VISUAL BLADE INSPECTION WITH UAV TECHNOLOGY

Christoph Thiel, tb engineers

Matthias Allendorf, copterproject

28 September 2016, Wind Europe Summit 2016, Hamburg

Droning On!: The use of UAVs in wind turbine O&M

copterproject

tb engineers

Agenda

- Introduction
- Blade Damages
- Requirements to UAVs
- Data Process
- Advantages and Challenges
- Outlook

Copterproject Industrial

Start-up with objective to develop professional UAV-based applications:

- Energy (Wind, Photovoltaic, conventional, distribution)
- Buildings
- Mapping (photogrammetry, LiDAR)
- Industry

We offer:

- Engineering and development
- Flight services
- Equipment (design, manufacturing, system integration)
- Consulting, flight training

Motivation

- Rotor blades of wind turbine are critical components
- Failure can be very expensive
- Early detection of failures may reduce costs (repair costs, downtime)
- UAV inspections offer the possibility of cheap and fast assessment of blade condition
- May complement with visual inspection by inspectors

Blade Damages

Typical blade damages are:

Surface damages (gelcoat damages, erosion, cracks)
⇨ can be detected by optical methods

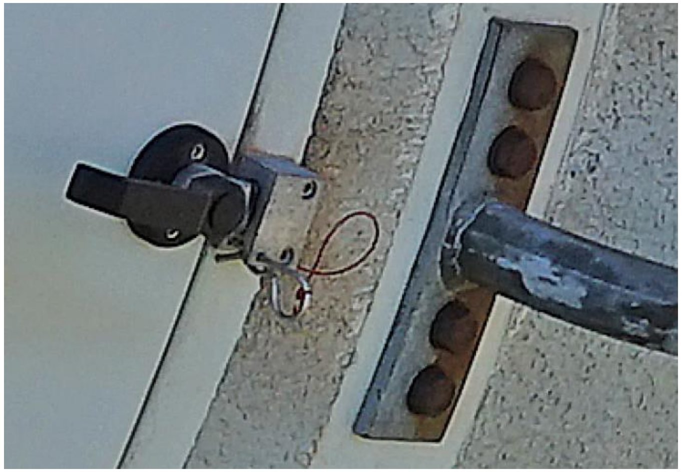
Structural damages (laminate, joints, bonding of beams)
⇨ require more sophisticated methods

Blade Damages

Example:

Lightning strike on blade

Blade Pictures



Requirements to UAV systems

UAV

- Fast
- Robust
- Easy to use
- Safe
- Enduring

Sensor

- High enough resolution
- Easy to use
- Detection of damages in case of difficult light
- Stability (Gimbal)
- Detect dimensions of damage
- Position of damage

Design of UAV

Balance of several parameters:

- Pay load: which sensor(s) need to be carried?
- Total weight: may have legal implications
- Flight time: determined by flight process
- Max wind speed: defines limits of flight mission
- Max temperature: influences flight time
- …

Examples: CP X12-22

Heavy Payload + Hot + High

Empty weight: 5 kg
Max payload: 12 kg
Max take-off weight: 22 kg

Endurance: 10 – 60 min

Application: professional movie industry

CP X12-22

Examples: CP 4-6

Lightweight (<5kg class)

Empty weight:	1,6 kg
Max payload:	2,0 kg
Max take-off weight:	6,0 kg

Endurance: 20 – 40 min

Application: aerial mapping, photogrammetry

CP 4-6

Required Features

Safety system:

- Redundancies: battery, electric circuits, flight data recorder
- Fail safe functionality: loss of radio, low voltage, health data transmission (telemetry), engine loss capability
- Anti-collision system

(mechanic or electronic)

- Optional rescue systems: parachute to prevent crash

Required Features

Simple to use:

- Automatic flight capabilities: distance control, shape-controlled flight
- Detection of dimension of damage
- Determination of position of damage
- Automatic data transmission and (pre-)processing
- Post-processing with pattern recognition, deep learning

