

SIEMENS DIGITAL INDUSTRIES SOFTWARE

Siemens wiring harness engineering solutions

Improve harness design and manufacturing efficiency with Capital E/E systems development solutions.

Wire harness manufacturers are burdened with constant change in a dynamic environment, which impacts every step in the design to manufacturing process flow. Still, they must deliver on product quality and cost targets to be profitable in the low-margin business of wire harness design and manufacturing.

Siemens Capital™ software E/E systems development solutions enable digitization, automation and data reuse, to provide unprecedented levels of process optimization, transparency and customizability, reducing cost, risk and error in the design process and accelerating the delivery of innovative harness designs to market.



Key challenges facing the wire harness industry

A number of trends are impacting the automotive industry: electrification the advent of autonomous vehicles, enhanced connectivity and mobility and mass customization. New technologies, materials and architectures are emerging in vehicle design, introducing additional complexity, and new market entrants are creating intense competition for incumbent suppliers.

Although wire harness manufacturing has been around for over a century, today's manufacturers continue to face myriad challenges:

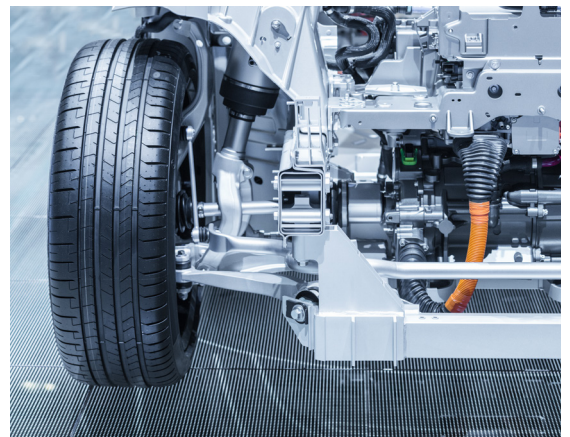
1) **Low margins:** Historically, wire harness manufacturing has been a low-margin business. Harness manufacturers are under constant cost and price pressure from OEMs looking to reduce their own manufacturing expenses, even as material shortages resulting from supply chain disruption since the beginning of the Covid-19 pandemic are driving up the price of parts. All of this leads to lower profit margins and tighter budgets.

2) **Stringent requirements for quality and delivery:** Quality requirements are extremely high, yet delivery schedules are tight. Design changes often happen late in the design process, causing delays. Meanwhile, legislation requiring traceability and documentation puts more pressure on manufacturers to implement continuous verification and validation processes. For example, ISO 26262 requires a certain level of redundancy in wire harnesses for autonomous vehicles.

3) **Complex processes and continuous change:** The wiring systems in today's wire harnesses are complex assemblies of multiple harnesses with vast amounts of components and an endless number of possible configurations. All these components must be managed and maintained in a database. To make matters worse, the majority — 80-85% — of a wire harness is still handmade.

4) **Loss of tribal knowledge:** When senior designers leave the company or retire, it's a huge risk. Without a way to capture tribal knowledge comprising organizational IP and best practices that they've acquired during their years of hard work, there's no efficient way to pass it along to new team members.

A modern harness design for vehicles such as a midsize European car can comprise 2,600 wires, 640 connectors and 100 splices. There may be 530 clips and 4,600 terminals, plus tubes, tapes, fuses, channels and special components. This pushes the component count to 10,000 or more, with 50 million possible configurations!



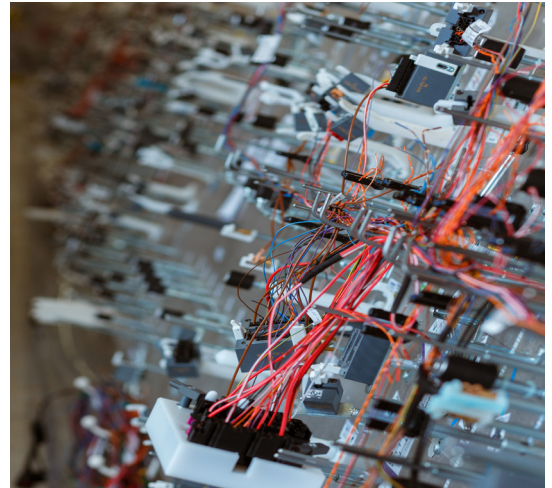
Capital E/E systems development solutions transform your business with model-based **harness engineering**

Model-based workflows unify previously fragmented domains of design and manufacturing by automating data exchange and facilitating cross-domain decisions. Tribal knowledge is captured by integrating design rules that support automation and provide consistency across the engineering process.

