THE VIRTUAL TWIN EXPERIENCE FOR AEROSPACE & DEFENSE

Optimizing operations by connecting the real and virtual worlds

DASSAULT SYSTEMES

AN INDUSTRY IN EVOLUTION

The Aerospace & Defense (A&D) industry is arguably one that was most immediately and severely impacted by the coronavirus crisis, especially in the commercial aircraft segment. It is evident that a lack of data and visibility in operations and manufacturing led to the inability of many A&D companies to pivot and make fast and optimal remedial decisions.

While passenger confidence is slowly returning, getting the commercial aviation industry back on track has to be done in a smart and cost-effective way. In addition, supply chains must be transformed to improve visibility and agility in order to be able to deliver on time, on quality and with less cost—to achieve the ultimate goal of operational resilience.

Resiliency is critical in these disruptive times to not only be able to weather disruptions but to also ensure business continuity and efficient operations, even when demand is constrained. A&D leaders and manufacturers can achieve this by digitalizing their operations and leveraging a virtual twin solution that enables them to visualize the perfect plans for new products, facilities and production processes in order to run optimized operations.

In this eBook, you will learn about:

- **Challenges and key trends in Aerospace & Defense manufacturing**
- **The advantages of using the Virtual Twin Experience to plan and manage operations**
- **How the Virtual Twin Experience can drive competitive advantages**

CHALLENGES & TRENDS IN THE AEROSPACE & DEFENSE INDUSTRY

By now, it is becoming clearer to many in industry that the path to resiliency and future-proofing operations relies on digital transformation, and that extends to transforming operations to become more virtual.

Although there is increasing digitalization occurring in silos within the organization (such as design), these systems were not designed to work together and have their own data models and processes. This not only leads to an array of drawbacks like unnecessary delays and sub-optimal quality of components, but leaves A&D companies and manufacturers vulnerable to disruptions, creating many challenges as a result:

Disconnected supply chains

Supply chains are at the heart of A&D companies' success and are very much global and diversified in nature. They're also incredibly complex ecosystems of different tiers of suppliers and customers[1].

To make matters more complex, supply chains have adopted digital technologies, are vertically integrated and operate on a just-in-time basis[2]. This makes the management of supply chains difficult, even in the best of times. On top of the lack of operational agility and flexibility, A&D supply chains were, and are still, impacted by smaller suppliers who struggle in the wake of the pandemic and global shortages of materials.

Constrained demand

As a result of the pandemic, international air travel came to a halt during the first half of 2020 and domestic demand was strongly affected. Commercial aviation was hit the hardest with many companies getting caught off guard, and it is likely that demand in this area will continue to be constrained—more so than in the defense, space and private jet segments. However, there are some signs of return on the horizon from the rising disposable income and pent-up demand for commercial flights.

[1] Miller, Randall. Ernst & Young. "Why supply chain management is important in aerospace and defense" (19 August 2020).
[2] Reid, Elizabeth. Bird & Bird LLP. "Aerospace & Defence supply chains: at the tipping point"

Increasing regulatory pressure

As A&D makes its way into more complex and connected industries, from the automotive industry to high-tech, manufacturers face greater regulatory and certification pressure to ensure that their products are high quality, perfectly functional and safe—and right first time.

Adoption of new manufacturing technologies

A&D manufacturers need to keep up with the accelerating pace of innovation as we find new ways to optimize operations. Companies are investing in technology, most notably digital twins, and processes today to prepare for the eventual return of demand, and for the next competitive normal. According to Ernst & Young, there are some leading aircraft engine manufacturers using 3D-printed fuel nozzles for one of its next-generation engines, resulting in fewer number of parts needed to make the nozzle, hence, a much shorter supply chain for fuel nozzle manufacturing.

Internal silos

A lot of companies are set up internally to operate in silos—planning, executing and making decisions in a bit of a vacuum. This structure becomes even more disruptive in times of uncertainty, amplifying already existing challenges and inefficiencies. As evidenced during the pandemic, many A&D companies struggled to align internal processes and had difficulty leveraging information from one department to the next.

The "next normal" that A&D manufacturers face due to modern disruptions has also amplified certain challenges that raise the urgency for companies to work towards the following to ensure the longevity of their business:

Prioritizing re-skilling and safety

to avoid dependency on key skills

More workforce automation

to help employees multitask and cover skills gaps

Supply chain resiliency

gives companies options to optimize in economically difficult situations

Maintaining business continuity

by ensuring that all operations are efficient

Flexible and agile manufacturing

is necessary to help companies adapt to new changes

KEY TRENDS IN AEROSPACE & DEFENSE MANUFACTURING AND OPERATIONS

There are three key elements that A&D manufacturers will want to pay attention to as these will drive future trends:

1. **Transform the Supply Chain:**
   More visibility and agility with less cost. Deliver on time, on quality with less cost.

