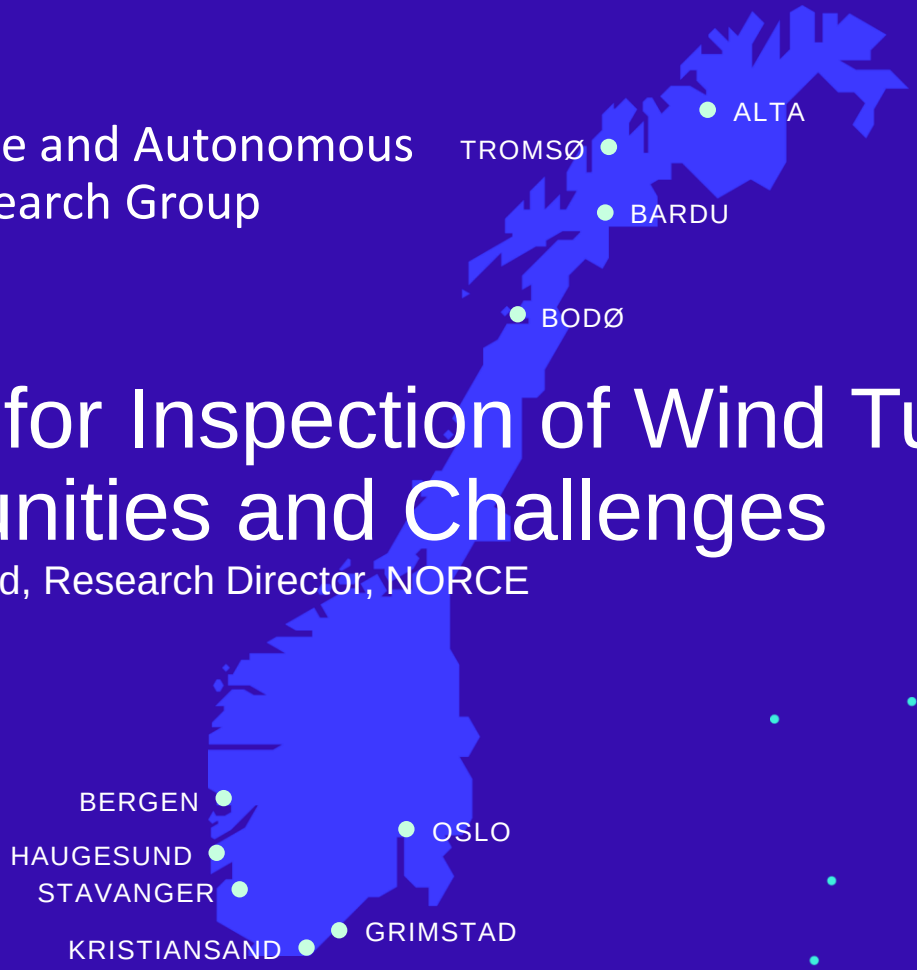
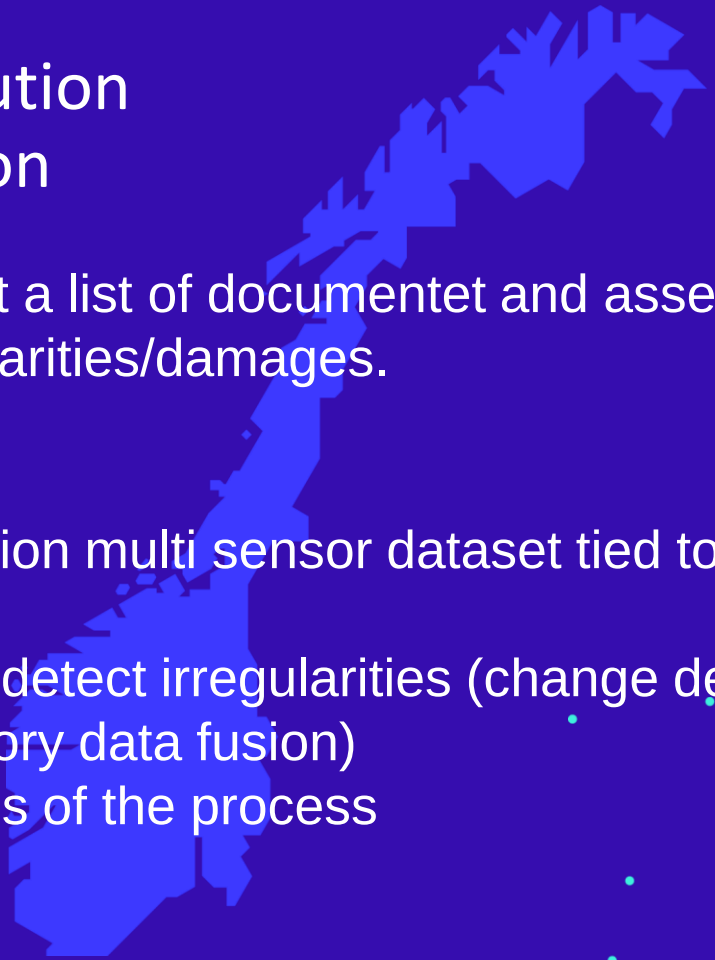
NORCE Drone and Autonomous systems Research Group



Drones for Inspection of Wind Turbines – Opportunities and Challenges

Dr. Rune Storvold, Research Director, NORCE

End-to-end solution
Drone Inspection



Press a button and get a list of documentet and assessed observations of irregularities/damages.