The three pillars of model-based harness engineering include:

1) **Digitization:** Use digital models of the wiring harness product and the manufacturing process to create an optimized digital twin.

2) **Automation:** Configurable rules and constraints not only help capture design guidelines, industry best practices and organizational IP, but also subsequently drive rules-based automation of the harness design and development flow.



3) **Data re-use:** Instead of recreating or re-entering data, create data once and re-use it to the greatest extent possible by all upstream and downstream consumers.

Leveraging these three pillars, organizations can create a comprehensive "Digital Twin" in which all tasks involved in architectural, functional and physical design, as well as manufacturing engineering and after-sales service, are connected by a coherent "Digital Thread" and can use a single set of data that is accurate and consistent throughout the harness lifecycle. All stakeholders have insight into decisions made across domains, which means issues can be caught and addressed early in the design process, accelerating design while reducing rework and associated costs.

Siemens expanded Capital wiring harness development software supports the model-based wiring harness engineering and manufacturing flow, from definition through production.

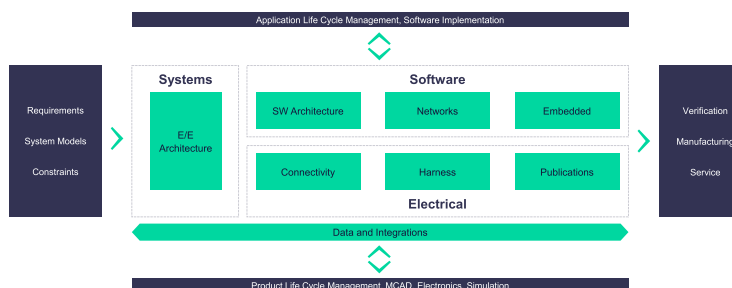
Siemens Capital wiring harness development software

As part of the Xcelerator portfolio of software, services and application development platform, Capital is integrated with adjacent Siemens solutions, including the Teamcenter® portfolio for product lifecycle management, NX™ software for mechanical design and Mendix low code development environments, which creates the world's most comprehensive wiring harness development solution to efficiently engineer and manufacture today's smart products.

Capital contributes to an optimized digital twin comprising a validated harness model and a digitized manufacturing process model, which can be used to transform a company's engineering, costing and manufacturing performance, ultimately boosting profits.

Capital's powerful design automation capabilities coupled with its model-based wiring harness engineering flow:

- Reduces new product introduction times with digital data continuity and IP reuse
- Optimizes designs and improves product quality with automation and simulation
- Improves efficiency and lowers costs with best-in-class technology



What is a digital twin?

A key concept in model-based harness design is the digital twin. 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.

Capital's digital thread

allows the digitalized product model to be consumed and reused by the other related tools in the manufacturing flow.

Wiring harness design through manufacturing process flow

The harness design through manufacturing process has two primary phases:

1) Harness design and engineering

- Harness design
- Harness product engineering
- Harness costing

2) Harness manufacturing engineering

- Harness formboard design
- Harness manufacturing planning & optimization
- Harness manufacturing documentation

Each of these phases provides essential data and information needed by various stakeholders who are in charge of business and manufacturing systems.

Capital wiring harness development software features a powerful graphical harness design and manufacturing environment that enables automated harness design and validation to support every phase in the process flow while enabling digital continuity throughout. Harness design and manufacturing engineers can capture and describe design intent, to rapidly and accurately create fully detailed and validated harness designs and define rules and constraints to facilitate comprehensive design automation and ensure consistency. The solution is highly configurable, as well, enabling organizations to customize the tool and process flow to meet their specific needs.



Key features & benefits

- **Capture and re-apply changes automatically:** Leverage the ability to capture, store and selectively re-apply changes, thereby eliminating many of the time-consuming and error-prone change management tasks required with traditional tools.
- **Integrate with ECAD/MCAD:** Create “right-the-first-time” harness designs using rules-based automation. Powerful data integration interfaces with all major ECAD/MCAD systems enable harness designers to import CAD and related wiring information, supporting error-free and swift data transfer from adjacent solutions.
- **Render multiple graphical representations:** Use configurable graphical templates to ensure consistent in-house standards and OEM standards and styles are applied.
- **Validate with standard & custom DRCs:** A comprehensive set of standard design rule checks ensure the design meets customer requirements. Custom DRCs supporting the organization's IP and best-practices can be easily added.

