

Siemens Approach to Improving the A&D Certification Process

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The extreme and growing complexity of aircraft and related products is making certification processes ever more costly and time-consuming. If a product fails certification testing it can be neither delivered nor operated, and the OEM cannot collect payment or generate revenue from the ordered aircraft or systems. Furthermore, many physical tests require complex setups that must be scheduled in advance and any program related issues can wreak havoc on schedules. The automotive industry has made significant strides in virtual testing and validation that are now being leveraged within A&D. As virtual testing improves over time, both internal staff and regulators' confidence in virtual testing will increase enabling fewer physical test requirements.

Connecting the program plan with the product data and processes including validation and certification testing improves visibility and reduces mistakes. To maximize benefits, suppliers and even regulators must have access to the program plan and OEMs must be confident in the quality of the supplier data to achieve overall product certification.

Siemens support for verification management and integrated program management is helping to transform the A&D industry. Their digital thread approach supports requirements, design, analysis, physical testing, and reporting and is focused on achieving product compliance faster.

Introduction

Aerospace and defense (A&D) manufacturers are under continuous pressure to evolve and improve how they operate. Operations across the entire lifecycle, from acquisition to engineering, design, production, certification, and service, must improve. As with most products produced today, electronics and software have become integral elements of A&D products, dramatically increasing complexity, testing and certification requirements, timelines, and of course, cost.¹

Over the years, A&D supply chains have also grown in size and complexity. Components are manufactured in sub-tiers while higher-tier suppliers perform system and subsystem assembly and the required verification and certification. Supply chain operations that include verification and certification can add significant schedule risk due to the lack of visibility into associated production and certification status. The Original Equipment Manufacturer (OEM) is ultimately responsible for certification of the delivered product, so they need to coordinate with suppliers and adjust production and delivery schedules based on supplier status. Without clear visibility into each supplier's production and

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certification processes, OEMs can't adjust to accommodate change and meet important certification and delivery dates.

To ensure a program runs on-time and within budget, it is critical the OEM have access to, understanding of, and the ability to respond to supplier status and feedback. Data from supplier tests and certification reports are important artifacts that OEMs use to assess issues raised by suppliers and to validate the quality of the design, product, and supplier performance. OEMs must be confident in the quality of the supplier data to achieve overall product certification.

In recent years, improvements to digital simulation and analysis tools have led to their expanded use, as they have proven capable of supporting virtual testing and validation, supporting certification. What started as automated testing in the machinery design industry has evolved to replace physical testing in more complex product industries. The automotive industry, for example, has made significant strides in virtual testing and validation. Structural, fluid, and dynamic analyses are combined to simulate entire vehicle operation. Improved computing performance has enabled larger, more complex analyses to execute in real-time, and with more speed so more use cases can be executed. This is especially useful when there are too many test cases to be physically tested.

Product Certification

Within A&D, as in many regulated industries, product certification is challenging. Ensuring flight and human safety is paramount, so A&D products must be certified three times over—for type, production, and airworthiness—and each certification comes with unique challenges. Certifying A&D products is expensive and on the critical path to delivery. However, by the time certification activities begin, A&D companies have invested enormous amounts of money building prototypes and pre-production units. If a product fails certification testing it can be neither delivered nor operated, and the OEM cannot collect payment or generate revenue from the ordered aircraft or systems.

In A&D, the certification plan is developed by the manufacturer and approved by governing bodies, the most important being the Federal Aviation Administration (FAA) in the US and European Union Aviation Safety Agency (EASA). Once the certification plan is defined, it needs to be executed and demonstrate traceability from requirements through virtual and physical tests to ensure product verification. It must also be placed under strict change control and reflect any certification-related factors (new materials, technology, manufacturing processes, etc.) that may emerge during the course of the development lifecycle.

