# Digital Twin / Dashboard/ Despatch – WP2

Airtub-Romi Annual Meeting 2025

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innovation for life

# Project Goals:

**The main goal of this project is to develop a resident drone-crawler system that can perform blade inspections based on the damage prognosis by the digital twin**

1. Evaluate the suitability and performance of different blade mounted sensor types to detect different types of damage; Successfully install and test innovative blade mounted sensors able to detect damages and give indication on damage location and severity.
2. Build and test a functional prototype drone/crawler system (integrated with an ultrasonic sensor )with its supporting base station and residency equipment;
3. Create a fit for purpose digital twin model of the blade types which are equipped with sensors; Successfully assess damage severity by combining digital twin information with inspection data to support O&M decision making.
4. Successfully test the blade mounted sensor system automated operation, acquisition and transfer of inspection data, and post processing, in a realistic environment;
5. Successfully test the drone/crawler system automated operation, acquisition and transfer of inspection data, and post processing, in a realistic environment;
6. Develop a dispatch strategy to support day to day automated drone inspection operations.
7. Develop an O&M cost model and Asset Management strategy with blade inspection performed by the drone/crawler system.

# Goals of WP2:

1. Development of a database environment that acquires data from the blade mounted sensors, SCADA data from the turbine.
2. Development of a digital twin of the blade to assess the severity of the detected damage thus enabling faster informed decision making.
3. Development of a visualization dashboard
4. Extending UWiSE Despatch tool to enable day-to day scheduling of inspection activities using resident drones and evaluation of various despatch scenarios.
5. Development of O&M strategies for blade inspections using resident drone/ crawler system and business case evaluations using UWiSE O&M Planner.

WP2

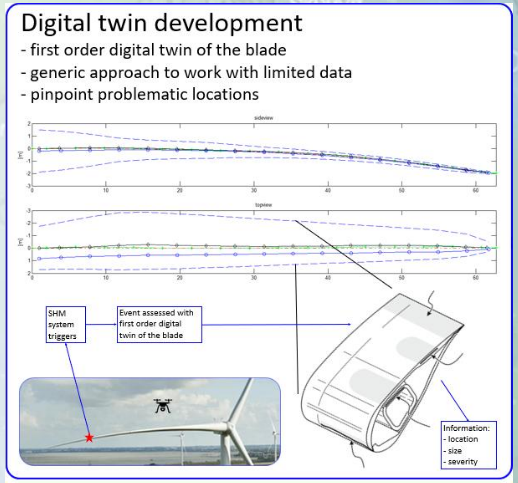
# Storyline of WP2

## DATABASE

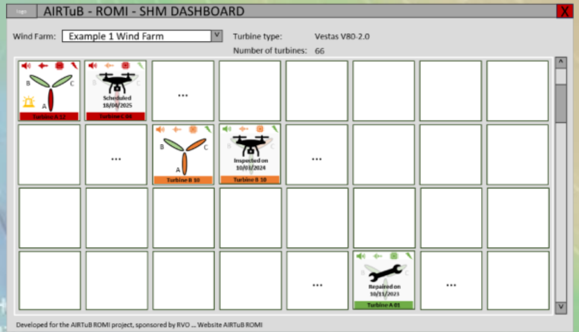
| WTG01 | | |
|---|---|---|
| | Signal | Data type |
| Mistras | AlarmHistory | Event-level |
| | AslTrends | Interval - 30min |
| | Grades | Interval - 7 days |
| | Hit data | Event-level |
| | TDD data | Interval - 1 sec |
| SCADA | Statistics | Interval - 5min |
| | High resolution | Interval - ~10 sec |
| DEHN | Alarm Meta data | Event-level |
| | Raw data (downsampled) | Event-level |
| | Raw data | File |
| Tarucca | Raw accelerometer data | High frequency |
| | Daily Statisticals | Interval - 1 day |

Collection of data from sensors and SCADA in the database

## DIGITAL TWIN




## DASHBOARD



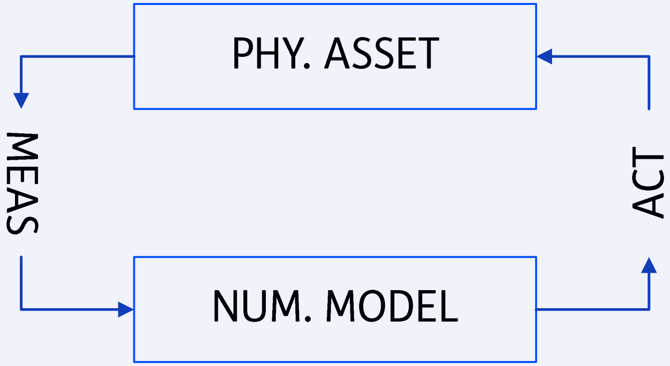

The operator will use the dashboard as the initial entry point to decide whether to deploy the drone for inspection.

