“ When the physical world meets, uniquely, the virtual world for a premium manufacturing, maintenance, and repair approach of the next generation aircraft composite structures ”

GENEX CONTRIBUTION TO DIGITALIZATION OF AVIATION

Visual assistance system for manual composite scarf repair

14th EASN International, 11/10/2024, Thessaloniki

Jens Kosmann (DLR)

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About GENEX

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GENEX goals

New end-to-end digital framework for optimized manufacturing and maintenance of next generation aircraft composite structures

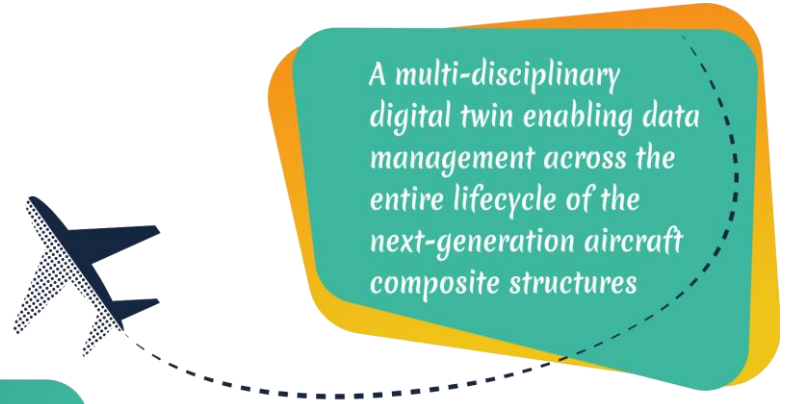
To produce **eco-efficient materials** and processes, monitoring systems, and numerical models supporting **advanced manufacturing** of composite aircraft components.

To invent a methodology built on **coupled physics -and data-based- algorithms** to improve the assessment of fatigue damage and residual life estimation of the aircraft structure under variable usage scenarios.

To develop **pioneering digital-based processes** and **tools** to optimize **maintenance** and **repair** operations while assisting the digital transformation of composite repair.

To create **a multi-disciplinary digital twin** of the aircraft component, rendering feasible a continuously updated model of the aircraft lifecycle.

What



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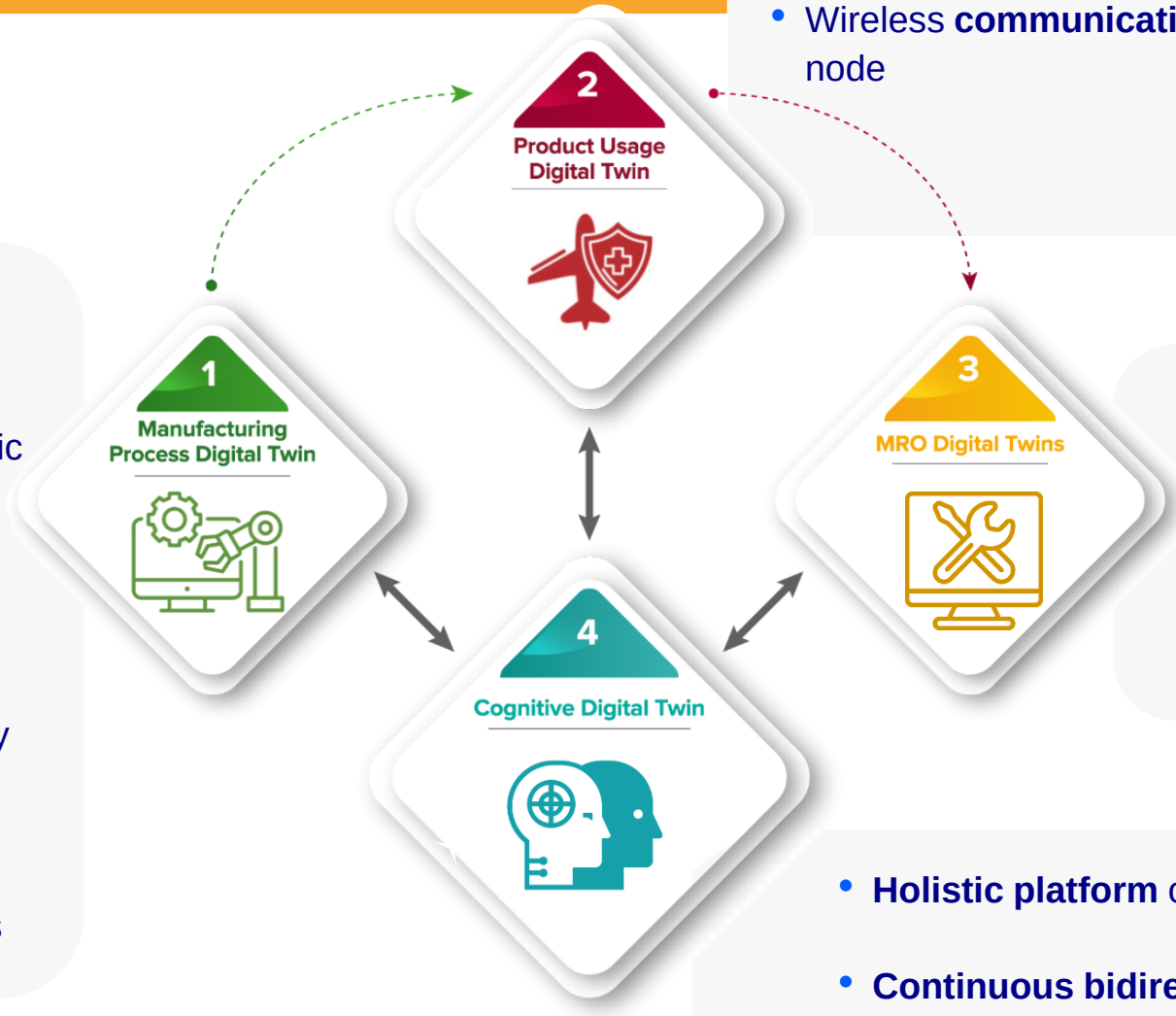
GENEX solution

1

- Recyclable **resin** with customizable Tg
- Embedded piezoelectric and FOS **sensors**
- Degree of curing **predictive models**
- In-line curing control by THz spectroscopy
- Digital twin of AFP manufacturing process

2

- MFC **sensor network**
- Wireless **communication** node
- **Multiphysics HPC simulation** for data generation
- **IA algorithms** for damage detection
- **Predictive models** for delamination growth



