilitate context-specific product deployments that address requirements for different countries, different customer usage and different compliance laws. The model also includes calibration and configuration data and the management of an extremely large number of parameters, formats and data across widely distributed engineering communities.

An additional benefit of capturing, managing and documenting the interfaces (signals and messages) is the ability for everyone in the supply chain to reference and re-use proven interface information. This reduces the likelihood that issues will happen late in any program. It also has the added benefit of being a central repository for the information needed when creating any ISO documentation, such as any ISO 26262 documents required to validate safety features.

Notes attached to objects capture issues, actions, questions and answers, and rationale. These notes help form a record of the decision support information required by downstream stakeholders during initial design or when assessing the impact of a change. They can be used in exported documents and in other information, giving you an integrated information gathering facility that enables you to capture information that is commonly lost.

The well defined shared semantic electrical, electronics and software model allows automotive OEMs and suppliers to manage all the dependencies of information across the entire lifecycle and across all vehicle programs and their variations. The relationships, with specific semantics, enable you to trace

information, such as requirements or implementation decisions, back throughout the entire development process. Through this traceability, it is not only possible to completely understand a system model and be able to validate its performance according to the requirements in a vehicle project, but it is also possible to easily understand the impact of a change of behavior and how this impacts existing and future vehicle programs. The ability to trace back all of the needed information also supports compliance and warranty reductions.

Re-use speeds development and reduces costs

For automotive OEMs and suppliers, the ability to reduce rework and increase reuse can improve the bottom line. Electrical, electronics and software is often re-used in vehicles to save development time and cost. Siemens PLM Software solutions enable the effective management of software in the context of the entire product. This embedded software design management supports the creation of software design components, software business objects, dedicated object relationships and lifecycle functions. Supporting unique design objects, you can create software design components which represent self-contained and re-usable software design elements. The management of the lifecycle of these elements remains independent of the released software and other parts of the product.

In the case of electrical and electronics, it is also very important to leverage existing components such as electronic control units, sensors, actuators and memory. Components that have been already used are tested to provide the expected performance and quality. From a purchasing point of view, it is much more efficient to standardize on components. Teamcenter helps you classify components for re-use by attaching key performance attributes to those elements, enabling users to easily identify desired components.

Systematic configuration enables re-use in many ways. For instance, a system model can be built in such a way that it serves many different requirements and can be configured for a given purpose by using variant configuration within a given context. The lifecycle configuration is the key to recognizing further evolutions for either a given component or an entire system model considering its own lifecycle and the particular usage of a certain version within a particular vehicle project.

An end-to-end solution for comprehensive multi-domain process integration

Automotive OEMs and suppliers have increasingly turned to electronics and software as the key mechanism to incorporate new features and capabilities demanded by consumers. The advantage of using software to implement much of this functionality is the speed with which vehicles can now incorporate new consumer electronics and keep pace with the fast changing requirements and desires of the global markets.

To be able to react to those demands as quickly as possible, it is important for the extended development team to have a comprehensive development process that provides an understanding of the entire electrical and electronics board net architecture as well as system design and interactions across the vehicle platform, systems, subsystems, assemblies and components.

OEMs and suppliers have alternative solution options for implementing functionality to satisfy the market demand, yet must ensure that the options are cost-effective and viable. These alternatives can also vary by market. Because OEMs and suppliers have to react quickly to changing demands, they simply cannot afford long development times with many iterations and cycles. With the increase in electrical, electronic and software content, it becomes even more critical to demonstrate that the performance of the vehicle meets the requirements through validation and testing, while also reducing the cost and time associated with hardware prototypes. The process used to design and build the product is comprised of numerous individual decisions, thus it is important for the extended development team to have information available to support the decision process.

Siemens PLM Software provides an environment that supports product development efficiency and increased product reliability by offering a complete automotive solution to drive comprehensive global vehicle development across systems and domains from planning and design through manufacturing and service.

The solution provides the processes, methods and tools to create and manage a cross-domain systems definition across the vehicle lifecycle. In turn, you can decompose key product requirements to these systems and use these connected requirements to understand how key characteristics such as performance, maintainability and ergonomics are affected by given requirements.

These solutions mitigate new product development risk by enabling the entire value chain to understand and align product requirements, program constraints, engineering concerns, compliance issues and manufacturing considerations. Just as importantly, you can use our solutions to combine systems-level understanding with requirements understanding to make better tradeoff decisions.

