Siemens Digital Industries Software

How to mitigate electrical compliance risk in aerospace: a new approach

Executive summary

Two major trends are shaping the aerospace industry today. First, increasing mission demands are escalating platform performance requirements. Whether it's further extending the range of a twin engine aircraft, increasing battery hold-up on a large commercial aircraft, or enhancing jet fighter effectiveness, OEMs now demand more mission capabilities.

The second trend relates to new levels of complexity due to increased electrification. More than ever, platform developers are implementing new functionality via electrical solutions. These electrically enabled capabilities include fly-by-wire systems, Electronic Flight Instrumentation Systems (EFIS), In-flight Entertainment (IFE), and Combined Vision Systems (CVS). Many of these electrical approaches are replacing mechanical, pneumatic, and hydraulic implementations of existing functionality – and are becoming commonplace on today's aircraft.

Anthony M. Nicoli
Director, Aerospace and defense
Integrated electrical systems

The rise of the electrical wiring interconnect system

An implication of the increased use of electrical solutions is the increased size, weight, and complexity of the Electrical Wiring Interconnect System (EWIS). On a typical business jet, for example, it's not uncommon to have over 120 electrical systems. This particular jet's electrical system could easily be composed of 350 harnesses, comprising as many as 30,000 wire segments. This could easily add up to over 50 miles of wire – and over 100,000 parts.

With the increased use of digital communications, EWIS content has moved from simple, point-to-point analog connections to more sophisticated digital network buses. This in turn, can require expensive data cables driving EWIS cost and manufacturing complexity. EWIS complexity is further compounded by a myriad of rules to minimize electrical interference, signal separation for redundant systems, and of course, to ensure compliance and/or commercial certification.

Modern methods to help mitigate electrical compliance risk

The electrical model-based enterprise

The use of digital technologies is transforming the aerospace industry in ways imagined – and in ways not yet imagined that will be realized in the future. Digitalization gives rise to an electrical model-based enterprise (MBE) which brings together multiple engineering domains to collaborate effectively up and down the organization. MBE allows for the creation of an interconnected and automated value chain, within, and extending beyond, the platform OEM. How is this possible? Stakeholders within the OEM ecosystem employ a digital thread (Figure 1), using digital data continuity to reference a single model of the platform's electrical system, its digital twin, across the platform's lifecycle.

A model-based approach brings design teams and business functions together, achieving the universal goal of innovation, a higher quality of product earlier in the program lifecycle, and faster, more efficient compliance during the later phases of platform development.

The digital twin/digital thread

The good news is progress has been made in this area – there are legitimate solutions now available – and OEMs are beginning to take note. Perhaps one of the biggest developments is embracing the electrical digital twin, something Siemens has been out in front of for many years now. A digital twin is a virtual representation of a physical product, which can be used to understand, analyze, and predict outcomes of the physical counterpart – before it actually takes shape. The digital twin provides a core model of the product, the processes used to produce it, and its performance throughout its lifecycle, which allows aerospace teams (and future engineers) to create, iterate, replicate, and improve valuable programs. The results are data coherency and stability, integration, and advanced automation. Using an electrical digital twin significantly de-risks and streamlines platform electrical system design and integration and makes meeting compliance milestones are a far easier task.

By incorporating data analytics and machine learning capabilities, a digital twin is able to demonstrate the impact of design changes, production options, usage scenarios, environmental conditions, and other aspects such as compliance. Figure 1 depicts the digital twin of product, production, and electrical performance. Incidentally, the digital twin of electrical performance is where engineers can evaluate the design for compliance.

