



Capaero

Extending
assembly service life



Meliad

Expertise &
technologies industrielles

Group Organisation



Capaero

Extending
assembly service life



Meliad

Expertise &
industrial technologies

Fatigue life enhancement

cold expansion

Expanded Bushing installation

Metallic and composite

Drilling composite panels

Compdrill device



Surface preparation
with Laser



Residual stresses
measurement

Main customers

BOMBARDIER

AIRBUS

APCO
TECHNOLOGIES

arianeGROUP

hemeria

MBDA

SAFRAN

STELIA

LEONARDO

ThalesAlenia
Space
a Thales / Leonardo company

AEROFLOT
Russian Airlines

Lufthansa Technik
More mobility for the world

S7 Technics

AIRFRANCE
INDUSTRIES

TURKISH TECHNIC

Ethiopian
የኢትዮጵያ

BOUYGUES
CONSTRUCTION
SERVICES NUCLÉAIRES

edf

framatome

NUVIA

NAVAL
GROUP

nexter

ONET
TECHNOLOGIES

orano

HUTCHINSON

MICHELIN
UNE MEILLEURE FAÇON D'AVANCER

RENAULT
La vie, avec passion

SKF



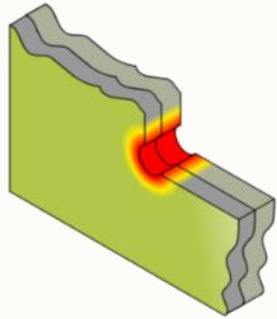
Capaero

General presentation

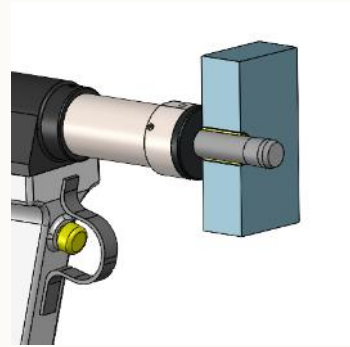


- Expansion technology and multi-material drilling
- Exclusive partner for GelSight : defect control & analysis

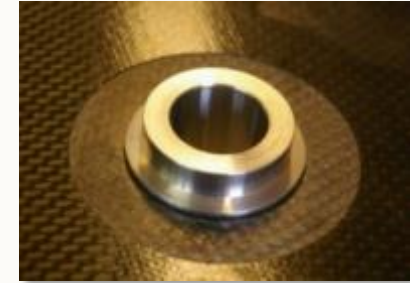
Fatigue life enhancement – Cold expansion



Metallic holes expansion
SplitSleeve – Split Mandrel



Bushing in metallic
Expanded Bushing – (EB)



Bushing in Composite
Expanded Bonded Bushing (EB²)

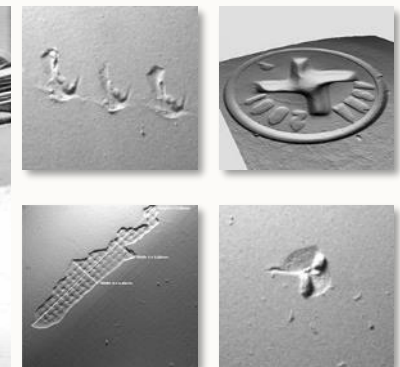
Composite drilling device



Drilling without delamination
CompDrill



GelSight

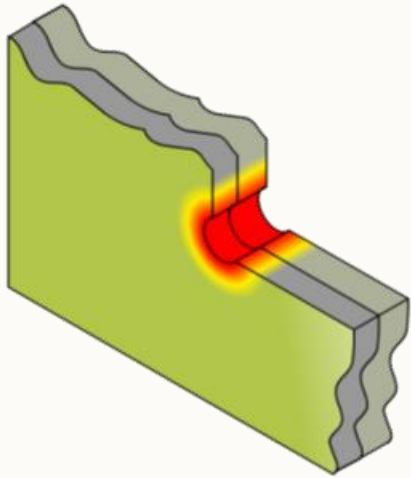


Cold expansion products

| Application | Process | | Metal | Composite |
|--|--|---|-------|-----------|
| Hole expansion <ul style="list-style-type: none"> Improved fatigue life Crack arrestor | Split Sleeve |  | X | |
| | Split Mandrel |  | X | |
| Hole drilling <ul style="list-style-type: none"> Avoid delamination | CompDRILL |  | X | X |
| Bushing installation <ul style="list-style-type: none"> Improved fatigue life High Push out & torque out resistance Quick installation | Expanded Bushing (<i>EB</i>) |  | X | |
| | Expanded Bonded Bushing (<i>EB</i> ²) |  | | X |



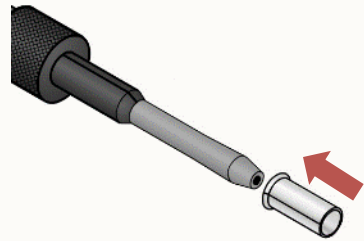
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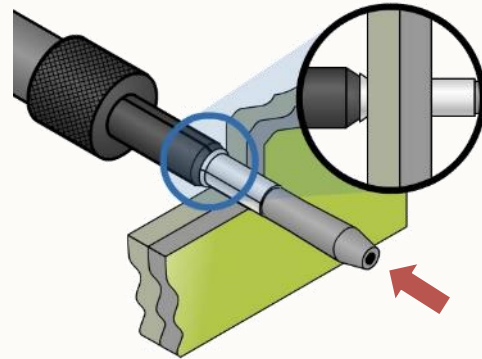
1. Hole expansion

Split Sleeve Process

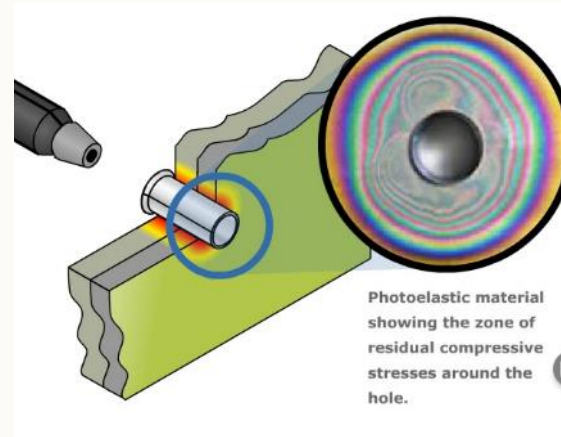
- Original license from a Boeing patent (1966)
- 100% interchangeable tooling with other coldworking suppliers



Slide the sleeve over the mandrel



Coldwork hole by drawing the mandrel back through the sleeve and hole.



Photoelastic material showing the zone of residual compressive stresses around the hole.

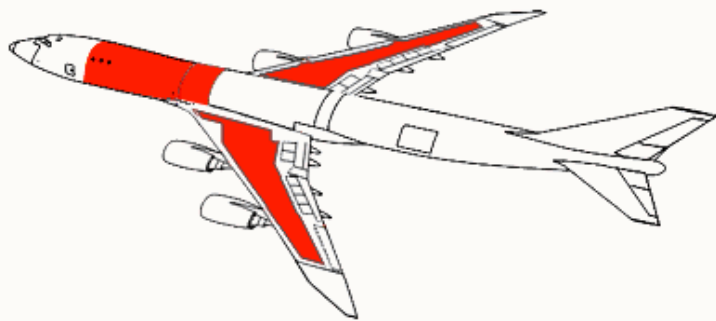
Remove used sleeve and discard.
The hole has been coldworked,



Split sleeve use

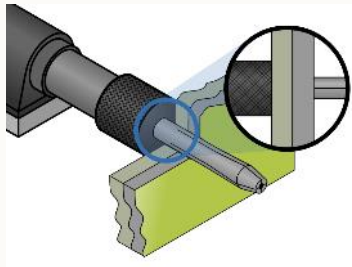
- Maintenance (SRM and SB)
 - MRO
 - Airlines
- Production
 - OEM
 - Supplier Tier-1 and Tier-2

BOMBARDIER

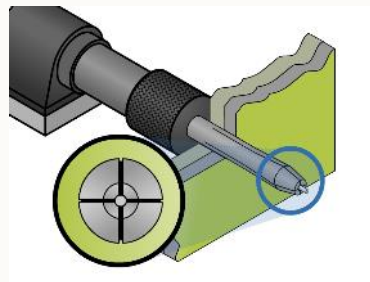


Split mandrel process

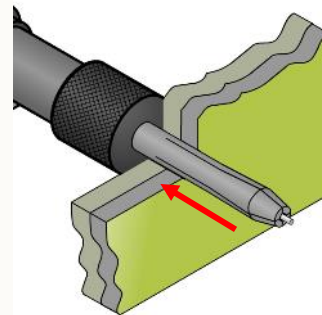
- Process without sleeve (no consumable)
- For Aluminium only



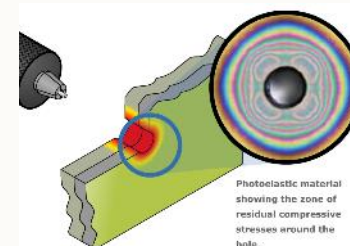
Start pass-thru of hole.
The hollow, split mandrel collapses.



Pass-thru is complete. Nosecap is placed flush to material. After depressing trigger, the pilot extends through center of hollow mandrel, which solidifies.



The hole diameter is expanded as the now solidified mandrel is pulled back through the material.

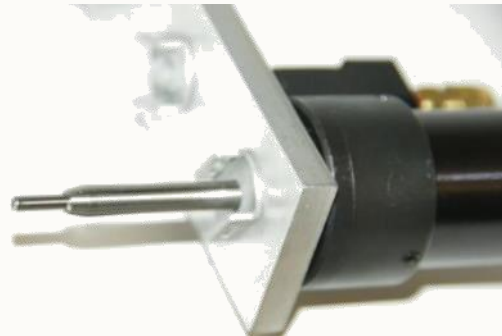


Photoelastic material showing the zone of residual compressive stresses around the hole.

With no sleeve to discard, the hole has been coldworked.

