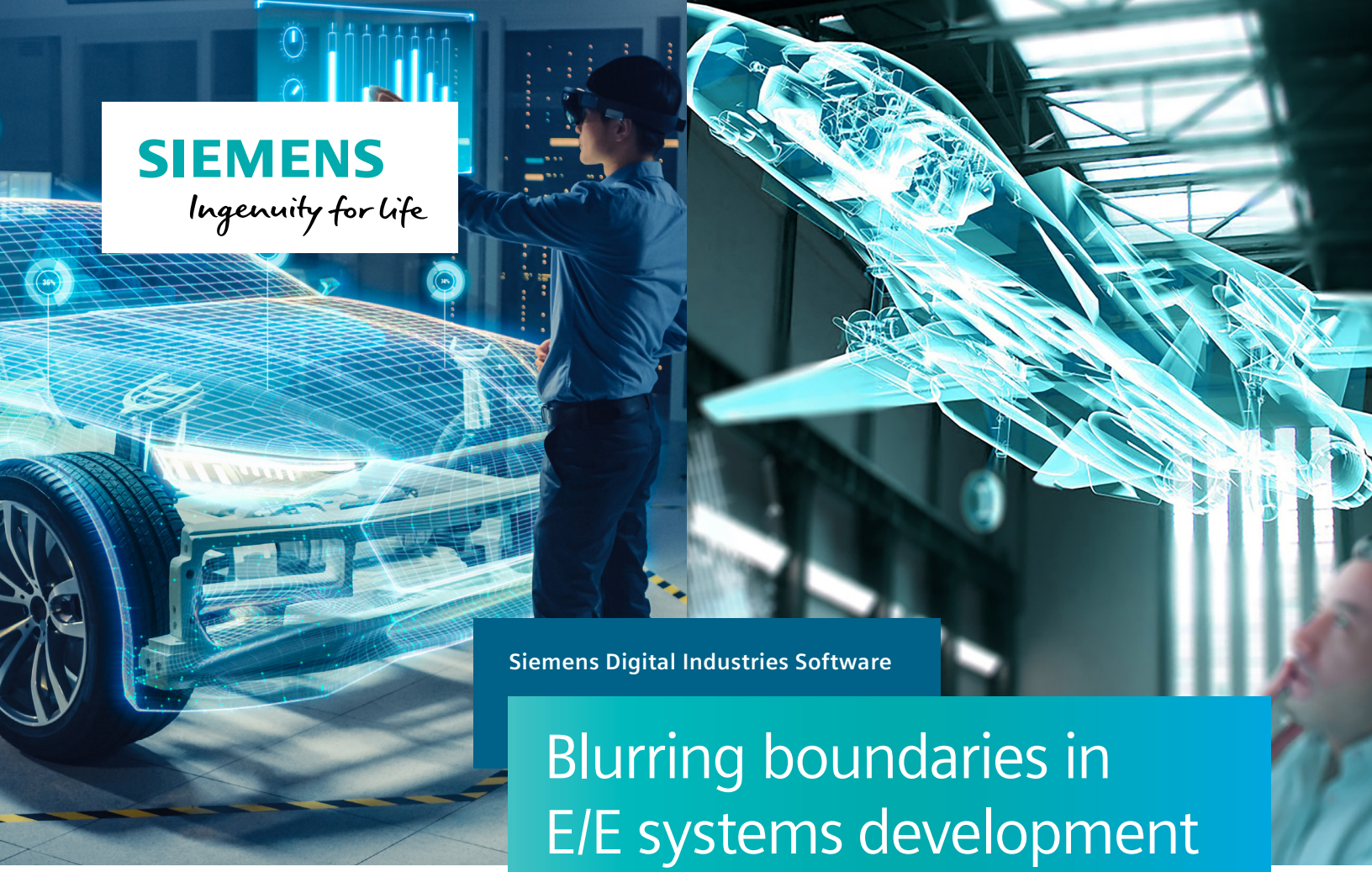

SIEMENS
Ingenuity for life

Siemens Digital Industries Software

Blurring boundaries in E/E systems development

Executive summary

Cross-industry trends (such as electrification, autonomy and connectivity) are challenging traditional product development approaches as companies look to deliver these new technologies in automotive, aerospace and adjacent industries. Much of this innovation is driven by electrical and electronic (E/E) systems including embedded software, communication networks, electronics and electrical systems. As a result, the complexity of the integrated E/E systems has skyrocketed, outpacing expert predictions from just a few years ago. One of the biggest challenges is developing these complex, multi-domain systems in a coherent, integrated way, which is driving companies to evolve their E/E system development approaches to meet the market challenges of tomorrow. The next generation of development approaches must blur the boundaries between software, electrical, electronic and network development to ensure comprehensive traceability and compliance whilst accelerating product development. This article will discuss the cross-industry trends and their implications for product development as well as outline the characteristics and benefits of next generation, comprehensive E/E systems development approaches.

Dan Scott, Siemens Digital Industries Software

Introduction

Cross-industry trends are challenging traditional methodologies for developing vehicles and industrial machinery. Companies have had to quickly develop responses to the economic impacts of the COVID-19 pandemic. Improving the efficiency and resiliency of all stages of the product development and