3

- **Augmented reality** for scarfing
- **LIBS** for surface cleaning
- Heating repair process **digital twin**
- **Smart** adhesive **bondlines**

4

- **Holistic platform** of integrated digital twins
- **Continuous bidirectional flux of information** through the component

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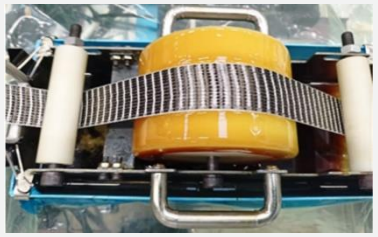
GENEX technologies

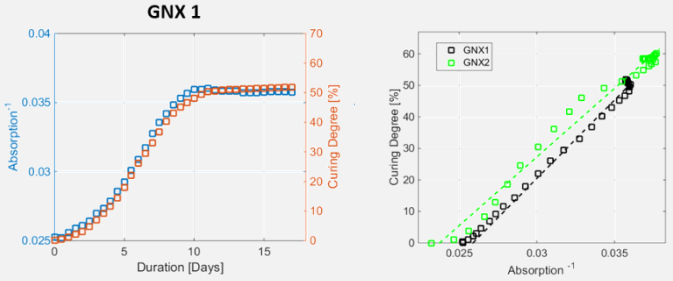
1
Manufacturing Process Digital Twin

CF-3R tapes with customized Tg



ATL process window

THz monitoring of DoC & DoCr

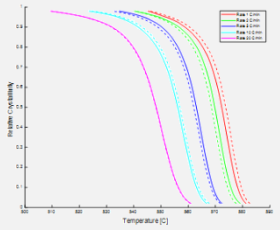


DoC & DoCr prediction

$$\frac{d\alpha}{dt} = f(t;\mathbf{p}) + \mathbf{g}(\mathbf{t};\mathbf{p})$$

Physics-based	✓	✗
Data-Driven	✗	✓
Hybrid	✓	✓

Hybrid model



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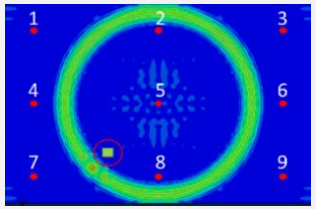
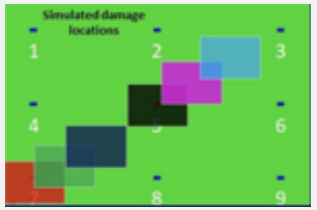
2
Product Usage Digital Twin

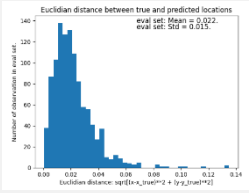
Validation

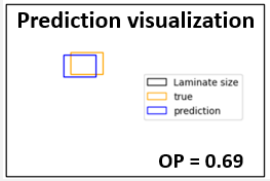
HPC - UGW Simulation



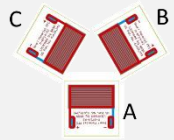


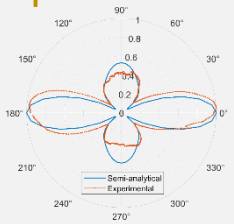
ML detection algorithms



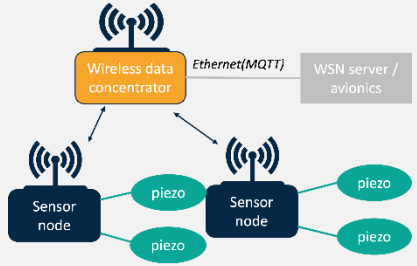


Sensor network optimization



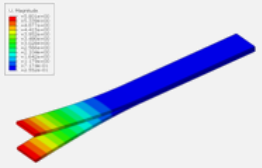


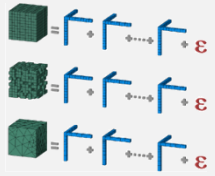
Wireless communication



Characterization

Fracture & Fatigue ROM model





Remaining useful life prediction

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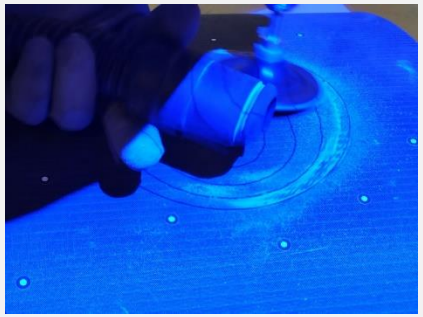
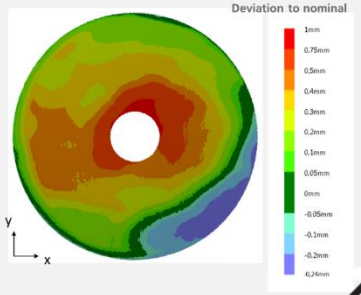
3
MRO Digital Twins

Visual assisted scarfing



Deviation of target



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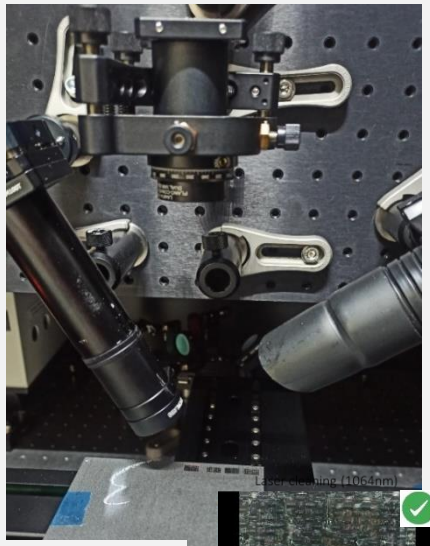
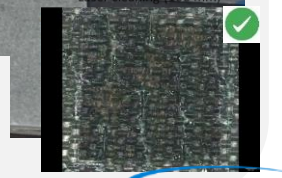
Portable LIBS cleaning system

