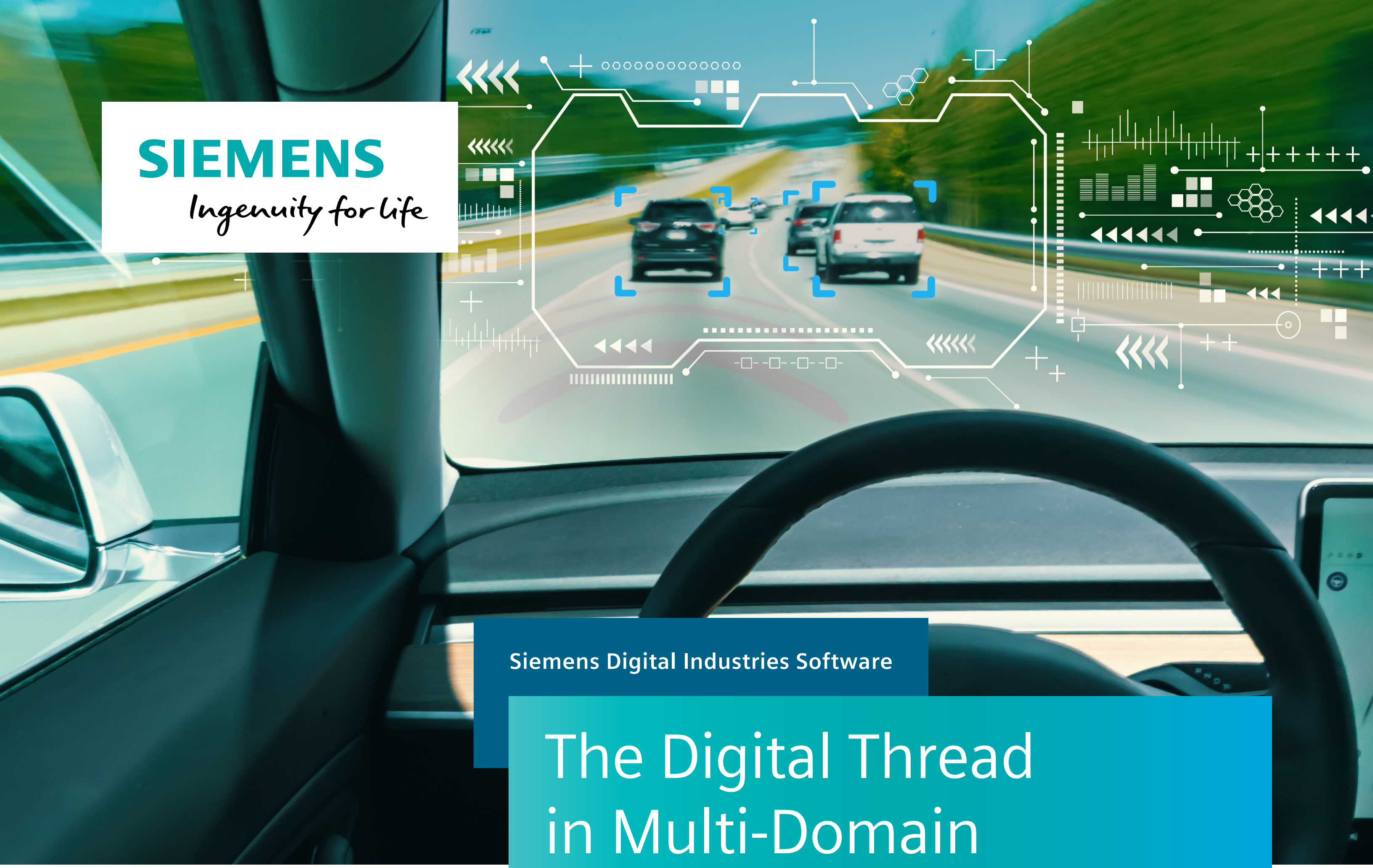

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The Digital Thread in Multi-Domain Integrations

Executive summary

The development of increasingly advanced vehicle features and functionality is contributing to a rapid growth in the cross-domain complexity of modern vehicles. Primarily, this is due to an explosion of electrical and electronic content within vehicle architectures. The continued growth of vehicle E/E architectures demands tighter integrations between the electrical, mechanical and PLM domains. As the E/E systems become more critical to vehicle features and functionality, cross-domain collaboration must become more frequent, and more effective.