For automotive electronics and software in particular, OEMs and suppliers often have significant investments in various 3rd party tools to address specific design needs, such as in circuit board design or software design, or to accommodate the need to work in a multi-CAD environment.

Siemens PLM Software believes in the importance of openness in its PLM platform and makes it easy for you to integrate these tools to build the cross-domain knowledge together into a single, logical location along the development process.

This includes openness not only in terms of standards, semantics, integration architecture and API's, but also in being open and flexible when it comes to integrating and adapting existing and best in class business processes. Siemens PLM Software leverages its shared semantic model and industry standard formats to develop and support integrations to industry leading applications in each domain. This provides OEMs and suppliers an opportunity to increase the development team's productivity while providing the best return on your existing investment.

Continuous validation

This end-to-end solution for the design and manufacturing of software-driven, electronics-based products addresses the business needs to define and manage the system design as well as the specific needs of each domain, including the opportunity to take advantage of "best of breed" applications in defining the electrical, electronics and software solutions in the context of the overall systems driven product development process. One of the advantages of this

solution is the ability to define, validate and manage system interactions across the domains throughout the lifecycle.

To illustrate this, consider the electrical system and control system interaction controlling the opening and closing action of a sunroof, including the motion sensors that allow you to drive the sunroof backward and forward on its track and activate the tilting mechanism. The requirements and the behavior of the systems are modeled at the functional and logical level.

You can combine your analysis of the control system with the mechanical system to see the behavior of the product before you manufacture it, ensuring that the control system and the software controls perform exactly as intended. A change to the wire routing can be assessed for impact to the system. The supplier validates the new harness and then completes further subsystem and system validation.

This example shows how you can virtually validate the requirements for the sunroof by combining the results of the different development disciplines along the lifecycle, ensuring that you get the desired performance of your product and that you can make the right decisions in a multi-disciplinary environment combining both software and mechanical control for this sunroof.
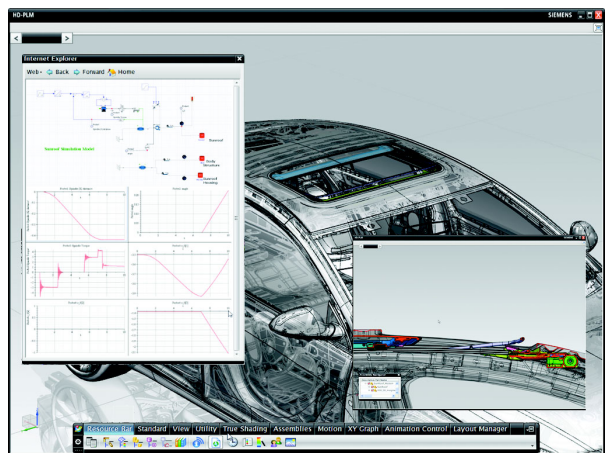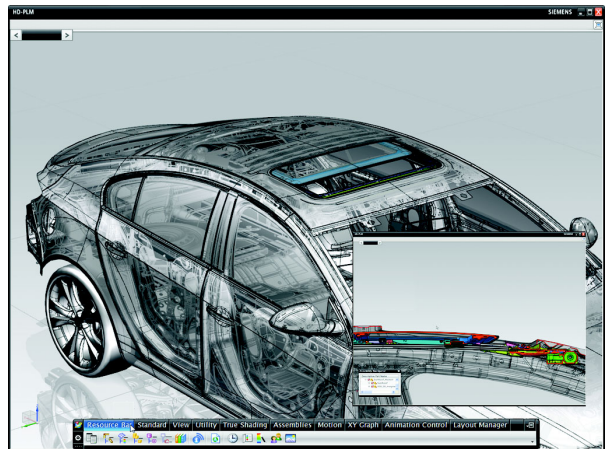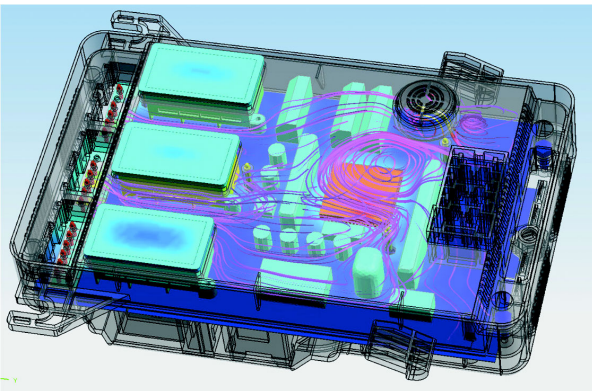
Siemens PLM Software's NX™ software for computer-aided engineering (CAE) offers a wide array of analysis types that can be conducted from within a single environment, including linear and nonlinear structural analysis, thermal, flow, motion, optimization, durability, composites, response dynamics, and specialized applications for electronics cooling and space systems thermal analysis.