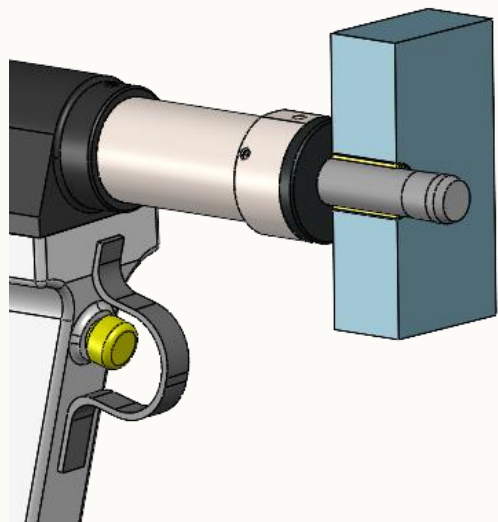
Split mandrel use

Manual or automated use in production





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2. Bushing installation

Expanded bushing (EB) in metallic part



Stainless steel bushing with
anti-fretting coating



Bronze alloy
bushing



Expanded Bonded bushings (EB²) in composite parts

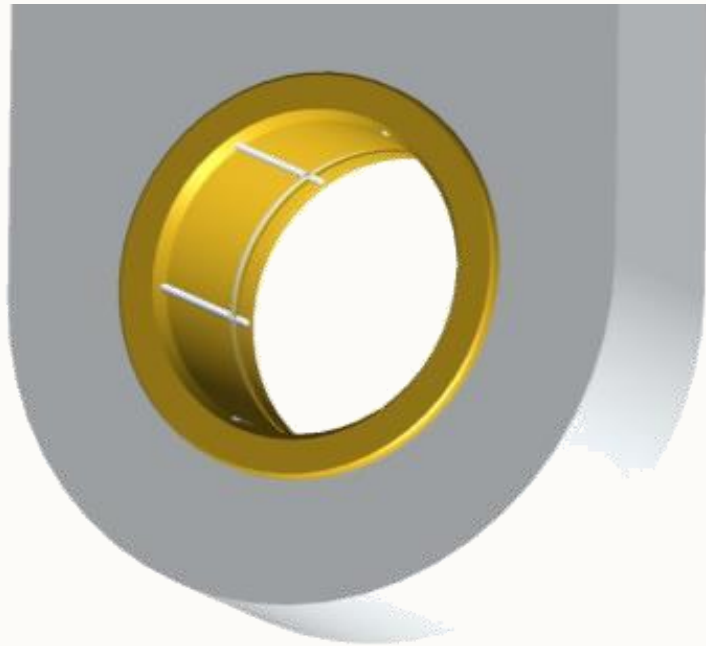


Straight version



Flanged version





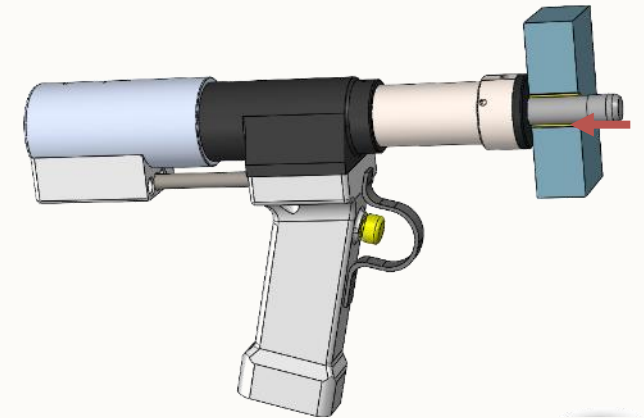
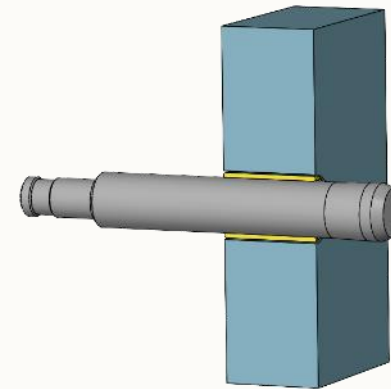
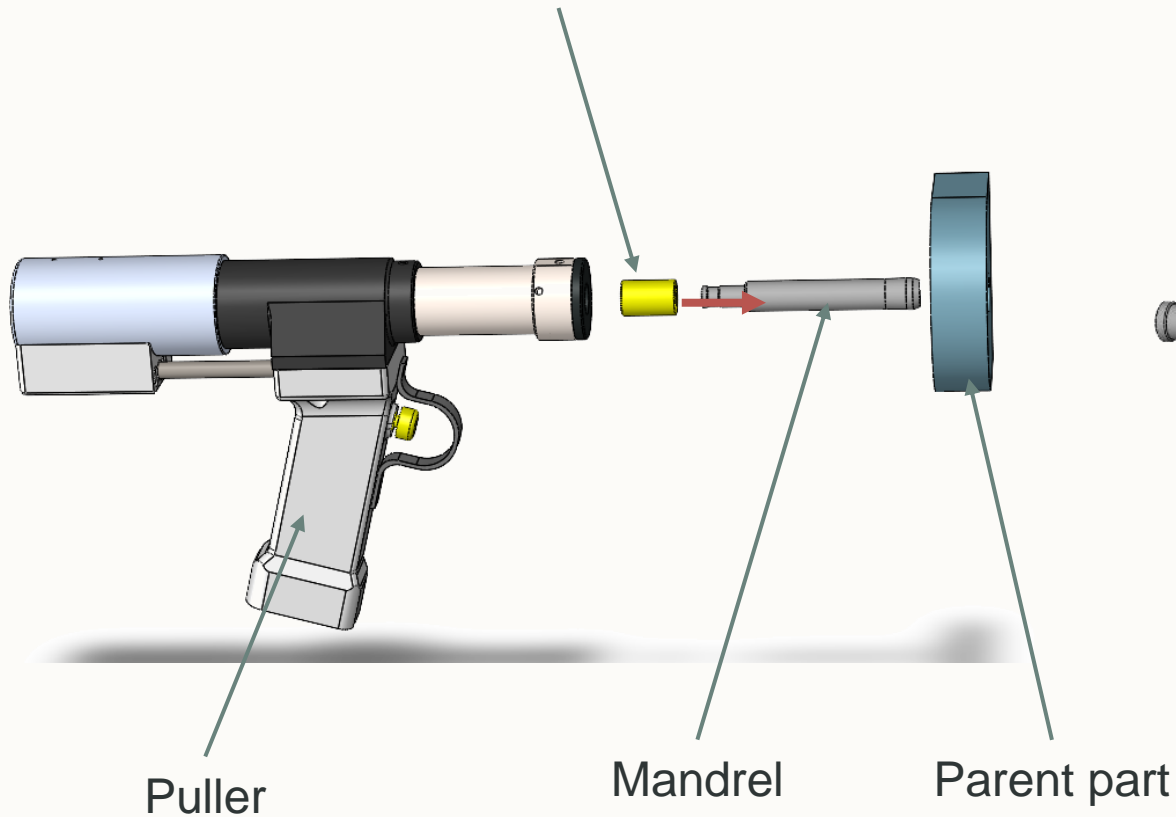
- **Bushing inside** : 4 mm → ~120 mm
- **Bushing geometry** :
 - Straight and flanged
 - Lube grooves and holes
- **Bushing material**: bronze, titanium, steel...
- **Parent material**: aluminum, steel, titanium...

EB : Expanded Bushing process

1. Slip the pre-lubricated bushing over the mandrel

2. Insert mandrel with bushing into the structure

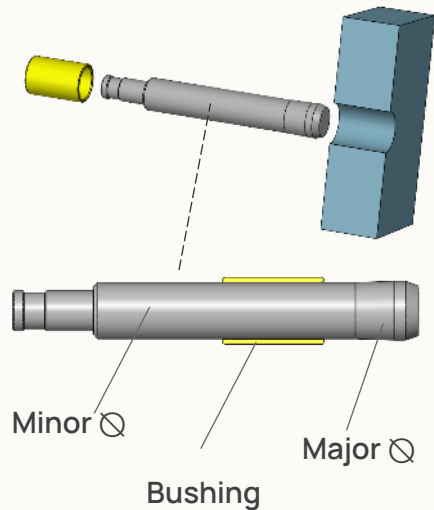
3. Chucks inside the puller can grab the mandrel and pull it



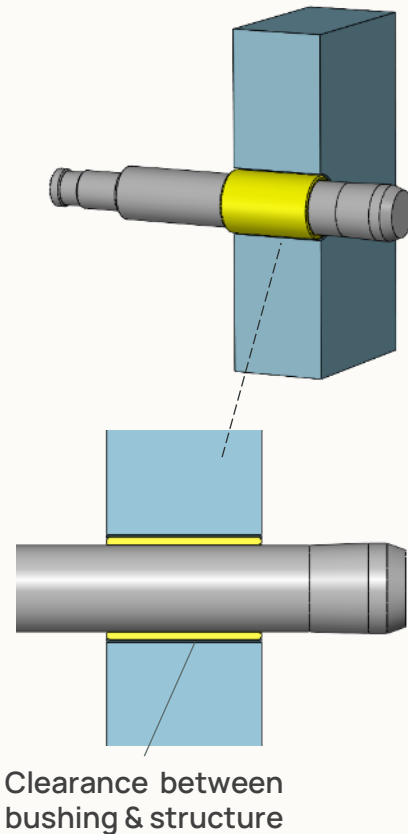
EB : Expanded Bushing process

Permanent metallic bushing in metallic parent material

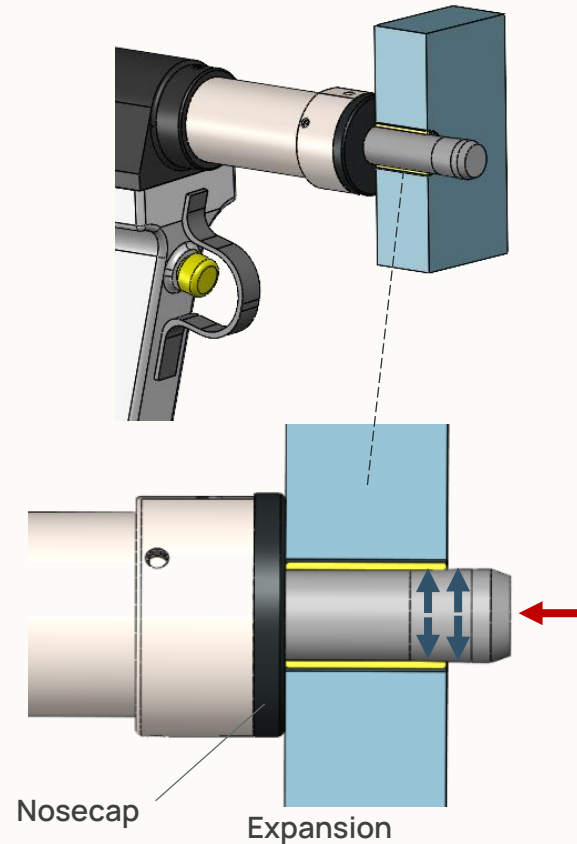
1. Slip the pre-lubricated bushing over the mandrel



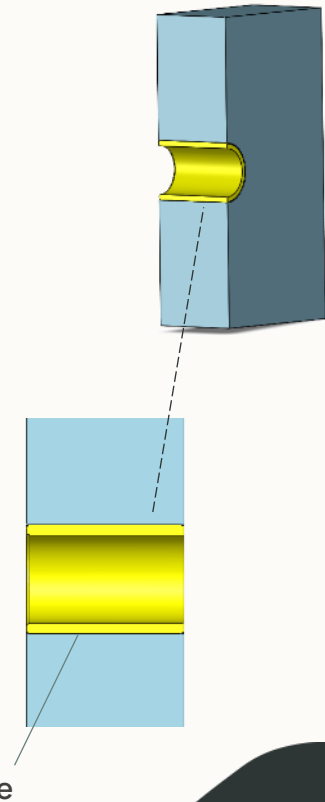
2. Insert mandrel with bushing into the structure



3. Place the puller against the structure and activate puller; bushing remains in the structure, axial movement is blocked by the nose cap



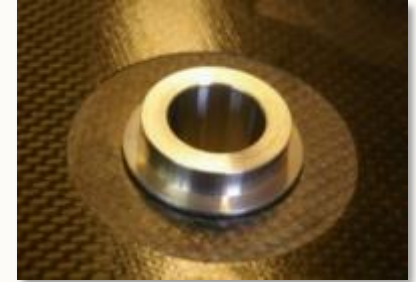
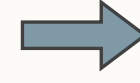
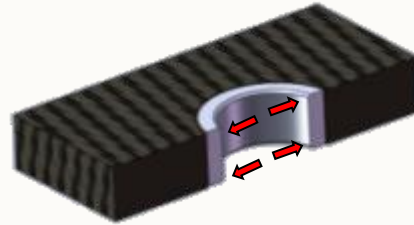
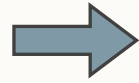
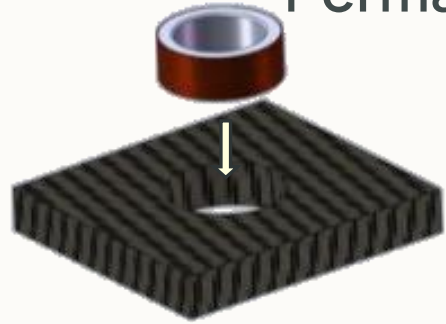
4. Ream bushing to required final diameter (optional)



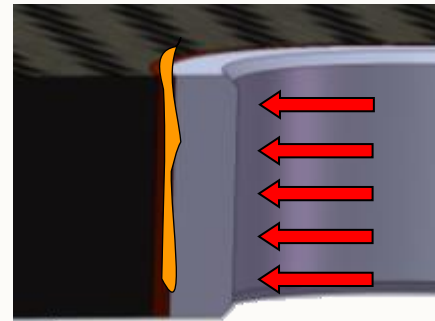
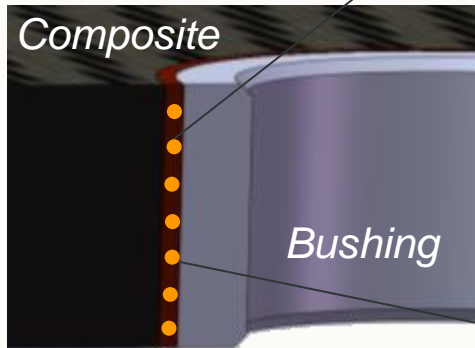
EB²: Expanded Bonded Bushing process



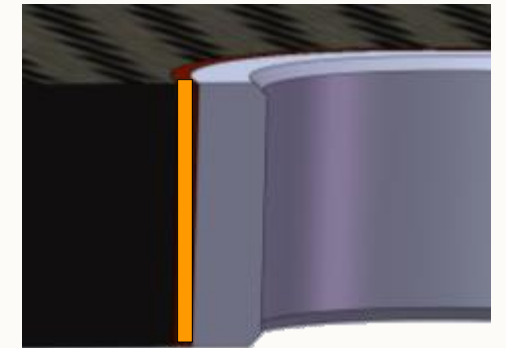
Permanent metallic bushing in composite parent material



Clearance



**Cold expansion
Process effect**



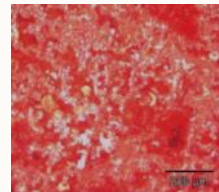
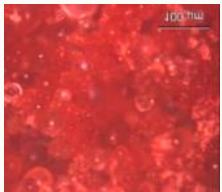
STEP 1: Micro-encapsulated adhesive precoated on the bushing



STEP 2: Mechanical interference breaks the micro-capsule



STEP 3: The polymerization is activated and bushing installed with interference



EB and EB² process benefits



Expanded bushing (EB)

- **Fast and One side Operation**

installation in a few seconds

- **Corrosion resistance**

Protective coating are not damaged by nitrogen

No condensation and trapped water

- **High Torque / Push-out resistance**

Greater than conventional methods, no running bushing in service

- **Installation safer and quicker**

No cryogenic fluid & more repeatable process



Expanded bonded bushing (EB²)

