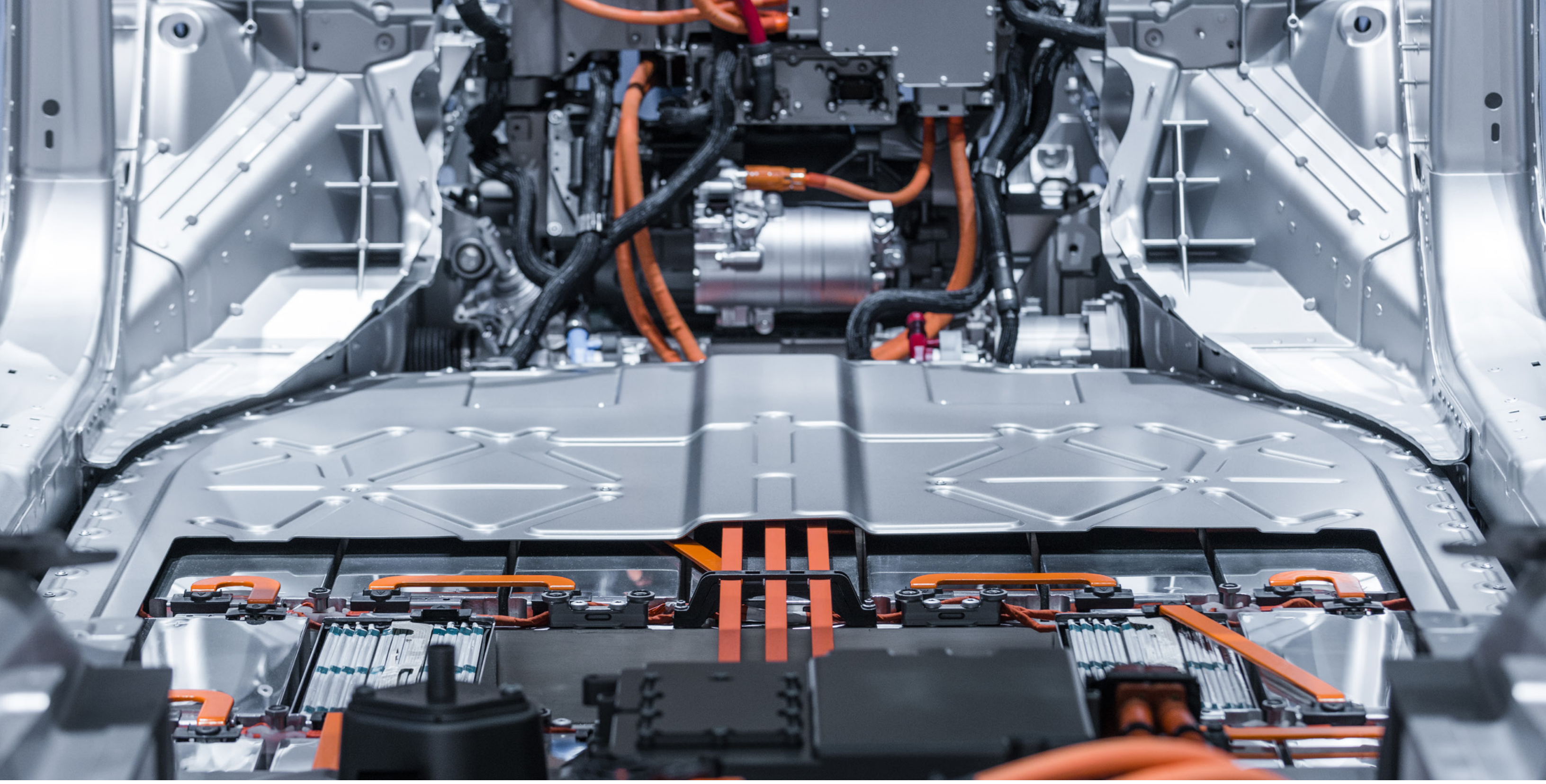

DIGITAL INDUSTRIES SOFTWARE

Opportunities and challenges for wire harness manufacturers

Executive summary

Whether design teams construct wire harnesses with a Build-to-Print, Build-for-Manufacturing, or Full-Service Supplier methodology, they can benefit from a holistic, digitized approach to manufacturing. As part of the Siemens Xcelerator portfolio of products, Siemens Capital™ software provides a comprehensive E/E systems development solution to efficiently engineer today's smart products. It covers the design, manufacture, and service of electrical systems, as well as E/E system and software architectures, network communications, and embedded software development.