manufacturing flow has suddenly become a core requirement across industries and throughout supply chains. Of course, companies have also had to quickly expand their virtual infrastructure to support employees while working from home. The combination of these factors has forced companies to reevaluate their product development methods, looking for efficiency gains and greater flexibility to secure their businesses.

Next, increasing electrification is rapidly gaining ground in the automotive, aerospace and heavy equipment industries due to consistent improvements in electric powertrain technology, as well as the looming restrictions of new environmental regulations. At the same time, products in all industries are becoming more intelligent and connected through the incorporation of sophisticated electronics devices and embedded software.

These trends are causing a significant increase in the importance and complexity of the electrical and electronic (E/E) systems within a variety of products, from passenger cars and aircraft to marine vessels and advanced industrial machinery. The rapid growth in complexity, in fact, has outpaced predictions. In 2014, Deutsche Bank conducted a study in which they measured rising vehicle complexity based on the software lines of code (SLOC) and the number of network signals implemented within a typical vehicle at various times (figure 1). The study predicted that the average vehicle in 2020 would contain 30 million SLOC and 10,000 network signals, both of which were at least double what was reported for a vehicle from 2012. According to conversations with our customers, the vehicles in 2020 can have 150 million SLOC and more than 20,000 network signals, and this growth is only expected to continue.

