VENTUS GROUP

Poul Anker Lübker

Digitalisation and Data Science in the wind industry.

Raising Efficiency of existing and future Wind Farms.

European Digital Innovations to Enhance Global Wind Power Performance for Benefit of Owners and Investors.

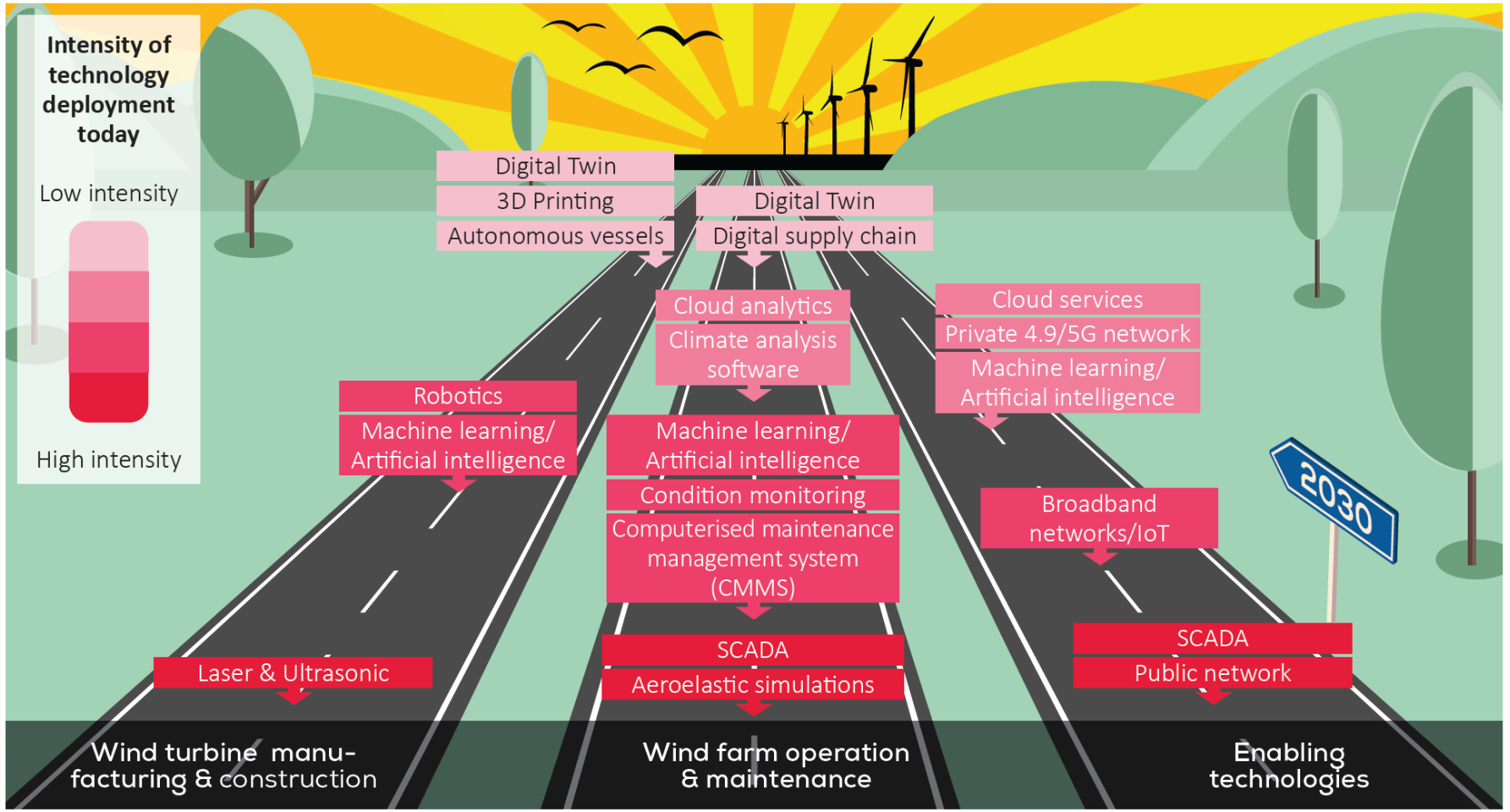
June 30th 2022

AGENDA

- DIGITALISATION IN THE WIND INDUSTRY PUT INTO PERSPECTIVE
- THE CHALLENGE AS OFF TODAY
- FUTURE TRENDS
- HOW DO VENTUS GROUP CONTRIBUTE TO DIGITALISATION

