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eBook

Digitalising aerospace manufacturing

How to land on a cost-effective digital manufacturing strategy that transforms operations

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Contents

01 An industry striving to work smarter

Aerospace OEMs and their suppliers will emerge from the COVID-19 pandemic into a more complex and volatile global market, forcing the industry to examine its technology investment priorities.

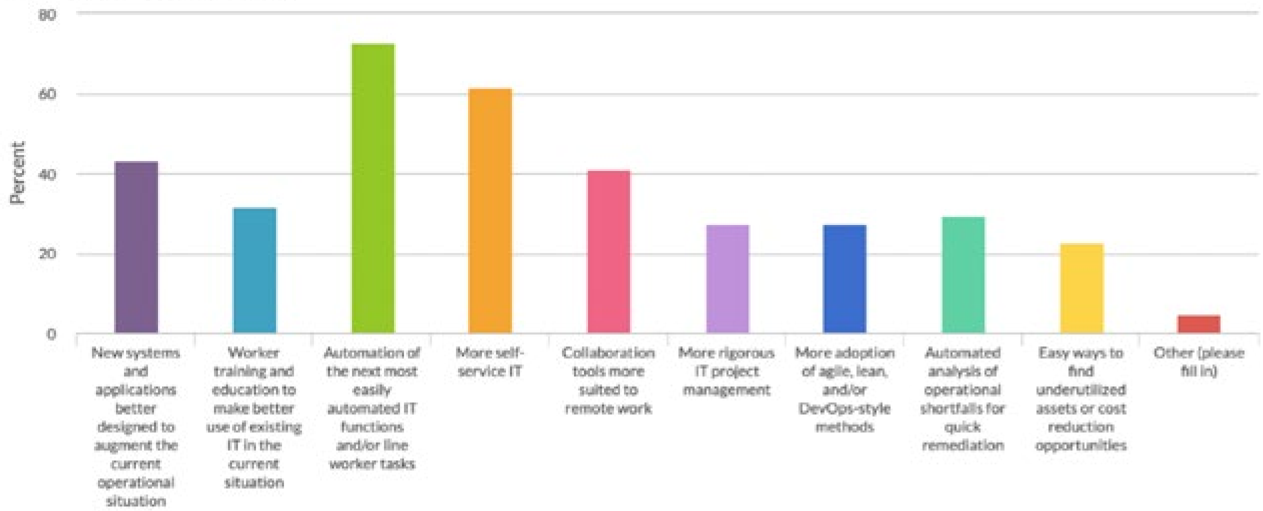
Not only are manufacturers and airlines dealing with the consequences of an unforeseen, precipitous, and prolonged drop in their activity and revenues, a new global player in the form of China's Comac is getting ready to enter the field.

Meanwhile, the production challenges that were present pre-COVID persist. In 2019, the global fleet was predicted to double in size by 2038.[1] Although some airlines have delayed the delivery of aircraft in response to the financial pressures of COVID-19, production backlogs remain.

At the same time aerospace OEMs and their suppliers need to invest in developing the sustainable aircraft of the future; pursue market share with new airlines, notably in Asia; and meet airlines' demands for services such as late-stage customisation.

Faced with a challenging environment, manufacturers across the aerospace and defence sector are having to balance the immediate need to make operations more cost-effective and productive with the longer-term strategy of making manufacturing smarter and more agile.

6. What do you estimate would dramatically improve IT effectiveness and/or ROI right now in your organization? (Select up to five that apply)



Source: Constellation Research

77% of CIOs name digital transformation as their biggest budget priority of 2021"

Recognition of the potential of digitalisation is increasing across the industry spectrum. In a survey of 100 leading CIOs in the fourth quarter of 2020, 77% of respondents identified digital transformation as their biggest budget priority of 2021.[1] For aerospace manufacturers, the question is where to focus digitalisation efforts for the greatest impact

This eBook looks at how investments in operational improvements can address short-term imperatives such as cost reduction, while supporting strategic aims to create a connected and more autonomous business that makes efficient and intelligent use of data.

Failure when designing, manufacturing and assembling complex aerospace parts comes with a high price tag. The more insight manufacturers have into inefficiencies or sources of error and how to address them, the better able they are to get things right first time, resulting in greater productivity and lower costs.

And indeed, manufacturers in the aerospace and defence sector consistently invest in technologies to collect and make better use of operational data and create smarter, more autonomous manufacturing systems.

Many, however, are now having to accelerate technology deployment with the aim of reducing costs and further automating processes.

[1] *WalkMe/Consellation Research: The CIO Outlook 2021 - Delivering Business ROI at Scale*

Putting data to work for smart manufacturing

Part of the response is tactical, with manufacturers identifying precise areas of design, manufacturing and inspection weaknesses and using specific technologies to address them. It's an incremental approach to digital transformation and has the benefit of providing measurable results quickly. There is a growing interest, for example, in automated inspection and remote asset monitoring, as well as advanced analytics software that models scenarios and recommends optimal actions.

Manufacturers are also saving money by virtually simulating how the physical demands of production and real-world usage will impact a designed part, allowing them to modify it before building an expensive prototype. In addition, they are using software to gain more precise results from existing operational machinery, for example by testing and verifying G-code before cutting metal for parts, thereby reducing errors and waste.