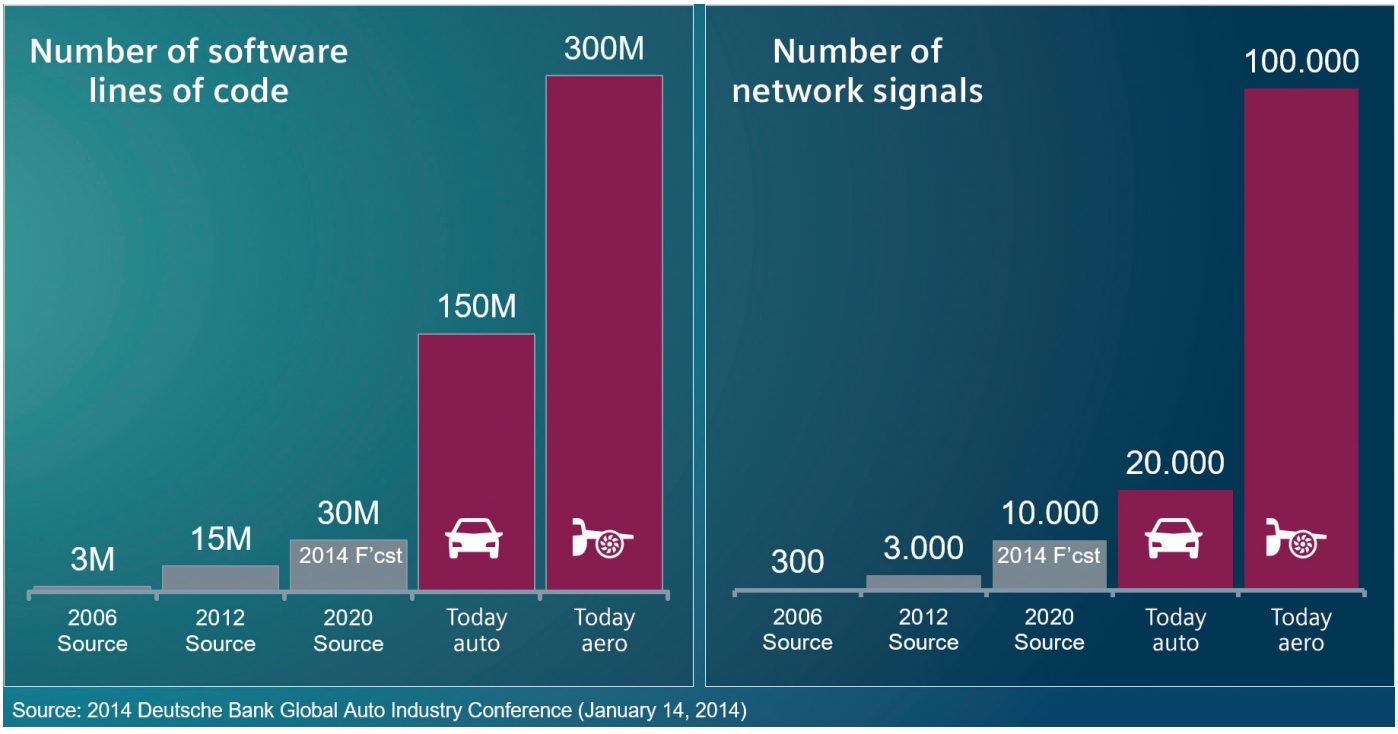

Figure 1: Predictions from a 2014 study conducted by Deutsche Bank have fallen short of the actual increases in SLOC and network signals.

Industries face a multi-domain challenge

Growing E/E system complexity, however, is not just a matter of an increase in the amount of electrical, electronic or software contents of a product. Each sub-system must incorporate a diverse combination of domains to enable product functionality. Take, for example, an automated take-off and landing system in a commercial aircraft. This system uses a combination of electrical wiring, electronic devices, embedded software, hydraulic and mechanical systems to guide the plane down the runway, control the throttle, engage or retract landing gear and operate control surfaces to ensure safe take-off and landing.

This cross-domain complexity also heightens the challenge of maintaining traceability throughout the product development lifecycle. Engineers now have to track thousands of components and functions across domains, coordinating the development, simulation and validation of electrical systems, electronic control units (ECUs), software applications and more.

Traditionally, companies have taken a siloed approach to developing vehicle systems, with teams often located in different offices, sites or countries. These silos can result in an inconsistent application of requirements in sub-system designs, lack of communication between domains and missing links in design traceability. These misinterpretations only become evident when different contributing aspects of systems are integrated together. For example, electrical, network, software and hardware teams may make different assumptions about network message timing and/or the signals passed between ECUs. The discovery of such inconsistencies necessitates additional engineering effort to resolve the issues that arise from incompatible systems. The result is increased cost, missed deadlines and greater program risk.

Manufacturers of aircraft, passenger cars, off-highway vehicles and industrial machinery are seeking to make the growing complexity of E/E systems into a competitive advantage through innovative designs. Advanced E/E system design enables the most sophisticated and desirable features in modern vehicles, including automation and electric propulsion. Manufacturers can also extend the value creating ability of their products well into their lifecycle through over-the-air (OTA) updates that add new features even after the initial sale. For example, automotive OEMs now have the ability to improve vehicle performance through software updates, allowing vehicles to get better over time.