FIGURE 13

Roadmap towards a digital wind sector by 2030 and the application intensity of digital technologies today



Source: WindEurope

A new wind is blowing through the energy system – digitalisation.

Over the past decade, most mature heavy industries have experienced a digital revolution, and the wind energy sector is no exception. Enhanced sensor data collection and high quality data exchanges between wind operators and the surrounding energy ecosystem are growing significantly.

New DNV GL report.

Report reviews progress, potential and barriers for digitalization in the wind energy industry.

Owners and operators:

Improving operational efficiency (identified by 52% of respondents), decision making (42%) and cost efficiency (40%) are top priorities for further digitalization.

New DNV GL report.

"Balance between OEM willingness sharing data and protecting competitive advantage and Intellectual Property is key to realizing full potential of digital technology in the industry."

The report highlights that the benefits of digitalization could be threatened by issues over OEM sharing data and limited willingness to provide more transparency.

Such doubts are particularly felt in the offshore sector where concerns over data sharing (37% of respondents) and inability to access data (25%) were cited as the biggest barriers to further digitalization.

DIGITALISATION - THE CHALLENGE AS OFF TODAY:

Today there is clearly is a conflicts of interests in between OEM, Owners and Operators of wind assets.

OEM allow access to selected normalised SCADA data like 10 min average data, 1 min. average data etc. These data only to a very limited extend allow for further relevant data analysis

OEM do not allow access to existing high frequency WTG raw data enabling owners and operators to perform further across fleet monitoring and deeper data analysis

For Owners and Operators focus is and will continue to be how to increase ROI over asset lifetime.

Therefore - How do we get access to raw data in sufficient high quality to take advantage of the new data analysis techniques and the global trends in digitalisation?

Optimization in wind turbine performance and lifetime extension:

- Predictive maintenance / failure diagnostics trend analysis enabling anticipation of failures and better planning of service, maintenance and related logistics.
- Lifetime extension by implementing improved inexpensive monitoring and alarm systems.

Optimization in Operation & Management of wind farms:

- Holistic data approach in logistics and predictive Service & Maintenance strategies for increased availability and reducing power loss in downtime periods.
- New Service & Maintenance concepts considering the wind regime on the actual site, failure predictions and also taking lifetime extension parameters into account.
- Digital visualisation tools will assist us keeping the overview

FUTURE TRENDS - HOW TO CREATE VALUE BY COMBINING DIGITAL TECHNOLOGY, DATA SCIENCE, PEOPLE AND BUSINESS STRATEGY

Third party non-invasive high-quality data acquisition systems using new modern sensor technologies will be retrofitted in existing WTG's and also in new WTG's primarily due to issues with permitted access to existing raw data collected by the OEM.

Data processing and analysis will be performed directly in the WTG's (closer to the data source and online) primarily due to higher sampling frequencies. (Example data collected before at 256Hz → now at 6.000Hz)

New third party monitoring, alarm and failure diagnostics trend analysis systems based on data coming from the new high quality data acquisition systems and using new analysis techniques will be an important driver in increasing ROI over lifetime of wind assets.

In Ventus Group we believe Digitalisation and data Science is very important part of the roadmap for the wind industry.

Excellence in design and operation of wind turbines and wind farms is hidden in the data!