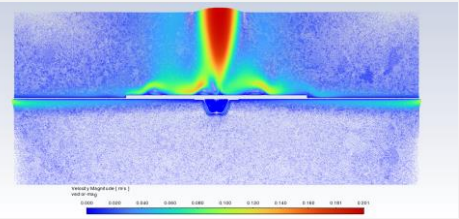


Laser cleaning



aimen CENTRO TECNOLÓGICO

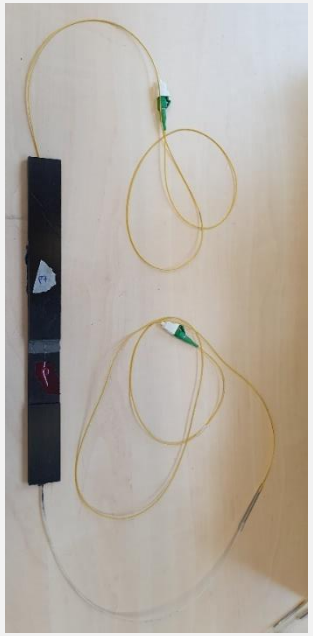
Online control of repair heating process



ita Instituto Tecnológico de Aragón

GMI AERO

Smart bondlines



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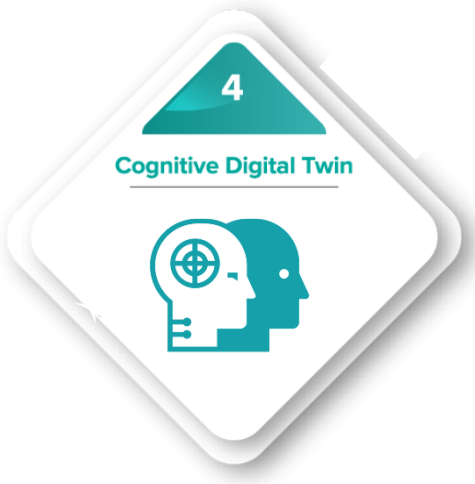

