WORLD CLASS MAINTENANCE

AIRTuB

Innovation Fieldlab Zephyros

Towards Zero downtime and Zero on-site maintenance

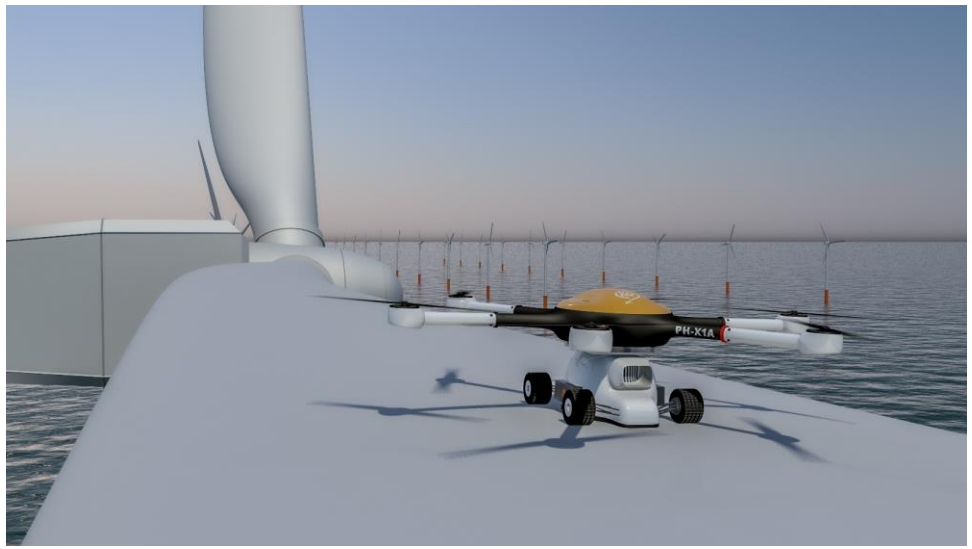
The partners

UNIVERSITY OF APPLIED SCIENCES
TU Delft Delft University of Technology
STORK A Fluor Company
Eneco
TNO innovation for life
Hanzehogeschool Groningen University of Applied Sciences
nholland university of applied sciences
SAXION UNIVERSITY OF APPLIED SCIENCES
LM WIND POWER a GE Renewable Energy business
FUSION ENGINEERING
nlr
DEMCON unmanned systems
Development Center for Maintenance of Composites
Dutch Teraherts Space Quality Inspection
qlayers

Fieldlab ZEPHYROS

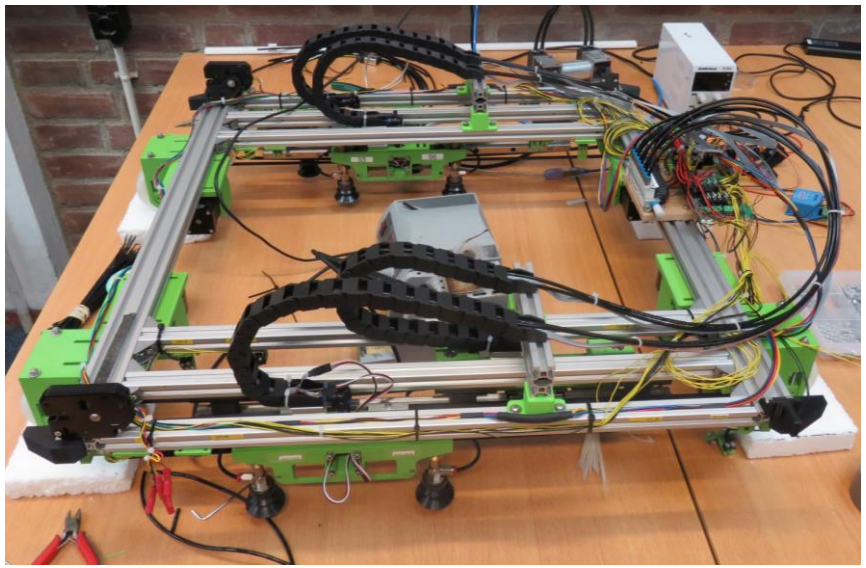
smart industry

Crawler development for blade maintenance



Courtesy of NLR

Crawler stage 1



Crawler stage 2

Vlissingen, 22 September 2022

Jos Gunsing, MaromeTech on behalf of HZ UAS

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Crawler development for blade maintenance

