Siemens Digital Industries Software

Managing change in platform electrical systems and turning it into a competitive advantage

Executive summary

Managing change always presents challenges and the outcomes are often expected. While we have no choice but to manage change in our daily lives, so too, do aerospace teams confront change in all facets of the design and manufacture of modern aircraft. Change can have an especially crippling effect when it comes to electrical system platform development. But in the age of digitalization, change is no longer to be feared. Rather, companies can learn how to embrace change and turn it into a decisive competitive advantage.

This paper focuses on electrical system development and offers methods and techniques to allow teams to master change and embrace it as a natural occurrence when developing highly complex electrical systems/platforms in the A&D industry.

Steve Caravella
Siemens Digital industries Software

Contents

Introduction

This paper discusses the challenges aerospace & defense (A&D) OEMs face when making changes to the platform electrical system and how these changes, when used with current development technologies, can be turned into an organization's competitive advantage.

Change can be a tough concept to handle. Obviously, as humans we know the one constant in life is in fact change. Perhaps British naturalist and biologist Charles Darwin had the best take on change, "It is not the strongest or the most intelligent who will survive, but those who can best manage change." Darwin's quote emphasizes how critical it is to handle and master change.

"It is not the strongest or the most intelligent who will survive, but those who can best manage change."

Charles Darwin

There is another suggestion in this quote as well. It suggests that if someone or some teams are better at managing change than others, it will give those who are most adaptable a distinct advantage over others.

This paper introduces a powerful methodology in which A&D teams can embrace change, and as a result, become more competitive.

Market factors forcing change

Several important factors exist in the market today forcing change. Engineers and program managers must increasingly respond to customer demands for configurations suited to highly specialized missions. At the same time, there is significant rise in product complexity and the need to integrate more technology into a product or platform. When aerospace manufacturers and their supply chain step up to meet these demands, they can do it in way that gives them the opportunity to differentiate their final product in the marketplace.

There are an increasing number of companies and start-ups entering new industry segments, such as supersonic flight, urban air mobility and commercial space travel. Innovation is fast, not just among major OEMs, but up and down the supply chain. The industry needs to keep pace and stay ahead of the curve.

Regulatory certification continues to become more stringent. High-profile events not only get the attention of the public, but also raise the level of oversight and scrutiny by regulatory agencies. Regulations continue to evolve as new market segments emerge. An OEM's ability to grandfather certain aspects or variants of an application when developing new aircraft has also been significantly reduced.

Cost pressures and competitiveness equate to more cost controls in all facets of engineering and manufacturing. Certainly, the industry can utilize new technologies to realize lower costs and improve performance. At the same time, it's critical not to lose sight of the need to quickly address unexpected problems to avoid significant cost and schedule setbacks.

How can OEMs and their supply chain partners use product change to their advantage?

When mentioning the word "change," it is often linked to situations where it's forced upon teams to address an unexpected issue or shortcoming. Inevitably the outcome is thought of as an unplanned cost or delay; a negative outcome that cannot be avoided.

But what if the other side of change is embraced? What if it's more about introducing a product change to increase value, competitiveness or grow a business?

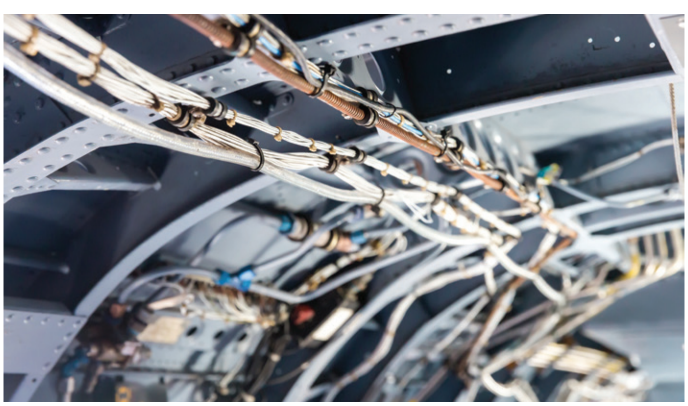
Examples of positive change

The positive side of change can be seen everywhere. Aerospace teams across the industry extend product life and improve performance through upgrades in avionics, engine efficiency or other aeronautical systems. On a regular basis, companies convert known platforms to take on new missions. Engineering teams add new systems to existing platforms on a daily basis. The industry as a whole helps customers maintain airworthiness time and time again, addressing obsolescence through refurbishment or replacement.

But the times... they are a changing. Managing change today is a far more challenging endeavor as complexity and system integration increase at unprecedented levels.

Introducing and managing change – electrical system platform development

Introducing change to the electrical system of an aircraft has become more challenging as electrical content has grown. This growth is evidenced by increased power demand. Electrical content in the latest aircraft platforms has grown tenfold over the past 50 years[1]. This growth has had an immediate impact on the complexity of the electrical distribution system. Electrical wiring now represents a significant weight component in today's aircraft, comprising on average approximately three percent of the total aircraft weight. It's not unusual for a modern aircraft to have electrical systems with more than 500 kilometers in total cable length, up to a hundred thousand wires and more than 40,000 connectors. This has substantially increased risk as teams try to manage change. This increase in content turns any design change and the related verification and compliance efforts into a rather significant task. If one slight detail is overlooked, personal reputations as well as that of the entire organization could be at risk.