VENTUS GROUP ACTIVITIES

Ventus Engineering GmbH
(AT)

R&D

- Rotor Monitoring System (TripleCMAS)
- Lightning system Monitoring (LEDS)
- Lightning system check using drone
- Ventus OS
- Ventus 24/7
- Graphene containing carriers for WTG

Ventus Wind Services
(AT, DK, UK, PL, IN, USA)

Services & Products

- Rotor Monitoring System (TripleCMAS)
- Wind farm performance and diagnostics analysis
- Dynamic Blade Pitch Angle Measurement
- Nacelle based LiDAR Measurements
- Drone Inspections
- Taking-Over & End-of-Warranty Inspections
- Dissolved Gas Analysis
- Wind Farm Lifetime Extension
- Ventus Academy

Ventus GmbH
(AT)

Insurance

- Extended Warranty
- Construction property damage
- Delay in start-up
- Machinery Breakdown
- Business Interruption

DYNAMIC BLADE PITCH ANGLE VERIFICATION USING HIGH SPEED CAMERA TECHNOLOGY:

Certified for Dynamic Relative Blade Pitch angle Misalignment (DRBPM) visual inspection service

Ventus Patent

- ✓ Ventus proprietary image acquisition software and methodology
- ✓ High speed and high-resolution camera technology
- ✓ No need to interrupt the operation of the wind turbine
- ✓ On site image processing
- ✓ Using AI and machine learning techniques (pattern and feature recognition, pixel coordinates detection, etc.)
- ✓ Detect also any other irregularities of the rotor performance and appearance (blade damages, bending or twisting differences, etc.)

Visual inspection system, by means of a (a) tripod and (b) drone

DYNAMIC BLADE PITCH ANGLE VERIFICATION PROCEDURE - FEASIBLE FOR ALL WTG'S:

Certified for Dynamic Relative Blade Pitch angle Misalignment (DRBPM) visual inspection service

Ventus Patent

The high-speed camera operate with a frame rate of 543 frames per second (fps).

A total number of 5.900 images is recorded of 59 blade passings which is 19 full rotor rotations.