- Bushing is **bonded during manufacturing**

- **Fast and one side operation** Installation process is similar to expanded bushing in metallic parts



Expanded bushing (EB)

- **Improved Fatigue life (usually from x3 to x15 lifetime improvement minimum)**

Fatigue life superior to press or shrink fit installation

- **Corrosion resistance**

Protective coating are not damaged by nitrogen

No condensation and trapped water

- **Multiple and complex bushing geometry**

Expanded bonded bushing (EB²)

- **Higher load transfer in the assembly**

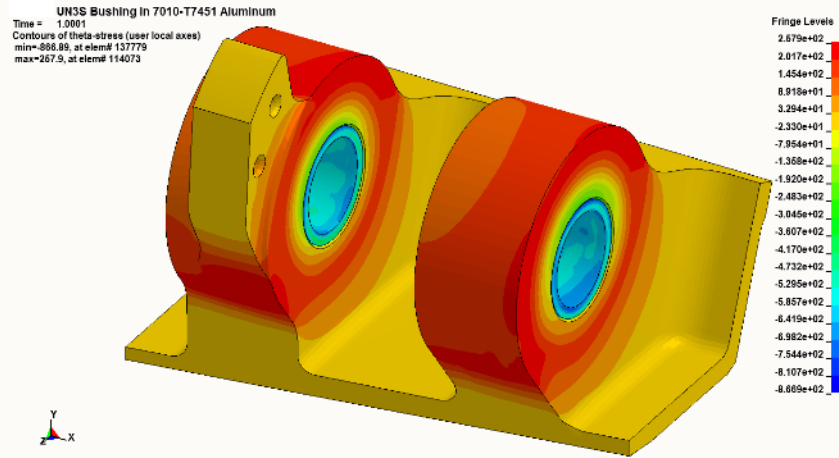
Break limit is significantly improved on static tests

- **Lighter assembly by assembling directly composite panels together**

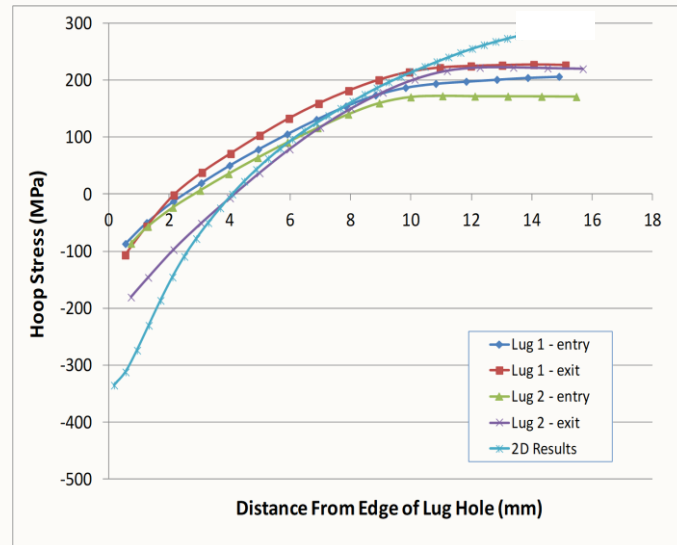
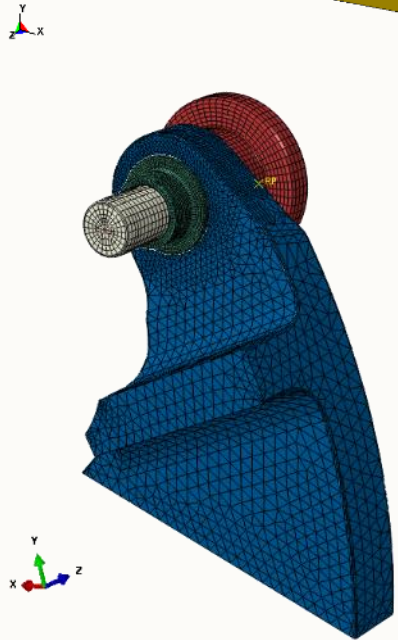
Metallic assembly parts can be removed

- **Reduced number of fasteners for the same mechanical performance**

Design & Calculation

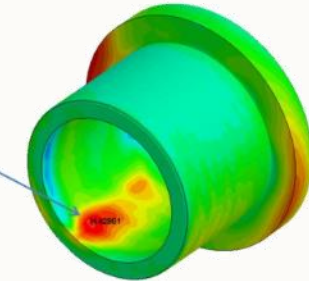


- 2D and 3D Analysis
- Report provided to the customer
 - Stresses view
 - Path plot
 - Focus on specific area
- Iterations to reach customer needs

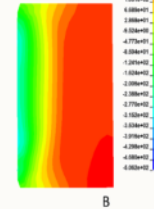
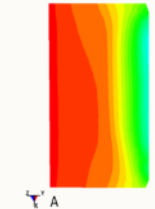


Contours of maximum principal stress

Max. principal stress = 1185 MPa
 $\sigma_{ult} = 1230 \text{ MPa}$

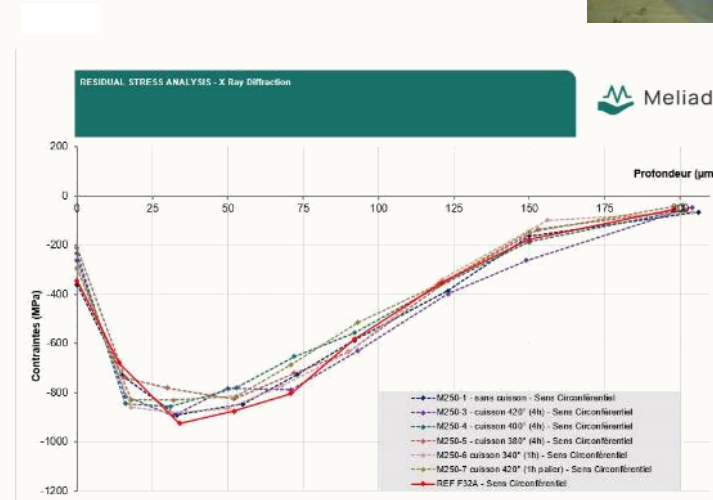
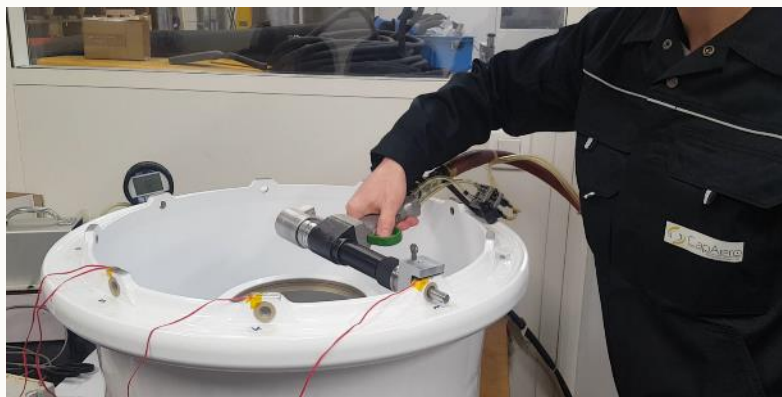
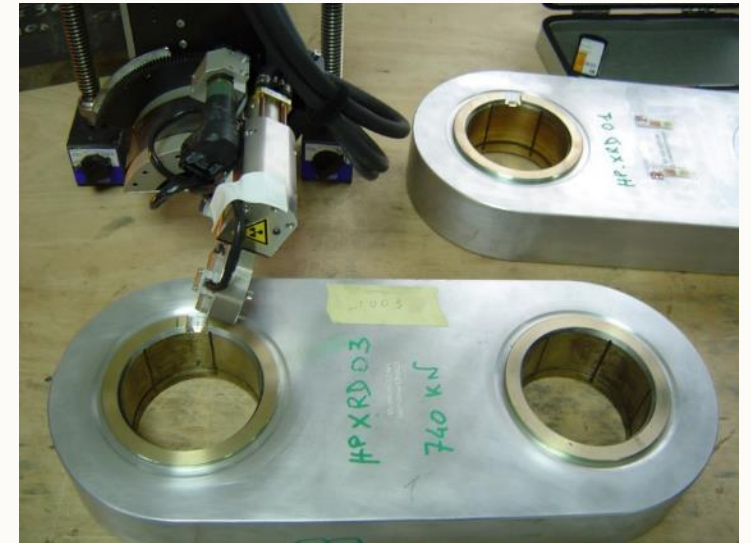


Alcorte UNSS Bushing in 7010-T7451 Aluminum
Time = 1.0001
Contours of theta-stress (user local axes)
min=-201.89, at elem# 110271
max=267.5, at elem# 114073



Tests in lab

- Tooling validation
- Geometrical deformation validation
 - Bushing internal diameter after expansion
 - Flange deformation (if applicable)
- Residual stresses measurement (optional)



Bushing manufacturing

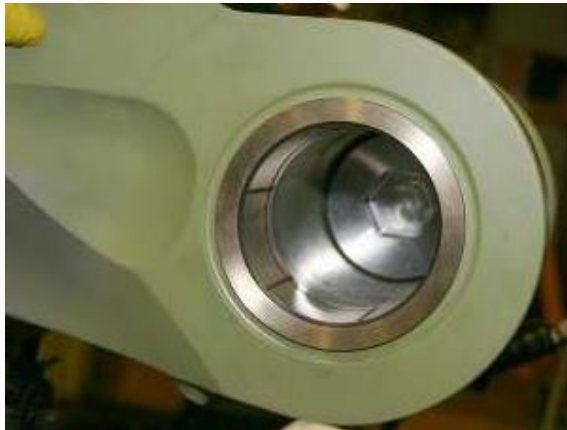
- Fully sourced and manufactured in France
- Free from Exportation license and regulations
- CAPAERO certificate of conformity delivered under EN9100 norm



Use cases

Landing gears and wheels

- A400M Landing gear (Around 120 mm diameter) - Flying
- A350 and B787 Wheels – Flying
- B777 Wheel : project in progress (in production 2021 or 2022)



Engines nacelles

- A318 Thrust reverser – Flying for 15 years



Helicopters (main rotor and tail rotors)

- T625 Helicopter, Tests in progress - with Browncoat
- Airbus Helicopter



Quality references

- EN 9100 certificate since 2018 under the scope :

Design and manufacture of Tooling, Bushings and fatigue life enhancement Engineering for the Aerospace Industry.



- Audited and qualified by customer for flying part supply





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3. Manual composite
drilling

A portable feed control drill for metallic/composite material

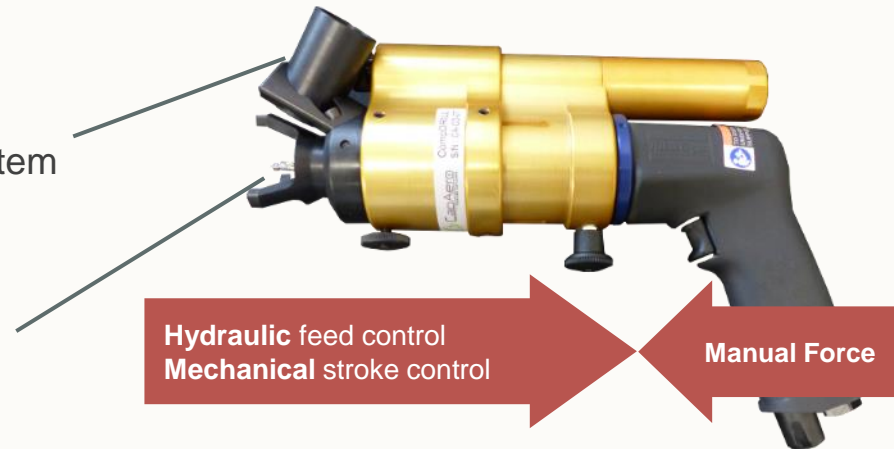


Drilling system

- Drilling machine
- Controlled feeding
- Vacuum attachment system



Specific Cutting tool



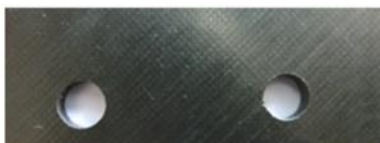
- Easy to use
- Very light system
- One side access
- Economic kit
- Drill hybrid stack up material
- Better alignment
- No backup plate

