Internal damage detection in wind turbine blades using an autonomous Aerial Radiography System

SpectX

Delftechpark 11 | 2628 XJ Delft | The Netherlands | www.spectx.nl | info@spectx.nl

ABOUT US

- Developing a solution for autonomous radiography inspection for internal damage detection in wind turbine blades.

- Using 2 synchronized drones and 3D AI fault detection.
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- Takes 2D X-ray radiographs of the composite blade structure and post-processes them in 3D.

SPECTX TECHNOLOGY

A digital radiography system integrated on synchronized UAV's for internal damage detection

SPECTX TECHNOLOGY

- Complete integrated system designed to detect structural internal defects such as delamination, debonding and cracks.

- The solution is built on the pillars of 4 technologies:
  1. Aerial positioning & synchronization
  2. Active control system / Robotic motion compensator
  3. Radiography control
  4. Image enhancement & processing

SPECTX TECHNOLOGY

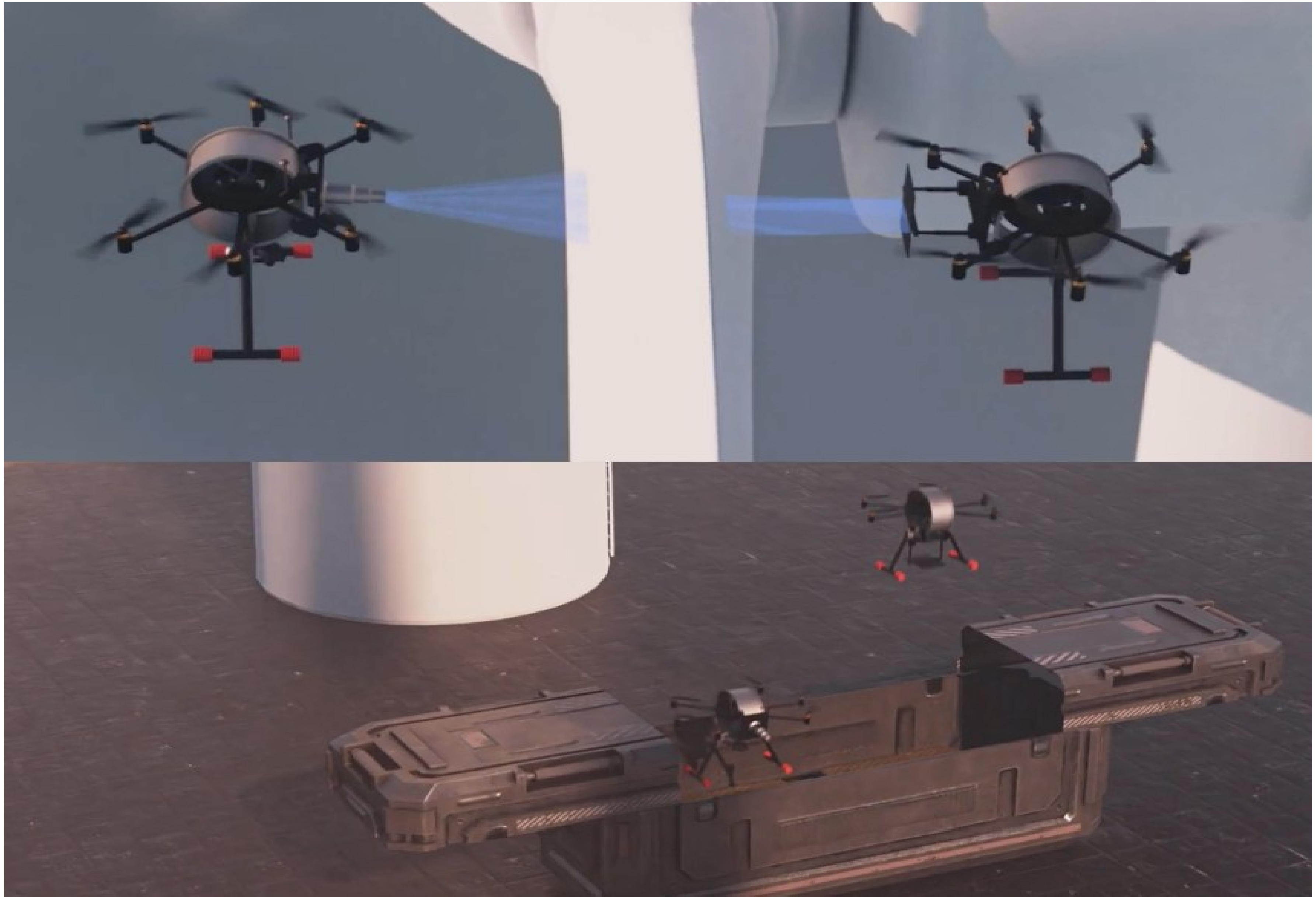
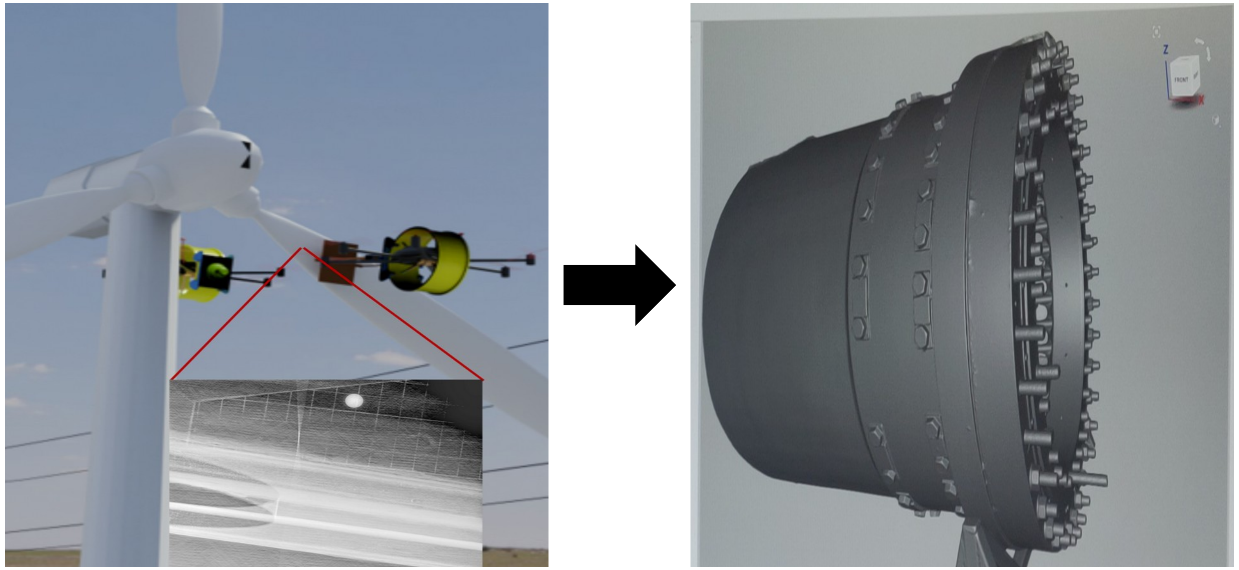


IMAGE ENHANCEMENT & PROCESSING

- After receiving blade X-ray scans, delicately produced via aerial radiography, the data would be sent for image processing and defect detection procedures.
- Our NDT defect detection approach would be carried out over a 3D tomographic reconstruction of the blade model from the 2D X-ray scans.
- A Generative Adversarial Network (GAN) is designed and trained to correct tomographic images using Simultaneous Algebraic Reconstruction Technique (SART), to reconstruct tomographic images.