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Introduction

In this white paper, we'll explore key trends and challenges in wire harness design, specifically with respect to Connectivity, and how organizations can leverage Siemens Capital to:

- Expand the profitability of wire harnessing
- Verify design information and customer requirements rapidly
- Automate processes and minimize data re-entry
- Eliminate mistakes earlier in the product lifecycle
- Turn product complexity into a key competitive advantage

Key trends in wire harness manufacturing

Wire harness manufacturing is a low-margin business, and auto manufacturers are challenged with creating complex products amid evolving electrical innovations and design uncertainty. The increase in software-delivered end-user features has resulted in a need for additional space to package electronic control units. Electrical engineers must work harder and smarter to keep up with those demands and requirements, and safely deliver electrical designs into production.

The following trends are impacting how OEMs and tier-one suppliers for wire harness manufacturing operate:

- **Pressure to reduce program costs and schedules** is undoubtedly present as competition from startups continues to grow. Everyone is motivated to reduce development schedules.
- **Electrification is seen everywhere**. Today, about 80% of product innovation and differentiation is based on advances in electronics and software, and this is true across all types of vehicles, from automobiles to airplanes, and even massive trucks used in open-cast mines.
- **Autonomous vehicles are gaining momentum** – in 2020, there were roughly 35 million autonomous vehicles worldwide. This trend drives an increase in electrical content, and the need for verification and compliance.
- **Globalization** has been an ongoing trend for a long time. As electronic design can't happen in isolation and typically involves stakeholders across geographic boundaries, many organizations are adopting the "design anywhere, manufacturer anywhere" concept.

These trends have significant impacts on OEMs across the Automotive, Heavy Equipment, and Aerospace industries. Gone are the days in which automobiles had just an audio unit and a few switches in the door. Since 2010, new electrical features such as sonar, heated seats and others were added. At that time, different types of networks were introduced to handle the increase in ECUs.

The heavy machinery industry also has to deal with ongoing business pressures of reducing costs, increasing margins, and improving quality, as well as bridging the gap between electromechanical collaboration. These agile yet robust processes specific to electrical design cannot hinder the time to market nor create additional compliance challenges. To meet the demand for customization, configurations must permeate the entire electrical process. A lack of design automation and integration can result in many critical wiring design errors that could impact costs or safety.

Finally, as with the automotive and heavy equipment industries, the electrical system context in Aerospace is growing rapidly at the rate of a 25% increase every five years. While that might sound manageable, keep in mind that this content needs to be designed into a platform that is shrinking, not growing, in size. Power demand has increased 10X over the last 50 years, and the electrical wiring interconnect system (EWIS) now accounts for up to 3% of aircraft weight.

Impacts for wire harness manufacturers

So, what does all of this mean for the tier-one suppliers or whomever else is making the wire harnesses for these industries?

1. **Material costs**: Harness manufacturing has always been a low-margin industry, and as such, optimizing the designs has always been a factor, especially when the price of copper – the main component in the harnesses – is beyond a manufacturer's control.
2. **Time to market:** Given that manufacturers across all industries need to accelerate the development cycle, wire harness manufacturing teams need to manufacture in low-cost countries and ship production parts by boat, which sometimes takes up to three months to reach the final destination.
3. **Shrinking labor markets:** Organizations operating with a minimum amount of staff and budget must find ways to automate tasks, to reduce manual labor while meeting required output levels and time-to-market objectives.
4. **Workplace globalization:** With many wire harness manufacturers working towards a "design anywhere" model, teams must be able to share data that is centrally available.
5. **Speed of change/change management:** OEMs must implement changes quickly, post-processing, verify their designs, and ensure that they can be manufactured at cost in record time – sometimes in 24 to 48 hours.
6. **Various inputs from OEMs:** Many wire harness suppliers and manufacturers work for multiple OEMs, each of which has their own systems and outputs. Various inputs can cause issues when attempting to standardize internal processes.
7. **Integration with legacy systems:** It's critical that new design tools work well with whatever legacy systems a manufacturer has.

To address these challenges, Siemens has long since been a pioneer of the comprehensive "digital twin," leading in the digitalization of many industries that benefit from this. Digital twins of both product design and manufacturing are created ahead of a collection of actual production feedback to mirror, optimize, and improve reality. Additionally, performance and operation information is brought back upstream to optimize product design and manufacturing and enable effective and efficient product modeling for mechanical, electrical, electronics, and software disciplines. Understanding and optimizing the flow of data and the relationships between those disciplines hinges on creating and maintaining a digital twin.