An increasing number of aerospace companies are combining the strengths of analytics and simulation software to create digital twins of parts and systems, which draw data from multiple sources to constantly mirror changes to their physical counterparts.

Whatever the operational issue, a cost-effective response is best achieved when technologies put data to work to deliver on both immediate tactical objectives and long-term strategic digital transformation goals by making it possible to:

1. Capture reality

Digitally collect process data from physical and digital machines and systems so that it can be contextualised and structured for use across the entire operation.

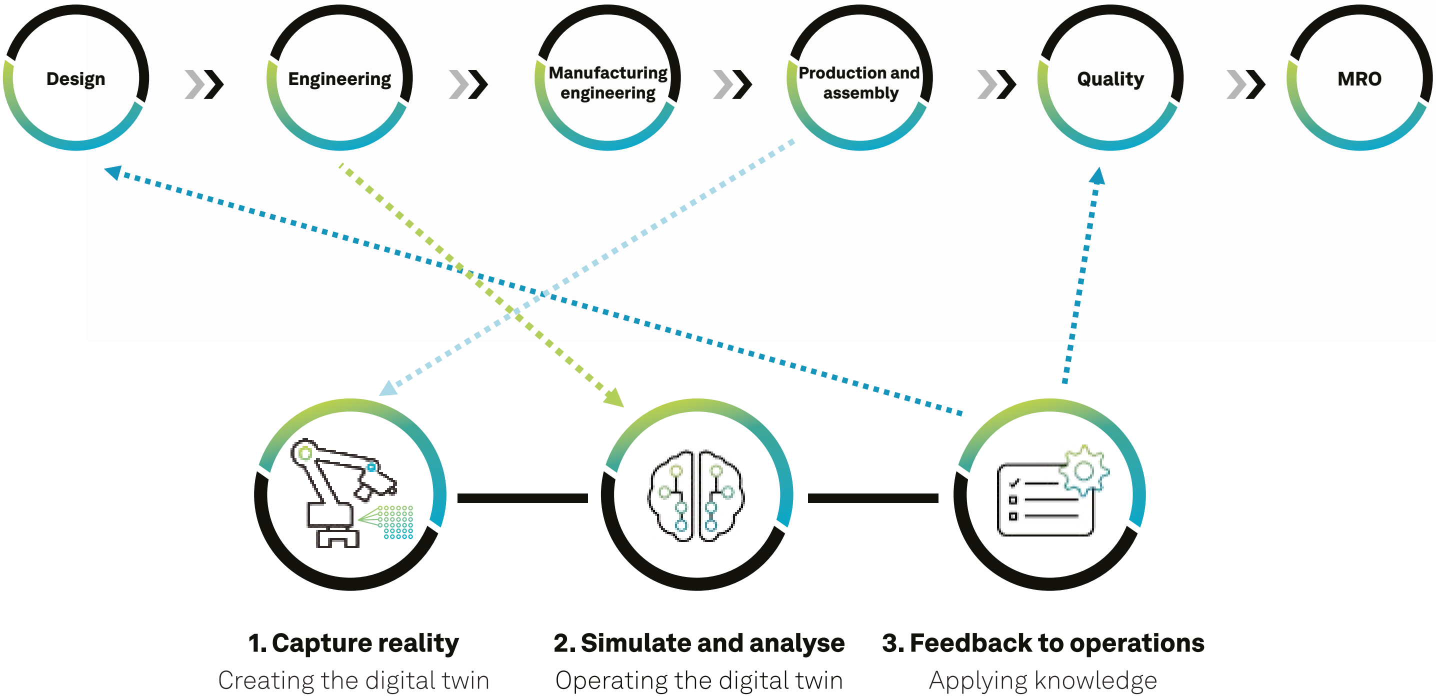
2. Simulate and analyse

Run advanced simulations that either inform decisions on correcting processes or directly correct processes, for example, by generating new CNC toolpaths

3. Feedback to operations

Filter and process data to visualise the key operational parameters and feed information back to where it's most useful

Creating and using the digital twin in three steps



02 A single truth about smarter manufacturing

The proliferation of reliable and affordable IoT systems, cloud computing, machine learning, visualisation and analytics tools makes it easier and much more affordable to automate and speed up the capture, analysis and use of data.

However, gathering process data from operational machines and virtual systems is not always simple, nor is structuring it in a form that designers, engineers, machine operators and business managers can share.

Often silos hamper interoperability, meaning data can be misinterpreted, lost or left unused as it moves between systems.

As a result, aerospace manufacturers miss out on crucial information about how products change throughout their lifecycle, which has implications for future product design.

If manufacturers are going to understand the lifecycle consequences of design decisions, then they need information about how each component, assembly and product turns out in real life.

Design, production and inspection teams are already bridging silos between systems to solve problems. For example, today inspection teams use real-time metrology systems to position fixtures for large aerospace assemblies, inspect them as they are being built, and then send modifications directly to design systems. And specialised packages CAD CAM software make it possible to generate, manage and optimise CNC machining toolpaths that greatly reduce milling time.