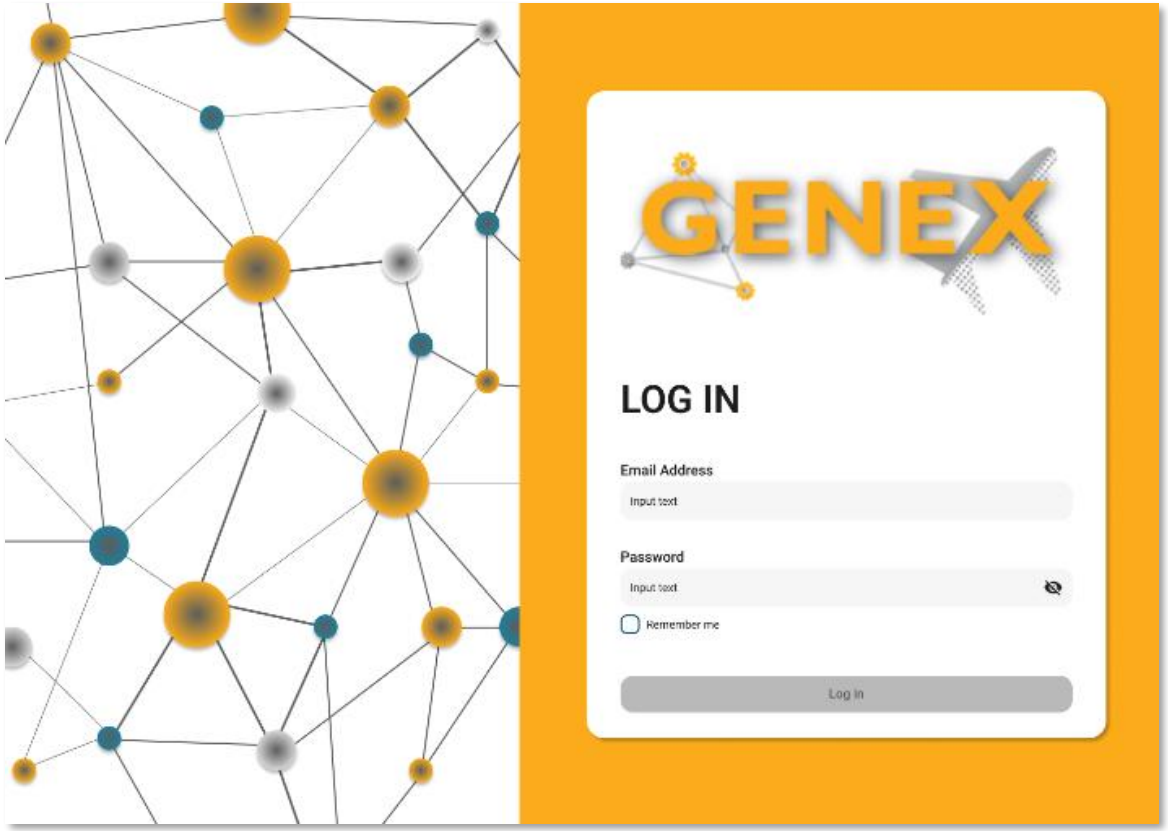

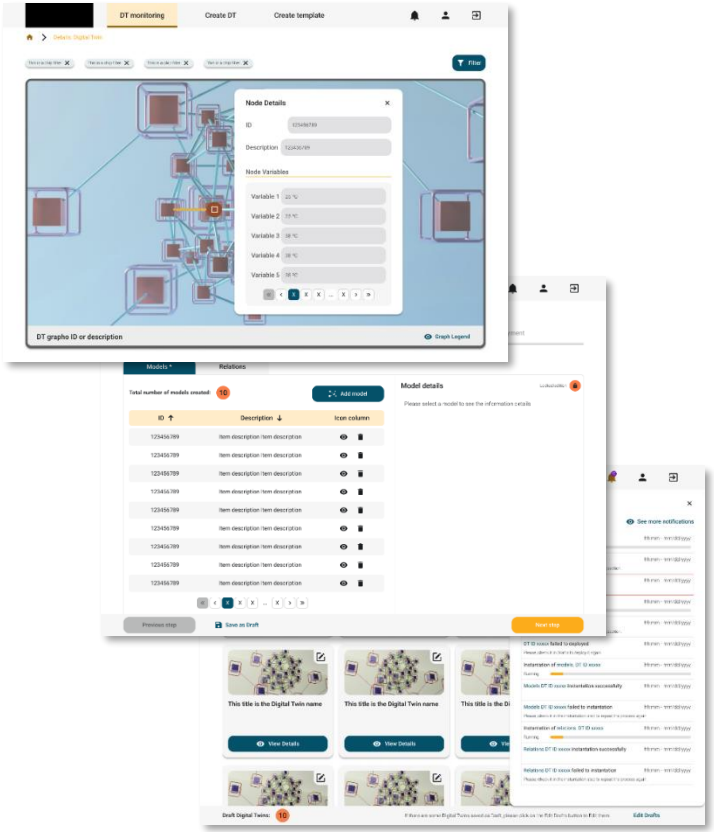

Capgemini engineering

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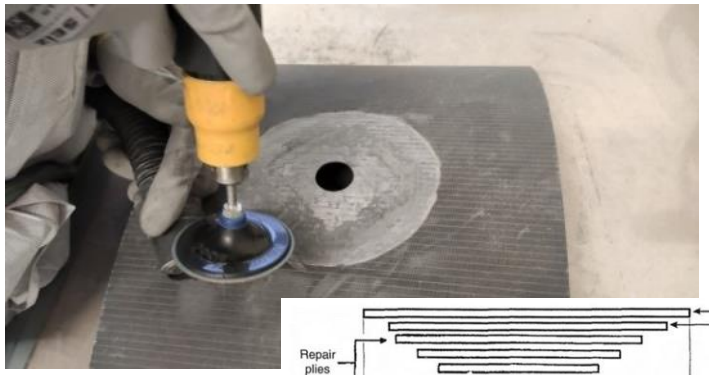
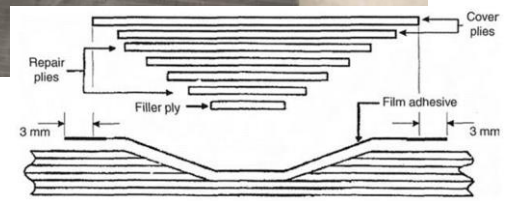
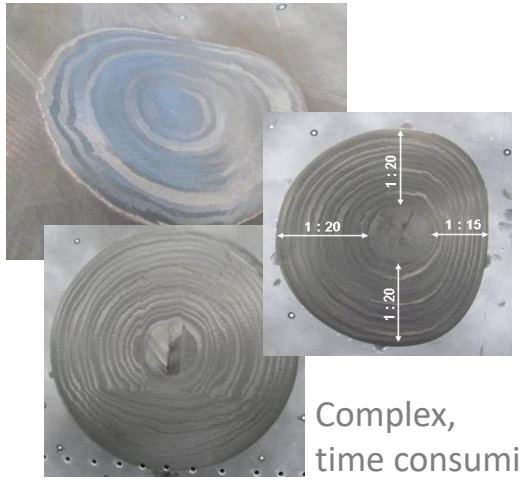
State of the art vs. Visual assisted Scarfing

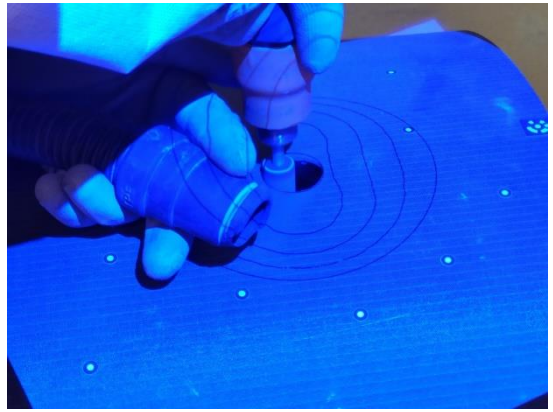




Manual scarfing



Complex,
time consuming,
High skilled experience



State of the art → **Genex**

Robotic Automation
- no business case
- high invest and labor costs

Assistance System for the laborer
- complex scarfs
- curved geometries
- Large repairs
- Support for additional processes

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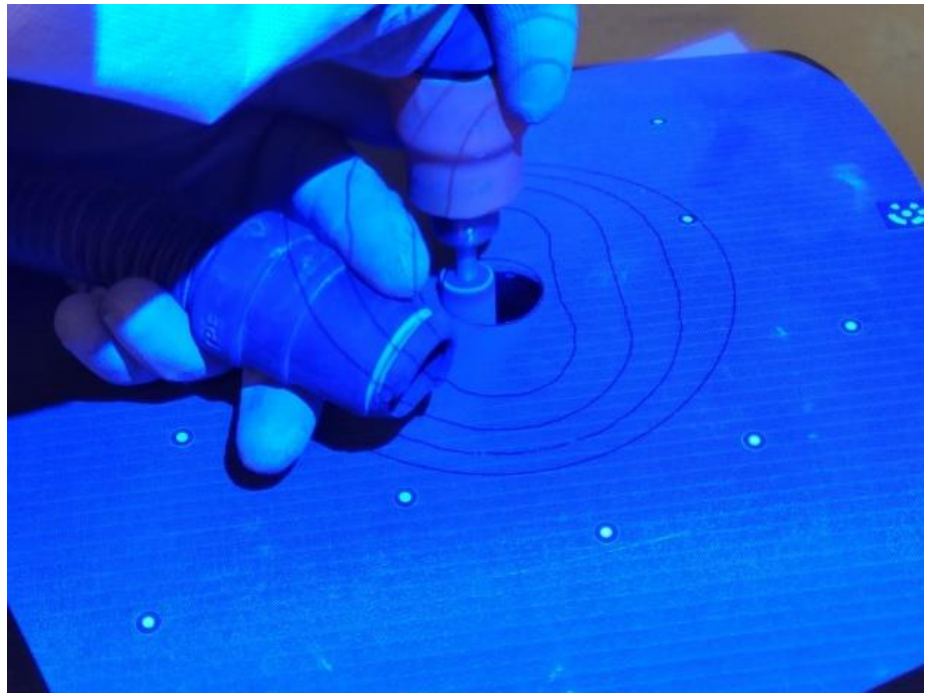
Goals for Visual assisted Scarfing

- Automated creation of the scarf geometry
- Needs to work on curved and complex geometries
- Must be easy to use
- Must be suitably for small and large repairs
- Support for additional processes
- Has to work in an on field environment



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Hardware - GOM ATOS Scanner

- 3D Scanning and projection in one system
- Industrial available system
  - Service around the world
- Dust proof housing for commercial use
- Mobile system for in field repair operation
- Flexible and adaptive software interface
- Suitable field of view for repair purposes
- Implemented augmented reality feature using USB Web Cam interface in Zeiss Software

