Siemens Digital Industries Software

Transform electrical change management with advanced collaboration capabilities

Executive summary

Rapid growth in E/E systems complexity is driving automotive manufacturers to rethink how they develop new vehicles. The sheer number of E/E and software components in a modern vehicle can be overwhelming to engineering teams as they try to implement and optimize various subsystems. As engineering teams confront these new challenges, they are often hampered by inadequate tools and processes that fail to help simplify the engineering task at hand. This is particularly true during the management of design changes. Now, the addition of enhanced collaboration features into the design environment improves change management processes by providing structured and traceable communications between engineers.

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Introduction

Modern cars are vastly more sophisticated than even their recent predecessors. An explosion of electrical, electronic and software enabled features over the last ten years has driven automotive complexity to new heights. Electrical and electronic (E/E) systems and embedded software are responsible for or involved in nearly every vehicle feature and function, including everything from acceleration, braking and steering to infotainment and advanced safety systems. The E/E systems and embedded software have grown enormously complex as they have become more and more critical to vehicle functionality.

This growth in complexity is evidenced by a startling rise in both the software lines of code (SLOC) and network signals implemented in an average vehicle. In 2014, Deutsche Bank estimated that the average vehicle in 2020 would contain 30 million SLOC and 10,000 network signals. This prediction has proven to be a conservative estimate. According to our customers, the average vehicle today contains 150 million SLOC and 20,000 or more network signals (figure 1). Raw complexity growth, however, is also being compounded by the increasing cross-domain nature of vehicle systems. A growing number of vehicle features and functions rely on a combination of domains, including the E/E, embedded software and mechanical domains. As a result, engineers are tasked with managing both highly sophisticated systems and their complex interrelations throughout the vehicle.