It's also important to note that NX CAE can also be used as a pre-processor to third party solvers, supporting ANSYS, MSC Nastran, Abaqus for nonlinear analysis, and LS-Dyna for explicit crash or drop test analysis.

The other advantage to conducting all these analysis types from a single environment is that analysts can speed multi-physics workflows. All of the modeling happens in the same environment, and because it is all tied to the same base design, analysts can rapidly re-run all their analyses with each new design iteration.

In addition, Siemens PLM Software's solutions facilitate closed-loop feedback that recognizes when strategic program intent is at risk and informs lifecycle stakeholders of this impending impact. For example, you can generate reports as part of the ISO 26262 template and FMEA (Failure Mode and Effects Analysis) as part of the quality assurance in the design and development phase.

Improved productivity for requirement creation, management, and re-use

Siemens PLM Software's requirements solution allows companies to create, capture and share requirements across the entire value chain. By defining both product development and production requirements early in the take to market cycle and linking these requirements to downstream processes, you enable decision makers and execution teams to understand how and why each requirement was created and how product and production changes will impact these requirements. This encompasses high-level to detailed functional requirements that are partitioned and allocated to products, to system components and domain areas such as software, electrical and mechanical design.

Model-based system design

Companies must model and analyze the interactions among a product's requirements, subsystems, constraints and components to optimize the tradeoffs that drive crucial decisions across the entire product lifecycle. Model management is important for maintaining the dependencies and relationships, especially as the models evolve, or are referenced in multiple products or configurations.

Visio, a functional and logical modeling/diagramming tool popular with systems engineers is embedded in Teamcenter and allows you to quickly create objects, connections and ports (signals and messages). The Visio stencil elements are mapped to Teamcenter objects and relationships, so you can create trace links from requirements to functional elements in a diagram.

In addition, Teamcenter's integration with MatLab/Simulink enables the use of the de facto standard in behavioral modeling in the integrated engineering system. You can easily investigate a wide range of alternative solutions and validate them against customer requirements and safety regula-

tions, which require OEMs to provide evidence of accurate and complete implementation of requirements.

Teamcenter provides model management and traceability to enable users to quickly find and confidently incorporate the correct version of the model need to validate the design. In addition, design teams can browse the links to assess the impact a change will have on the design and the models it uses, thus saving time and improving product quality.

By enabling the definition of the system and modeling its functional behavior, overall quality improves since all stakeholders are provided with a system-level understanding of the product and how each of its systems and components fit together.

Collaborative, concurrent engineering

Today's consumer is highly informed, more discerning and very product savvy. Furthermore, with vehicle price, performance and perceived quality on a virtually level playing field (per sector), design has never been more critical to success. However, design is fashionable, ever changing and evolving, which puts automotive manufacturers and suppliers under continuous pressure to meet the demands of the customer and get products to market faster. To do so, vehicle and product designers require tools that enable them to rapidly explore ideas, reuse knowledge, optimize concepts, and visualize and validate designs from ideation through production, all within a collaborative environment that facilitates informed cross-functional decision making and ultimately accelerates the global vehicle development process.

NX provides knowledge-based engineering templates to enable designers and studio engineers to explore vehicle architecture and packaging configurations to rapidly progress designs from ideation to feasible concepts while simultaneously taking into account the voice of the customer. Early visibility of design data (by the wider organization) can reduce design iteration and facilitate smooth progression through development gateways. Throughout design development, geometry is continuously validated to ensure the myriad requirements are satisfied without compromising aesthetic integrity. NX delivers comprehensive visualization and validation diagnostics within a visually engaging environment, providing high definition decision support throughout the process.

