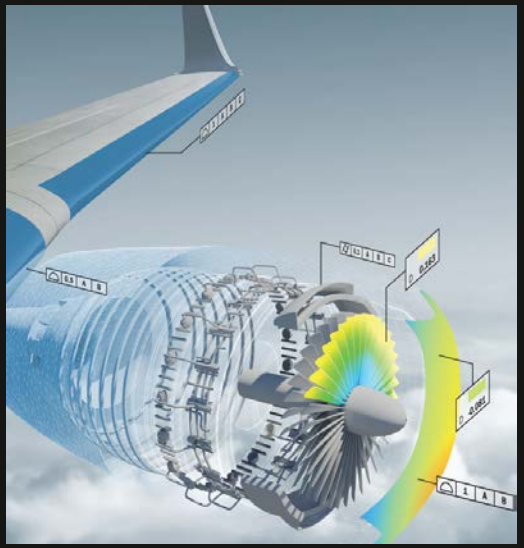
IMPROVEMENT OF AIRCRAFT MECHANICAL DAMAGE INSPECTION WITH ADVANCED 3D IMAGING TECHNOLOGIES



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SEPTEMBER 2017, FORT LAUDERDALE, FL, USA

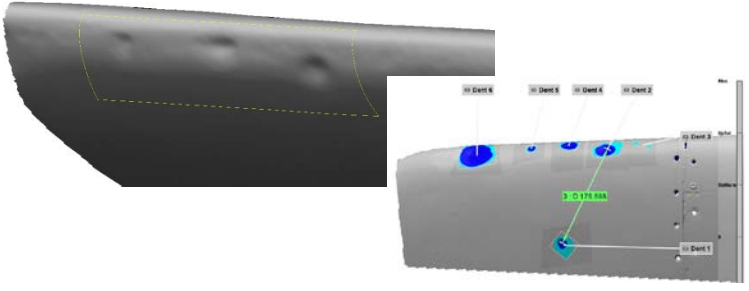
CREAFORM

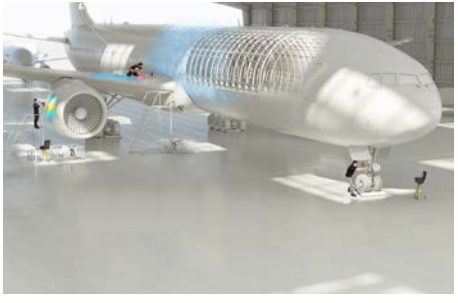
AMETEK®
ULTRA PRECISION TECHNOLOGIES

BRIDGING PHYSICAL AND DIGITAL WORLDS

- 3D scanners: understand the 3D scanners available today/needs

- Software: identify the application

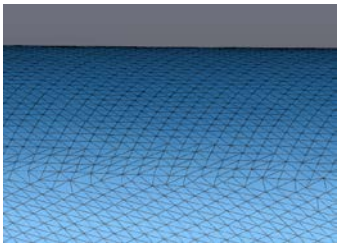




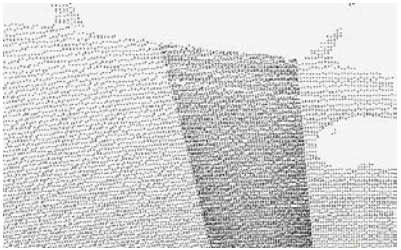
3D SCANNER TECHNOLOGIES

3D SCANNERS

- There are two major categories of scanners based on the way they capture data:
  - White-light and structured-light systems that take single snapshots/scans
  - Scan arms and portable handheld scanners that capture multiple images continuously
- 3D scan files can be a point cloud or a triangle mesh
- **Scan alignment or registration** can be performed during the scan itself, called dynamic referencing, **or** as a post-processing step.