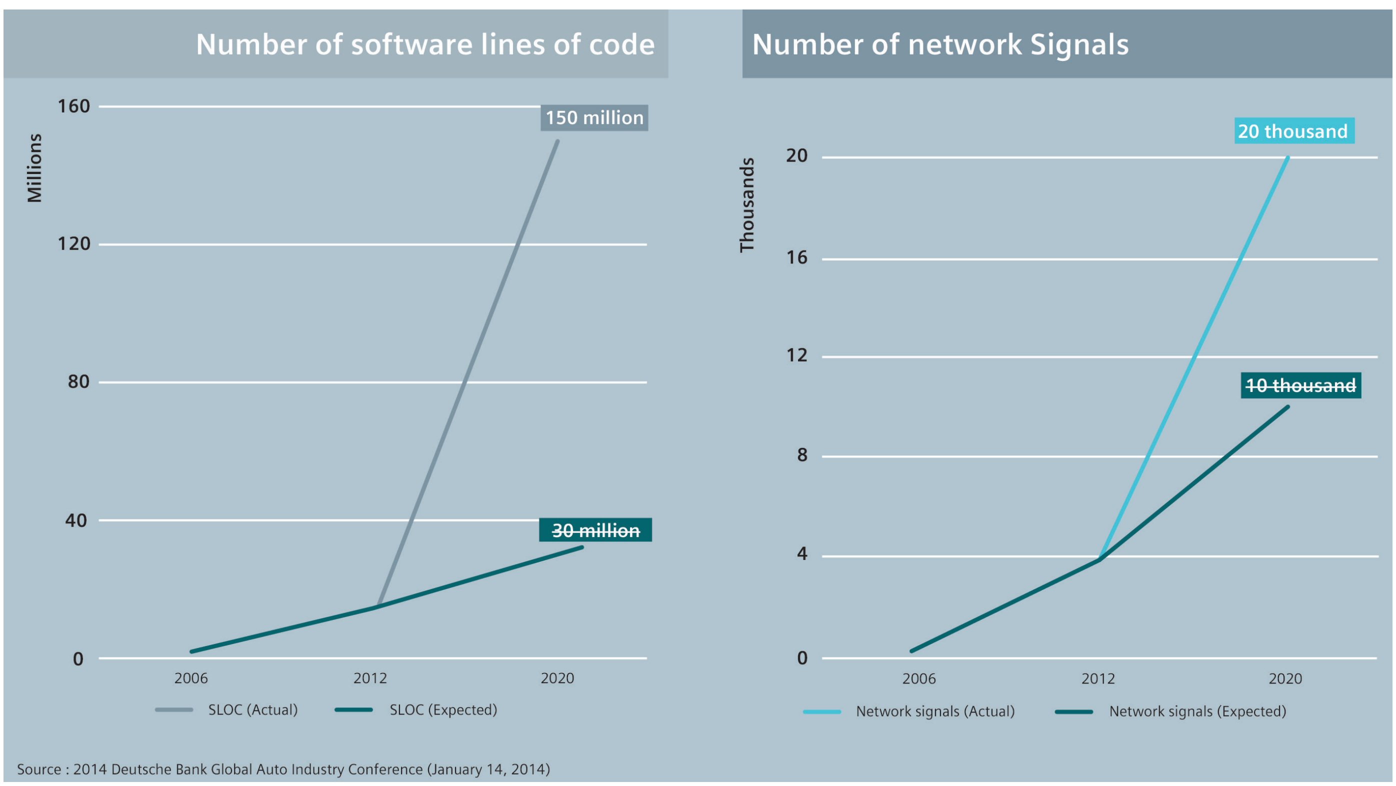

Figure 1: The average vehicle today contains 150 million SLOC and 20,000 or more network signals.

The considerable complexity of modern vehicles means that they are more complicated than ever to design, engineer, verify, validate and produce. In particular, change management and collaboration among cross-domain teams has become a constant obstacle in vehicle design and engineering. Design changes are a guarantee in the life of automotive engineers. How these changes are managed is critical to the speed and efficiency of vehicle development, as well as the ultimate quality of designs and the ability to trace design iterations throughout development.

The immense growth in E/E systems complexity means that engineering teams must track and manage hundreds of thousands of components, from electrical wiring to ECUs and software applications, to ensure design progress and deliver quality results on time. As systems continue to integrate across domains, tracing these designs and managing changes becomes even more difficult. Design changes can be initiated from any one of a multitude of design teams across engineering domains. And each of these changes can have wide-ranging effects on system and vehicle functionality, altering or even invalidating implementations in related domains.

Maintaining a robust change management methodology is crucial to the development of high-quality, sophisticated vehicles at the pace required in the industry today. A robust change management methodology should be able to track and manage changes as they are propagated across all affected vehicle systems and domains. Furthermore, it should be able to track the implementation of changes in these various systems and domains, and check that the changes were implemented correctly. Finally, a change management methodology needs to help manage the verification and validation of updated designs after changes have been implemented.

Change management through automation and the digital thread

The Capital flow is built on a robust digital backbone that enables model-based engineering (MBE) throughout product definition, design, production and maintenance (figure 2). This backbone, or digital thread, manages electrical and electronic (E/E) design data and models, and provides a platform for electrical design. As engineers progress through E/E development, the robust digital thread stores and maintains the various models that are created, such as architectural or network models, as well as other assets including libraries, design rules, manufacturing patterns and more. This digital thread can supply this information back to design applications when needed, and integrate with adjacent engineering disciplines and the supply chain to manage the end-to-end electrical flow. This ensures that engineers throughout development work from the same source of truth that is constantly updated.