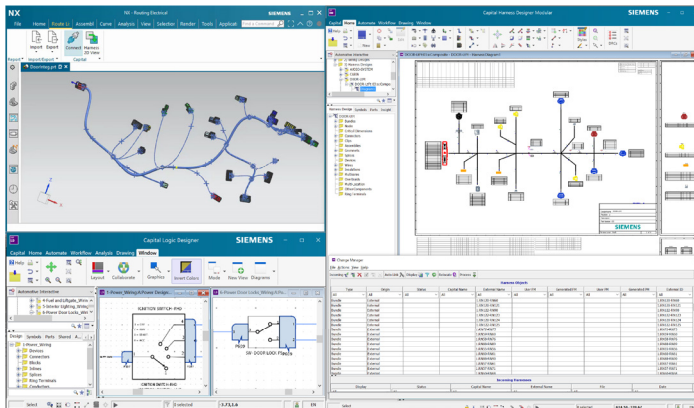
“We needed a development environment to visualize the entire vehicle. Capital provides the environment to make Mazda’s electric development much more efficient.”

Kazuichi Fujisaka
Technical Leader
Mazda

Wiring harness design engineering

Capital Harness Designer and Capital Harness Designer Modular: Graphical harness design environment

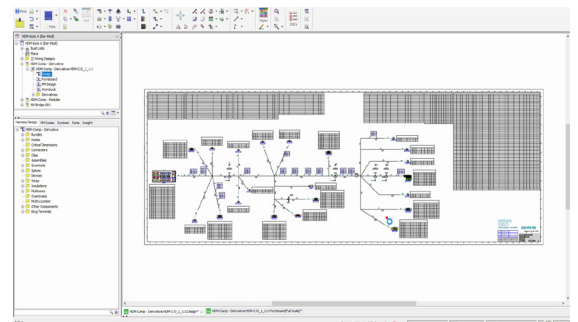
Capital Harness Designer and Capital Harness Designer Modular provide a powerful graphical harness design environment, designed to support all of the necessary activities involved in creating a detailed harness design. Leveraging automated design and validation, they accurately capture and describe design intent and requirements, enabling engineers to tailor process flows for graphical outputs and reporting to meet their needs.



Engineers can also define rules and constraints to enable automation and ensure consistency.

- **Integrated design authoring and ECAD/MCAD integration:** Create “right-first-time” harness designs using rules-based automation and advanced functionality. The powerful data integration interfaces with all major ECAD/MCAD systems, enabling you to import CAD and related wiring information, for swift, error-free data transfer from adjacent solutions.

- **Automated capture and re-apply design changes:** The data-centric architecture of Capital provides multiple change management capabilities like the ability to capture, store and selectively re-apply changes, tabular and graphical difference reports and version management. It thereby simplifies change management and eliminates time-consuming and error-prone data-entry tasks required with traditional tools.
- **Rules-based graphical diagram styling:** Render multiple graphical representations from the same design using configurable graphical styling templates, so you can create a design that conforms to consistent in-house standards and styles. Designs can be automatically re-rendered into other required styles, such as an OEM engineering drawing, internal engineering drawing and formboard drawing.
- **Standard and custom DRCs:** Leverage a comprehensive set of standard Design Rule

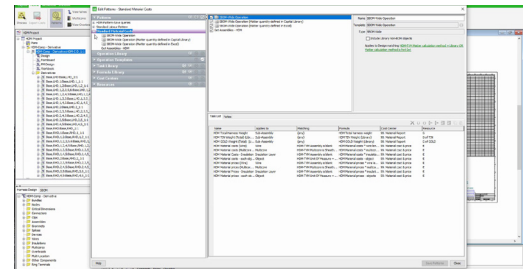


Checks (DRCs) for validating the final design and ensuring it meets customer requirements. You can also add custom DRCs to support your IP and documented best-practices.

Capital Harness Designer and Capital Harness Designer Modular: Data-driven harness product engineering

During product engineering, data is embellished and enriched with information specific for the wire harness manufacturer to optimize the design for manufacturing. The design is enhanced with relevant details such as component information, material quantities and more. The goal is to produce a complete and accurate harness definition along with documentation that can be leveraged across the design flow. Capital Harness Designer and Capital Harness Designer Modular provide automated engineering, validation and reporting capabilities to help engineers prepare product data for costing and manufacturing.