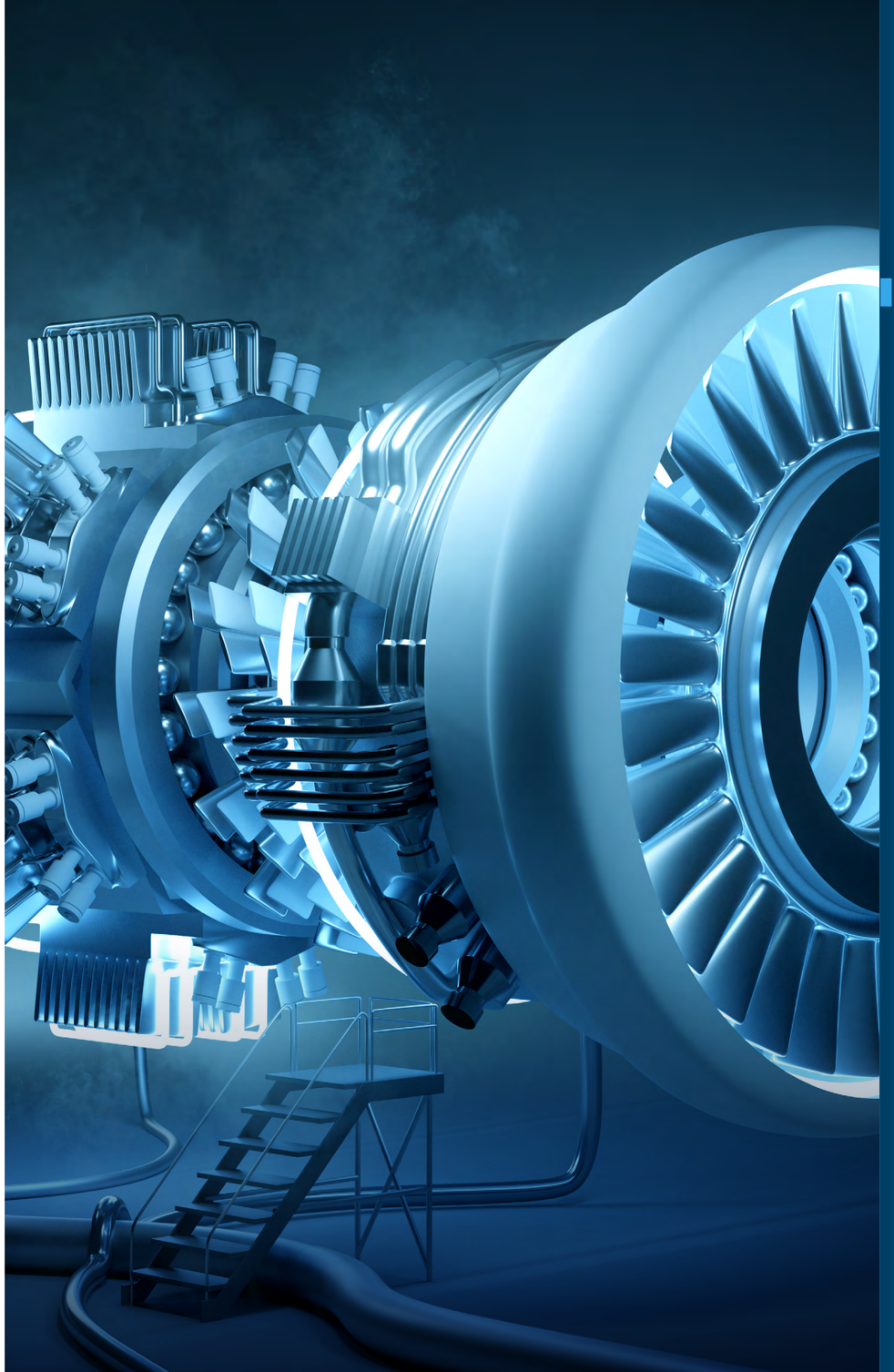
2. **Invest Now to Return Lean and Competitive:**
   Take advantage of constrained demand to restructure processes, become leaner and be positioned in a more competitive way.

3. **Accelerate Technology Investment:**
   Digital twins will be a primary technology investment to drive operational efficiency and innovation.

DIGITAL TWINS VERSUS VIRTUAL TWIN EXPERIENCE

Digital twin technology goes as far back as the late 1980s to early 1990s, and as many in the realm of manufacturing know, digital twins serve as virtual representations or digital counterparts of physical assets or processes. However, the drawback of this early technology is that it's linear and static by nature, typically designed for a single purpose and often results immediately in an almost out-of-date model as it is not connected to the real world of processes and operations.

Enter virtual twins—expanding upon the technology of the digital twin, they employ virtual modeling, simulation and optimization capabilities. And unlike digital twins, virtual twins are dynamic, connected models of products, facilities, resources and people that apply real-world, real-time information and can be used in multiple different contexts. The ultimate goal of a virtual twin is to create a perfect, or near perfect, virtual model of a physical asset, with minimal risk in the real world. This will enable companies to more easily introduce new manufacturing models and operational processes and create new products at an unprecedented rate, rapidly improving the ability to innovate.



7 ADVANTAGES OF VIRTUAL TWINS IN AEROSPACE & DEFENSE MANUFACTURING

1

UNLIMITED SIMULATION

A&D manufacturers lack the time and resources to experiment and find optimal facility layouts and processes when restricted to using older, established methods with a limited ability to improve them. The virtual twin, or what Dassault Systèmes calls the Virtual Twin Experience, allows such experimentation to take place digitally and determine the best configuration before spending precious time and resources changing real-world operations.

2

CONTINUOUS IMPROVEMENT

The Virtual Twin Experience enables a closed-loop connection between the virtual and real world, allowing simulated plans to be immediately and confidently executed. At the same time, real-time updates are captured from manufacturing to inform the Virtual Twin Experience, allowing it to continuously refine and optimize processes for a longer-term strategy.