Without CAPAERO drilling kit



Delamination and Wide tolerances

With CAPAERO drilling kit



Delivered in kit with cutting tools





Capaero



4. GeISight

Available surface inspection methods are inadequate & reliant on human touch



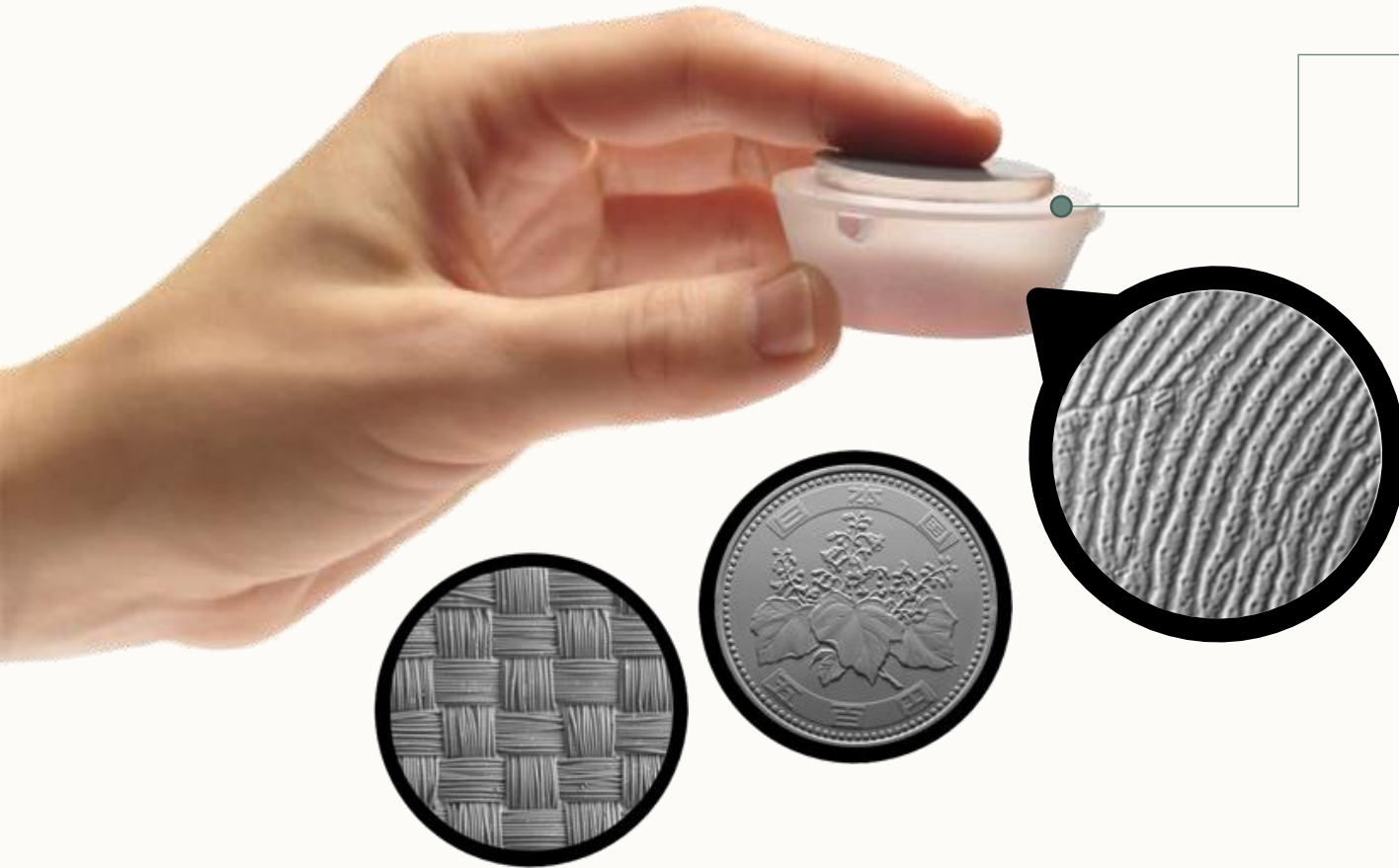
Current surface inspection methods in aerospace manufacturing & MRO have several deficiencies:

- Qualitative, not quantitative
- Not repeatable or traceable
- Time and human capital intensive
- Contribute to over-machining and scrapping parts

There are **no available sensors** that emulate the human touch; **soft** and **highly sensitive**.



GelSight is a soft, high-resolution tactile sensor similar to human skin

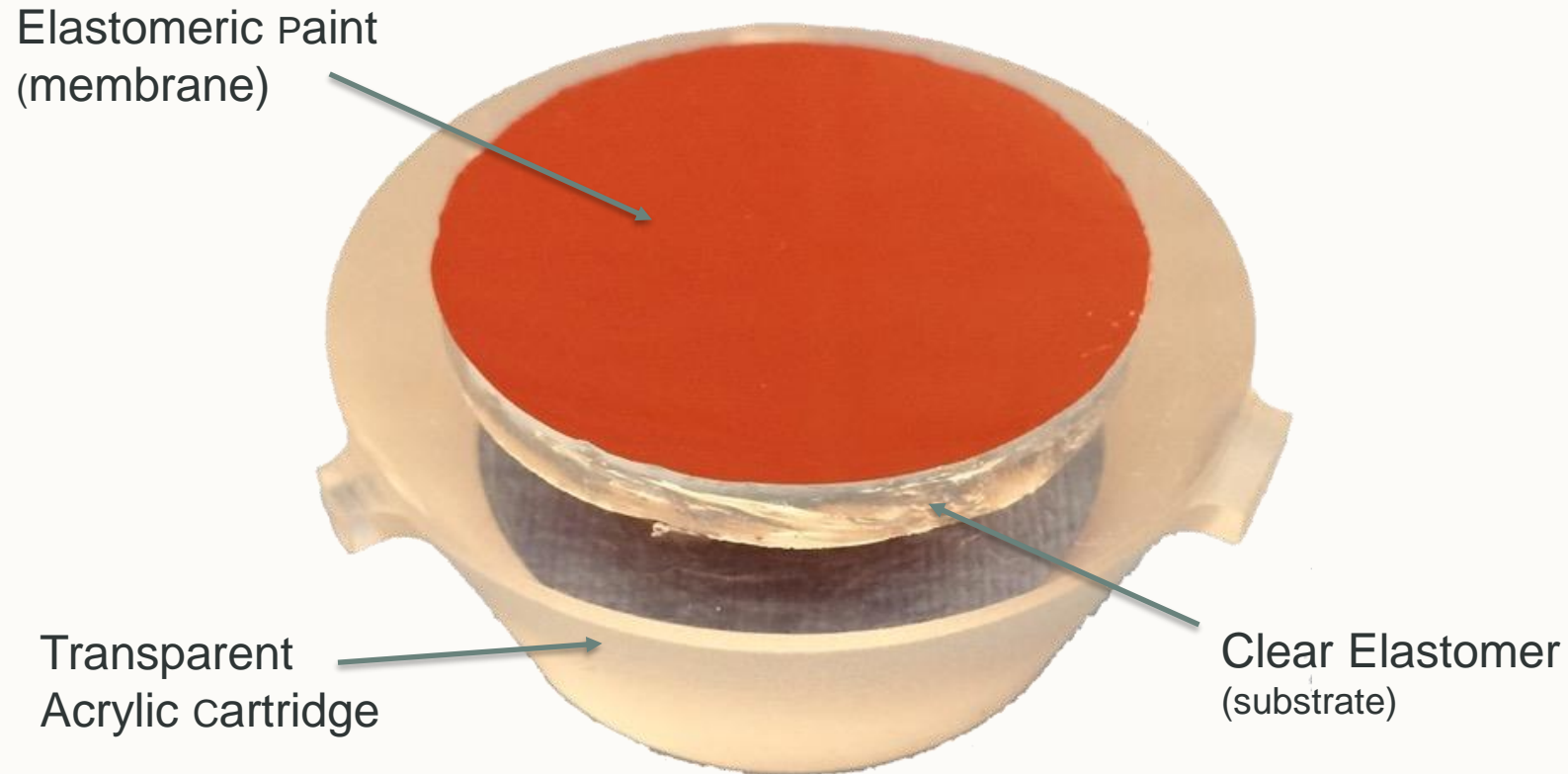


The intelligent sensor is a proprietary elastomeric platform that can be engineered to **conform to the shape** of any object on contact

Reveals detailed surface features **regardless of lighting conditions or material reflectivity**, e.g., specularly or translucency

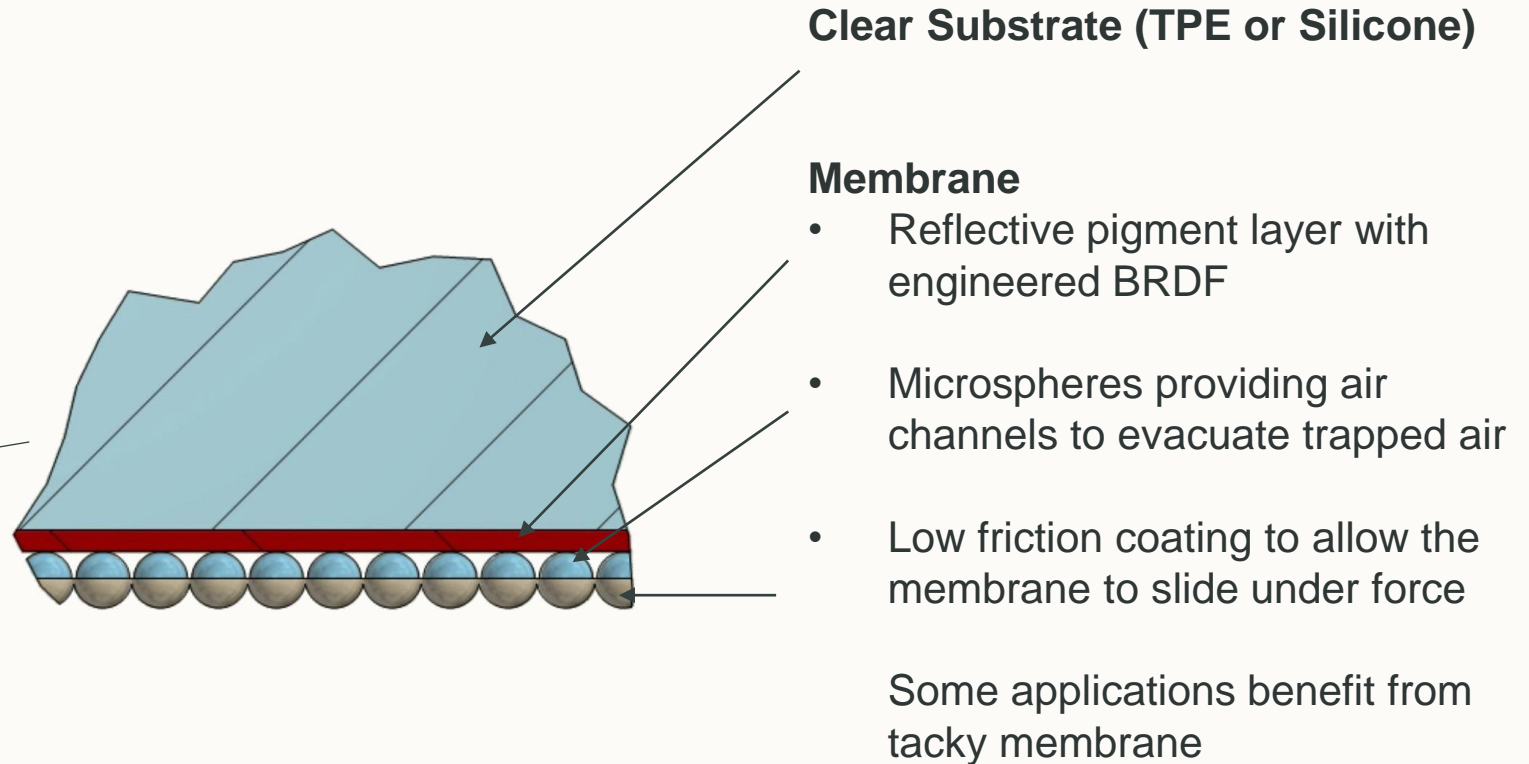
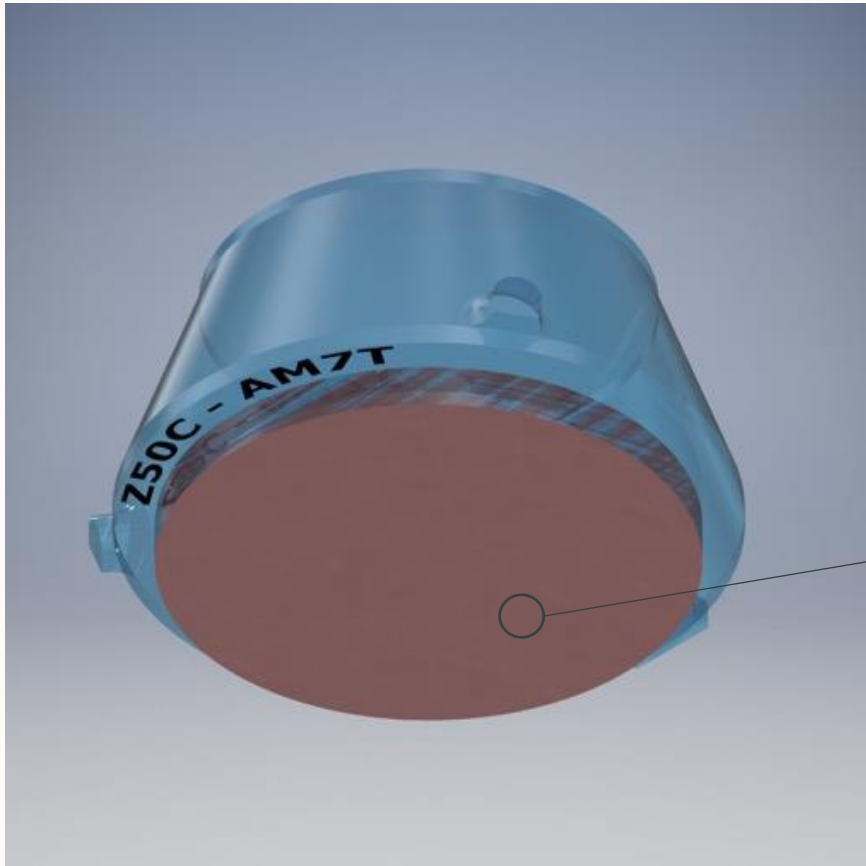
GelSight is *digital touch.*

How it works?

