DIGITAL INDUSTRIES SOFTWARE

Leveraging Siemens solutions to achieve additive manufacturing in aerospace and defense

Using NX to power next-generation additive design and production

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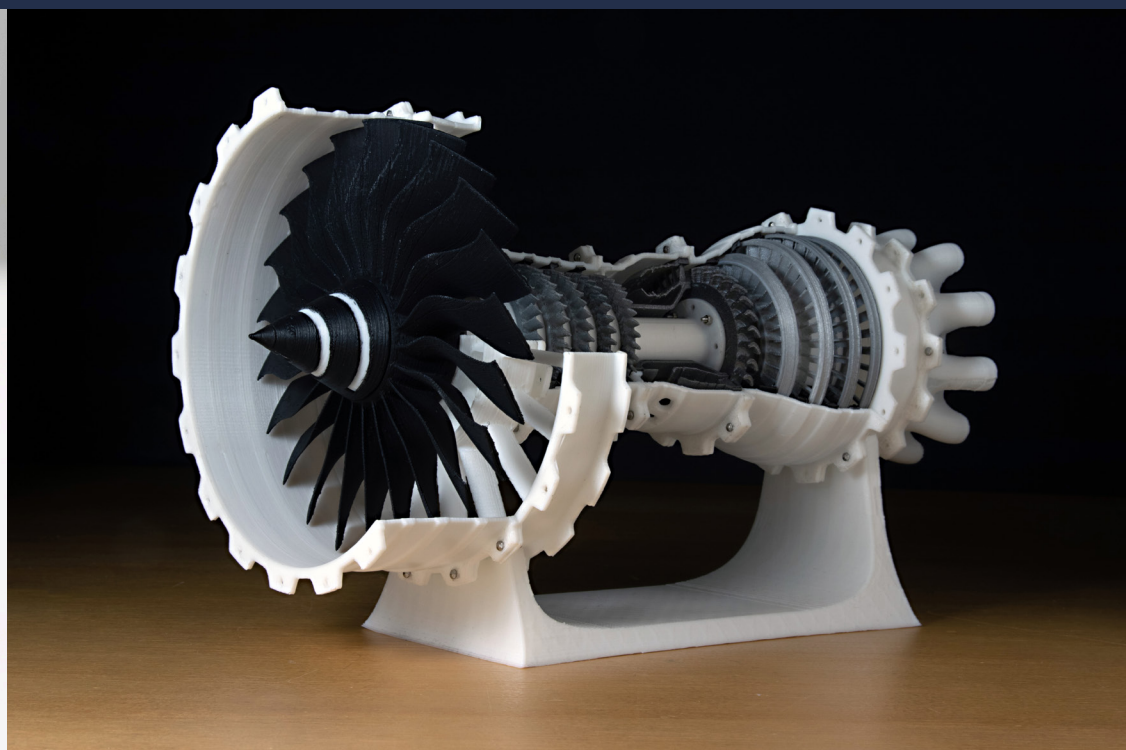
In aerospace and defense (A&D), additive manufacturing (AM) as a materials and process technology has matured from a novelty into a necessity over the last few decades. This evolution occurred with a tight coupling between materials science, manufacturing engineering and computer-aided design (CAD) and computer-aided manufacturing (CAM). Without fundamental innovations in materials science, additive manufacturing technologists could not have effectively render production ready parts. Likewise, without digital innovations embedded in CAD/CAM software, manufacturing systems would not have the data necessary to produce the kinds of highly optimized, high-performance designs that fulfill the promise of additive manufacturing.

As the initial hype over additive manufacturing waned and high value, industrial use cases become more apparent, Siemens Digital Industries Software developed specialized design capabilities that ensure a smooth process for conceptualizing and realizing production-ready parts. Software innovations like this from Siemens have revolutionized the A&D industry over the last several decades. Design for additive manufacturing is just one of the latest cutting-edge technologies Siemens has brought to the A&D industry.