3

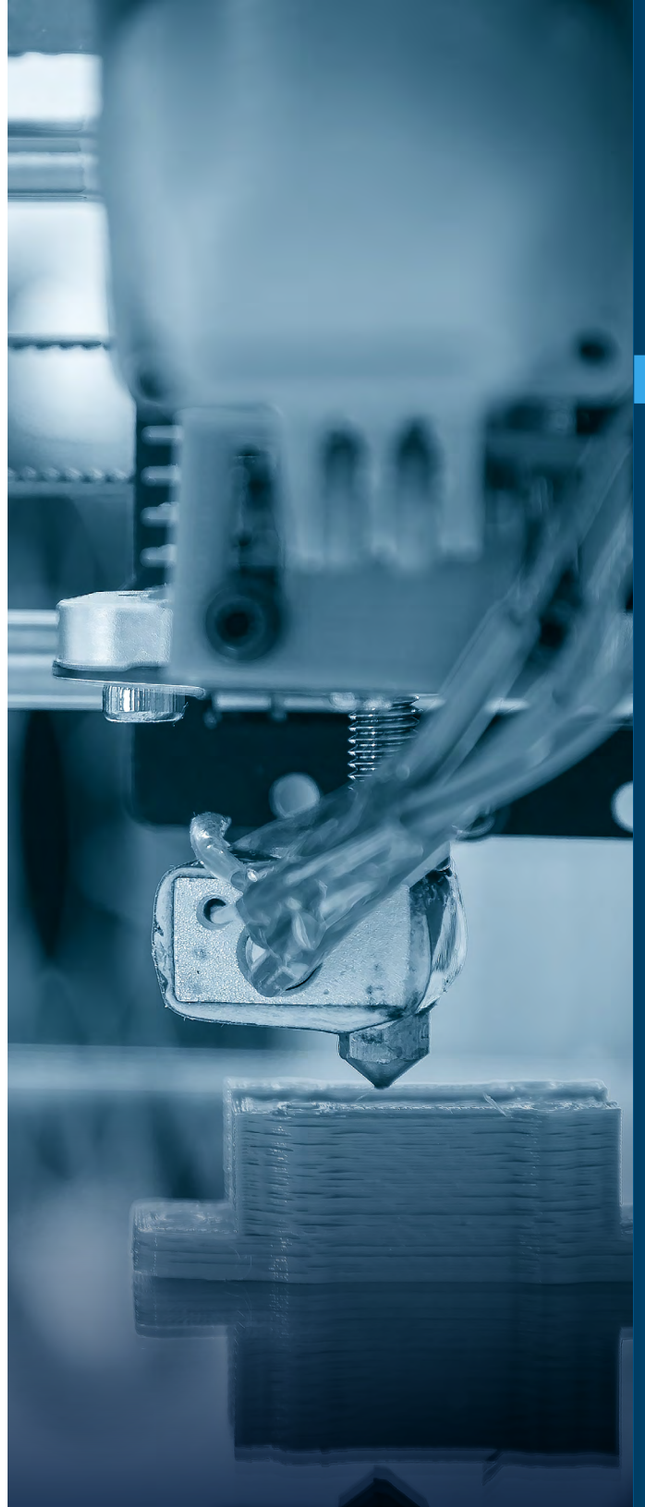
IMPROVED HUMAN FACTORS

Workplace safety is paramount, but some unsafe working conditions may not be immediately apparent until an incident takes place. With real-world data input, the Virtual Twin Experience can simulate worker operations in a facility and address safety concerns, such as identifying assembly tasks that could create repetitive strain injuries or creating social distancing measures.

4

ADDED AGILITY

A&D manufacturers struggle with suppressed margins due to competitive pressures while working with complex production runs, making downtime costly when configuring an assembly line. The Virtual Twin Experience helps A&D manufacturers be more flexible by simulating operations ahead of time and identifying the quickest and most cost-efficient way to do so, minimizing downtime.



5

GLOBAL COLLABORATION

There are often digital "divides" between engineering and manufacturing departments that result in lost time and quality. The cloud-based Virtual Twin Experience enables stakeholders to share detailed information and unified 3D models that allow collaboration and input from all departments for optimal operations. Simulations in the Virtual Twin Experience even calculate how external factors affect the production process, improving its accuracy in optimizing configurations.