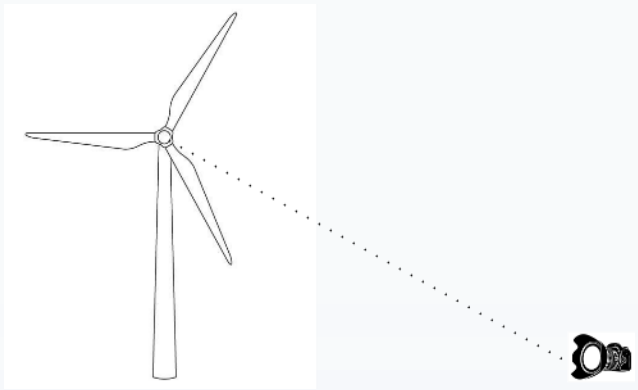
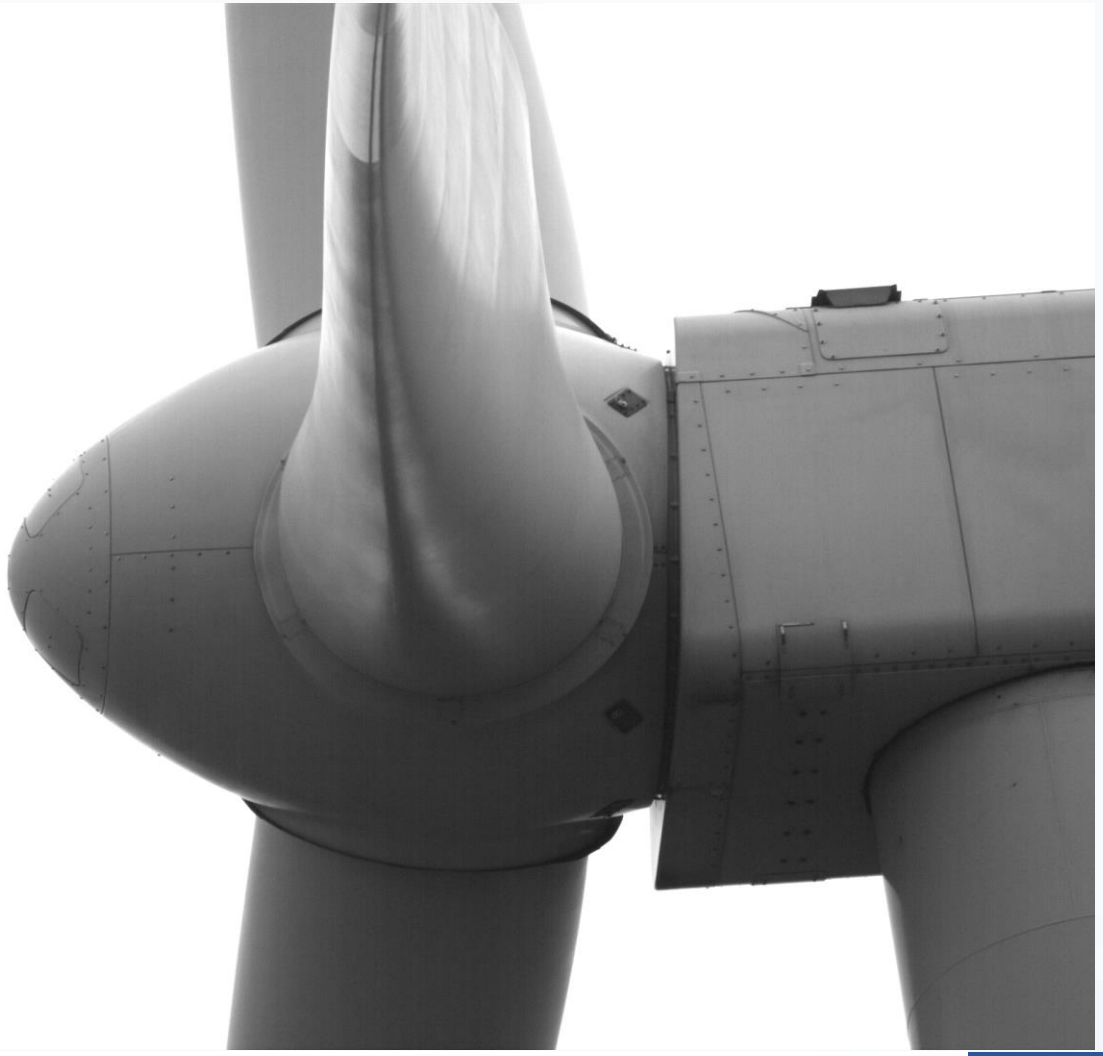


