#**HandsOn**Metrology

ZEISS

Reverse engineering of large, heavy-duty metal parts

This application report covers the reverse engineering process of a heavy-duty gripper arm using ZEISS T-SCAN hawk 2 and ZEISS REVERSE ENGINEERING (ZRE). The central task is to recreate the legacy part of the gripper arm.

3D scanning for maintenance, repair and overhaul

When critical heavy-duty equipment needs repair, but original CAD data is missing, 3D scanning and reverse engineering close the gap. With the portable T-SCAN hawk 2, MRO teams capture worn parts quickly and accurately directly on-site – even on large, contaminated parts.

ZEISS REVERSE ENGINEERING then transforms the scan data into robust, idealized CAD models, ready for manufacturing and future-proof documentation, helping to minimize downtime and extend asset life.

The application arises in a typical heavy metal industry context, such as steel production, forging, mining equipment manufacturing, or heavy machinery handling. In these industries, gripper arms are used to grab and move large, heavy components. They are constantly exposed to high static and dynamic loads, impacts, dirt, scale, oil, and other contaminants.

Over long periods of operation, these conditions lead to wear, deformation, and local damage. In this case, the gripper arm is so old that the original design data is not available anymore. However, the part must be reproduced to keep existing machinery operational and avoid costly downtime.

Reverse engineering is therefore the most efficient way to create a reliable digital model that can be used for manufacturing new parts.
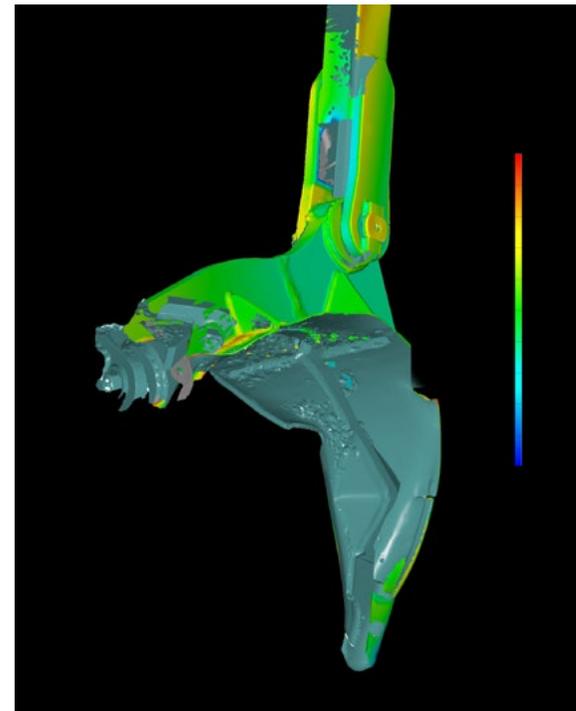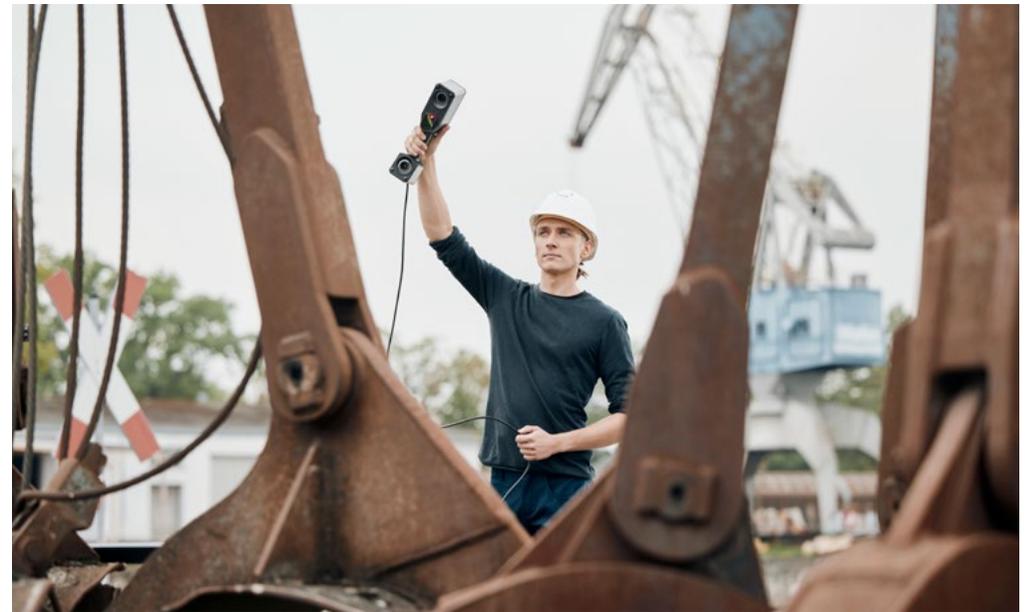
Executive introduction