How:

- Collect high resolution multi sensor dataset tied to a digital tween of the turbine.
- Train algorithms to detect irregularities (change detection, machine learning, multisensory data fusion)
- Automate all phases of the process

Todays methods

- Manual
- Ground based robotic tele-lens cameras (more difficult without a stable platform)
- Drones

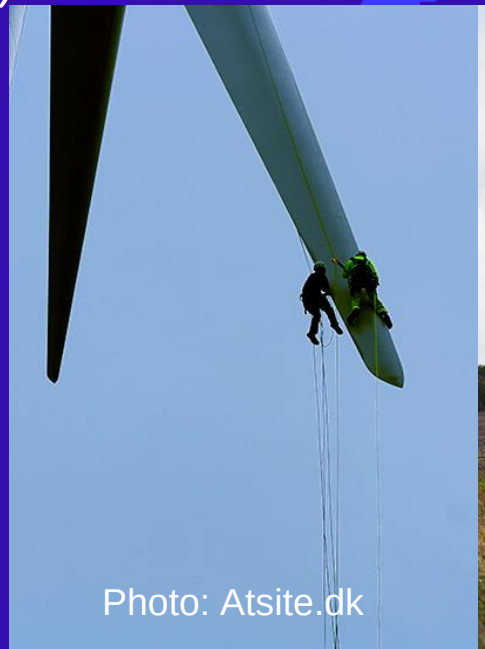


Photo: Atsite.dk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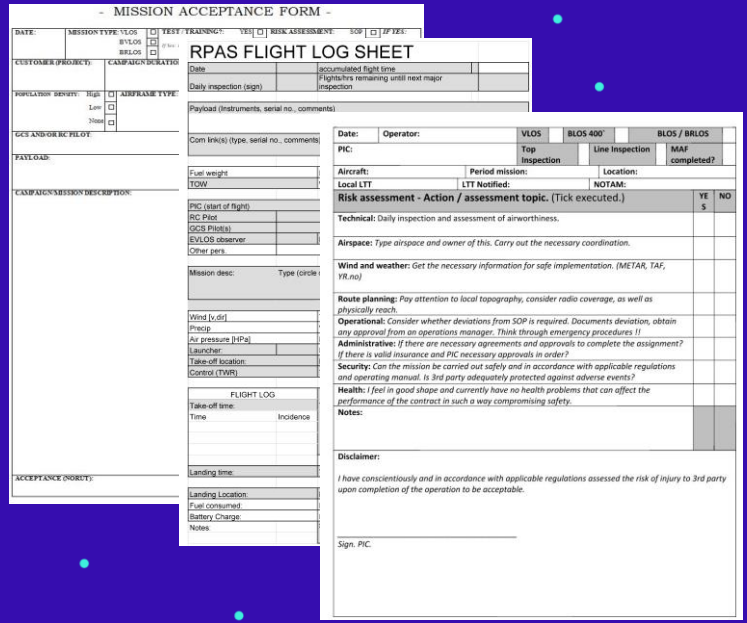
How could a drone inspection look like

What is involved in an end-to-end Drone Inspection Mission

Pre-mission requirements

- Regulatory requirements (Change from July 2020)
- Concept of operation
- Risk assessment and handling
- Approved operations



- MISSION ACCEPTANCE FORM -

DATE: | MISSION TYPE: VLOS / BVLOS / BRLOS | TEST / TRAINING?: YES | RISK ASSESSMENT: SORA / SPTZ:

CUSTOMER (PROJECT): | CAMPAIGN DURATION:

POPULATION DENSITY: High / Low / None | AIRFRAME TYPE:

GCS AND/OR RC PILOT:

PAYLOAD:

CAMPAIGN/MISSION DESCRIPTION:

ACCEPTANCE (NORUT):

RPAS FLIGHT LOG SHEET

Date | accumulated flight time

Daily inspection (sign) | Flights/hrs remaining until next major inspection

Payload (Instruments, serial no., comments)

Com link(s) (type, serial no., comments)

Fuel weight

TOW:

PIC (start of flight)

RC Pilot

GCS Pilot(s)

EVLOS observer

Other pers.

Mission desc: | Type (circle

Wind [v,dir]

Precip

Air pressure [HPa]

Launcher:

Take-off location:

Control (TWR)

FLIGHT LOG

Take-off time:

Time | Incidence

Landing time:

Landing Location:

Fuel consumed:

Battery Charge:

Notes:

Date: | Operator: | VLOS | BLOS 400' | BLOS / BRLOS

PIC: | Top Inspection | Line Inspection | MAF completed?