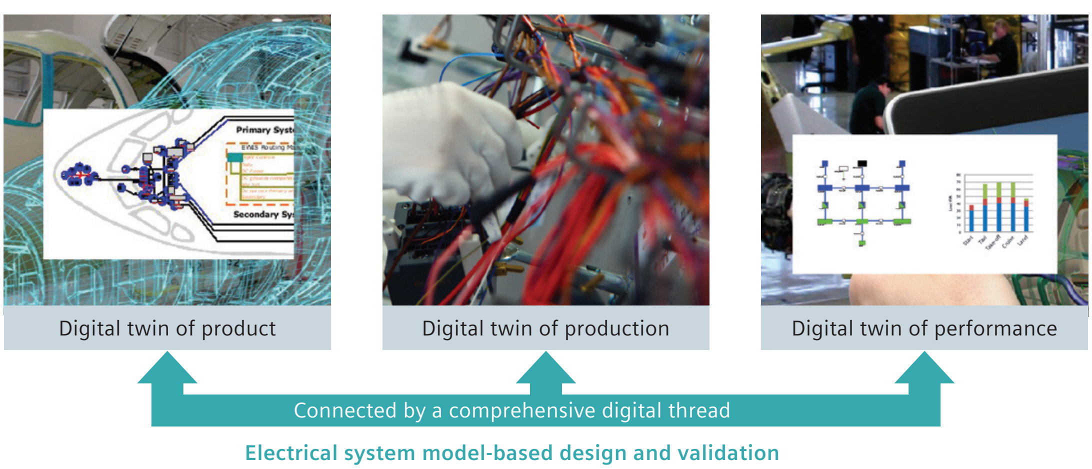

Figure 1: The digital twin of product, production, and electrical performance is connected by the digital thread, the "lifeline" that brings data together from the design, production, and operating lifecycles.

Addressing the need for more electrification – while mitigating compliance risk

As previously mentioned, modern aircraft systems are requiring more power, have more electrical content, and to complicate matters further – incur higher compliance risk due to increased complexity. To address the many challenges, the Capital® software suite from Siemens Digital Industries Software, has introduced a new compliance tool to assist users responsible for conducting Electrical Load Analysis (ELA).

The goal of this new technology is to simplify aircraft electrical design compliance and certification. This new approach, Capital Load Analyzer, is one of the industry's first electrical systems technologies to leverage automation and digital data continuity to facilitate regulatory compliance.

Outdated methods still in use today

Electrical Load Analysis (ELA) is an important aspect to ensure adequate power for electrical systems during all phases of flight. For the most part, ELA today is done manually using spreadsheet-based tools. Design data is manually transferred into these stand-alone tools, leading to the possibility of analytical errors. For example, ELA is often performed on old versions of the design, sometimes omitting entire portions of the most recent design configuration. With increased electrical complexity the old manual way of doing things no longer suffices because it doesn't scale well for increased complexity. In fact, many of the current methods used today were developed in an era when aircraft electrical systems were far less complicated. The current manual process often results in error-prone data capture and requires an extremely long duration of time to create compliance documents.

Further, the current methods used today often mean compliance issues are found after the major electrical design work has been completed. This can not only lead to missed critical milestones, but force expensive design iterations at a critical program phase which could result in serious cost and schedule setbacks for the entire program.

Employing the capital electrical digital twin

To mitigate such risks, the Capital Load Analyzer compliance tool draws upon Capital's electrical digital twin to perform accurate and rapid load analysis on the aircraft's electrical system. It predicts power demand for the aircraft's entire electrical system as designed to ensure sufficient power for each phase of flight (figure 2), even for emergency conditions. The electrical digital twin can be employed to meet load, separation, and derating requirements. This also includes electrical load analysis and design validation along with analyzing every generator, rectifier, battery, and bus for each flight phase.

The Capital Load Analyzer ELA methodology follows traditional ELA guidelines and provides a convenient means to address the following key compliance perspectives:

- Manage the required information for ELA, such as single-line wire diagrams, operation scenarios (all flight phases), analysis notes, etc.
- Perform ELA iterations, ELA reports, and ELA analysis and report iterations
- Show compliance for every configuration as needed

Figure 2: Capital Load Analyzer ensures that the design under consideration has enough power for electrical connected systems in each flight phase.

Capital load analyzer user advantages

A single place for all ELA-related information management

Users can manage all ELA-related data as part of the native design data. Some of this data includes: all devices related to ELA, such as AC/DC sources, AC/DC loads, converters, inverters, and contractors; all design information extracted from related devices, such as power ratings and power factors; all transient load information operation scenarios, engineering notes; and airplane information for the ELA report.

Since all ELA-related data have been managed through the data manager, it is now possible to have the data synchronized with the underlying design data. This type of capability improves the traceability of the design process.

Fast creation of the source utilization analysis

The analysis results in Capital Load Analyzer are displayed in chart and graph forms. Today, when a user performs an ELA, the analysis results and graphs are manually created, which is extremely time-consuming and often fraught with errors. Using this new capability in Capital Load Analyzer, the charts and graphs can be created immediately and can be inserted into the ELA report, delivering the most up-to-date charts and graphs whenever a report is generated.

On-demand analysis of a single-line wire diagram

The single-line wire diagram is derived from the underlying product design and is an illustration of the power architecture. Figure 3 depicts a single-line wire diagram and an example of the underlying design. Notice, in this example, the common device "DC_BUS_LEFT" is the link between the single-line wire diagram and underlying designs.