Handheld 3D laser scanners
for on-site applications

ZEISS T-SCAN hawk 2 is chosen for this application because it combines portability, industrial robustness, and metrology-grade accuracy. One of the key features that matters here is satellite mode. It allows for an accurate scan of large parts. Gripper arms are elongated parts, often in the range of roughly 800 to 1200 millimeters per segment. Satellite mode enables the operator to move along the length of the gripper arm, scanning section by section, while the scanner maintains a stable, accurate scan. This is especially valuable in a workshop environment where it is not possible to bring the part to a dedicated metrology lab.

Another important feature is the button workflow on T-SCAN hawk 2. The scanner includes a multi-button interface that allows the operator to trigger scanning, pause, and switch modes directly on the system. Combined with the guided workflow in ZEISS INSPECT, this makes the system easy to use even for operators who are not metrology experts. In a heavy metal industry setting, where staff often must work quickly and in demanding conditions, this intuitive operation significantly reduces training needs and minimizes user errors.

The scanner's large measuring volume also plays an important role. It allows the user to cover substantial areas of the gripper arm without constantly repositioning the system or adding large numbers of reference markers as it would be the case for optical tracked solutions.

Scanning preparations

The scanning procedure begins with basic preparation of the gripper arm segment. The part is typically manufactured from steel or cast steel and often shows signs of heavy use, such as worn edges, dents, corrosion or chipped corners. The surface is cleaned as necessary to remove loose dirt, scale and oil. No scanning spray is required because T-SCAN hawk 2 can handle most metallic surfaces without additional treatment.

Magnetic reference cubes are then distributed along the length of the gripper arm. These cubes can be quickly attached to and removed from the steel surface of the gripper arm. Because they are magnetic, they do not require adhesive and can be repositioned easily as the scanning progresses. This is advantageous on rough or oily surfaces where adhesive markers might fail. The result is a flexible and very fast setup compared to many traditional measurement methods.

