TNO innovation for life

- # INTRODUCTION INTO BLADE DAMAGE AND OVERVIEW OF DETECTION METHODS

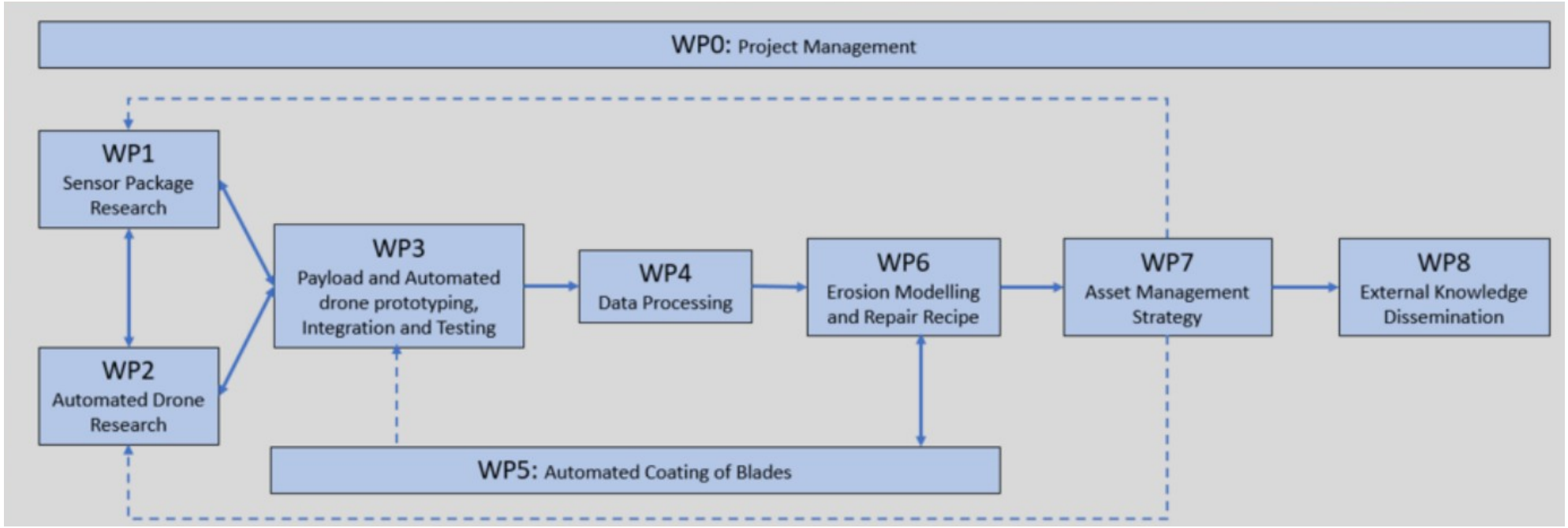
(ROGIER NIJSSEN, TNO)

WP1 AIRTUB | DR. IR. R.P.L. NIJSSEN

DAMAGE DETECTION AND REPAIR….WHY?
AND WHY AUTOMATED?