6

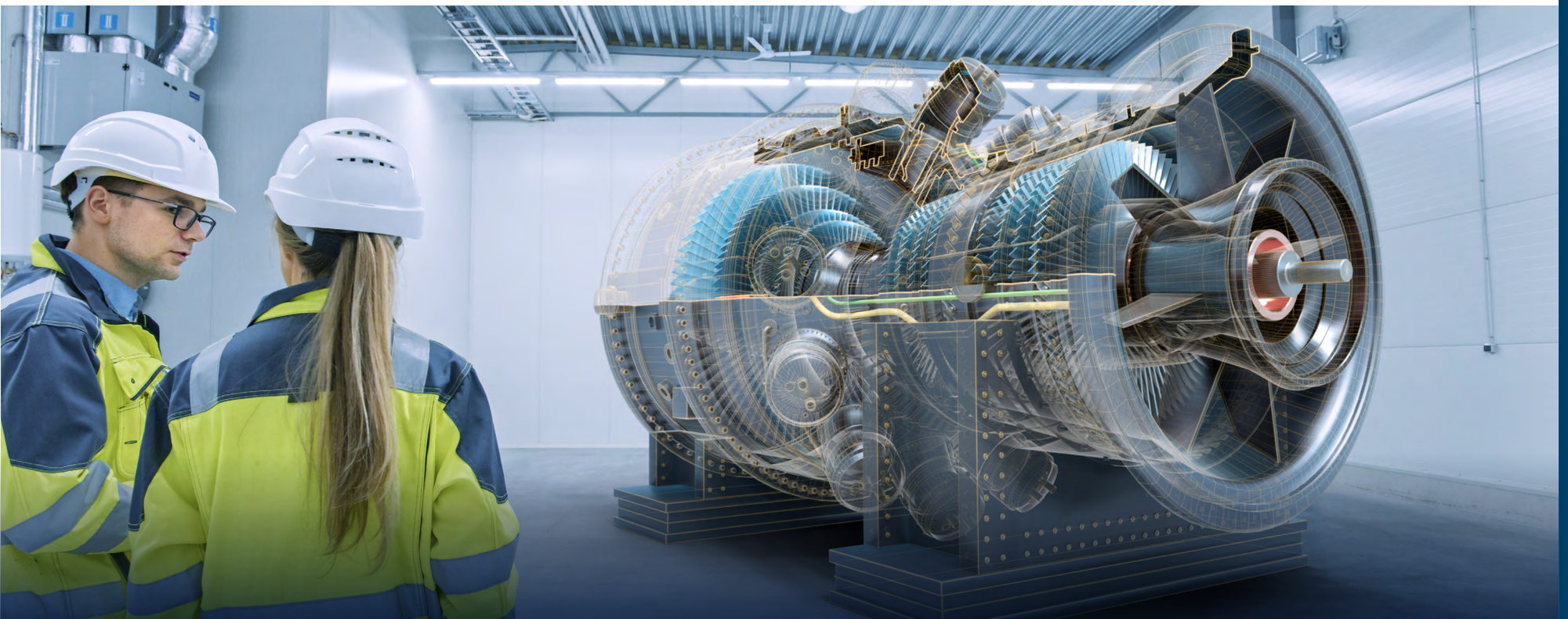
IIoT INTEGRATION

Most modern production equipment is sensor-driven and generates large quantities of real-time data—much of which is used for quality control and production monitoring. The level of integration that is now possible with the Virtual Twin Experience makes modern factory operations fully transparent to engineers and managers, allowing greater optimization.

7

KNOWLEDGE RETENTION

Losing key personnel with extensive knowledge of a manufacturer's processes or translating code from obsolete legacy equipment for newer systems have traditionally hindered older A&D manufacturing operations. These problems no longer trouble manufacturers who rely on the cloud-based Virtual Twin Experience, which integrates all information on the cloud and ensures data continuity.



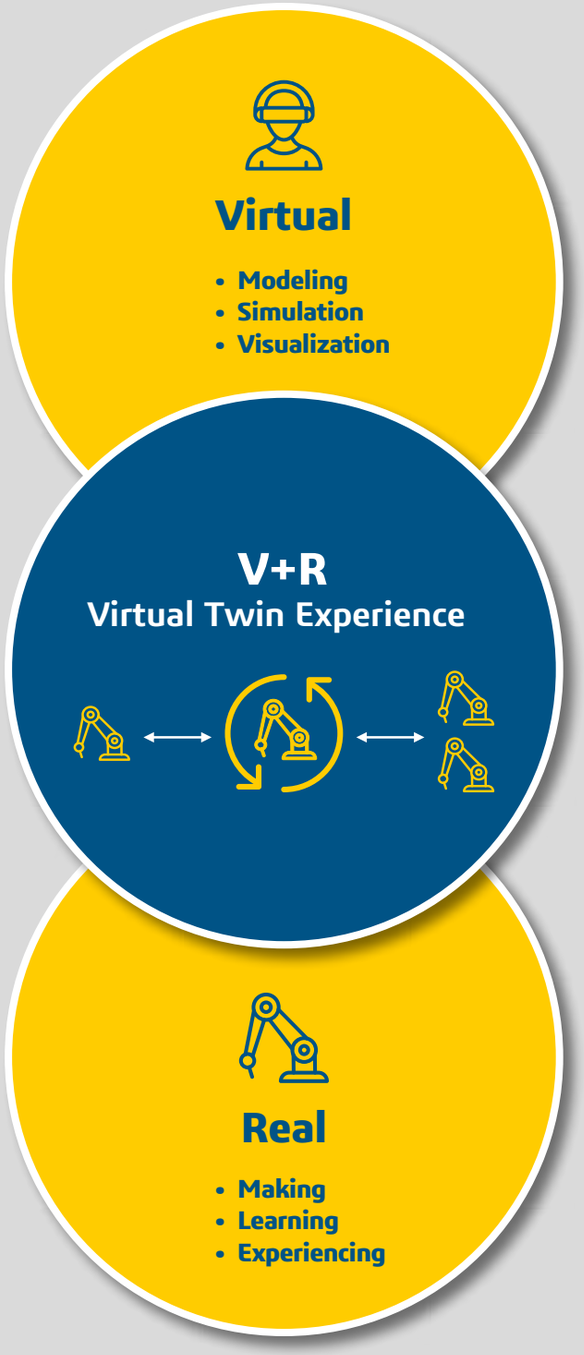
THE VIRTUAL TWIN EXPERIENCE

The **3D**EXPERIENCE platform is what our applications and solutions run on—it is the foundation for supporting model-based design, planning and execution. This cloud-based platform provides what we call the Virtual Twin Experience. In the **Virtual Twin Experience**, the virtual world enables users to see what they want to accomplish through modeling, simulation and visualization, which can then be implemented and executed in the real world. At the same time, experience and data collected in the real world is used to update the virtual twin model and maintain it as a perfect twin that can be used to improve all aspects of real-world operations. This convergence of the virtual and real worlds and the continuous cycle of information between the two achieves a closed-loop capability that enables optimization in virtually any scenario.