Consider that many of the processes in place today were developed at a time when most functionality was implemented mechanically, including via pneumatics and hydraulics. Up until now, the industry has learned how to work through changes with a type of patchwork approach. But as electrical systems and aircraft electrification move front and center in aircraft platforms, the implementation of innovative change can easily overwhelm these outdated approaches.

A new way of implementing change within an aircraft electrical system is required.

Rapid increase in complexity

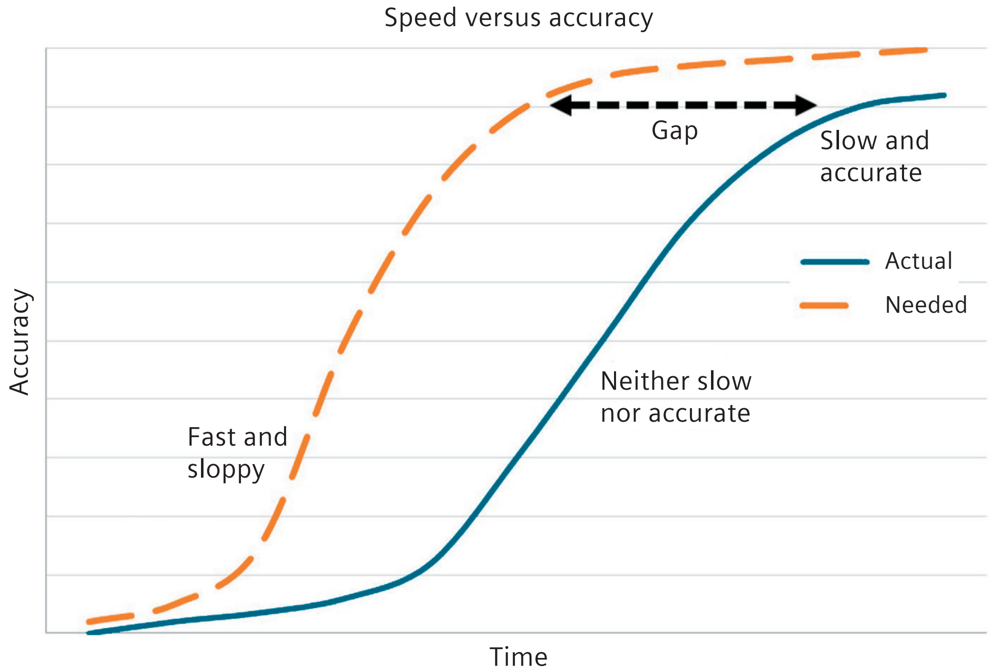


Figure 1. The gap between what is needed and actual delivery.

The increase in system complexity has outpaced the ability to manage change with traditional semi-manual methods. The traditional paper-based, hand-off approach makes it more difficult to do such things as respond quickly to requests, comprehensively assess impacts, accurately coordinate and integrate disciplines, and effectively manage the increasing numbers of configurations.

The expectation for responsiveness has placed teams in a time crunch (figure 1). Tasks can be accomplished quickly, but accuracy will suffer. However, if an OEM takes too long to make a change, it creates an opening for the competition.

What is needed are tools and processes to accelerate the completion of work while retaining the required level of accuracy. The need for speed means teams need to look beyond what Darwin said.

Consider this:

"Your success in life isn't based on your ability to simply change, it's based on your ability to change faster than your competition, customers and business.."

Mark Sanborn
Strategist, Speaker and Author
President, Sanborn & Associates

The question remains: How do A&D companies quickly and effectively accomplish change when faced with growing complexity?

Introducing digitalization into the electrical system development process

The best place to begin a discussion on digitalization is to address how to leverage the configuration-controlled electrical digital twin. The comprehensive digital twin is comprised of three major components (figure 2):

- **Product digital twin** - represents the full digital design representation of the product and its functionality.
- **Production digital twin** - utilizes the digital design and manufacturing process to represent production.
- **Utilization digital twin** - provides the information needed to support the product in service through diagnostics, procedures, component identification, etc.

While the importance of the digital twin cannot be emphasized enough, there is one essential component that brings all of the digital twin functionality together – across all domains. To be fully functional, an interconnectedness for the seamless and automatic flow of information downstream as well as delivering feedback upstream needs to be in place. In this way, the sharing of product information is automated, which enables teams to reduce the time to make a change.