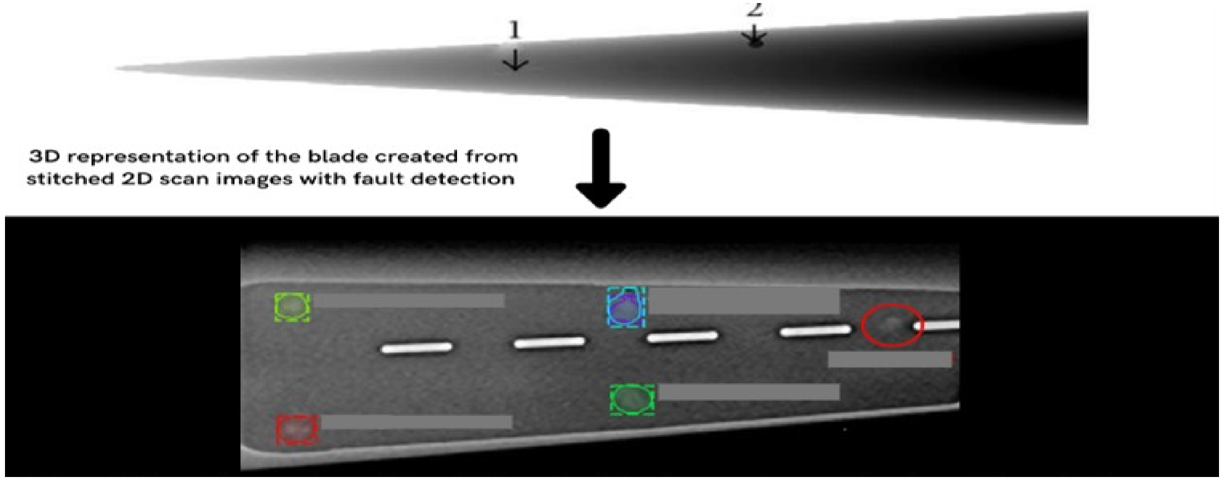


IMAGE ENHANCEMENT & PROCESSING

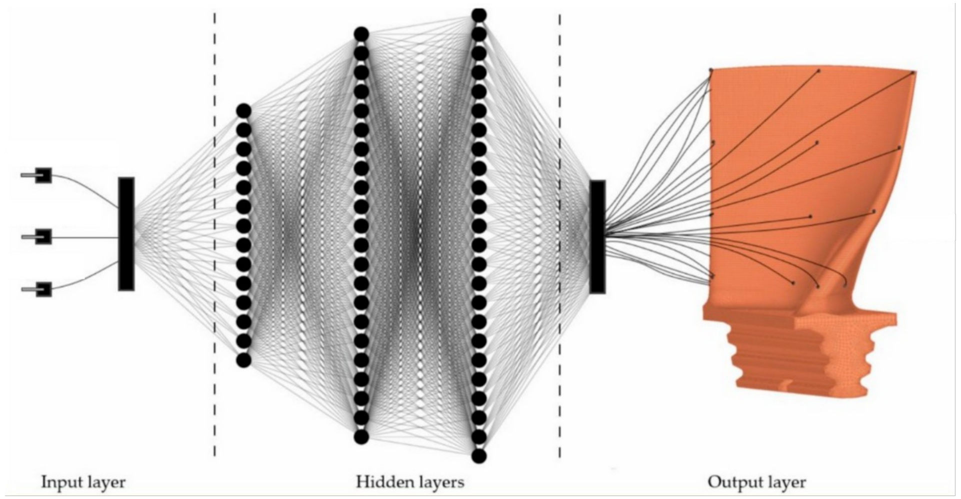
- The network is trained on a mixed dataset of varying-dose, sparse-view, limited-angle and distorted data, and employed as a signal prior to the iterations of SART.