- AIRTuB project; part of Workpackage 2 and 3; -
  - Development of drone incl. flight controller and lidar path planning
  - Development of crawler
  - Integration with sensor package,
  - Test program
- In close cooperation with:
  - NLR, drone development and test, integration wioth sensor package and crawler
  - Demcon; lidar development and path planning
  - Fusion Engineering; flight controller
  - Eneco; maintenance data and test planning/facilities
- With support of:
  - TU Delft: sensor integration in drone and crawler
  - LM Windpower; turbine blade knowhow

nlr

DEMCON | unmanned systems

FUSION ENGINEERING

Eneco

LM WIND POWER
a GE Renewable Energy business

TU Delft Delft University of Technology

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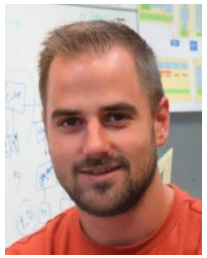
Crawler development for blade maintenance

Team HZ and Scalda for crawler development

- 100+ students in 20+ teams
- Coached by teacher/researchers from HZ and Scalda:







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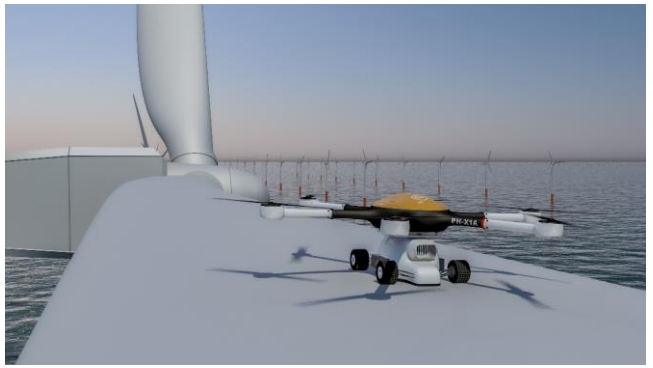
Crawler development for blade maintenance

Starting from scratch

- **Task:**
  - Development Drone:
    - Carry external damage sensor
    - Carry Crawler with internal damage sensor
  - **Development Crawler:**
    - Carry internal damage sensor
- **Key question for all AIRTuB involved parties:**
  - **Definition of:**
    - **minimum defect size to be detected;**
      - **→ type/size of sensor**
    - **in combination with required autonomy (in this case time)**
      - **→ type/size of crawler**
      - **→ type/size of drone**

Courtesy of NLR



Courtesy of NLR

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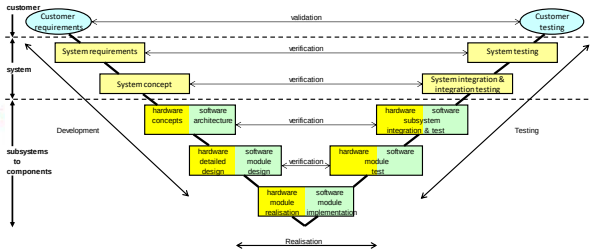
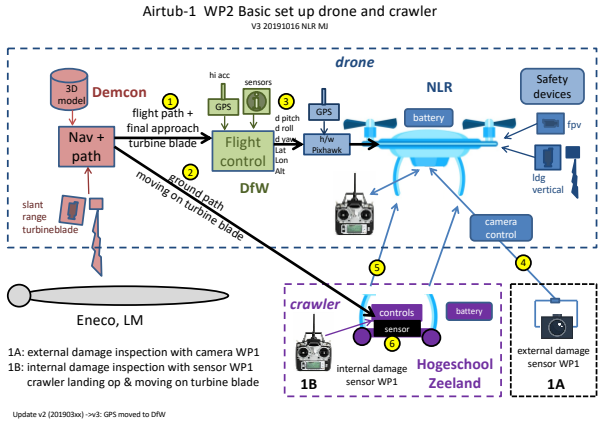
Crawler development for blade maintenance