Certification is not a one-and-done process. Type certification verifies that aircraft design and its components meet airworthiness requirements. Production certification verifies that an aircraft type can be produced in series and that the organization, facilities, and quality systems can produce each copy to conform to its type requirements. The final certification, airworthiness, allows an aircraft to

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be used in commercial operations with minimal restrictions. Other [special airworthiness certifications are listed on the FAA website](#).²

Verification is not just used to demonstrate initial compliance; compliance must be maintained over the lifespan of the aircraft to ensure safety. Aircraft have tens of thousands of requirements applicable to many systems and subsystems that are more interconnected than ever. Aircraft have an operating life measured in decades and need meticulous, properly-documented maintenance to keep airworthiness certificates current.

Certification is also used to identify design flaws. This is done by continuously verifying the design during development. Historically, certification has been a parallel, independent process often done long after the design. In the old days, certification consumed an average of 25% of the aircraft program budget, but with the increased complexity of modern aircraft and systems, it can range from 50% to 75% of the overall program cost.

The cost increase for verification is driven by growing complexity, especially with the addition of more electronics and software. Manual and legacy test and verification processes cannot scale to meet the complexity of today's (and the future's) products. A digital transformation is required to not only keep costs under control but also to ensure products are properly and completely verified and certified.

Within modern PLM platforms, the various digital analysis solutions enable verification and certification to be done regularly during design. This significantly reduces costs and timelines by eliminating flaws early in the process when the cost of change is low. Digitalization, the process of converting manual paper and document-based processes into data-driven, traceable processes, is commonly implemented using a PLM platform. By converting to a digital paradigm, processes are sped up, more traceable, and the artifacts necessary for certification are captured as a byproduct of daily work. This helps lower costs, shorten timelines, and minimize the scrambles that happen when trying to find and gather certification documentation using legacy approaches.

Virtual and Physical Testing

Verification and certification testing are evolving from physical to virtual. With virtual testing, simulation models confirm product requirements before physical instances of products exist. The ability to certify products based on simulations has been developing for many years. Simulation solutions have been solving structural, thermodynamic, and fluid flow problems for decades. More recently, systems engineering tools have automated the development and verification of electronics and systems models. PLM and simulation data management solutions keep test requirements and results in sync with the product configurations to support verification and certification processes.

Physical testing continues to be used to validate virtual testing, but this is still far from complete. Some level of physical testing will likely always be needed

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² https://www.faa.gov/uas/advanced_operations/certification/

because A&D products push designs and materials to the limits of the physics and logic encoded within them. Virtual testings' value is obvious; it saves time and money by enabling routine tests to be done virtually and frees up resources so important, difficult to model, tests can be completed physically. A more recent capability within virtual testing is the virtual sensor. Virtual sensors are used in simulations to report what a physical sensor would display had it been included in the test equipment. Often, physical sensors cannot be installed because of space or operating constraints. For example, by running a simulation using data from physical tests, such as inlet temperature and outlet temperature, the simulation can confidently predict a temperature at an intermediate point at which a sensor cannot be installed. Confidence in the intermediate point is based on an accurate prediction of the inlet and outlet temperature.

In most companies, even those with virtual testing strategies, there is a significant opportunity to save time and money through continuous improvements to testing. The critical point is that virtual and physical tests need to accurately correlate. Achieving correlation can be challenging as the simulations need accurate models with the proper loads and constraints and be executed by a skilled analyst. Over the years, the modeling tools have improved, making it easier to develop accurate simulations, but companies still need to validate the correlation.

A surprisingly difficult activity is ensuring the virtual and physical configurations of the product, test equipment, and validation inputs are correct. A complete configuration-controlled product model that includes mechanical, electrical, and software components is the foundation of a robust validation solution. In recent years, companies have turned to the digital twin to ensure configurations are accurate and useable to meet validation and operational requirements and lead to timely certification. Creating a digital thread and using a digital twin to manage validation speeds up the design process by eliminating mistakes. As this solution improves over time, both internal staff and regulators' confidence in virtual testing will improve.

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Integrated Program Management

Integrated program and project management does much more than just keep track of the schedule. Connecting the program plan with the product data and processes improves visibility and reduces mistakes. By connecting deliverables with project tasks, a holistic view of the data is captured in a context that is much easier for non-engineering staff to consume. Rather than navigating a large BOM structure or searching for inconsistent item names, people can navigate product structures (often graphically) to find appropriate deliverables to do their work.