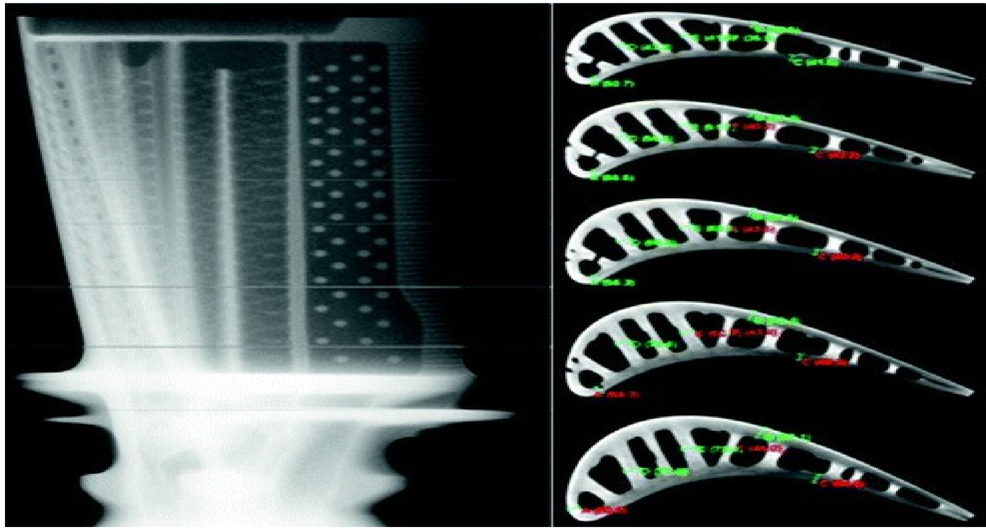
- The purpose of this stage would be to output the precise 3D radiographic model of the blade including even the slightest traces of internal anomalies signified in a high- resolution model.

- 3D radiographic representation of the blade would then be used as input for the 3D defect detection system.

FAULT DETECTION

- Composite material-based blade defect abnormality manifests in various forms and severity and is not easily representable in the visible structure of the blade. Blade defects are multidimensional and vary with type and severity.
- Our 3D defect detection method will be built to distinguish different abnormalities for various internal structural defects.
- A deep Convolutional Neural Network (CNN) will better represent the internal abnormalities from 3D radiographic volumetric data compared to the 2D radiographs.

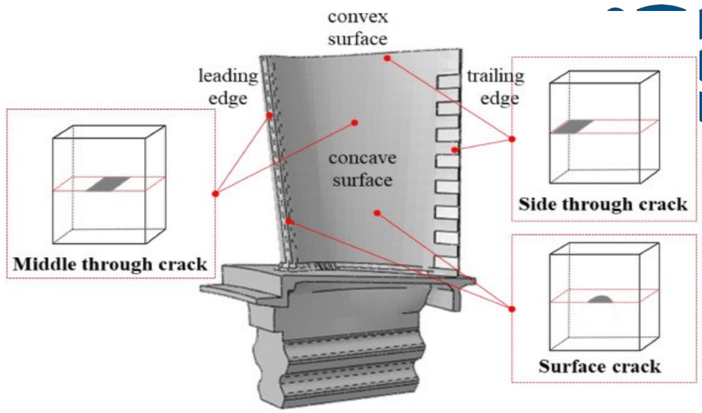




Source: https://link.springer.com/chapter/10.1007/978-3-319-59573-3_9/

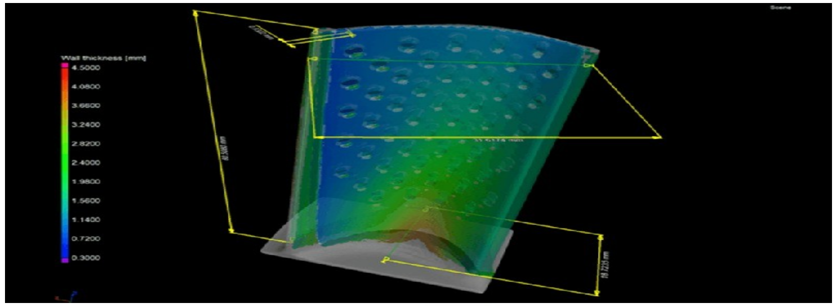
Source: https://www.researchgate.net/figure/Tomograms-of-Turbine-blade-at-different-locations-selected-from-DR_fig2_237362902