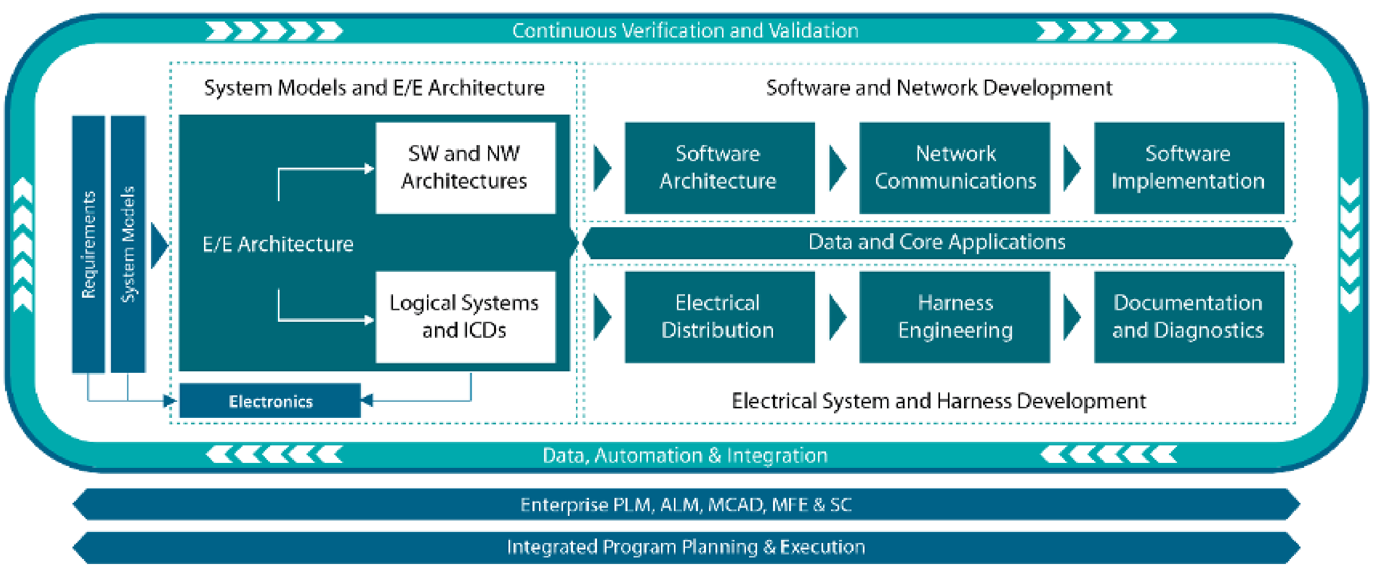

Figure 2: The digital backbone that underscores the Capital flow enables MBE from product definition through design, manufacturing and maintenance.

Even with a robust digital thread, change management is still a difficult process.

The persistent challenges of change management

The change management process involves an array of persistent challenges (figure 3). One of the first most engineers encounter is the identification of new design changes and how they affect the characteristics of the design. Engineers have to understand the initial state of the design data and the state of new data coming in from a variety of sources, both internal and external. Some changes may be more obvious, such as addition or removal of components, while others are much more subtle, such as changes in the attributes of components in the design.

Figure 3: A number of challenges persist in change management processes.

These changes must be easily identifiable so that engineers can quickly see which design components are being updated, and understand the nature of the changes being made. Indeed, not only do the engineers need to understand the immediate effectsof the incoming changes, but also the manner in which these changes may ripple through the rest of the design and affect broader system functionality. These exchanges are critical between internal teams and OEMs and suppliers as well.

After implementing the changes, engineers have to propagate these changes to other affected domains or design abstractions to ensure traceability and consistency throughout abstraction levels. Propagating design changes can be particularly difficult late in design cycles as engineers rush to, first, implement the necessary changes and then push them to other design abstractions. For example, a late change to the wiring harness design must be propagated both upstream, to the logical designs, and downstream to the harness manufacturing documentation. Similar to change identification, it's important that engineers can quickly and easily understand how the initial changes affect other abstraction levels. Easy identification of these changes will help engineers not only update each design abstraction more quickly, but also more accurately.

Tight control over changes is a key feature for enabling effective change propagation. Capital features a robust change policy tool that enables engineers to set rules for how data can be altered on an object-by-object and attribute-by-attribute basis. An engineer could, for instance, specify that data imports from the mechanical CAD solution overwrite data for wiring insulation and harness clips in the electrical environment while leaving connectivity information alone.