3D mesh file



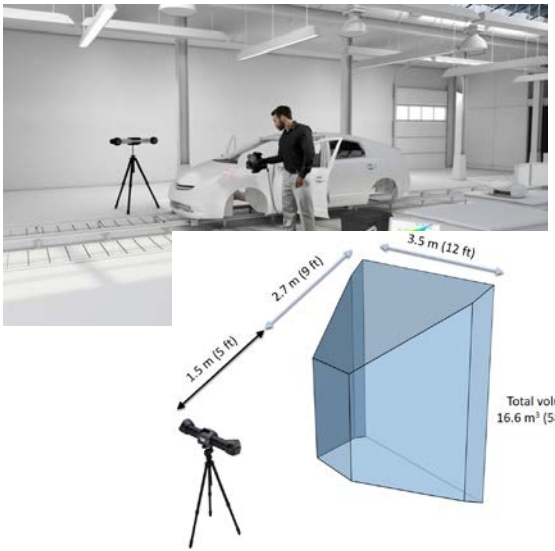
Point cloud

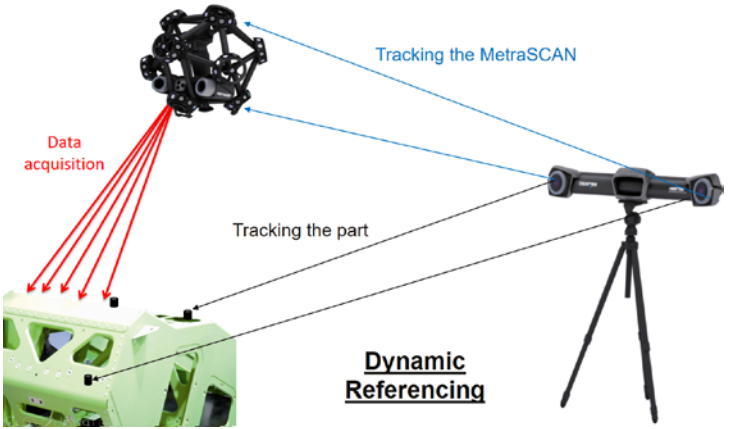
MEASURING ARMS, PORTABLE CMM SCANNERS

- CMM (coordinate measuring machines) and measuring arms can be equipped with probing or 3D scanning heads.
- Using mechanical encoders integrated in the arm means lack of flexibility
- Vibrations can affect accuracy

TRACKERS 3D SCANNERS

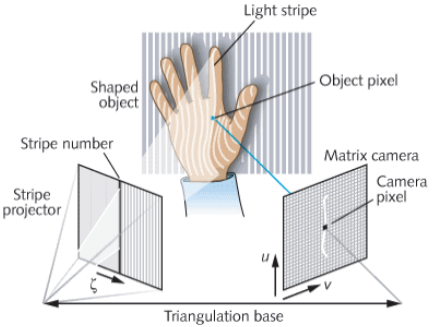
- Trackers can be used along 3D scanners.
- They provide very good accuracy and excellent precision throughout the measurement volume
- The tracker must always have a clear and direct line of sight to the 3D scanner

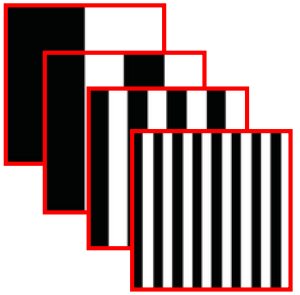




STRUCTURED-LIGHT 3D SCANNERS

- Patterns are distorted by an object and observed by a camera.
- All images are integrated into a single 3D snapshot.
- All 3D snapshots must then be merged into a single 3D model.
- Merge process can be time consuming especially for larger scans.
- Sensitive to environment and surface finish.





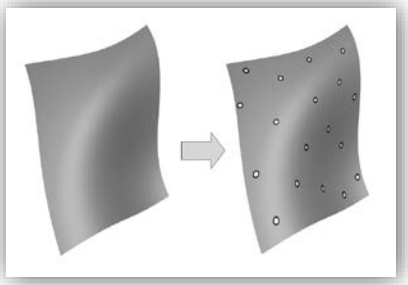
PORTABLE 3D SCANNERS

- Laser scanners project one or many laser lines on an object while white-light devices project a light and shade pattern.
- The most advanced technologies can acquire more than half-a-million points per second and rebuild the 3D triangle mesh live during the scanning process.
- Handheld scanners do not require a mechanical link or a direct line of sight with a tracker. This enables them to reach narrow and enclosed areas.
- Can scan in sunlight and shiny or dark surface finishes

POSITIONING METHODS FOR PORTABLE 3D SCANNERS

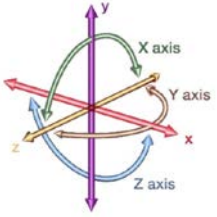
POSITIONING THROUGH TARGETS

- Targets enable users to register all the different camera frames for the 3D data sets acquired by the scanner.
- Targets' size is constant and makes it a known reference
- A minimum of three targets is used to position the scanning frame.
- Positioning through targets is the only method delivering metrology-grade quality (independently from the inspector/part/environment)



POSITIONING BY GEOMETRY WITH NATURAL FEATURES / MANUAL

- This method uses the object's shape and texture to record object positioning.
- Unlike positioning targets, natural features vary from one object to another.
- The resulting precision and accuracy can be greatly affected by the type of objects being scanned.
- Cylindrical/flat/spherical shapes usually **don't offer enough geometry to lock all 6 degrees of freedom**.