## DRONE INSPECTION

The operator can schedule the drones for inspection of WTs using Despatch

# Digital twin

What is digital twinning?




Digital twinning the dynamic behaviour of wind turbines is not trivial:

- Complex dynamics (large rotations, large deflections, advanced composite material structures)
- Unknown excitation (wind, waves)
- Nonlinear system with different modes of operation (partial load, full load, idling etc.)

# Digital twin in WP2

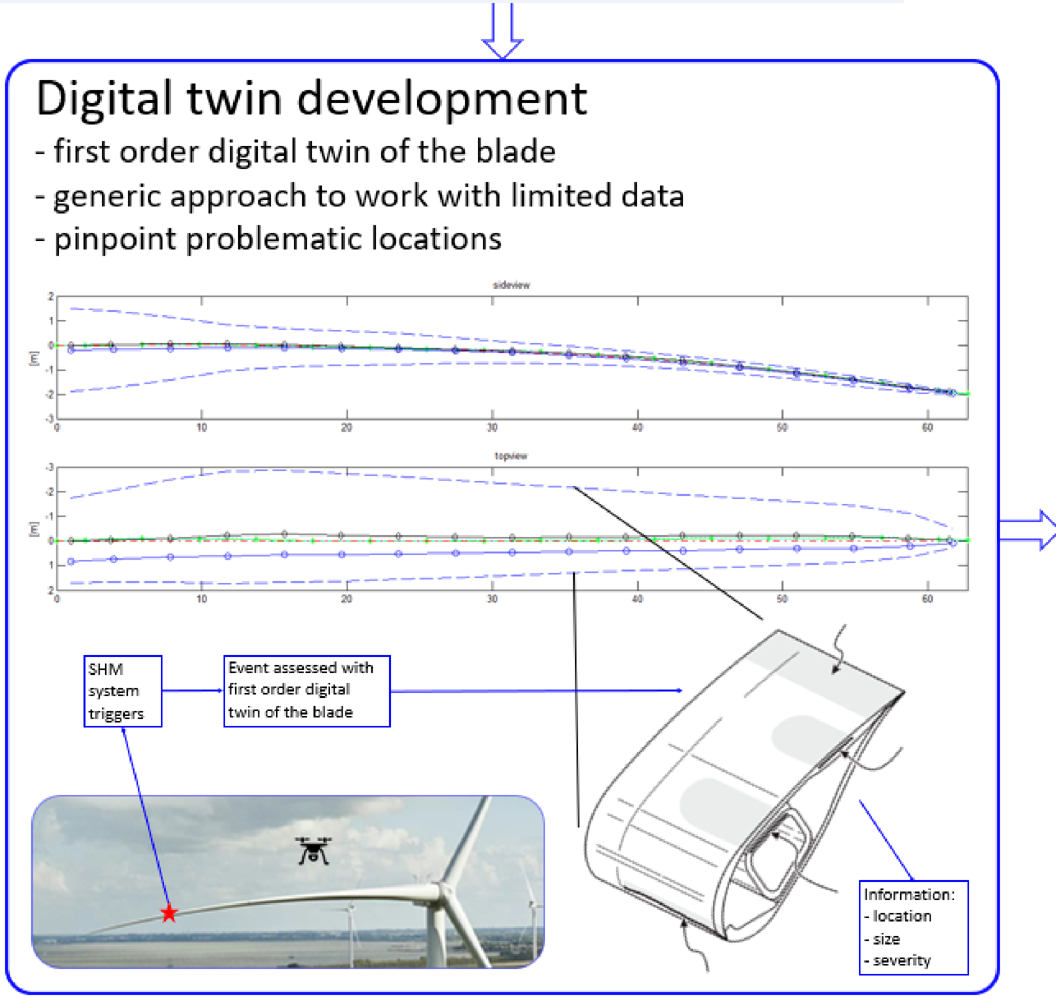
<u>From measurements to information</u>

<u>Goal:</u>

- Provide more information on the blade health, while reducing the amount of instrumentation.
- Support operators with targeting drone inspections towards the “region of interest”.