Next, each design change to the wiring harness design has an associated cost. New or additional components may increase the component cost of the harness. In addition, design changes can affect how harnesses are manufactured, thus increasing the manufacturing cost. Clearly, the costs of design changes are critical to understand as they are implemented and propagated. Wire harness manufacturing costs, in particular, are difficult to assess as they are dependent on multiple factors including materials and labor.

For many companies today, both OEM and supplier, a primary focus is the automation of these change management and costing processes. 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. Furthermore, designs can be compared across abstractions with inconsistencies called out automatically by the solution.

These capabilities, however, are not enough on their own to facilitate the robust methodology described above. Effective communication and collaboration among team members and engineering domains is essential for the effective management of design changes, especially as complexity has increased. E/E systems and wire harness engineering software must foster collaboration among engineers to improve vehicle design, engineering and change management processes.

New collaboration capabilities – Comments, notes, checklist and notifications

To that end, Capital, from Siemens Digital Industries Software, features new collaboration capabilities that enhance the pre-existing automation and continuous digital thread. These features help engineers to identify, propagate, implement and track design changes, all directly within the engineering environment. These additions include four primary functionalities to facilitate collaboration among engineers: integrated comments, notes, checklists and notifications for design changes.

Comments

When using traditional electrical engineering solutions, engineers are forced to collaborate through external channels of communication. Email, phone calls, face-to-face conversations and annotated schematics are among the most common. These methods are ad hoc, unorganized and, thus, error prone. Emails requesting a design change or review are frequently lost among the dozens that most engineers receive in a normal work day. And while phone calls are harder to misplace, there is no record of the conversation to provide reference or traceability later.

Integrating comment functionality into the design environment enables immediate, structured and tracked communication between engineers collaborating on the same design (figure 4). These comments provide a standard collaboration platform for the electrical systems and wiring harness engineering teams. Feedback, corrections, questions and more related to the design are preserved along with the data, associated either to the entire design or specific objects within it, ensuring they are both visible and traceable.