AIRTUB PROJECT

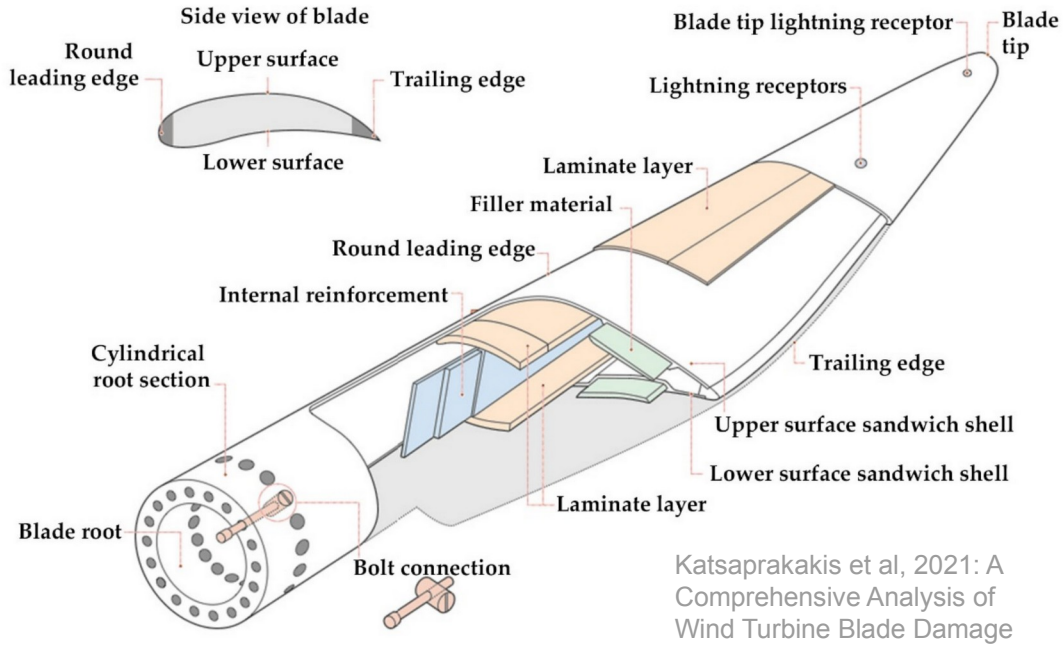
In the AirTuB project, automated inspection and repair is developed. The first step is to detect damage (WP1)



DAMAGE DETECTION AND REPAIR….WHY?

SAFE LIFE VS DAMAGE TOLERANCE DESIGN

- Wind turbine rotor blades are designed safe life
  - Use plenty of material to guarantee technical life (ca. 25 years)
  - NO inspection or maintenance required
  - Need to account for degradation and unforeseen ☾ **heavy designs**
  - Cracks and damage unexpected



Katsaprakakis et al, 2021: A Comprehensive Analysis of Wind Turbine Blade Damage

DAMAGE DETECTION AND REPAIR….WHY?

SAFE LIFE VS DAMAGE TOLERANCE DESIGN

- Wind turbine rotor blades are designed safe life
  - Use plenty of material to guarantee technical life (ca. 25 years)
  - NO inspection or maintenance required
  - Need to account for degradation and unforeseen ☾ **heavy designs**
  - Cracks and damage unexpected
- Aircraft are designed damage tolerant
  - Cracks ‘guaranteed’
  - Maintenance included in design and operations
  - Degradation and unforeseen accounted for during operation ☾ **lighter designs**

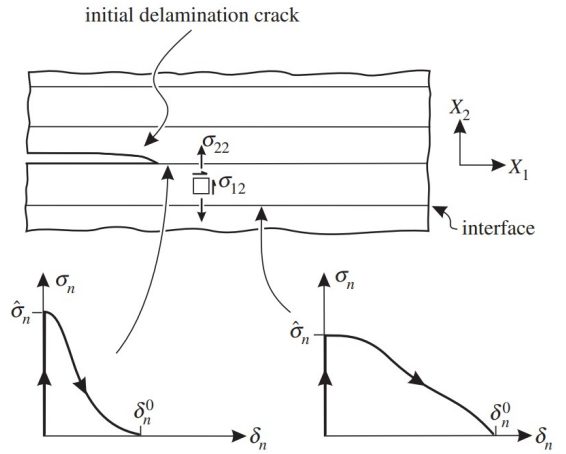


Image from: Damage tolerance and structural monitoring for wind turbine blades | Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences (royalsocietypublishing.org)

DAMAGE DETECTION AND REPAIR….WHY?