Approach of crawler development

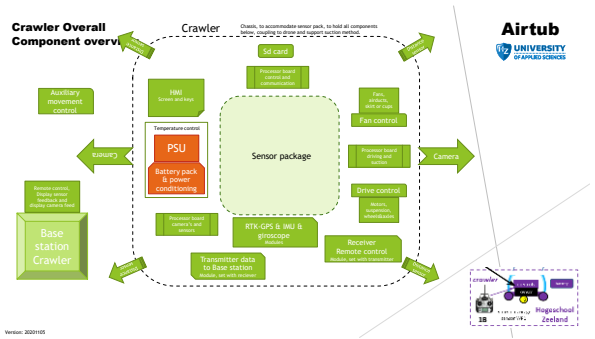
- Process
  - **Definition of preliminary maximum size/volume and mass based on minimum defect size**
    - **Autonomy max. 30 minutes (battery life and size)**
    - **Sensor package max. 10 kg, crawler max 15kg incl. sensor package**
    - **Drone (span approx, 3m) max take off mass of 40+ kg**
- Set up of use cases
  - Normal operation
  - Starting/stopping of systems
  - Extraordinary situations incl. misuse
- **Parallel : business case development (AIRTuB workpackage 7)**
- Definition of functions/functional decomposition incl. relation of functions
- Concepts
- Risk analysis



Development process



System drone-crawler-sensor package



Functions crawler

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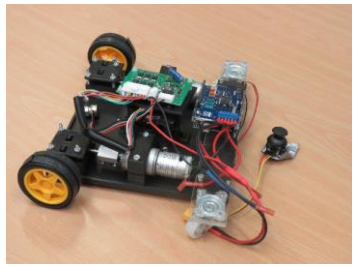
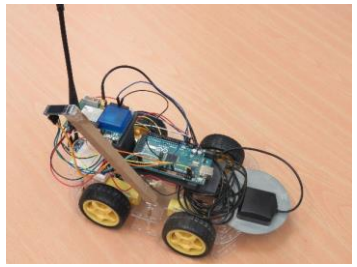
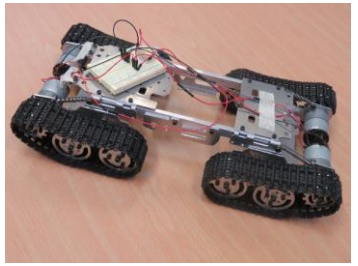
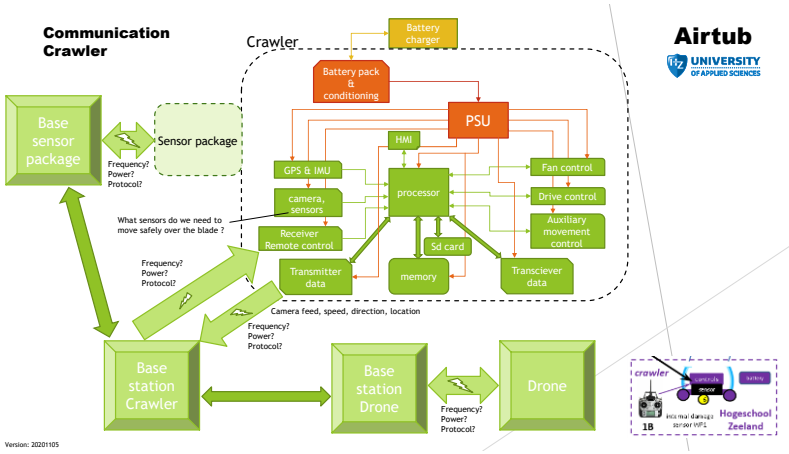
Crawler development for blade maintenance

- Risk analysis/concepts:
  - Feasibility models
    - Suction systems
    - Navigation accuracy
    - Drive system control/steerability
    - Remote control
    - Canera systems including live streaming
  - Travelling on turbine blade
    - Type of movement
      - Holding in combination with moving
      - “Meandering” over region of interest; scanning in one direction
    - Size of region of interest approx. 1 m^2
    - Accuracy of travel; cm-range
  - Communication of :
    - drone, crawler and sensor packages with respective base stations
    - Commercially available components whn possible