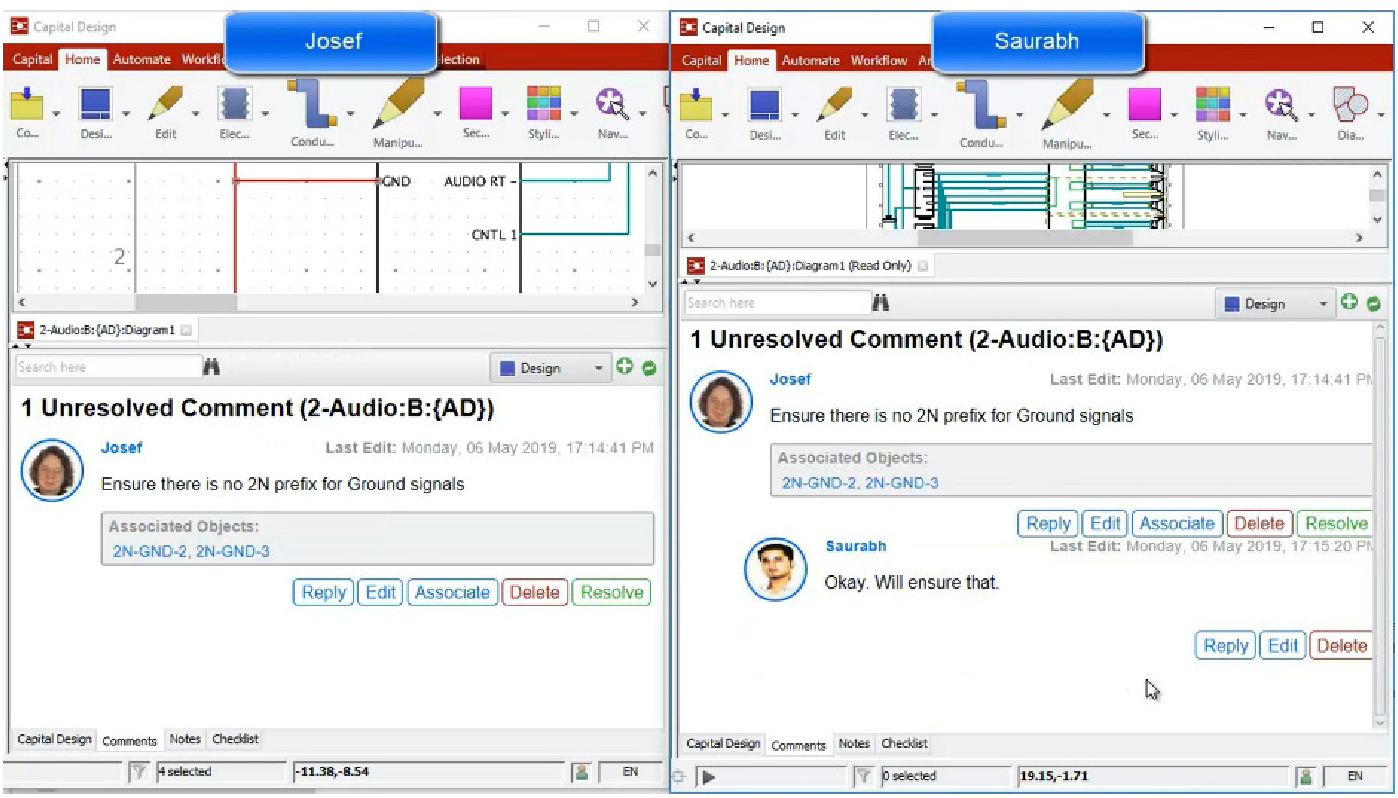

Figure 4: Integrated comments provide structured and tracked communication between engineers, enabling more effective collaboration than through email or other channels.

By integrating collaboration tools into the design, feedback loops can be greatly reduced.

Comments can be particularly useful, for example, when reviewing and analyzing designs. An engineer may notice incorrect connectivity in the design, a signal that exceeds the parameters of its wire, or other issues. They can quickly create a comment associated with the wire, component or other design object indicating the problem. Then, as the other engineers review the comment and potential issue, they can respond directly to this comment to recommend a solution or ask for additional information regarding the problem.

In addition, once an issue has been fixed or a comment thread otherwise concluded, these solutions allow the engineers to resolve the comment thread. Resolving a thread not only visually indicates that a comment has been addressed, but also feeds into automated design rule checks and tracking the progress of issues. The automated checks can be configured to prevent release of the design while open comments remain in the design. As a result, integrated comment features both make it easier for multiple engineers to collaborate and provide a robust tracking infrastructure for design issues.

Notes

The second piece of new functionality is the ability to create notes in the design. Notes are a common addition to electrical system and wiring harness designs. They may indicate a manufacturing specification or other specific instruction from the designer to the next link in the lifecycle. The problem with these notes is that they are just text added on top of a design or schematic. They are not captured as data and feature no intelligence. As a result, these notes remain as static objects that cannot drive any processes or integrate with automation downstream.

Along with moving past the use of paper drawings, integrated notes features in Capital aim to eliminate the use of unintelligent text-based notes (figure 5). Instead, integrated notes functionality captures this information as data, allowing it to drive automation and downstream processes.