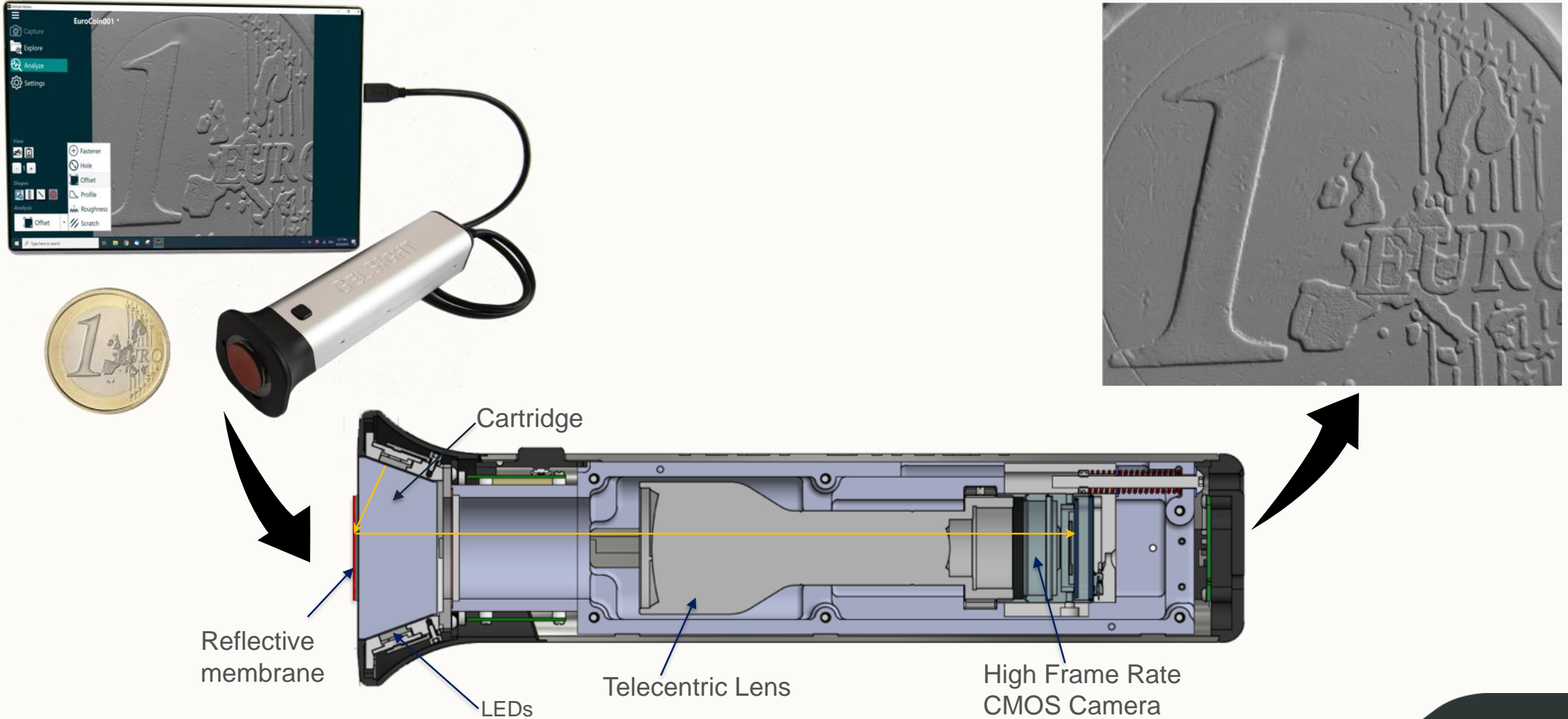


The Gel Cartridge

Addressing application specific challenges



How it works?



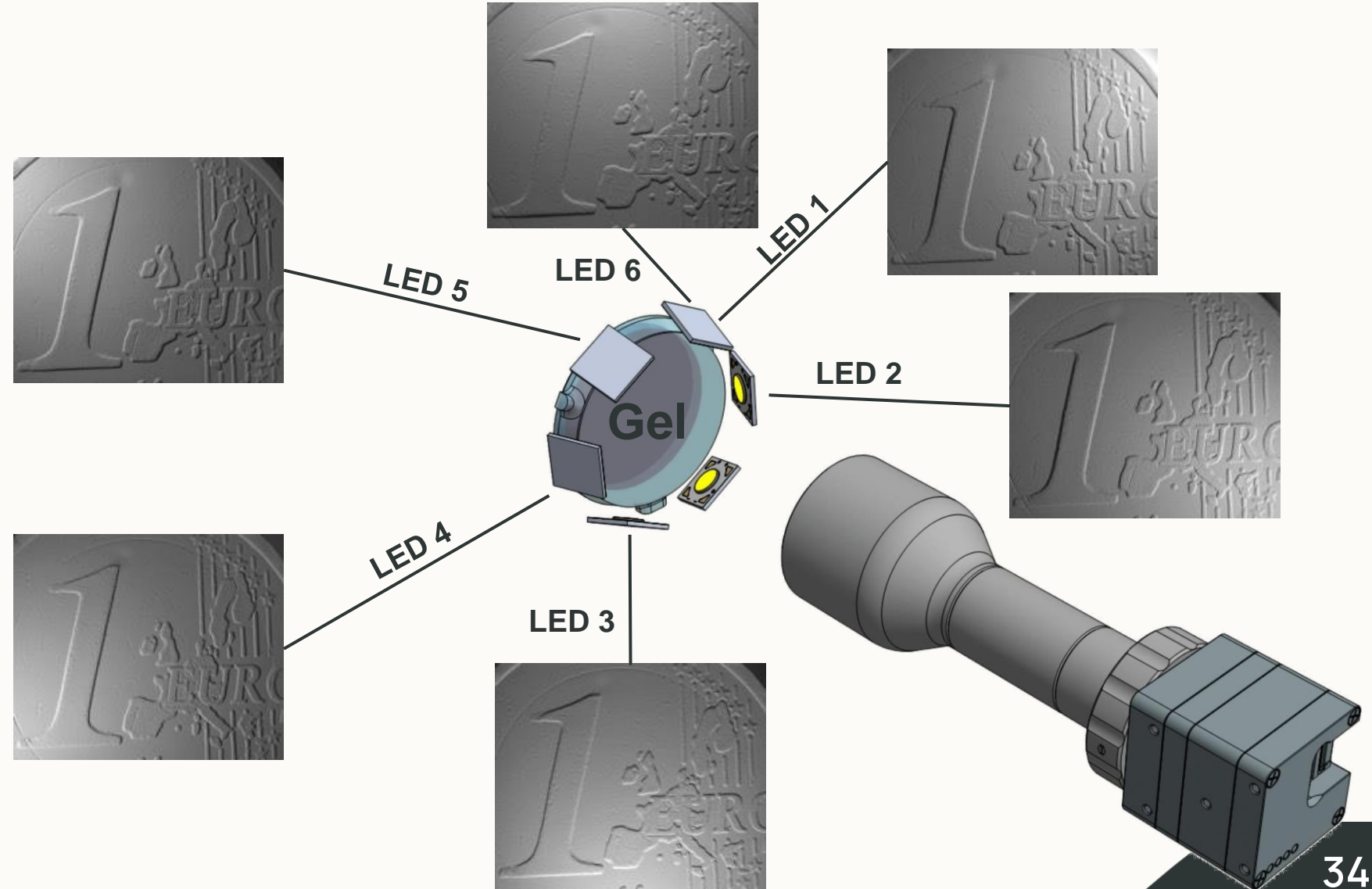
Based on Photometric Stereo

6 LEDs light up in turn

6 photos are taken in
100 milliseconds



For each photo, light intensity is
recorded for the 5 Mpixels

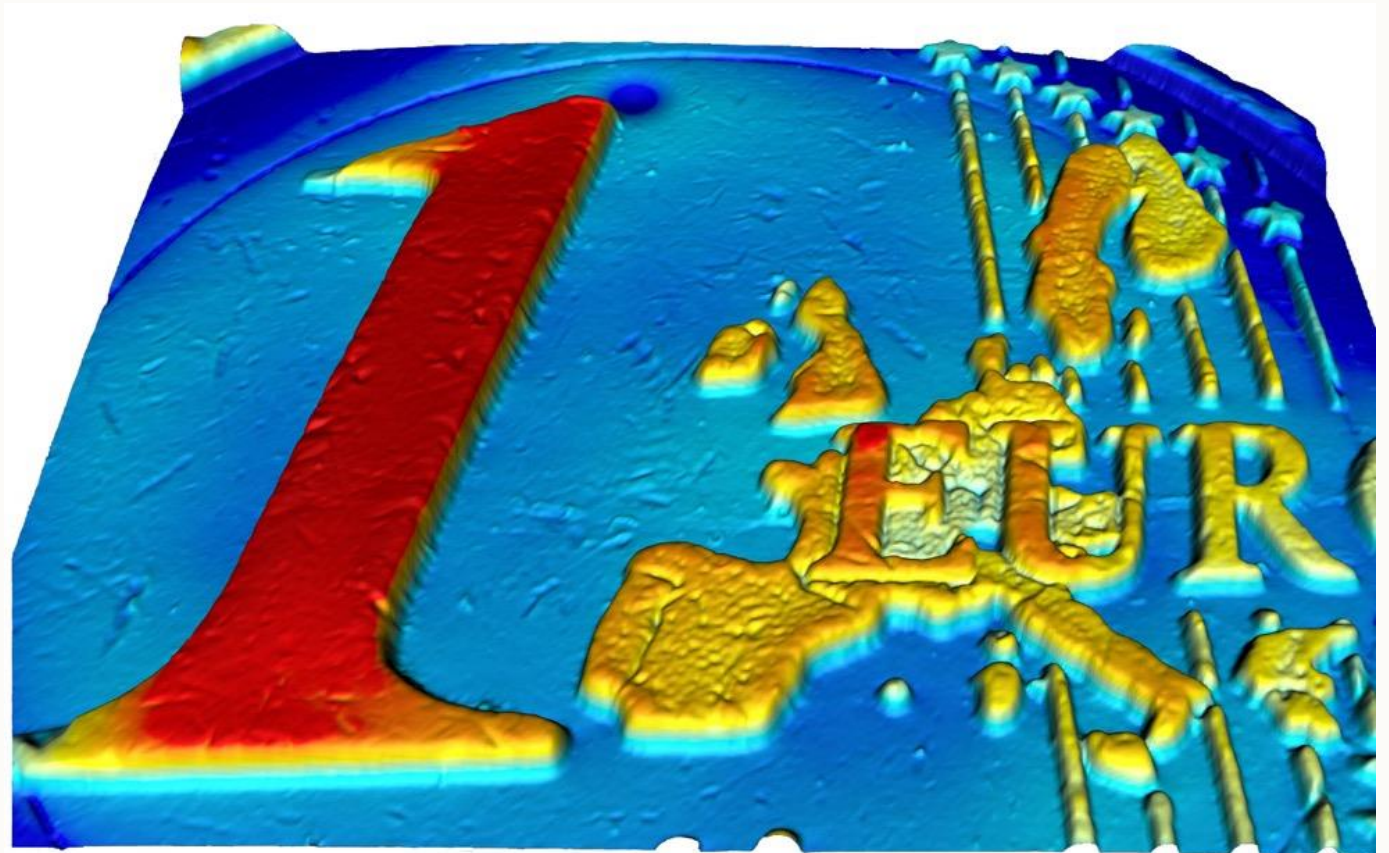


3D Surface Reconstruction

For each pixel, the light intensity allows to measure the normal and the tangent of the surface.

From the 6 images, the 3D surface is reconstructed in few seconds from the surface normal map using protected algorithm.