Yet the biggest cost savings will kick in when aerospace manufacturers can access relevant data from inspection and production systems and analyse it to understand the full lifecycle consequences of design and manufacturing decisions. Once they have the full picture, based on virtual and real results, they can act quickly to cut waste, improve productivity or tweak designs to make a component easier to manufacture or an aircraft faster to assemble.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CB54684Q
SYSTEM
Production Capacity: 409/day
Uptime: 99%
Energy State : Active
Auto
Errors : 0
Part 03
95%
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Part 04
99%
CB54684Q
Part 05
97%

03 Virtual twin and simulation

With ready access to physical and virtual information, designers can undertake early design validation and verification (V&V) to spot errors and thereby avoid having to make expensive and time-consuming modifications during the ground and flight test phase.

The statistical analysis and machine learning systems that inform decisions in smart manufacturing, however, are only as good as their source data.

Meaningful statistical analyses and AI rely on a connected, open ecosystem, irrigated by links to accurate and usable real and virtual data. For this reason, manufacturers need to overcome the interoperability issues that impact data flow by using open systems. And they need to do so without incurring high integration costs or adding complexity. Otherwise, they will be hampered in their deployment of a digital thread and digital twins that allow then to identify and implement cost saving measures.

04

Can the real digital twin please step forward?

Digital twins are a virtual representation of physical objects and processes. They set out to save time, resources and money by making it possible to simulate the impact of choices in a virtual environment before implementing them in the real world.

A digital twin might exist, for example, to enable designers and engineers to adjust designs without having to build expensive prototypes. Digital twins also play an important role in gauging the manufacturability of a component, allowing engineers to develop a right-first-time system and prevent the need for reworking components at the physical validation stage. Equally it is possible to create a digital twin to trace and visualise the root cause of issues on the shop floor in real time, help commission new equipment, train new operators or simulate various shop floor configuration, helping production managers solve problems that delay production.

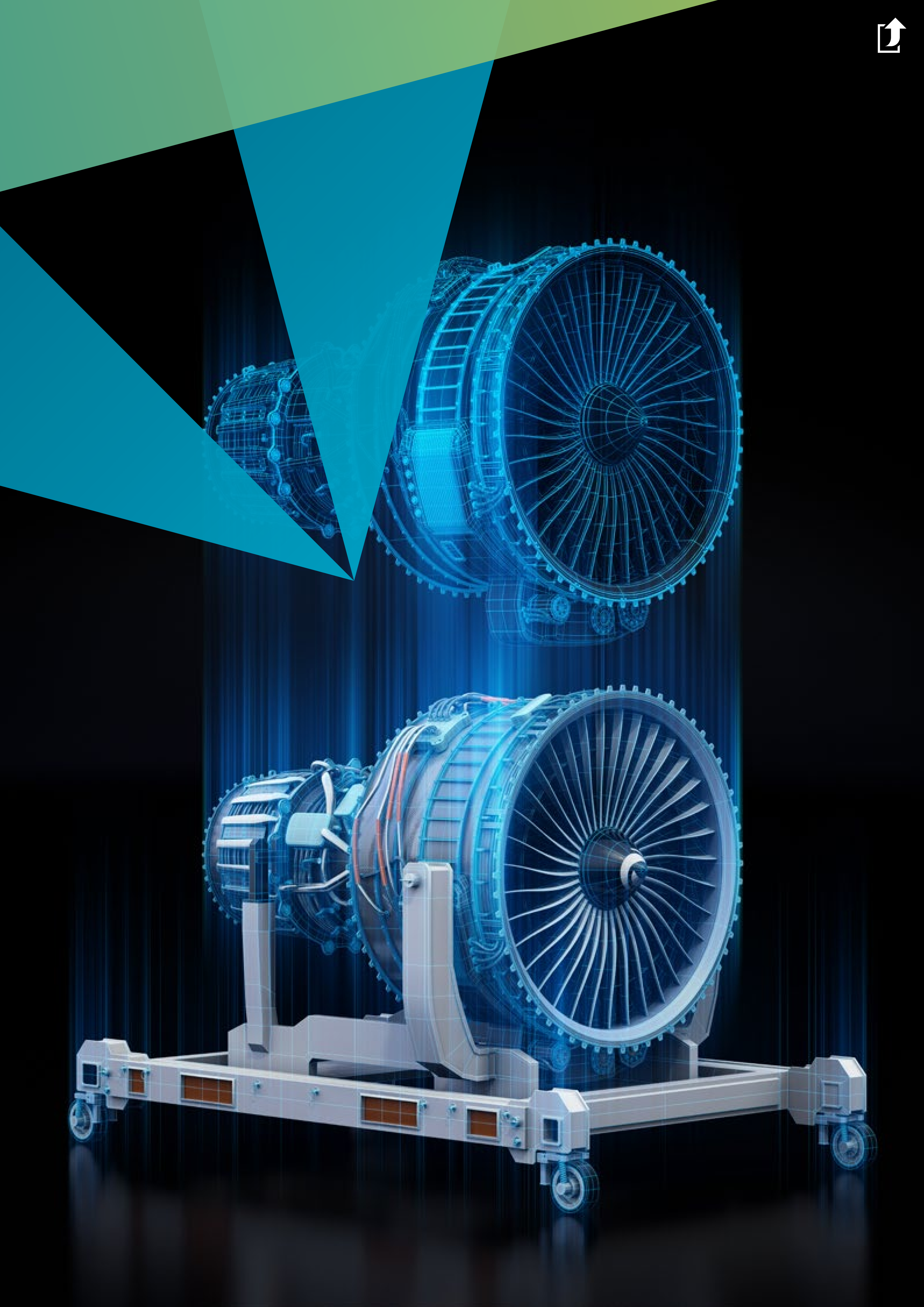
As these examples suggest, digital twins are often created and used within discrete functional parameters, but they can also interconnect to create a more complex system.

