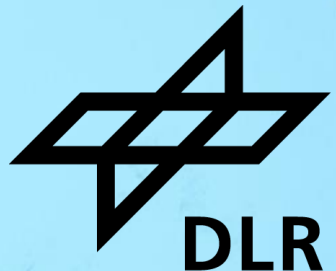


FROM THE REAL TURBINE BLADE TO THE DIGITAL COMPONENT TWIN – COMPARISON OF METHODS AND CHALLENGES

DEUTSCHER LUFT- UND RAUMFAHRTKONGRESS 2024

30.09.2024

Y. Chodvadiya, P.-B. Ebel, A. Kamtsiuris, E. Grishchenko
German Aerospace Center (DLR)



Needs for Digital Component Twins

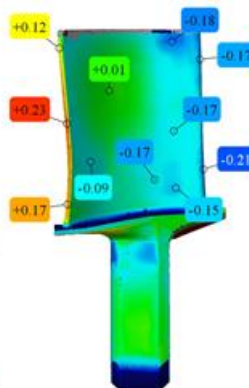
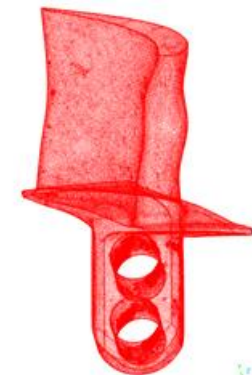
Design to production to design

