Dedicated to innovation in aerospace

AIRTub drone and demonstrations

Martin Joosse, 24 November 2022

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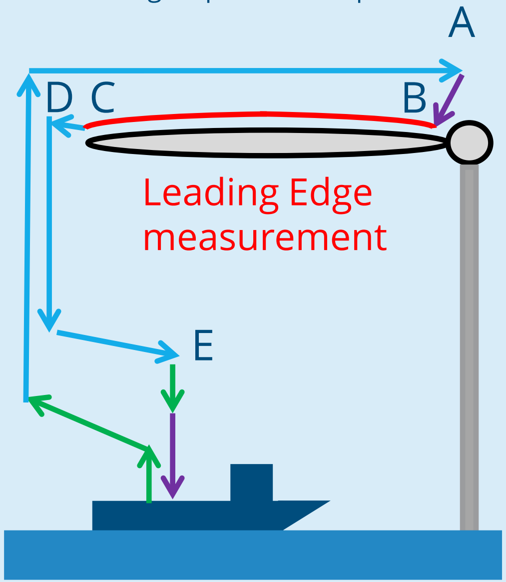
Arjan, Marco and Martin

Leading Edge inspection

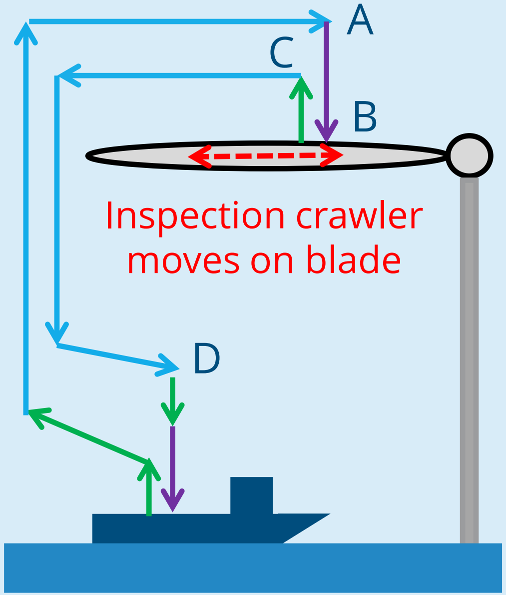
during inspection LE upwards

1. Take off from ship (manual)
2. Fly to A via waypoints
3. At A: locate blade (position/orientation)
   Fly to B to start measurement
4. Fly to C at 1.3 -1.7m above Leading Edge
5. Fly away from blade to D
6. Fly to E via waypoints
7. Locate landing area sensor (IR)
8. Land on ship



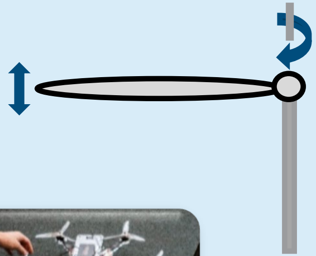
Inspection internal structure

1. Take off from ship (manual)
2. Fly to A via waypoints
3. Locate blade (pos/orientation), fly to B and land
4. Land on blade (and stay on blade)
5. Disconnect crawler and start crawling
6. Inspection by crawler+sensor
7. Return to drone, connect to drone
8. Take-off
9. Fly to D via waypoints
10. Locate landing area sensor (IR)
11. Land on ship



Development

Drone	Large + heavy drone Perform Hi Risk operation (distance, mass) Land and stay on curved blade (landing gear, suction)
Positioning (Demcon)	Detection of position & orientation windturbine LE-inspection: accurate flightpath above blade
Flightcontroller (Fusion)	Follow flight path with high accuracy (wind gust) • New INDI technique, new H/W, S/W, special ESC Internal inspection: Land on exact point on blade
Crawler (HZ)	Develop & transport crawler, (dis)connect



finally: integrate all systems in drone and ensure legal & safe operation

Max Take-off Mass Drone

A. Leading Edge Payload : **5 kg**

Flying Laser line scanner 1.3-1.7m above LE
expected 30min flight

B. Internal structure Payload: **15kg**

Bring crawler+sensor, land on blade
attach to blade, (dis)connect crawler

Weight:
15 kg payload
7 kg additional AIRTuB equipment
18 kg drone
20 kg battery
60 kg Max Take-off Mass

1-2kg	MTOM	60kg
30cm	size	3 m
300%	overpower	50%

- High amperages
- high inertial moment, less overpower
    - less easy to correct
- structure drone

NL CAA register (2020)
In total ca 2500 drones, 96% < 10kg
only 3 'fit to fly' rotary with MTOM >30kg