Feasibility models; examples

Communication crawler



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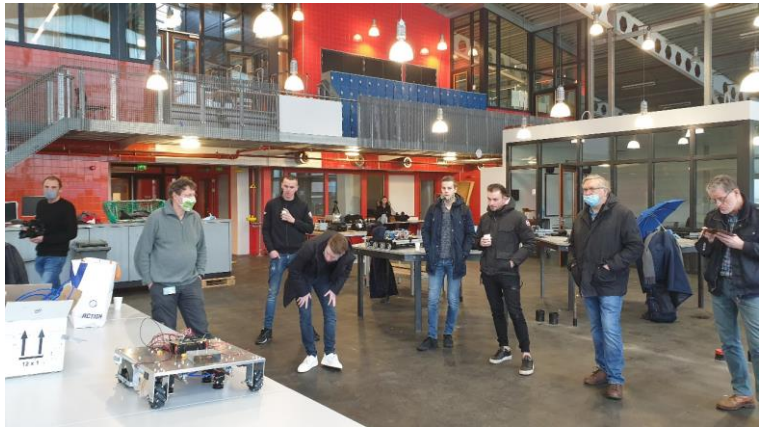
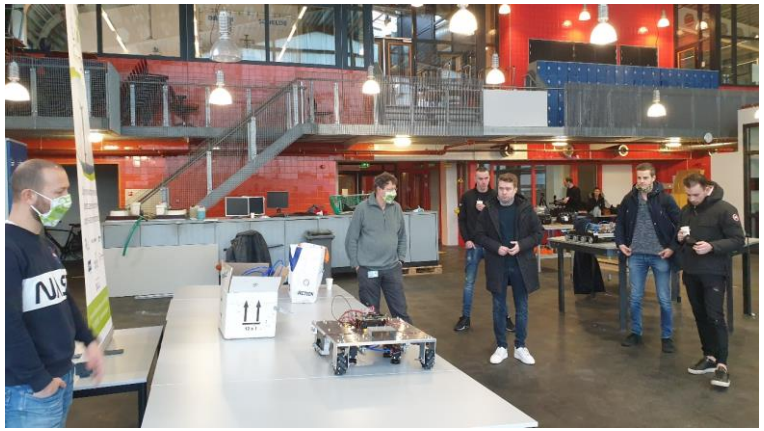
Crawler development for blade maintenance

Crawler stage 1

Student groups from both HZ and Avans Hogeschool (Breda) developed both in parallel:

- Crawler stage 1a; Avans Hogeschool (Breda)
- Crawler stage 1b; Hogeschool Zeeland





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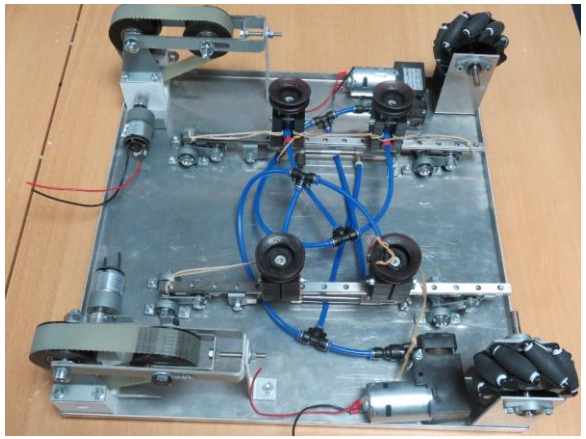
Crawler development for blade maintenance