Unlocking design and simulation capabilities

NX™ software, specifically NX Design for Additive Manufacturing, offers industry leading capabilities for design optimization, weight reduction and customization of parts.

Although this is important in many industries, it is particularly relevant in A&D. NX is part of the Siemens Xcelerator business platform of software, hardware and services.

NX isn't just a generic CAD/CAM tool. It's tailored to A&D with specific modules and features designed to address industry-specific challenges. This includes support for aerospace-specific materials, compliance with aerospace standards and integration with A&D manufacturing processes, making it the first choice for companies looking to leverage additive manufacturing.

A&D products operate in extreme environments and must meet demanding performance criteria. For example, these products are subject to complex structural and thermal loads and they require more design iterations to achieve the performance necessary for next-generation performance. This means that the engineers developing these products are pushing the envelope of what is possible. These factors require components of those products to be lightweight, strong and specialized in their operation, making their designs highly intricate. Quite frequently, these products operate at the very limit of applicable physics.

The company SpaceX is a good example of how the industry is using additive manufacturing as a technology enabler to build products that can operate in extreme environments. It is widely reported that the current version of the Starship engine, Raptor 3, heavily utilizes additive manufacturing as part of achieving 21 percent more thrust than Raptor 2 while being 7 percent lighter. Elon Musk is quoted on the social media site X as saying, "It is not widely understood that SpaceX has the most advanced 3D metal printing technology in the world." SpaceX is one of many industry leaders rising to engineer additively manufactured structures capable of withstanding the extreme load cases A&D products face.

Using NX offers tightly integrated design and simulation capabilities that help engineers address these complex loads to achieve next-generation product performance. NX excels in topology optimization, where material is strategically placed only where it's needed, leading to parts that are lighter yet maintain strength. This software also uses advanced algorithms to simulate how materials will behave under different conditions, including the prediction of manufacturing problems before they occur. This predictive capability is invaluable in ensuring that A&D components meet performance requirements and rigorous safety standards.