The best program and project management environments are fully integrated, which enables secure data exchange and collaboration across the supply chain and with regulatory bodies. This helps reduce confusion and mistakes, shortening timelines and ultimately reducing costs while improving quality. When fully integrated, the solution captures all information (e.g., requirements, specifications, CAD and simulation models, software, manufacturing data, test results, service information, etc.) needed for certification processes. Workflows

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representing business processes, including the change process, ensure configuration integrity and give regulatory agencies confidence that data is high quality, consistent, and valid.

In legacy processes in which validation was done after the fact by digging through documents and data, certification data packages were outside configuration control, forcing error-prone manual efforts to validate that the data being sent to the regulatory agency was complete and accurate. Furthermore, physical testing is time-consuming and expensive, and many tests require complex setups that must be scheduled in advance. When testing teams are excluded from the project plan and change process, the disconnects cause delays and errors. Even worse, when validation and certification of subsystems are performed by out-of-the-loop suppliers, additional waste can occur. Ensuring that the entire supply chain is connected to a common integrated program and project management solution that includes certification deliverables enables the impact of change to be managed effectively as the initial plan evolves.

Putting It Together

The Xcelerator™ portfolio from Siemens Digital Industry Software contains out-of-the-box solutions that support A&D products across the full lifecycle shown in Figure 1. There are a variety of integrated solutions that address the A&D industry from requirements management and model-based systems engineering (MBSE), through simulation, design, manufacturing, and service. Teamcenter, Siemens' product innovation platform, provides data and process management services, acts as the backbone for the digital thread and manages the data representing the digital twin.

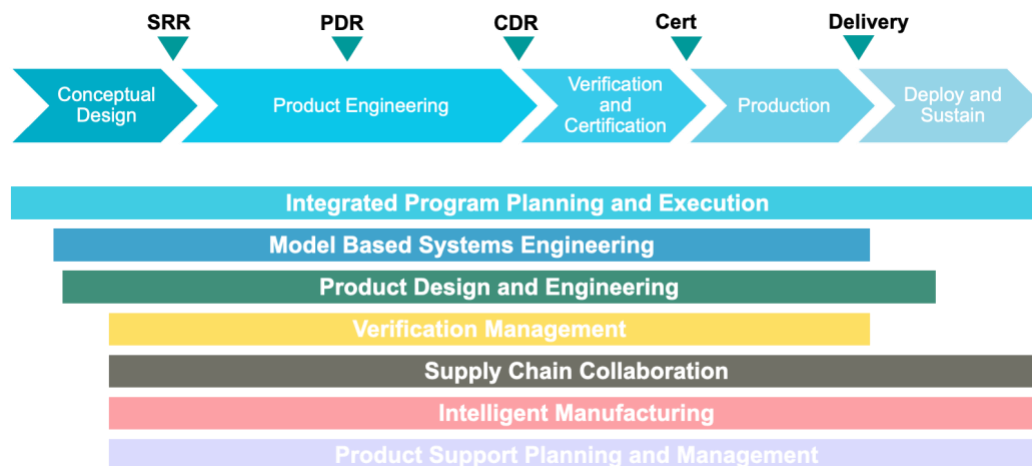


Figure 1—A&D Digital Threads Supported by Siemens Xcelerator Portfolio

Two digital threads originating from the Xcelerator portfolio, Integrated Program Planning & Execution and Verification Management, are critical solutions for the A&D industry. The Verification Management digital thread supports requirements, design, analysis, physical testing, and reporting focused on achieving product compliance faster. Figure 2 shows the Verification Management capabilities included within the solution.