It may sound simple enough, but digital twins are not always easy to build in practice. Part of the problem is the cost and complexity of feeding the models with reliable and consistent datastreams and linking the models both to the shop floor equipment as well as the PLM MES and ERP systems. Without an integrated and unified data flow between systems, digital twins can lack necessary perspective on the way products and processes evolve throughout the workflow.

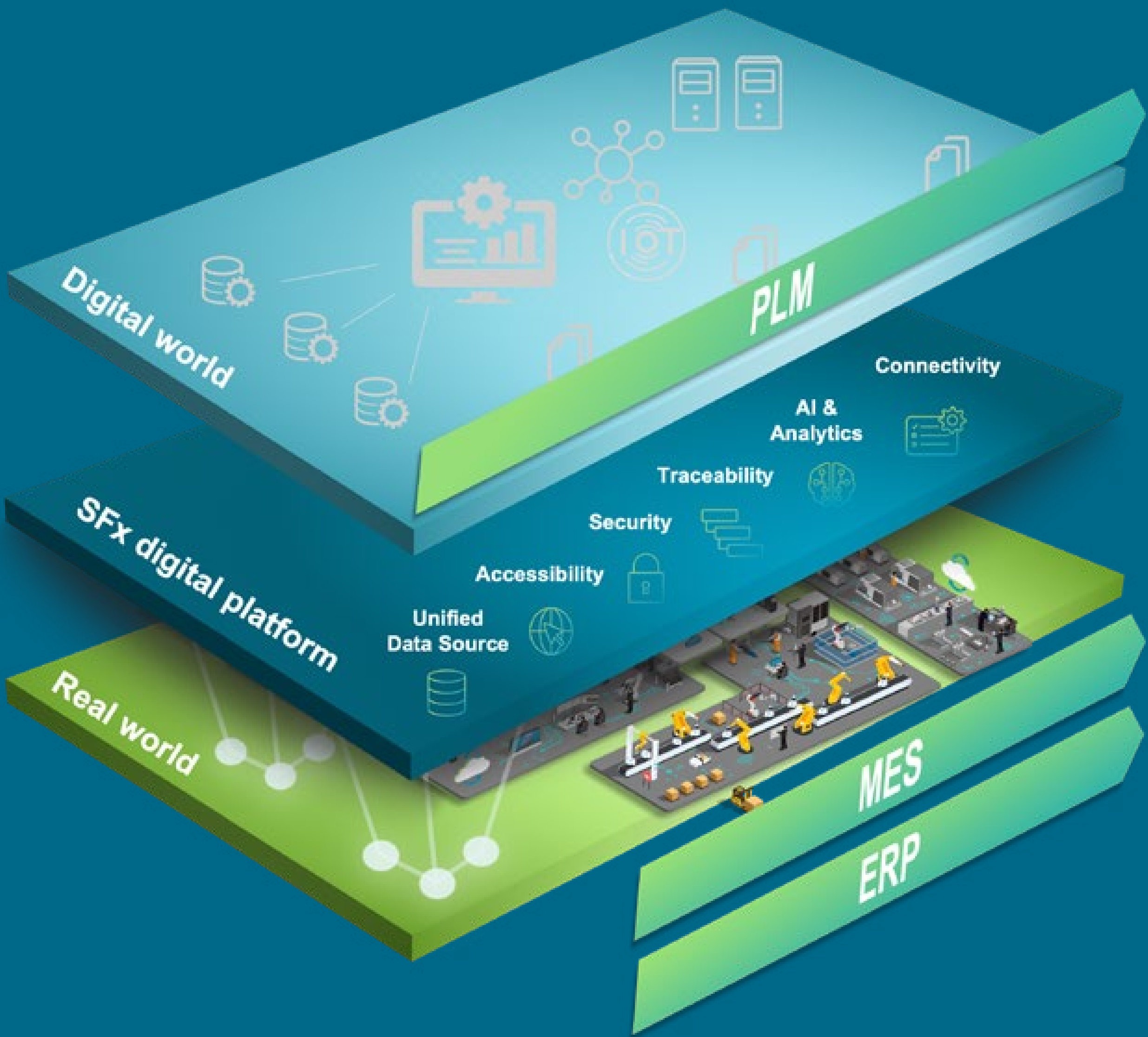
The analyst company, IDC has highlighted how a lack of integration between OT siloes and IT enterprise systems is making it difficult to use data in decision making.