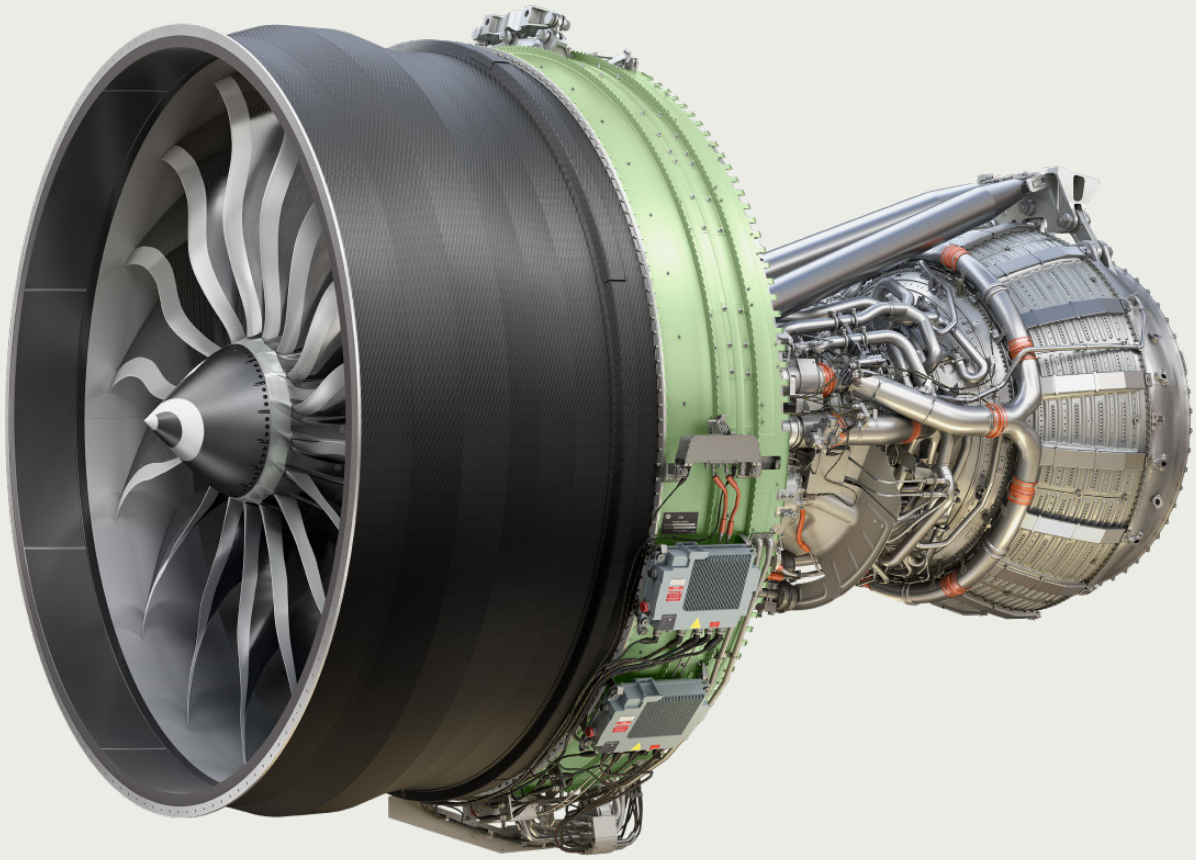
Leveraging unprecedented design freedom

One of the most significant advantages of Siemens additive manufacturing solutions for A&D is the unprecedented design freedom it offers.

Traditional manufacturing processes, such as machining or casting, often impose limitations on the geometry and complexity of parts that can be produced. Components typically require multiple manufacturing steps and their complex shapes may necessitate assembly from several parts.

Additive manufacturing, on the other hand, allows engineers to create intricate geometries that would be impossible or prohibitively expensive to produce using conventional methods. NX enables engineers to design parts that are lighter, stronger and more efficient, without being constrained by traditional manufacturing limitations. For example, complex internal structures, such as lattice frameworks, can be printed to reduce weight while maintaining structural integrity – a critical capability for A&D applications where weight savings directly translate to improved fuel efficiency and range.

Also, many aerospace and defense applications benefit by creating multifunctional parts. These parts must serve multiple functions. For example, a single component in a jet engine may act as a structural support, a heat dissipater and a channel for fluid or air flow. These multifunctional parts



necessitate more intricate designs that integrate various features into a smaller, lighter package.

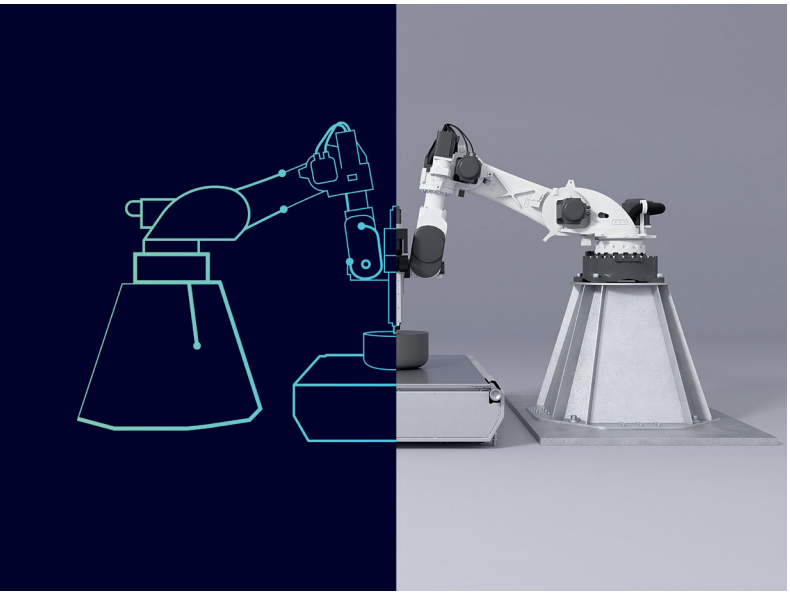
NX allows engineers to explore the design space and finds (the sometimes-non-intuitive) solutions that produce efficient designs. By combining parts in this manner, engineers can improve various performance metrics while simultaneously taking full advantage of the potential that additive manufacturing offers.