Special Requirements Offshore

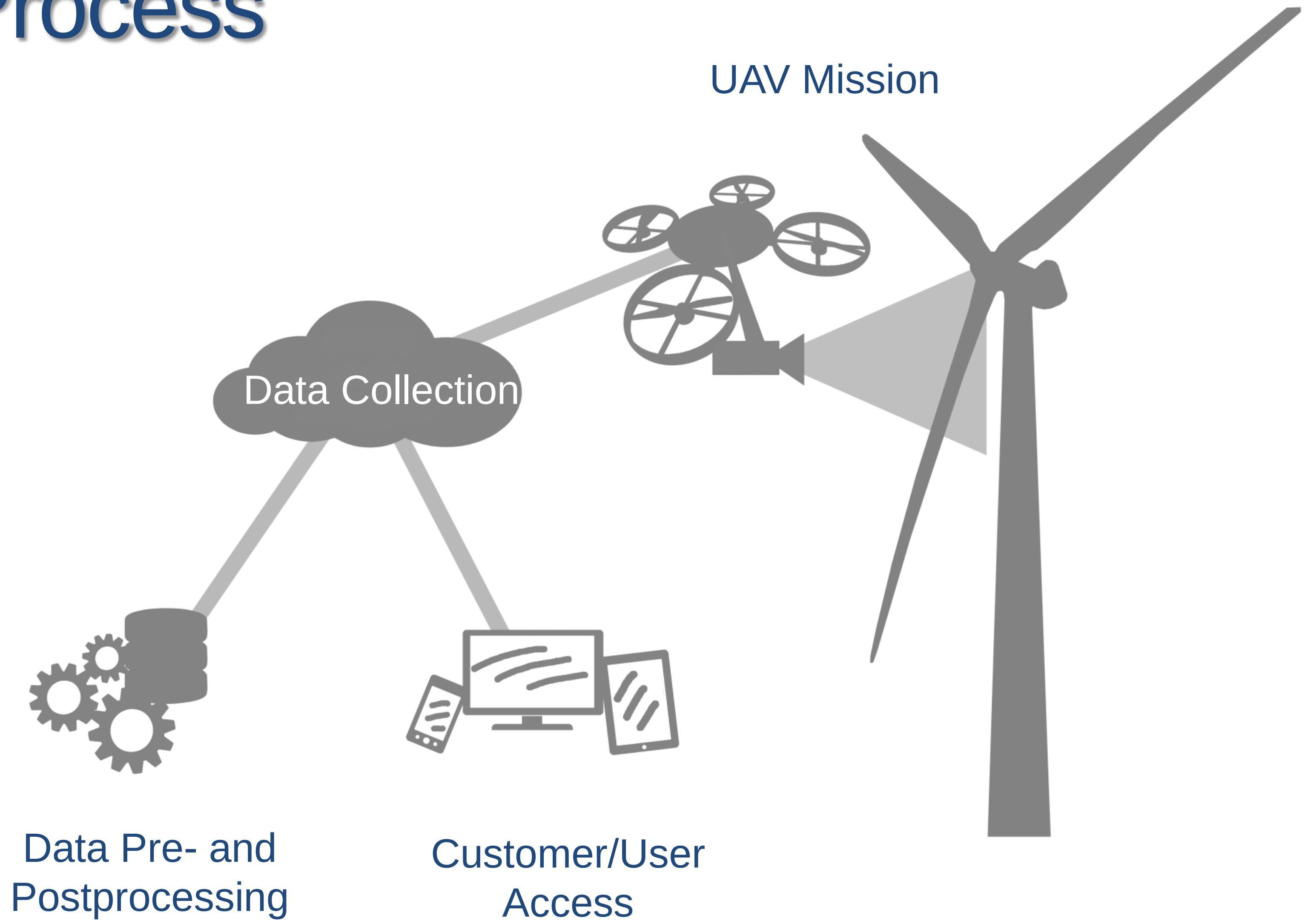
Offshore Features:

- Salt water proof
- Floatable
- Long endurance
- BVLoS capability (below visual line of sight)
  -> legal implications
- Geofencing

Process

- End to end
- For a single inspection: from contract to report: process needs to cover flight planning, inspection incl. operating of turbine, data pre-processing, data processing and reporting
- Automatic process:
  - Needs to securely identify damages which are there
  - Needs to securely make a statement in case no damages are there

Process


UAV Mission
Data Collection
Data Pre- and Postprocessing
Customer/User Access

Advantages of visual UAV method

- Low cost of service for onshore wind turbines
- Small downtime wind turbine (ideally <20 minutes per blade)
- Very fast, instant results
- No auxiliary costs such as cranes, lifting devices
- Safe for inspectors, no working in heights

<u>When done frequently (e.g. yearly):</u>

- Allows tracking of damages over time (propagation)
- Allows building up of databases
- Gives advance information to inspectors

Challenges

- UAV: introduce sophisticated automated flight routines: e.g. follow blade shape
- Positioning: precise positioning of damages incl. secure identification of blade
- Dimensions: measuring dimensions of damages
- Marking: instant marking of damages for later repair (requires instant detection)
- Data process: handling and fast processing of large amounts of data, immediate statement on damages preferred
- Secure automatic detection of damages (condense large amount of data to relevant information)

Research/Development

- Application of thermographic methods. Method currently used offshore with manned helicopters, onshore from lifting devices
- Tactile methods: low frequency ultrasonic

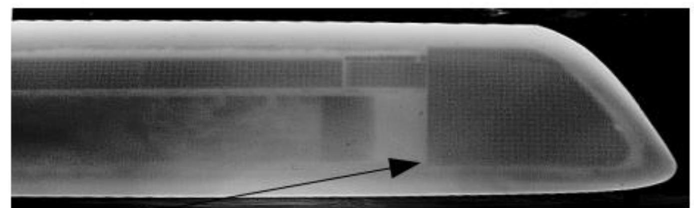
Research/Development

Dual Sensor copter with high resolution thermographic camera

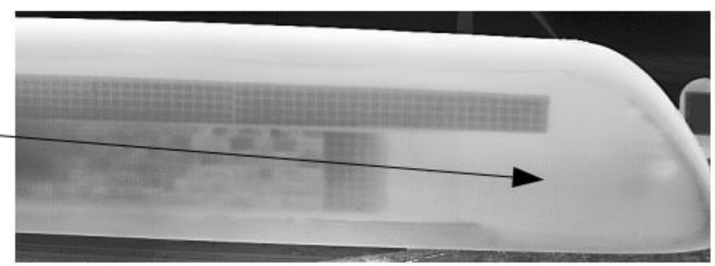
Example Thermography

No visible damage

Nominal as specified



Delamination



Courtesy of COMPOSCAN GMBH Voraussehen mit bester Technik

copterproject

tb engineers

Future

- Frequent inspection of blades with UAVs by manufacturer, service teams, independent UAV operators
- Regular inspections by blade inspectors with advance information
- Build up data base of each blade to track history:
  - Check on damage propagation
  - Document condition over lifetime, e.g. yearly to plan preventive maintenance (before damage)
- Assessment of asset value in case of change of ownership

Thank You For Your Attention

tb engineers

copterproject

Christoph Thiel

Phone: +49 171 7452369

Email: christoph.thiel@tb-engineers.de