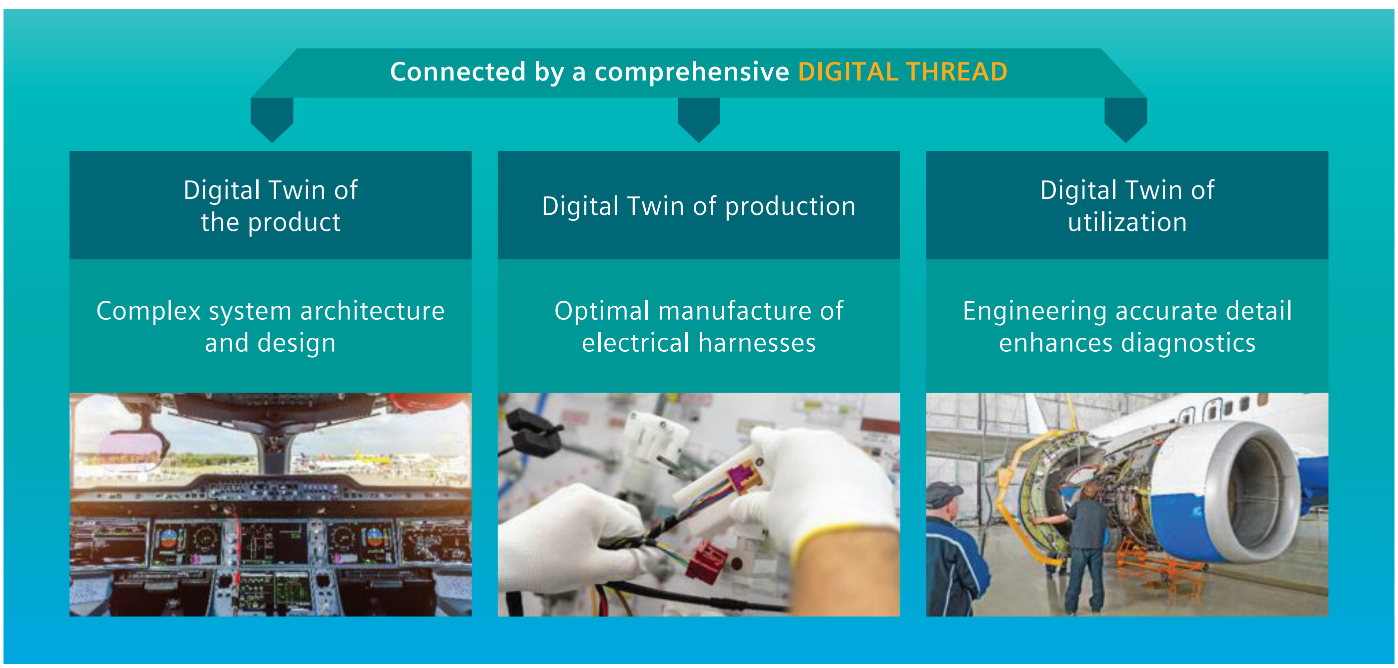


Figure 2. The interconnectedness of digital data is made possible via the digital thread.

The critical flow of data via the digital thread

A digital thread connects domains throughout the entire product lifecycle so there's constant collaboration and sharing of data both upstream and downstream. When addressing the electrical system and all its cross-domains and disciplines, the Siemens Capital suite encompasses the necessary domains for a complete, highly digitalized approach to managing change. With both a digital twin and digital thread in place, teams gain a model-based design approach that connects a full spectrum of domains.

When looking at the Capital suite electrical design flow depicted in figure 3, the process first begins as the information from functional models is utilized to generate architecture in the systems domain. From there, logical systems designs are advanced into physical wiring designs in the electrical domain. This is then used to create harness designs from which teams can generate manufacturing aids, such as form boards and bill of process. Finally, this information is sent into the service documentation domain to be used during operation and maintenance of the product.

The outcome of this approach is better integrated teams and domains, which improves data sharing and reduces downtime during handover. It also enables early and frequent analysis to reduce risk. Teams can now validate systems during design implementation and more readily optimize designs with simulations.

Although this is shown left to right flowing downstream, having a digital thread means that the flow is bi-directional, enabling feedback to be incorporated more quickly.