A&D products are typically produced in lower volumes compared to commercial industries, but with highly customized specifications. Defense projects, for example, often require highly specialized, mission-specific equipment that cannot be mass-produced. This results in complex part designs tailored to specific applications with unique features that make them difficult to manufacture at scale and that are extremely costly. Sometimes these suppliers even need to develop custom parts for specific missions. These may include components for one-off experimental aircraft, space laboratory test rigs or limited-run weapon systems, where traditional design and manufacturing methods must be adapted for rapid customization and prototyping.

But how can you overcome these design limitations?

Additive manufacturing approaches are perfect for meeting these challenges and NX stands out for its robust capabilities tailored specifically for these applications.

NX provides an integrated environment where design, simulation and manufacturing are seamlessly connected. This integration is crucial when rapid design cycles are required for specialized components. Leveraging NX allows aerospace engineers to design complex geometries, optimize them for additive manufacturing, and simulate the manufacturing process all within the same platform. This reduces errors, speeds up development cycles and ensures the companies achieve significant return on investment (ROI) on their additive manufacturing investments.

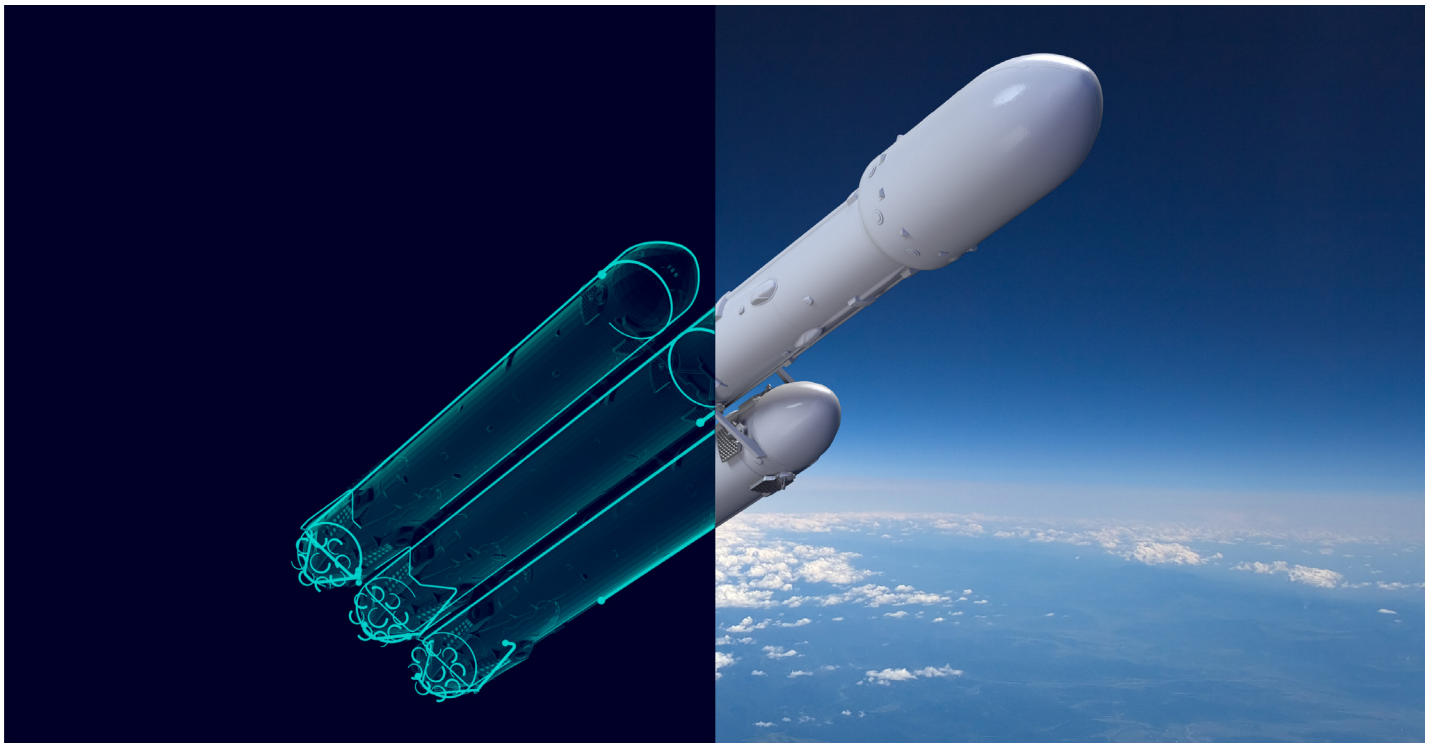


Traditional manufacturing processes often involve long lead times due to the need for specialized tooling, molds and fixtures. This can be a major bottleneck, particularly in sectors where innovation cycles are accelerating and the need for customization is increasing.

Because NX streamlines design for additive manufacturing, it significantly reduces lead times by eliminating expensive tooling, allowing direct production of parts from CAD. This capability is especially beneficial for A&D companies, which often require low-volume, high-complexity parts for prototypes, spare parts or specialized applications.

Part of the value NX provides in addressing these challenges is in its concept of a digital twin, where a virtual model of the product and its manufacturing process is created. This is pivotal in modern A&D manufacturing. Using NX helps create this comprehensive digital twin for design ideation, real-time process monitoring, maintenance and future redesigns. For A&D, where every component's performance can affect the mission's success, having a digital twin that matches the part in production and service offers significant operational advantages.