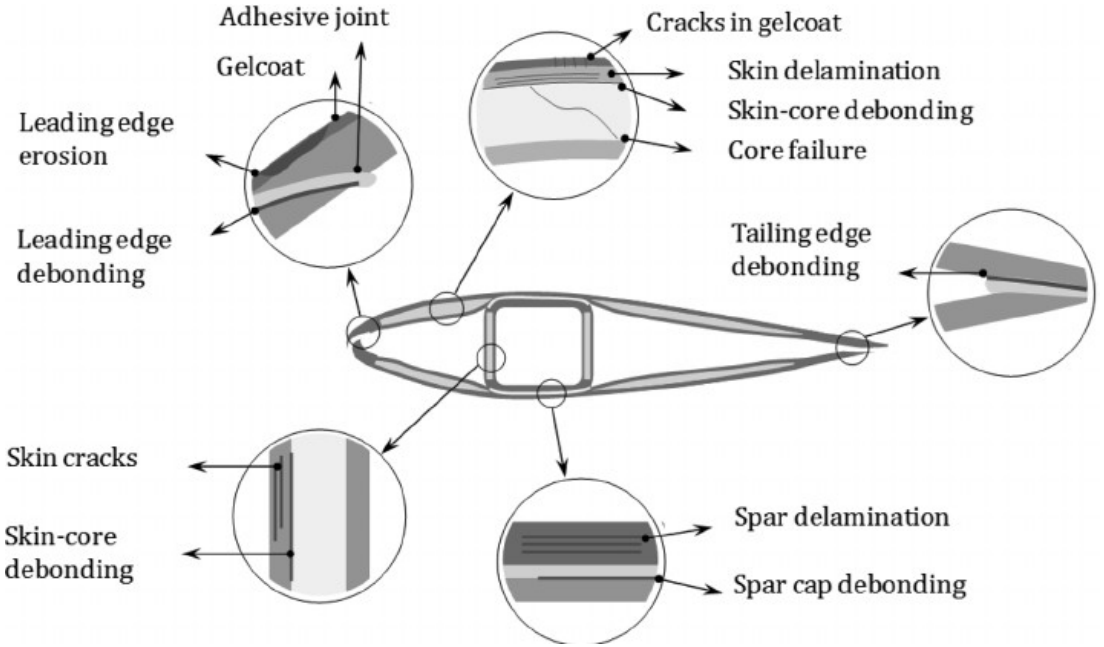
SAFE LIFE VS DAMAGE TOLERANCE DESIGN

- Wind turbine rotor blades are designed safe life
  - Use plenty of material to guarantee technical life (ca. 25 years)
  - NO inspection or maintenance required
  - Need to account for degradation and unforeseen ☾ **heavy designs**
  - Cracks and damage unexpected
- Aircraft are designed damage tolerant
  - Cracks ‘guaranteed’
  - Maintenance included in design and operations
  - Degradation and unforeseen accounted for during operation ☾ **lighter designs**

The easier we can make inspection and maintenance, the lighter blades can be!

DAMAGE IN ROTOR BLADES

- Two damage types are taken into account:
  - Structural damage (remaining strength and/or stiffness of the structure affected)
  - Non-structural damage (other performance affected. Focus on Leading Edge Erosion (LEE))



Katnam et al: Composite Repair in Wind Turbine Blades: An Overview, Journal of Adhesion, 2014

DAMAGE DETECTION IN ROTOR BLADES
TECHNOLOGY

AIRTUB SENSOR DEVELOPMENT

- Two damage types are taken into account:
  - Structural damage (remaining strength and/or stiffness of the structure affected)