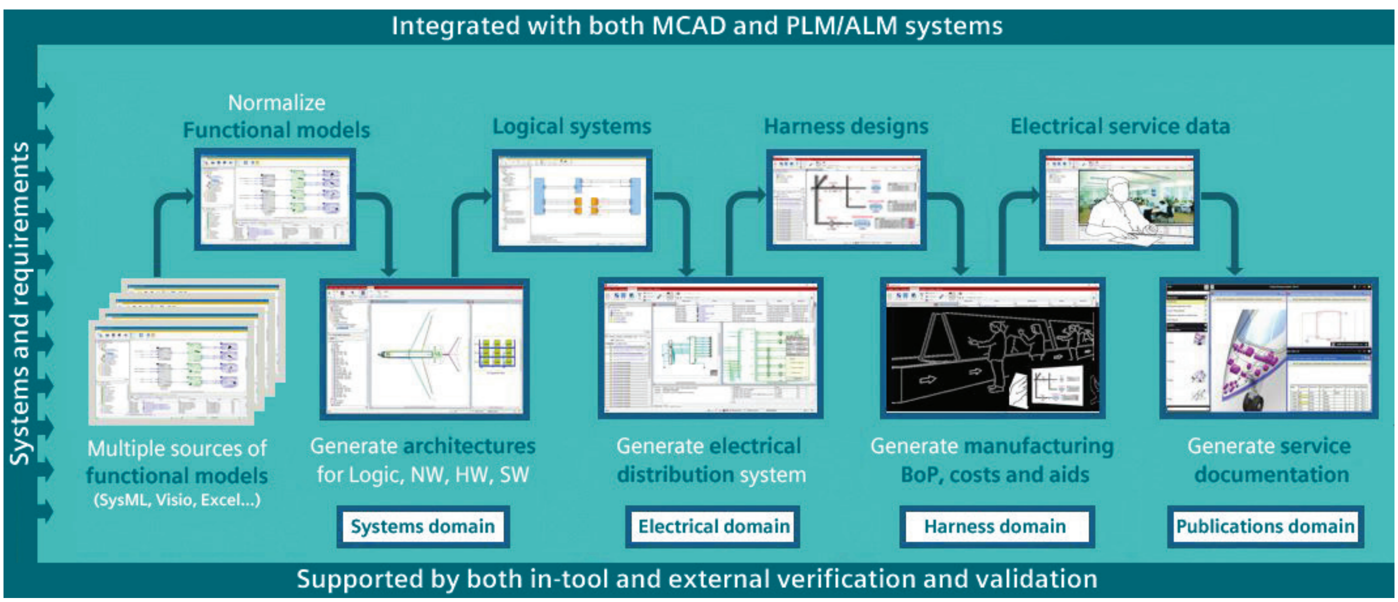


Figure 3. The digital thread connects the electrical digital twin across the entire product development lifecycle.

The change process – leveraging the configuration-controlled digital thread

With a basic understanding the digital twin and digital thread, it's imperative to take a closer look at how these technologies impact the change process. To further understand change in this context three main phases must be examined (figure 4).

Figure 4. The sequential process and stages of managing change.

The first phase, known as **change assessment**, is where change proposal, evaluation and approval occur. This is where a proposed change is prepared and impacts are gathered for multiple areas for technical and financial analysis of feasibility and return on investment. Once approved, the next phase is to generate and implement the **design change**. In this phase engineering implements the change in design and configuration, and then communicates the requirements to manufacturing and the rest of the teams involved. The final phase is to **implement change** downstream and involves many groups including certification, materials, suppliers, and others.

To understand how digitalization effects these various phases, a deeper dive into each phase is required.

Phase 1: Change assessment

To begin, as an example, suppose the engineering team received a request to install a new satellite communications system. To build such a system, the team will need to install an antenna on the tail and route wiring to this location. To examine the feasibility of this change, teams will develop a preliminary layout of wiring running to the tail. As the design is developed, design rule checks can be utilized to ensure that defined standards on data quality are met. The checks validate that the data match the expected design rules and therefore reduce the risk of design and user errors. Different rule sets can be run manually, in the background, or at the time of design release. With this approach teams are able to validate that the preliminary design is valid.

With a digitalized process in place teams can create several design solutions and conduct side-by-side comparisons. Perhaps as a first option, the team elects to run the wiring alongside an existing wire run which may provide the shortest route. The design team creates a second option which is an alternate routing path because it's more accessible and easier to install. This may require more wire length and additional inline connectors, but will save labor costs. Impacts to each design approach can be generated rapidly through automation and teams will be able to examine elements such as cost, weight, part count, as well as other factors. At this point, the team can do preliminary analysis on each option using connected analysis tools to ensure electrical load, voltage drop and signal loss requirements are satisfied.

Finally, a comparison can be made between the approaches for cost, weight and other aspects of each proposed solution (figure 5). In this case, the wire and connector cost and weight is higher when routing along path #2. This can now be evaluated against expected labor savings and other factors worthy of consideration.

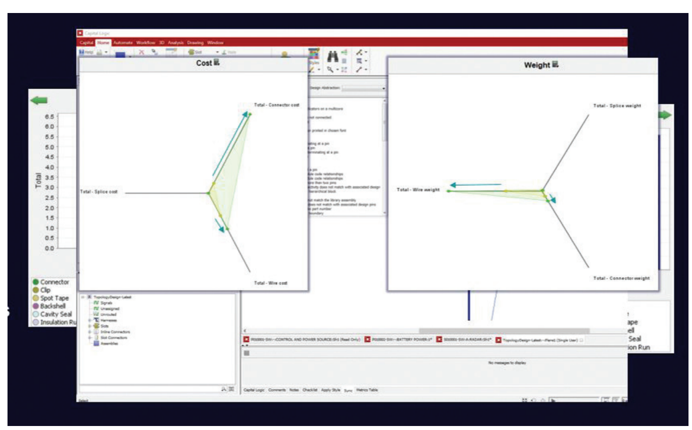


Figure 5. A comparison between option #1 and option #2 can be made quickly using a variety of detailed charts and graphs.