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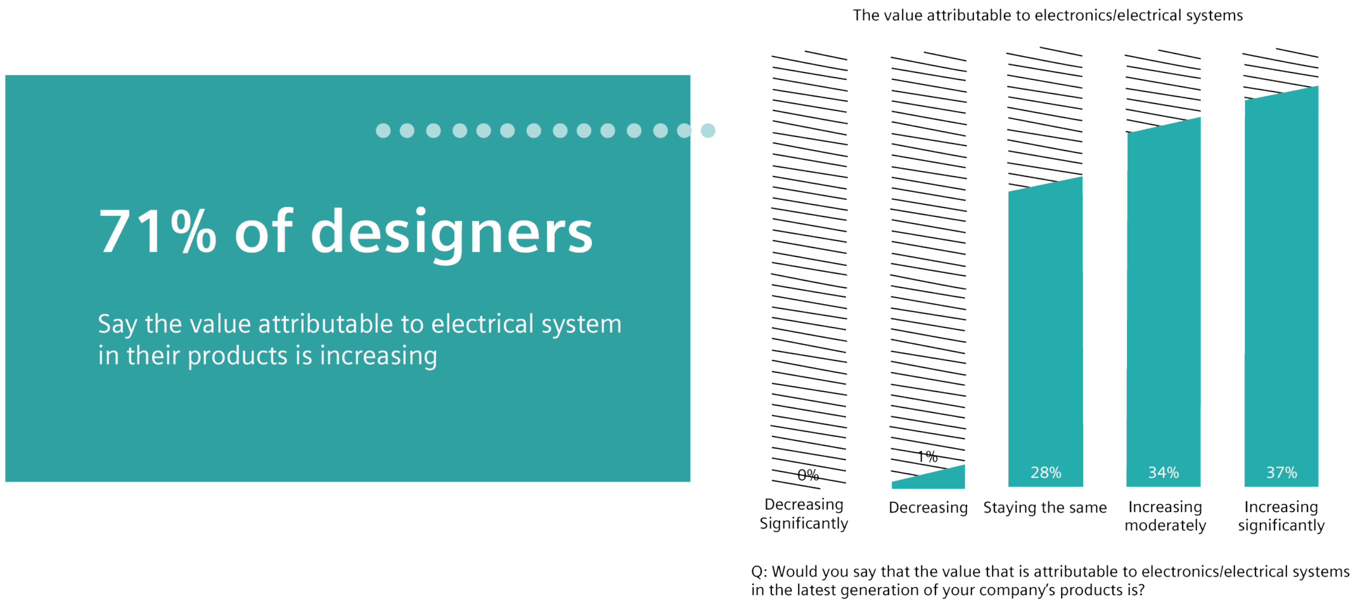
Introduction



*Engineering.com research report: Integrating Electrical and Mechanical Design. Do product teams see value?

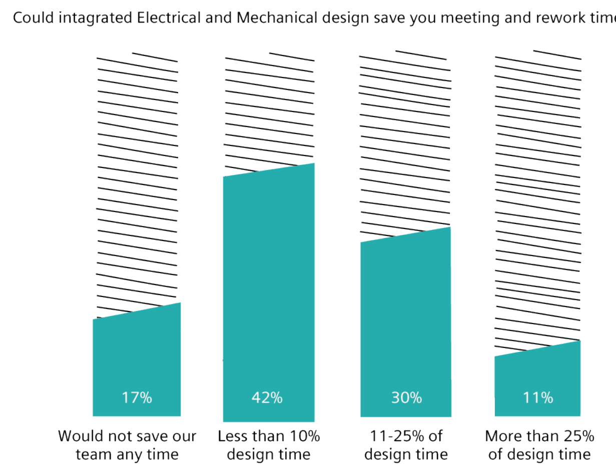
Figure 1: A majority of designers report growth in the electrical and electronic systems of their products.

The complexity of products in every industry, from automotive and aerospace to consumer products is increasing. One of the primary drivers of this growth in complexity is a near-universal increase in electrical content across products of all types. According to a survey conducted by Engineering.com (2018), 71 percent of designs have increased in electrical content in the last few years (figure 1). Mega-trends such as autonomous vehicle development, electrification, IoT connectivity and increasing consumer demand for advanced features have caused the electrical explosion in modern products. And, the growth of electrical and electronic content is only expected to continue in the future.