What Is a digital twin?
A digital twin is a virtual representation of the actual harness design, and it's a key concept in model-based systems engineering (MBSE). Replacing antiquated manufacturing engineering tools and methods while continuing the flow of design data through use of a digital twin is vital for efficient and cost-effective wire harness manufacturing.

Most vehicle manufacturers have implemented a full lifecycle digital twin, to maintain traceability of the design, manufacturing and usage processes of a vehicle. Capital extends the concept of the digital twin to harness design by providing a validated harness model and a digitized manufacturing process model, which can be leveraged to transform a company's engineering, costing and manufacturing performance, and, ultimately, boost profits.

Siemens Capital: Streamlining E/E systems development

Capital is designed explicitly to simplify and streamline this E/E systems development task (see Figure 1).

Siemens' approach for vehicle electrification E/E systems is to cohesively integrate requirements and system models into a comprehensive E/E architecture that drives the development of software architecture, network communication architecture, integration, verification, and visualization of embedded software systems – all while ensuring proper electrical distribution, drives, electrical harness design, manufacturing, and service publications. This entire flow ensures that vehicle-level features are collaboratively implemented with the necessary traceability and systemic prompt for reuse.

With the exploding complexity of E/E systems, development happens in the context of Model-Based Systems Engineering (MBSE). Moreover, E/E systems are part of our broader lifecycle program within organizations, and Siemens provides deep integrations into PLM systems and other necessary domains

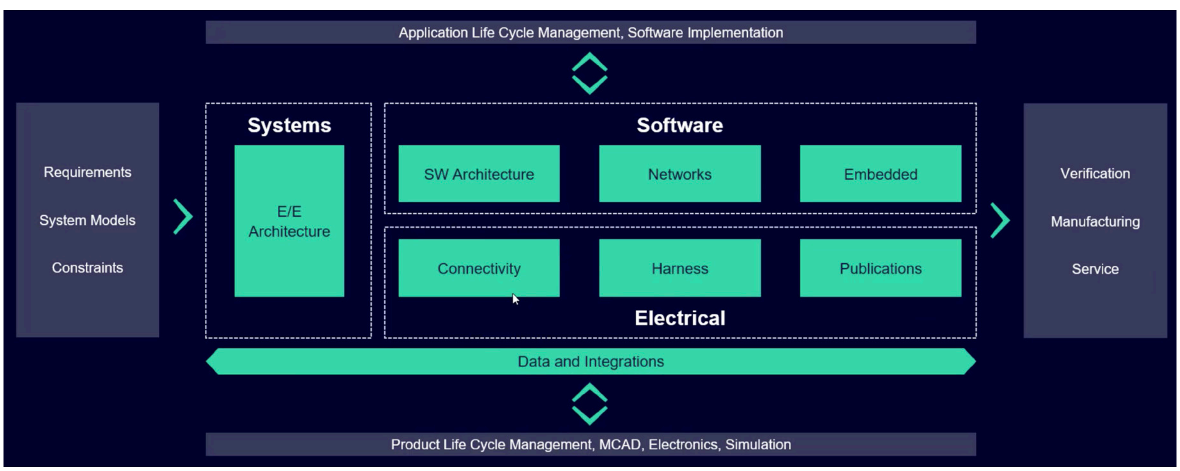

Figure 1: Siemens Capital Open and Integrated Portfolio

throughout the product development process. Capital integrates into other domains to deliver truly integrated system development that encompasses MCAD, PLM, and ALM systems.

For vehicle electrification, Siemens focuses on three key elements of this comprehensive solution, driven by a common E/E architecture: network communication, software development, and electrical distribution. For the purpose of this whitepaper, we'll focus on the Connectivity domain, where the electrical distribution design is performed.

Designing the electrical distribution system

Let's turn our attention to the electrical distribution system and learn how Capital addresses the challenges of the Connectivity domain in wire harness design (see Figure 2).

The electrical system carries the signals that support the software and hardware that realize the platform's functions. It also supplies power to the myriad devices on the platform, including sensors and actuators, supporting the journey toward greater reliability and lower weight.

Traditionally, the system has consisted of wires and cables carrying dedicated analog and digital signals; however, these are increasingly being replaced by data buses implementing high-speed networks. Logical systems, end devices, and requirements from the E/E architecture can be captured in the digital twin through the familiar interface of the schematic. These schematics and wiring diagrams are model-based instead of simple drawings. They are intelligent data, hence fully traceable and verified against the requirements of the upstream E/E architecture. As such, wiring can be developed using the familiar interactive paradigm, system by system. This process is underpinned by electrically focused data and process management coupled with the Siemens Xcelerator data backbone, to further extend the digital twin's scope.