6 degrees of freedom

Crosses added usually resulting in manual registering

HYBRID POSITIONING

- It is possible to combine target and natural positioning into a hybrid positioning mode.
- Users can compensate for the lack of natural features in a given object or specific areas by adding positioning targets
- Although hybrid positioning would appear to be the best of both worlds, it will not generate metrology-grade results.

ANALYZING SURFACE DAMAGE

EQUIPMENT

- This section presents the results for external corrosion assessment for portable scanners using the following positioning methods:

    1. **Natural features**
    2. **Hybrid positioning**
    3. **Using targets**

- In parallel, the impact of not having any positioning method will be studied.

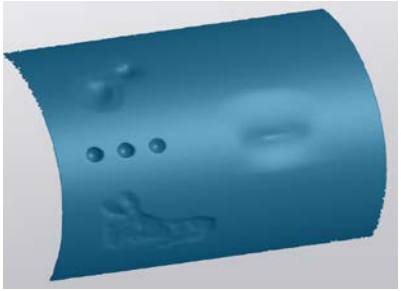
- The equipment used for this experimentation was two different structured-light scanners and a laser-based scanner.

- Reference used fixed CMM accurate to 0.0005'' (*)

(*) All gathered data were compared the results acquired from Mitutoyo Crysta-ApexS CMM mounted with a Kreon KZ50 optical head.
The positioning of the CMM has an uncertainty of 0.0127 mm (0.0005 in) and the KZ50 specifies between 0.0127mm (0.0005 in) and 0.0254 mm (0.001 in). To insure the best correlation between results extracted from all scanners positioning methods, the same software platform was used to analyze all data.

EQUIPMENT

- Section used for measurements



- Surfaces larger than the field of view of the **natural feature scanner** (10''x10'') could not register/position images as it lacked features to position images. Therefore, a part smaller than the field of view was used

IMPACT OF PICTURE REGISTRATION

- Comparison shows that using targets as positioning method for portable scanners is the only way of getting metrology-grade results all within 0.035 mm (0.0015 in).
- Natural features method (within 0.088mm, 0.0035in) seems to deliver an interesting level of accuracy compared to not having any positioning method*.

*for a small area with a single picture

	Positioning Methods					
	CMM	Natural Features	Hybrid	Targets	None	Pit Gauge
Feature 1	**8.146**	8.094	8.201	**8.147**	8.572	8.15
Feature 2	**2.916**	2.903	2.922	**2.926**	3.656	2.89
Feature 3	**4.203**	4.232	4.162	**4.241**	5.890	4.23
Feature 4	**3.607**	3.565	3.546	**3.626**	4.025	3.61
Feature 5	**4.590**	4.554	4.521	**4.602**	5.052	4.62
Feature 6	**5.588**	5.500	5.510	**5.623**	6.094	5.61

CONCLUSION

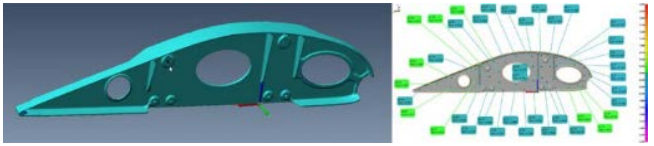
- Using positioning targets is the best method to deliver accurate results independently of inspector and environment conditions (vibrations, temperature).
- Scanners using natural features to register images are limited when features are not sufficient

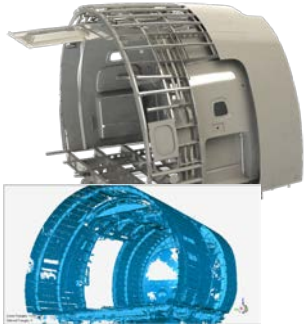
Note: One of the structured-light and the laser-based systems used during this study offered different positioning method for different results. They both had real time registration of the data which made the analysis faster and easier.