A post processing tool is available to perform basic measurements like profiles, offset, min & max, roughness



GelSight's rapid & precise surface measurements enhance aerospace quality control processes



Precise: Incredibly detailed, micron-level measurements



Versatile: can be used on any surface (metal, glass, carbon fiber) or surface (reflective, transparent)



Easy to use: ergonomic handheld on the factory floor or out in the field



Enables fast decisions: measurements in seconds



Decreased cost: reduced scrap and inventory



Repeatable & traceable: eliminates human error & enhance documentation/audit trail of data



Display on contact & easy 3D depth map generation enable fast decision-making



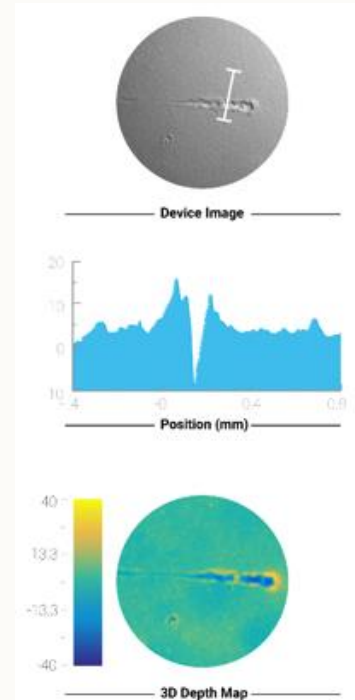
1 GeSight's intelligent sensor enables instant visual feedback, displaying the surface detail on contact through custom algorithms based on photo stereo imaging.



2 The 3D depth map is calculated using the images of the surface and the intuitive software interface, providing position, depth, and other derived surface measurements at a high resolution.



3 Make an immediate decision on part quality on the shop floor or out in the field. Automatic generation of control report for traceability and quality assurance purpose.



Pass

Fail



GelSight's versatility enables a diverse set of use cases



GelSight can inspect surfaces of aerostructures, cowlings, engine fan blades, fuel lines, windshields for scratches, dents, tool marks, fastener assemblies and more.

Segments



Engines & Nacelles



Aerostructures



Commercial MRO



Landing Gear

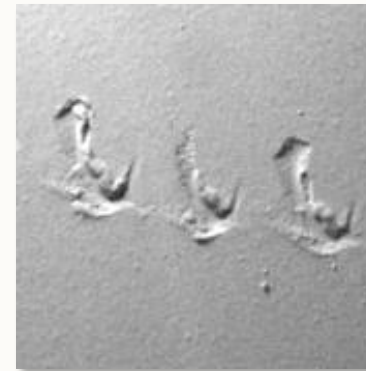


OEM Aircraft Assembly



Military Operations

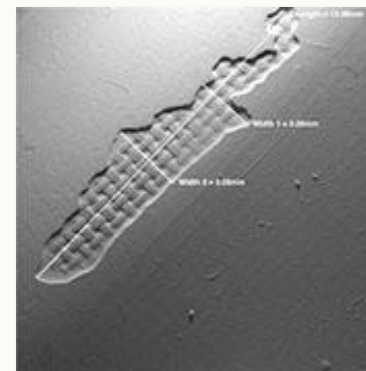
Inspection Examples



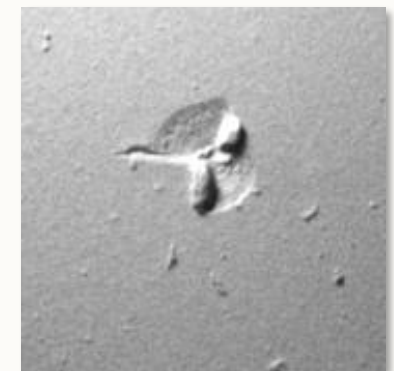
Tool Marks



Fastener Assemblies



Composite Panel



Dent

Preparing for Takeoff

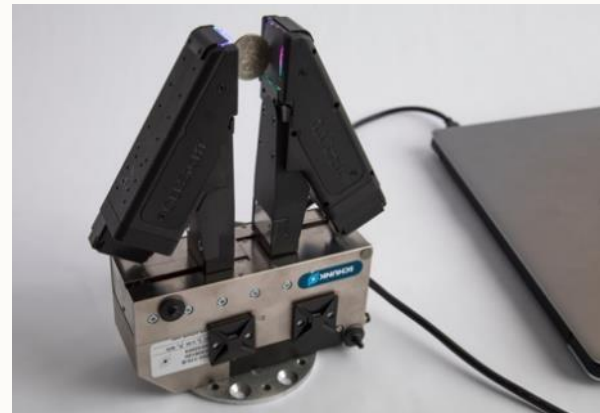
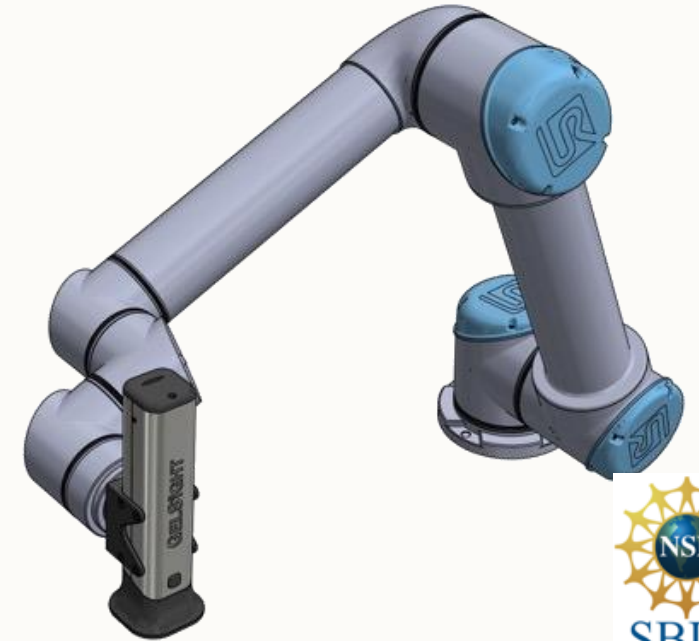


*year represents customer onboarding, quantities and locations cannot be disclosed

Tactile sensors for robotics application

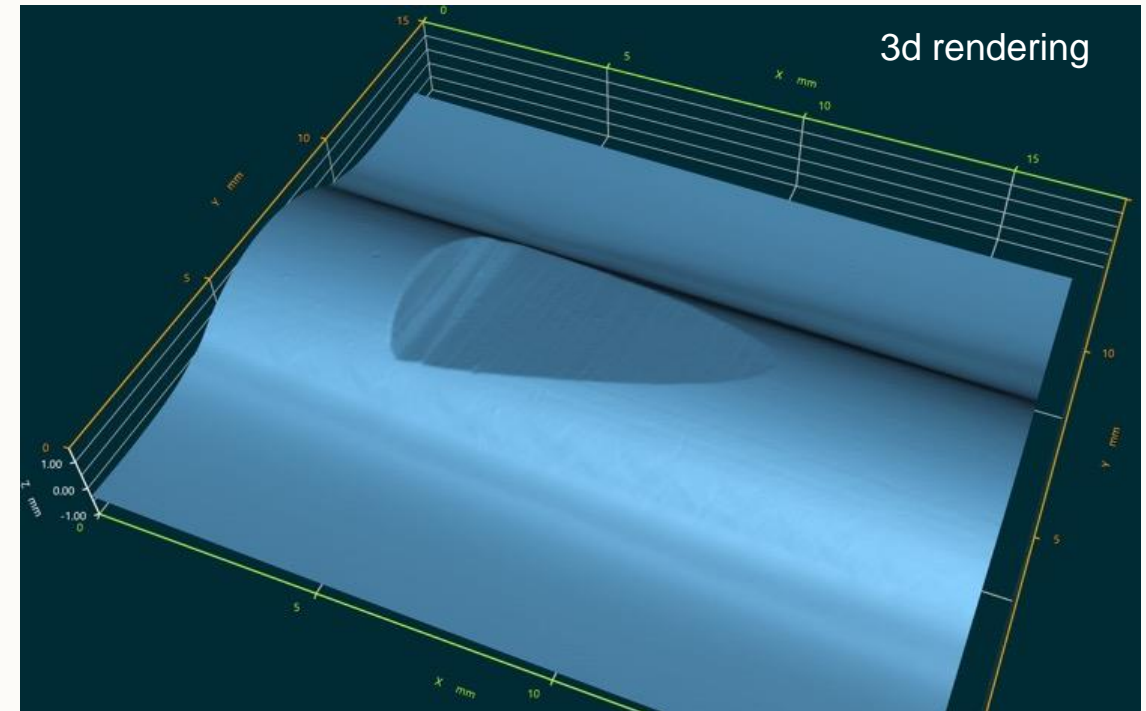
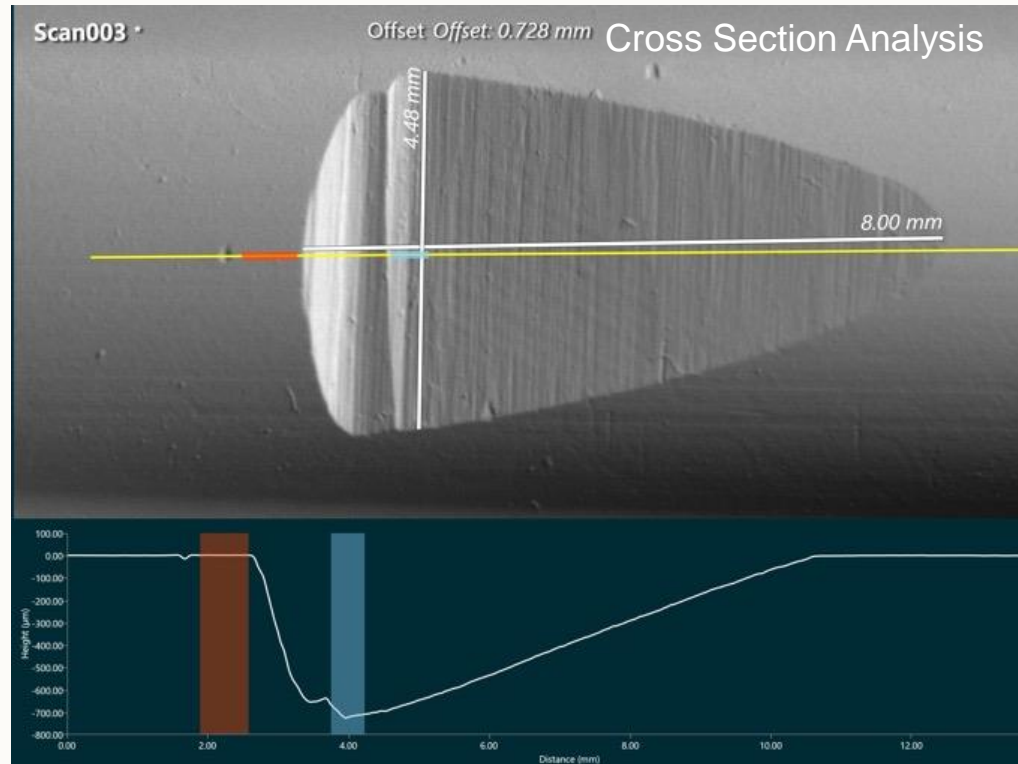


- End of Arm Tooling applications
- Tactile sensors
 - Proof of concept to pick up a 6 DoF part using GelSight tactile sensors
 - Evaluation of the accuracy and the repeatability
 - Part identification and 3D reconstruction
 - Positioning the part on target



