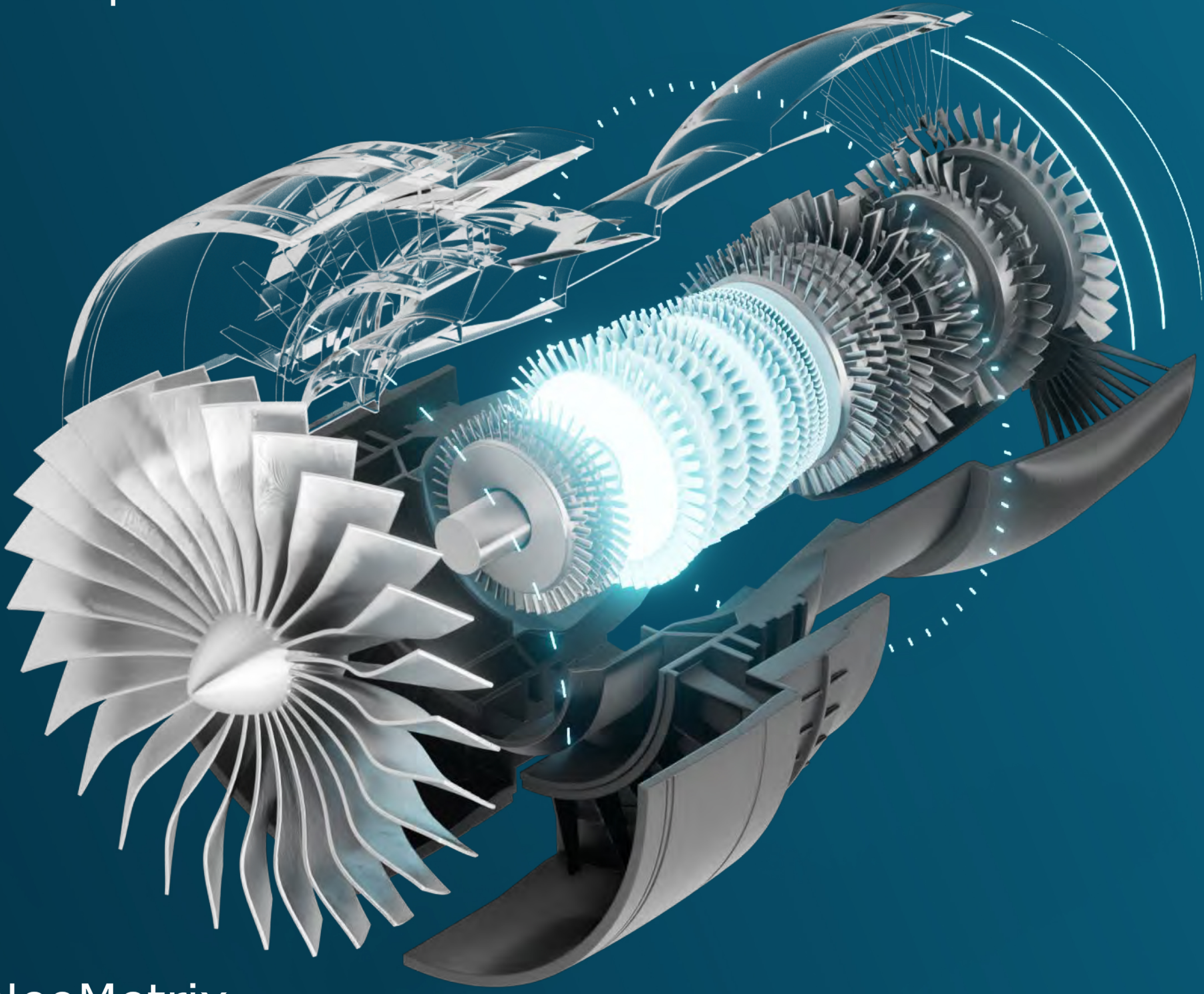
WHITEPAPER

From Physical Part to Parametric Model

3D Scanning Applications in Aerospace



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Introduction

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The aerospace industry is responsible for moving millions of people and thousands of tons of cargo every day. As a result, aerospace manufacturers and suppliers are held to extremely demanding **standards for quality, precision and durability**.