Method:

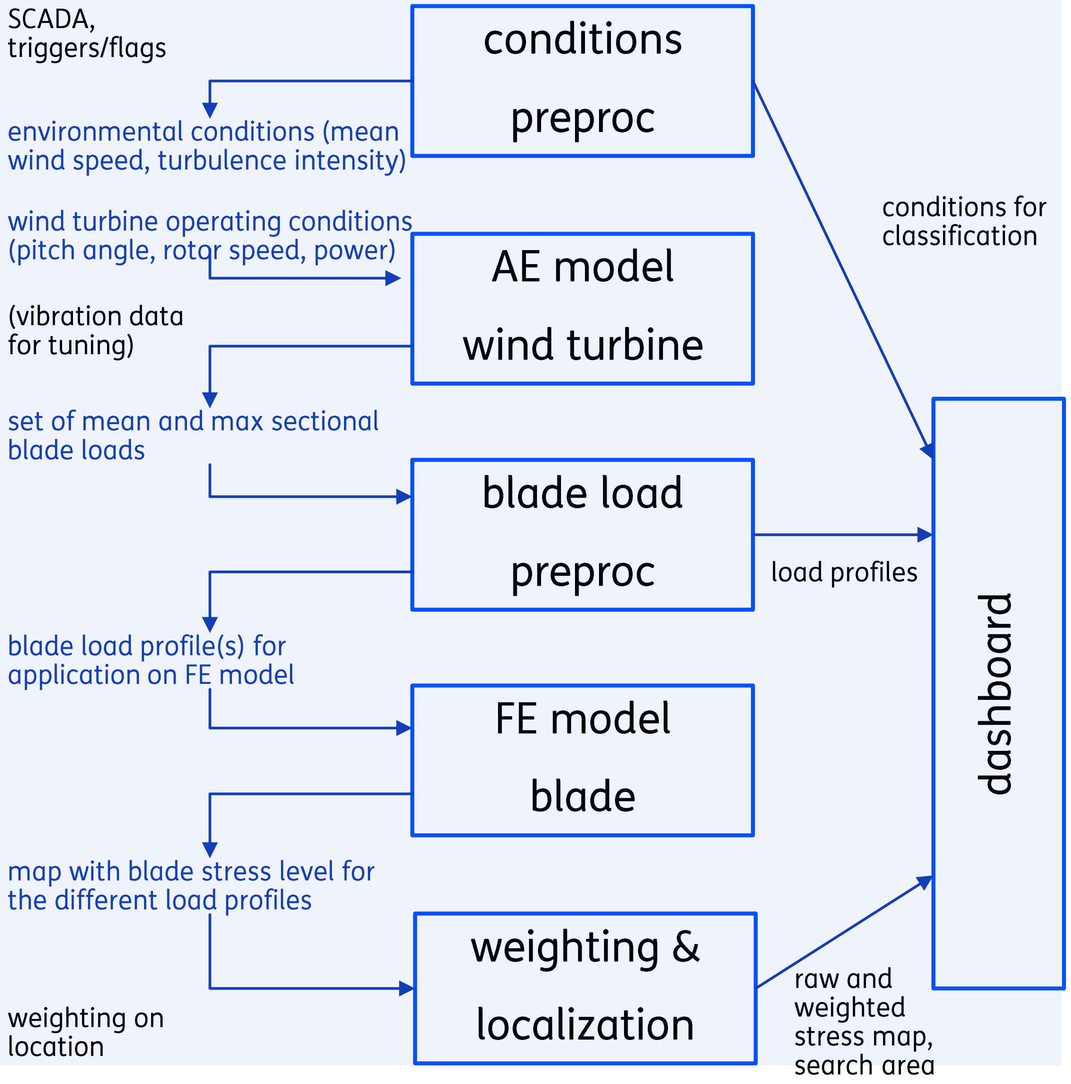
- Input from measurements (‘data acquisition and storage’)
  - SCADA, SHM instrumentation
- Output to dashboard (‘data processing and visualisation’)
  - State of the blade
  - Time traces of selected events
  - Output of the DT -> a heat map indicating stress levels



