Realizing Digital Manufacturing and Product Support in Aerospace & Defense

Driving innovation has become a mantra at most companies. Siemens started on this journey of innovation more than ten years ago, setting its sights on being the trusted partner for companies in the process of digital transformation and helping to increase innovation and productivity of teams through task automation. Smoother data flow and task automation frees up team members from administrative tasks so that they can focus on what they do best: be creative at solving complex problems.

Innovation and Disruption Is Everywhere

As Orville Wright famously said, “If we worked on the assumption that what is accepted as true really is true, then there would be little hope for advance.”

Everywhere we look, we see more innovation and disruption. We are seeing companies who are applying innovative zero CO2 electric propulsion systems in airplanes, providing green solutions in general aviation and enabling urban taxis, and developing supersonic flight which will change the nature of high-speed mobility in a sustainable manner. In space, we see companies launching new satellites, and creating space travel for tourism. In government, they are seeking new approaches to large program acquisition and transforming themselves into digital enterprises in order to achieve it.

Obviously, there are engineering challenges. With the complexity that comes with some of these products, new ways to manufacture them are needed, and with long product lifetimes, new ways are needed to provide product support. As we think about manufacturing in the aerospace and defense industries, here are some of the trends we’re seeing:

Pressure to reduce program costs and schedule – Companies are under pressure to reduce program costs and schedule. Whether you’re an original equipment manufacturer (OEM) or supplier, reducing program and product costs as well as improving your overall schedule is essential.

Increased program complexity and integration – This complexity and innovation is used by companies to drive more performance out of their products.

Increased electrification of products – The demand for greener solutions in the industry is apparent. Companies are also seeking more electrification to increase the reliability of their products and to improve the maintainability of their products.

Globalization – Whether it is your competition, your supply chain, or your workforce, many companies are experiencing greater globalization.

These trends are not mutually exclusive. For example, increased program complexity and globalization place a lot of pressure on your schedule, and they interact and work together to drive innovation and drive disruption. What these trends have in common is an explosion of complexity.

Rather than simplify and try to minimize complexity, several companies are embracing this complexity and embracing digital transformation and are truly disrupting and innovating. In doing this, they have higher-performing products and can complete them in less time at better cost, while minimizing risk as they go forward.

Intelligent Manufacturing

We often talk about the future of engineering or the factory of the future, but many of these solutions are available today. More importantly, they point to where manufacturing is headed as we go into the future.

How do companies accelerate product, ramp up, exceed quality targets, and deliver products faster? By using a closed-loop manufacturing process that is enabled by a digital thread, called Intelligent Manufacturing. The entire focus is to ensure consistent, seamless alignment with as-designed or as-built, achieving higher quality at lower cost.

Organizations are able to virtually commission their factories and production lines and create an advanced visualization to change how people are working. The digital thread in the intelligent manufacturing process represents the full lifecycle of engineering to manufacturing to improve production rate ramp up and quality through closed loop manufacturing systems.

As most products today are becoming smarter, organizations need to develop manufacturing processes and multiple manufacturing and assembly technologies and bring those together to produce structural parts, electrical and mechanical systems parts, composites, printed circuit boards, and more.

The digital thread in the manufacturing process is taking the build process, a multidomain description of how a product or part comes to life that contains all the information and communicates it directly as a technical package not only into manufacturing and execution systems but also into ERP systems. Forward-thinking organizations understand how to leverage all aspects of product design data into the production.

In the aerospace and defense industry, build issues that impact quality and production have dropped significantly, by developing a method to perform a digital preassembly and leverage this digital thread of the process. This flows all the way down into the final parts.

Additive Manufacturing Is Revolutionizing Design and Build

In advanced manufacturing, additive is changing the way parts are designed and built. As we look at the future of production, this could be one of the most significant changes we've seen. Additive not only revolutionizes how parts and assemblies are built, but also dramatically changes how those parts are designed.