Having used satellite mode to capture the reference points, they now provide a stable reference geometry that the scanner uses to maintain its spatial tracking. To start the scanning process for this gripper arm, ZEISS T-SCAN hawk 2 gets calibrated for the extended measurement volume. This feature allows to keep the number of cubes at a minimum while capturing the big part even faster with the highest accuracy possible.
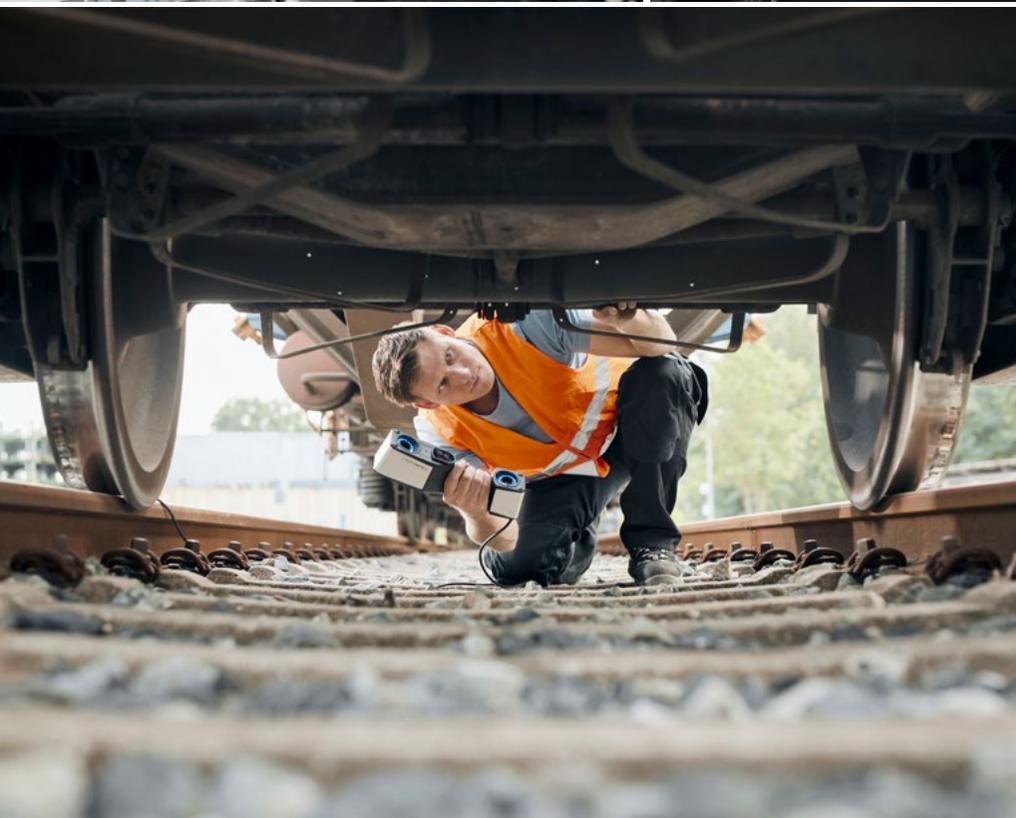
Dimensions – scanning

big

parts

The operator starts with a global scan of the accessible surfaces, following the outer contours of the gripper arm segment. In this pass, the scanner captures the overall shape, including the main body, gripping surfaces, and interfaces. After this initial coverage, the operator focuses on critical regions, such as functional faces, mounting interfaces, holes, bores, and any surfaces that are essential for fit and load transfer. In these areas, the scanner may be run with a higher resolution setting to ensure that fine details are captured accurately. The damaged regions are also scanned carefully, even though they will be corrected later in software. Capturing their true condition is important for understanding the extent of wear and for making informed decisions in the reverse engineering stage.

Once scanning is done, the software uses the reference points to merge the scans into a coherent dataset.
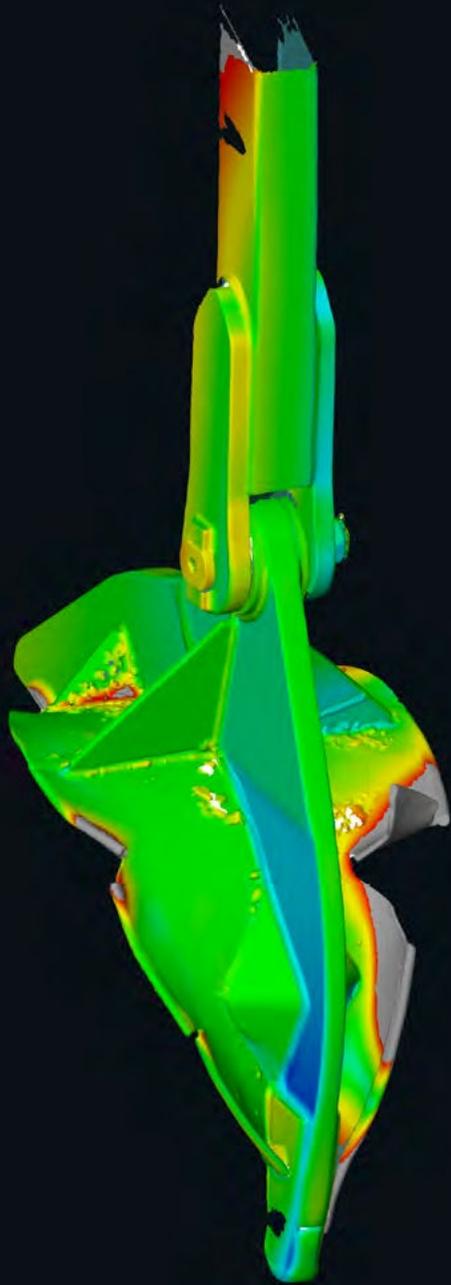
3D data – the base for reverse engineering