"Driving a strategy of IT/OT convergence is a priority that more than 90% of industrial organisations have, but in practice the integration is still very difficult. Companies have expressed that the biggest challenge when utilising data for decision making is the integration of OT systems across siloes, and of those systems with enterprise systems in particular enterprise resource management systems (ERP)," according to IDC.[2]

[2] *IDC: IDC Asia/Pacific Unveils Predictions for IT/OT Convergence to Support Resilient Decision Making in 2021 and Beyond*



Bridging the gap between the shop floor and the virtual world



05 Getting into the flow without complex integration

Unless starting with a greenfield operation, the best way to create a real digital twin and digital thread is to build a digital platform that orchestrates and monitors the physical domain, connecting different stages in the workflow, as well as PLM, MES and ERP systems. In this way every step in design, production and inspection can benefit from multiple relevant sources of virtual and physical data to create a trusted flow of information that can be used to optimise real-world operations.

Hexagon has therefore drawn on its aerospace domain knowledge in the digital and the physical world to develop the HxGN SFx digital platform for the aerospace industry. The SFx platform connects IT and OT systems from design right through to inspection to help capture and deliver a consistent, accurate and unified source of data.

The diagram above shows how the path of unified data is facilitated within an aerospace manufacturer's OT/IT systems by the SFx digital platform and an open, interoperable approach to technology development.

ABOUT SFx SOLUTIONS →

Hexagon's commitment to ensuring interoperability with third parties, using standard protocols, including SYSML, STEP, XML, and OPC-UA, helps aerospace manufacturers drive smarter manufacturing by building on existing PLM, MES and ERP systems.

One of SFx's strengths is knitting together the digital and real worlds together by facilitating the capture and monitoring information about physical systems and allowing it to be shared with virtual systems.

It is possible to trigger and monitor domain tools in the SFx architecture to optimise the sequencing of tasks. This makes it simpler for engineers to see how changes to one element, such as material composition or acoustics will impact overall performance, early in the design process. Not only does this reduce the time spent on design, it gives engineers the insight, speed and confidence they need to make design innovations.

The SFx orchestration platform bolsters the MES, meanwhile, by bringing information from machining, drilling, fastening, inspection or additive manufacturing activities on the shop floor, linking it to an intelligent, connected process chain.

06 A more flexible operational model

Crucially, ready access to simulation, production and inspection data makes it possible to conduct virtual manufacturability analysis. Hexagon's digital manufacturing solutions help create a digital model of the as built components using scanned metrology data which is then connected to the customer's PLM to perform correlations with the latest as designed model. From machining processes to additive manufacturing or metal forming, 'real' digital twins can then perform the most advanced simulations scenarios, suggesting the optimum set of parameters. Knowledge can then be applied back to the shop floor – through MES – in several forms such as new toolpaths, new part fixturing modes, new materials or operational dashboards based on the expected productivity gains.

Hexagon's digital manufacturing solutions uniquely combine more than 40 years of aerospace domain knowledge into flexible digital twin solutions connected to customers' IT/OT infrastructure, delivering the right information to the right place at the right time. Designed to be workflow oriented and fully modular, the SFx operational orchestration tool helps teams leverage aerospace process knowledge to anticipate manufacturing and assembly issues, monitor production processes and take quick recovery actions on the shop floor.

The result is readily customisable and automated workflows that facilitate advanced data management and analytics.

Being able to simulate production processes in advance is a huge potential source of cost savings, given the expense and time needed to correct imperfect real-world production processes once they are in place. The result is a more flexible operational model that emphasises manufacturing accuracy and product quality.

Hexagon's SFx platform also facilitates the rapid adoption of discrete technologies that solve specific operational problems, while enabling the creation of a more automated and autonomous smart manufacturing ecosystem. Autonomy is the ultimate form of putting data to work, and enables human resource to be freed up from tasks that can be as or more effectively completed by machines in order to focus on the creative, problem-solving tasks in manufacturing. By moving this way, aerospace manufacturers can secure measurable returns on investment in the near term while delivering on longer term goals to create a more cost-effective and flexible smart manufacturing environment.