Individual system wiring can be merged to mechanical models of the platform, enabling real-time interactive physical design in the context of the platform's topology. This enables engineers to easily understand and manipulate the physical bundle paths. In

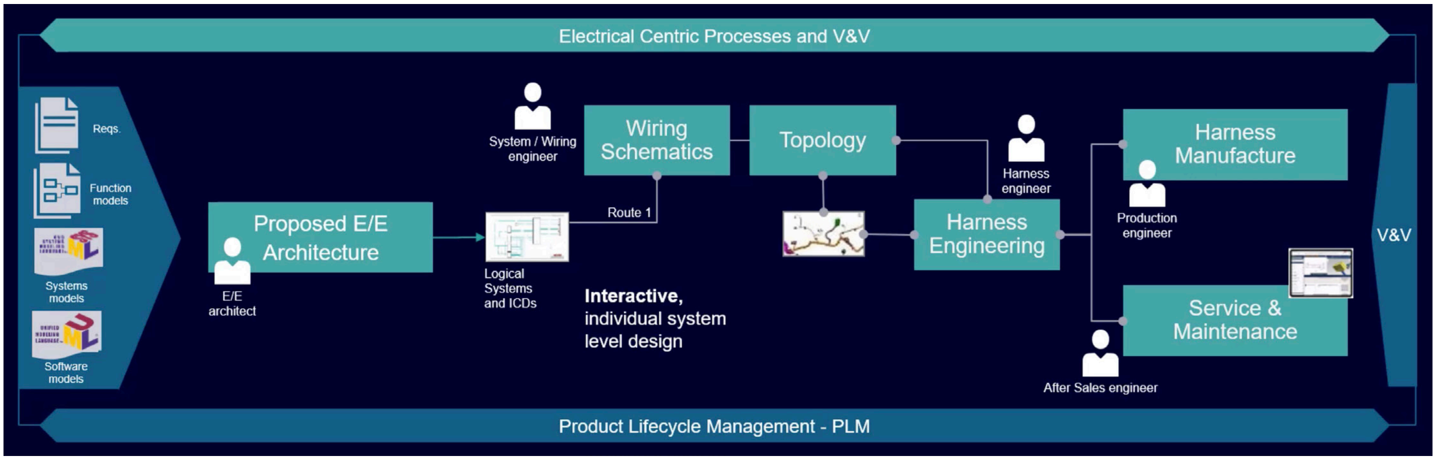

Figure 2: Capital E/E Systems Development: Connectivity

addition, engineers can use the native multidisciplinary integration provided by Siemens Xcelerator to work with their mechanical counterparts, to reserve 3D volumes for the wire bundles. This facilitates efficient and accurate routing of individual harnesses and prevents electromechanical physical conflicts from derailing program schedules.

As engineers have continuous access to the E/E system digital twin, they can apply Siemens Xcelerator's electrical simulation and analysis in real time to validate multi-system performance under stress conditions or measure the voltage drop. They can also rapidly generate simulations and reports to address the many challenges of attaining and improving regulatory compliance. For example, they can conduct electrical load analysis, check 3D separation of wiring, and even interrogate wire-to-rating status. Then, at the touch of a button, they can produce a predefined report that can be shared with any regulatory authority. Wiring is thus validated before release for harness design, where harnesses are engineered and ready for manufacture, assembly installation, and service.

Generative wiring design

Siemens Xcelerator takes wire harness design a step further by generating the proposed wiring for the entire platform (see Figure 3).

Capital consumes the inputs, such as MCAD, uses customizable design parameters (for example, from corporate IP), and delivers consistent, repeatable and cost-optimized wiring connectivity. Sharing corporate IP within a tool helps ensure that knowledge remains available, whether someone retires or moves to another area of the organization. Results can be measured and validated against design rules, all within Capital.

Once the generated wiring connectivity satisfies all needs, the data can be passed to the desired outputs, such as harness design or documentation. Unlike solutions from competitors, Capital delivers these capabilities at a platform level, not at the level of a single, independent set of harnesses.