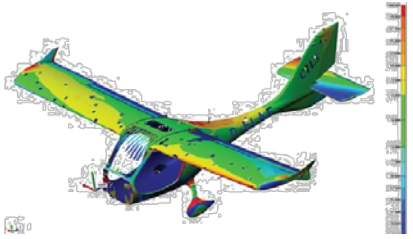
SOFTWARE CAPABILITIES

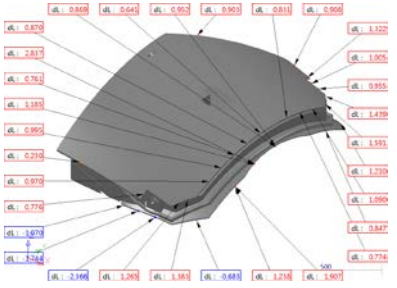
QC / REVERSE ENGINEERING

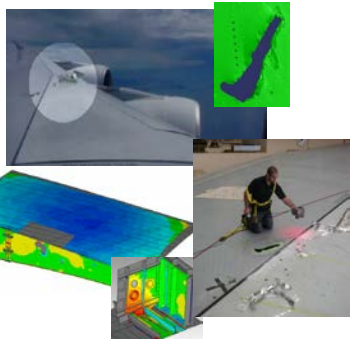
- Scan to CAD inspection
- Scan to scan color maps
- Flush gap measurements
- Profile views
- Create 3D CAD models
- As built drawings
- 3D models for retrofit purposes
- 3D printing

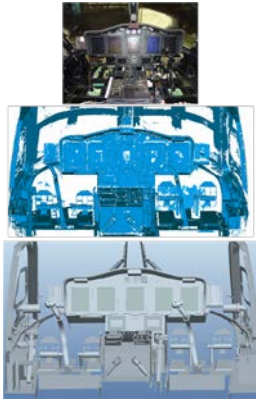


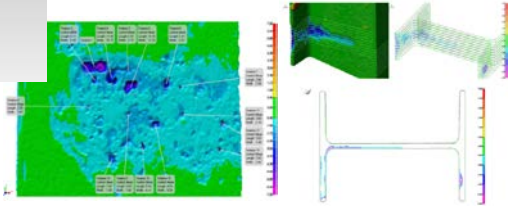






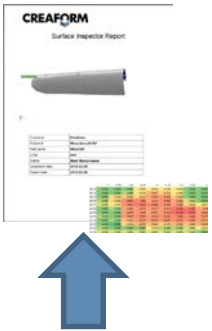


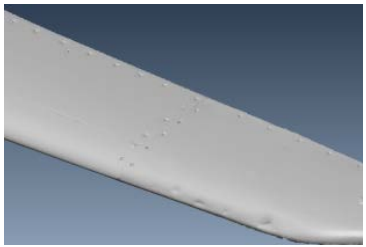


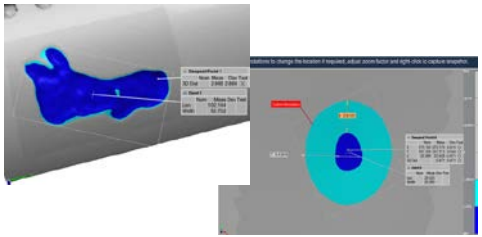


SURFACE INSPECTION: MAKE A TEDIOUS PROCESS FAST, SIMPLE, ACCURATE

1. Surface acquisition (30 secs/m²)
2. Surface reconstruction/extraction of inspection data (1 min)
3. Reporting (seconds):
   - PDF or spreadsheets, editable
   - Damage characterization
   - Skin waviness (2D depth mapping)



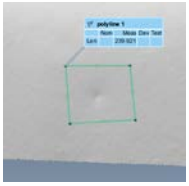


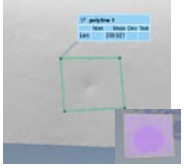


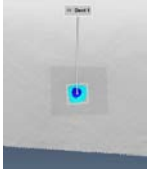
SURFACE INSPECTION: AUTOMATIC SURFACE RECONSTRUCTION

- 4 clicks around the area of interest (single or multiple defects)
- Automatic surface reconstruction based on good material and measurement extraction
- Automatic report generation
- Report personalization on the fly
- Possibility of adding annotations and distances