At the same time, aerospace presents some of the most difficult operating conditions for any manufactured components. Aerospace vehicles are **incredibly complex** and **expensive to manufacture**, and are designed to **deliver reliable, long-lasting performance**.

These dynamics create a situation where aircraft fleets must be **regularly** and **meticulously inspected for damage and wear**. Parts and components must be replaced when they fall out of **tolerance with rigorous standards**. But aerospace vehicles are built to last, which means the parts that need to be replaced may lack easily available documentation.

This is why 3D scanning is becoming increasing essential to the industry. Fast, accurate 3D scanning is creating opportunities to **simplify and streamline part development**, **reverse engineering**, **inspection** and other applications that are vital for aerospace manufacturers.

In this whitepaper, we will take a deeper look at these workflows as well as real-world examples of how 3D scanning is changing how aerospace manufacturers address common challenges.

Understanding the challenges

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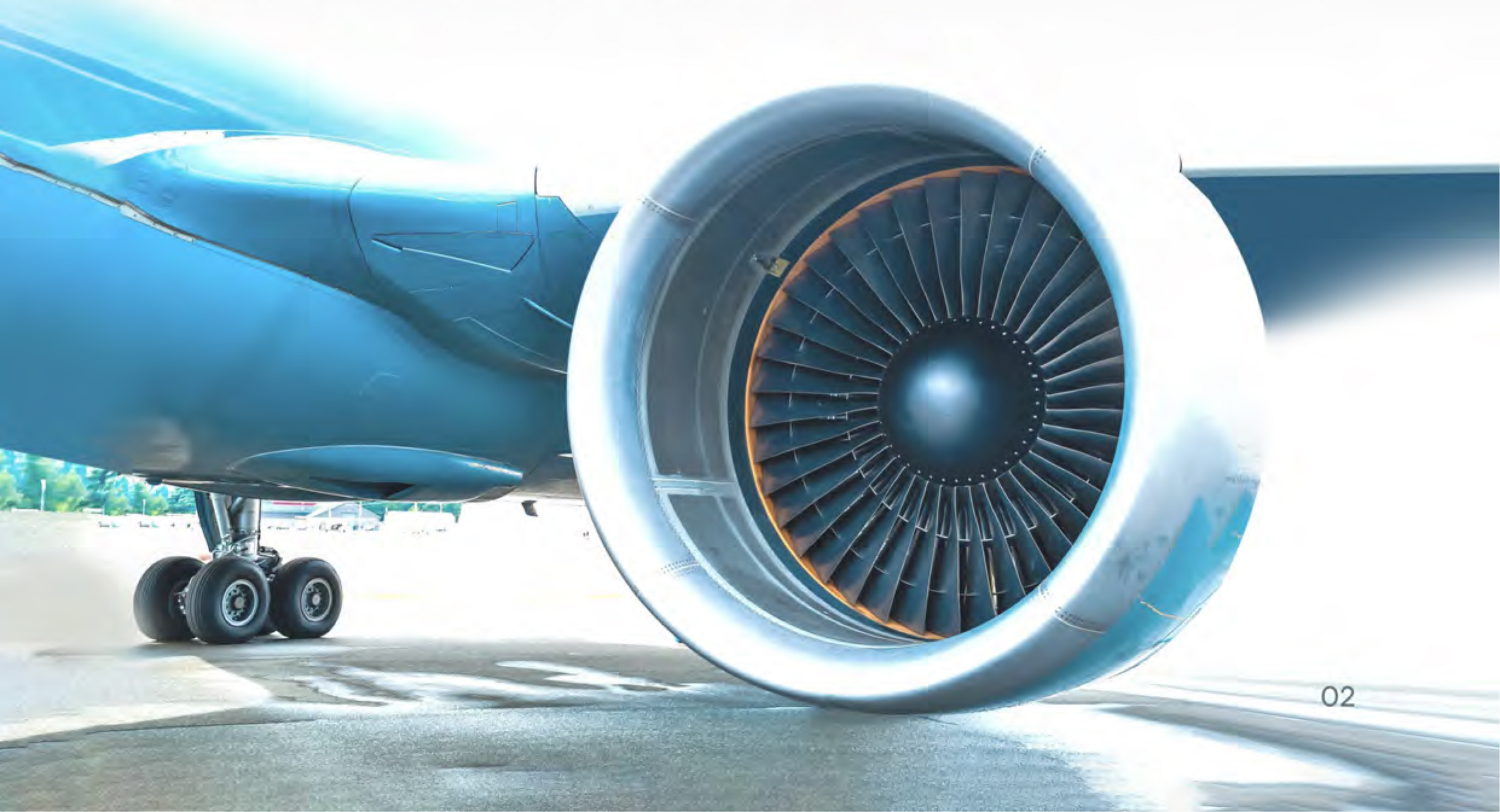
To help explain the changing role of 3D scanning in aerospace manufacturing, let's start with an important example: turbine blades. Turbine blades are subjected to incredibly strenuous operating environments that combine **high temperatures, stresses** and **vibrations** — all three of which can lead to blade failure and destroy the engine.