# Digital twin

Building blocks:

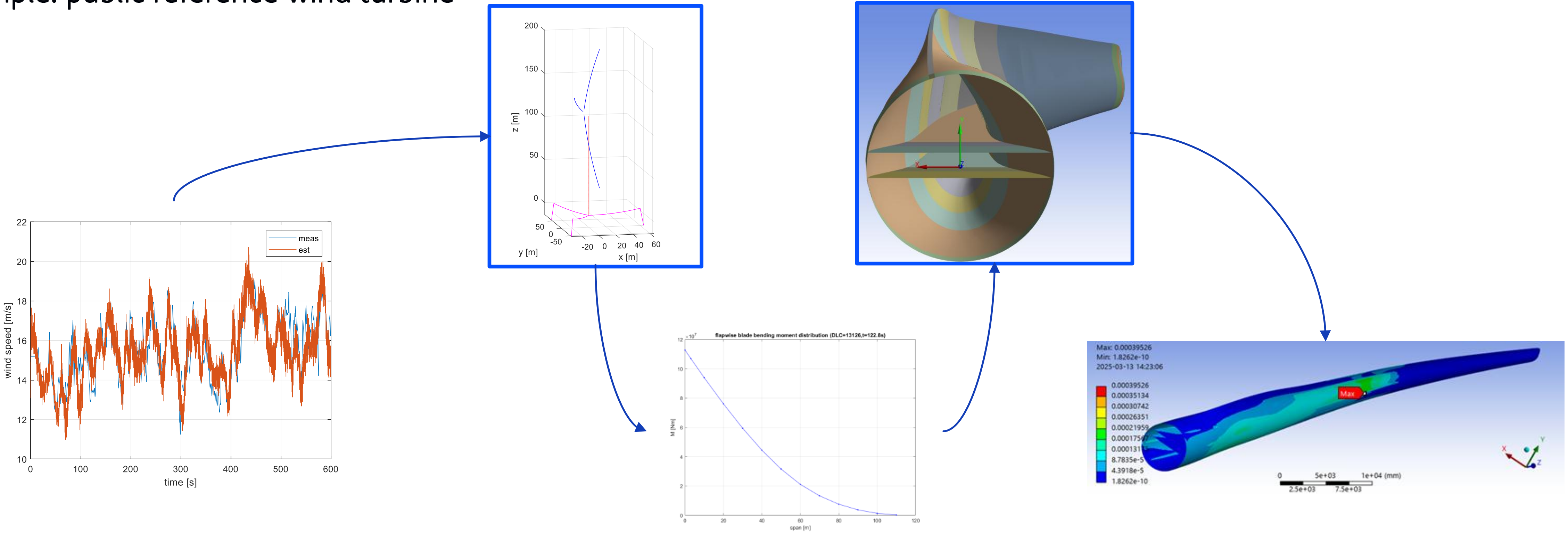
- Conditions preprocessor
  - Load data and derive conditions for model run
- Aeroelastic wind turbine model
  - Calculate mean and variation of blade loads
- Blade load preprocessor
  - Derive blade load distribution
- Structural blade model
  - Calculate blade stress map
- Postprocessor weighting & localization
  - Process stress map with area weighting to localize most likely area to inspect
- (Dashboard)