Additive manufacturing embodies the full digital thread of the process, from the design of the part, throughout the build process, to producing the final part. Additive manufacturing starts with a 3-D model, seamlessly carrying it through to the topology optimization, on to the light weighting of the parts to validate them through process simulation. After the part is fabricated, post-processing and inspection are conducted, and in the end, you have the final part. The additive manufacturing

process generates a much different-looking part than would normally be created by the constraints of a traditional machining process, and that allows for some of the innovation now being experienced in the aerospace industry.

However, there are challenges in adopting additives. One of the most significant challenges is to be able to change the process with the new solution and address regulatory questions about the design and fabrication methods. Using simulation analysis solutions in designing the parts also help validate the designs and the manufacturing processes with a rich understanding provided by the digital twin. The goal is to simulate how that part is going to perform in an asset before it is ever produced. Once we simulate the functionality of that part, what's next?

Production Has a Twin Too

Virtual production, the digital twin of production, examines not just how a part is going to be manufactured, but creates a digital twin of the entire manufacturing sustainment operation, both in a macro view and more of a micro view. These production digital twins simulate facilities, how technicians interact with each other and the work environment, move parts in or out, map how machines and manufacturing cells interact, and predict how material equipment can move around a facility or between facilities in a larger space.

How can an organization take that product's digital data that it simulated and drive it down into actual operations for both sustainment and manufacturing, then couple that with how the asset performs in the field? How does the equipment perform, and how can they take insights from that performance and drive that back upstream in the digital thread?

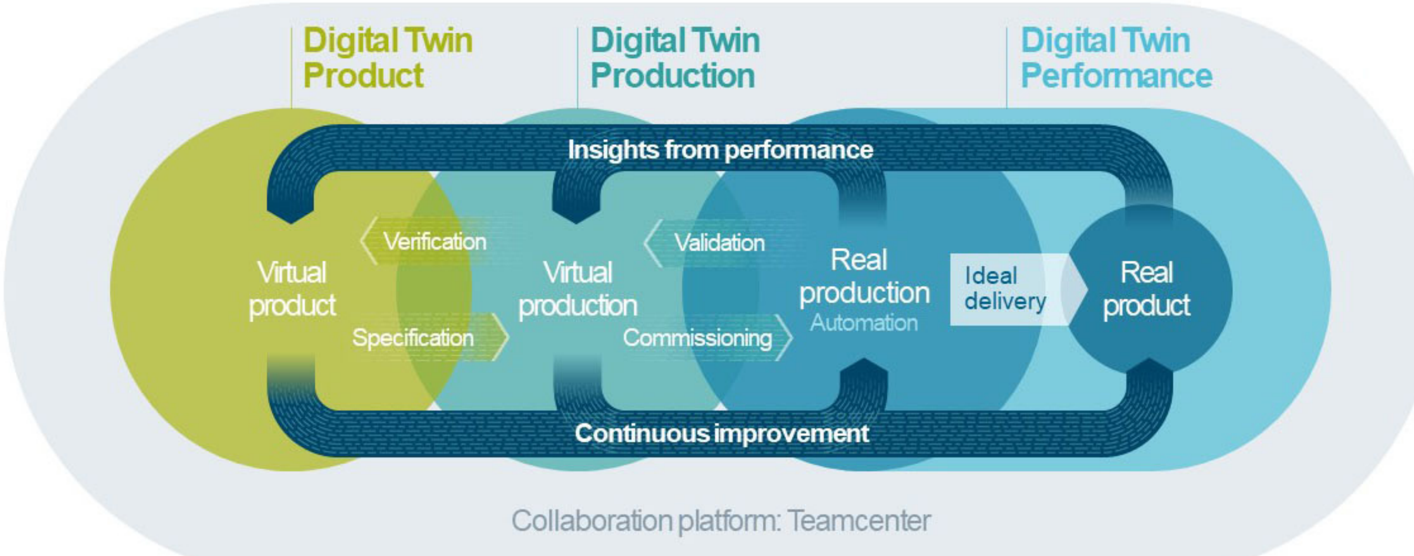
Understanding how manufacturing sustainment operations are executed and how a part is performing in the field drives engineering and manufacturing improvements, allowing companies to focus on throughput capacity to optimize how facilities operate. The manufacturing process is further optimized by using flexible automation, which takes the comprehensive manufacturing digital twin and helps optimize the process. This digital thread from design to manufacturing enables organizations to understand a process and understand the risks before the build process begins. Problems can be identified before millions of dollars are invested in automation, tooling, and even facilities. This same digital approach can be used to verify and improve product reliability.