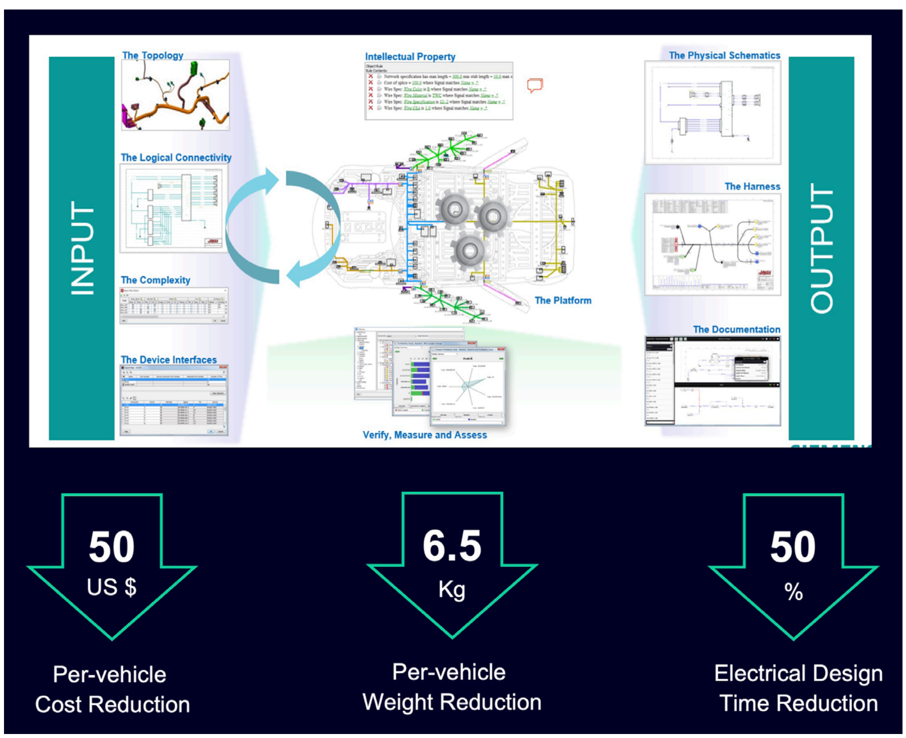

Figure 3: Generative wiring design

DRCs and integrations

As electrical designs have grown in complexity across all industries, detailed verification tools are required to identify and respond to design violations rapidly. In Capital, multiple integrated verification tools are available to ensure correct-by-construction design.

Design rule checks (DRCs) are at the core of Capital's design verification capabilities and available across the Capital tool suite. Our standard DRCs provide real-time feedback on design issues, focusing on areas of periods, connectivity, consistency, constraints, and naming, helping to navigate increased design complexity.

The latest release of Capital introduces multiple DRC improvements to provide more granular management of DRC issues, such as:

- The ability to enforce DRCs on all release levels
- Out-of-the-box severity management of custom DRCs
- Reduced time to certification
- The ability to track and override DRC failures
- Granular user access and object management
- A rich DRC library and analysis tools

Capital offers deep integrations with MCAD tools such as NX and SolidEdge, but designers can also bridge in data from many other tools, including CATIA or Creo (see Figure 4). Bridging eliminates the need for manual data entry, which is key to reducing errors and time spent in the tool.