From powder bed fusion to directed energy deposition, NX supports the gamut of additive manufacturing technologies. This versatility is crucial where different projects might require different printing technologies based on material properties, part complexity or other desired outcomes. NX can manage these technologies ensures that A&D



companies can innovate without being constrained in manufacturing process selection.

Post-processing in additive manufacturing, especially for aerospace parts, is as critical as the printing process itself. The comprehensive digital twin simulates post-processing, which helps in planning operations like support removal, surface finishing and even quality checks through advanced metrology integration. This ensures that the final parts not only meet design specifications but also pass the stringent quality checks mandatory in A&D manufacturing.

Whether it's a small aerospace startup or a large corporation, NX scales to fit the need. It allows companies to start with basic functionalities and expand as their additive manufacturing capabilities grow. This flexibility is particularly beneficial in A&D, where projects can vary significantly in scope and scale.

That flexibility is also built into the NX deployment strategy. NX, through NX X, can be deployed in the cloud to ramp up a production engineering environment that happens practically overnight. This reduces capital outlay and ongoing maintenance cost associated with traditional CAD software management.

Using NX integration, simulation environment, digital twin capabilities, scalability and industry customization make it exceptionally suited for additive manufacturing in aerospace and defense. Siemens solutions address current needs and help new capabilities evolve in sync with the additive manufacturing industry, making it an invaluable asset for companies aiming to innovate with this powerful manufacturing technology. This comprehensive approach ensures that A&D companies can push the boundaries of design and manufacturing efficiency, which is paramount in an industry where precision, performance and innovation are essential for success.

Siemens Digital Industries Software helps organizations of all sizes digitally transform using software, hardware and services from the Siemens Xcelerator business platform. Siemens' software and the comprehensive digital twin enable companies to optimize their design, engineering and manufacturing processes to turn today's ideas into the sustainable products of the future. From chips to entire systems, from product to process, across all industries, Siemens Digital Industries Software – Accelerating transformation.

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