Unified data source

Accessibility

Security

Traceability

AI and analytics

Connectivity

Empower your organisation

Autonomous workflows

Embedded and assured quality

Flexible scalability

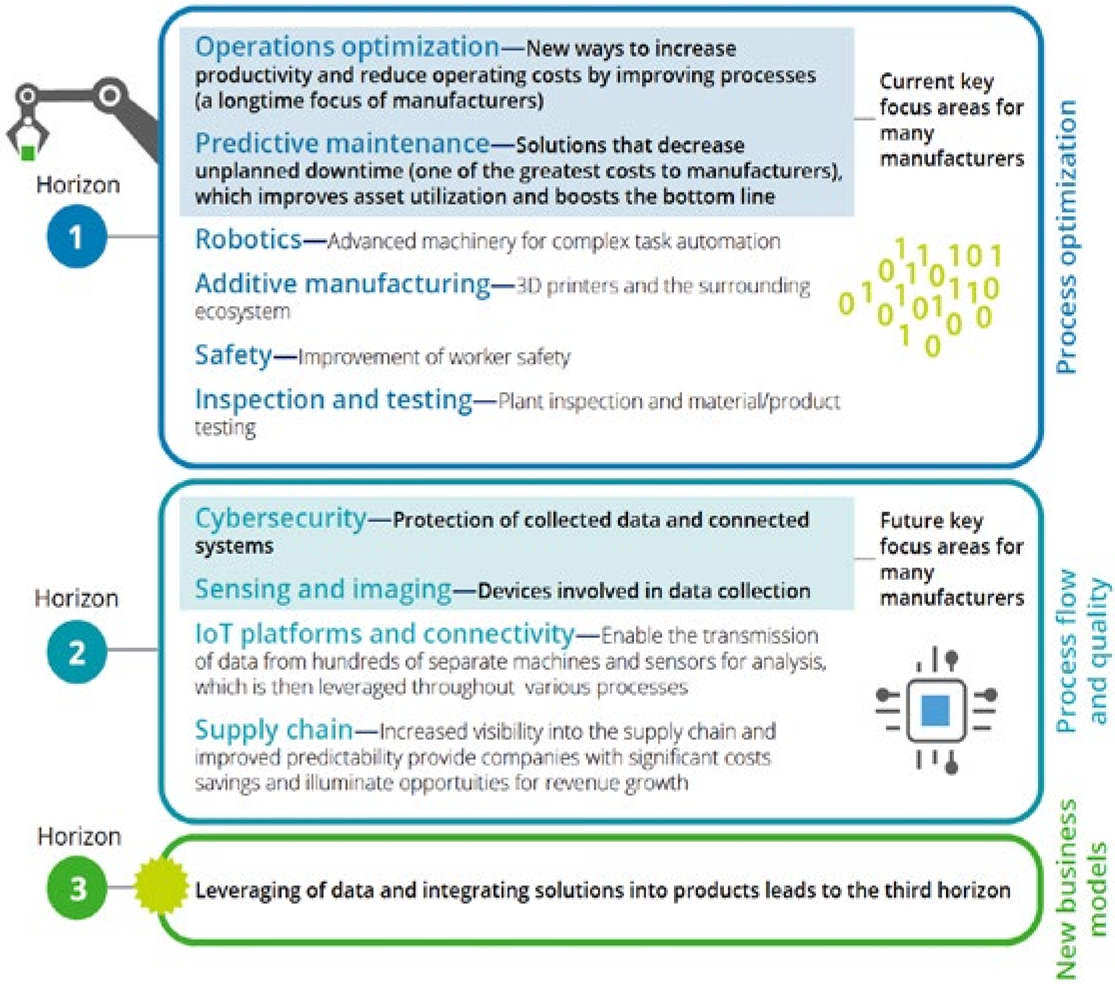
Advanced analytics

Collaborative innovation

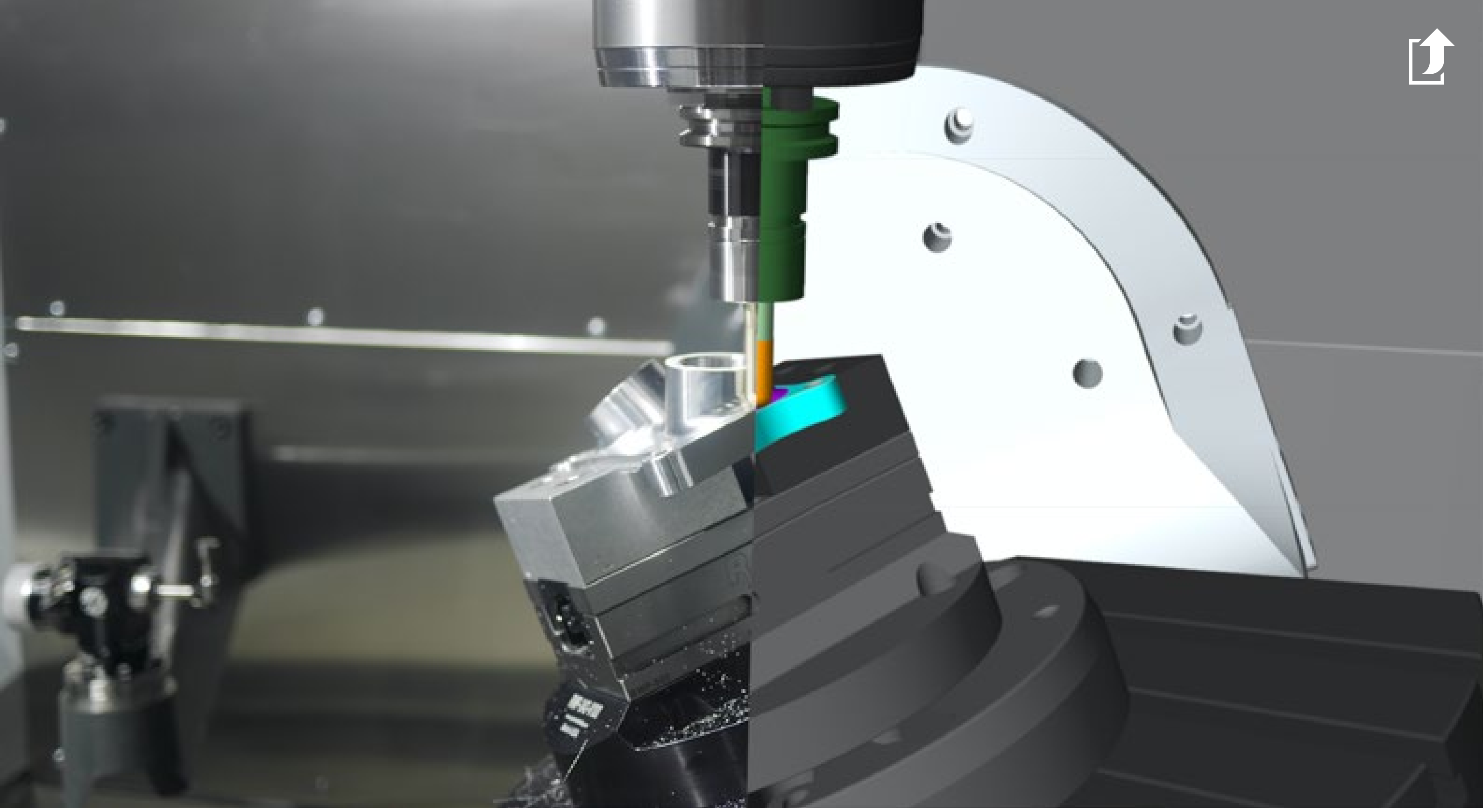
Cost optimisation

Increased productivity

Key focus areas for **digitalisation initiatives**



Source: Deloitte



07 Digitalisation use cases in aerospace manufacturing

One of the biggest challenges for manufacturers in successfully implementing a digital strategy is selecting, scoping and scaling projects to deliver value. For all the potential of smart manufacturing, research suggests that less than 30% of digital transformation projects succeed.[3] Those that do succeed do so because they address key success factors from project planning through to delivery – starting with identifying the critical focus and intended outcomes of the project.

This chapter explores four specific aerospace industry use cases that can gain immediate benefit from digitalisation and the implementation of smart manufacturing technology:

1. **Closed-loop CNC machining**
2. **Additive manufacturing**
3. **Virtual assembly**
4. **In-process automation and inspection**

By focusing new technology initiatives on activities such as these, aerospace manufacturers can ensure that the strategic investment delivers value before scaling a similar approach into other areas of operations.

[3] *McKinsey: Unlocking success in digital transformations*

Closed-loop CNC machining

One of the many areas in which aerospace manufacturers can benefit from connected, data-driven operational improvements is closed loop CNC machining.

With a closed-loop CNC machining system, feedback is automatically sent to CNC controllers, enabling the machine programme to make adjustments and prevent errors. This is of particular value in the aerospace industry where large, intricate parts are milled using expensive materials.