Once the scanning is complete, the data is processed in ZEISS INSPECT. The first step is to clean the raw scan data. If there are small holes in non-critical areas caused by shadowing effects, the software can be used to fill them, although care is taken not to modify critical functional regions at this stage. The individual scan patches from different orientations are checked to ensure correct alignment and registration, which is usually already handled robustly by the tracking based on the reference points.

A global coordinate system is then established. For example, a main plane on the gripper arm may define the base plane, and the axis of a central bore may define the primary axis. This alignment is important, because downstream CAD and manufacturing processes rely on a meaningful coordinate system that corresponds to how the part is mounted or assembled in the machine.

The mesh is then optimized automatically by the software, using smoothing and polygon reduction methods where appropriate, but with specific focus on preserving sharp edges and important geometric features. The goal is to produce a well-structured mesh that is ideal for reverse engineering.

Reverse engineering
of legacy parts

This optimized mesh is exported directly from ZEISS INSPECT to ZEISS REVERSE ENGINEERING (ZRE). The seamless transfer avoids compatibility problems and ensures that the high quality of the scan is preserved. Inside ZRE, the reverse engineering process begins with affirming that the global coordinate system is in the proper place. The mesh is then segmented into logical geometric regions. Planar areas, cylindrical features, conical surfaces, and freeform regions are identified.
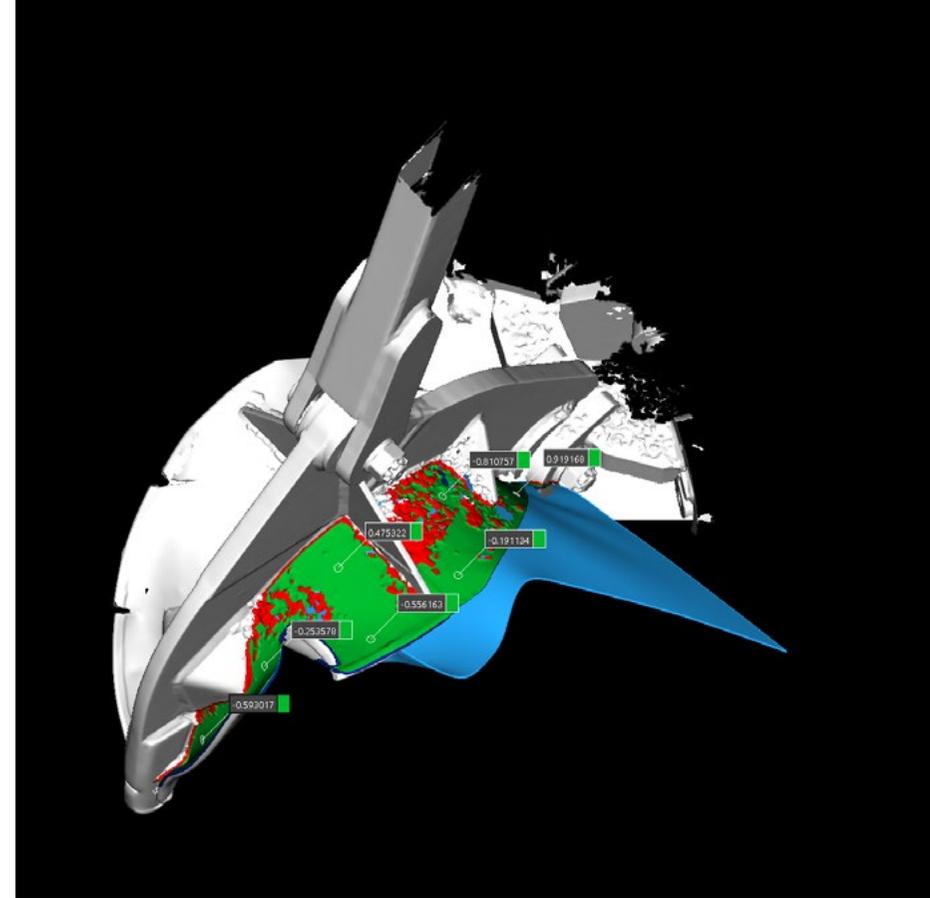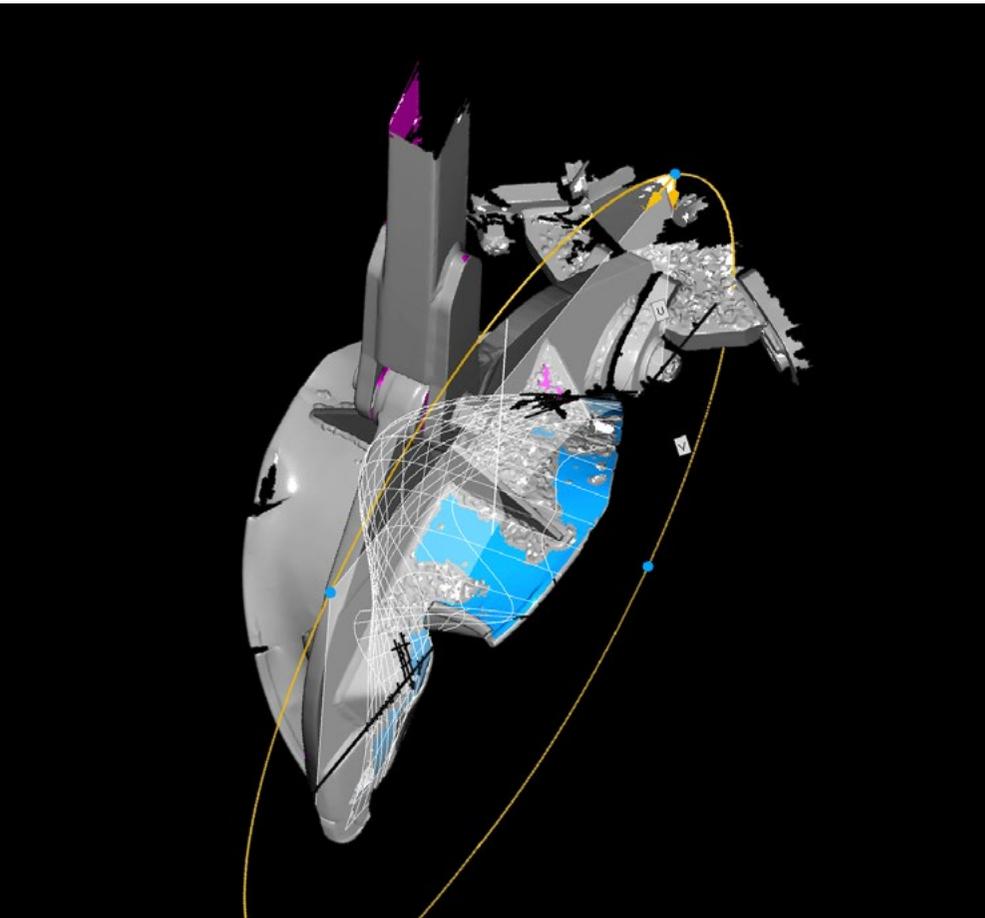

At this point, the condition of the part becomes particularly important. The gripper arm is heavily damaged, so the scanned geometry does not represent the ideal original design. Therefore, the task in ZRE is not merely to fit surfaces to the mesh, but to reconstruct the original design intent and to correct for wear and damage. The operator uses the sketching tools in ZRE to create cross sections and sketches directly on and through the scanned mesh. These sketches capture the approximate shape but are then adjusted to produce idealized geometry. Bent areas, dented surfaces or chipped edges are corrected by redrawing curves and surfaces so that they meet engineering expectations for strength, clearance and function.