However, companies in all industries are facing increased competition and expectations for faster time-to-market, causing development cycles to contract. As these companies seek to deploy new technologies and innovative designs, they must do so faster than ever before.

This perfect storm that juxtaposes accelerating development cycles with rapidly increasing systems complexity can result in painful consequences for companies of all sizes. Products could arrive to market later than the competition, and may lack the innovative and exciting new features that will attract customers. On the other hand, vehicles that are delivered on time may suffer quality issues leading to warranty claims or even legal action. Failing to meet internal requirements or increasingly stringent safety and environmental regulations can be even more damaging due to costly product recalls, fines and eroded customer trust. Inefficient development caused by this growth in complexity will increase program risk and the potential for cost and schedule overruns.

Manufacturers of aircraft, automobiles, commercial vehicles and more must evolve their E/E system development methodologies to meet the challenges of the markets of tomorrow. The next generation of development methodologies must blur the boundaries between software, electrical, electronic and network development to ensure holistic traceability and accelerate product development. These methodologies must also leverage automation to enable faster, more frequent design analysis and iteration and to allow engineers to focus on product innovation instead of repetitive design tasks.

Next level E/E systems development with an end-to-end environment

The need for today and the future is to support integrations across domains, blurring the boundaries between silos to provide persistent data continuity throughout E/E systems design, manufacturing and service (figure 2). With this approach, companies drive electrical, electronics, network and embedded software architecture design from the E/E systems architecture. Downstream support for harness manufacturing and vehicle service domains completes a comprehensive E/E systems development environment.

These comprehensive E/E systems development capabilities provide a number of benefits to companies developing next generation products. Key benefits include faster time-to-market, reduced program risk, improved product quality, streamlined collaboration and a focus on innovation.

Faster time-to-market

First, companies can accelerate development cycles to bring new products to market faster than ever – a critical capability for automotive, aerospace and other companies. In a 2019 report, McKinsey & Company noted that, "By breaking up domain silos... OEMs can speed up time to market for new E/E architecture definition and sourcing decisions." The tight integrations supported by a comprehensive E/E development environment drastically simplify the sharing of critical data across engineering teams and domains. Before, information and data sharing was handled with ad hoc processes that lacked structure and traceability. With direct connections to mechanical CAD, PLM, ALM, simulation tools and an integrated E/E systems design and manufacturing portfolio, engineers can exchange information directly through their respective tools with the added benefit of traceability of changes and design iterations. This reduces downtime during handover and the prevention of errors from manual data entry.

Powerful automation technology can further accelerate the development of E/E architectures, system designs (such as the EDS or networks) and the creation of reports and documentation for manufacturing or service. Rules-based automation capabilities can allocate functions around the E/E architecture, synthesize wiring and generate reports and documentation based on rules