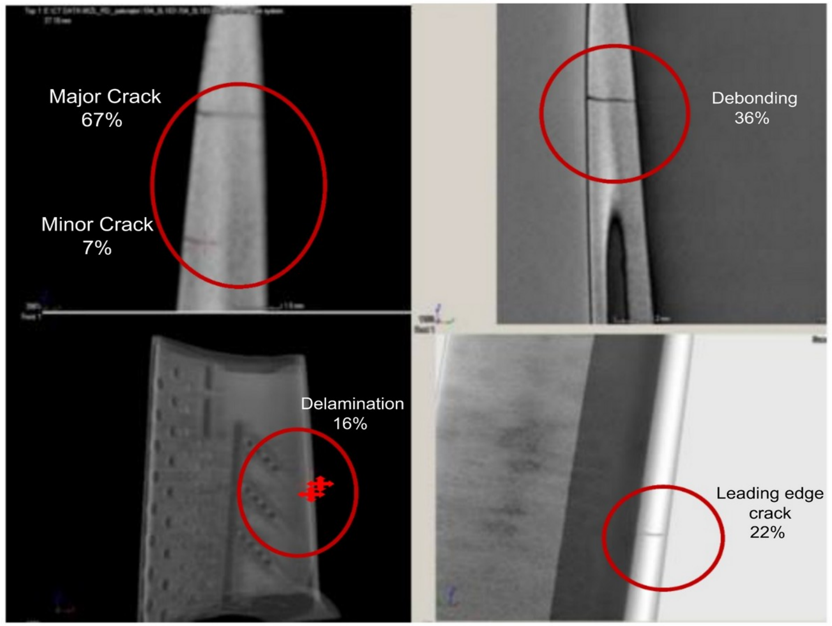
FAULT DETECTION



- Construct a 3D CNN architecture specifically designed and trained for detecting various types of internal defects common for wind turbine blade composite material structure.

- The preprocessing stage of the data is carried out via specifically designed kernels in convolutional steps all designed for signifying various types of defects in volumetric radiographic data.