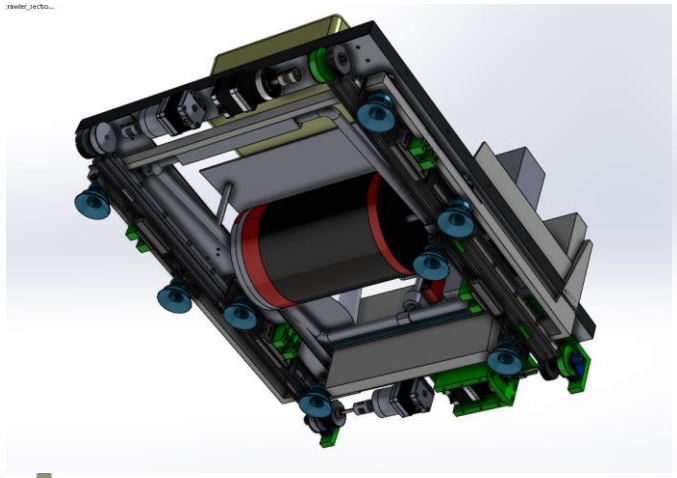
Several generations crawler

- **Results:**
  - Crawler stage 1a
  - Crawler stage 1b
  - Crawler stage 2



1a

1b



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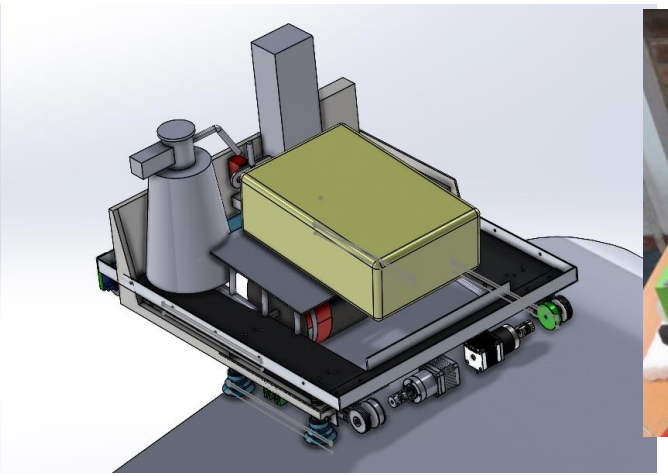

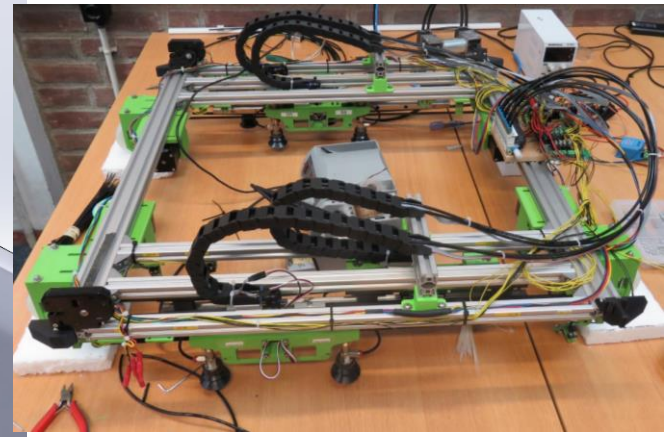

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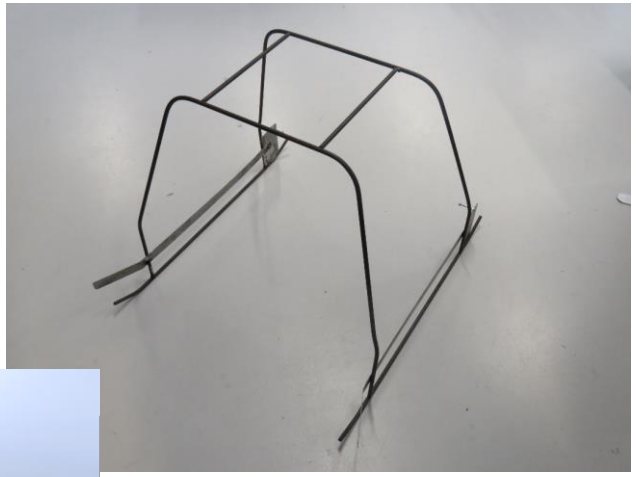
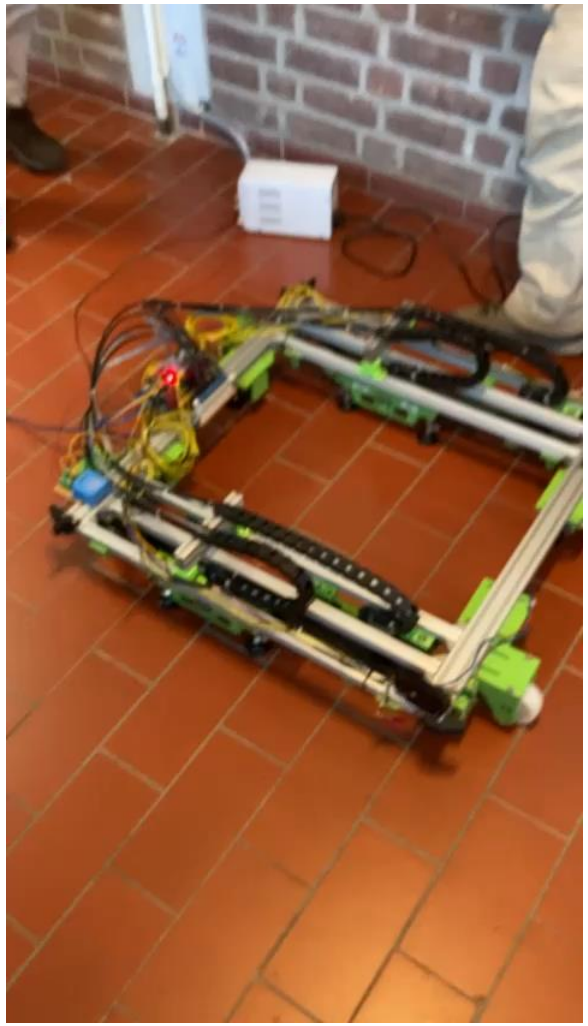
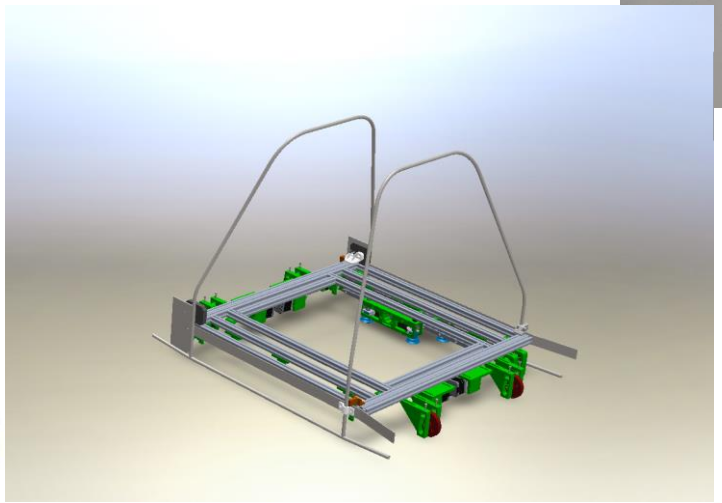
Crawler development for blade maintenance