Furthermore, certain aspects of the E/E systems design in modern products are now critical to the functionality and safety of the product. As a result, E/E systems are no longer a secondary objective, but crucial to overall product development. Historically, E/E systems have been added and integrated late in the product development lifecycle, while the mechanical design has tended to drive product development. As the electrical domains have become more important, a growing need for integration between engineering domains during product development has become evident. As systems, particularly safety or mission-critical ones, are increasingly enabled by a mixture of electrical, electronic, mechanical and software components, they require a similar mixture of domain expertise during design and development.

83% of designers

Could save time with better integrated electrical and mechanical design



Engineering.com research report: Integrating Electrical and Mechanical Design. Do product teams see value?

Q: Would an integrated system of Electrical and Mechanical design save you meeting and rework time.

Figure 2: 83 percent of designers feel they could save time through improved integrations between the electrical and mechanical domains.

Current methods, processes and engineering tools, however, do not support such integration among domains, leaving engineers to attempt cross-domain engineering through manual and ad hoc processes. In fact, as shown in figure 2, 83 percent of designers said that they could improve their design time with better integrations between the mechanical and electrical CAD environments (Engineering.com, 2018). 30 percent of those respondents indicated that these integrations could save up to 25 percent of their time spent in meetings and design rework (Engineering.com, 2018). Finally, 73 percent of teams indicated that they could reduce the overall product development schedule with integrated ECAD and MCAD environments (Engineering.com, 2018).

Given the significant potential benefits, modern E/E systems and wire harness solutions support tighter integrations between the electrical and mechanical domains. Advanced solutions, such as Capital from the Xcelerator portfolio, can interact with mechanical and product lifecycle management (PLM) solutions in multiple ways. For instance, Capital and Siemens NX can connect directly, enabling engineers from each domain to understand the context of the other. The electrical engineer can trace a given wire from the electrical environment directly to its placement in the 3D model, checking for potential issues such as being routed close to a power source or wet zone.

Advanced E/E systems and wire harness engineering solutions already support such improved cross-domain integration and collaboration. The products of tomorrow, however, are only expected to become more complex. As a result, additional capabilities and more advanced features are in development that will help electrical and mechanical engineers overcome this complexity through more frequent and effective collaboration.