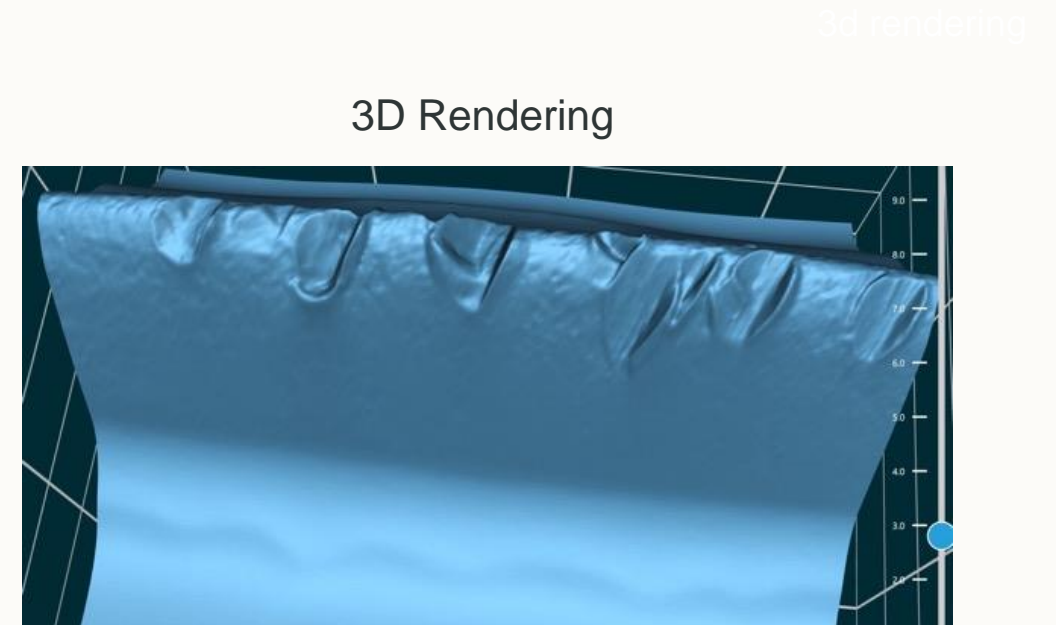
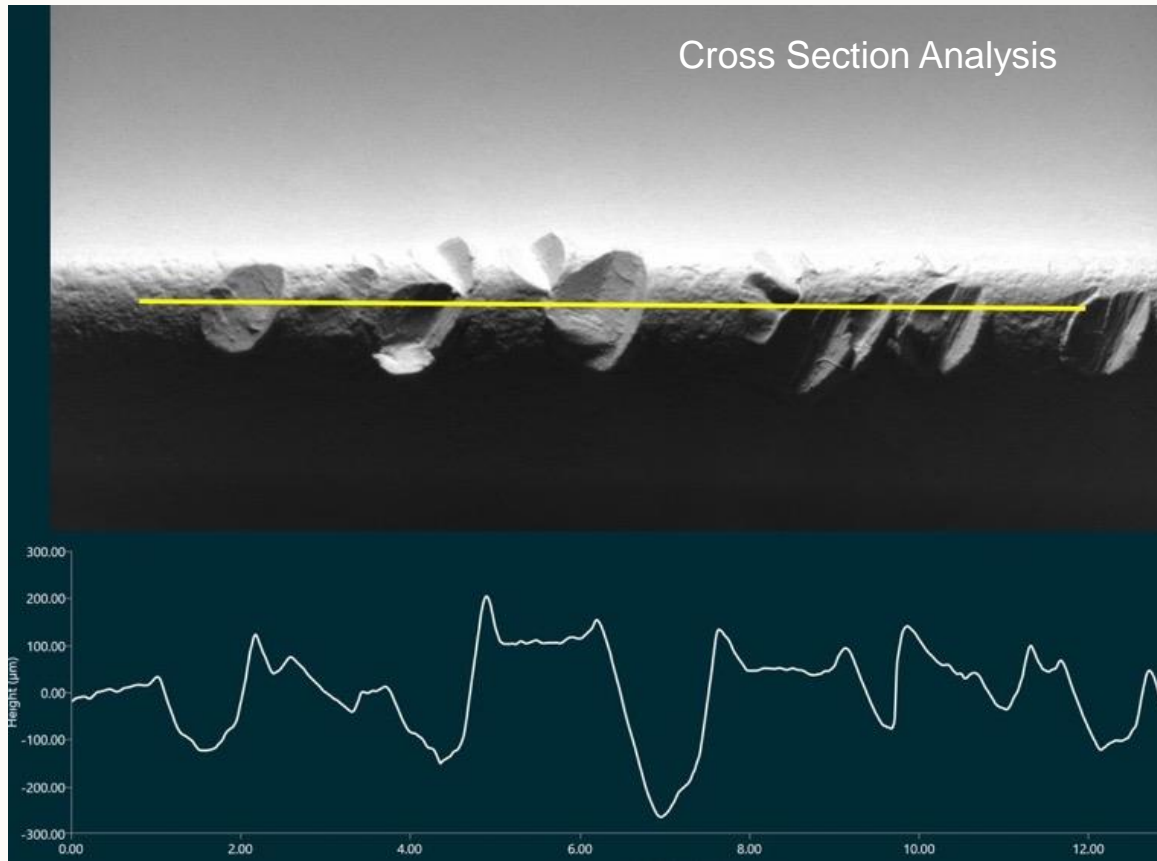
Engine fuel line damage

Civil aerospace – Airline maintenance operations



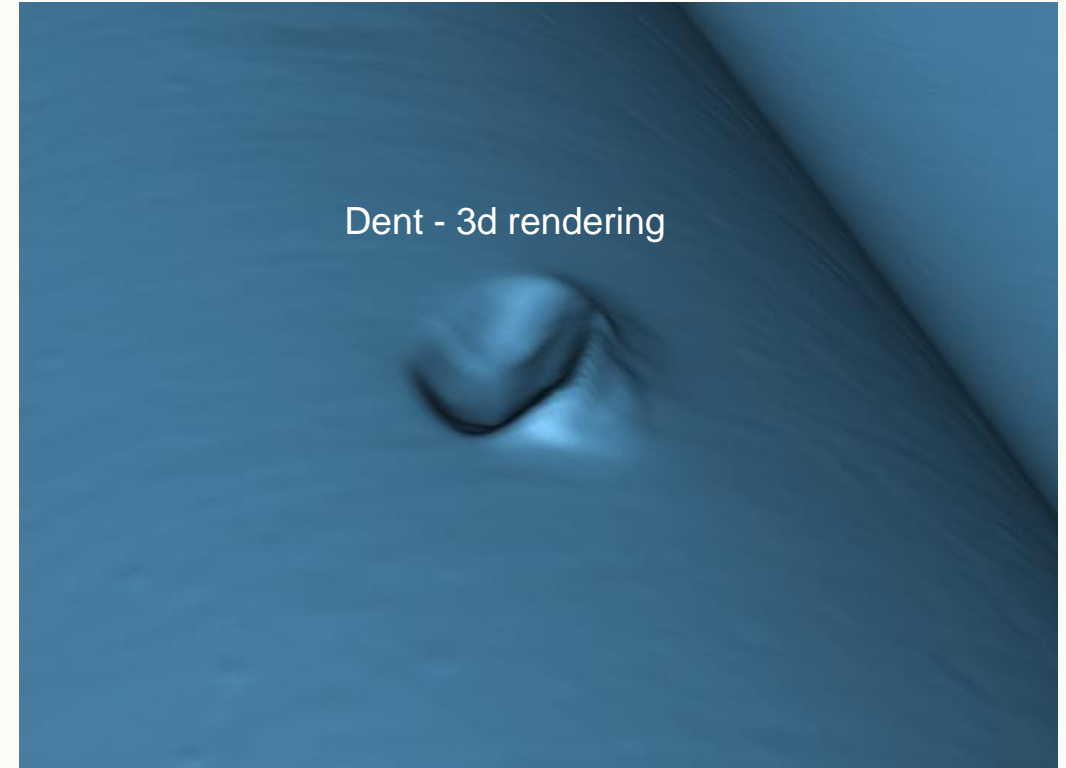
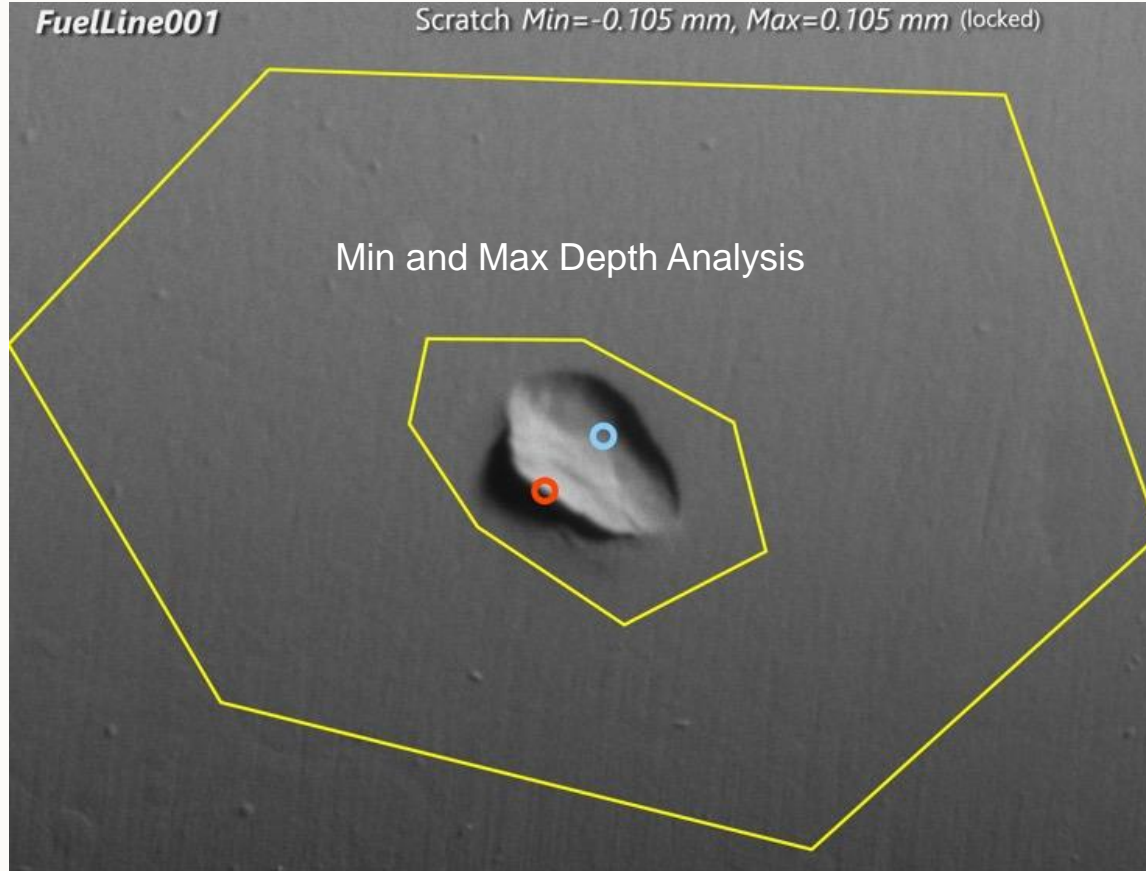
Rear rotor blade impact

Civil aerospace – Helicopter maintenance operations



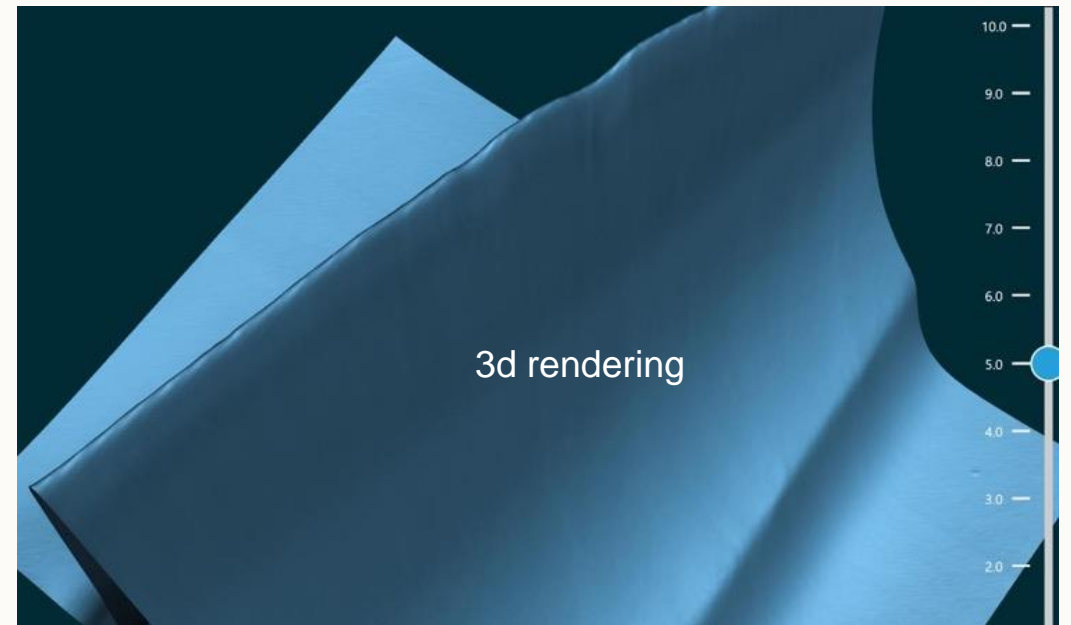
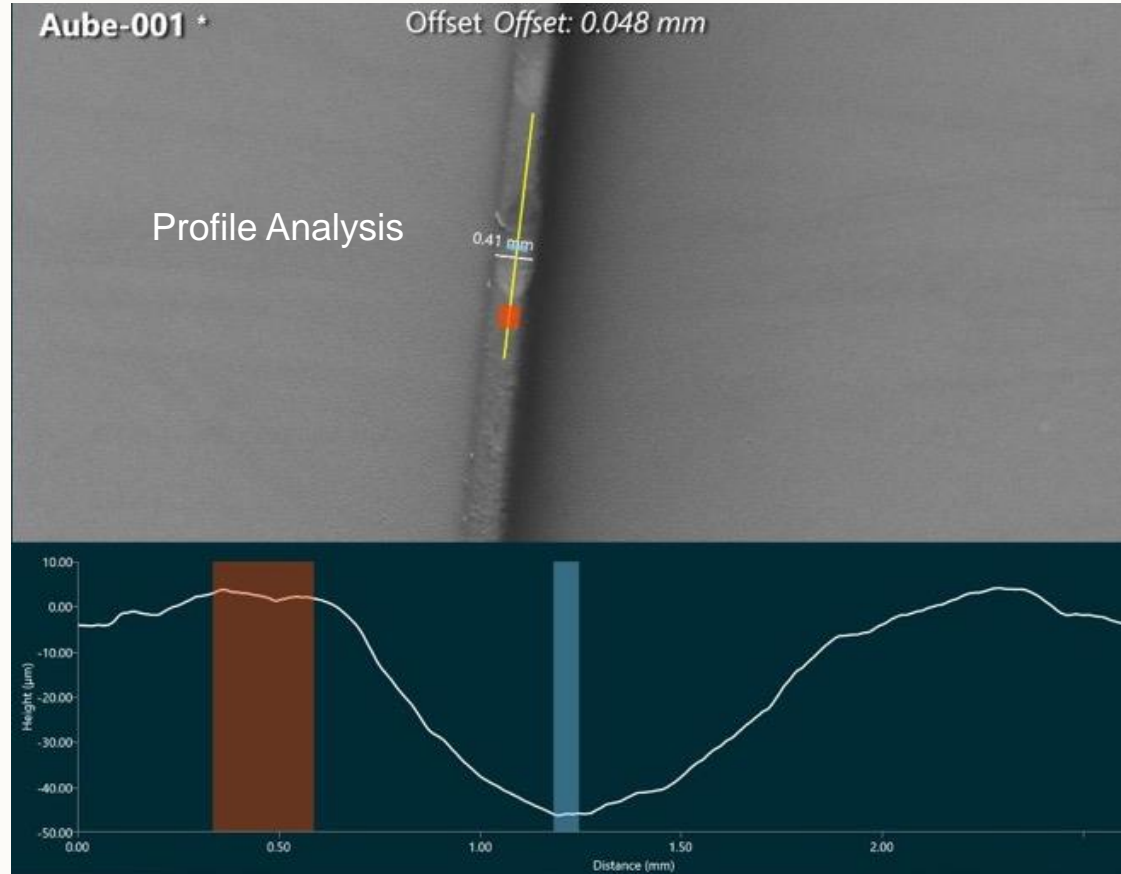
Engine fuel line dent