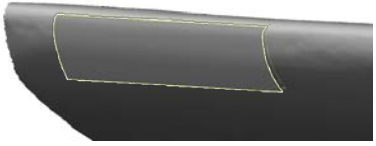
Single Dent

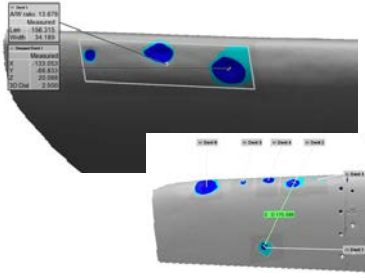


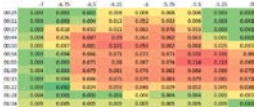


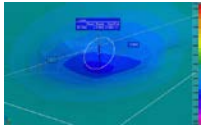


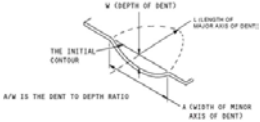
Surface inspection





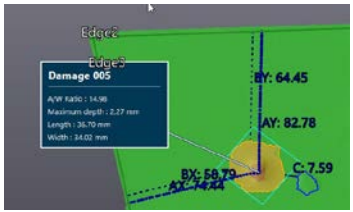


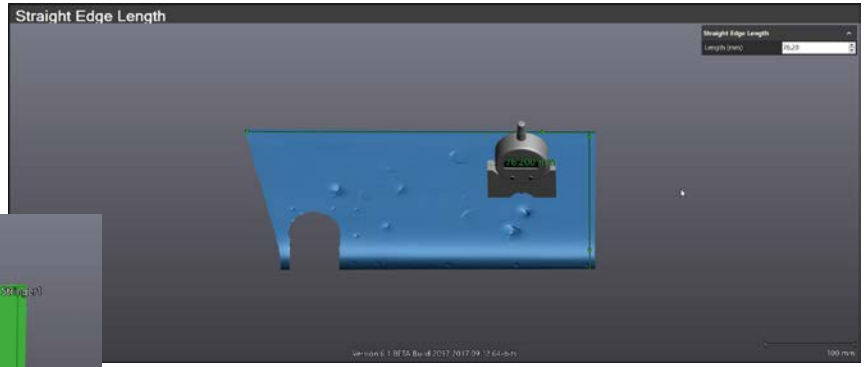


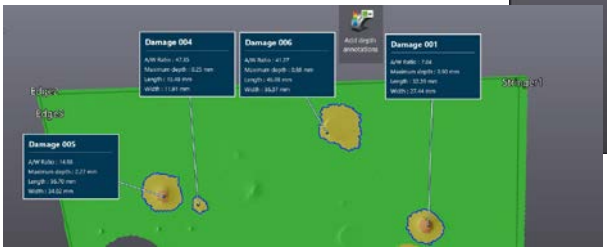


SURFACE INSPECTOR NEW RELEASE

- Complete automated process for simple geometries: one axis of rotation maximum (leading edge, cylinders, flat surfaces)
- Run automatically virtual pit gage and generate reports on site
- Release date: November 2017!







Questions?

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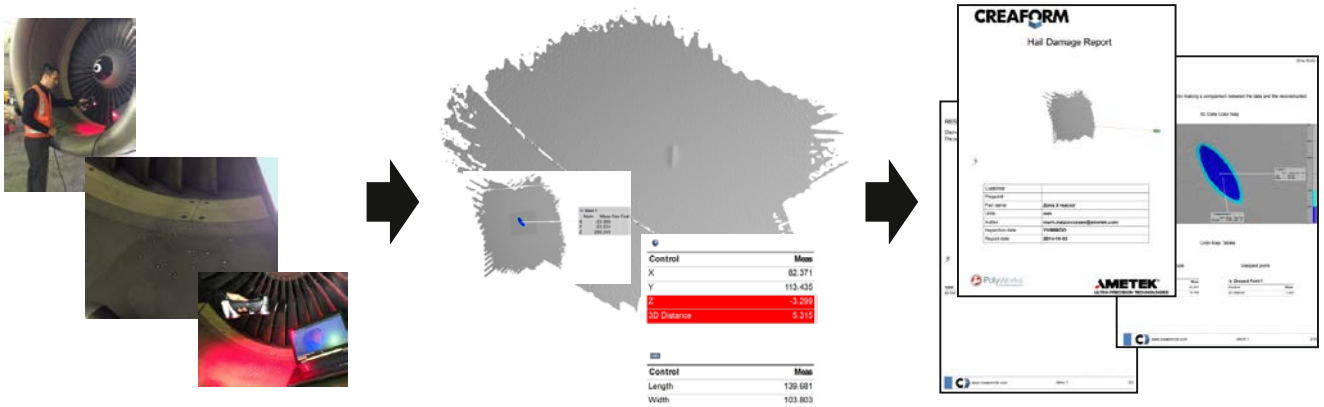
ANNEX 1: CASE STUDIES