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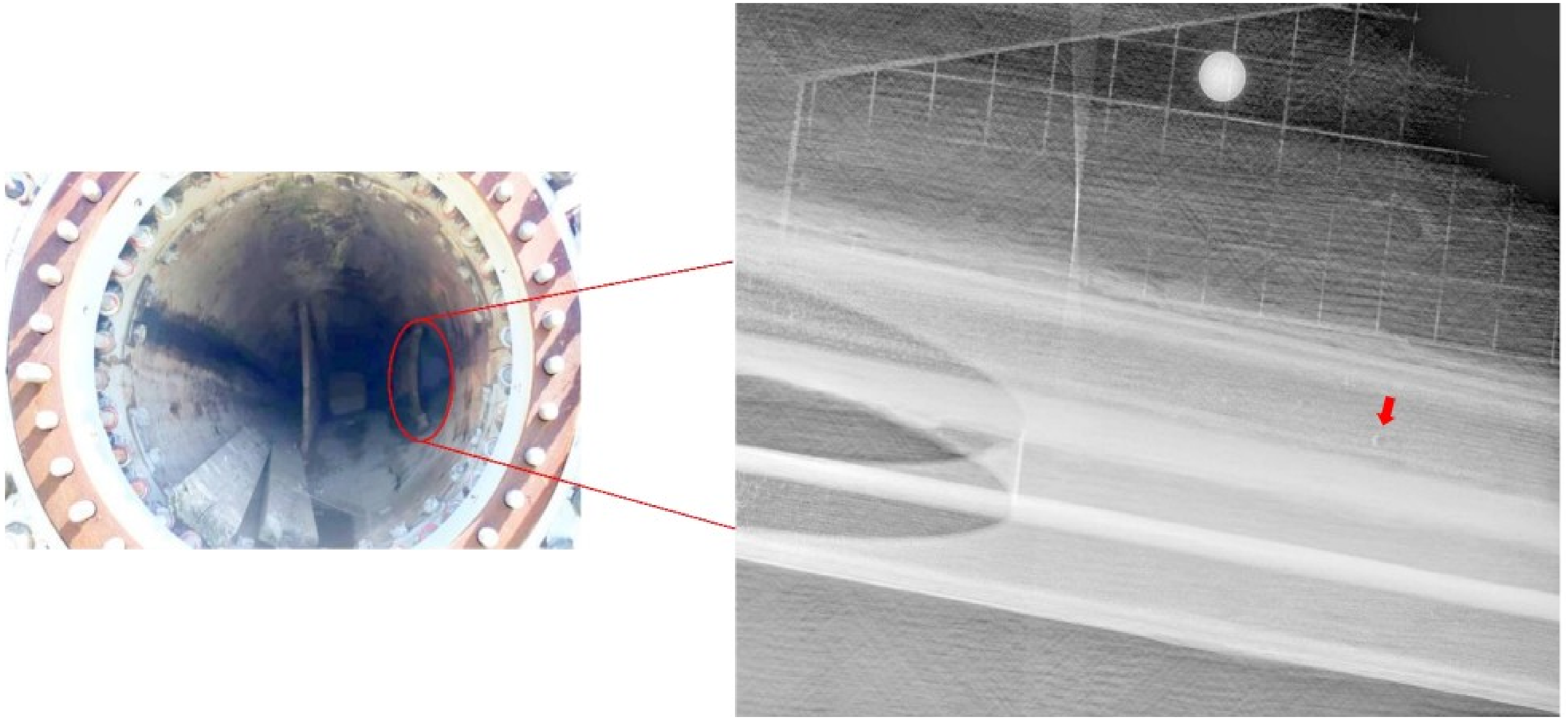
FEASIBILITY TEST

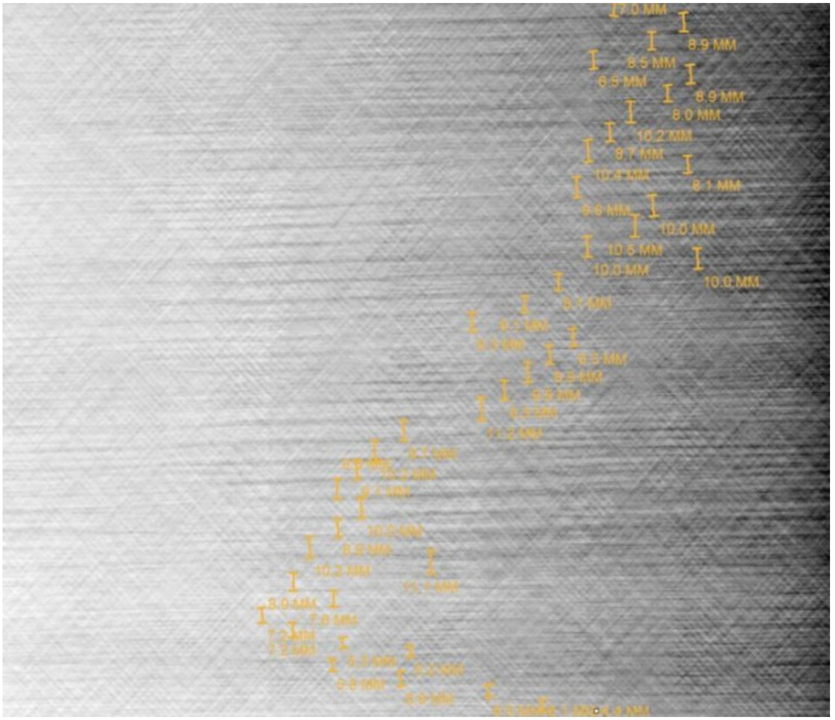
- Collaboration between WyndTek, NLR – Royal Netherlands Aerospace Agency & DreNDT Industries through the World Class Maintenance, AIRTuB Project.

