Agile Development: Supporting the Aerospace & Defense Industry

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May 2021

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This white paper discusses the growing need for agile development in the Aerospace & Defense (A&D) industry. It describes key development issues pertinent in the A&D industry and how an agile development approach can address these issues to enable shorter, more efficient, and less costly product development and delivery while improving in-service availability and support. Readers will also gain an understanding of the agile development paradigm and the business value that can be achieved by applying agile methods in A&D. Finally, this paper describes how Siemens Digital Industries Software (Siemens), with its Xcelerator portfolio, addresses these challenges and provides solutions for enabling agile development in the A&D industry.

Key Takeaways

- *Product development paradigms in A&D are evolving—reflecting the need for more efficient and faster development cycles.*
- *The United States Department of Defense (DoD) is moving to a new acquisition model requiring A&D companies to deliver solutions faster within a construct of validated modules.*
- *Companies need to adapt agile development methods pioneered in the software industry to accelerate A&D product development.*
- *Product development teams must use modern, open, and integrated design ecosystems leveraging the comprehensive digital twin and digital thread to boost innovation, as well as reduce costs, technical risks, and design-cycle time throughout the entire product development process.*
- *Manufacturers must be more flexible to efficiently address their customers' evolving needs and work more collaboratively with their supply chain partners.*
- *Siemens' Xcelerator portfolio of solutions provides a proven set of capabilities to enable agile development in the A&D industry.*

Introduction

For a host of reasons, product development in the A&D industry continues to be a challenging endeavor at the highest level. A&D products and systems are extremely complex, have long service lives, and must function in a wide range of harsh and demanding environments. These products and systems generally push the boundaries of available technology and design in the areas of materials, electronics, software, functionality, speed, fluid flow, etc. Additionally, many A&D products are highly regulated and often subject to extreme operating conditions where any type of product failure could lead to catastrophic consequences.

Because of this range of complexity, A&D development cycles have tended to be formal (e.g., using major stage gates in a waterfall development paradigm) and drawn out. During these extended product development process cycles, functional requirements and available technologies often evolve so there is the potential for a high volume of change throughout the program. However, it is difficult to incorporate new capabilities and technologies after program "go." Adjusting requirements and/or changing the solution technology increases the overall program development time and cost.

The US DoD has an initiative to improve and accelerate A&D program development and acquisitions—"Rather than just building better systems, it builds systems better."[1]

The United States DoD has recognized the need for accelerated and incremental development and acquisition processes. As a result, it is now implementing a paradigm shifting initiative to achieve those goals. The objective of the initiative is:

> *"Rather than just building better systems, it builds systems better"*[1]

The desired result is to drive faster design, seamless assembly, and easier upgrades that help reduce overall program lifecycle cost.

To support this DoD transformation, A&D companies need to adopt a different way of thinking about and executing product development. Traditional A&D sequential product development methodologies have not evolved to take advantage of new development paradigms that can reduce the overall product development time. Successful, timely, and cost-effective development requires a more flexible, agile development approach. This approach breaks processes into smaller, more easily achievable blocks of effort called "Sprints."

To improve their development processes, A&D companies need to undergo a digital transformation in process definition, enablement, and execution. They must create environments that use digital information more effectively to enable more efficient, productive, and collaborative development processes that span their end-to-end value network. This digital transformation will enable A&D manufacturers to better collaborate with their supply chain and design partners no matter where they are or what design tools they use, as well as involve these partners in a more agile development process.

Concepts of Agile Development

For the most part, traditional A&D waterfall- or phase-gate-driven product development is a step-by-step process, where the next step cannot proceed until the previous step has been completed. For many A&D companies, collaboration among multiple disciplines during a major development step is standard practice, but these "steps" are major elements within rigid structures, all part of a traditional sequential programmatic timeline.

In contrast, agile development is a group of methodologies whose core values are:

- Individuals and interactions are prioritized over processes and tools

1 Roper, Will. "There is No Spoon: The New Digital Acquisition Reality." Assistant Secretary of the Air Force for Acquisition, Technology and Logistics. October 7, 2020.

- Working solutions are prioritized over comprehensive documentation
- Customer collaboration is prioritized over contract negotiation
- Responding to change is prioritized over following a plan

Agile is about doing the right thing, which can often mean not doing things completely right. Agile requires the assessment of the project continuously throughout the product development activity. An agile development approach is most effective where the problem to be solved is complex, solutions are initially unknown, product requirements will most likely change, and the work can be modularized.

Agile development is an iterative, incremental process built on doing the right thing, not always doing things right.