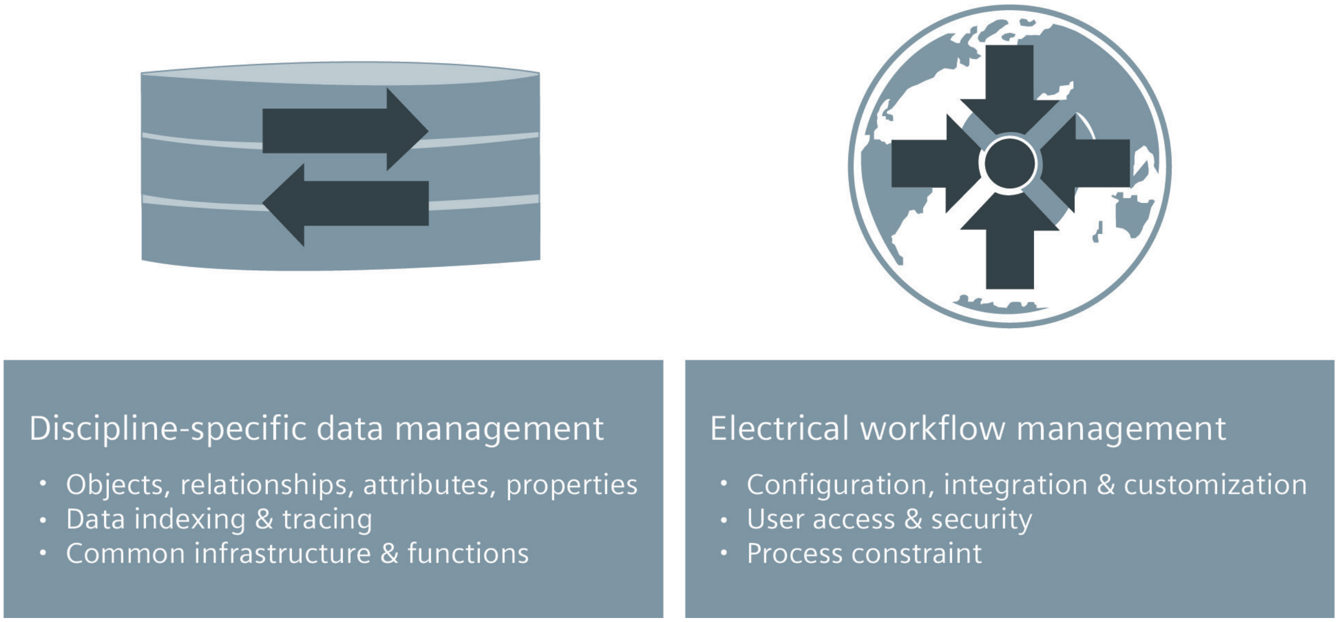


Figure 3: A strong digital thread provides data management and workflow management during the vehicle engineering process.

The robust digital backbone of modern E/E systems engineering solutions provide two fundamental services during the vehicle engineering process (figure 3). First, they maintain a comprehensive database of design data including design objects and relationships throughout all abstractions and design levels. This database is one of the most critical advantages a modern solution holds over legacy systems and engineering methods. Data is maintained in a consistent, organized, and secure fashion, ensuring the accuracy and integrity of the data at all stages of vehicle development. An engineer can understand how a functional block in the E/E architecture manifests as devices, wires and software application in the detailed wire harness and software domain designs.

The second service provided by the robust digital backbone of modern E/E systems engineering solutions is workflow management. Modern solutions include security and access features that ensure the appropriate engineering teams and domains can access relevant designs at the appropriate time. Furthermore, these solutions feature design status functionality that allows each team to control when their design is released to other groups, or indicate the current state of a design and next steps. Integrations with product lifecycle management (PLM) environments and cross-domain engineering solutions extend these capabilities to help manage workflows among cross-domain teams, a crucial feature in light of the growing trend towards multi-domain systems in modern vehicles.

Product lifecycle management (PLM) integration

More robust integrations with PLM solutions are being developed with the goal of bringing the E/E systems and models fully into the top-level product lifecycle. Such integrations enable each stage of the E/E systems design to interact with the overall product context, both pulling from and adding to this context. Today, PLM solutions can facilitate design exchanges, store bills-of-materials and engineering reports, and provide mediated and controlled interactions between ECAD and MCAD solutions. As the integration of ECAD and PLM environments improves, additional capabilities will be unlocked.

For example, publishing data from the electrical environment will be streamlined, and companies will be able to implement additional security measures like user authentication. Furthermore, electrical engineers will be able to incorporate their designs into product configuration management and control processes. This will allow engineers to import configuration data to drive automation in the ECAD environment. Additional capabilities will include synchronized parts libraries between engineering domains managed by the PLM solution, workflow integration and requirements linking throughout the entire product development lifecycle.

MCAD integration

Direct connections between ECAD and MCAD solutions can enable more than just live cross-probing between environments, streamlined data sharing and design integration. Tight integrations between these environments will allow engineers to begin leveraging generative design technologies at the vehicle platform level, automatically generating outputs for each domain, including mechanical, electrical, software and other domains. In addition, tight integrations enable cross-domain change management, allowing engineers to control the flow of changes.

Platform-level generative design with integrated ECAD/MCAD

Generative design takes inputs from a variety of sources and automatically fuses them together to produce the required output for that stage. At the platform-level, the generative engine takes in a full model of the vehicle, including logical designs and physical constraints, and synthesizes wiring based on a set of configurable rules and constraints.

Each of these inputs provides certain constraints on the potential output of the generative design. The harness topology from the MCAD environment provides physical constraints for the wiring and other harness components, such as bundle lengths, and the available routing paths through the mechanical components. The logical systems define devices and connectivity, and a device interface list specifies the parts that should be used and their properties. Finally, the configurable design rules guide how wiring and other outputs are synthesized. These rules can specify when to use splices, minimum distance between splices, routing constraints of primary vs. secondary systems and more.