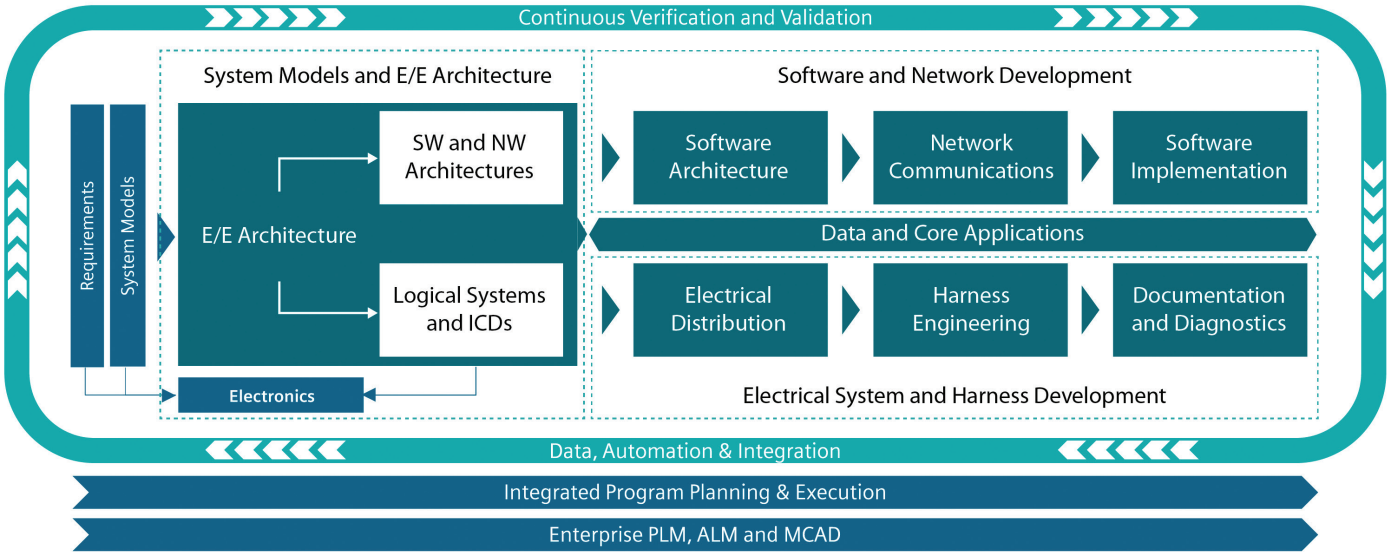

Figure 2: Today, vehicle and complex machine manufacturers need to adopt a methodology that blurs boundaries between domains and supports holistic data continuity.

and constraints defined by the engineers. The result is rapid, repeatable and accurate design creation in which engineers are free to focus on finding the best solution rather than tedious manual tasks.

Reducing program risk

As vehicles become more advanced, and thus complex, development programs become costlier and entail more risk.

There is a need for constant innovation in today's competitive markets. But, innovation brings risk. While advanced electronic, electrical and software content infuse long-term value into product platforms, they bring new uncertainty to the task of platform integration. Compounding design complexity, new regulations and new market competition only heighten the urgency with which companies must address program risk. Now more than ever, design requirements interact across multiple disciplines impacting the product hierarchy across the supply chain, demanding sophisticated implementations and increasing program risk.

Moving to an integrated and digitalized approach allows manufacturers to achieve a much better balance between innovation and risk by seamlessly taking advantage of what is known about the product and its production process at any given time through the comprehensive digital twin. Robust traceability ensures that products are developed to internal and regulatory requirements and constraints, and allows for an auditable development process to uncover errors or mistakes. Direct integrations with tools from other domains also improves information sharing and traceability between domains and enables holistic requirements management (figure 3).

Furthermore, an advanced portfolio enables early verification and validation of product functionality. Engineers can begin evaluating designs as early as the architectural definition phase to uncover issues or non-optimized implementations. These capabilities eliminate surprises during development and help design project teams to stay within budget and time constraints.