- **Automate component selection:** Enhance harness data with automated component selection to create a full manufacturing bill-of-materials. As a result of the applied style set, relevant part symbols such as different connector views, insulation line styles, and special instructions are automatically added, enhancing the graphical representation of the design data.
- **Automate engineering calculation:** Automatically calculate wire lengths, bundle diameters, splice positions, taping quantities, harness weight and more. Real-time metrics provide visibility into the impact of design decisions to facilitate systematic trade-off evaluations. Graphical and tabular reporting can be used to compare designs and guide engineering decisions.
- **Automatic derivation of variants & modules:** Design engineers can define 150% composite designs from which buildable harness variants are automatically generated by derivative or modular decomposition. In a KSK flow, functional assignment algorithms identify modules based on codes assigned to



the wires, then automatically identify and configure all related components to complete the definition of each module. In a derivative flow, Boolean option expressions on the wires are evaluated for inclusion based on the applicable options of each buildable variant and all required, related components are automatically determined.

Capital Harness Costing: Accurate harness engineering

The final step in the design flow is to obtain a quote for the cost of the harness, to be included in the business plan and provided to the customer. Harnesses must be manufactured at a competitive and well-understood cost. However, with tight project timelines and margins and variable component pricing, this is no easy task. Capital's purpose-built solution automates the costing process, providing a formal framework for rapidly generating accurate material and labor costing:

- **Automate resource costing:** Determine the cost of labor, material, machines and other resources required to manufacture the harness, leveraging company-defined cost standards, with the option to use multiple costing models. Detailed, accurate and rapid harness costing enables engineers to keep up with the dynamic nature of product changes.
- **Leverage rules-based, IP-driven calculations:** Traditional approaches rely on approximation, labor-intensive and detailed analysis, and manual processes that are slow and error-prone. By contrast, Capital provides a rules-based framework to automatically and rapidly generate accurate labor time calculations, enabling competitive quotes and improving profitability.

| Harness manufacturing engineering

Capital Formboard Designer and Capital Formboard Manager: Optimized formboard design

Capital's powerful graphical and design-management environment for formboard design enables manufacturing engineers to rapidly create full-scale, detailed and manufacturing-ready formboard diagrams.

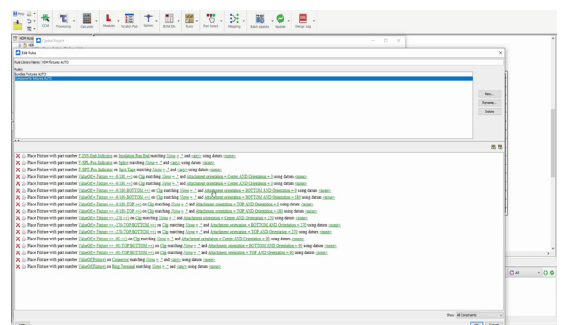
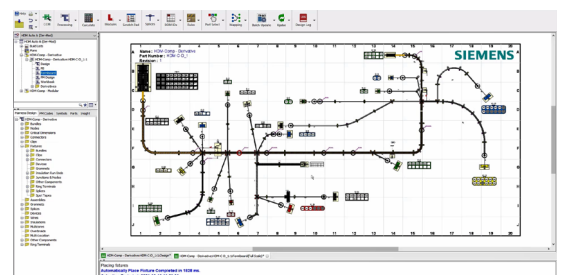
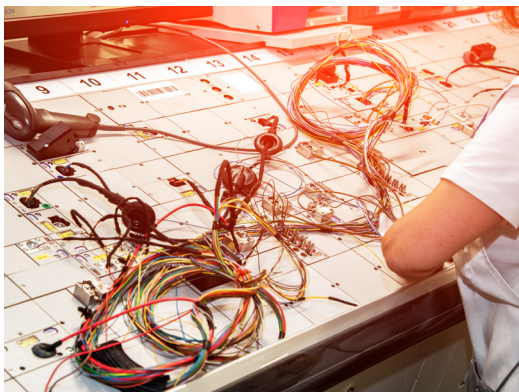
Capital Formboard Designer guides designers to create an optimized, ergonomic layout based on dynamic feedback of labor effort related to each component, as it is placed in a particular zone on the board. Changes made to the harness design are automatically updated in the formboard diagram.

Designers can use the Capital Formboard Manager to create and maintain merged or combined formboards for efficient production lines and factory space usage.

- **Automate fixture selection and placement:** Select and place fixtures interactively or automatically using custom design rules, ensuring best-practice manufacturing engineering. Graphical styling capabilities accelerate the design process by automatically generating symbols, text, fonts, auto-colored insertion views and more.



- **Merge / combine formboards:** Capital facilitates the creation and maintenance of merged or combined formboards in an environment based on contiguous data flows. Capabilities like the automated merge functionality enables retention of existing fixtures position during a merge operation. These deliver significant time savings that can be re-invested into production line optimization tasks.