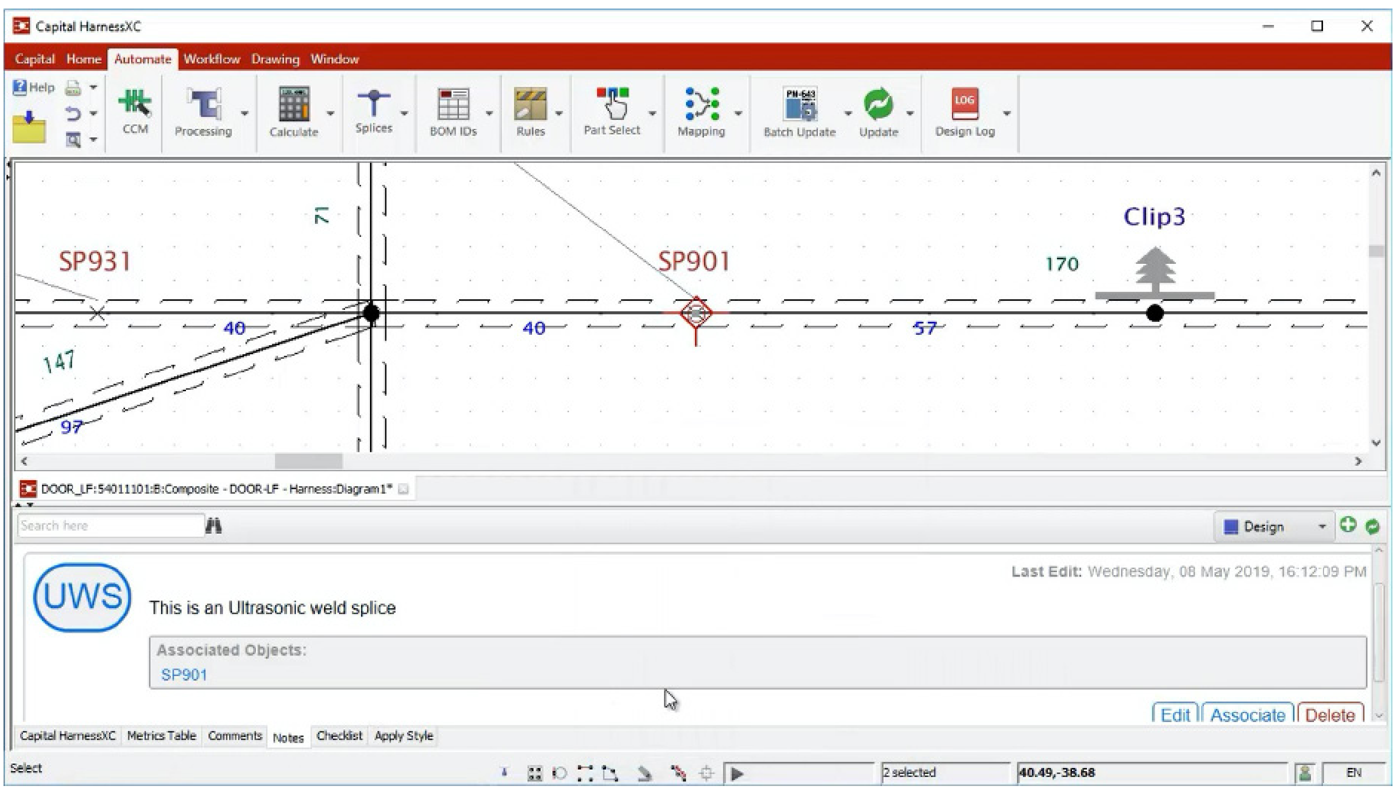

Figure 5: Integrated notes functionality eliminates the use of unintelligent text-based notation, allowing information to be captured in data and used.

In addition, advanced solutions such as Capital, feature powerful styling capabilities for electrical system and wire harness designs. These features separate design style from technical content and stores each type of information differently. Styles can be used to configure how and where information contained in notes is displayed. For example, applying a configured style type can automatically place certain notes onto a wiring diagram as needed, instead of manually adding them to the face of the diagram.

Checklists

Checklists are used by engineering teams and companies throughout the automotive, aerospace, heavy equipment and other industries. Checklists provide an easy, organized method of ensuring certain criteria are met before a design is released. However, these checklists are frequently stored outside of the design environment, either in Excel® spreadsheets, Word® documents or even physical pieces of paper. Similar to notes, this means that the checklists are not intelligent, dynamic, or connected to the design data. As a result, they require additional manual effort to maintain and use, and hamper collaboration.