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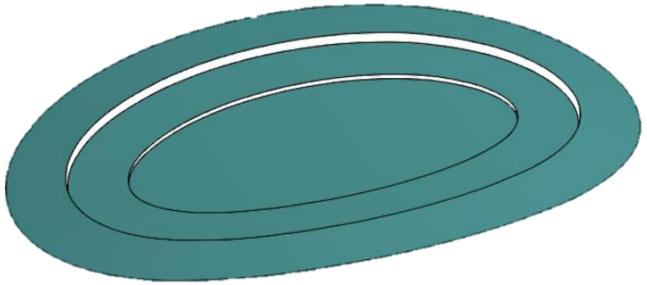
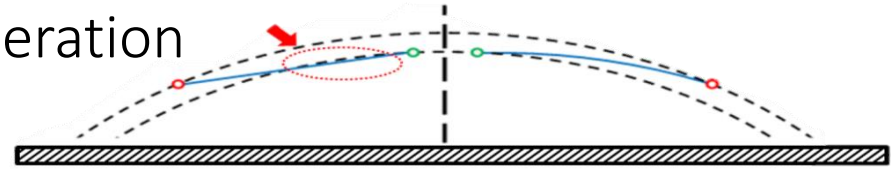
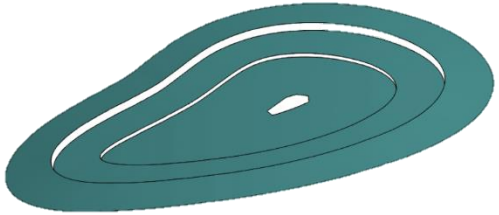
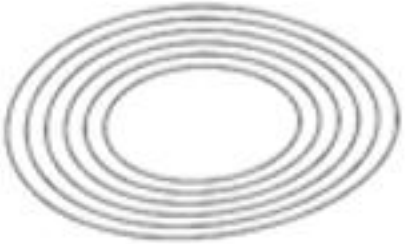
VAS - Software Interface

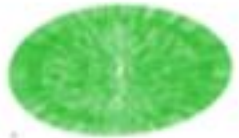
- High detail scarf contour using the original surface geometry
- Automated repetitive scanning and deviation analysis during scarfing
- Improved automatic scarf generation

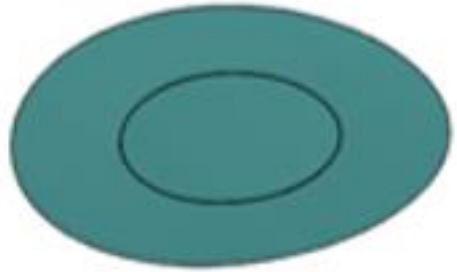












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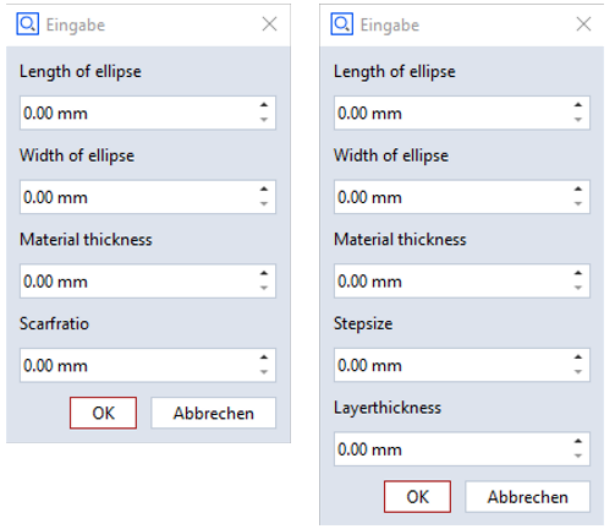
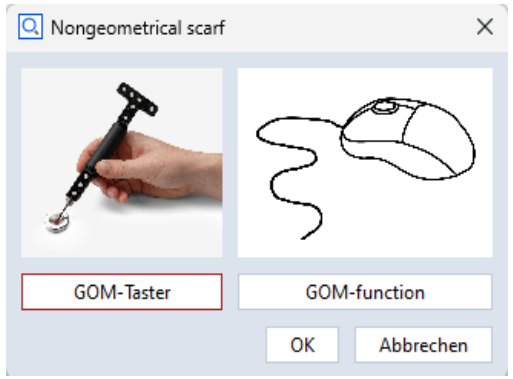
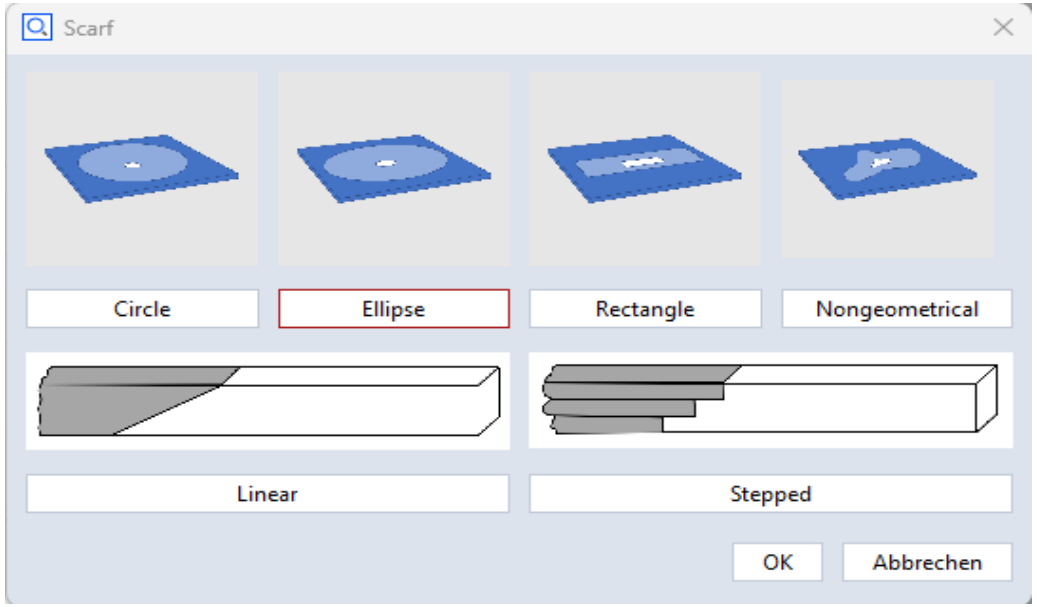
VAS - Software Interface