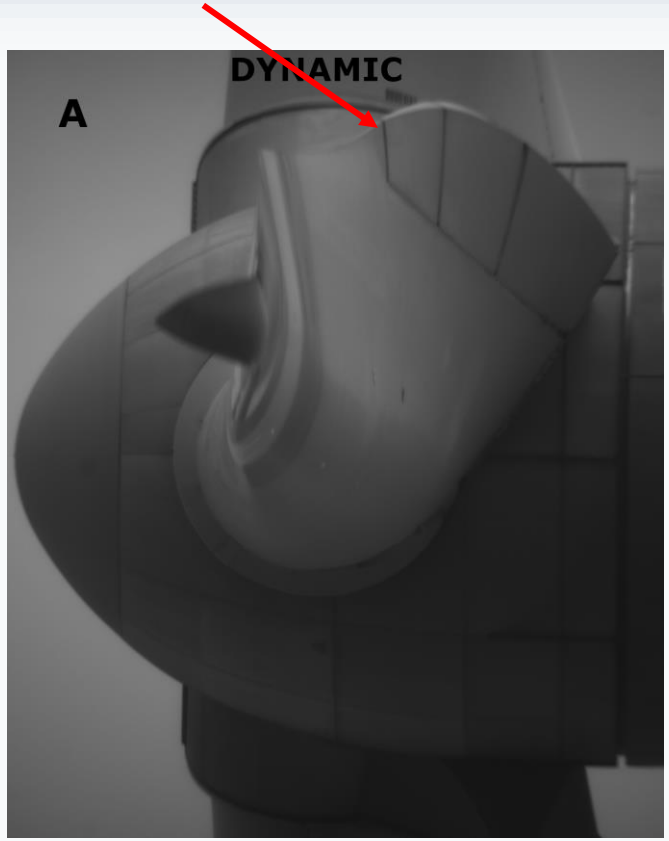
Image acquisition example

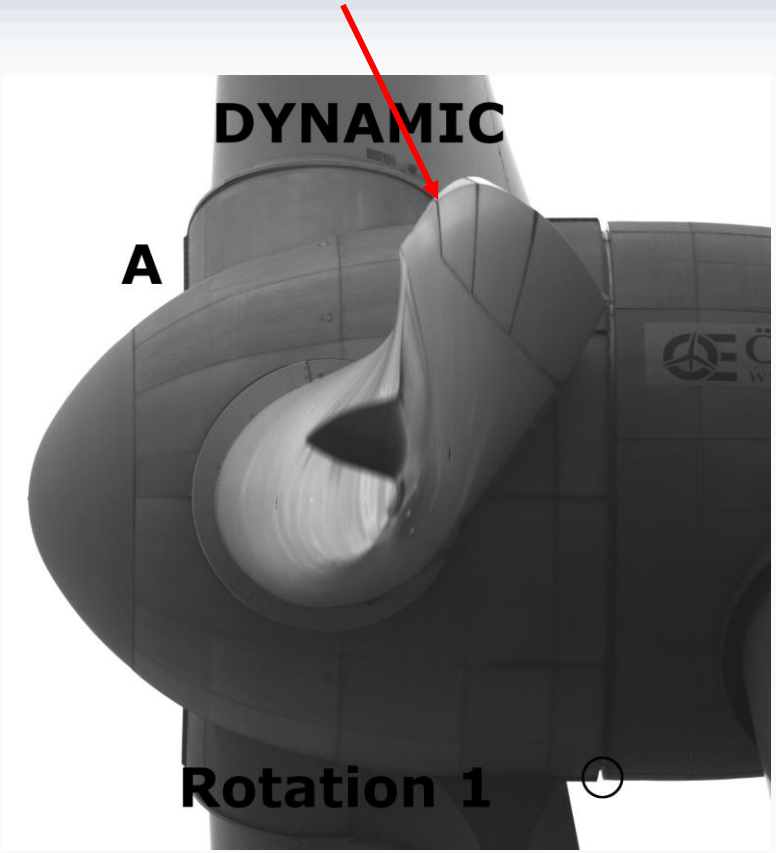


DYNAMIC BLADE PITCH MISALIGNMENT MEASUREMENT AND CORRECTION SERVICE VERIFICATION EXAMPLE:

Certified for Dynamic Relative Blade Pitch angle Misalignment (DRBPM) visual inspection service

Ventus Patent





Before correction:

Blade A to be corrected -2,7° to reach Blade C

Blade B to be corrected -2,0° to reach Blade C

Blade C bending clearly different

After correction:

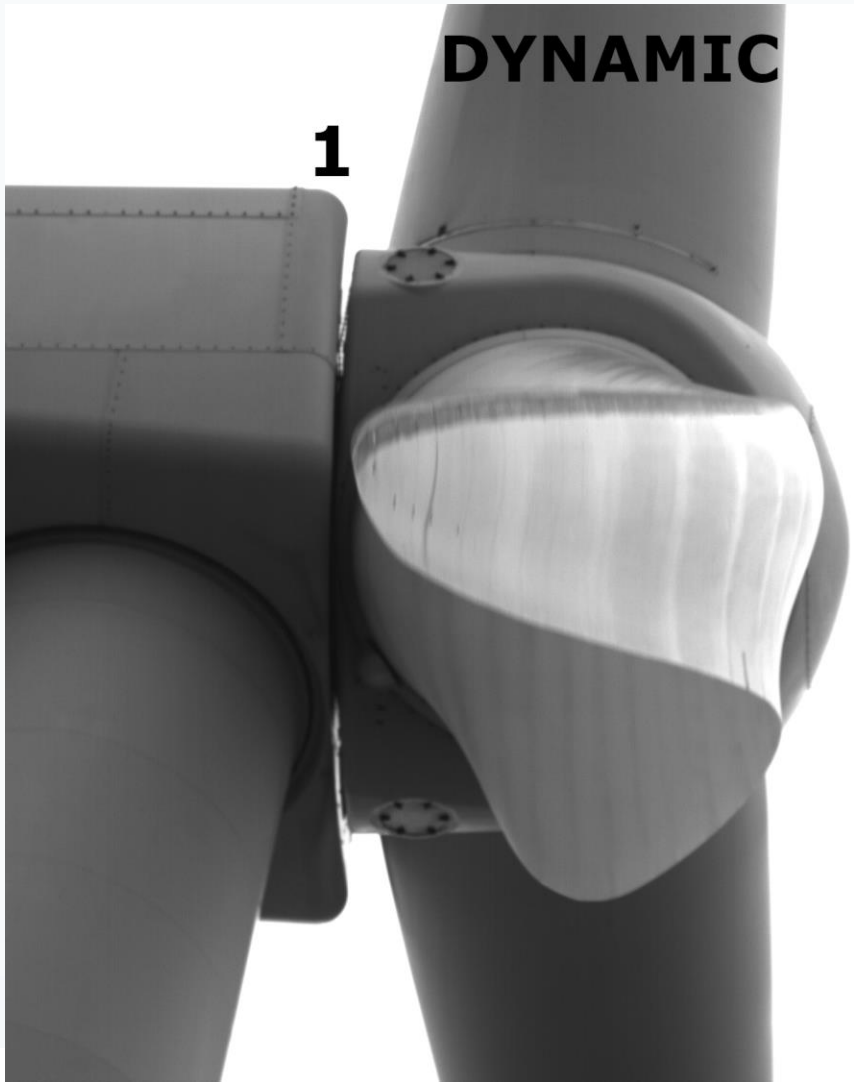
Now all 3 blades within +/-0,3^0

Now bending is the same on all three blades

DYNAMIC BLADE PITCH VERIFICATION EXAMPLES WTG #4 8MW:

Certified for Dynamic Relative Blade Pitch angle Misalignment (DRBPM) visual inspection service

Ventus Patent



Results of relative blade pitch angle misalignment detected:

- blade 1 is misaligned relatively to blade 3 with - 0.92
- blade 1 is misaligned relatively to blade 2 with - 0.72

According to the type approval then blades should be pitch relative to each other within +/- 0,3 degrees which is not the case for this WTG.
Misalignment in this magnitude cause additional loads due to aerodynamic unbalance in between the blades and reduced the generated power output.

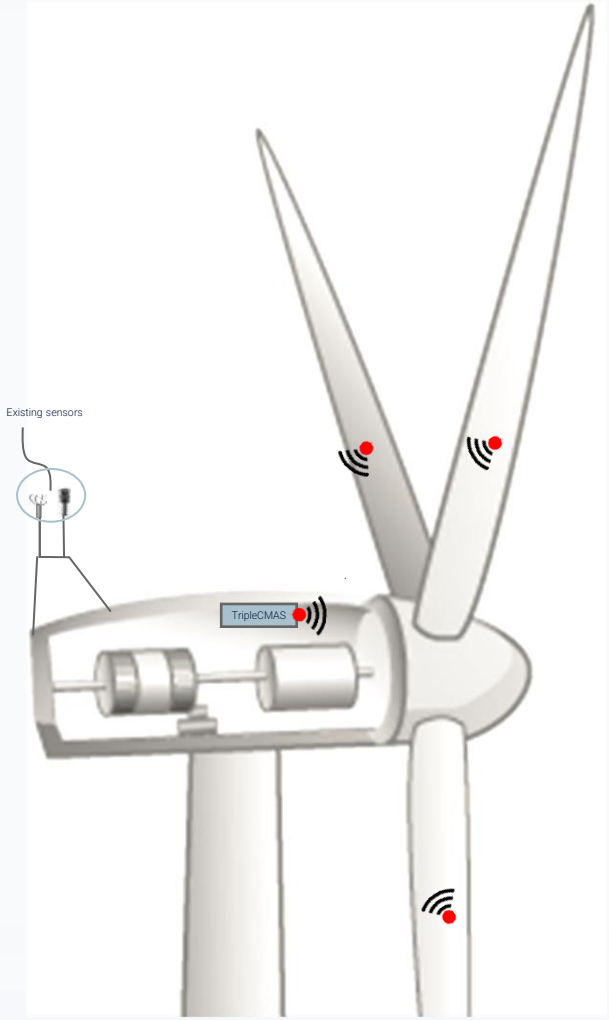
Critical Components Condition Monitoring, fault detection and instant Alarm System