Advanced machining verification software simulates the real characteristics of CNC machines, tools and materials to simulate, verify and optimise CNC programs for 5-axis and more complex machines. In this way it becomes possible to create collision free machining, which limits waste, and to reduce a part’s cycle time by automatically optimising cutting tool feeds and speeds. Such solutions can also facilitate information exchange through CAD/CAM interfaces and enables the seamless import of any existing CAM data.

Hexagon’s machine tool inspection solutions enable the inspection and alignment of fuselage and floor components during the machining process, making it possible to detect any deviations and step in to take action.

Intelligent machine control solutions meanwhile, make it possible to manage different machine tools, providing detailed insights and historical analyses that can be used to improve future processes. Advanced versions are capable of calculating the tool-specific correction values and delivering them directly to the machine tool’s control system, thereby automating improvements to product quality and optimising process stability.

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Figure 1: Adaptive CNC solutions like Q-DAS IMC use data to make in-process corrections

Additive manufacturing

Additive manufacturing (AM) plays an important role in creating more sustainable and lighter weight aircraft. Automated production processes, such as automated fibre placement (AFP) and automated tape laying (ATL) make AM faster and more efficient, particularly when supported by specialist automated inspection techniques capable of detecting details like fibre orientation for composite parts such as wing panels.

However, the AM market is fast changing and offers an array of technologies that are not always easy to deploy industrially. The SFx platform makes it possible to flexibly integrate AM processes across design, engineering, production and inspection systems. This allows manufacturers to incorporate better insight and automated analytics into their processes and continuously improve their AM workflows.

The result is an accelerated industrialisation of AM technology from generative design, through to manufacturing operations all the way to final product quality assurance.