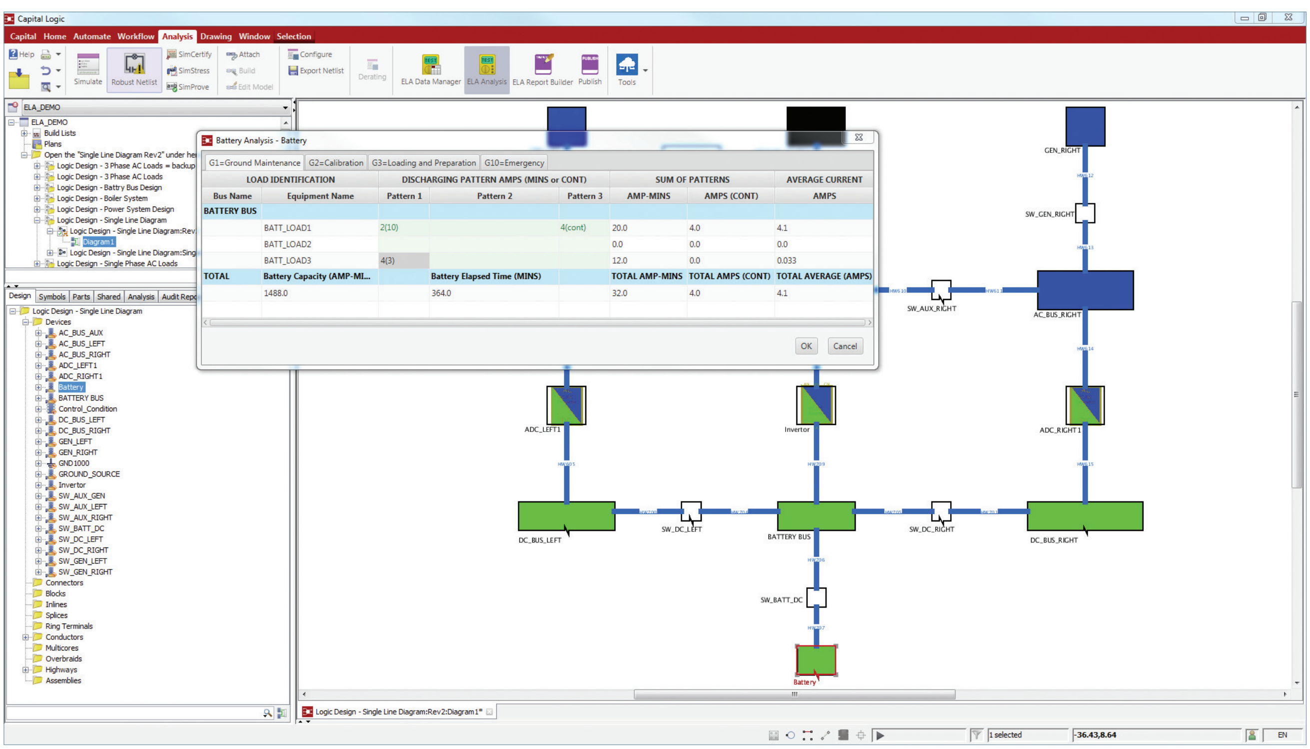

Figure 3: On-demand analysis is performed on the single-line wire diagram, allowing teams to analyze the utilization for each source component.

With Capital Load Analyzer, the creation of the single-line wire diagram is extremely easy to use and is 100 percent in-sync with the underlying design. The styling of the single diagram can also be changed to match the user's design preference. The filtered view of the single-line wire diagram also gives the user an architectural view of each individual operation condition. Any component within the single-line wire diagram can be tagged with a certain operation scenario(s) the user specifies. This is particularly useful when evaluating various failure modes and load shed sequencing.

On-demand analysis is performed on the single-line wire diagram and allows the user to analyze the utilization for each source component. At any time, within any stage of the design, a user can run the analysis and view the analysis charts and graphics to immediately see the electrical loading impacts of design changes. The changes for the underlying design along with the changes for the operation scenario definition will be directly applied to the ELA and will appear in the analysis results.

New ways to model the battery

The battery onboard any aircraft is a special device. It behaves as a load when there are other power sources feeding into it, and as source device when there are no other sources available.