Integrated wire harness design
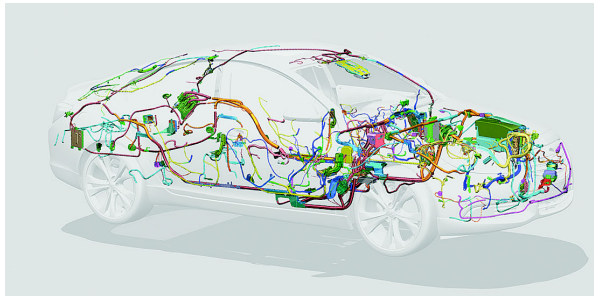
The wire harness touches every other system in the vehicle. Vehicle build combinations drive tremendous complexity in the variations of harness assemblies that must be designed and built. Securing the routing and package space throughout the vehicle is a continuous challenge, especially because products and systems the harness interfaces with can have changing dimensions, feature content and functionality as the vehicle program moves to production. Further, the wire harness is perceived differently by various members of the extended vehicle team. For example, a wire harness is a three-dimensional geometric structure to the engineer designing the routing or for the manufacturing engineer determining the installation process. It is a schematic to the electrical designer looking at its electrical properties and it represents a communication structure to the embedded systems engineer. Siemens PLM Software's solution supports these differing engineering perspectives while ensuring that each view remains aligned to the bill of material.

To facilitate logical design, the Teamcenter solution is integrated with key third-party solutions, including CIM-Team E3 Series and Mentor Graphics' Capital Harness (CHS). This flexibility allows manufacturers to tailor the solution to their own electrical design processes and tools. To ensure best-in-class support for the physical design process, Teamcenter is integrated with Siemens PLM Software's NX™ design system (NX Electrical Routing), and with a variety of third-party mechanical CAD systems.

NX helps you eliminate the need to build a physical prototype and reduces product development time by allowing designers to perform interface checks, validate design rules, visualize the routing pattern in 3D, and trace the location of specific wires and connections. The shared semantics data model discussed earlier is based on various aspects of the

STEP and KBL standards. As a result, Teamcenter helps you transfer, store and manage all of the logical, physical and bill of material (BOM) data in a single secure location.

In addition to helping you manage your data, Teamcenter enables design teams to define wire harnesses consisting of multiple configuration options and variants from a single wire harness design. This robust data management capability enables design teams to improve design efficiency, increase re-use and reduce scrap. Teamcenter enables design teams to establish effective workflows and change processes that maximize design productivity and minimize the time needed to create a fully verified wire harness design. In the Teamcenter environment, design teams are able to easily identify what aspects of the wire harness have changed, determine where changes will be incorporated and quickly assess what other parts of the wire harness will be affected.

Integrated printed circuit board design

Today's vehicles contain dozens of electronic control units (ECUs) linked together with communication networks and embedded software to deliver the

necessary controls to meet emissions, fuel economy and safety standards and many driver information and infotainment features. The design of the printed circuit board (PCB) remains a critical part in the ECU, often accounting for up to 30 percent of the unit's cost.

From the initial inception, to creation, to analysis and to manufacturing, companies need a comprehensive solution for PCB design and manufacturing that includes visualization tools that provide quick diagnostics and error tracking. Any change in the product may affect PCB performance, such as power requirements or components chosen and the binary code specified by a second subsystem supplier.

Teamcenter is integrated with virtually all major ECAD and MCAD tools, helping you manage all of the design, fabrication, assembly and visualization data produced during the electronics lifecycle. By combining these mechanical and electrical design tools with Teamcenter applications, product manufacturers can transform otherwise disconnected tools and processes into an integrated electromechanical design solution that enables them to lower costs and improve quality, while increasing design productivity.

Teamcenter enables ECAD teams to increase productivity by integrating design tools from Mentor, Cadence, Intercept and Altium. It also provides a gateway to integrate ECAD tools you may have developed internally or procured from other third parties. On an enterprise level, these integrations allow widely dispersed design teams to align ECAD design implementation with product requirements, capture PCB design and manufacturing data, manage ECAD part libraries, coordinate with suppliers, foster environmental compliance initiatives, facilitate collaboration and concurrent engineering initiatives and quickly assess the impact of change, thereby minimizing change-related rework. At the user level, the integrations enable designers to open and save native design files, access approved parts, generate visualization files, share fabrication and assembly data, create BOMs containing both mechanical and electrical parts and collaborate with other domains and suppliers.