Production
deviation

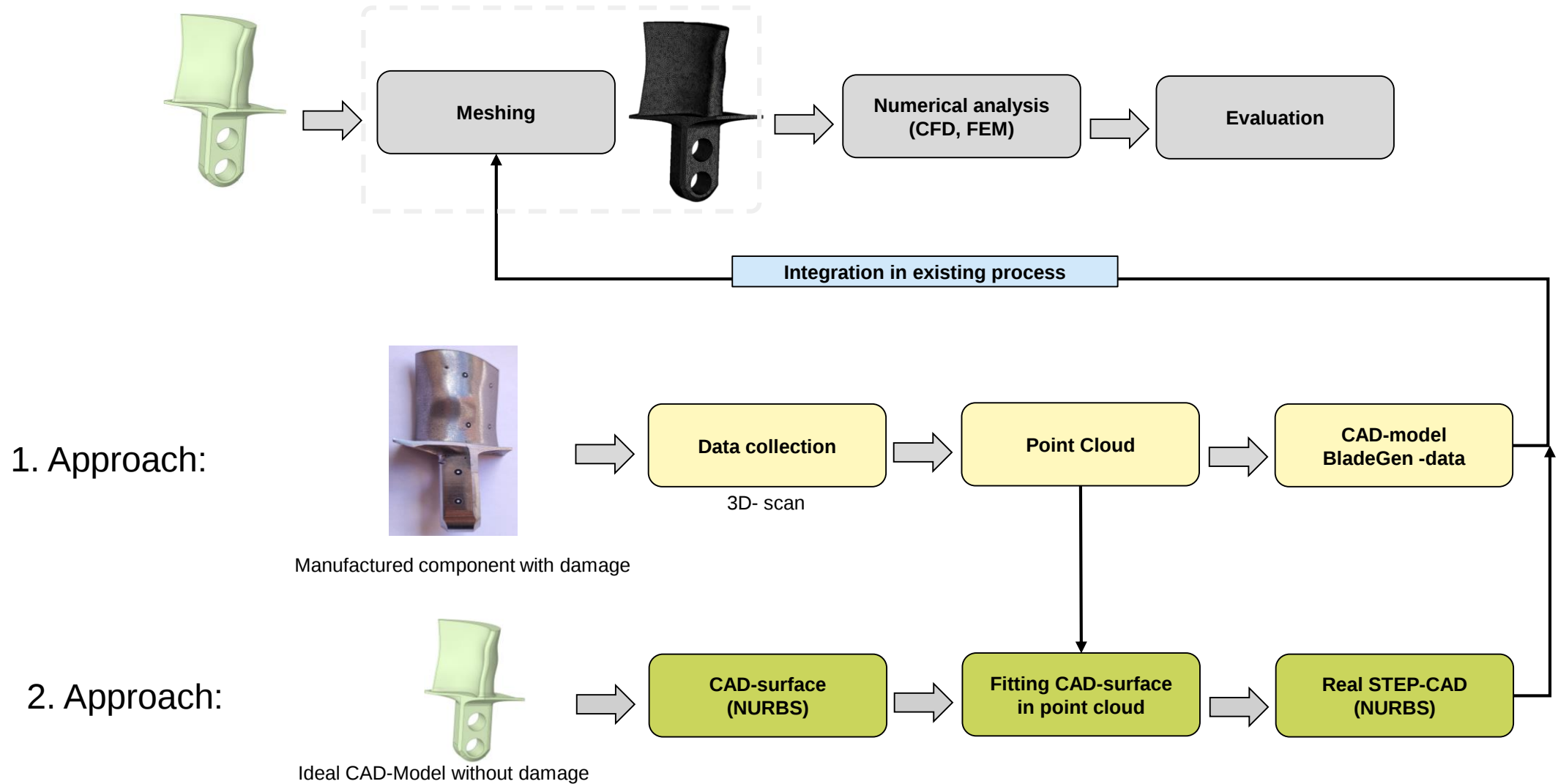
Quality control

Degradation and
damage of
materials

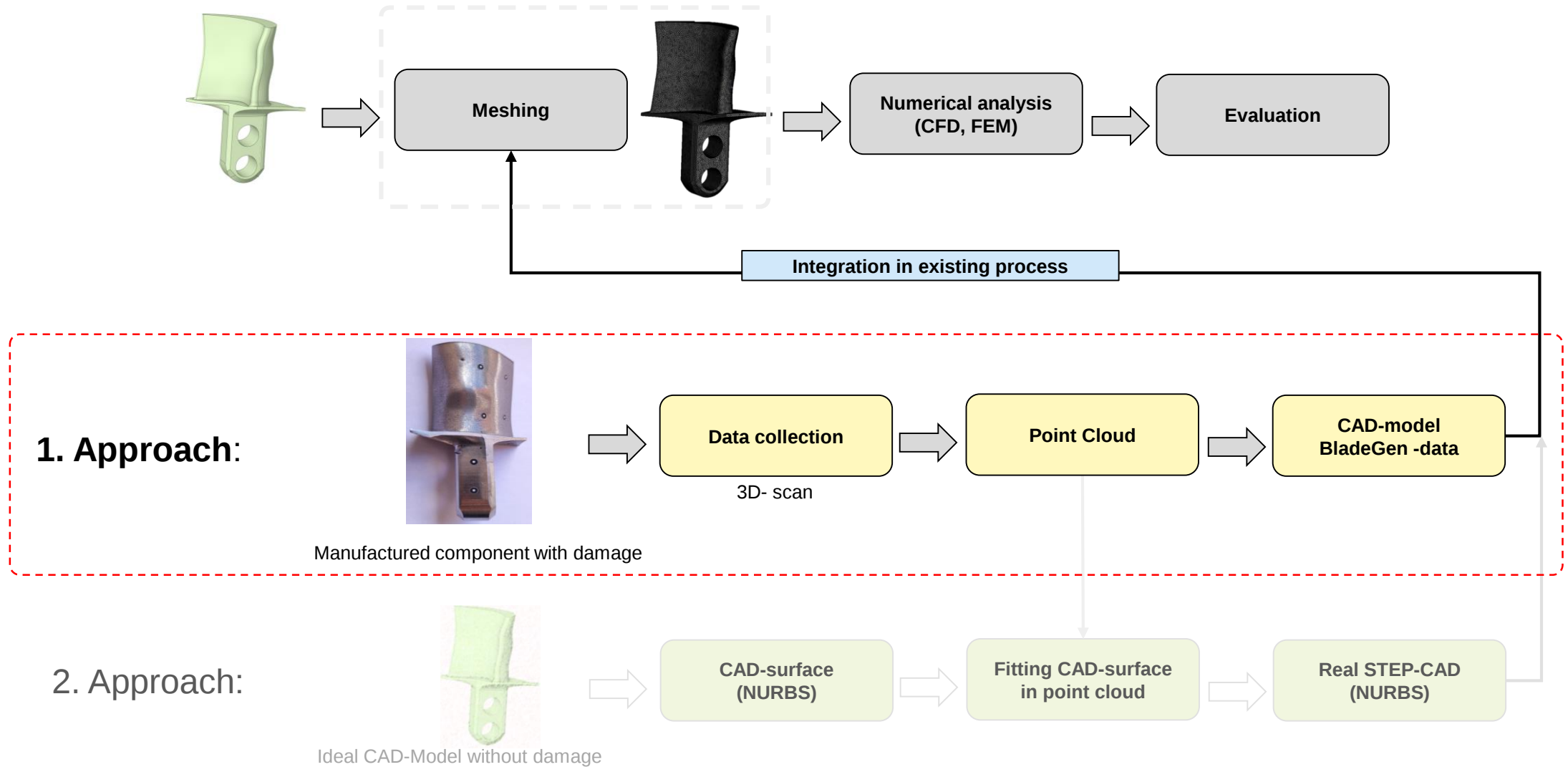
Reverse engineering, end-to-end process



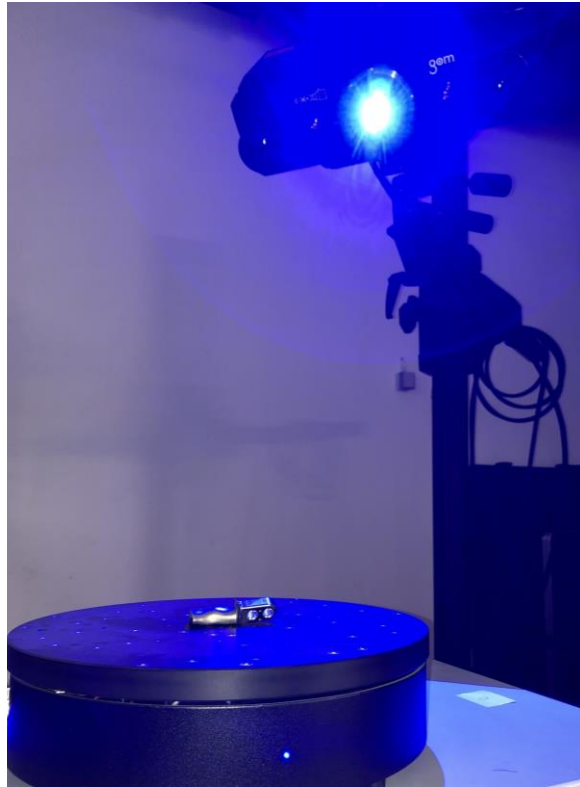
Current Process and Desired Process



Current Process and Desired Process

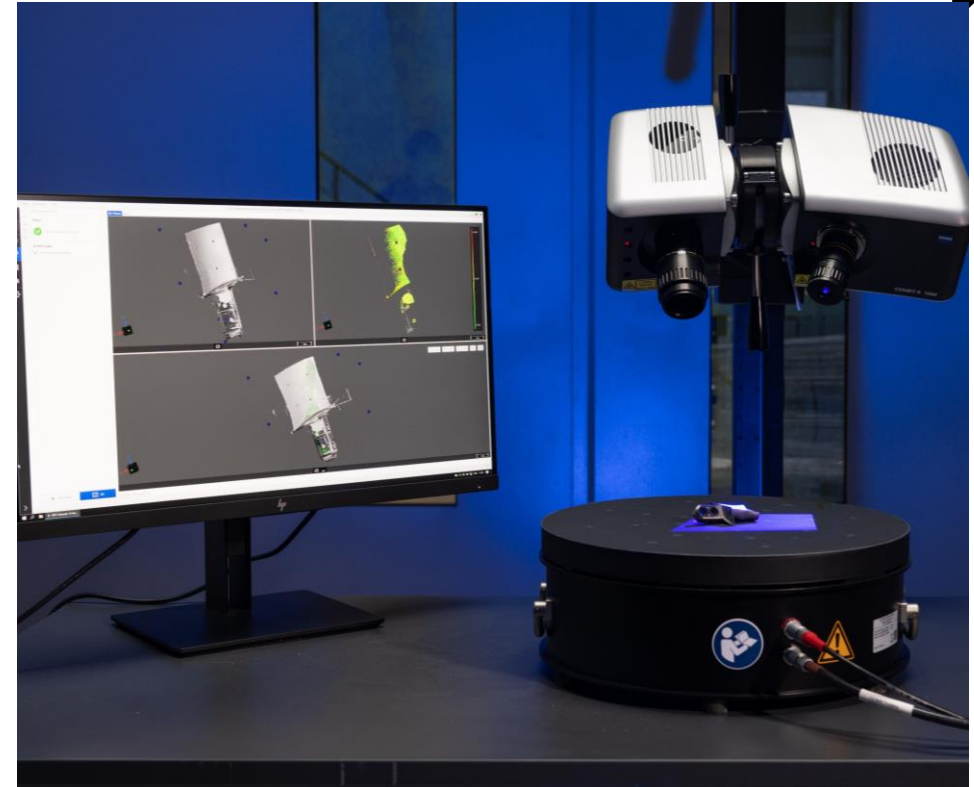
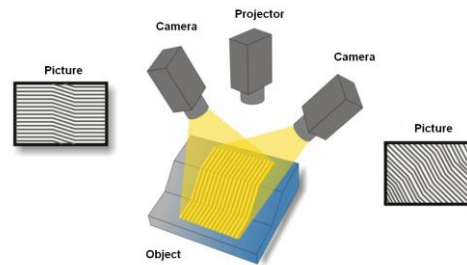


1. Approach: 3D Scanners



GOM ATOS 5 + GOM software suite

- Two camera + one projector
- Resolution: 8 MP / 12 MP
- Measuring volumes: MV170, MV500, MV1000
- Measuring area (MV170) $185 \times 140 \times 140 \text{ mm}^3$
- Auxiliary markers and markers on the object

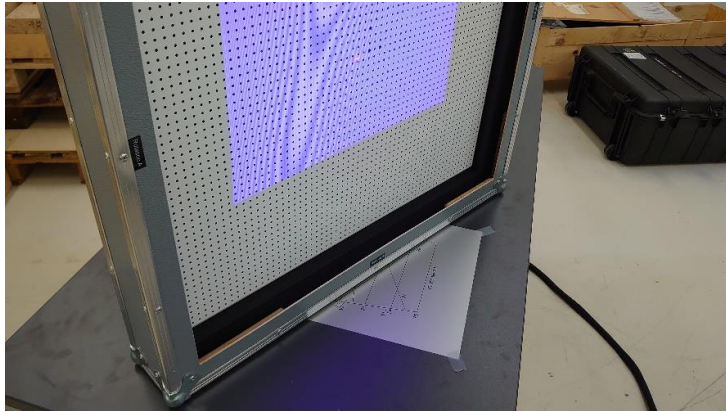


Zeiss Comet 6 16M

- One camera + one projector
- Resolution: 4896×3264 (16 MP)
- Measuring volume: $81 \times 54 \times 40 \text{ mm}^3$ (measuring field 80) to $656 \times 437 \times 400 \text{ mm}^3$ (measuring field 700)
- Auxiliary markers on tables

1. Approach: 3D Scanning Procedure

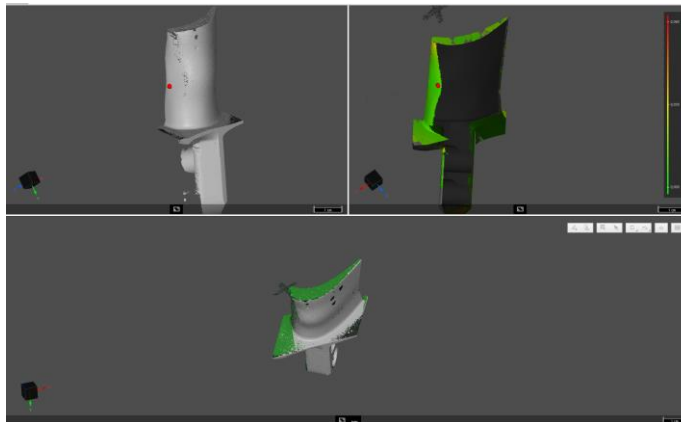
Calibration of the measuring field



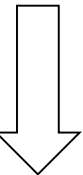
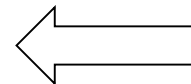
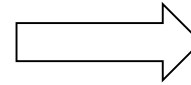
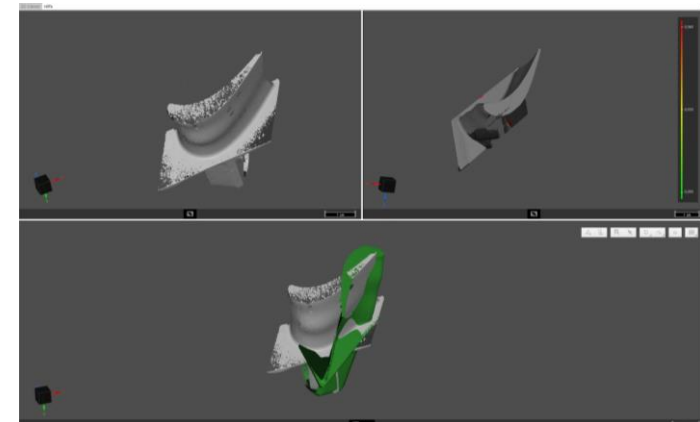
Scanning with turntable and auxiliary markers