Specifically, turbine blades undergo stress from the centrifugal force of operating speeds in the tens of thousands of RPMs. They may experience temperatures as high as 2500°F, up from 1500°F in earlier designs of these engines. High temperatures can weaken individual blades, making them more susceptible to both creep failure and corrosion. Meanwhile, intense vibrations from both the engine and the turbine can cause fatigue failure.

As a result, the need for replacing turbine blades is constant. However, there are many instances when there is no parametric CAD file available for the part in question. Without that information, manufacturers would need to create the design from scratch, which would be very expensive and time-consuming, given the complexity of the geometry, the high tolerances involved, and the value of the part, where every micron could mean millions of dollars in fuel efficiency.

With highly accurate 3D scanning, manufacturers can capture the entire geometry of complex parts very quickly and with a high degree of accuracy. Portable, non-contact 3D scanners capture more data than traditional measurement techniques like CMMs, delivering a fuller picture of the part that can be more easily incorporated into digital workflows.



3D Scanning applications in aerospace

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Here are four ways that 3D scanning is helping aerospace manufacturers create accurate parametric CAD models of parts when CAD files are not otherwise available.

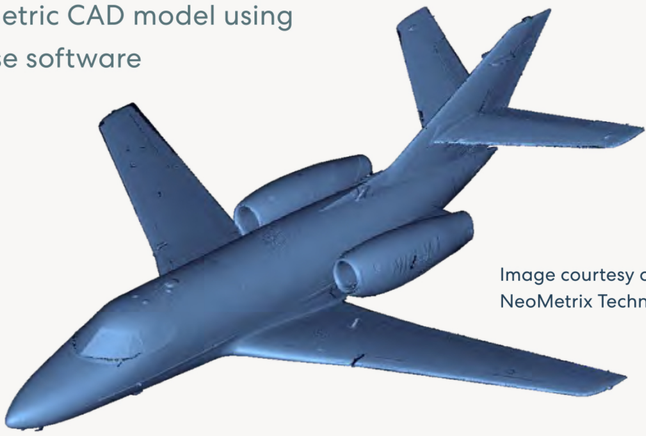
1 Reverse Engineering

There are many situations that arise when the original drawings of a part are not available. In the highly competitive aerospace industry, proprietary details about parts, components and systems are often closely guarded. That means OEMs may not be permitted to share these files with suppliers, contract manufacturers, MRO shops and other partners. In other cases, acquiring the original CAD files may be prohibitively expensive, or files may even be lost.