Symmetry and constraints are applied wherever possible. Many gripper designs are symmetrical about certain planes or axes. ZRE allows these symmetries to be explicitly enforced. Dimensional constraints, such as nominal diameters for fits or standard stock thicknesses, can be incorporated into the sketches. This combination of scan-based reference and parametric correction makes it possible to derive an idealized CAD model that is both true to the original intent and suitable for manufacturing.

From these sketches and reference curves, surfaces are generated and then converted into solid bodies. The goal is to obtain a fully closed solid model of one gripper arm segment. Once this is available, the operator adds details such as fillets and chamfers. These are important both for functional reasons, such as stress distribution and ease of manufacturing, as well as for matching the original part design. ZRE allows fillets and chamfers to be added with defined radii and angles.

The gripper arm in this case is symmetrical around a central axis, and the complete assembly consists of several identical segments arranged around that axis. Instead of reverse engineering each segment individually, only one segment is fully modeled and refined. ZRE then allows this segment to be copied and rotated around the central axis to form the full gripper assembly. The operator specifies the number of identical segments and the angular spacing between them. This method produces perfect symmetry and significantly reduces the time and effort required.

Before the CAD model is finalized, it is verified against the original scan. The idealized CAD is overlaid with the mesh, and deviation plots or sectional comparisons are used to check how the new geometry relates to the scanned data. This step confirms that the corrections applied in the reverse engineering process are appropriate, and that critical functional areas still align with the real-world constraints of the machinery. If deviations are too large in important zones, local adjustments can be made.
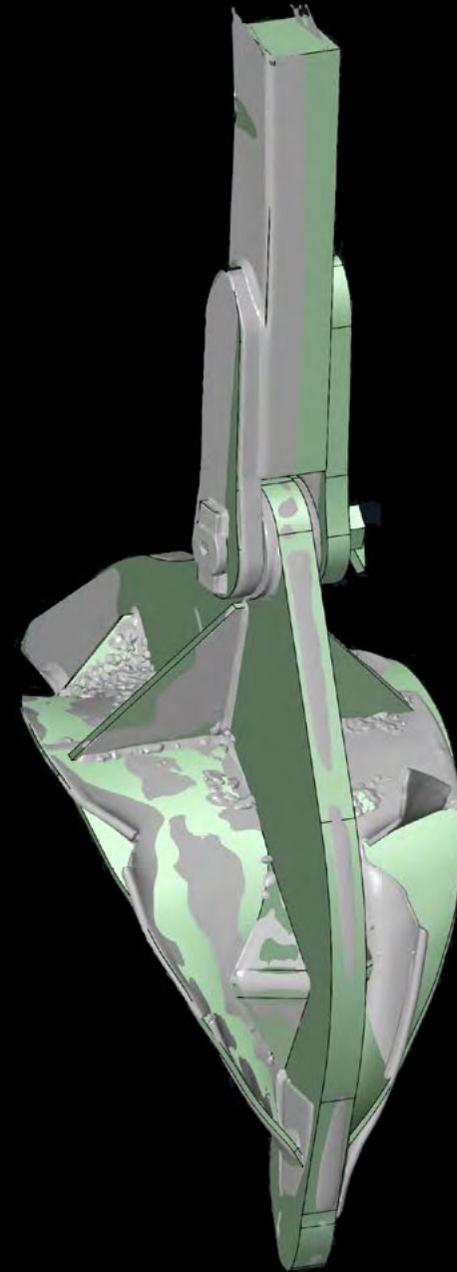
Reverse engineering completed

The result is a clean CAD model of the gripper arm segment and, if needed, the entire gripper assembly. This model can be exported in common formats such as STEP or IGES. From there, it can be used to create manufacturing drawings, to generate CNC machining programs or casting tooling, and to run simulations such as finite element analysis. The company now has a digital twin of a part that previously existed only as a worn physical component, thereby preventing the loss of design data in the future.