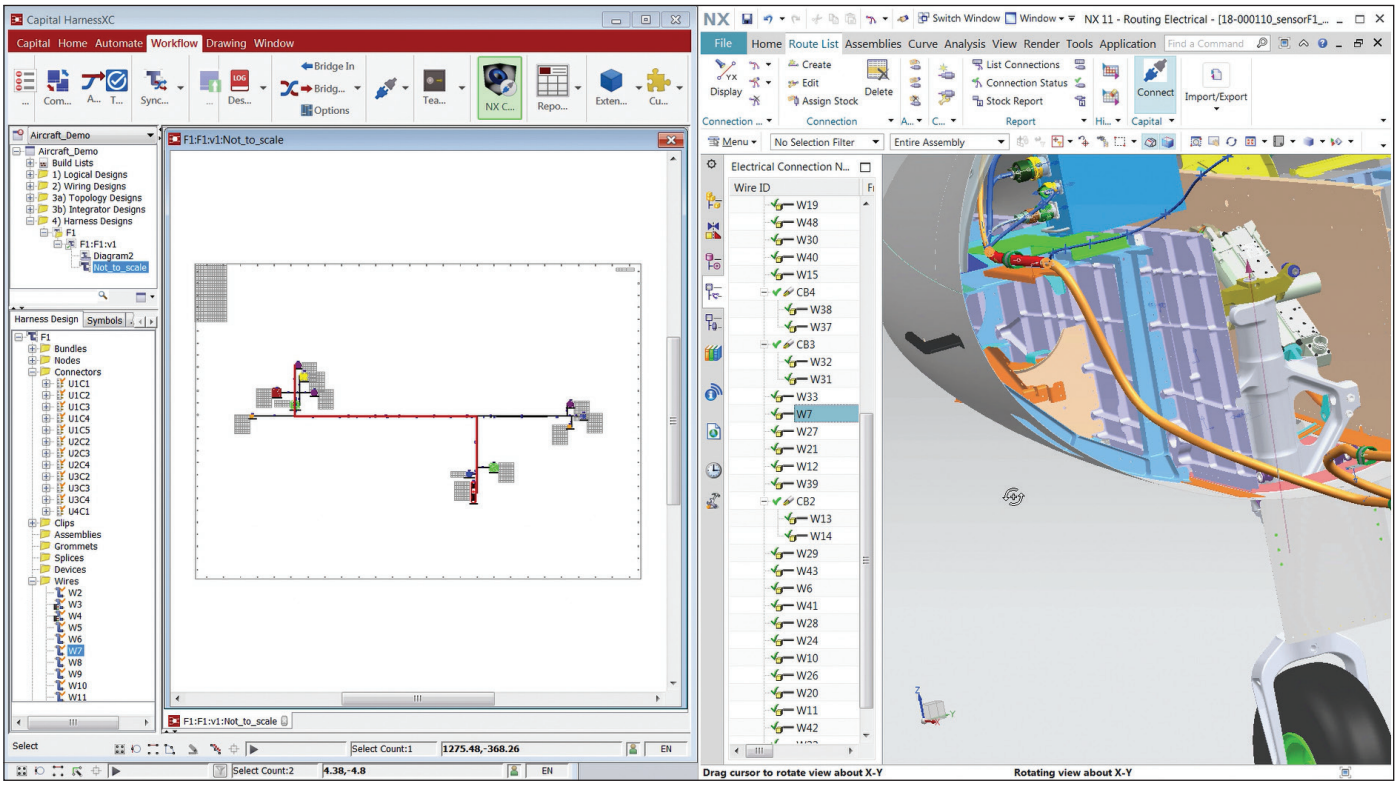

Figure 3: Direct integrations with MCAD, PLM, ALM and other domains enable streamlined information sharing. Here, an engineer uses real-time cross-probing to investigate the physical routing of a wire from the electrical diagram.