A whole product approach for managing the automotive embedded software lifecycle

To address the increased role of software in today's products, best-in-class companies are focusing their product development efforts on effective management of software in the context of the entire product.

Teamcenter's embedded software design management capabilities enable software design teams to manage software deliverables in the same single source of product and process knowledge environment used to manage electronic and mechanical design information. This whole product approach accelerates product introductions, lowers costs and improves product quality.

Teamcenter embedded software design management supports the creation of software design components, software business objects, dedicated object relationships and lifecycle functions that enable the effective management of component-based software design processes in alignment with other product design disciplines. Supporting unique design objects, you can create software design components representing self-contained and re-usable software design elements. You can manage the lifecycle of those elements independent of software release versions and other parts of the product.
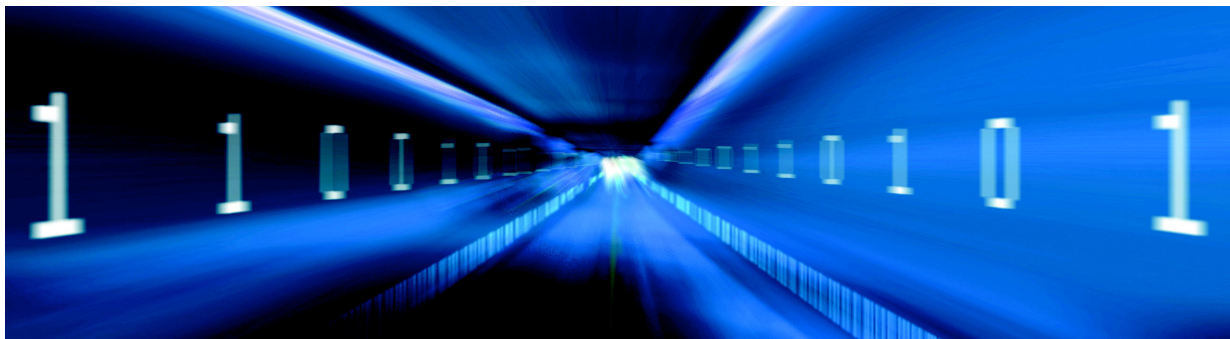
Together with requirements and systems engineering modeling capabilities, Teamcenter provides a complete software and product management environment including:

- IBM-certified "Ready for Rational" integration with ClearCase for software configuration management

- Embedded software management to track and manage software binaries as a "part"

- Signal and message management to define, track and manage message sources and targets

- Software calibration and configuration data management to define, track and manage the software parameters used by embedded software modules to control product functionality and behavior

- Embedded software design management to define, track, manage and re-use software design components, business objects and object relations across multiple products and platforms

By using Teamcenter to help manage software as part of the entire product lifecycle, best-in-class companies accelerate the development process and ensure product quality and reliability. Just as importantly, this state-of-the-market approach ultimately enables product makers to meet, or better, their delivery schedule and product cost targets.

Unifying the lifecycle execution and management

An automotive electronic product typically includes content from multiple domains such as mechanical, electrical, printed circuit board design and embedded software. Each of these domains typically has a different development process and lifecycle that needs to be integrated effectively to deliver the product that will meet its expected requirements. OEMs and suppliers have significant investments in existing IT and businesses processes and want to get the best return on that investment. This means that the PLM platform must be open to integrate existing and homegrown solutions and act as a single source of reliable and verified information for all domains, including electrical, electronics and software.

OEMs and suppliers work globally to develop and manufacture vehicle options to address different markets. This requires the ability to execute processes, methods and tools with a global reach and to make all those different participating sites part of the integrated model-based systems engineering process for electrical, electronics and software. In addition, suppliers might have different interaction models running concurrently based on their business role in particular projects. This needs to be securely implemented and to be modified as needed when business requirements change.

To support the speed and complexity of change in products and processes, it is critical that OEMs and suppliers have one single source of accurate and reliable information for managing all aspects of the electrical, electronics and software development and manufacturing and integrating it with the overall vehicle context, change control, configuration management and schedule management.