Agile development is an iterative and incremental process that is responsive to change and is designed to reduce the overall cost and timeline of development. Work is conducted by the members of the product development team in work cycles called "Sprints," "Scrums," or "Iterations." An agile process typically includes daily meetings, a clear definition of "Done," and incorporates frequent releases. In agile development, requirements are allocated and bundled into user stories (or use cases). User stories are prioritized and one or more are selected as the scope for each particular sprint. During the sprint, a product solution element is designed, analyzed, optimized, and validated. At the end of each sprint, the team delivers a product increment ready for deployment and/or use in the following sprints. This process continues throughout the development lifecycle until all the defined capabilities of the product or system are ready for release.

The goal behind a sprint can vary in nature in terms of scope and size. A few examples include:

- A potential feature the company thinks would add value to the product they are building
- A minor change that the team thinks will improve the product
- A last-minute change identified via collaborating with a customer

Agile allows development of the product in parallel with revelation of new insights, ongoing changes to requirements, and acquisition of other impactful information. The shortened development cycle time allows the product to be more attuned to the shifting state of the market and helps ensure the product is still fully relevant when launched.

A&D product development teams often face uncertain and unpredictable scenarios. Dealing with new requirements or late changes is difficult, costly, and often, only partially successful. Often these changes result in:

- Scrapping previous work put into the earlier stages of development and starting completely over again, or
- Ignoring the implications of market shifts and pushing through with the product development, while hoping that the product at launch will still fit the market need

In an agile development environment, teams can respond quickly when these unpredictable scenarios come up and adapt accordingly. Teams that adhere to an

agile methodology are less constrained by formal operating procedures. This allows them to be more flexible, instead of being boxed in by specific and rigid rules—rules that they sometimes work around or ignore with mixed results.

Agile Development for A&D

While agile development practices are widely applied by companies for the creation of software and electronic solutions, the approach is rapidly gaining traction within companies that develop complex mixed-technology (i.e., mechanical, electrical/electronic and software) products and systems. This is an emerging trend within the A&D industry. An additional driver for these companies is the DoD acquisition strategy shift towards procurement of weapon systems as modules to be assembled within a complete system of systems platform architecture.

To improve the speed, adaptability, and modularity of their products and systems, leading A&D companies have recognized the need to implement a more flexible, agile development paradigm and transform their businesses to be more responsive to mission and market changes. They are moving away from the classical phase-gate waterfall approach and breaking the overall development process into smaller phases (chunks) to reduce risk, work in parallel, and document and communicate the decisions made in these individual work cycles.

Beyond a shift in methodology, achieving these goals will require a digital transformation—adopting and applying digital technologies in new ways to enable agile development teams. More than just moving to digital documents and data records, a digital transformation enables new methods of working—leveraging digital technologies and applications to transform how the company operates. A key part of digital transformation is implementing a comprehensive digital twin and digital thread spanning the company's value network to enable collaboration and information access and sharing throughout the development process—from concept through realization. Having a digital thread enables agile development teams to have access to all the information they need to use as part of their individual sprints. All personnel involved in the development process have broader information access so they are less likely to sub-optimize their area of design and are more aware of interdependencies with other disciplines.

The digital thread enables a company to define and maintain a comprehensive digital twin representing the product or system, its production environment and processes, and its use and performance in operation. Using the digital twin, complemented with simulation technologies, can enable agile teams to quickly identify and evaluate design options, thus shortening their decision and sprint development time while reducing risks. Teams are able to evaluate more design options earlier in the overall development lifecycle. Bringing the digital twin to life enriches the range of possibilities and enhances the productivity of agile development teams.

New technologies used in A&D agile development processes include:

- Simulation-driven and generative design solutions that incorporate Artificial Intelligence (AI) and Machine Learning (ML) technologies integrated with advanced solutions for composite and materials definition to enable new additive and hybrid manufacturing techniques.
- Integration of MCAD, ECAD, and software development tools and processes to enable a more comprehensive systems engineering development paradigm.
- Using simulation tools to "operate" the design using a virtual integrated vehicle before building costly physical prototypes, improve and accelerate verification and validation processes, and reduce the cost and risk of test programs.

Digitalization and digital transformation are keys to implementing agile product development in A&D and a robust digital thread enables managing complex, multi-domain product structures and configurations.

Agile Development in A&D Example

The Boeing Corporation T-X program is a good example of the benefits that can be achieved by applying agile development in A&D. The T-X program is a United States Air Force (USAF) development and acquisition program for a new two-seat jet trainer to replace the Northrop T-38 Talon.

Boeing used new design and manufacturing technologies to win the contract with an all-new aircraft. The company also viewed the T-X as a proving ground for a design and development approach it could apply to future programs. Boeing determined that using modern, computer-driven design and manufacturing could dramatically shorten the development cycle, saving time and money using 3D modeling and precision manufacturing that would reduce labor and accelerate development.

Mr. Paul Niewald, Boeing's T-X chief engineer, said "We adopted an agile mindset and a block plan approach to hardware and software integration." He went on to explain that "This had us releasing software every eight weeks and testing it at the system level to validate our requirements. By doing this, in such a disciplined way—at frequency—it allowed us to reduce our software effort by 50 percent."[2]

On the T-X program, Boeing used agile development techniques to reduce software development hours by 50%.