Civil aerospace – Airline maintenance operations



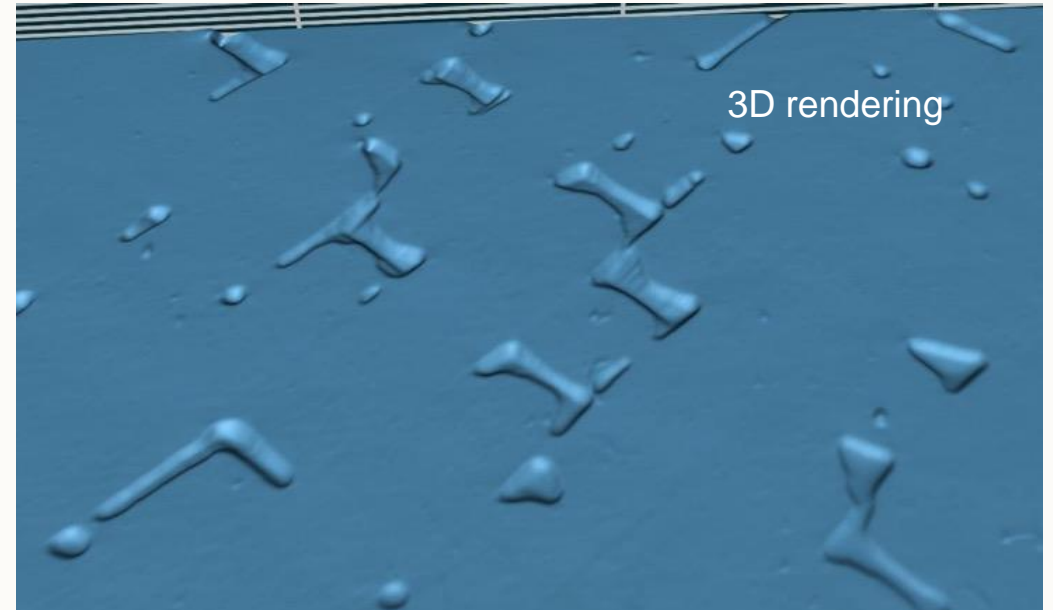
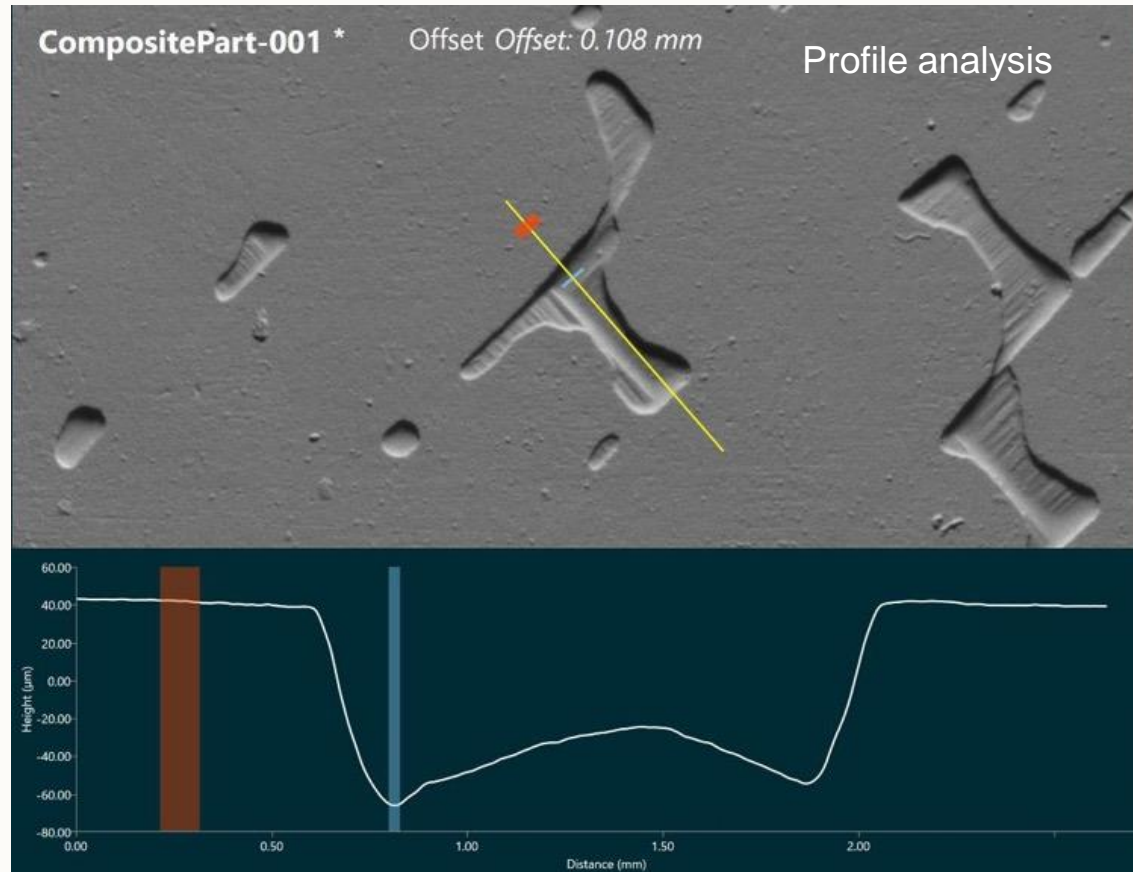
Compressor blade dent

Civil aerospace – Aircraft engine manufacturing



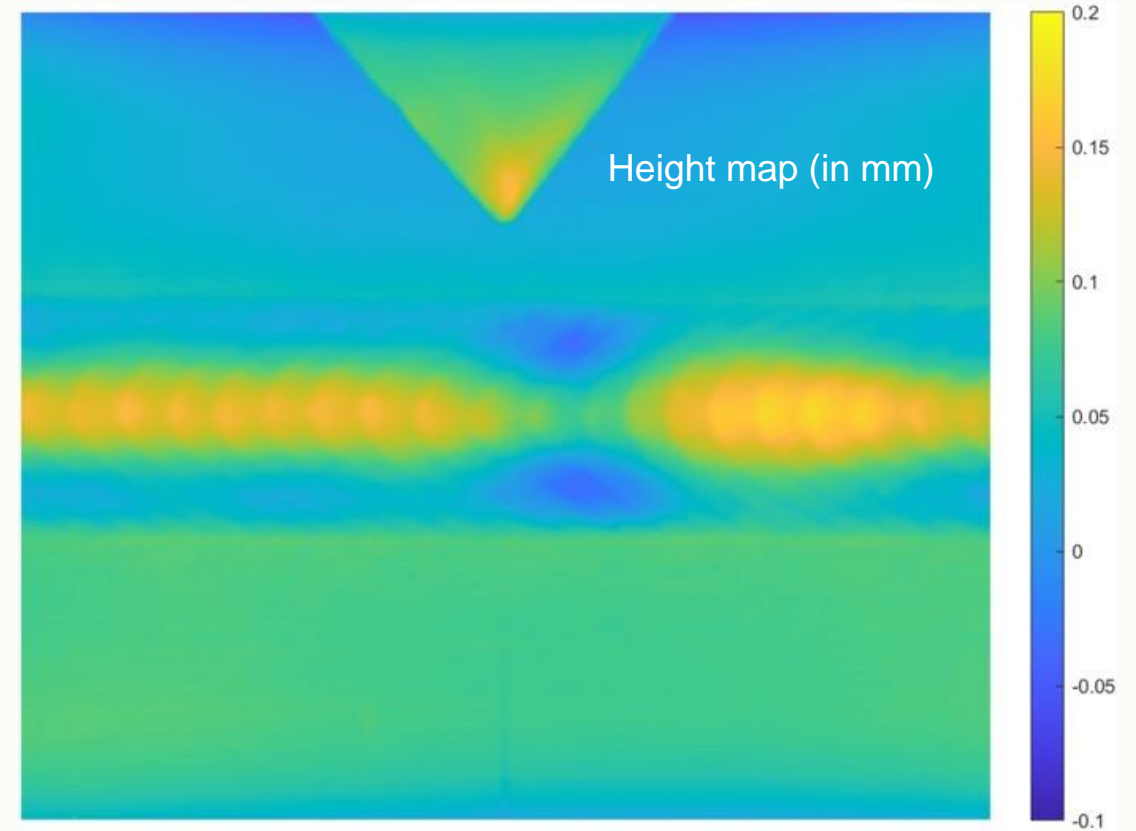
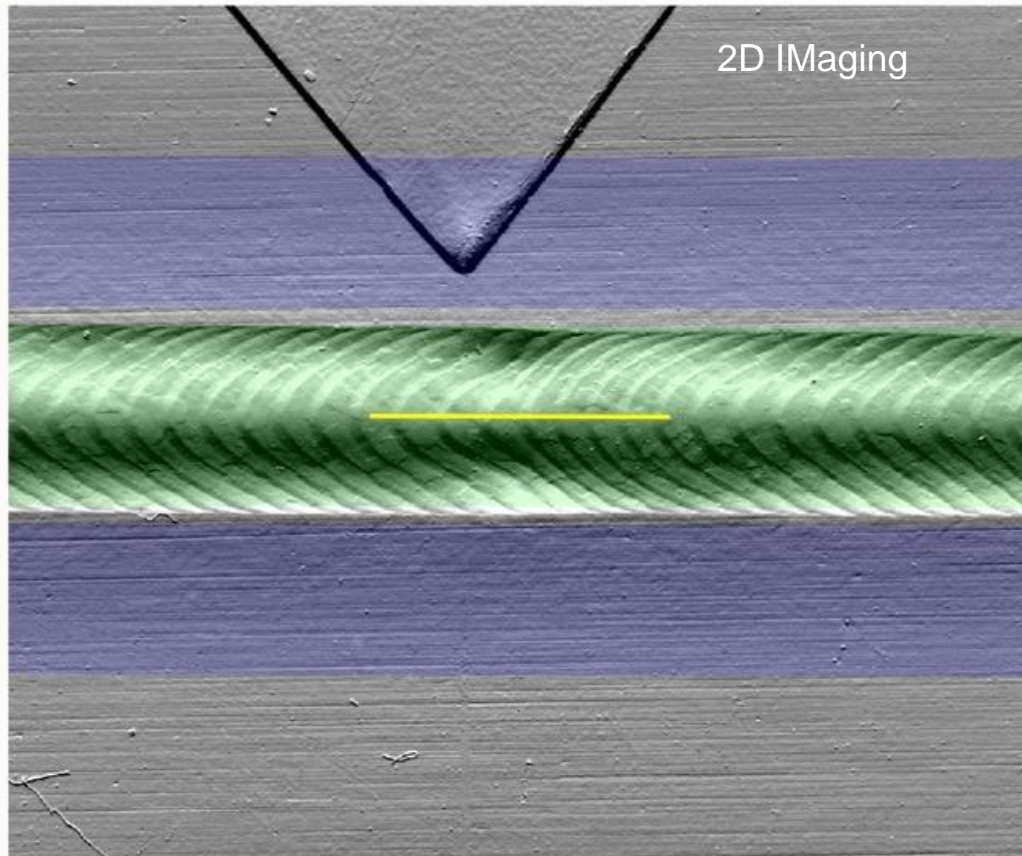
Composite panel – lack of resin

Civil aerospace – Aircraft composite panel



Weld bead analysis

Civil aerospace – Aircraft panel welding



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