- Workflow assistance for different repair types
  - circlular; elliptical, rectangle and non geometrical
  - either linear or stepped
- User Interface for easy Usability







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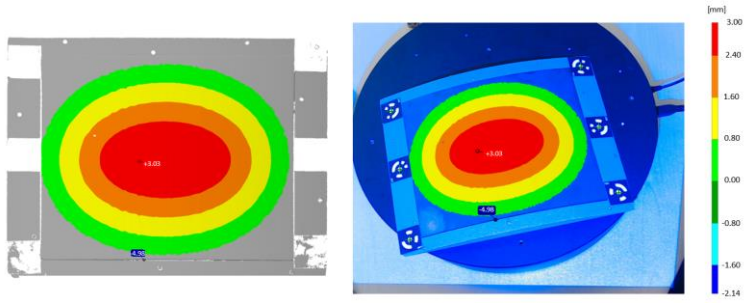
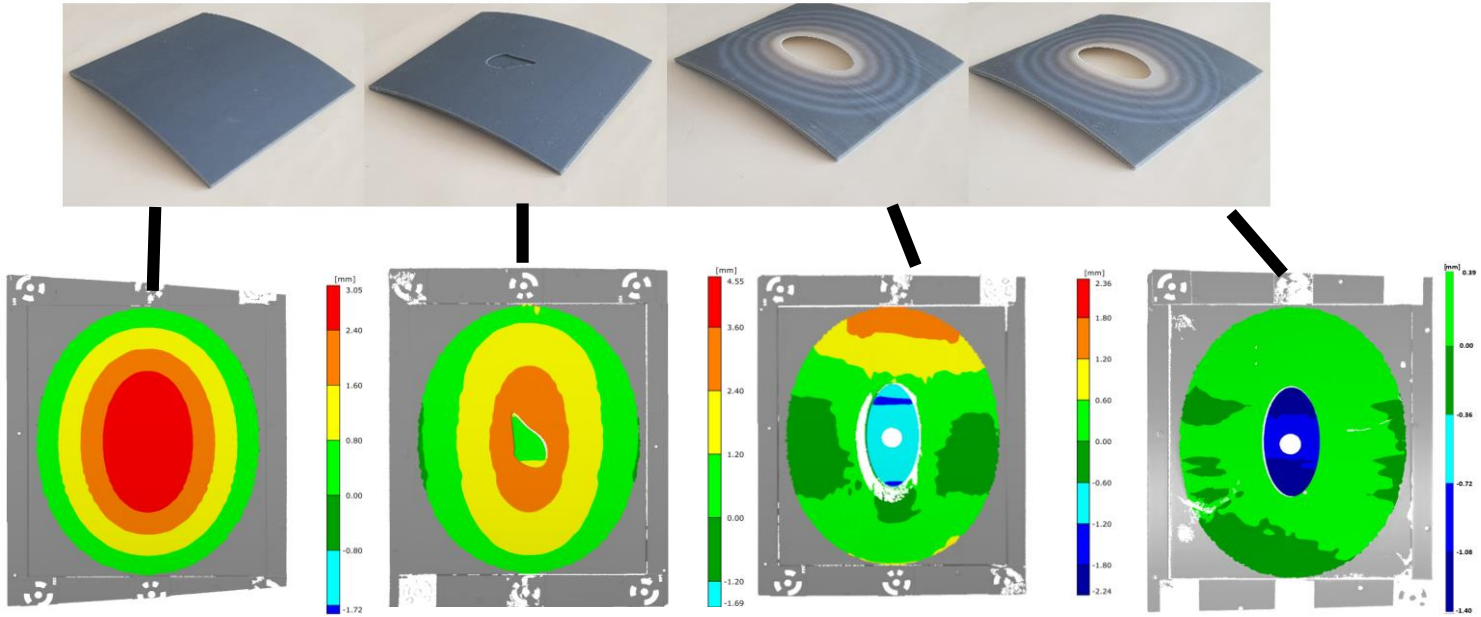
VAS - Lab-Scale test

- System trials and verification with predefined scarf structure
- Augmented reality usability test
- Real structure test with qualified personal is planned





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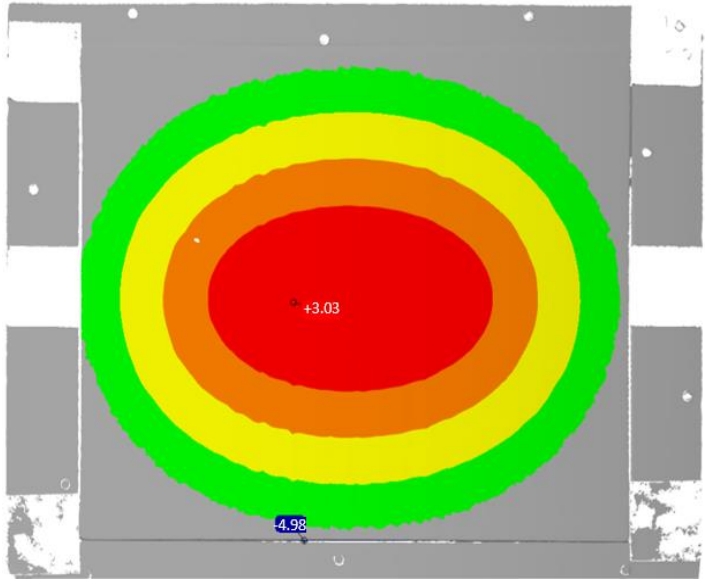
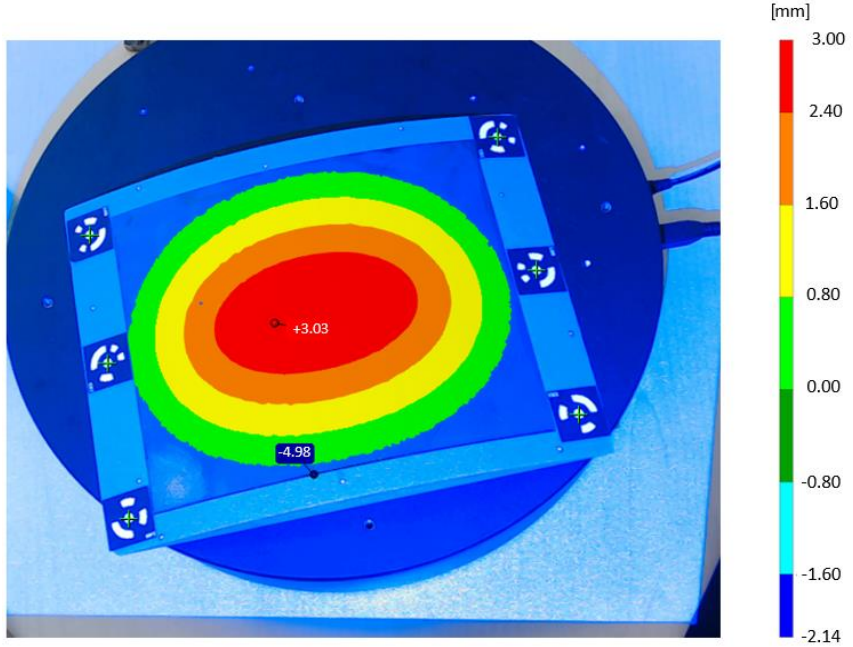
VAS - Comparison between different display results