Phase 2: Design change

After receiving go-ahead, the change needs to be made to the engineering design in a number of domains. It's important to note that because the change assessment used data from the digital twin, teams are able to leverage the preliminary design models and gain a significant head start on engineering; saving time from having to recreate what was already done as part of the study. In this case, the electrical design change needs to be propagated across the system architecture, topology, connectivity, and harness designs. Integrated design automation across these domains (via the digital thread) ensures this is done quickly and accurately. Again, this is because of the digitalized process.

Utilizing the electrical digital twin, the mechanical design change can be implemented and synchronized with electrical design. Figure 6 depicts an integrated common bridge framework between Capital and any number of various MCAD formats. With this capability, synchronization of these MCAD environments is automated, saving time and avoiding mistakes. There are many available MCAD tools and formats, so specific adapters working across a common bridge framework will be required.

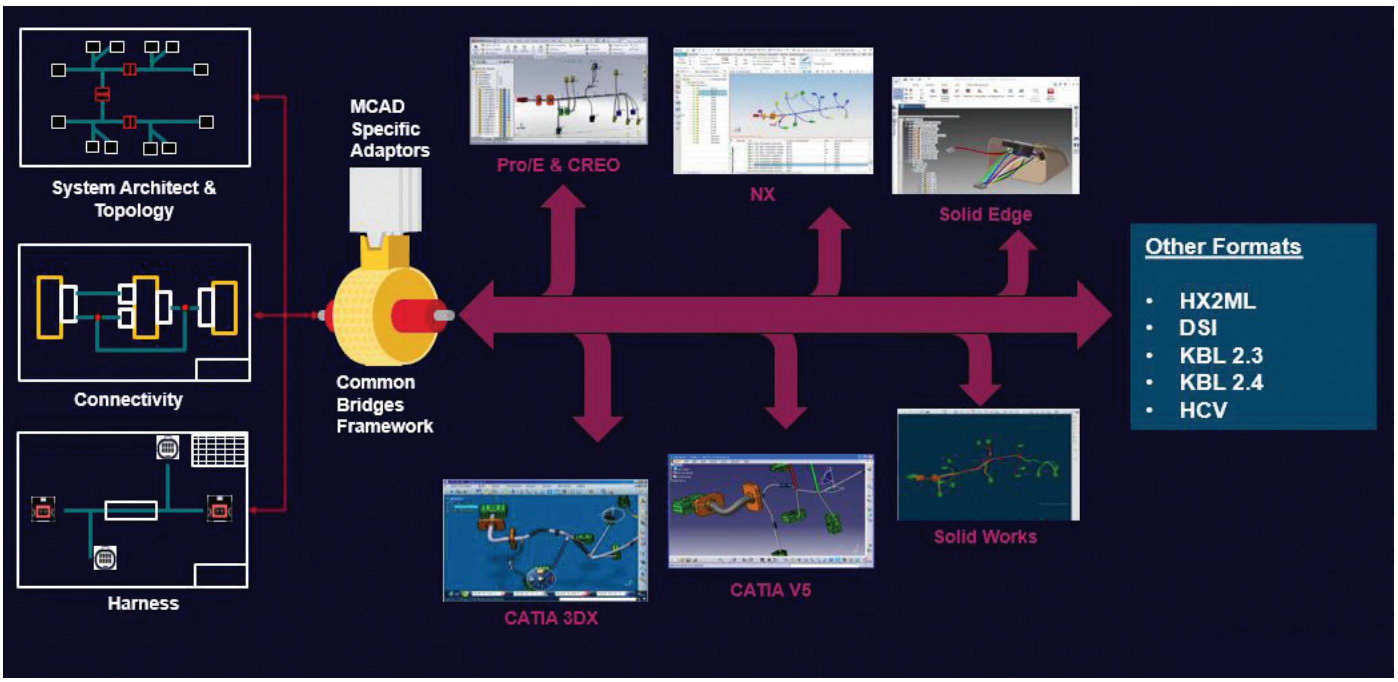


Figure 6. Electrical design synchronized across domains and with mechanical design through the digital thread. Capital supports bridging to multiple MCAD tools.