Achieve Sustainable Innovation and Excellence

Support Creation of Value Network

Empower the Workforce of the Future



What the Virtual Twin Experience enables for A&D manufacturers:	How this is achieved:	Where the solution applies:
• Assess **new assembly operations** and address **potential changes** in production • Assess **manufacturing strategies** and capacity to evaluate new manufacturing technologies • Determine the impact of **demand and supply disruptions** to prepare for sustainable business operations	• Create a **virtual model** to control and operate in the real world for improvements • Ensure layout **efficiency** for operator **safety** • Leverage simulation as a lever for **continuous improvement** • Simulate facility flow to **increase flexibility** and productivity • **Optimize layouts**, work centers and process plans	• Value networks: suppliers, contract manufacturers, original equipment manufacturers (OEMs), line builders, machine builders, robotic vendors and system integrators • Facilities, warehouses, construction projects, etc.

INNOVATION TIME HORIZONS

The **3D**EXPERIENCE platform features solutions that help A&D manufacturers at every stage of a product's life cycle from the initial planning phase all the way down to manufacturing execution and delivery. The platform keeps A&D manufacturers informed in their strategic decision-making—which involves planning in the virtual world—as well in their tactical decision-making when it comes to execution in the real world.

FACILITY PLANNING

How to optimize physical space and assembly lines to manufacture new products?

Capabilities of the Virtual Twin Experience

- Create 3D virtual models (BIM & CAD) from any available 2D documentation or drawing
- Conduct mobile or fixed-point scans of facilities to convert into a 3D point cloud
- Position and manipulate resource positions in 3D
- Validate and define plant and/or production line design to improve accuracy, backed by an extensive library of assets and resources

Goals & benefits

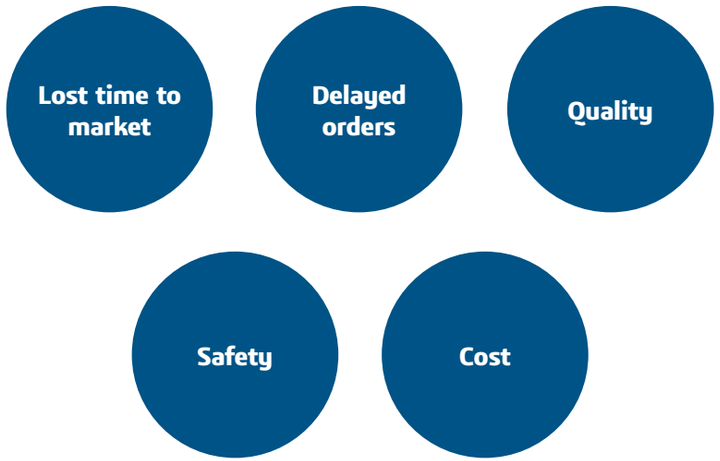
- Reduce cost of traditional design methods and rapidly create and evaluate new layouts
- Anticipate equipment commissioning constraints and issues
- Minimize risk by simulating the dynamic behavior of production scenarios with workers, fixed and mobile equipment, machines, tools and more
- Save costs by reducing idle times, number of required workers and costly equipment through "what-if analysis" and factory flow simulations in 3D
- Ensure new product introduction (NPI) capability in existing layout and by using existing equipment and tooling
- Produce a validated model of potential facility changes that strategically supports innovation

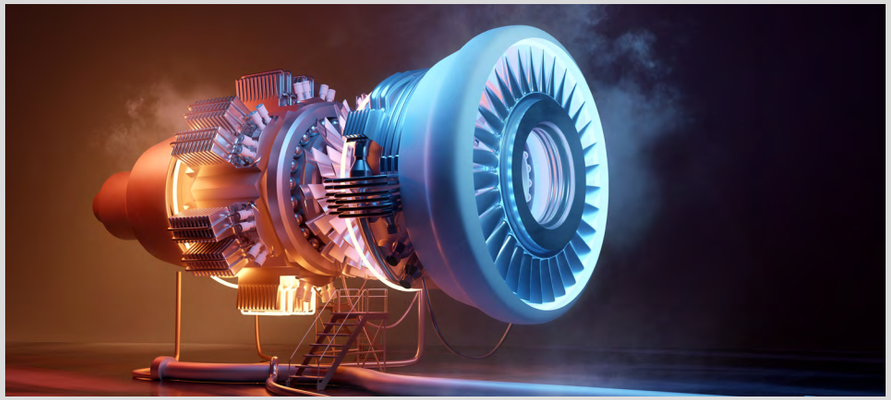
ASSEMBLY PROCESS ENGINEERING

How to optimize production process to maximize efficiency, cost & quality?

Once you have established your physical facilities and resources, the next step is to look at how to optimize production and the assembly process to maximize the efficiency of your overall manufacturing operations to meet cost and quality guidelines. Assembly process engineering requires movement and action between various departments in the organization, which can be a challenge for a lot of A&D companies due to the gap between the engineering and the manufacturing process.

Translating designs into real-world plans can be tricky as both engineering design and manufacturing execution traditionally use different sets of tools that do not connect with each other. The lack of information flow and collaboration across the digital divide has real consequences for production:

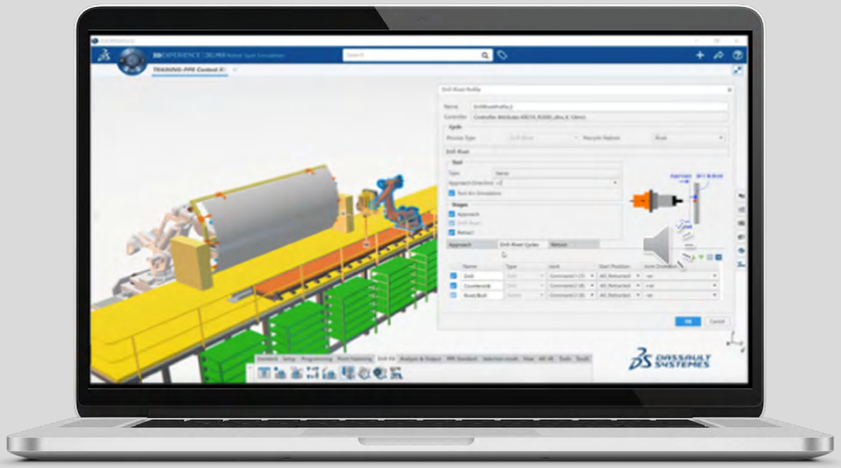




Bridging this digital gap is critical in order to efficiently manufacture products precisely how they are designed to be—doing so efficiently and in a way that eliminates costly and time-consuming manual prototypes. This is possible through assembly process engineering and virtual build to improve the efficiency of manufacturing planning through product builder visualization and assembly plan, and process plan validation to manufacture right first time. This can be accomplished by using the engineering bill of materials (EBOM) to build up a manufacturing bill of materials (MBOM) through the **3D**EXPERIENCE platform.

Once this is done, the next steps involve looking at the 'how' and 'where' to manufacture the product. The **3D**EXPERIENCE platform enables A&D manufacturers to virtually simulate their process plan in order to identify potential issues ahead of execution, which avoids many of the risks associated with real-world testing and also reduces product launch times.

A&D manufacturers can then create a complete virtual build that incorporates the MBOM and process plan and identifies the resources needed, how to improve resource utilization and potential quality issues in order to reduce work and scrap. Doing this virtually helps A&D manufacturers save time and money that is otherwise spent on manual prototypes—shortening the time needed to bring products to market while raising quality and validating the process steps across the time horizon.



Simulating the manufacturing of robotic arms to ensure future production rate and quality

After connecting the engineering and manufacturing worlds together via simulation of the virtual build, you can then feed product information and the manufacturing process into the virtual model to produce a true-to-life product in the real world. The Virtual Twin Experience delivers this, drilling down to pinpoint accuracy at any stage of the model build—from the level of detail for machining and manufacturing strategies to evaluating how different technologies can be used to produce and assemble structures and frames.

For example, when developing robot arms, the Virtual Twin Experience evaluates the drilling and riveting process to assess tool paths and the feasibility of the product build and assembly leveraging models from design, engineering and manufacturing. It provides flexibility to experiment with different manufacturing technologies, such as numerical control (NC) programming, additive manufacturing and robot programming. Virtually designing and validating new optimized robotic systems by these means ensures the final physical product is detailed and accurate to the highest degree, in addition to helping manufacturers:

- Drive smarter and faster programming of robots
- Ensure future production rate and better quality
- Reduce waste and capital investment
- Deliver first-time quality

As an added element, modern disruptions have amplified the importance of planning for worker safety on the facility floor. The Virtual Twin Experience can also account for this—not just in creating ergonomic work conditions, but also in simulating social distancing in facilities, calculating the new productivity rate and optimizing within these constraints.

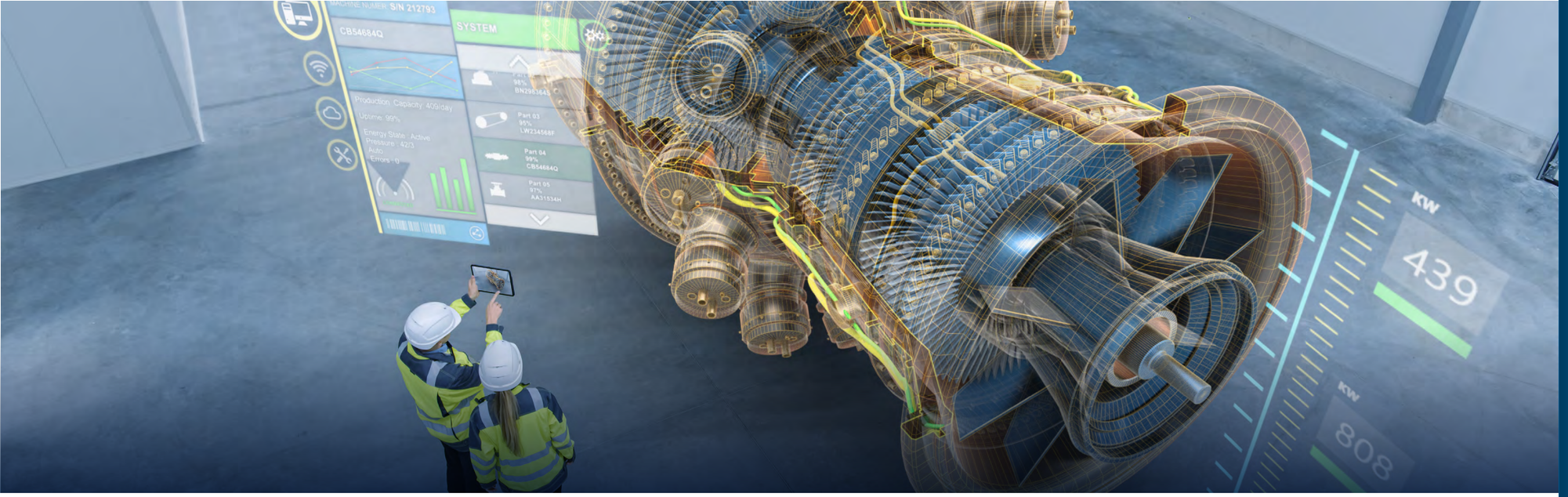
Now that the Virtual Twin Experience has both the model and process set up, A&D manufacturers have a clearer picture of how their product will be manufactured in their facility. The simulation can then be used as a lever for continuous improvement in manufacturing flexibility and agility.