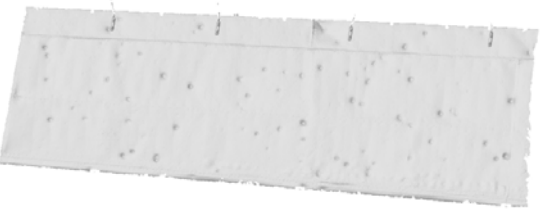
DENT IN ENGINE AREA

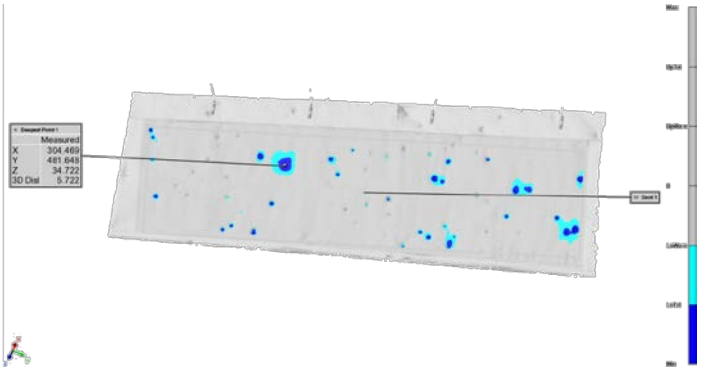
- **Simple setup:** scanner, laptop, battery
- **Human factor controlled**
- Benefits: **high analytical accuracy, repeatability**, traceability, portability and ease of use
- Report **in seconds**



FIND DEEPEST POINTS ON PART

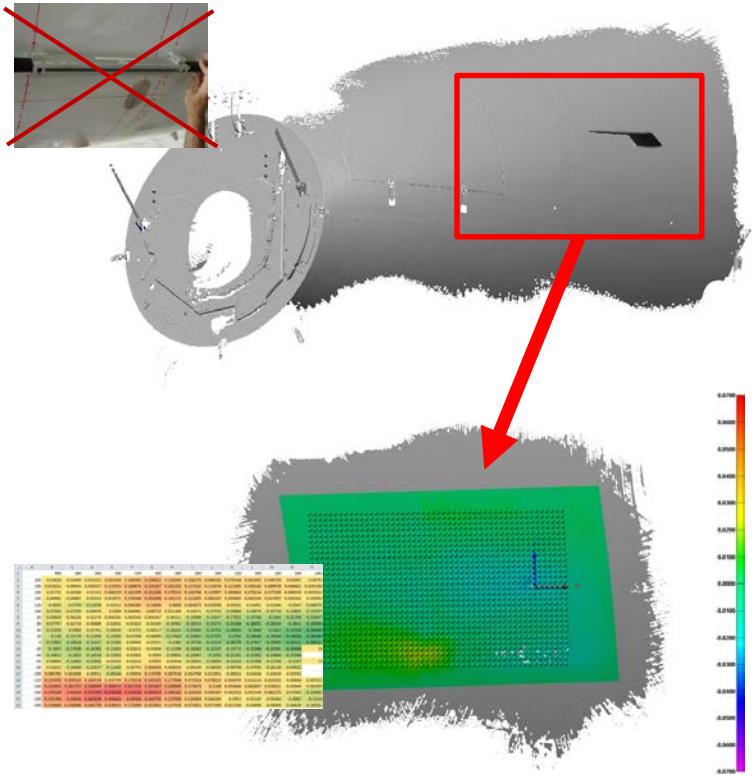
- Scan whole fin which suffered mechanical damage
- Reconstruct surface
- Deepest point coordinates and value calculated
- 80% reduction in time compared traditional method **4-5hr/m² ➔ 15 min/m²**
- **<u>Completely automated process</u>**





SKIN WAVINESS

- No operator error
- Insured repeatability, accuracy and speed
- Automatic depth mapping measurement (any grid size)
- Digital record available
- **Applications:** RVSM certification, doublers, patch repair measurements…



DAMAGE ASSESSMENT/LOGGING

REVERSE ENGINEERING + CNC: CUSTOM BRACKETS