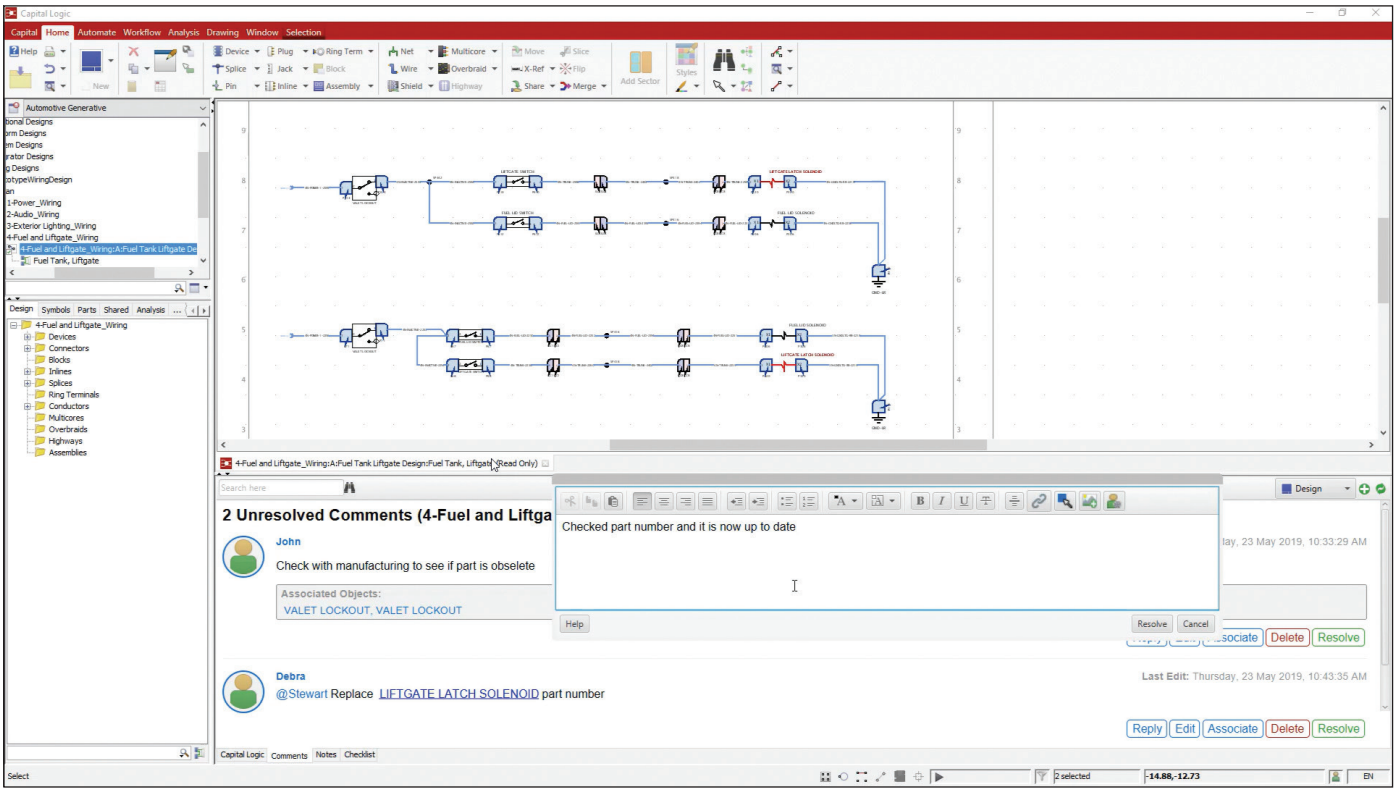

Figure 4: Notes and comments in the design ensure clear and consistent communication among engineers. Here, a comment response describes the resolution of a required change.

Improved product quality

In addition to helping reduce the risk associated with developing complex products, advanced simulation and verification capabilities can help improve product quality before launch. The ability to 'shift-left' verification in the development cycle allows engineers to verify and validate the functionality and performance of the product and its sub-systems as they are developed. Real-time metrics also provide real-time feedback on design decisions, allowing engineers to perform quick 'what-if' analyses and design iterations to arrive at optimal implementations. For example, advanced solutions such as Capital allow electrical engineers to evaluate electrical loads in all phases of operation. This is particularly useful in applications such as off-highway heavy equipment and agricultural equipment where regular usage of vehicles include using power take-off to drive ancillary equipment, as well as vehicle propulsion. Using advanced solutions for analysis can ensure system functionality earlier in the development cycle and lead to higher confidence of regulatory compliance.