Overall model triangulation as a .STL network

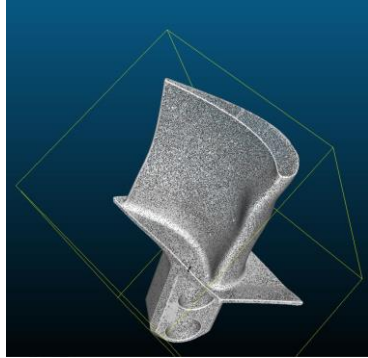


Aligning individual scans

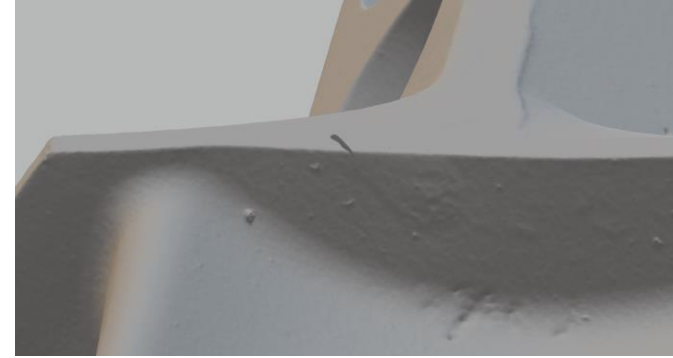


1. Approach: 3D Scan to Finite Element Mesh

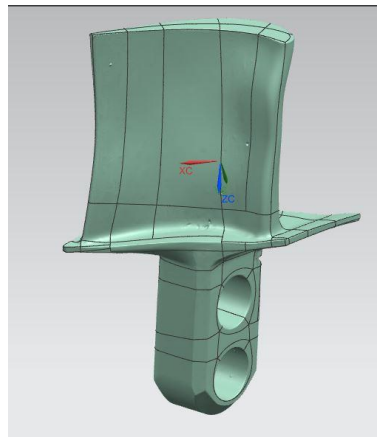
Scanned point cloud - .stl file



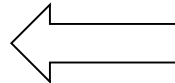
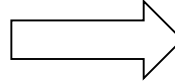
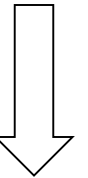
Smoothing and cleaning



Surface to solid CAD Model



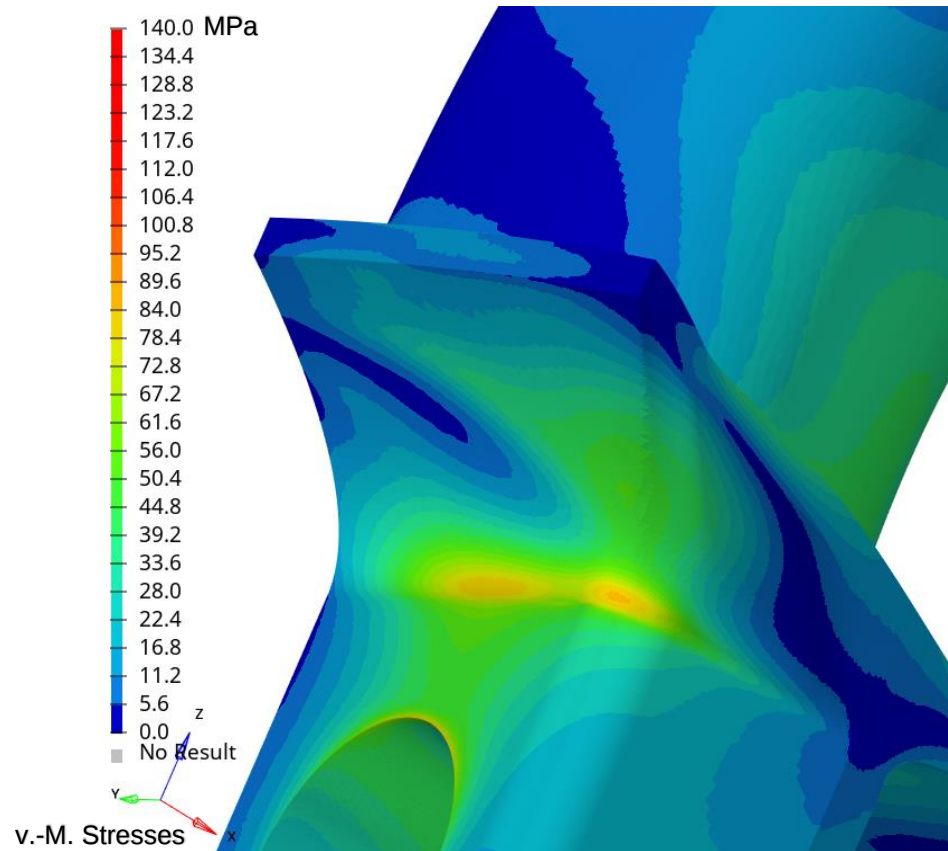
Water tight surface and reconstruction



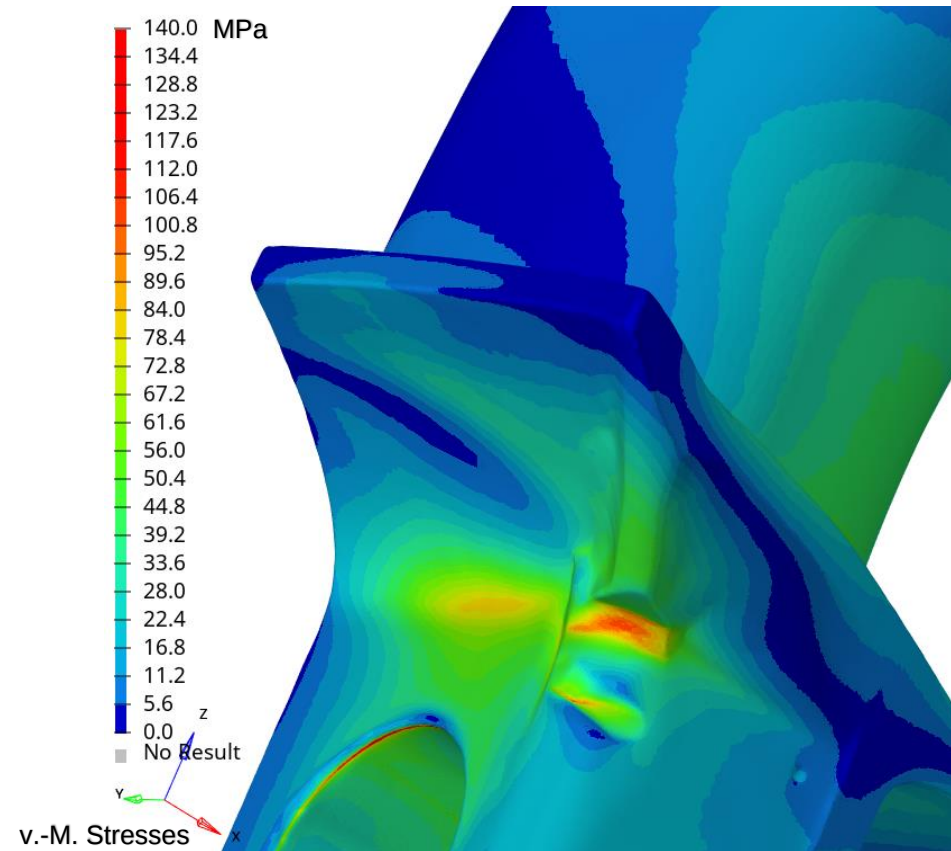
1. Approach: Integration to current process