# DT approach (2)

Toolchain: measurements → AE → FE → dashboard

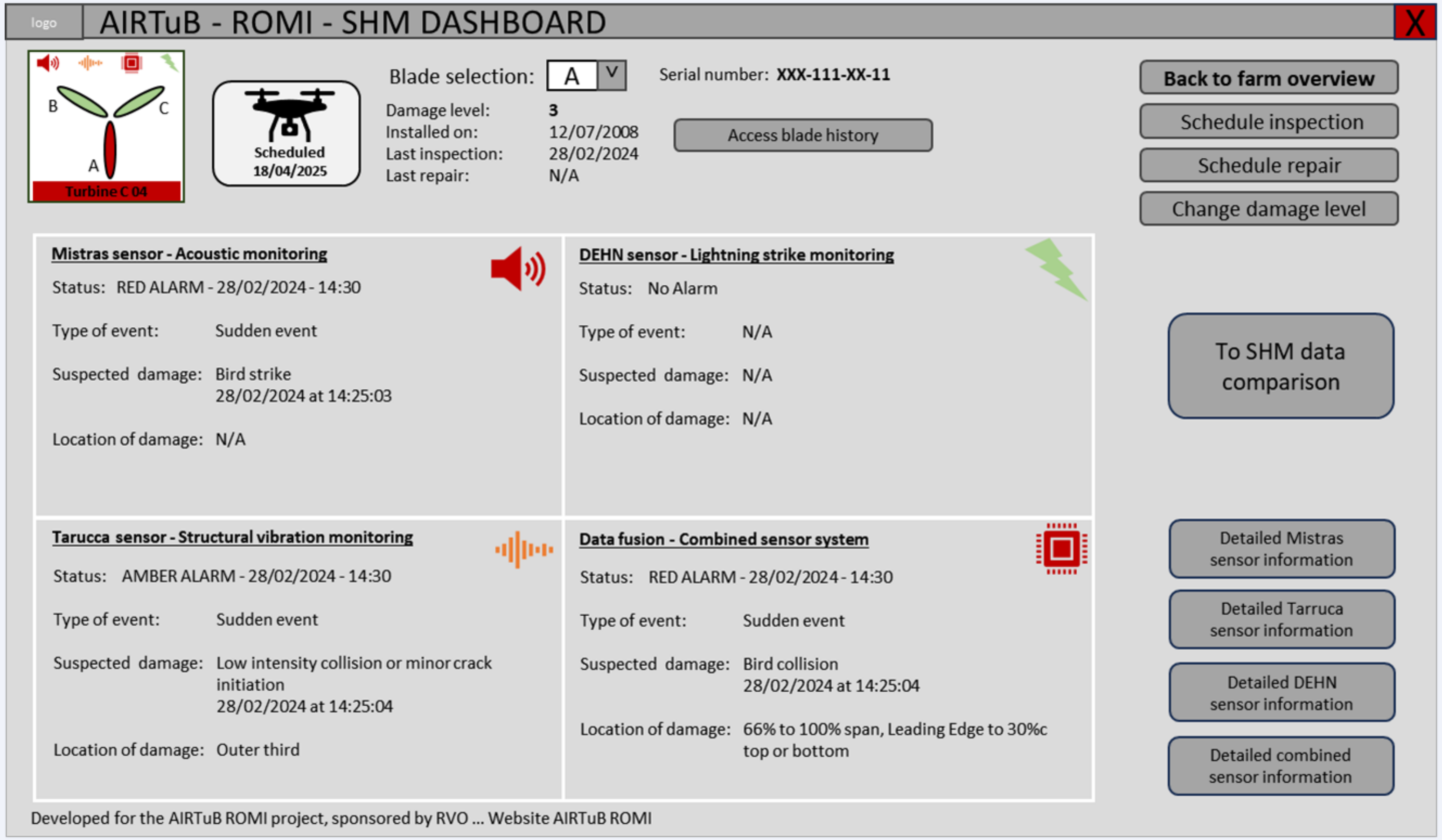
Example: public reference wind turbine



# Dashboard

Decision support dashboard with:

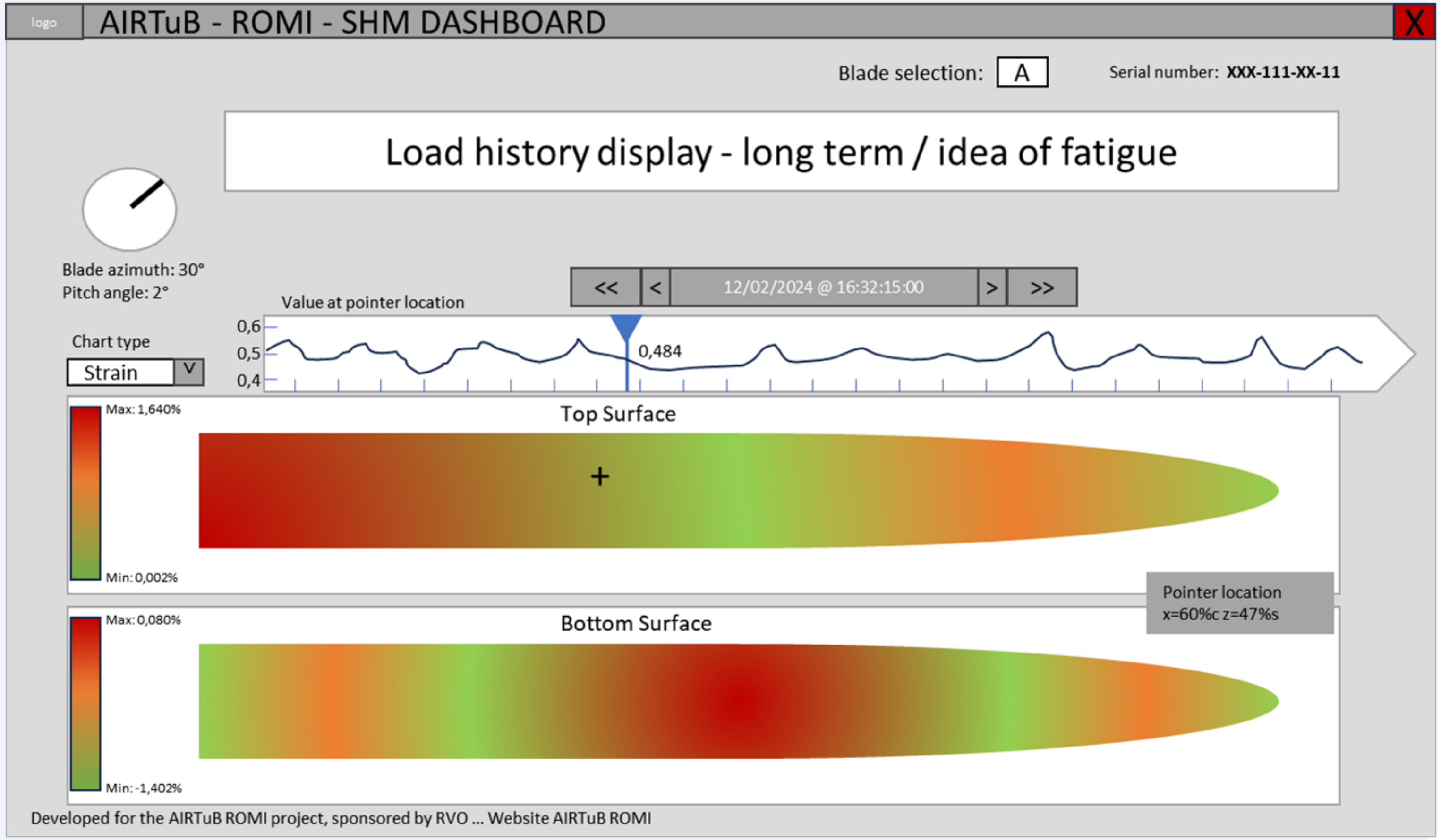
- Wind farm overview
- Individual asset status
- Measurements, flags and metadata from the different SHM instruments
- Output of the DT



# Dashboard

Combined overview to support operator with selection of inspection area, using layers with:

- Previous inspection report
- Output of the SHM instruments
- Output of the DT
- Drone and sensor specs



# Despatch

UWiSE Despatch helps the user **find the optimal schedule of daily maintenance activities** on offshore wind farms