In all of these situations, reverse engineering makes it possible to reconstruct an accurate parametric 3D CAD model from an existing physical part. With this information, engineers can study the part's performance and functionality, remanufacture it to the original specifications, or integrate it within a new system or vehicle.

Using 3D scanners greatly accelerates reverse engineering. Typically, this involves scanning a 'gold standard' part that is known to be accurate. An operator can maneuver a 3D scanner around the part, capturing millions of data points per second. Importantly, the entire facility does not need to pause operation in order for the scan to be completed successfully.

The accuracy of 3D scanning is very high, up to 12 microns (0.0005"). Millions of data points are first stored as a mesh (also known as an STL or OBJ file) that can be converted into a parametric CAD model using specialized scanning software. These software tools can automatically extract features from the scan data, analyze the accuracy of the scan, tune out deviations, and create a functional parametric CAD file that is ready for manufacturing or further analysis.



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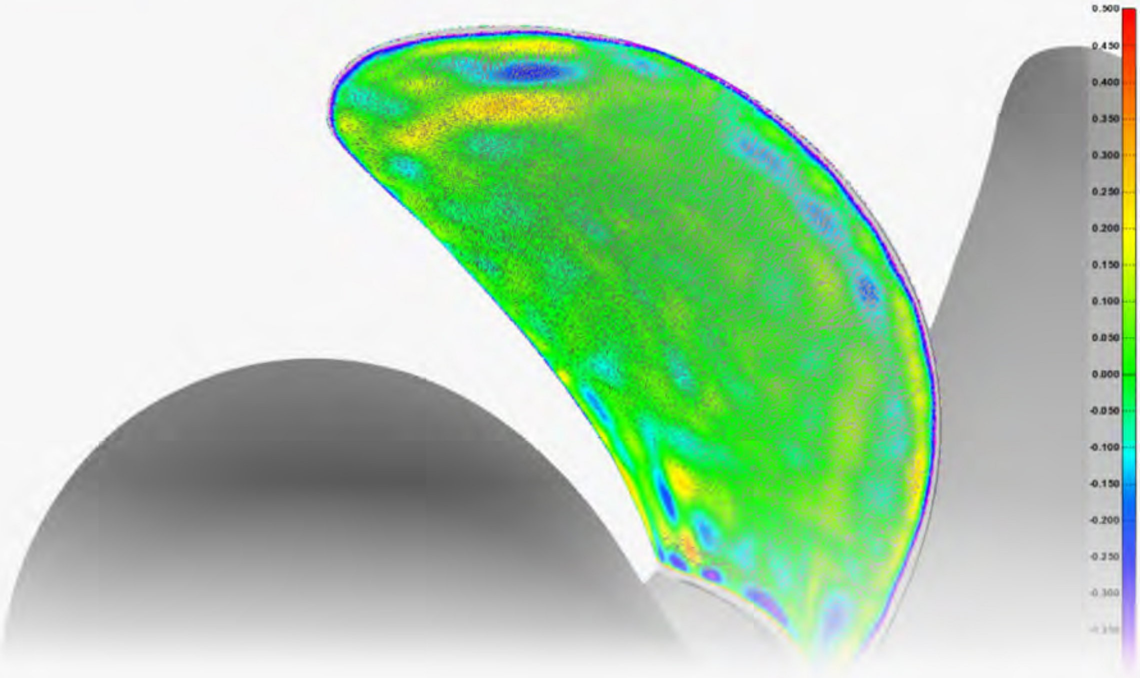

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2 Inspection

Aircraft must be inspected on a regular schedule to detect potential issues and help prevent catastrophic failures that would endanger lives. These inspection processes rely on capturing precise information about parts and assemblies very efficiently.

The challenge of engine part inspection is the number of components involved that must meet safety standards, and the complexity of the entire engine. In these cases, 3D scanners help provide comprehensive information about multiple components very rapidly, delivering data sets that can be used to inspect engine parts for their entire lifecycle.