Outcome – Effects and Usability in CSM Simulations

Ideal CAD model

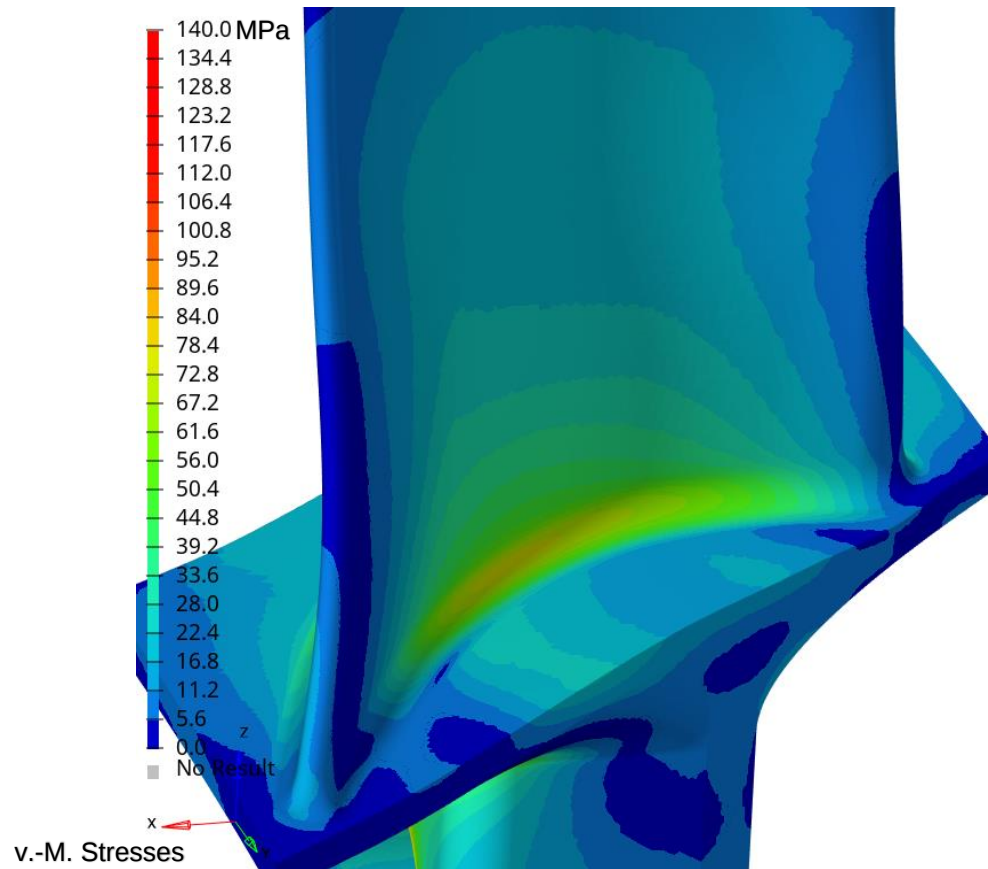


Scanned CAD model

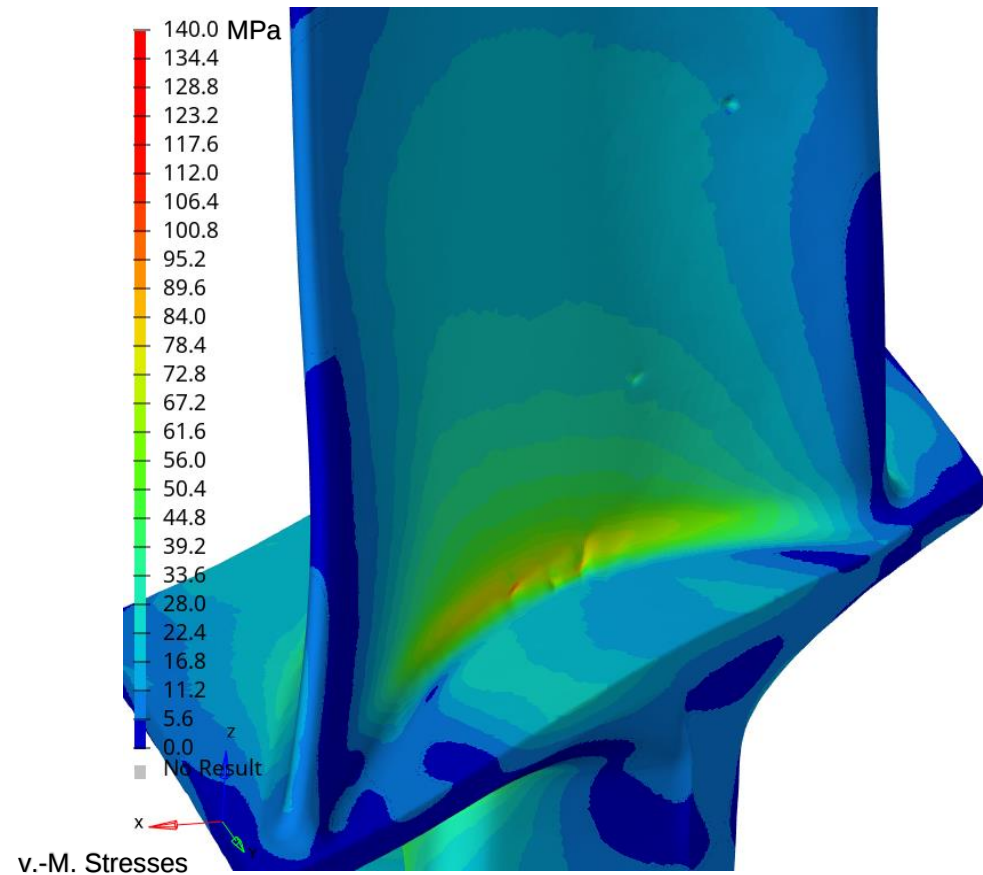


1. Approach: Outcome – Effects and Usability in CSM Simulations

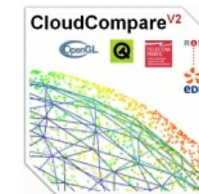
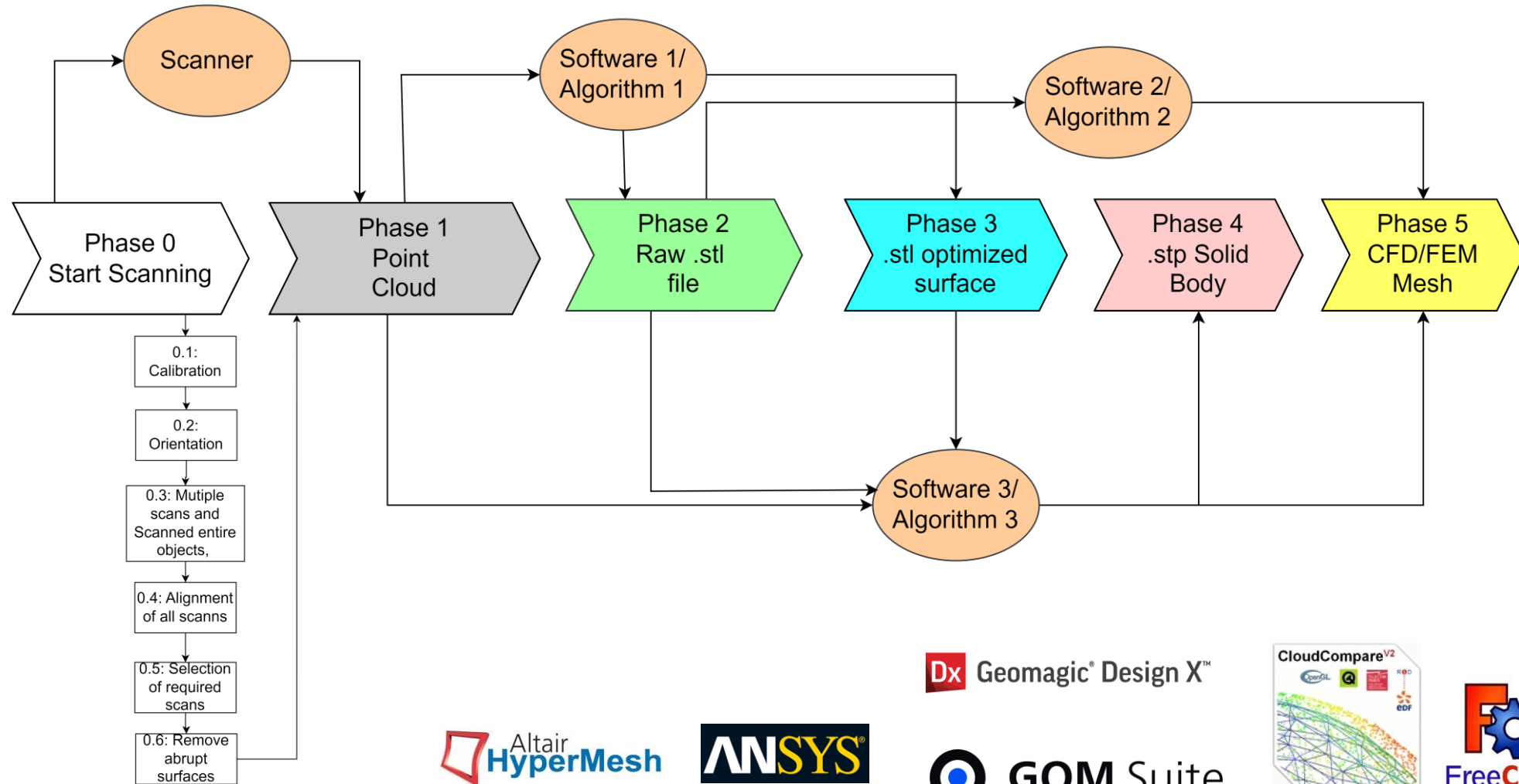
Ideal CAD model