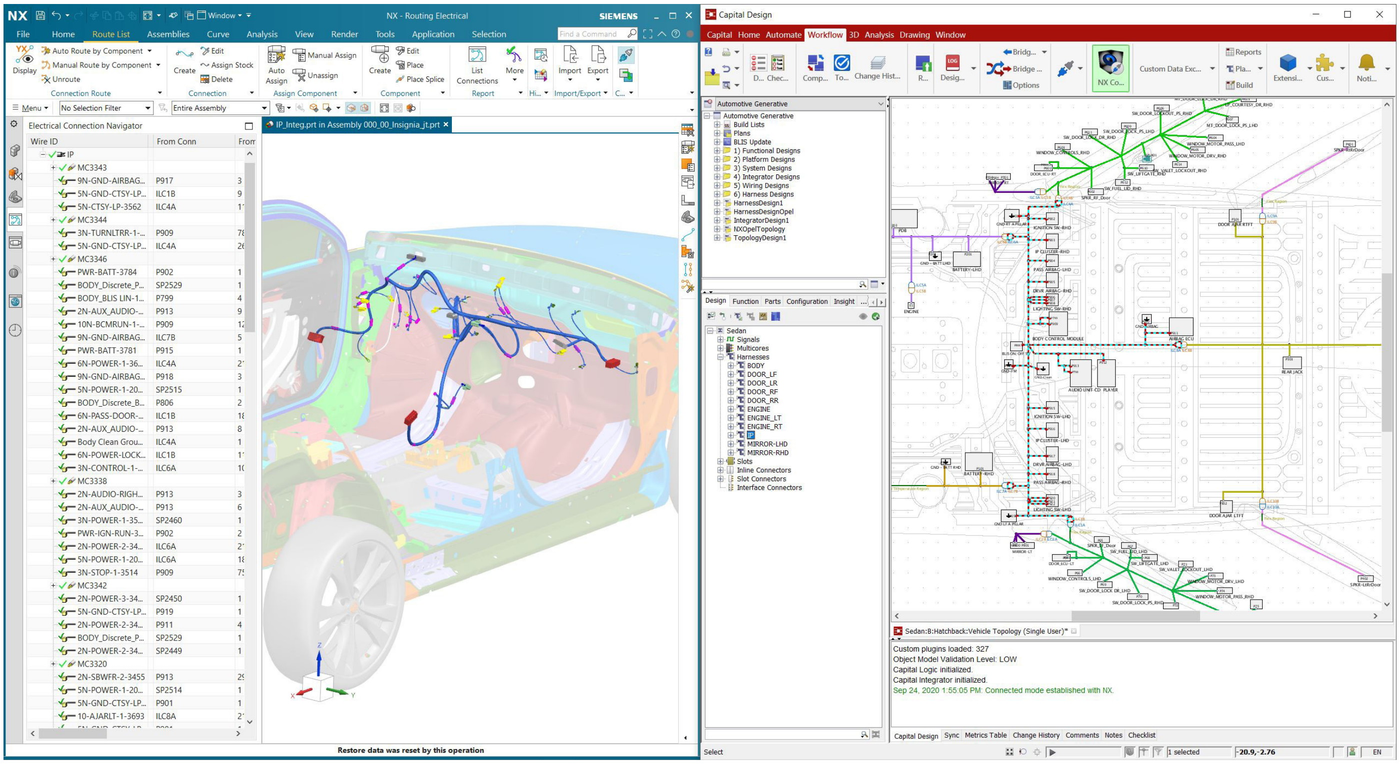


Figure 4: Integrations between ECAD and MCAD environments enables generative design to leverage cross-domain information. Here, the mechanical engineer uses electrical information to generate the physical routing for the wiring (seen in blue).

Generative design then synthesizes wiring, connectors, splices and more to satisfy the required connectivity, physical dimensions and other constraints (figure 4).Platform-level generative design outputs can then be used throughout the rest of the vehicle development. In fact, the outputs from the platform-level synthesis can be used as inputs to generate more detailed outputs for downstream processes.

For example, synthesized wiring and connectivity data can be used to generate physical schematics of the electrical systems. Such schematics are still widely preferred for design reviews or to drive the creation of technical publications. Wire harness definitions can also be extracted from the synthesized data and fed directly into the wire harness design tools. The harness engineers can refine the harness designs and even automatically generate service documentation for vehicle maintenance and service technicians.