Integrating checklists into the electrical systems and wire harness engineering solution captures the checklist items as data, allowing the incorporation of these lists into process controls (figure 6). In other words, integrated checklists can both become control points in a process, or be acted upon by other facilities in the engineering solution. This allows for checklists to be dynamic, intelligent and automated. For example, each design abstraction usually requires a unique set of checks associated to the contents of the abstraction. Logical, wiring, harness, formboard and other design levels all have different checks required. Integrating checklists into the electrical systems engineering solution allows these various lists to be associated to the appropriate design level, and automatically pushed to engineers as they work at each level.

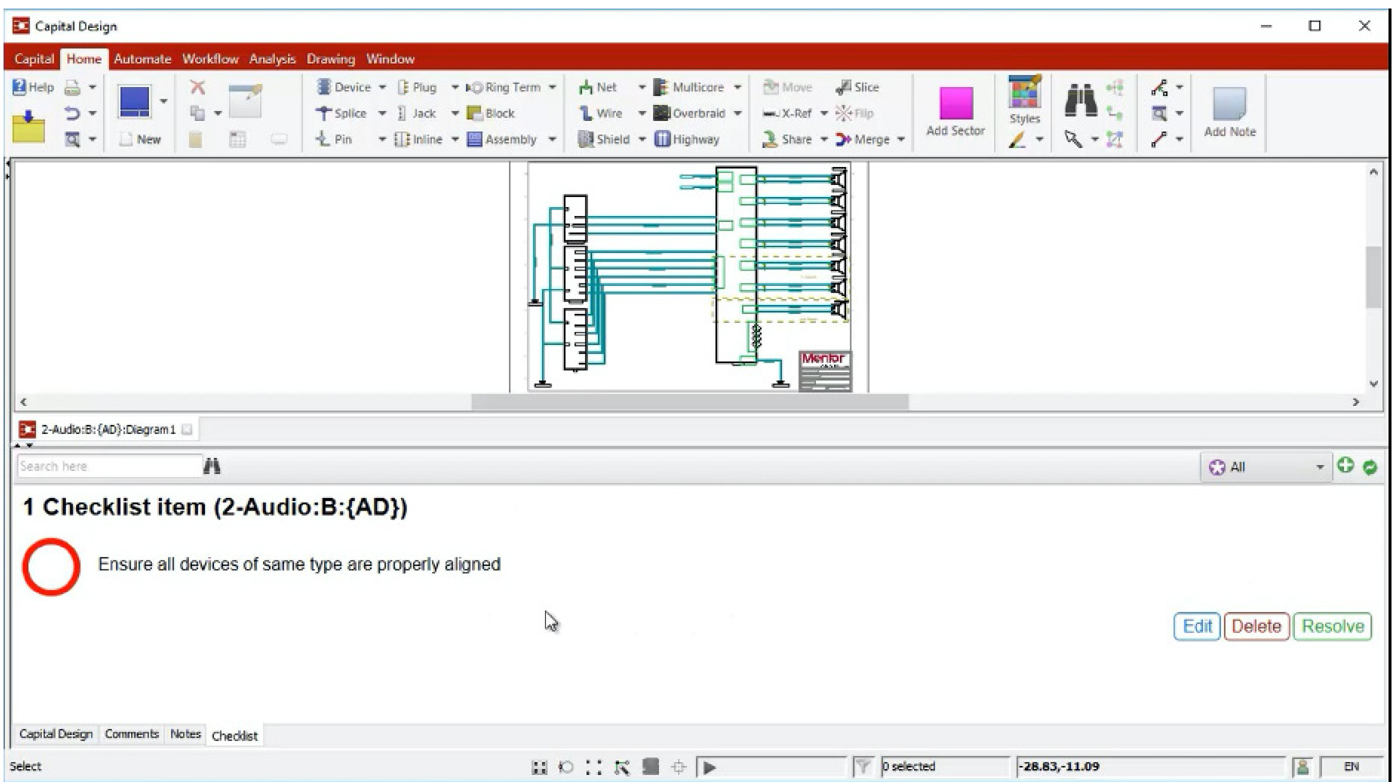

Figure 6: Built-in checklists can be incorporated into process controls, helping to ensure that checklist items are completed before a design can progress in development.