Benefits reported to date in the T-X program using agile development include:

- 50% less program cost than USAF expected
- Model-based engineering resulted in a 75% increase in first pass quality
- Agile software development resulted in 50% fewer software hours
- Advanced manufacturing produced an 80% reduction in assembly hours

In an article for the Royal Aero Society titled "Breaking the Mould," Mr. Tim Robin stated, "The T-X's approach to rapid design and development, along with affordable support, could have lessons for more complex and sophisticated aerospace projects—not just in Boeing—but around the globe as companies and nations aim to break the mould on the spiralling cost of military aircraft."[3]

Siemens' Agile Development Solutions

Siemens' agile development solutions are part of a larger digital portfolio called Xcelerator, which is a comprehensive, integrated suite of software, services, and an application development platform. Regardless of company size, Xcelerator helps organizations become digital enterprises by incorporating and integrating multiple tools and technologies. This allows A&D companies to implement and

2 Tirpak, John A. "How Boeing Won the T-X." Airforce Magazine. July 1, 2019.
3 Robinson, Tim. Royal Aeronautical Society, 28 May 2019. https://www.aerosociety.com/news/breaking-the-mould-boeing-t-x/

excel at agile product development. The Product Design & Engineering (PD&E) digital thread for A&D is a key component to this digital transformation.

Using the PD&E digital thread, A&D manufacturers can build a collaborative, model-based design (MBD) environment, combining electrical, mechanical, software, and other critical disciplines to foster iterative and innovative designs, using virtual verification and manufacturing to test their designs. The PD&E digital thread also supports comprehensive multi-disciplinary design, which enables a system engineering development paradigm, providing better understanding of cross-discipline impacts, and breaking the overall development process more easily into short, focused sprints.

Siemens PD&E digital thread is enabled by Xcelerator—an integrated portfolio of software, services, and an application development platform that supports agile development.

PD&E digital thread employs next generation, simulation-driven design technology to capture intent to facilitate downstream activities for testing, manufacturing, and service. This digital thread also enables manufacturers to create open, extended enterprise networks so they can more easily collaborate with supply chain partners, no matter where they are or what design tools they use. Personnel from any location can access authorized product related information and participate in agile development sprints. This open network environment enables partners, and customers if appropriate, to contribute their expertise and verify their requirements are being addressed earlier in the development process than in traditional development paradigms.

Additionally, the solution incorporates modern visual technologies so that participants throughout the extended value chain (i.e., design partners, customers, etc.) can "see" and better understand the product at every stage of its lifecycle from concept through end of use. The use of these visualization technologies, including augmented reality (AR) and virtual reality (VR) tools, enables participants to give feedback about the design and the product earlier in the development process, thereby providing the information needed to better design for manufacturability and supportability.

Finally, this digital thread enables design for manufacturability that allows manufacturers to simulate and analyze factory and manufacturing methods, including in-service tasks. This helps reduce time and cost to commission production facilities, shorten time to first item production, and provides the flexibility to rapidly respond to the evolution of the product design, features, and components that impact production over the life of the product.

Conclusion

A&D product development is complex, generally executed in a serial fashion, and prone to having requirements change over time, thereby driving up cost and increasing time to delivery. Traditional product development paradigms are being replaced by a more modern, agile approach that offers greater flexibility and more responsiveness as mission scope and market demands change.

Ultimately, an agile development paradigm and associated methods need to be applied to the A&D development processes, enabling teams to work in smaller,

more parallel phases. In addition, by leveraging digital technologies—the comprehensive digital twin and digital thread—a company transforms how it operates, collaborates, and shares information across the product development process from concept to realization.

Agile development paradigms need to be applied to the A&D development processes. Siemens PD&E includes the tools and technologies companies can used to enable agile paradigms

The Siemens Product Design and Engineering digital thread solution for A&D includes the tools and technologies needed to assist A&D companies transitioning to a more digitalized process and establishing a more agile product development environment to address the complexities and challenges of today.

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 through the identification and implementation of appropriate digital initiatives. Since its founding over thirty-five years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) solutions and the digital transformation they enable. These solutions incorporate and enable digital business processes, data and process management best practices, and a wide-ranging set of technologies.

CIMdata works with both industrial organizations and solution providers of technologies and services seeking competitive advantage in the global economy. CIMdata helps industrial organizations establish effective digital lifecycle management strategies, assists in the identification of requirements and selection of appropriate digital technologies, helps organizations optimize their operational structure and processes to implement solutions, and assists in the deployment of these solutions. For solution providers, CIMdata helps define business and market strategies, delivers worldwide market information and analyses, provides education and support for internal sales and marketing teams, as well as overall support at all stages of business and product programs to make them optimally effective in their markets.

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