Scanned CAD model

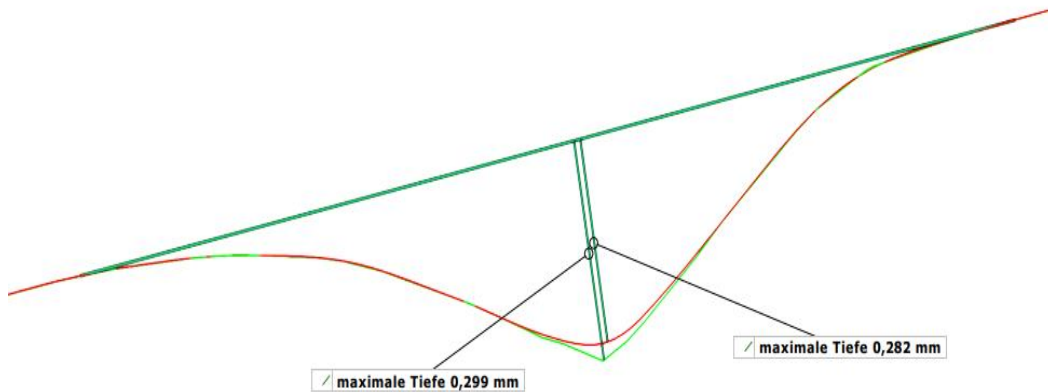


1. Approach : Process steps, 3D scan - CFD/FEM Mesh

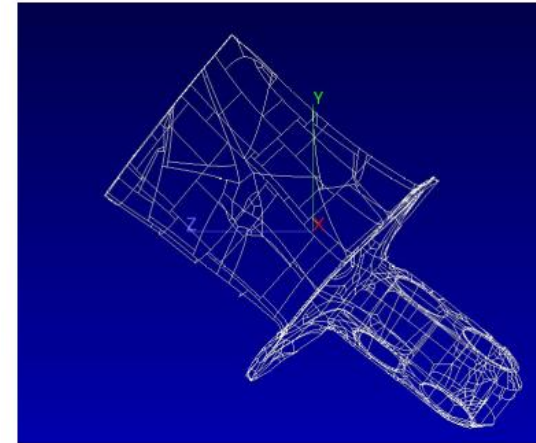


1. Approach: Comparison of Software and Scanners

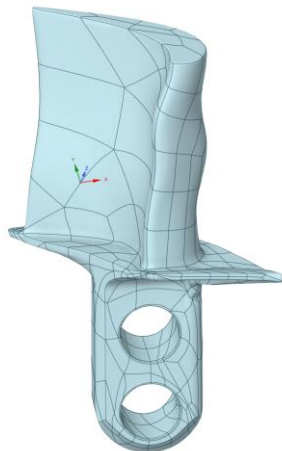
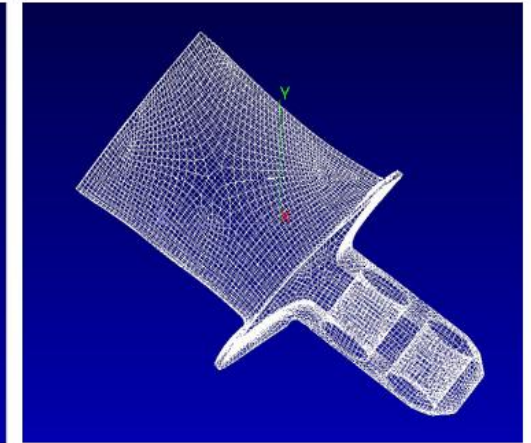
■ Reconstruction parameters and defects



764 panels



11017 panels



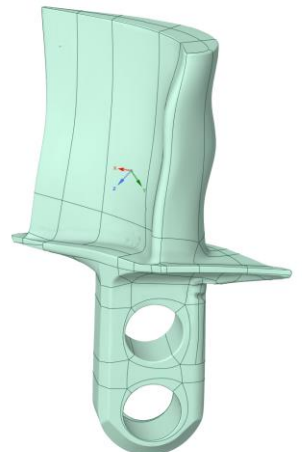
Scanner 1:

- No gaps and less noise in point cloud
- Less manual work
- Less Data points, less accurate

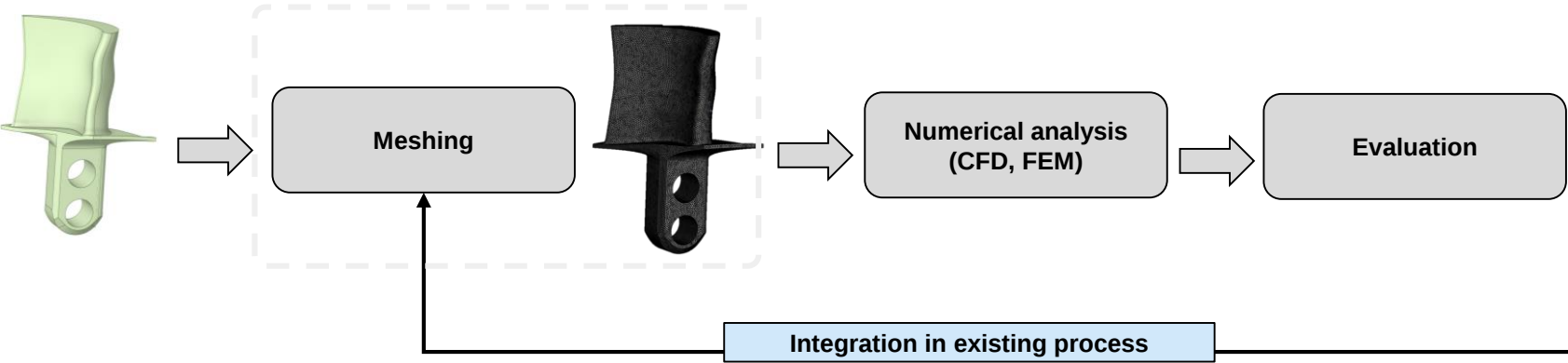
Scanner 2:

- Gaps and noise in point cloud
- More manual work
- More Data points, more accurate