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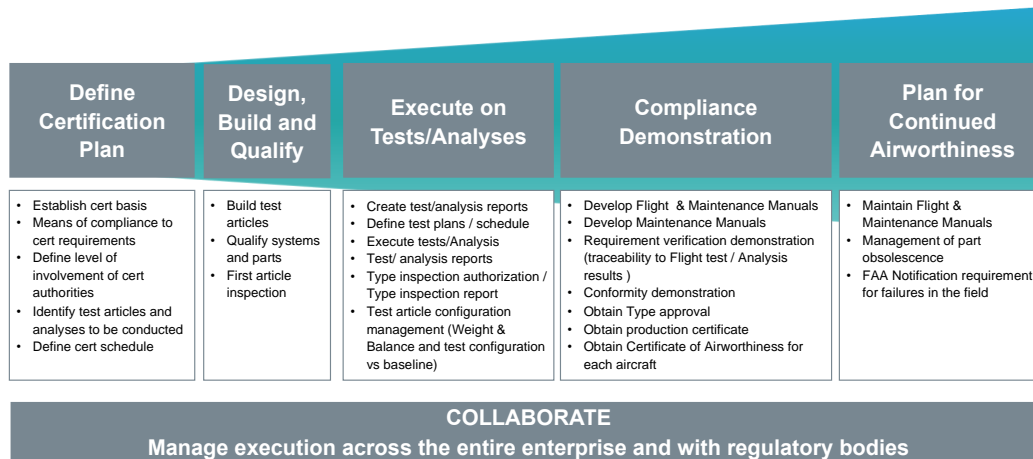


Figure 2—Verification Management Capabilities Provided in Xcelerator

Verification Management extends Teamcenter’s capabilities and tailors them to the A&D industry. Capabilities from requirements through design, analysis, manufacturing, test, and service are all maintained under configuration control by Teamcenter, easing one of the major issues with certification—keeping data properly organized. Teamcenter’s collaboration capabilities and security model support data sharing and communication across the supply chain and regulatory authorities for both initial and continuous airworthiness certifications throughout the lifecycle of the aircrafts. By leveraging integrated verification management, change impact analysis identifies certification artifacts that need to be reviewed, minimizing delays and mistakes by ensuring accurate information is distributed across the extended enterprise. Traceability enabled by Teamcenter gives the extended enterprise complete visibility to source data for certification artifacts, improving confidence in the digital and physical versions of the product.

While the data and process management enabled by Teamcenter provides data authors with robust capabilities, the Integrated Program Planning & Execution (IPP&E) solution coordinates the activities across the extended enterprise, ensuring they get completed on time and within budget. IPP&E uses a common work breakdown structure (WBS) to organize planning and execution and create work package definitions that integrate cost, schedule, requirements, processes, inputs, and outputs. Additional capabilities include the ability to generate estimates based on past performance and manage risks and opportunities. It supports Integrated Master Plan, Integrated Master Schedule, and Earned Value Management.

By including A&D tailored capabilities that align with industry best practices, the Siemens solutions enable the creation of a comprehensive digital twin that not only support products’ development and operation but also ensures that initial and ongoing certifications, especially airworthiness are effectively and efficiently managed.

Teamcenter’s collaboration capabilities and security model support data sharing and communication across the supply chain and regulatory authorities for both initial and continuous airworthiness certifications throughout the lifecycle of the aircrafts.

Conclusion

Certification is a critical, expensive process in bringing A&D products to market; one that is ripe for digital transformation. It needs to evolve from an artifact scavenger hunt to executing a verification process as a part of daily work managed by proper program planning and execution. The extreme and growing complexity of aircraft and related products is making physical testing ever more costly and time-consuming. It is becoming impossible to execute all needed tests in a reasonable timeframe.

Incorporating verification management throughout the extended enterprise supply chain enables more effective program execution, including simulation and physical test coordination and correlation, which will reduce costly physical testing and improve confidence in simulation-based virtual testing and certification.

Siemens Digital Industries Software has been enabling digitalization for decades. Their digital thread bolstered by the digital twin enables incorporation of verification management within an integrated program management methodology, leading to improved program performance and a faster, more efficient certification process that results in better, safer products.

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About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise's ability to design, deliver, and support innovative products and services by identifying and implementing appropriate digital initiatives. For nearly forty years, CIMdata has provided industrial organizations and providers of technologies and services with world-class knowledge, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) solutions and the digital transformation they enable. CIMdata also offers research, subscription services, publications, and education through certificate programs and international conferences. To learn more, visit www.CIMdata.com or email info@CIMdata.com.

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