FEASIBILITY TEST

- A portable Digital Radiography system is capable of penetrating through the bulk of a 22m wind turbine blade made up of composite GFRP material.

FEASIBILITY TEST RESULTS

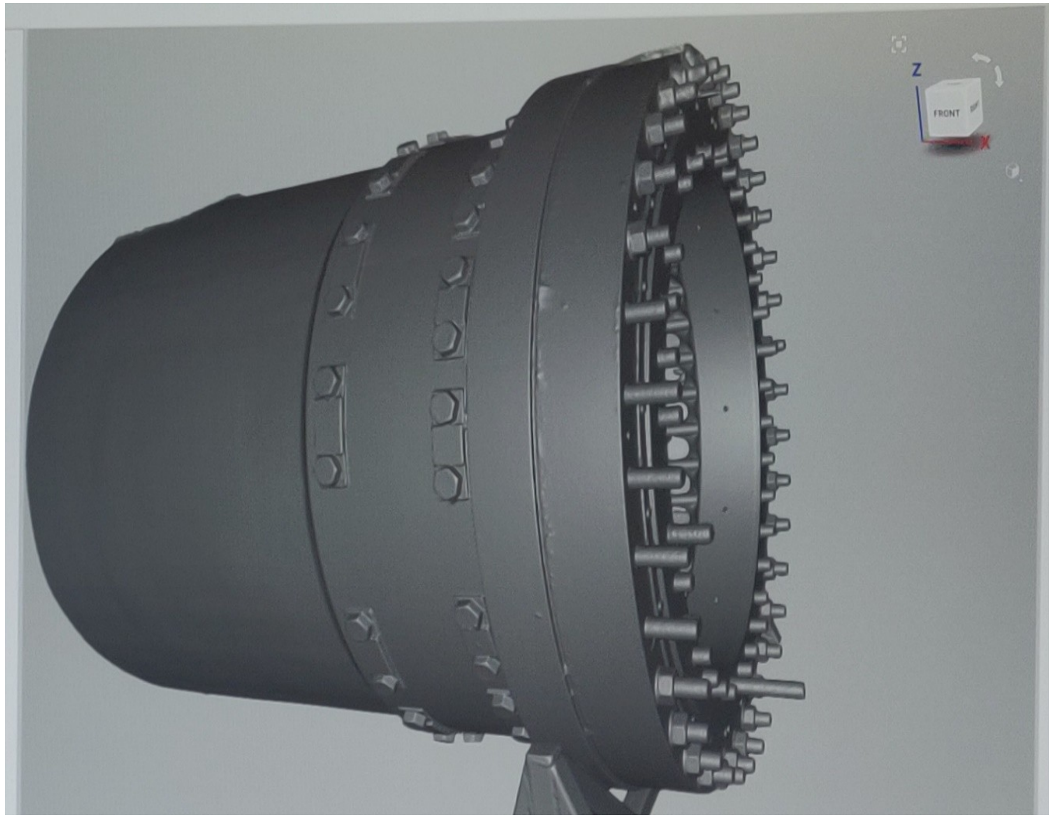




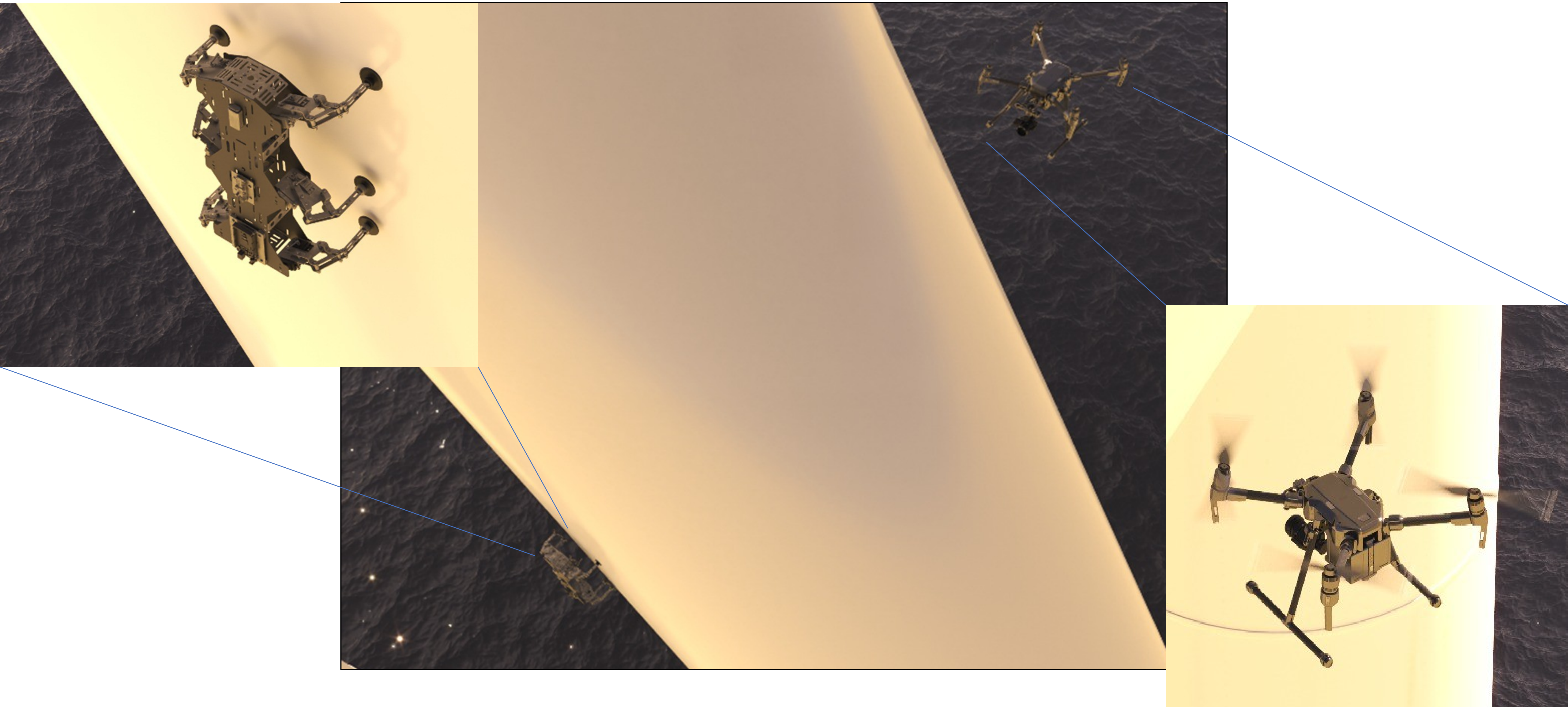
- Blind hole detected in the bulk of the left shear web structure
- The multidirectional layered fibre's stacked on top of each other seen in the radiographs
- The distance between the individual composite glass fiber layers can be computed
- Delamination defects can be possibly detected by scanning 360° around the bulk blade structure and stitching the 2D scans to make 3D radiograph models

LIDAR SCANNING

- LiDAR scanning of turbine blades for 3D reconstruction of scanned 2D radiographs.



CURRENT STAGE OF DEVELOPMENT



Thank you for your attention