Analyzing a battery manually has been problematic for a lot of platform OEMs. For the purpose of ELA, battery charging has been modeled using a battery charging factor. The battery charging factor is derived from the battery load current chart and can be used to calculate the battery current for each operation scenario and each time interval. The discharge of the battery has been modeled using different discharge patterns. We get the battery hold-up time by combining all discharge patterns from all connected loads. Figure 4 shows the battery model and output of the battery analysis. This enables the user to: 1) model the battery very easily when it behaves as a load, and 2) obtain the real time feedback of battery hold-up time when it behaves as the source.

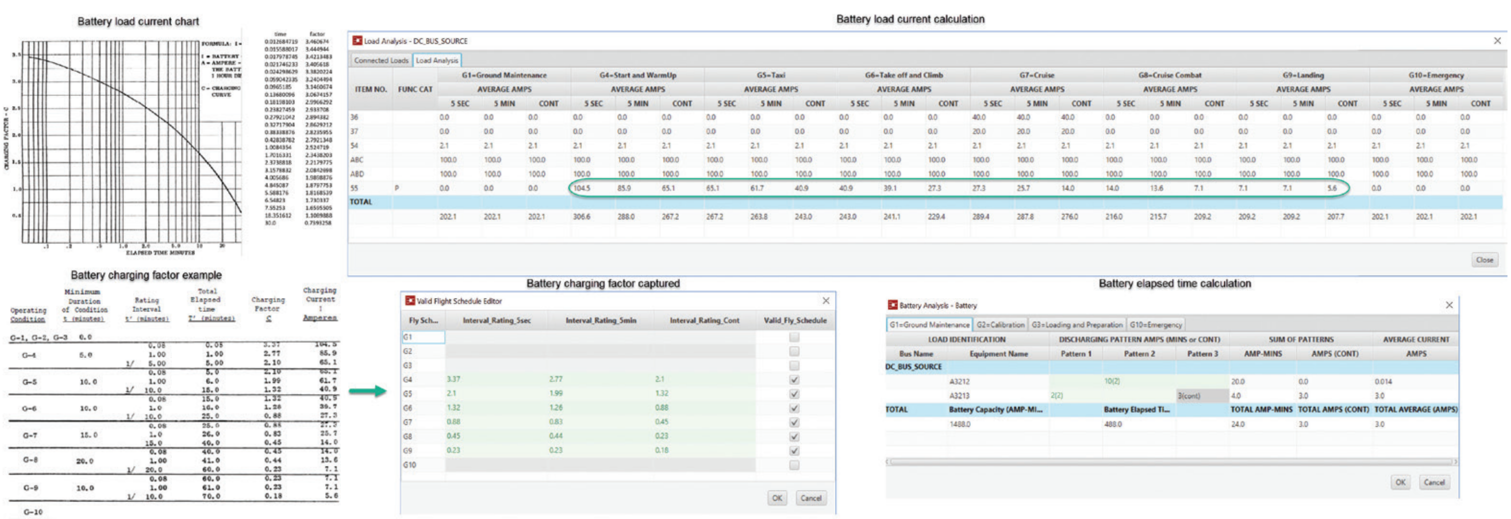

Figure 4: Battery analysis for battery as load or source.

Automatic and comprehensive analysis and reporting – in real time

ELA engineers spend a vast majority of their time manually creating and maintaining an ELA report. Since this is primarily a manual process, the report does not always synchronize with the design changes as they occur – and thus, the report quickly becomes outdated by the time the product design is finished.

Capital Load Analyzer (figure 5) automatically extracts all electrical load analysis data into the user's own reporting template for easy and efficient report generation. This technology pulls directly from the electrical digital twin so the user can see the impact of design changes at any time and at any stage of the design process. The ability to quickly generate real-time reports enables users to monitor design tasks and identify potential issues early in the design process, thereby mitigating program risk.