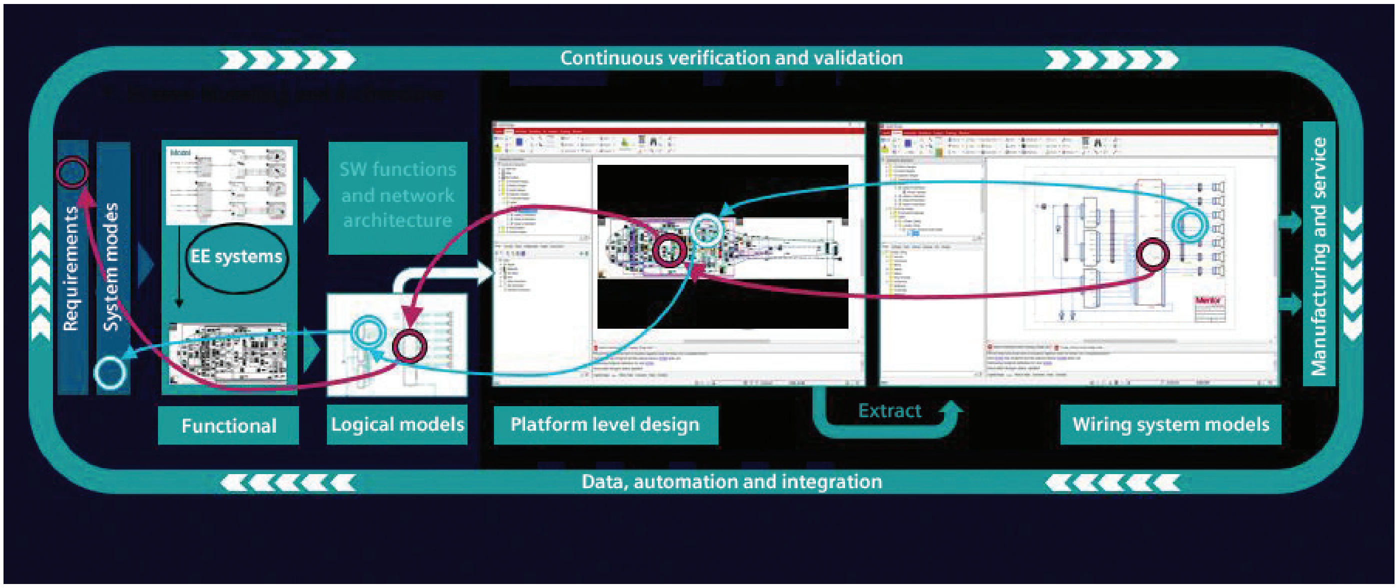


Figure 7. With the digital thread in place, the Capital E/E Systems environment offers continuous verification and validation.

Throughout this entire process, the digital thread offers traceability back to the original set of requirements (figure 7). Likewise, the integration across domains enables validation back to the system models. The example cited in this paper is to install a new satellite communications system, but what if, once the team is deep into the process, a need is discovered – *an unexpected change develops* – to upgrade an existing system? The same capabilities already used in this current process can be applied to this new change requirement along with some additional tools specific to that particular system.

If a sudden change is required to an existing system, how do teams ensure that every detail is addressed across multiple domains? Within Capital, a tool called Converge displays the design differences between different revisions or different design domains. The user can interactively view the design changes by choosing the desired design and viewing the differences via hyperlinks that will take the user to the object in question. For example, in one scenario, the wiring design has already been released, but the harness design is still in progress. The user needs to confirm that the agreed upon and approved harness design is in sync with the released wiring data. Using Capital's to-do list functionality, all design differences are automatically populated for all teams to see.

Communicating change upstream and downstream

Once both the wiring and harness design are in sync, how do teams clearly and accurately share what has changed with downstream customers or outside partners? Capital's Change Illustrator tool is used to auto-populate these design changes. This tool helps engineers to understand and validate changes in their design and provides a reporting tool for delta change. As an example, Change Illustrator can be used by a Designated Engineering Representative (DER) to validate changes and accelerate the acceptance process, getting a team one step closer to certification. It's also important to note that this report can be exported in an Excel file, allowing those outside the Capital environment to review and interrupt the data.