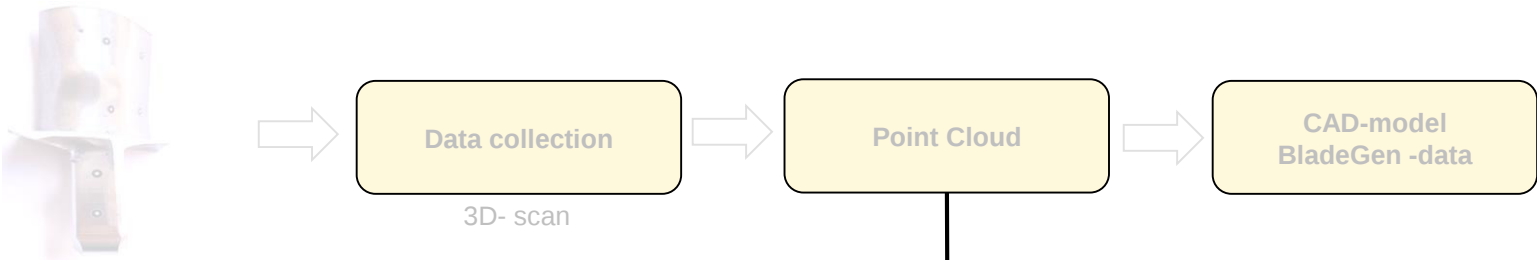
- No parametric CAD model



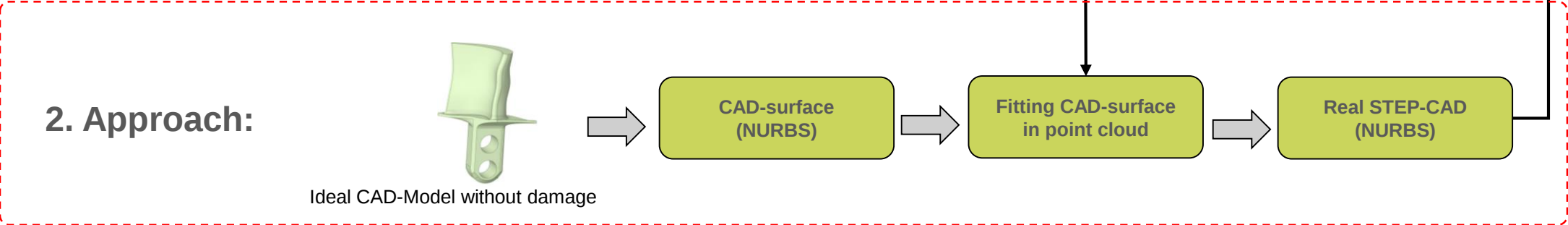
Current Process and Desired Process



1. Approach:



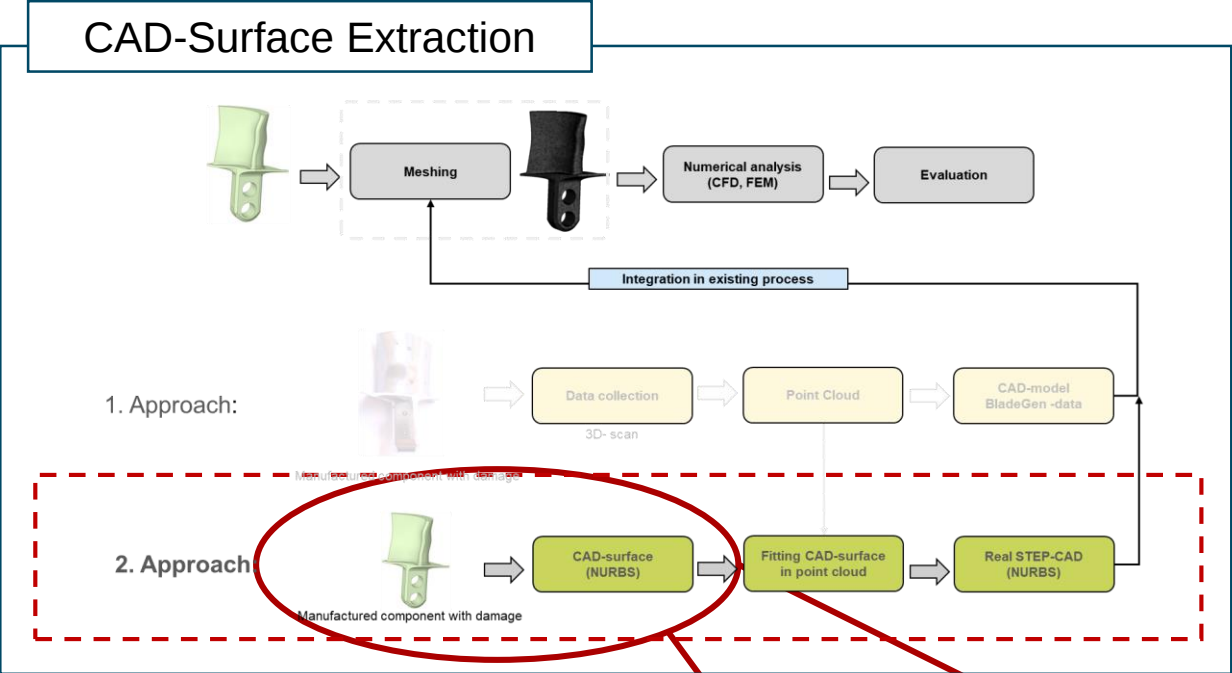
2. Approach:



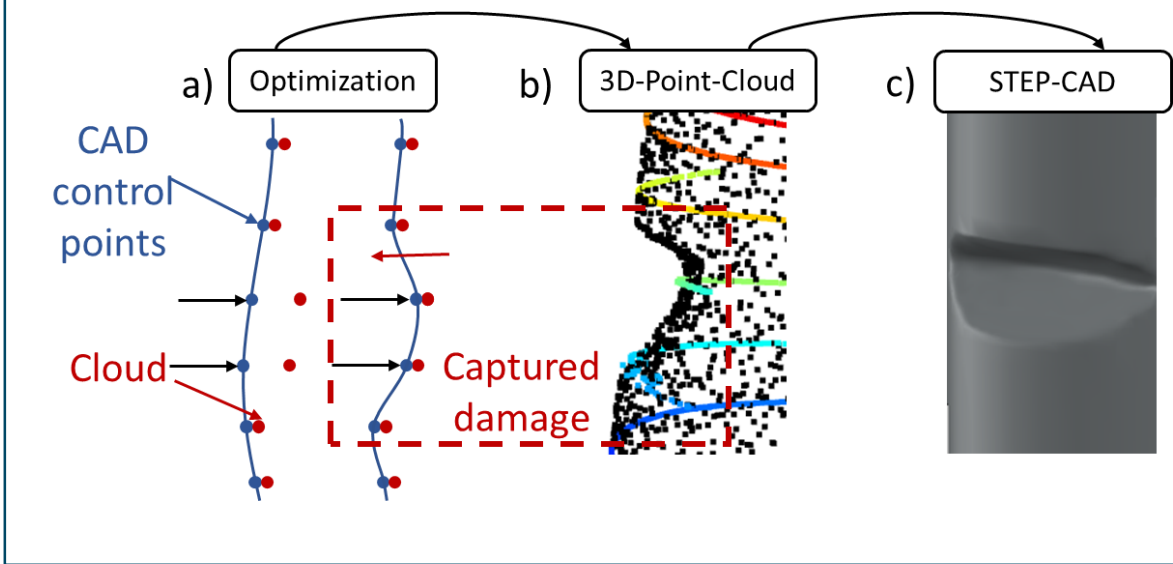
2. Approach



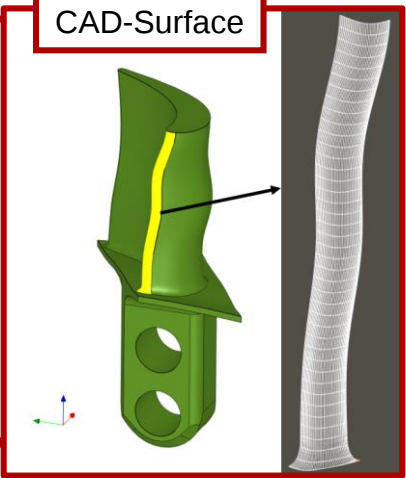
CAD-Surface Extraction



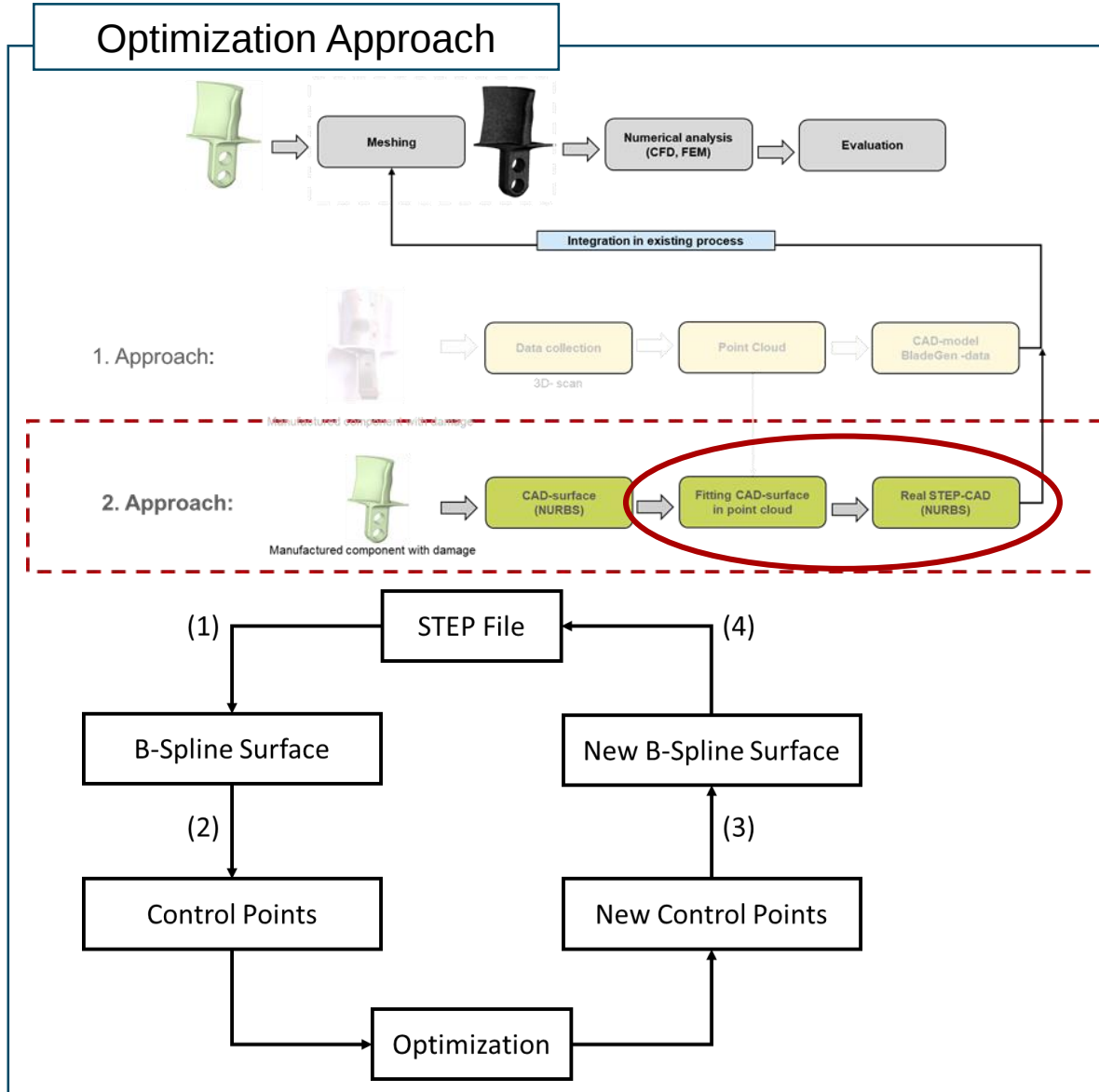
General Approach: Local CAD-Surface Adaptation



