

ROOT CAUSE ANALYSIS

INTRODUCTION

The **Root Cause Analyses** performed by nabla allows to detect the reason of failure of a specific component of the turbine.

CONCEPT

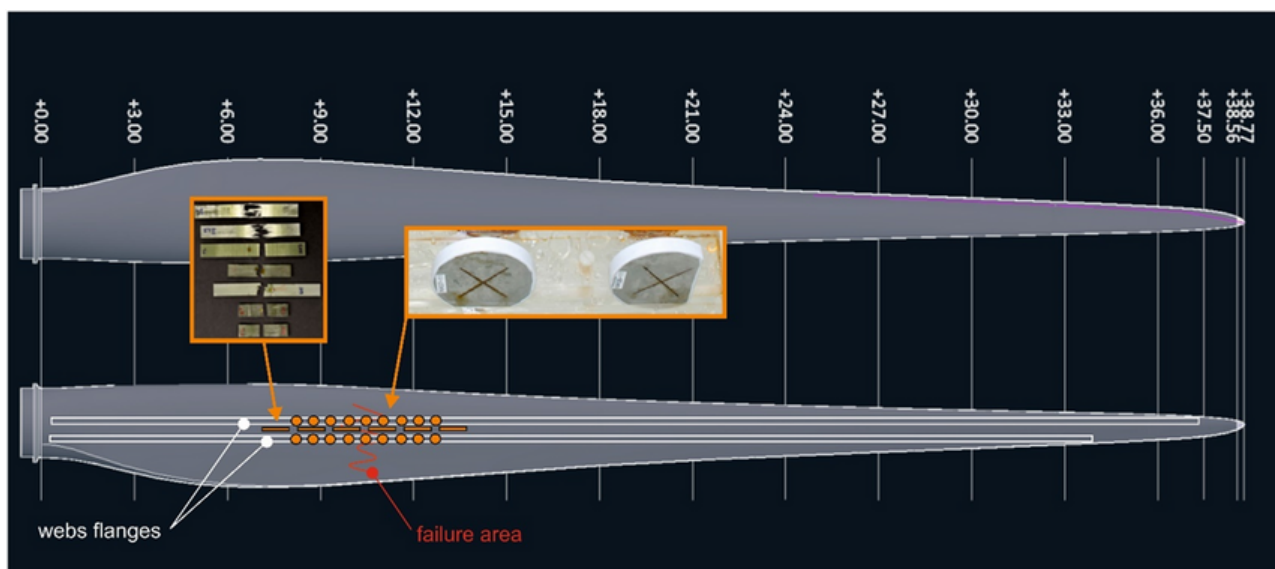
When an unexpected failure of a component happens on a specific turbine or turbines of a fleet, nabla wind hub's Root Cause Analysis seeks to identify the reason of such failure in order to prepare the correct AMP for the component and avoid suffering from the same failure in the rest of the wind turbines.

The failures can be caused by different issues, from Design or Manufacturing defects, to Performance Improvement upgrades/addons.

METHODOLOGY

Usually an RCA is made up of the following task:

- **On Site Inspections:** for the affected component in order to assess failure modes, affected substructures, and manufacturing quality and materials. In addition, the verification of the status of main structural components is done through visual Inspections. Depending on the component the specific inspections add-ons can be carried out by nabla at client request, such as:
 - **Sampling and Materials testing** by the extraction of some coupon tests from the damaged blade specimen (when possible), to enable its measurements and tests, ensuring that manufactured composites are according to design characteristics



- Inspections of **Blades** which can be based on thermographic inspection plus tap coin with a crane and a basket, or using high resolution **Thermographies** with drone.
- **Gearbox and Bearings Videoendoscopies.**
- **Electrical Systems Thermographies.**
- **Foundations** detail **cracks measurement and patterns identification**, measuring the cracks with uncovered foundations.
- Inspections of **Weldings** via **Penetrant Liquids.**
- **Inspections of Bolted Joints.**
- Specific **Corrosion Inspections**, sanding the surface, carrying our geometrical measurements of material loss and checking structural integrity of the subtract (via penetrant liquids) when necessary.
- **SCADA Data Analysis** allowing to perform a detailed operation condition analysis determining at the time of failure the real operation of the turbine in terms of:
 - number of transients and alarms per wind speed
 - yaw misalignments in power production and idling regimes
 - periods of ice accretion loads
 - long-term parked conditions
 - or seasonal variations (especially relevant for stall regulation)
 - with eventual surface degraded conditions (especially relevant for stall regulation)
- **Loads Analysis:** developing a detailed loads analysis using the SCADA data in terms of wind and operation conditions at the suspected period of failure to identify the realistic loads occurred on the turbine and the affected component.

Optionally, nabla wind hub can perform an specific **FEM analysis** of the component, by identifying Margin of Safety and Reserve Factors of the substructures, detecting weak points in the structure and providing best basis for configuration of the preventive retrofits for a Long Term Maintenance Plan.

OUTCOMES

Nabla will deliver a Technical Report per Task of the RCA, including:

**findings detected
at the On Site
Inspections**

**SCADA and Environmental
Conditions Analysis at
failure moment**

**findings detected
at the On Site
Inspections**

As per client request, nabla wind hub can **support in claims and litigations.**

REFERENCES

nabla wind hub is an independent technology platform that delivers asset redevelopment projects for the wind industry worldwide. End-to-end & one-stop-shop partner for SPVs and Portfolios revaluation, through Life Extension, Performance Improvement and Maintenance Optimisation; based on state of the art technologies, such as top-accuracy aeroelastic models, in-house rerotoring components, and advanced monitoring solutions.



600 wind farms
assessed



1200 sensors
installed



2000 blades
installed



+250 Wind Turbines
monitored

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