- Use cases:
  - Normal behaviour
    - First steps
  - (Un-)Locking mechanism from/to the drone
    - Several concepts;







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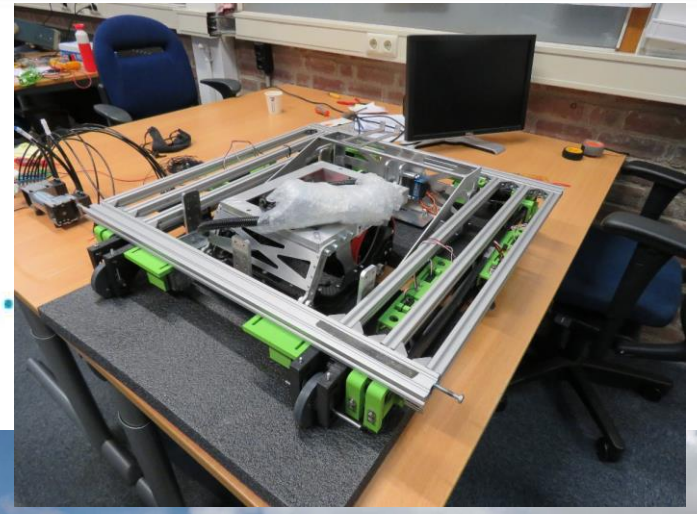
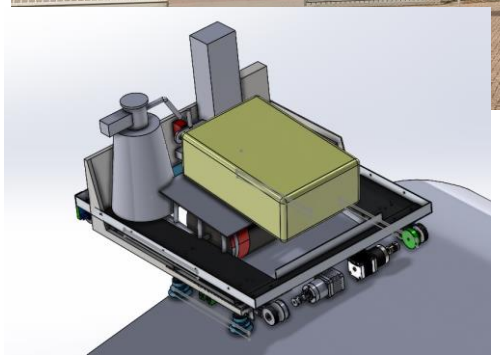
Crawler development for blade maintenance



Work in progress/future outlook

- Ongoing:
  - Business case confrontation
    - Costs versus benefits
  - Test equipment ; turbine blade on trailer ; testing under different positions/conditions
- Future outlook:
  - Further research (in line with roadmap AIRTuB):
    - Extension to other types of damage inspection
      - Lightning damage
      - Internal damage inspection of leading edge
    - Extension to maintenance/repair
    - Resident drone/crawler plus sensor and repair packages in windpark
  - Research/development parallel to business case development
  - Always open for alternative solutions
    - Avoiding inspection & repair
    - Alternative solutions for turbine blade inspection and repair
      - E.g. cable/umbillical operated crawler i.s.t. drone/crawler combination



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