So far, generative design outputs have been leveraged throughout the E/E design domains. Continuing development of the integrations between ECAD and MCAD solutions, however, allow this data to be pushed back into the mechanical domain as well. Synthesized wiring, components and other electrical data can be bridged back into the MCAD solution via a direct connection with the ECAD tool. In the mechanical design, the harness structure is updated with all the relevant electrical information, such as component names, wiring specifications and more. Now that the mechanical design is updated with all electrical information, the electrical engineers can understand the physical placement of electrical components within the vehicle.

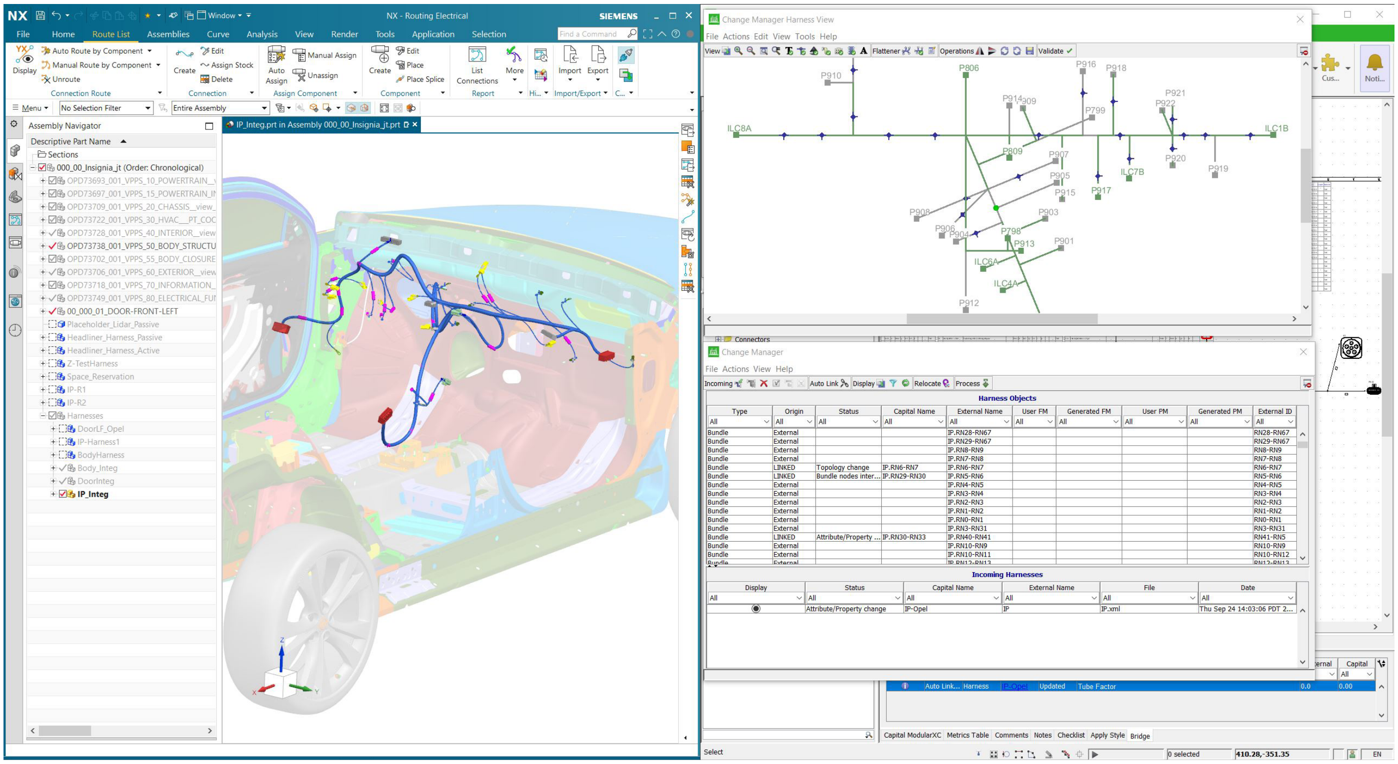


Figure 5: Automated change management tools help engineers identify and sort through incoming design changes. On the right, the electrical engineer examines incoming changes from the mechanical domain.