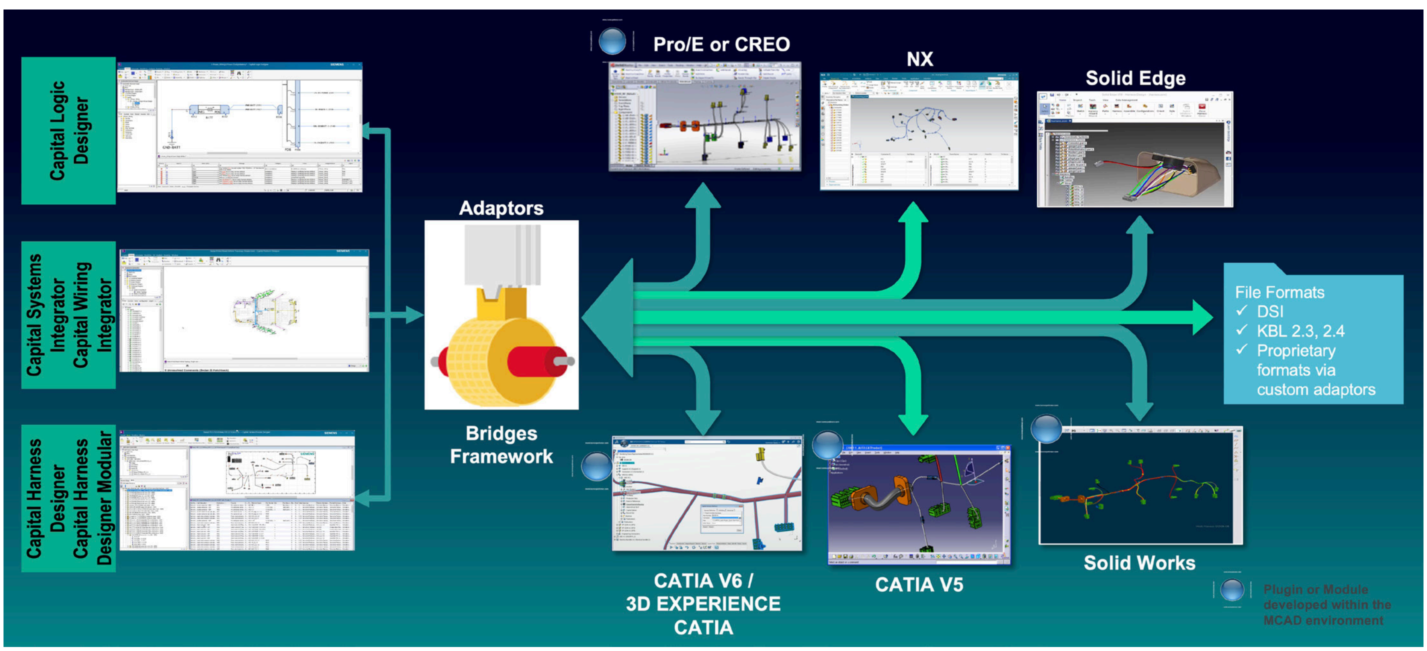

Figure 4: Capital MCAD Integrations

Balance performance targets instantly
Siemens is committed to developing ways to help our customers optimize their designs as early as possible, by combining the real world and the digital world. Using the correct-by-construction generative flow to create a platform architecture, engineers can evaluate tradeoffs associated with a design – costs, weight, or variables that impact sustainability targets, such as reducing carbon footprint or maximizing recyclability. In this way, Capital empowers organizations to drive business priorities right into the daily design decisions made by their engineers.

- Get real-time feedback on design decisions
- Explore innovative solutions quickly
- Balance metrics to achieve targets

EMC/EMI verification with Capital and Simcenter 3D

By importing harnesses from an MCAD tool such as NX, engineers can study the effects of one harnessed automatic switches, such as high-voltage wiring effects on low-voltage wiring routed closely to each other. With the ability to visualize them together, they can make decisions on wire routing between harnesses to ensure the optimal distances are managed.

EMI simulation reduces physical prototypes, enabling engineers to design for electromagnetic compatibility, understand EMI susceptibility up-front, mitigate emissions and cable cross talk, and reduce the cost of compliance.

Using Capital and Simcenter 3D, design teams can:

- Use the context of the full platform
- Cross probe between the electrical design and 3D view to see the relative wiring position
- Import and embellish Capital data to prepare for analysis
- Import and generate the 3D wiring in relative vehicle position
- Perform EM simulation and identify issues
- Investigate EM field and current flow behavior
- Perform wire harness-specific analysis and cable cross-talk
- Overcome EMI/EMC challenges, quickly and efficiently

Key benefits of capital for wire harness connectivity

- Focus on business priorities
- Leverage integrations with MCAD and PLM tools
- Tailor output based on product specification configurations
- Support global teams throughout design and development
- Automate tasks to free up resources and accelerate time to market

Connectivity, simplified

Siemens Capital addresses many of the challenges associated with the Connectivity domain in wire harness design, helping engineers optimize solutions, work with integrated data, manage complexity, and benefit from automation.

Learn more about Siemens solutions for the Automotive industry here.

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For additional numbers, click here.

Siemens Digital Industries Software helps organizations of all sizes digitally transform using software, hardware and services from the Siemens Xcelerator business platform. Siemens' software and the comprehensive digital twin enable companies to optimize their design, engineering and manufacturing processes to turn today's ideas into the sustainable products of the future. From chips to entire systems, from product to process, across all industries, Siemens Digital Industries Software is where today meets tomorrow.

About the author

Erica Van Berkum is a Senior Product Manager, Capital Electrical Distribution, Siemens Digital Industries Software. She has more than 20 years of diverse automotive industry experience, ranging from wire harness design and electrical component implementation to software deployment. Erica is responsible for the strategy and roadmap of the Capital Electrical design tools for E/E system development.

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