In this case, no additional ZEISS INSPECT apps were required. The workflow was carried entirely by the core functions of ZEISS INSPECT for scanning and mesh preparation and ZEISS REVERSE ENGINEERING for modeling. This shows that even without specialized apps, the combination of T-SCAN hawk 2 and ZRE provides a complete solution for complex reverse engineering tasks.
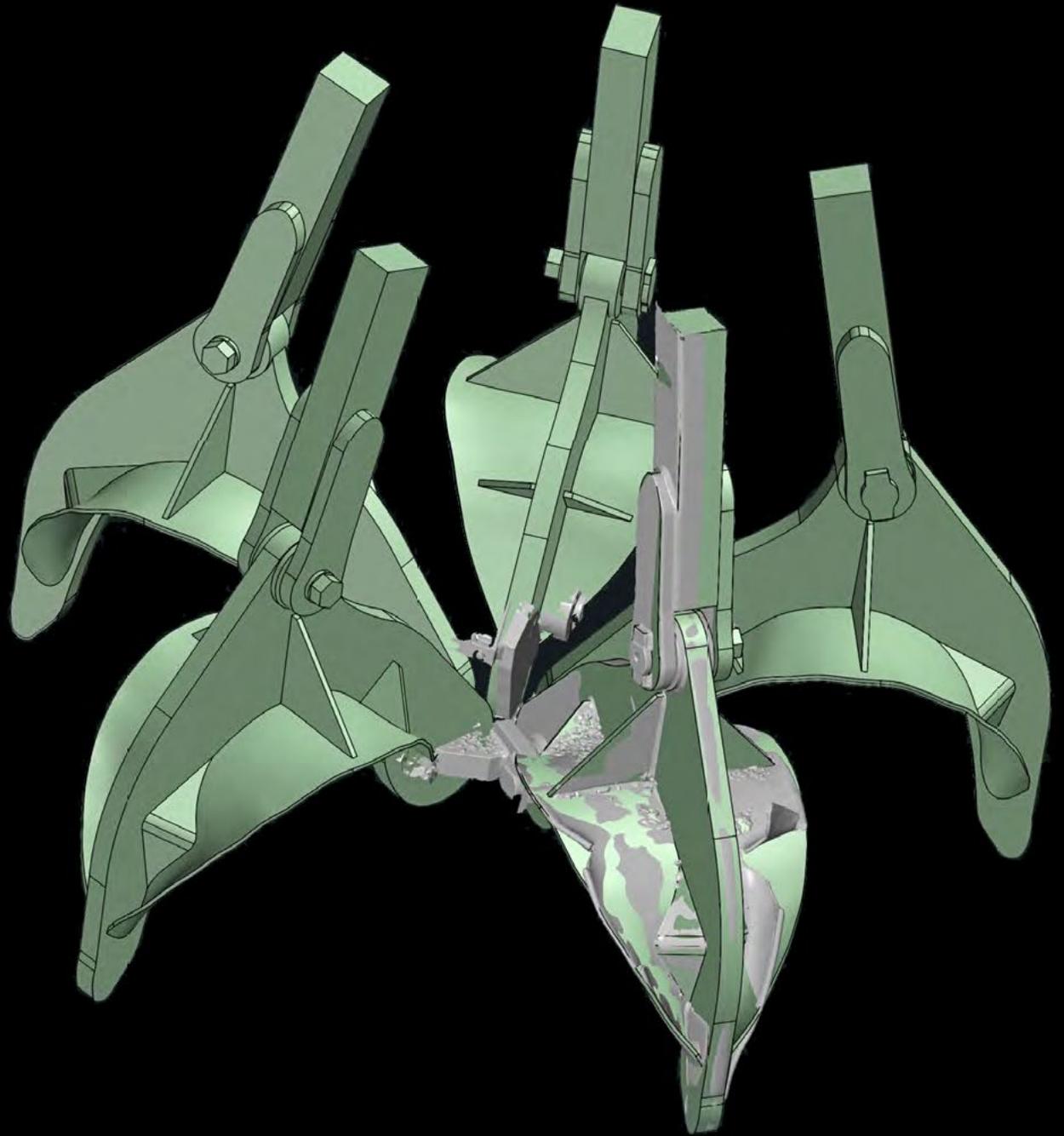
Application recap