Multi-domain change management

After generating designs and updating each domain, inevitably changes are made that must be propagated back through each affected design. For the engineers, the challenge is how to propagate these changes in a controlled and consistent fashion to each affected design. This includes changes initiated in either the mechanical or electrical domains that manifest in the other. Managing such cross-domain design changes can be a significant obstacle to development progress.

Modern electrical systems and wire harness engineering solutions, such as Capital from Siemens Digital Industries Software, feature integrated tools that automate and accelerate these tasks. Changes are automatically highlighted and identified by the affected components, design level and more to help engineers quickly locate and understand what is being changed and how (figure 5). Furthermore, designs can be compared across abstractions with inconsistencies called out automatically by the solution.

As changes flow across domains, it is important to maintain control over ownership of the design data. The integrated change management tools in modern E/E systems engineering solutions, such as Capital, feature change policies that automatically constrain who can modify design data. Ownership over data can be determined at an object and attribute level so that the change policy can be tailored to individual design flows. This also allows for highly detailed change policies, such that rules may be set for specific attributes of individual components. For example, a rule can be set that specifies that MCAD is only able to update the weight attribute of a connector, but not the electrical characteristics.

Specifying data ownership down to the level of objects and attributes ensures that data always flows in the correct direction, and encourages concurrent engineering. Mechanical engineers can continue development of the vehicle's mechanical systems without concern of overriding progress being made in the electrical design. As both mechanical and electrical designs progress, the automated change policies ensure that design changes are accurate and enacted by the appropriate domain.

Example of connected ECAD-PLM-MCAD flow

Let's walk through a short example of an integration between ECAD, MCAD and PLM environments. In this example, we will examine the integrations between Capital, NX and Teamcenter, all part of the Xcelerator portfolio.

Teamcenter Active Workspace acts as the main integration point between the ECAD and PLM environments. It provides a direct view into Teamcenter from all of the Capital design and engineering tools. The links between a design in the ECAD environment and data in the PLM solution are context-sensitive. From a design in Capital, an engineer can open Teamcenter and be taken directly to the relevant data. Menus within the applications are also context-sensitive, providing choices appropriate for the design in question. The electrical engineer can also publish data and designs to the PLM solution, or access data stored in it, without leaving the ECAD environment through Active Workspace. Furthermore, the relationships between design objects and data are maintained in PLM and displayed in intuitive diagrams, making it easy to understand how a given design is related to the rest of the product.

For instance, an electrical engineer working in Capital Logic can publish the wiring design to Teamcenter and investigate its connections with other design data, all without leaving Capital Logic. The lifecycle of the wiring design will be maintained in the PLM environment. If additional work is required, the engineer can use Teamcenter to drive the creation of a new revision in the context of the required change.

Next, both the ECAD and PLM solutions are tightly integrated with NX and other MCAD applications. Capital can export PLMXML data for a wire harness design and store it within Teamcenter. Then, the mechanical engineer can access this PLMXML harness data from the PLM environment and use it to define the physical connectivity for the harness design. The mechanical engineer can then pass the physical connectivity data for the harness back into the controlled PLM environment. From here, the electrical engineer can obtain the updated harness design data and import it into the ECAD tool. In Capital, change management tools can help the engineer to identify changes to the design and automatically flatten MCAD model into a 2D representation ready for detailed design activities.

Finally, through these integrations, the PLM environment can store comprehensive bills-of-materials that include both mechanical and electrical components, terminals and more for an engineered harness. This, in turn, streamlines the preparation of a harness design for manufacturing.

Conclusion

The development of increasingly advanced vehicle features and functionality is contributing to a rapid growth in the cross-domain complexity of modern vehicles. Primarily, this is due to an explosion of electrical and electronic content within vehicle architectures. The continued growth of vehicle E/E architectures demands tighter integrations between the electrical, mechanical and PLM domains. As the E/E systems become more critical to vehicle features and functionality, cross-domain collaboration must become more frequent, and more effective.

Fortunately, modern E/E systems and wire harness solutions support tight integrations between the electrical, mechanical and PLM environments. These capabilities allow for robust model-based engineering of the electrical and mechanical systems with a robust data backbone managed in the PLM environment.
As vehicles continue to become more complex, improved integrations between ECAD, MCAD and PLM solutions will enable faster design cycles through platform-level generative design, robust data continuity and automated configuration control. As a result, vehicle manufacturers will be able to bring advanced vehicles to market on increasingly tight timelines.

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