Siemens PLM Software provides the ability to:

- Consistently manage change across multiple domains and different development stages and with respect to the schedule of the overall vehicle project

- Simplify design collaboration by defining, managing and sharing working contexts for product development

- Provide Lifecycle representations that can associatively define and relate multiple BOM representations of the product structure for different lifecycle stages or processes

- Manage options and variants to organize products into modules and marketing options, thereby facilitating faster response to market opportunities and increased product/part reuse

Teamcenter supports a best-practice solution that enables you to define workflows and initiate, administer, review, approve and execute product changes or new part requests on an enterprise basis. Within these structured processes, you can leverage change documents such as problem reports, change requests, change notices and approval cycles.

In addition, product teams can relate electrical, electronic and software design data to the product, platform and model where it is used. Product teams can define each product option and variant in the same product structure and establish all appropriate connections and dependencies. These connections and dependencies help design teams quickly search and identify relevant data for any product variant. These features are especially valuable for avoiding

data duplication and facilitating the re-use of proven electronic modules and other intellectual property. These connections and dependencies also help product managers identify what other parts of the product will be impacted when changes are proposed.

Project tasks and resources can be incorporated into schedules and managed workflows. Product managers can assign and track resource workloads (for both humans and tools), identify dependencies and resource constraints, and determine the progress and current status of each item defined in the project. As a project proceeds and new requirements arise or unexpected issues appear (such as supplier resource constraints to develop in the given timeframe or a new technology / functionality), the product manger can quickly identify what impact these activities might have on the overall schedule and whether team members from other projects are available to assist with the development effort. By balancing and optimizing the project's time and resource constraints, these capabilities help mitigate project risks and eliminate last-minute surprises.

Leveraging a unified lifecycle execution and management environment with structured workflows, end-to-end issue tracking, coordinated change, and configuration and schedule management processes enables development organizations to meet delivery targets, eliminate errors, reduce costs and ensure total product quality.

Conclusion

Siemens PLM Software offers OEMs and suppliers an automotive electronics product development solution to improve distributed development teams' understanding of the product as a whole, and to use that total product understanding to better optimize the trade-offs that drive detailed design, manufacturing, sourcing, sales and service decisions throughout the product lifecycle. The solution provides a rich, integrated environment for the development and management of mechanical, electrical, electronic and embedded software content in a single source of product and process knowledge.

Using this integrated resource, engineering teams can retain their domain focus, even while working in each other's context to jointly meet overall development goals. This ensures a clear understanding of design intent and continuous change impact across the entire electro-mechanical system, minimizing warranty issues, and improving the cross-domain collaboration that fuels innovation.

Automotive OEMs and suppliers can:

• Define and capture the complete set of requirements across the vehicle in a single requirements environment, accessible globally 24/7

• Effectively assess and manage the impact of requirements and product changes to ensure that the overall performance of the vehicle meets requirements and satisfies the customer

• Understand the system definition and interfaces across domains and avoid integration issues by linking requirements, functions, logical and physical interfaces, architecture definition and product structure

• Define and manage interfaces and dependencies between the different vehicle systems and domains so that the impact of a change can be quickly identified and assessed, thereby avoiding iterative loops and rework

• Leverage integrations with best-in-class tools for modeling, software, electronics, and mechanical design, allowing engineers to work within familiar tools sets while capturing the information in one location for improved productivity and potential re-use

• Demonstrate compliance with customer and regulatory requirements through full traceability and control of requirements across systems and across domains

• Manage all the complexities of global product variations by accurately representing the bill of materials, including software and electronics, for all product configurations

The ability to couple the automotive electrical, electronics and software solution with other enterprise processes ensures effective management of work across the lifecycle, and that all information is organized, traceable, and accessible globally. This highly efficient automotive development and manufacturing environment helps automotive OEMs and their suppliers to build the right product and build the product right, resulting in innovative products getting to market faster, at lower cost, with improved quality and reliability.

About Siemens PLM Software

Siemens PLM Software, a business unit of the Siemens Industry Automation Division, is a leading global provider of product lifecycle management (PLM) software and services with seven million licensed seats and more than 71,000 customers worldwide. Headquartered in Plano, Texas, Siemens PLM Software works collaboratively with companies to deliver open solutions that help them turn more ideas into successful products. For more information on Siemens PLM Software products and services, visit www.siemens.com/plm.

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