Capabilities:

- **Design factory layouts and analyze multiple production scenarios**
- **Optimize process performance with alternate product routings**
- **Natively integrate robot, NC machine programs and human tasks into model**

Goals & benefits:

- **Workforce safety**
- **Agile manufacturing**
- **Optimized production performance**



MANUFACTURING PLANNING

How to optimize production while managing constraints?

This stage of the time horizon is where manufacturers apply forecast data on demand and supply to the model to simulate how the model performs and how operations can be optimized while managing constraints in manufacturing, assembly and distribution.

The time horizon for this stage may still be quite varied. At the highest level, Sales & Operations Planning (S&OP) might be performed monthly or quarterly and look up to years out. This allows organizations to help analyze global supply chain constraints and possible "what-if" scenarios to deal with fluctuating supply and demand scenarios and even disruptions, as well as to align the many different stakeholders involved in the strategic planning level onto a common plan.

The time horizon could also be more tactical—for example, generating a more detailed Master Production Schedule that considers more granular constraints of resources, materials and bottlenecks in production.

There are numerous opportunities in this area and the various optimization engines that leverage Machine Learning and Artificial Intelligence are significant drivers of agility and planning in the face of both certain and uncertain future elements. With so many possible scenarios to consider, it is sometimes difficult to develop any single feasible plan, let alone an optimal plan. For the A&D industry in particular, this is because a lot of the planning at this stage is typically done manually or in spreadsheets, both of which are insufficient methods given the multitude of constraints to consider.

When developing strategic plans, it is important to represent the business KPIs that are critical to success in multiple scenarios so that A&D manufacturers will have a sustainable plan in place yet are able to respond quickly to sudden changes in factors, both internal and external. And as change is constant, having the ability to replan on demand, almost in real time, is essential to make the most of optimization to adapt to changes and to inform decisions for the best outcome based on a companies' unique business goals.

MANUFACTURING EXECUTION

How to execute flawlessly and deliver products on time with superior quality?

Manufacturing operations management (MOM) has a broader scope than manufacturing execution systems (MES) as it involves automating, executing and managing the performance of all business processes relevant to manufacturing execution, which includes manufacturing production, quality, warehousing, the workforce and maintenance. The ability to manage all of this on a single platform provides many advantages:

- **Visibility for production operations to promptly carry out unplanned maintenance**
- **Quality events can trigger maintenance alerts and move work in progress**
- **Can immediately identify a need to requisition materials or replace components**
- **Visibility that allows management to respond faster to unplanned events**
- **Eliminates silos and rogue applications**
- **Reduces risks and increases operational flexibility**

Machine integration enables the MOM solution to connect to all machines and devices in the physical world through IIoT. Open standards for connectivity—both directly and through partner hardware and software—empowers the MOM solution to work across all operations. This drives better compliance with regulatory requirements, enforces best practices and enables lean operations.

Creating that IIoT connection between the physical world and MOM solutions can be challenging for companies, but it makes up a key part of the Virtual Twin Experience philosophy. The connectivity enables closed-loop synchronization of the virtual and real worlds, which drives productivity, provides complete real-time visibility, enables predictive maintenance and predictive execution, improves product quality and lowers costs—whether in assembly operations, quality inspection or material synchronization.

A&D manufacturers typically find it a challenge to realize this connectivity as the array of software and technology they rely on often use different communication standards that do not translate well between systems. There is no single medium that is universally accepted as the industry standard. Incompatibility between legacy machines and newer systems makes this even more difficult.

DELMIA adopts an open and agnostic approach to these challenges. With no stake in the hardware game, our approach is to adopt widespread industry standards and utilize a one-size-fits-all solution that can work with all forms of hardware; working only with partners to ensure that all systems are able to connect with the **3D**EXPERIENCE platform. It is also during this stage where we can determine areas for improvement across operations and leverage the Virtual Twin Experience to drive informed decision-making and ultimately enable the goal of flawless execution, quality and delivery of products.

Manage and connect all elements of manufacturing operations

MAJOR IMPROVEMENTS THROUGH THE VIRTUAL TWIN EXPERIENCE

Here is a real-life example of an aircraft engine manufacturer that took full advantage of the **3D**EXPERIENCE platform to manage and optimize its global fabrication requirements:

THE CHALLENGE

- Thanks to new-generation engine market success, the company expected high manufacturing workload.
- It needed to set up a more lean, unified and flexible collaboration environment to maintain highest quality standard and manage costs.
- Each of its production sites previously worked with different tools and methods and did not efficiently communicate with one another.

STRATEGY

- The company leveraged the **3D**EXPERIENCE platform as a single secure collaborative environment to ensure efficient submission of engineering design changes into the system.
- All players in manufacturing planning were granted immediate and secure access to these updates for swift action to dramatically reduce errors.

RESULTS

- A **unified collaborative environment for managing all manufacturing data** across all internal and external stakeholders of the industrialization processes.
- **Digital continuity from engineering to manufacturing industrialization** for process planning and work instruction, to NC programming and simulation.
- **Efficient configuration management** of all shop floor deliverables.

Another real-life example of the **3D**EXPERIENCE platform in action comes from an aeronautics company leveraging the Virtual Twin Experience to determine the most optimal way to build a new factory:

THE CHALLENGE

- To build a new factory and its virtual twin model for next-generation production line.
- Reach first time quality, on budget and on schedule.

STRATEGY

- The company introduced virtual production, installation and inspection.
- Managed quality and time deviations in real-time, applying root cause analysis with less risk, thanks to digital continuity from the company's 3D functional and physical digital mock-ups, through manufacturing planning to the shop floor.