CAD-Surface

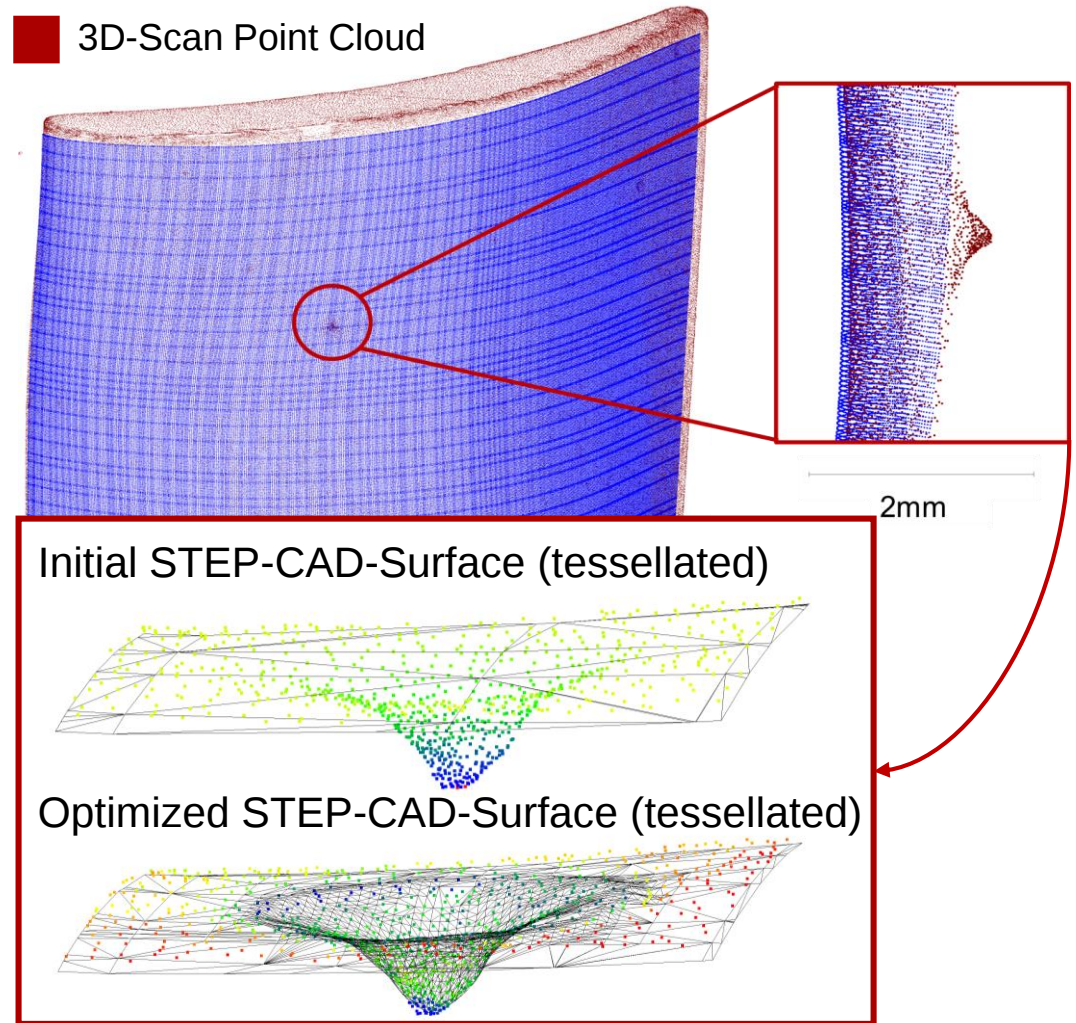


2. Approach

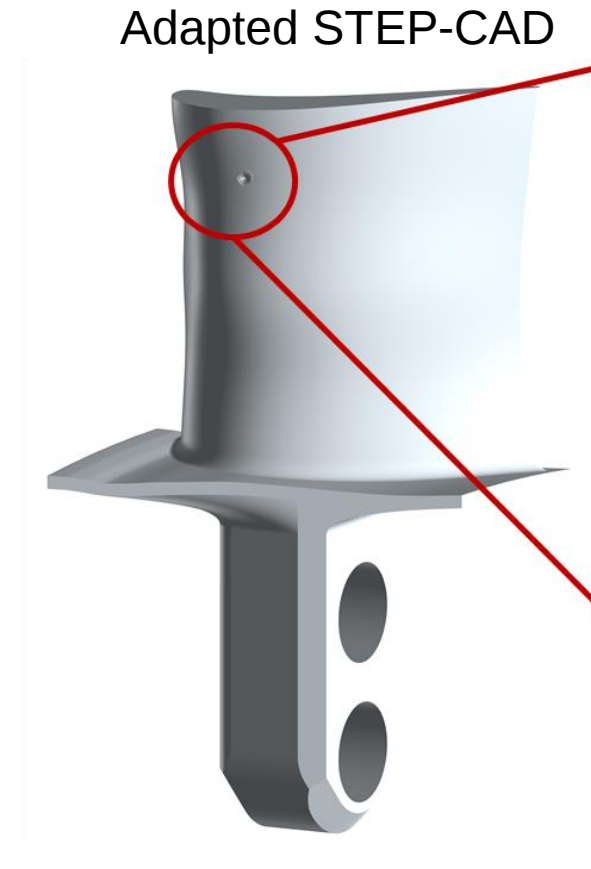
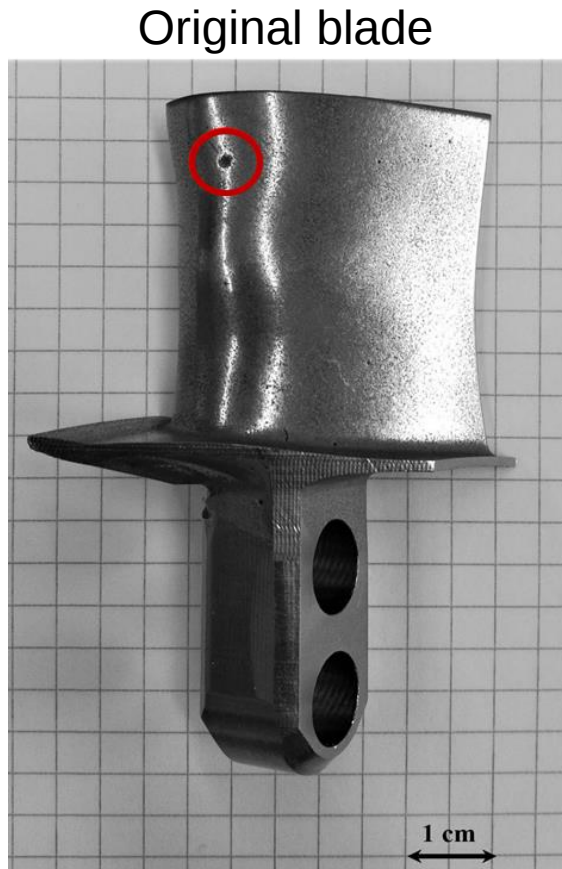


CAD-Surface Fitting

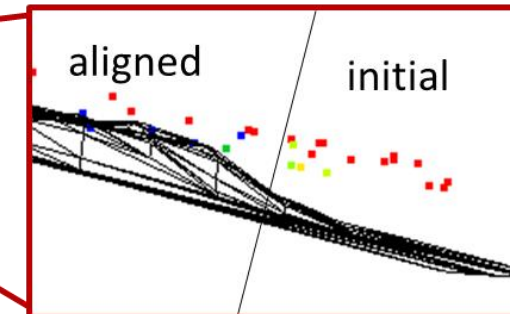
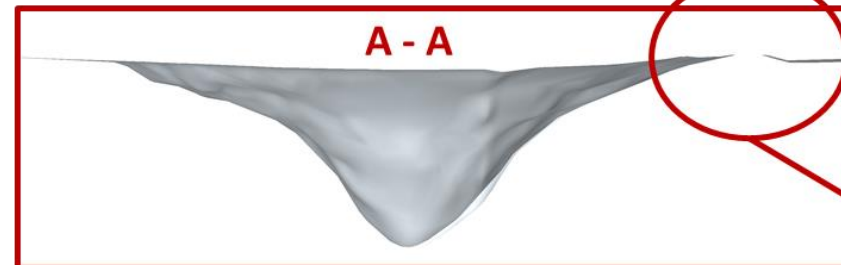
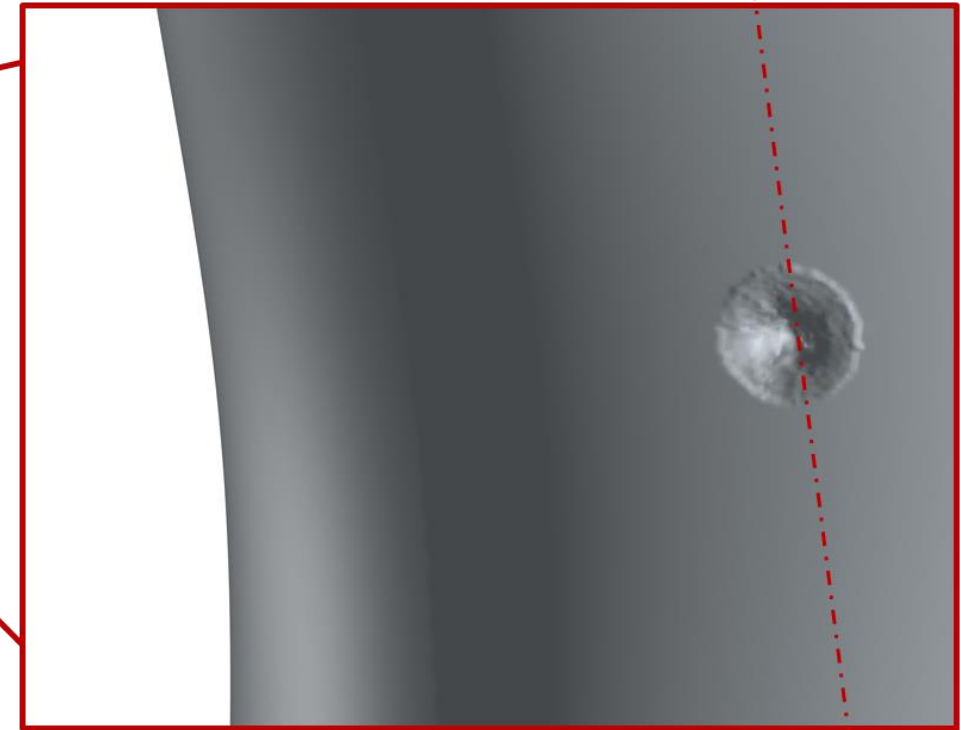
- CAD-Surface Control Points
- 3D-Scan Point Cloud