**INPUTS:**

- Work order list
- Weather forecasts
- Objective
- Assets description

**CONSTRAINTS:**

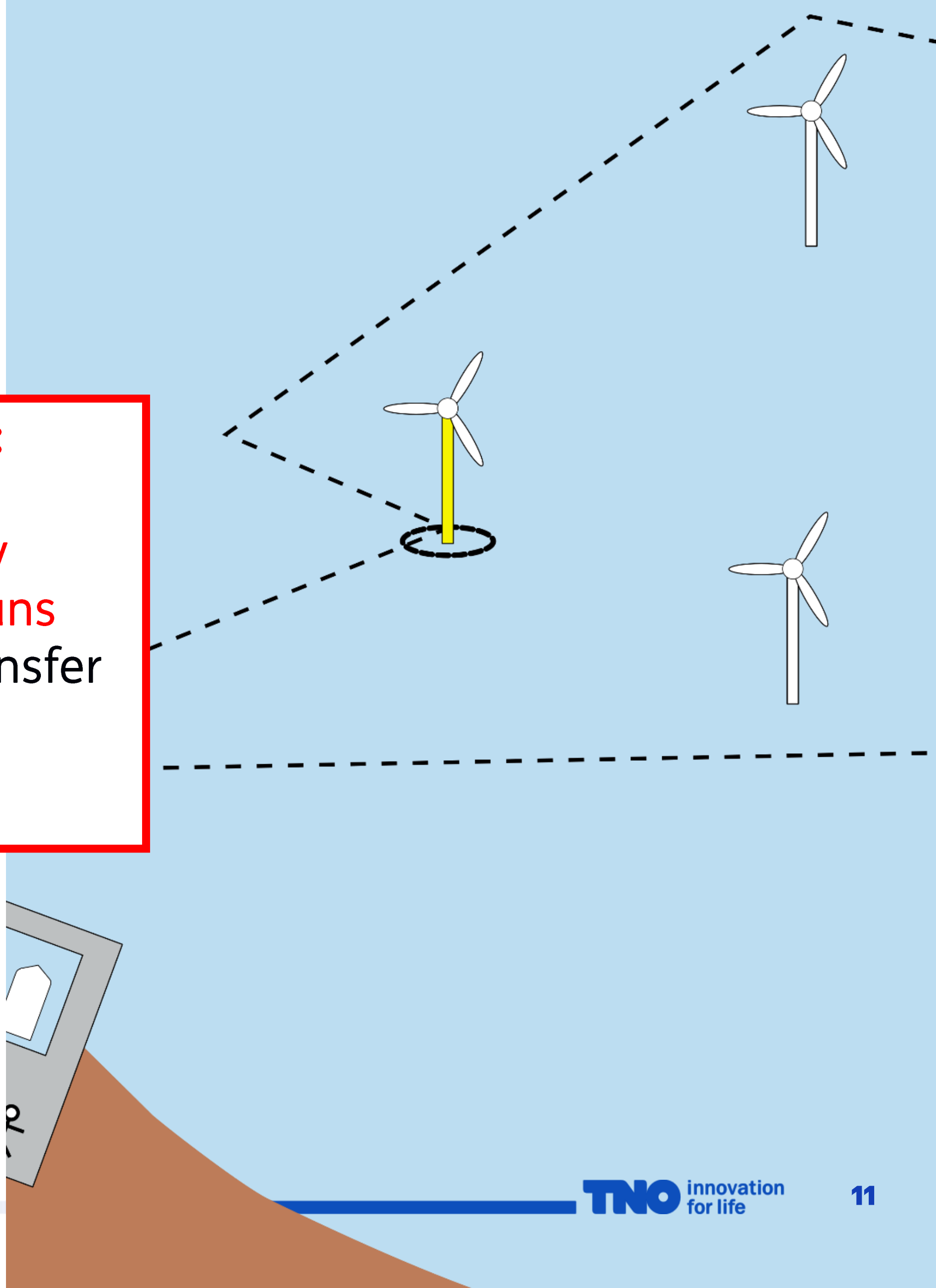
- Access limits
- Transfer limits
- Safety restrictions
- Technician skills, shifts, availability
- etc…