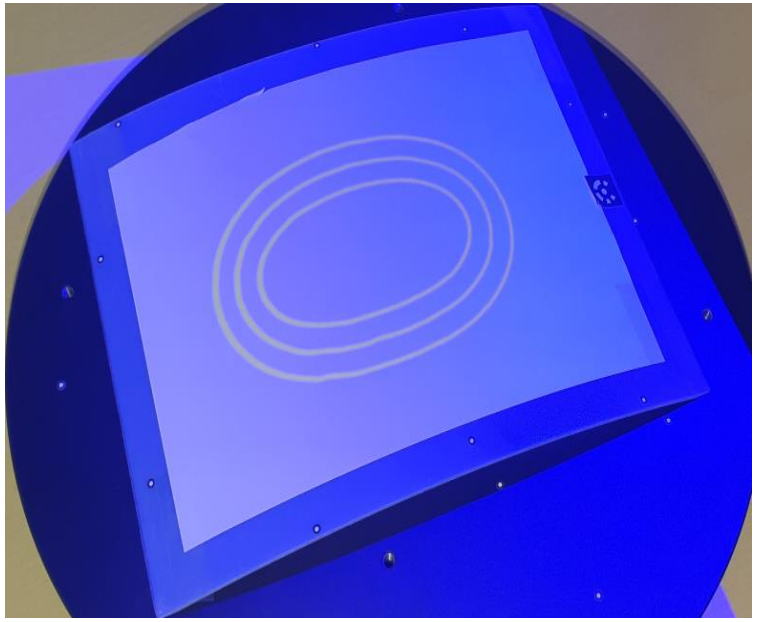
- Calculated deviation analysis



- Augmented reality view



- Projected results on original surface



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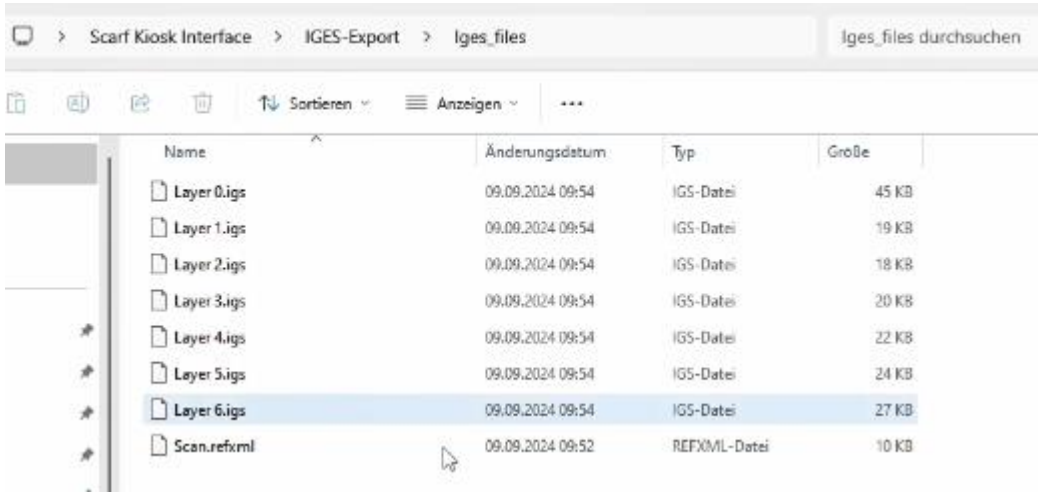
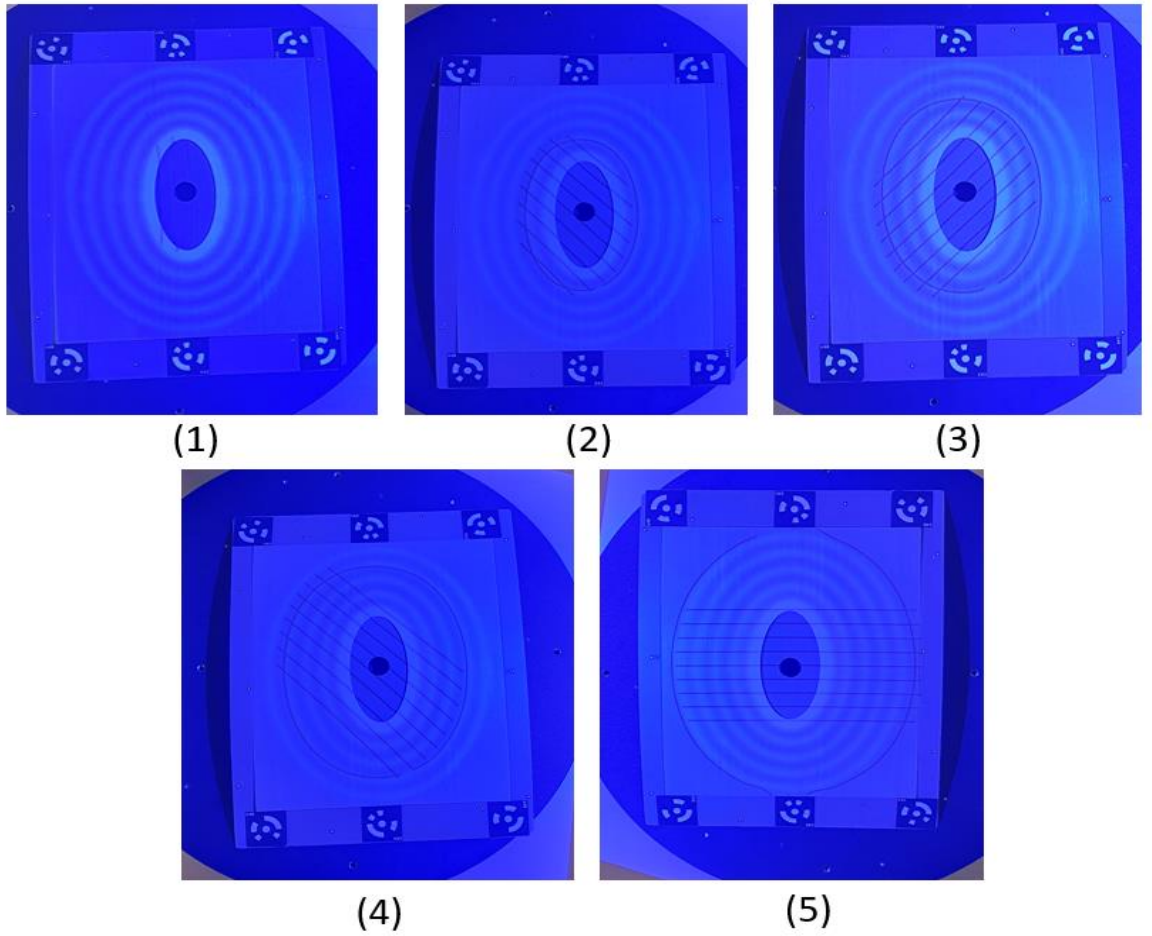
Visual assisted Repair patch placement feature