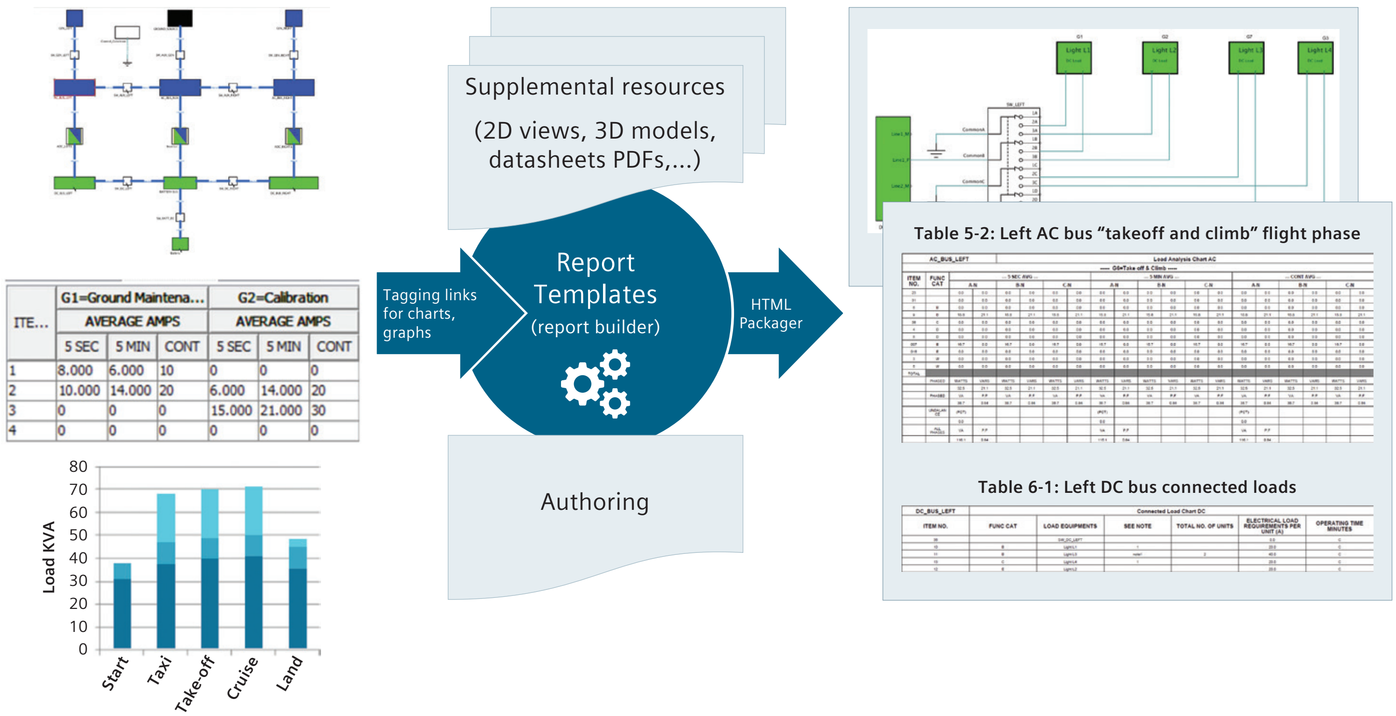

Figure 5: Report generation features integrated reporting, allowing groups to automatically populate a report using their own template format – then automatically refresh the report data using live designs in Capital.

Conclusion

By applying a more modern method to meet the challenges of compliance risk, teams are now able to effectively mitigate program risks for electrical compliance. The Capital compliance tool discussed in this paper offers numerous advantages:

- **Complete ELA earlier in the program:**
  Frees engineers to do other more critical tasks
- **Reduce program risk:**
  Mitigates risk for type certification and customer acceptance milestones
- **Fewer findings during peer reviews:**
  All analysis results are correct by construction
- **Higher first-time quality:**
  Entire design is analyzed correctly every time
- **Quickly validate early electrical system designs:**
  Reduces the probability of late-program design changes
- **Avoid late program design Iterations:**
  Enables program leaders to keep their commitments

An automated, template-based report generation mechanism not only allows teams to reuse the ELA report

template across the organization, but enables users to create the ELA report with the most up-to-date design data contained in the configuration-controlled electrical digital twin. With this approach, users are able to generate a report and send it across multiple teams, or locations, in real time so the entire design team can act accordingly and ensure that all aspects of the design are consistent with electrical compliance guidelines.

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About Siemens Digital Industries Software

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About the author

Anthony Nicoli leads the aerospace business for Siemens Digital Industries Software's Integrated Electrical Systems (IES) business segment. He is charged with expanding IESD's contribution to this market. Prior to this role, Tony led the Mentor Graphics technical sales team serving The Boeing Company. He joined Mentor in 1999, growing to lead the marketing organization for Mentor Graphics' integrated circuit physical verification product line, Calibre, before joining Mentor's sales team. He spent nearly twenty years in the defense industry, developing electro-optic and electro-acoustic systems and businesses, working primarily in the tactical missile countermeasure and underwater imaging domains. Tony holds Bachelors and Masters Degrees in Electrical Engineering from the Massachusetts Institute of Technology and a Masters in Business Administration from Northeastern University.

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