Streamlined collaboration

Growing vehicle and system complexity also demands clear and frequent communication among engineers to enable efficient and accurate design. Today, engineers are used to collaborating with peers through email, phone conversations, marked-up schematics or face-to-face conversations. These methods of communication are disorganized, error-prone and difficult to track for future reference. Requests for reviews, updates and other communications are easily lost in the noise of numerous other emails and conversations, delaying design progress.

Modern E/E systems development solutions help to streamline communication between engineers by allowing engineers to leave notes and comments directly within the system design. Notes help engineers clarify design intent, and can be associated with specific design objects to make the information easy to locate (figure 4). Replying to a comment creates a thread for clear communication and built-in checklist functionality helps engineers to track open and completed tasks. Finally, modern E/E system development software supports configurable email notifications for design updates, replies and more to help the user stay up-to-date on design activity.

Encourage innovation

Finally, the powerful capabilities of an advanced E/E systems development portfolio, such as Capital, encourage and support engineers as they find new and innovative solutions to the pressing challenges of today's products. Automation and detailed metrics support rapid design analysis and iteration, allowing teams to explore new ideas without incurring too much cost in design resources or time. Tight cross-domain integrations and robust support for collaboration also make it easier to implement innovative new designs.

The ability to begin verification and validation early on in development, leveraging the digital twin, means that new system implementations can be tested virtually, without producing any physical prototypes. Likewise, extensive virtual testing will ensure that only the best, most effective ideas are developed and brought into the prototype or production stages. This means the first "physical" prototype is actually an iteration of the virtual design and subsequent improvements.

An integrated E/E solution solves the challenges of tomorrow

Common trends across the automotive, aerospace, off-highway and adjacent industries are causing dramatic changes in the nature and challenges of product development. First, the COVID-19 pandemic has changed the world, and it's social and economic effects will be felt for years to come. Second, product complexity is growing rapidly, driven primarily by new features and capabilities supported by E/E systems. The mounting challenge of complexity, however, is the result of more than just a raw increase in E/E content. Enabling the advanced features expected in the products of today requires an integration of components from across domains. Mechanical, electrical, electronics, and embedded software all must come together to implement desirable features, including autonomy, connectivity and electrification.

Meanwhile, development cycles are shrinking in an attempt to keep up with the accelerating pace of change and innovation. Companies that are unable to accelerate product development while developing and incorporating next-generation functionality will be left behind in the markets of tomorrow. For many, traditional E/E design and development methodologies are holding them back from achieving these goals.

Companies must evolve their processes to tackle these challenges, in order to survive and thrive.

An integrated, end-to-end E/E systems development environment will support companies as they strive to overcome complexity and reduce time to market. Capital, from Siemens Digital Industries Software, features unparalleled reach to drive electrical distribution system, networks and embedded software design, as well as the creation of manufacturing and product service deliverables from the E/E architecture. As a part of the Siemens Xcelerator portfolio, tight integration with mechanical, PLM, simulation and manufacturing planning solutions ensure that E/E systems designs support model-based systems engineering, contributing to a comprehensive digital twin of the product and production, as well as into product usage.

As companies embark on their digital transformations the Siemens Xcelerator portfolio will help realize the critical characteristics of a digital enterprise: the comprehensive digital twin, personalized solutions and participation in an open industrial ecosystem.

This is where today meets tomorrow.

Siemens Digital Industries Software

Headquarters
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 972 987 3000

Americas
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 314 264 8499

Europe
Stephenson House
Sir William Siemens Square
Frimley, Camberley
Surrey, GU16 8QD
+44 (0) 1276 413200

Asia-Pacific
Unit 901-902, 9/F
Tower B, Manulife Financial Centre
223-231 Wai Yip Street, Kwun Tong
Kowloon, Hong Kong
+852 2230 3333

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. The Xcelerator portfolio helps companies of all sizes create and leverage digital twins that provide 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 or follow us on LinkedIn, Twitter, Facebook and Instagram. Siemens Digital Industries Software – Where today meets tomorrow.

siemens.com/software

82276-C3 7/20 N