Strain sensing

Ultrasonic methods

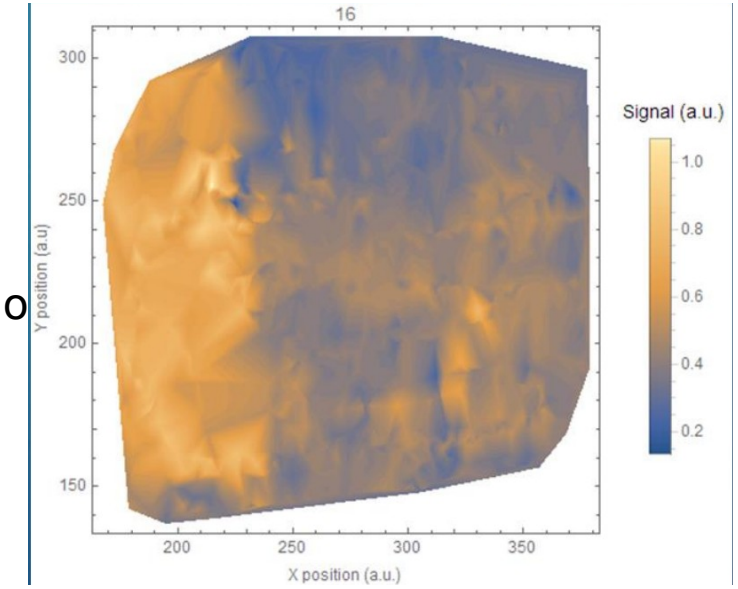
Infrared sensors

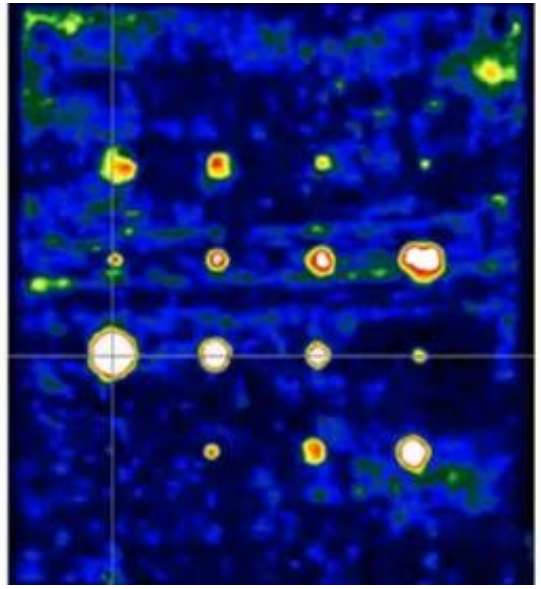
Shearography

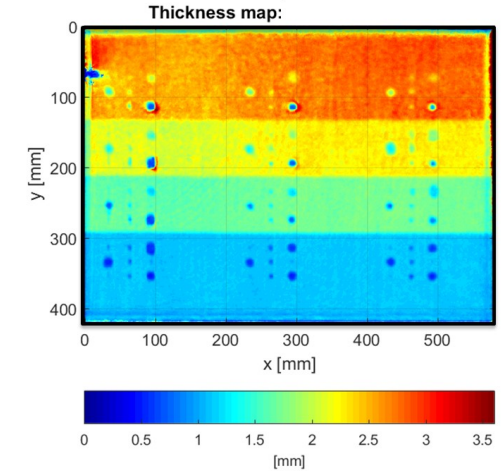
Digital image Correlatio

X-ray

Teraherz







https://vereniging-ion.nl/sites/default/files/files/Presentatie%20Alena%20Balitskaya%2C%20Dutch%20Terahertz.pdf

N
on-contact MEMS sensor developed b
y TNO (outside
Airtub project) – link to video

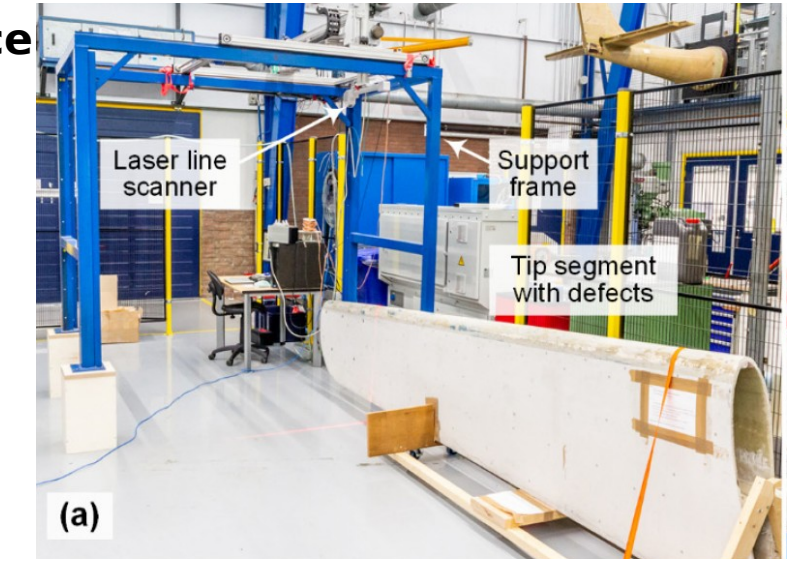
DAMAGE DETECTION IN ROTOR BLADES
TECHNOLOGY