- Automated generation of Ply cutting files
- Visual assisted Repair patch placement feature
  - Orientation
  - Positioning
- Automated Data Uplink to Digital Twin and report generation





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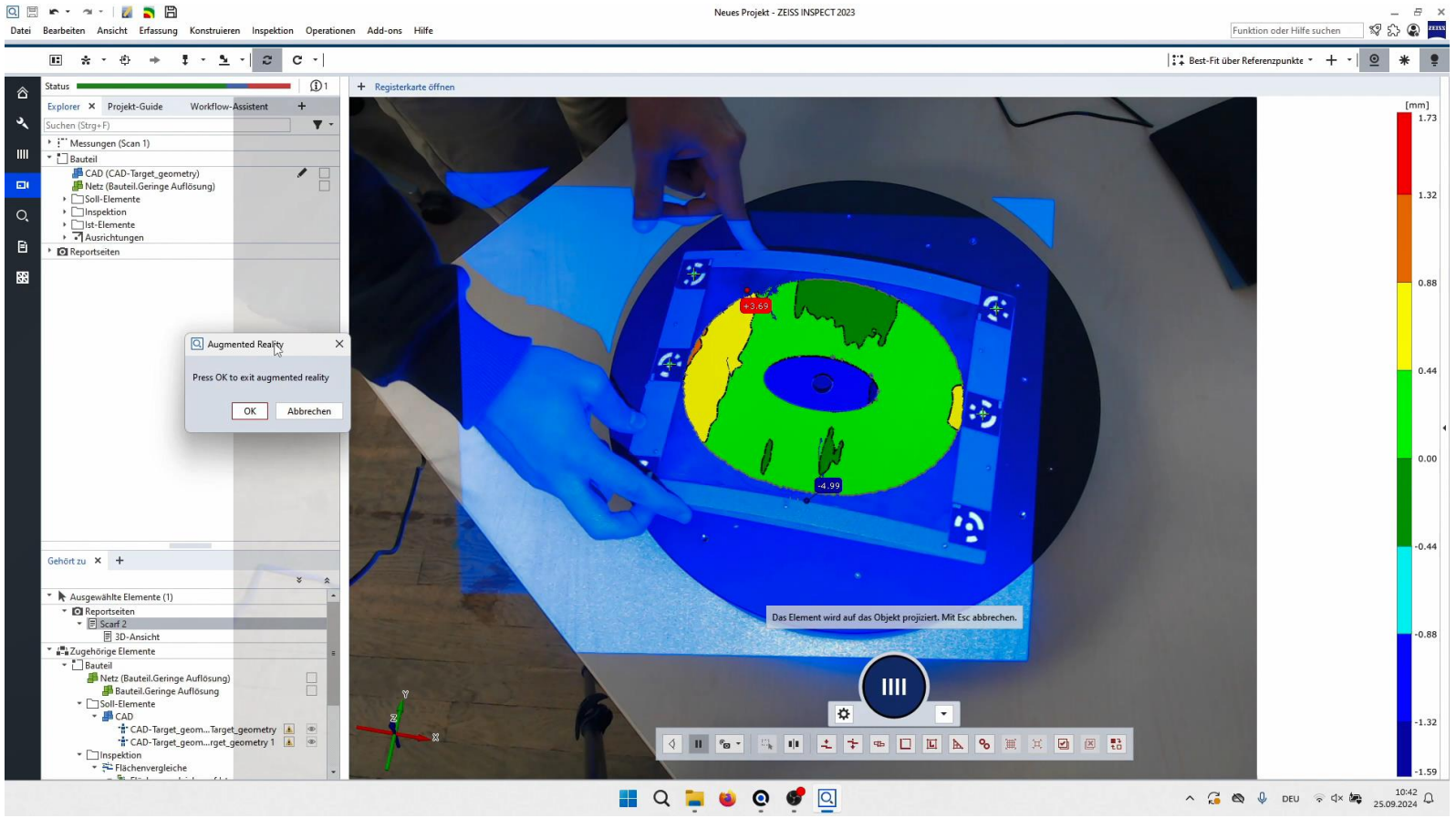
VAS System Live Demonstration



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GENEX technology transfer to the industry

GENEX industrial partners

AERnnova

ZIEGLER AEROSPACE

GMI AERO

Advisory board

EASA European Aviation Safety Agency

Lufthansa Technical Training

Guidelines for:

- MRO assessment
- Composite repair certification

LCA/LCC

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Conclusion

- Industrial of the shelf hardware with worldwide support
- Fully automatic Scarf contour generation based on original surface
- Fully integrate User Interface
- Augmented reality ready
- First Labs scale test are successful
- Real structure tests are planned

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THANK YOU!

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