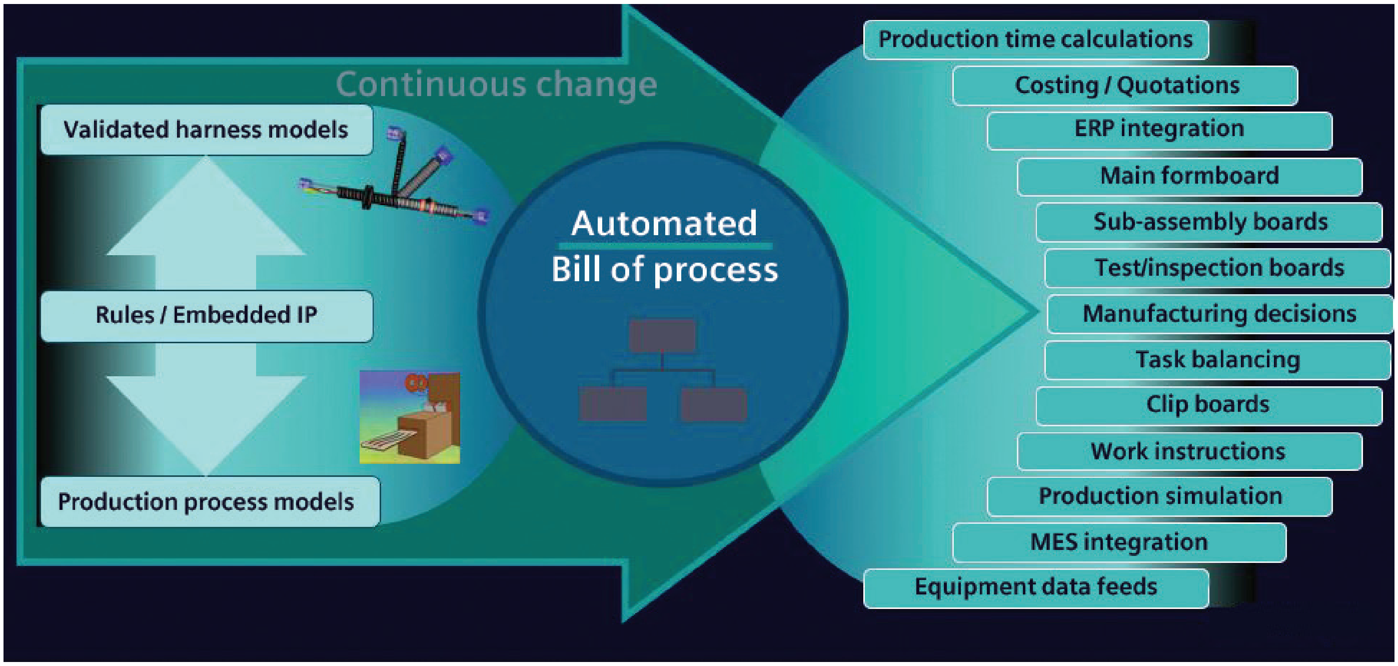


Figure 8. An automated Bill of Process (BoP) capability ensures change is made continuously to all downstream components.

Phase 3: Implementing change downstream

It's one thing to communicate the change to all involved teams, but how is the change information put into motion downstream? By combining validated harnessed models, company know-how, rules and standards and production process models, Bill of Process (BoP) automation (figure 8) is used to generate the manufacturing plan and supporting artifacts.

BoP automation greatly improves accuracy and reduces lead time, allowing for continuous change to happen. Changes may also require support publications to be updated. Being connected to the digital twin source data allows publication teams to derive the necessary documentation components and update the published documents and manuals to support the product.

Once the BoP is generated, it's easy to think the entire process has been completed. However, one more task needs to be done.

The final step is to update the platform configuration. While managing the effectivity of a given design is relatively straightforward, it quickly becomes complicated when numerous designs are changing and being implemented over time. Keeping track of this and communicating it throughout the organization using spreadsheets, PDFs or other semi-manual methods can become overwhelming and onerous. No doubt mistakes will be made. Productivity will suffer.

To illustrate this point, consider a team working on five different designs which are part of one single platform (figure 9). Initially, this is rather straightforward as each

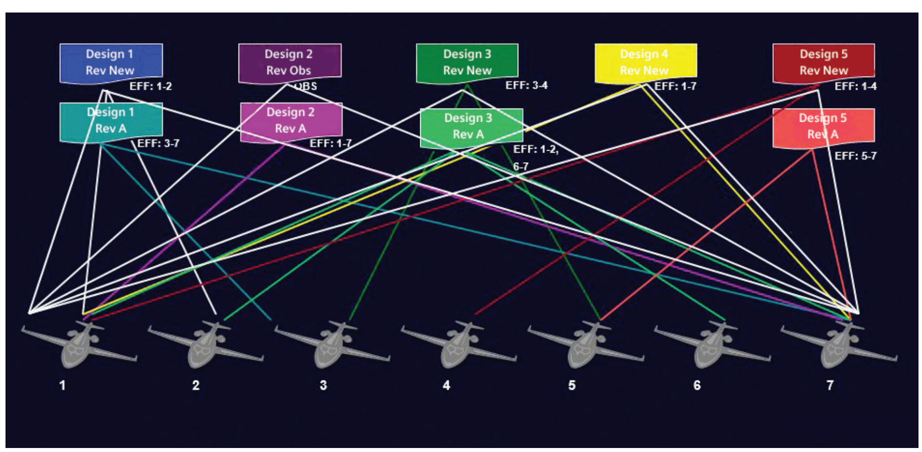


Figure 9. Complexity in managing platform change is illustrated by showing the application of multiple designs and their revisions over a series of units.

tail number will use each of the original designs, but over time it's common for designs to be changed and cut in at different times. Suddenly identifying the complete configuration of a given tail number becomes more complicated. Imagine using manual methods to keep track of this and keeping it updated with the hundreds of designs over hundreds of vehicles.

This is where leveraging the configuration-controlled electrical digital twin is most beneficial. As an example, using Capital development software, a user is able to assign effectivity (figure 10) to each revision of a specific design and manage it within the tool or through integration with a PLM system.