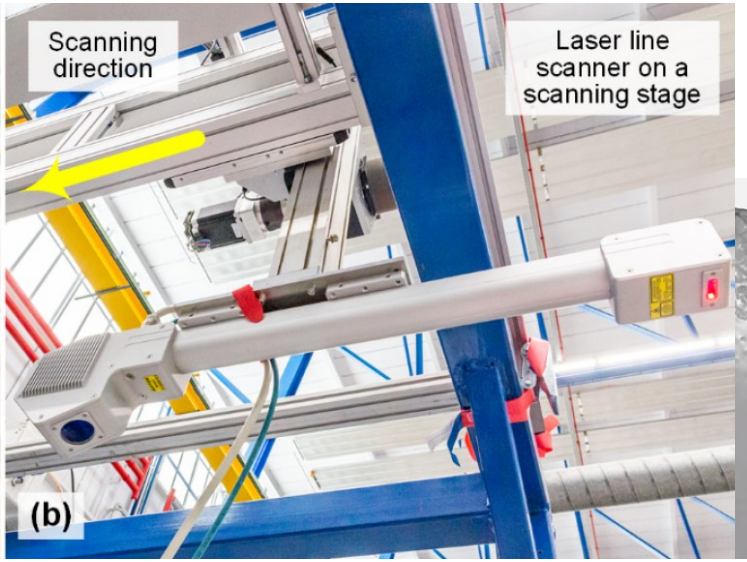
AIRTUB SENSOR DEVELOPMENT

- Two damage types are taken into account:
  - Structural damage (remaining strength and/or stiffness of the structure affected)
  - Non-structural damage (other performance affected. Focus on Leading Edge Erosion (LEE))

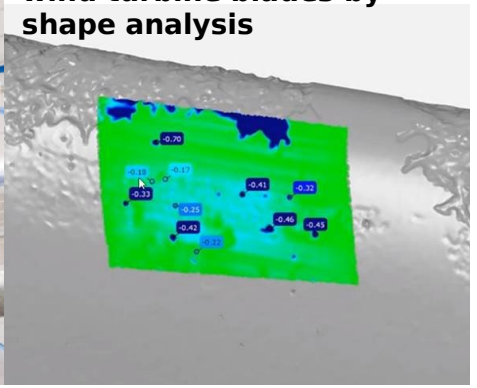
Photo/video

Laserline Surface





Anisimov et al: AIRTuB: towards automated inspection of leading edge erosion of wind turbine blades by shape analysis



CHALLENGES

- Find ‘sweet spot’ damage size and select optimal detection tool
  - Jason Hwang et al: A Literature Survey on Remote Inspection of Offshore Wind Turbine Blades ,
  - Nijssen and Manrique: Literature review of structural and nonstructural wind turbine blade damage
- Deal with
  - Drone/crawler issues (partly other WPs of Airtub – stay tuned for more seminars!)
  - ‘False’ damage detection due to damping, glare, dirt, material tr

THANK YOU
FOR YOUR
ATTENTION

- Laserline scanning for leading edge erosion inspection

(Andrei Anisimov, TUD)

- Ultrasonic inspection

(Jason Hwang and Ali Nokhbatolfoghahai, NLR and TUD)

- Teraherz technology for blade inspection

(Andrei Barychev, Dutch TeraHertz (online))

- X-ray inspection

(Akilesh Goveas, Wyndtek)

- Internal sensoring of windturbine blades

(Hans van Beek, Tarucca)

- Solution for robotized blade inspections with ultrasonic and laserline scanner

(Jan-Erik Bree, Invertrobotics)

TNO innovation for life