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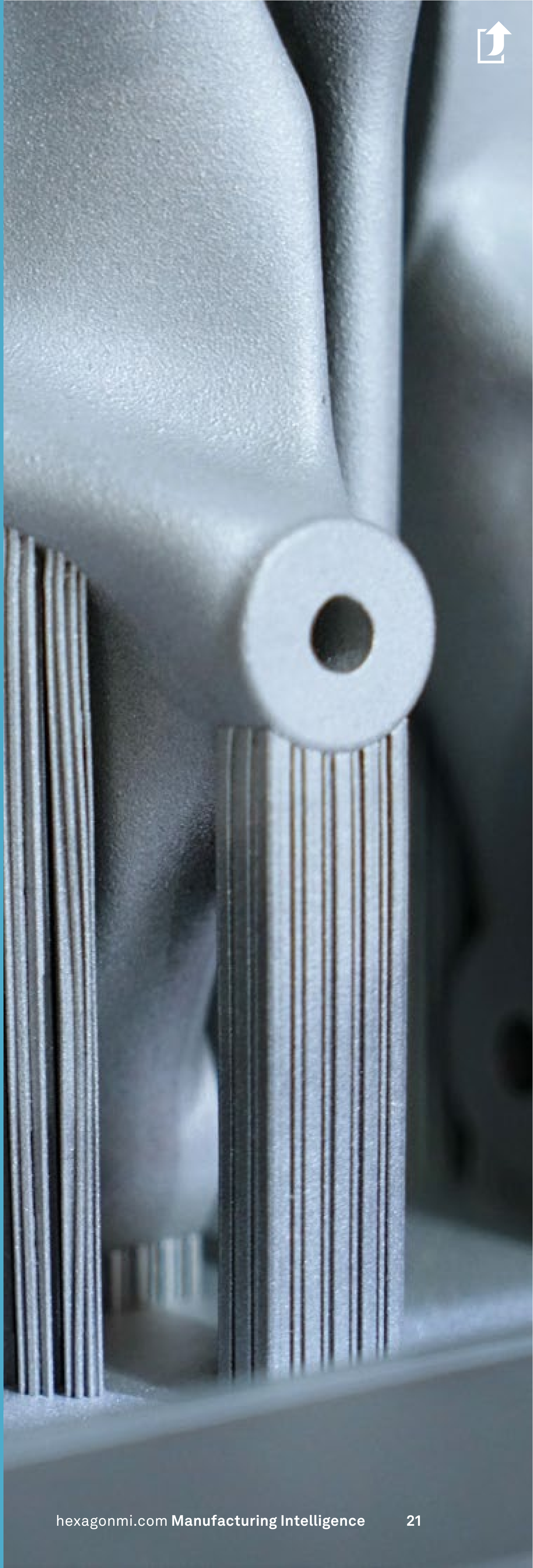

Figure 2: Additive manufacturing of aerospace part offers great potential in areas such as lightweighting

Virtual assembly

Traditionally, aerospace manufacturers have tackled the practical difficulty of assembling wings to bodies once the parts have been produced. A faster, more accurate and cost-effective approach is to address assembly challenges during the initial design phase, deploying a mix of simulation data and information from inspection systems.

Sophisticated metrology equipment inspects the dimensional characteristics and features of aerospace parts, as well as setting and verifying jigs and fixtures, and providing measured data to virtually simulate assembly. For example, laser trackers can be used to acquire references to virtually calculate the final real moves with metrology-assisted assembly, by both people and automated systems.

Metrology software systems make it possible to detect and address errors in the manufacturing process, before the final airframe assembly. And because all inspection data feeds into the digital thread, it not only increases productivity, it enables continual improvement and reduces tooling costs.

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Figure 3: Metrology-assisted assembly of an aircraft fuselage

In-process automation and inspection

The highest level of accuracy is required when manufacturing and inspecting aero engine components, such as blades and gears. Yet the parts are not simple to capture. Fan blades, for example, are geometrically complex and often have complicated curvatures, freeform surfaces, no axis of symmetry, varying thickness, and small radii at the edges.

At the same time, inspection teams cannot afford to sacrifice speed and must collect a full set of accurate inspection data.

Coordinate measuring machines (CMM) with automatic sensor changing systems enable optical scanning for high-speed profile measurements and high-accuracy tactile probes for critical alignment of the blade's root geometry, all in a short inspection cycle. A CMM with a temperature compensation system should allow inspection to be accurately executed in challenging shop-floor environments at temperatures of up to 40°C.

Aerospace components can be challenging to measure using non-contact systems, as they can include both very shiny machined aluminium and carbon fibre. More advanced laser scanners, however, can deliver highly dynamic and detailed surface measurement data at high speeds, while inspecting parts at speed.

For larger components automated 3D laser scanning using a SCARA robot can enable fast, inline surface inspection for large and multi-material fuselage panels and fan blades. This robotic solution is very flexible and requires fewer calibrations, making it an ideal solution for a range of large surface inspection tasks.

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Figure 4: Non-contact blade surface inspection on a high-accuracy CMM

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08 Conclusion

As the aerospace and defence industry ramps up production post-COVID and looks towards developing and building the more sustainable and higher performance aircraft of the future, it will need to combine increased innovation with greater cost control and efficiency. This can be achieved through a focused deployment of digital transformation that delivers measurable improvement to the shop floor, as well as the design room.

Hexagon's SFx platform is a cost-effective way to simplify the collection of process data from physical and digital machines and systems and make it available across a business' entire operation. By combining analytics with visual software tools, operators are able to analyse data from across design, production and inspection systems to take informed decisions that reduce development and production costs as well as lead time. In this way they can create a more efficient and flexible manufacturing environment in which to develop the aircraft of tomorrow that meet customers' desire for sustainable travel.

SPEAK TO AN AEROSPACE EXPERT →

Hexagon is a global leader in digital reality solutions, combining sensor, software and autonomous technologies. We are putting data to work to boost efficiency, productivity, quality and safety across industrial, manufacturing, infrastructure, public sector, and mobility applications.

Our technologies are shaping production and people-related ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 21,000 employees in 50 countries and net sales of approximately 3.8bn EUR.

Learn more at hexagon.com and follow us @HexagonAB.