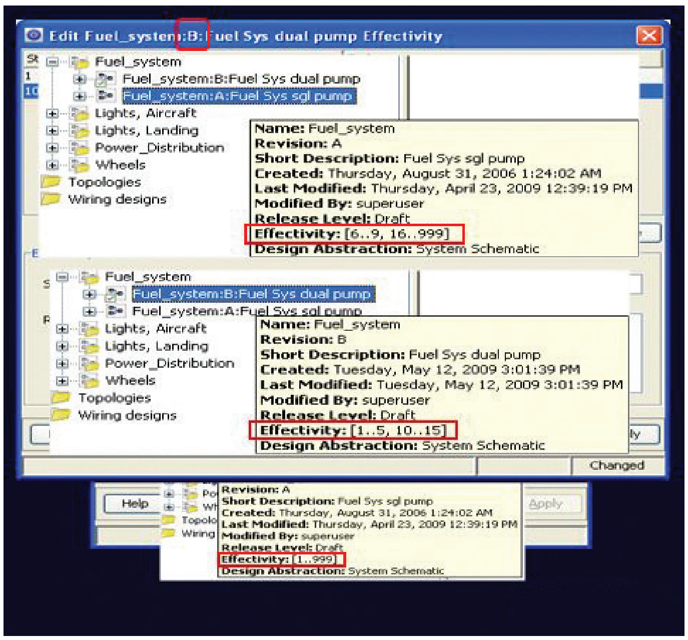


Figure 10. An effectivity is assigned to the design revision – all effectivity ranges will automatically adjust and be correct.

As the data evolves, the effectivity can be updated and internal checks ensure that effectivities of a design at different revision levels do not overlap.

As effectivity is assigned to a design revision, ranges are automatically adjusted and will always be correct. Altogether, the designs and the revisions for a given tail number or a block of effectivities can be viewed via Capital's build lists. To aid in understanding this, different platform configurations can be readily viewed in tabular format shown in figure 11.

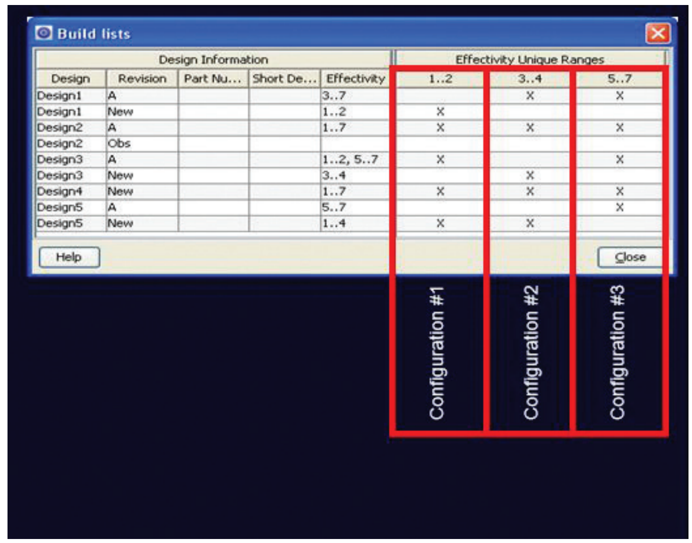


Figure 11. Capital automatically identifies unique configurations (platforms) within a build list based on revision activity.

This information can be shared throughout the organization and integrated into various PLM and manufacturing systems. By assigning effectivity to newer change designs, an organization is able to complete the final step in implementing the change into the platform design.

Conclusion

In today's world, success is tied to the ability to rapidly change and innovate. Risks increase as the pace of development intensifies while commitments for delivery and cost must still be honored. This adversity can be turned to advantage.

This paper has cited the challenges the industry is facing today, primarily the growing complexity of electrical systems, and provided concrete examples on how the change process can benefit from a configuration-controlled electrical digital twin. The paper touched on how Capital is the comprehensive E/E Systems development tool for change assessment, management and implementation processes.

The Siemens approach for embracing change – from the initial wiring system architecture and design to wiring harness manufacturing – offers several advantages to the aerospace OEM and supply chain partners. Primary among these advantages are modern automation, propagation, synchronization, validation and traceability, all of which assist in the clarity of the change management process across all involved disciplines or domains.

Several Siemens customers, in a variety of industry segments, have realized significant savings due to the reduction in unplanned changed engineering and manufacturing design times and project schedules. This type of approach benefits the user with speed, agility and accuracy. Additionally, quality has greatly increased with realization of first-time right harnesses and zero scrap for the first time ever. This has led to greater business success not only by embracing change, but being faster to market and increasing profits.

Reference

1. V. Madonna, P. Giangrande and M. Galea. "Electrical power generation in aircraft: review, challenges, and opportunities," in IEEE Transactions on Transportation Electrification, vol. 4, no. 3, pp. 646-659, Sept. 2018

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, 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 or follow us on LinkedIn, Twitter, Facebook and Instagram. Siemens Digital Industries Software – Where today meets tomorrow.

About the author

Steve Caravella is solutions architect for the Integrated Electrical Systems (IES) segment of Siemens Digital Industries Software. He has over 28 years' experience in the aerospace industry ranging from new aircraft development to in-service modification for civil and government customers. His experience includes leading and executing projects and programs in technical and program management roles, defining and implementing new business processes/tools, and developing and mentoring engineering teams. He possess a broad experience base, with technical strengths in Airworthiness and engineering design (Structures, Systems Engineering) combined with a strong customer and end-user focus. Caravella holds a Bachelor of Science in Engineering Mechanics from University of Wisconsin-Madison.

siemens.com/software

83748-C3 6/21 H