Overall, the use of T-SCAN hawk 2 and
ZEISS REVERSE ENGINEERING in this application
offers substantial benefits for the heavy industry.
The portable scanner can be used directly in the
production environment, without complicated
setup or sensitivity to line-of-sight issues.
The guided button workflow makes scanning
accessible to new users. Satellite mode allows
long heavy components to be digitized accurately
and quickly. In the software, the ability to
correct damaged geometry, respect symmetry,
and recreate design intent results in a robust,
manufacturing-ready CAD model. This approach
reduces downtime, avoids manual measuring
errors, and ensures that critical legacy components
can be reproduced reliably even when original
technical documentation is no longer available.

ZEISS T-SCAN hawk 2
The tool to get about anything done

Getting started is easy
Capture high precision data in no time. See how to do a fast one-shot recalibration of the sensor – and find out everything else that makes T-SCAN hawk 2 so easy to use with our Getting Started sessions.

Operate with a push of a button
T-SCAN hawk 2 features four buttons to start and navigate your workflow directly. No need to operate the software separately on your laptop.

Switching between different tasks
T-SCAN hawk 2 features seamless adjustments for resolution and field of view. Whether small parts, fine details, larger objects or deep pockets, confined spaces or hard-to-reach areas, this 3D laser scanner does the job.

Strong on dark and shiny surfaces
T-SCAN hawk 2 supports scanning on a wide range of materials and surfaces, delivering 3D measurement data with the highest precision.

Techical data

ZEISS T-SCAN hawk 2

High-speed scanning	Included (multiple blue laser crosses)
Deep pockets	Included (single blue laser line)
Flexible depth of field	Included (on-object distance radar)
Detailed scan	Included
One-shot sensor recalibration	Included (Hyperscale)
Large parts	Supported (Satellite mode, no coded targets required)
Extended measurement volume	Supported
Carbon-fibre lengths standards	Certified (DAkks / ILAC) [1]
Volumetric accuracy	0.02mm + 0.015mm/m [2]
Laser class (IEC 60825-1:2014)	Class 2 (eye-safe)
Weight	< 1kg
Cable	10m (ultra-light)
Software	ZEISS QUALITY SUITE / ZEISS INSPECT
Full remote workflow	Supported

(1) D-K-21312-01-00 according to DIN EN ISO/IEC17025:2018
(2) Acceptance Test based on ISO 10360

Versatile use cases

Automotive
3D laser scanners complement the automotive industry by accurately capturing detailed geometries to ensure high-quality standards. Their portability allows for efficient scanning on the production line and fast prototyping.

Design
With T-SCAN hawk 2 you easily digitize complex shapes and physical objects for design projects. The 3D model acts as a suitable base for product modifications, interior design tasks, and comprehensive 3D visualization.

Power & Energy
T-SCAN hawk 2 is ideal for the power and energy sector because it quickly captures intricate component details in compliance with industry standards. The portability allows efficient scanning on-site for comprehensive asset management.

Aerospace
The 3D laser scanner is used to perform safety-critical inspections on large aerospace structures to minimize downtime. The captured data makes identification of dents, bulges and wrinkles efficient and straight forward.

Experience ZEISS T-SCAN hawk 2

Handheld precision, developed and produced by ZEISS

The portable T-SCAN hawk 2 is the next-generation lightweight 3D laser scanner: With metrology-grade precision and remarkable ease of use, it's your powerful solution to get the scanning job done.

Do you want to find out more?
Get in touch with your local
#**HandsOn**Metrology partner