Aircraft: | Period mission: | Location:

Local LTT | LTT Notified: | NOTAM:

Risk assessment - Action / assessment topic. (Tick executed.)	YES	NO
Technical: Daily inspection and assessment of airworthiness.		
Airspace: *Type airspace and owner of this. Carry out the necessary coordination.*		
Wind and weather: *Get the necessary information for safe implementation. (METAR, TAF, YR.no)*		
Route planning: *Pay attention to local topography, consider radio coverage, as well as physically reach.*		
Operational: *Consider whether deviations from SOP is required. Documents deviation, obtain any approval from an operations manager. Think through emergency procedures !!*		
Administrative: *If there are necessary agreements and approvals to complete the assignment? If there is valid insurance and PIC necessary approvals in order?*		
Security: *Can the mission be carried out safely and in accordance with applicable regulations and operating manual. Is 3rd party adequately protected against adverse events?*		
Health: *I feel in good shape and currently have no health problems that can affect the performance of the contract in such a way compromising safety.*		
Notes:		

Disclaimer:

I have conscientiously and in accordance with applicable regulations assessed the risk of injury to 3rd party upon completion of the operation to be acceptable.

Sign. PIC.

What is involved in an end-to-end Drone Inspection Mission

Planning phase

- Information gathering (Weather, NOTAMs, info on turbine position)
- Airspace access (BSL-G 4-2, within Norwegian EES) NOTAM; UTM
- Logistics, data handling
- Flight planning

Ehang Scandinavia

What is involved in an end-to-end Drone Inspection Mission

Operation Phase

- Effective use of flight time
- Navigation
- Sensor steering
- Data capture and storage
- Data transfer
- Real time analysis

Photo: Storytrender

What is involved in an end-to-end Drone Inspection Mission

Analysis phase

- More advanced algorithms
- Comparison with older data
- Analysis of findings
- Reports

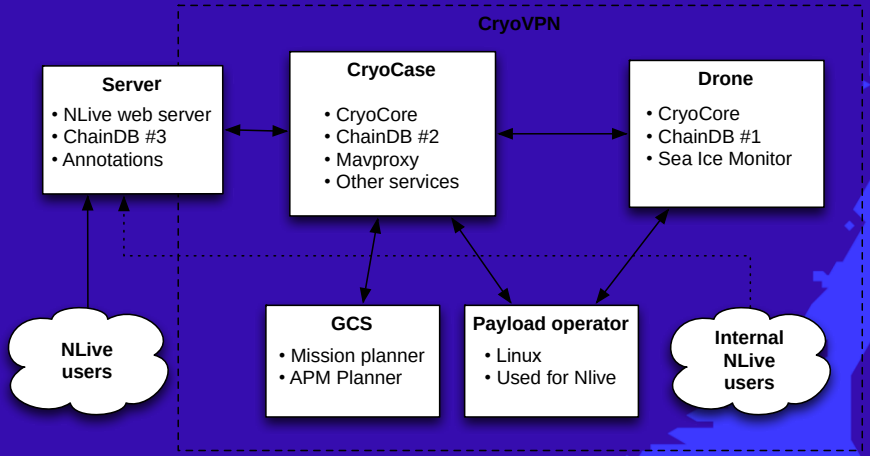
Challenges
It’s all in the software, almost

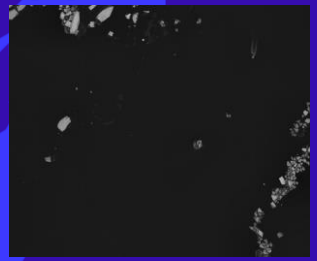
Automate all three phases of the inspection operation

Drone garage on nacelle could even further reduce need for support vessel

Weather limitations, two fold, limitation for drone – detoriating data quality

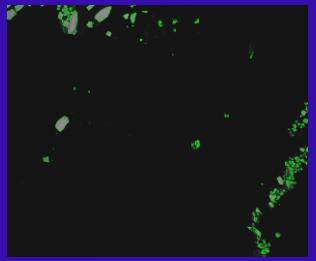
Drone System Software
Onboard processing and Chain database





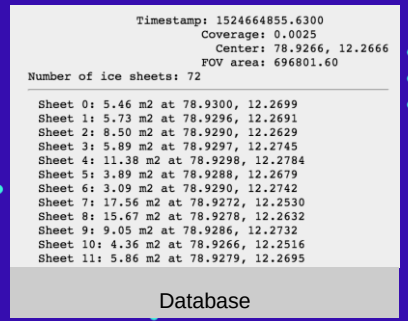
RGB image

Thermal image



Ice floe detection

- All data processed onboard and indexed in local database
- Optimized to work over “fragile” communication links
- Data is synchronized with priority
  - User requests (Areas, objects), metadata, images
  - Works with video (Nlive demo)
  - Within frame synchronization between all users



Sensors and ability to detect

What are we looking for:
cracks, holes, shelling, delamination, water intrusion and erosion, more?

Commonly used today
- RGB cameras
- TIR cameras

Potential new sensors
- UWB radar (cm/mm wave)
- Ultrasound

Fusing different sensor data
Machine Learning, training data sharing
Real time feedback

Conclusions

10 minute per turbine inspections possible
With multiple drones efficiency improves further
Use of AI is coming, data sharing could be beneficial for all

Questions?