2. Approach: Results

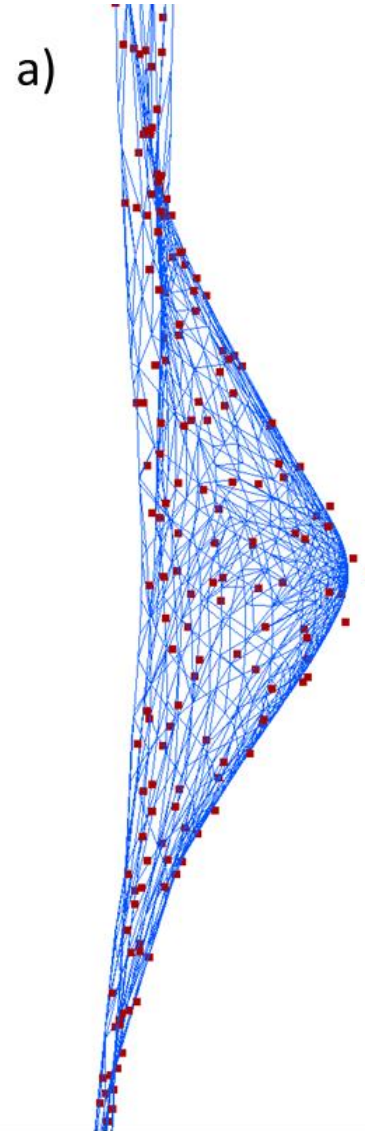


Locally fitted CAD-surface

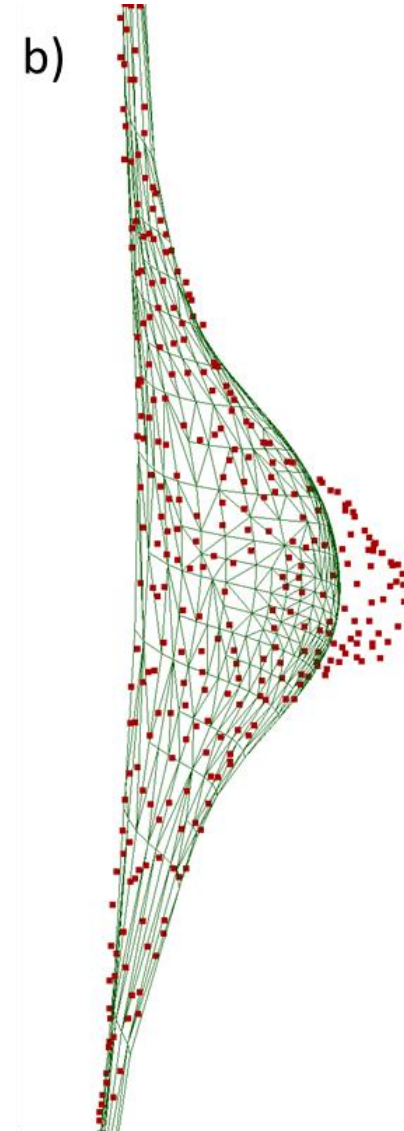


Compare of Results in Dent Area

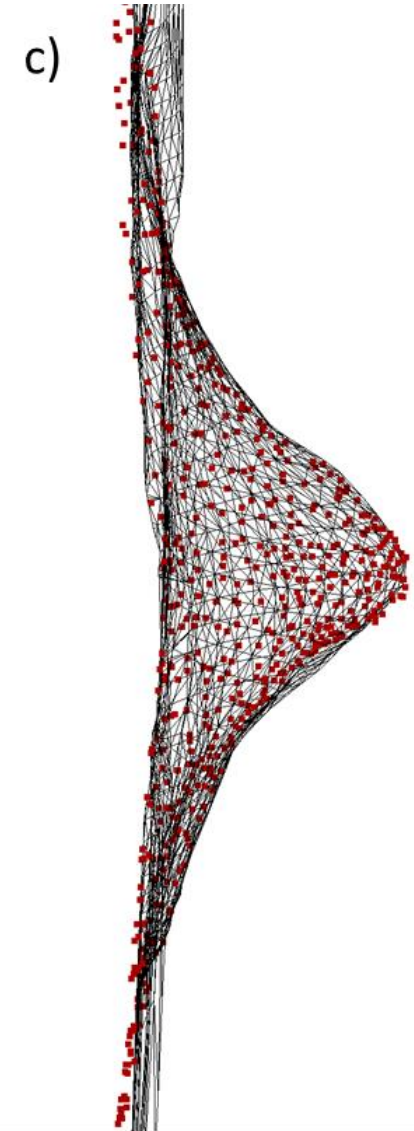
- a) Approach 1 and Scanner 1
- b) Approach 1 and Scanner 2
- c) Approach 2 and Scanner 2



Point Cloud: 287.822 points



Point Cloud: 794.369 points



Conclusion and Outlook

Approach 1

- Digital Component Twin is usable, further improvements required
- Improve conversion and area generation
- Improve usability of the output for specialist disciplines
- Routines for detail capture and accurate replication
- Find alternatives to additional commercial tools (e.g. OS software, e.g. existing CAD software, in-house developments, ...)
- Supplement optically non-scannable areas

Approach 2

- Creating Digital Component Twin with local CAD-Surface-Adaptation is possible
- Improve Pre-Processing alignment
- Testing the created CAD-data in simulation environments
- Extension to further damage classes with artificially created damages in CAD

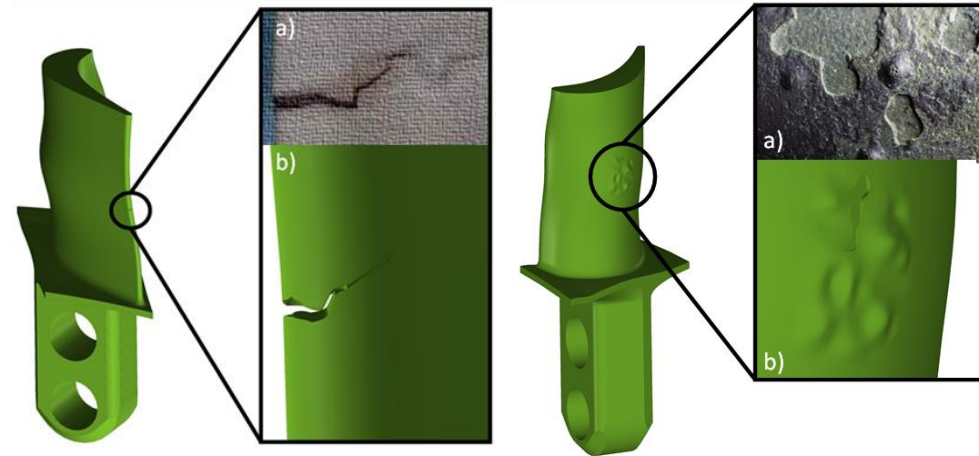


Fig. 1: Artificially created damage classes in CAD

Thank you for your attention!

DLR-PROJECT DigECAT: [HTTPS://WWW.DLR.DE/DE/KI/FORSCHUNG-TRANSFER/PROJEKTE/DIGECAT](https://www.dlr.de/de/ki/forschung-transfer/projekte/digecat)

✉ yogesh.chodvadiya@dlr.de

✉ paul.ebel@dlr.de

✉ eugen.grishchenko@tuhh.de

✉ alexander.kamtsiuris@dlr.de

☎ +49 8213198742114

☎ +49 711 6862 614

☎ +4940248941126

☎ +49 40 2489641 127