RESULTS

- The company identified **significant savings** in work in process, labor, quality costs and outstanding work of **10%** to **40%**.

The benefits of the Virtual Twin Experience are real and documented, with our customers realizing major improvements in these areas:

PRODUCTIVITY	COST	SUSTAINABILITY
• **60%** increase in Aircraft Production • **20%** Lead Time Reduction • **3x** Operations Throughput • Scenario Testing Time Reduced by **87%** • **50%** Reduction in Time to Market • **58%** Reduction Production Cycle Time **"Every hour of virtual testing saved 25 man hours of real-world time."**	**25%** Reduction DOH Inventory	**25%** Reduction Errors & Waste
	30% Planned Inventory Reduction	**15%** Scrap Reduction

REALIZING THE VIRTUAL TWIN EXPERIENCE IN AEROSPACE & DEFENSE

Transitioning to a Virtual Twin Experience represents a profound shift in A&D manufacturing decision-making. Dassault Systèmes Strategic Business Development Director, **Adrian Wood** breaks down the Virtual Twin Experience into four distinct parts:

COLLABORATION

is where organization stakeholders determine the needs, wants and goals of the project. Design engineering, manufacturing engineering, quality assurance, sales, procurement and management all contribute to the creation of a unified system.

MODELING

is the payoff from the Virtual Twin Experience, where changes are tested virtually to eliminate bottlenecks and improve efficiency. This is where planning changes become true "what if" experimentation—on everything from equipment cycles to worker time and motion study.

OPTIMIZATION

is the starting point for digitalization, creating an accurate representation of machines, processes and workflows. Accuracy must be maintained throughout the project; ad hoc or emergency changes to equipment or processes must be reflected in the models, which helps managers test solutions before implementation.

PERFORMANCE

is the goal; the actual implementation of new processes and procedures tested in the virtual factory. With a successful Virtual Twin Experience, production changes are swift and trouble-free, and downtime is minimized. Equipment with sensors then feed real-time data back to the twin to confirm outcomes and establish a new baseline for the next series of experiments and improvements.

CONCLUSION

Though it still seems like a long way for the industry to return to some semblance of normalcy, it is clear that demand is starting to return, and many companies are taking advantage of this downtime to prepare for that. Lessons learned in 2020 around how major disruptions have magnified existing challenges and inefficiencies drives these players to become agile and build resiliency through investments in technology and processes.

The Virtual Twin Experience will become an increasingly important tool not just as a means of recovery, but as a key transformation enabler, and the backbone of future competitiveness. It will be the difference between companies that emerge resilient, competitive and lean and those that are still lagging. Though it is a daunting prospect, and the starting point may vary between different segments of Aerospace & Defense, the time is ripe for your organization to take transformational steps.

With DELMIA, A&D manufacturers have an opportunity to optimize operations and maximize returns by leveraging the endless possibilities of the Virtual Twin Experience, powered by the **3D**EXPERIENCE platform. In addition to the capabilities highlighted in this ebook, we offer the A&D industry solutions as a service through our outcomes-based objectives, which can help power your organization to achieve the agility and synchronization necessary to soar above the competition and take innovation to greater heights.

Learn more about our solutions for the Aerospace & Defense industry at:
https://www.3ds.com/products-services/delmia/solutions/aerospace-defense/

For more insights into transforming your organization for operational resilience and competitiveness, check out our Transformation Journey Research Series:
https://discover.3ds.com/transformation-journey-research-note-series

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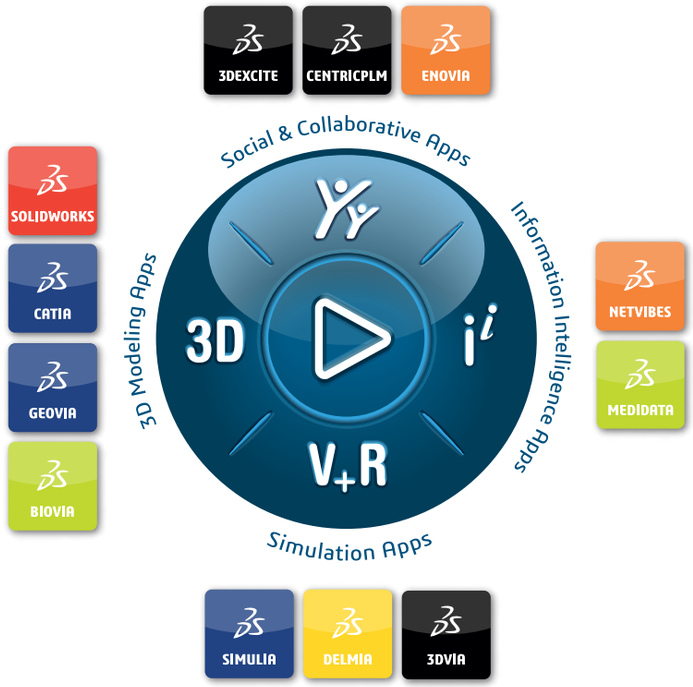
Our **3D**EXPERIENCE® platform powers our brand applications, serving 11 industries, and provides a rich portfolio of industry solution experiences.

Dassault Systèmes, the **3DEXPERIENCE** Company, is a catalyst for human progress. We provide business and people with collaborative virtual environments to imagine sustainable innovations. By creating 'virtual experience twins' of the real world with our **3DEXPERIENCE** platform and applications, our customers push the boundaries of innovation, learning and production.

Dassault Systèmes' 20,000 employees are bringing value to more than 270,000 customers of all sizes, in all industries, in more than 140 countries. For more information, visit **www.3ds.com**.



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