In addition, as with comments, capturing checklists in data allows automated design rule checks to be applied to the checklists. Automated checks, for instance, can ensure that all checklist items are completed before allowing a design to be released to downstream teams. Overall, integrated design checklists allow engineering organizations to formalize and provide structure to processes that have traditionally been ad hoc. The result is stronger process controls at all levels of the electrical systems and wire harness engineering.

Notifications

Finally, how do engineers, especially in cross-functional teams, know when a design has been updated? How do they know if a comment has been left that they need to respond to or address? Again, email, phone calls and other forms of communication are commonly used. These channels, however, are separate from the design environment. As a result, communications regarding design updates, comments and more cannot be automated. Engineers also have to spend additional time explaining the context of design changes, comments and notes to their colleagues so that they understand what to look for when reviewing the design.

Rather than rely on these manual processes, modern solutions, such as Capital, incorporate automated notifications that ensure any and all relevant team members are immediately aware of updates when they are made. Individual users can subscribe to certain designs, ensuring they will remain up-to-date on all activity relevant to that design. Notifications may also be triggered when one team member mentions another in the comments.

Integrated and configurable notifications ensure that the right team members are brought into the design at the correct times. Engineers can directly notify team members when appropriate, or the tool can be configured to notify certain members when relevant design items are updated. Each engineer can also subscribe to each design, allowing them to remain in the loop as the design progresses through its lifecycle.

Conclusion

Rapid growth in E/E systems complexity is driving automotive manufacturers to rethink how they develop new vehicles. The sheer number of E/E and software components in a modern vehicle can be overwhelming to engineering teams as they try to implement and optimize various subsystems. Furthermore, this explosion of electrical, electronic and software components in the vehicle architecture has coincided with a consistent integration of systems across domains. What used to be purely mechanical or electrical systems are now implemented with a mixture of mechanical, electrical, electronic and software components, each as important as the other to system functionality. As a result, engineers must now understand increasingly complicated interrelations between systems within the vehicle.

As engineering teams confront these new challenges, they are often hampered by inadequate tools and processes that fail to help simplify the engineering task at hand. Management of design changes is one particularly critical process that traditional engineering methodologies have struggled to support as complexity increases. Modern electrical systems and wire harness engineering solutions, such as Capital, feature automation and robust digital threads to help engineers identify, implement, propagate and verify design changes quickly and accurately.

Now, the addition of comments, notes, checklists and notifications into the design environment further improves change management processes by providing structured and traceable communications between engineers. Rather than relying on emails, phone calls, spreadsheets and other ad hoc methods of communicating design changes, integrating comments, notes, checklists and notifications into the design environment ensures that important information is organized and easy to find, thus reducing feedback loops. Furthermore, integrated communications are captured in data, allowing automated checks for open comments or incomplete checklists before a design can be released.

Collaboration drives innovation and quality

Comments	• Collaboration within the design team leads to more innovation and higher quality
Notes	• Notes captured as data become part of the model and enables automation in later design stages
Checklist	• Ensuring design processes are followed reduces late detection of errors and improves product quality
Notifications	• Automated feedback loops improve time to market and overall communication within the team

Figure 7: The integration of these new collaboration features support structured, traceable, effective and more frequent communication between engineers as they develop tomorrow's products.

In sum, these new collaboration features enhance the benefits of the automation and digital thread capabilities already present in modern electrical systems and wire harness engineering software. Frequent collaboration and communication among engineers will only become more important as complexity continues to grow in the vehicles of tomorrow. ADAS, electrification, autonomy and connectivity will all bring unique challenges to vehicle development. As engineers work to overcome these challenges, consistent and effective communication will be critical to their success.

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