**OUTPUTS:**

- Automatically generated plans
- Evaluated transfer plans (KPIs)
- Gantt charts

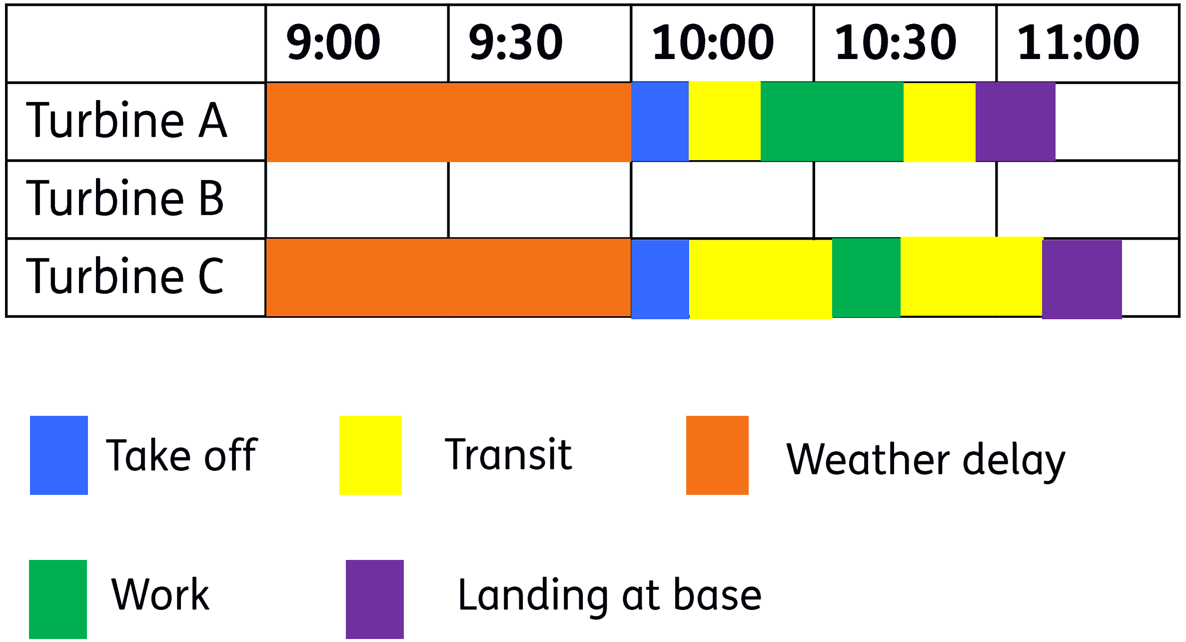
The **minimization objective** can be total cost, wind farm downtime, greenhouse gas emission, etc.

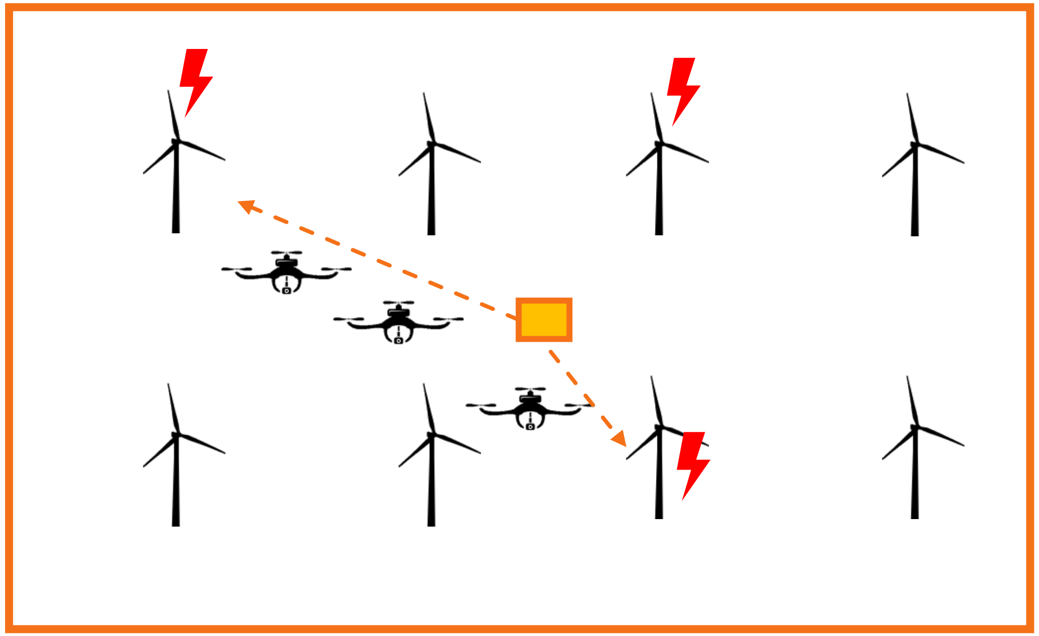
Despatch **automatically creates a list of candidates according to the objective set by the** user based on the genetic algorithm



# Despatch

In AIRTUB-RoMI, we look into the scenario where *a swarm of Airtub drones inspect multiple wind turbines in a farm*, and given a certain optimization objective to investigate *what the optimal scheduling for the drone swarm inspection is.*



Wind farm

WP2

# Thank you for your attention