Using Digital Technology to Improve Product Reliability

Product support is being transformed by a digital thread approach that implements model-based product support planning, management, and configuration control. Digital technology is being used to improve reliability and supportability of products that now last for several decades. The goal is to leverage digital data further and further downstream, to better support assets and to more effectively plan and execute against sustainment tasks over assets.

How are companies doing that? They are creating a more well-connected digital thread that is focused on model-based definition and leveraging that model-based definition further downstream in model-based product support. This digital thread manages product configuration and maintenance information and is focused on details such as having an as-maintained definition of those assets, along with that traditional rich set of engineering data. They are exploring how they can leverage that engineering data – that rich digital data – further and further downstream as well as supporting those assets.

We are seeing a greater leveraging of Industrial Internet of Things (IIoT). The focus is not just on productivity-condition based maintenance of assets but also on logging how all of the manufacturing equipment is performing, predicting downtime,



and creating a better understanding of how the equipment that supports manufacturing sustainment operations is performing. This extends that digital thread and looks at closed-loop deficiency trapping. We're not just managing data down to manufacturing and sustainment operations, we also are able to tie deficiency back to engineering and process planning. It closes that loop between what it is we're doing and how we are performing maintenance and manufacturing operations.

IIoT solutions provide real-time feedback back to engineering and manufacturing sustainment planning, stimulating improvement in manufacturing operations.

Real World Examples of the Value of Virtual Technology

Digital Thread in Advanced Manufacturing

Naval Air Systems Command (NAVAIR) is the air side of the U.S. Navy, and is responsible for acquisition and sustainment of the air assets of the Navy. One of the interesting projects that Siemens and NAVAIR have tackled is implementing a model-based definition digital thread that directly supports digital manufacturing at the fleet readiness centers at the air depots in the United States.

The focus has been on the configuration management of data all the way down from engineering through simulations and through manufacturing planning, then through manufacturing operations. Of particular importance has been the ability to reuse data; to examine past manufacturing operations, bill of process and bills of material, and understand how NAVAIR can reuse that information to more efficiently manage manufacturing operations. The goal is to have manufacturing operations at the air depots directly support sustainment of those air assets and ultimately contribute to operational availability of the uptime of those air assets.

In the case of NAVAIR, that digital thread is being extended to advanced manufacturing equipment at the Cherry Point (N.C.) Fleet Readiness Center. At Cherry Point, they are moving beyond creating a build process and manufacturing machine code, to connecting data from a digital thread directly down to three-axis and five-axis machines. That allows the machine artisans on the shop floor to pull that machine code directly to the machines in the shop floor, confirming that the proper data and the correct version of that data has been released for a particular operation, a particular artisan, or for a particular machine. This ensures that the right manufacturing operations are taking place with traceability all the way back through planning and engineering with an understanding of what data was used at any given point of that product or part's lifecycle.

The process allows the Cherry Point Fleet Readiness Center to measure performance impacts based upon simple reuse cases and the ability to reuse manufacturing data multiple times. By reusing manufacturing data multiple times, first article passes have a 25% reduction in Technical Touch Time, while Repeat jobs have a 98% reduction in Technical Touch Time. Being able to organically manufacture these parts more efficiently, with greater quality, has a direct impact on the availability of those assets and the uptime of those air assets.