Ensure legal and safe operation

Operator: mandatory ‘permit to fly from NL-CAA’ and Insurance (EU785/2004)

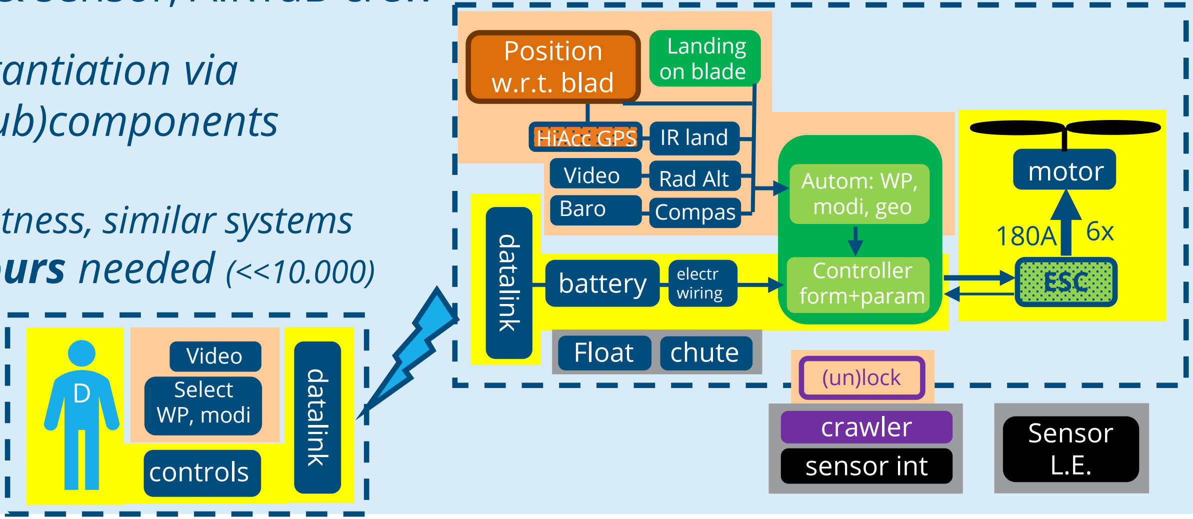
- NL-CAA : air+ground risk, focus on uninvolved people (< *10^{-4}*/flighthour + **evidence**)
- Insurance : 3th party, financial damage (>> 1 M€)
- Ourselves : Loss of drone & sensor, AIRTuB crew

Evidence: # flight hours or substantiation via

- *Safety analysis of drone & (sub)components*
- *Design, manufacturing, **test***
  - *material, complexity, robustness, similar systems*
- *Proven reliability -> **flight hours** needed (<<10.000)*
- ***Training** (procedures, crew)*

Flight critical
mission critical
project critical

Fusion
NLR
Demcon
HZ



Phases in development and integration

Marknesse (EHR66): testing (sub)systems and integration

- With small windturbine blade for testing

- Testbed (smaller version, easier, cheaper)
  1. Build and test subsystems drone
  2. Testbed with conventional flightcontroller (check system)
  3. Fusion flightcontroller initial tuned
  4. Demcon positioning + 'Fusion land' and test
  5. Training, build track record
- AIRTuB drone
  - Repeat 1, 2-5
  - Integrate LE sensor and test
  - Integrate crawler and test

On-shore inspection: rehearsal for offshore

Offshore inspection: measurements for AIRTuB

Timeline made to start first measurement in jan-2022

Realisation

NLR

- Testbed & AIRTuB drone ready for flightcontroller, (sub)component developments
- Preparations integration and offshore measurement

Research project with challenging developments:

- Delay at partner: development drone on hold, no inspections at windturbine possible
- Scope change (1st Sept 2022): develop subsystems to the highest possible level

NLR after scope change:

- Use conventional flightcontrollers and continue development and integration
- 2nd testbed at NLR to continue with ‘other work’ (1st testbed at Fusion for tuning)
    - test, training & integration LE sensor
- AIRTuB drone
    - Tune flightcontroller and fly drone and prepare for crawler

NLR demonstrations

AIRTuB drone — 60kg drone, conventional flight controller
fly with payload (max 15kg)
crawler disconnecting

2nd Testbed — payload Leading Edge sensor
(with limited flighttime)
demonstrate LE-inspection

(Fusion demo: 1st testbed empty, initially tuned)

Small drone (5kg) — land via IR marker (on ship)
land on curved blade (landing gear)
stay on blade (suction system)

(HZ+ TU-D demo: inspection with crawler)

Flying drones can be dangerous: safety instructions

Questions ?

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