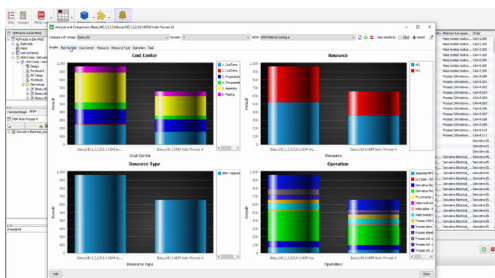


Capital Harness Process Designer and Capital Harness Line Balancer: Manufacturing planning and optimization

The next step in the design flow is to model the manufacturing process and balance the final assembly workstations, so that every worker on the assembly line has approximately the same amount of work to complete and assembly runs smoothly. The bill of process is finalized during this stage, enabling accurate manufacturing costs to be compared to the quote developed during Capital Harness Costing, providing insights into how to improve future quotes.

Capital Harness Process Designer and Capital Harness Line Balancer decompose harness designs against previously captured descriptions of manufacturing capabilities, using a reasoning engine that incorporates wire harness assembly logic. Engineers can capture and apply best-practice techniques to manufacturing process planning and cost estimation tasks, for fast and accurate planning, cost optimization and improved shop floor decisions.

- **Generate and analyze production line processes:** Rapidly and accurately configure and synthesize harness build processes, tasks,



costs, manufacturing times and more. Capital's graphical process management tool generates multi-level bills-of-process and structured bills-of-materials to feed ERP systems, improving efficiency and reducing cycle times. Best-practice process expertise can be applied across multiple manufacturing sites, improving standardization and reducing costs.

- **Balance and optimize processes:** Quickly and accurately distribute manufacturing tasks across production line workstations for maximum efficiency. Drag and drop tasks and benefit from dynamic guidance, including alerts that notify engineers if a task is assigned to a workstation before the material is present, or before a prerequisite task is complete.

Capital Work Instruction Publisher: Automated, accurate documentation

As a final step, work instructions are created for operators on the assembly line. Given the complexity of today's harnesses, instructions and visual aids must be generated automatically, and they must be explicit and error-free to ensure consistent, high-quality assemblies. Capital Work Instruction Publisher enables documentation to be created directly from engineered harness data and the defined assembly process sequence.

- **Automatically generate work instructions:** Leverage rules and a configurable and extensible page template design interface to automate documentation while achieving consistency across documentation and the ability to re-use best practices. Documentation can be delivered in multiple languages, thanks to a built-in dictionary.
- **Reduce errors with visuals:** Produce detailed work instructions accompanied by intuitive visuals that show splicing details, connector cavities, routing paths, sub-assemblies and more, eliminating confusion and maximizing operator efficiency.

“Capital is by far the most capable commercial off-the-shelf software addressing wire harness design, engineering and manufacturing.”

Leoni Wiring Systems

Achieve profitability under pressure

While digitalization is an essential step toward the implementation and realization of Industry 4.0, the success of harness manufacturers is dependent upon their ability to accurately design, optimize, and cost the manufacturing processes, labor, material and resources required to produce wire harnesses. Siemens Capital Wiring Harness Development Software enables harness designers to accomplish all of these goals by:

- Eliminating re-drafting errors with first-time accurate manufacturing data creation, reducing correction cycle times and accelerating product launches.
 - Increasing product quality, and reducing rework and cost with rules-based product validation.
 - Providing configurability and customizability, enabling teams to capture and benefit from tribal knowledge to optimize product definition and manufacturing costs.
- Enabling process modeling and simulation, to drive transparency and standardization across the design flow.
 - Ensuring production line tasks are balanced to increase production line efficiency.
 - Automating data flow throughout all phases of manufacturing to mitigate risk.

Together these benefits reduce design errors by 50%, improve quote to production cycle time by 30% and improve formboard design time by 85%, leading to increased profitability and better business outcomes.

- **Reduce design error by 50%**
- **Improve quote-to-production cycle time by 30%**
- **Improve formboard design time by 85%**

About Siemens Digital Industries Software

Siemens Digital Industries Software is driving transformation to enable a digital enterprise where engineering, manufacturing and electronics design meet tomorrow. Xcelerator, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, helps companies of all sizes create and leverage a comprehensive digital twin that provides organizations with new insights, opportunities and levels of automation to drive innovation. For more information on Siemens Digital Industries Software products and services, visit [siemens.com/software](https://www.siemens.com/software) or follow us on [LinkedIn](#), [Twitter](#), [Facebook](#) and [Instagram](#). Siemens Digital Industries Software – Where today meets tomorrow.

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