An Example of a Production Digital Twin

Naval Sea Systems Command (NAVSEA) has a program office, PMS 555, that is tasked with the modernization of naval shipyards, starting with their four primary public yards: Pearl Harbor, Puget Sound, Portsmouth, and Norfolk Naval Shipyard. These four naval shipyards were last significantly updated in World War II. They were designed to manufacture and produce surface ships and submarines, but their mission has changed because the Navy no longer manufactures equipment. Now their mission is to sustain equipment that has been delivered to them by the original equipment manufacturer.

Significant research has gone into how these facilities could be modernized, and the amount of money that it will require to modernize them is relatively significant. Siemens is leading a team that is responsible for the digital modeling of these shipyards. The models extend far beyond what the bases could or should look like. The models are helping PMS 555 understand what happens when a submarine, carrier or fleet readiness center comes into one of these Navy bases, providing insight into how the bases actually function.

How does material move? How do people move performing maintenance operations? How does equipment and parts of other assets move around the shipyard in its entirety? The focus of the digital modeling is on establishing a baseline to determine how the process could be streamlined without jeopardizing quality or safety. Typically, tens of thousands of processes occur when a submarine or carrier comes in for maintenance, and the amount of downtime for that asset typically is a minimum of six months. PMS 555 wanted to know how to conduct those operations more efficiently, potentially reducing downtime and costs.

Siemens was asked to create “what if” scenarios. For example, if NAVSEA started to modernize the facilities and moved some

operations closer to the point of need or closer to a particular dry dock, what would the impact be on overall turnaround time and the quality of maintenance activities during those maintenance operations?

These scenarios served as a way to quantify what the monetization spend is going to be. If the decision was made to invest millions of dollars in a new dry dock production facility, for example, and to move some of the operations closer to a particular dry dock, what is that impact going to be? If the money is spent, what savings will result?

The modeling process not only offered an overall perspective of the shipyard and how material moves around it, but also provided a deep dive down into some of the back shops to understanding what actually occurs in a sheet metal shop or one of the machine shops. The exercise offered insight into how the shipyards could optimize what they have today and provided insight into the outcomes if NAVSEA invested in recapitalization of facilities and equipment. It allowed NAVSEA to understand the impact on the optimum mission, which in this case is sustainment of the submarines, carriers, and fleet readiness centers.

Closing the Real/Virtual Loop

How do you contextualize all the data collected by digital twins and digital threads so that you close the loop between virtual and real product operations? How do you use that rich data to drive continuous improvement into the entire lifecycle of your assets?

While the focus here has been on manufacturing, quality operations should be brought early in the asset lifecycle. Organizations need a consistent build process that drives how they execute work orders and execute operations, not just from the factory operation standpoint, but also from a quality operation standpoint. Connecting digital processors can optimize not just manufacturing or quality, but also can foster continuous optimization, reduce costs, save time, and improve quality.

Although we talk about "the factory of the future," advanced manufacturing technology is available today. How do you ensure that the virtual product twin, virtual production twin, and the virtual performance touch on each other, and how do you close the loop between all those elements?

Intelligent manufacturing allows you to close the loop between your engineering and manufacturing process planning operations, and your actual manufacturing and quality execution operations on the production sustainment floors. It ensures that all the rich data that is collected – any deficiencies or discrepancies, negatives or positives – feeds back into the digital twin along digital threads. This allows you to innovate and disrupt, not just based upon failures, but also based upon successes of how you manufacture and sustain your assets.

It is the most exciting time to be part of the aerospace and defense community and Siemens is leading this digital transformation with the most comprehensive digital technologies. Siemens provides the aerospace and defense industry with a flexible ecosystem that combines both an open software platform and rapid application development to easily build, integrate and extend data and existing systems. Leveraging the breadth of the Xcelerator portfolio combined with access to technology and solutions partners across the globe, Siemens has created a series of adaptable digital threads that enable aerospace and defense companies and governments to optimize their operations, to successfully, safely and securely execute the most challenging programs that are transforming air travel, space exploration and defense.

About Siemens Digital Industries Software