Inspecting aircraft wings is just as important because wings deform under load whenever an aircraft is in flight. These deformations can significantly affect the aircraft's performance and are extremely challenging to inspect using conventional methods. Using 3D scanning, inspection teams can easily generate an accurate picture of the wings. Specifically, teams can use long-range and handheld scanners to capture precise wing data. This data can be compared to a CAD model of the wing or a previous scan of a 'gold standard' wing. The resulting comparison can be used to generate a detailed deviation map that shows the extent of all deformation.

Of course, 3D scanning can also be used to streamline the inspection of parts manufactured via reverse engineering. After a part is made from a CAD model generated by 3D scanning, the same scan data can be used to inspect the part over time to detect wear and other issues.

3 Development of new parts

Aerospace manufacturers are continuously attempting to improve aircraft designs to generate better fuel efficiency, performance and safety. These efforts rely on the development of new parts, and in many cases 3D scanning is helping to make the process faster and more cost-efficient.

In situations where the design objective is to enhance the performance of an existing part, engineers may prefer to start with a 3D scan of that part in its actual operating environment rather than create a completely new CAD file or the original CAD file of the part. This is a similar application to reverse engineering, but the intent is to adapt the current design to meet new performance specifications rather than to remanufacture the original part. Starting with a parametric CAD model based on a highly accurate 3D scan also allows engineers to better understand the current part's actual working relationships with other parts in the system or assembly.

Manufacturers may also need to design a new part to fit within an existing design envelope. Generating a 3D scan of the area helps engineers better understand the exact dimensions of the area as well as the constraints that affect where and how the new part will be incorporated.

For completely new aircraft designs, 3D scanning can play a role in the initial concepting phase by quickly capturing 3D data of physical models or workpieces. This data can be used to jump start the process of creating the initial 3D model.

4 Scan-to-print

Finally, aerospace manufacturers can use 3D scanning to accelerate 3D printing applications. Additive manufacturing, or 3D printing, can be used to quickly manufacture prototypes of new parts and design concepts. Typically, manufacturers would need to create a CAD model of these concepts before printing. But with 3D scanning, engineers can quickly scan a physical object and create a 3D CAD model that is suitable for immediate printing.

The critical role of 3D scanning software

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It is important to note that 3D scanning involves two kinds of technology: **the scanners** that capture the scan data and the **scanning software** that converts the scan data into a usable format for CAD modeling, CNC milling or 3D printing. Both are equally necessary to make these applications viable. The most common application of scanning software is converting the mesh data of a 3D scan into a parametric CAD model suitable for further analysis or manufacturing.

Scanning software offers other advantages as well. For example, say that a design team is reverse engineering a helicopter blade and has scanned the data from an existing part. In some cases, there is no way to know if the scanned blade is the best or worst product of its kind. If the blade is very worn, how can this wear be removed from the resulting CAD model? **Scanning software enables this by using scan data from multiple parts, overlaying them and finding the average values of tolerances, defects and errors in order to get as close as possible to the original design intent.**

Applications in the industry 5

Advanced Composite Structures leverage cutting-edge 3D scanning technology to **digitize** helicopter blades

Feature-based model derived from scan data plays a pivotal role in creating drawings and manufacturing replacement parts for the blades.

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NEXT-GEN **DESIGN**

& MANUFACTURING

SOLUTIONS

Retrofitting Dassault Falcon 10 aircraft **without CAD data**

The Falcon 10 ceased production in 1989, so the original CAD data (if it ever existed) was not available.

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Nexair Avionics **upgrades instrument panels** for existing aircraft to incorporate latest digital instrumentation

A glove box was required for a Cirrus SR22 aircraft, but with the part no longer available from the manufacturer, 3D scanning was called up to solve the challenge.

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Scanning & 3D Modeling **a Carbon Fiber Drone Blade**

By employing 3D scanning technology for this application, engineers can develop required 3D CAD models faster and more accurately than with traditional methods.

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