(TripleCMAS™)

Feasible for all existing and future wind turbine types.

VENTUS TripleCMAS™ ROTOR BLADE SENSOR NODE:

Ventus Patent

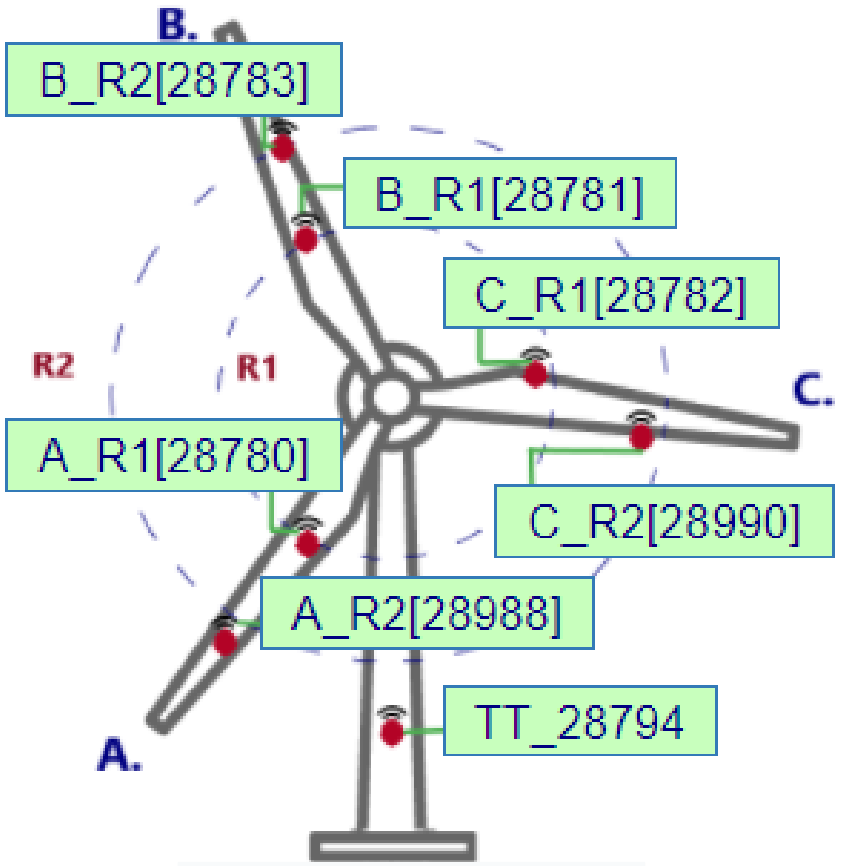


Ventus wireless and battery powered sensor node located inside the blade

Ventus RCM wireless and battery powered sensor node located next to iphone5

VENTUS GROUP SENSOR NODE SETUP IN BLADES, AND TOWER TOP. SAMPLING FREQUENCY ON ALL SENSOR NODES 256Hz AND ALL DATA COLLECTED BY VENTUS GROUP COLLECTION BOX LOCATED IN NACELLE:

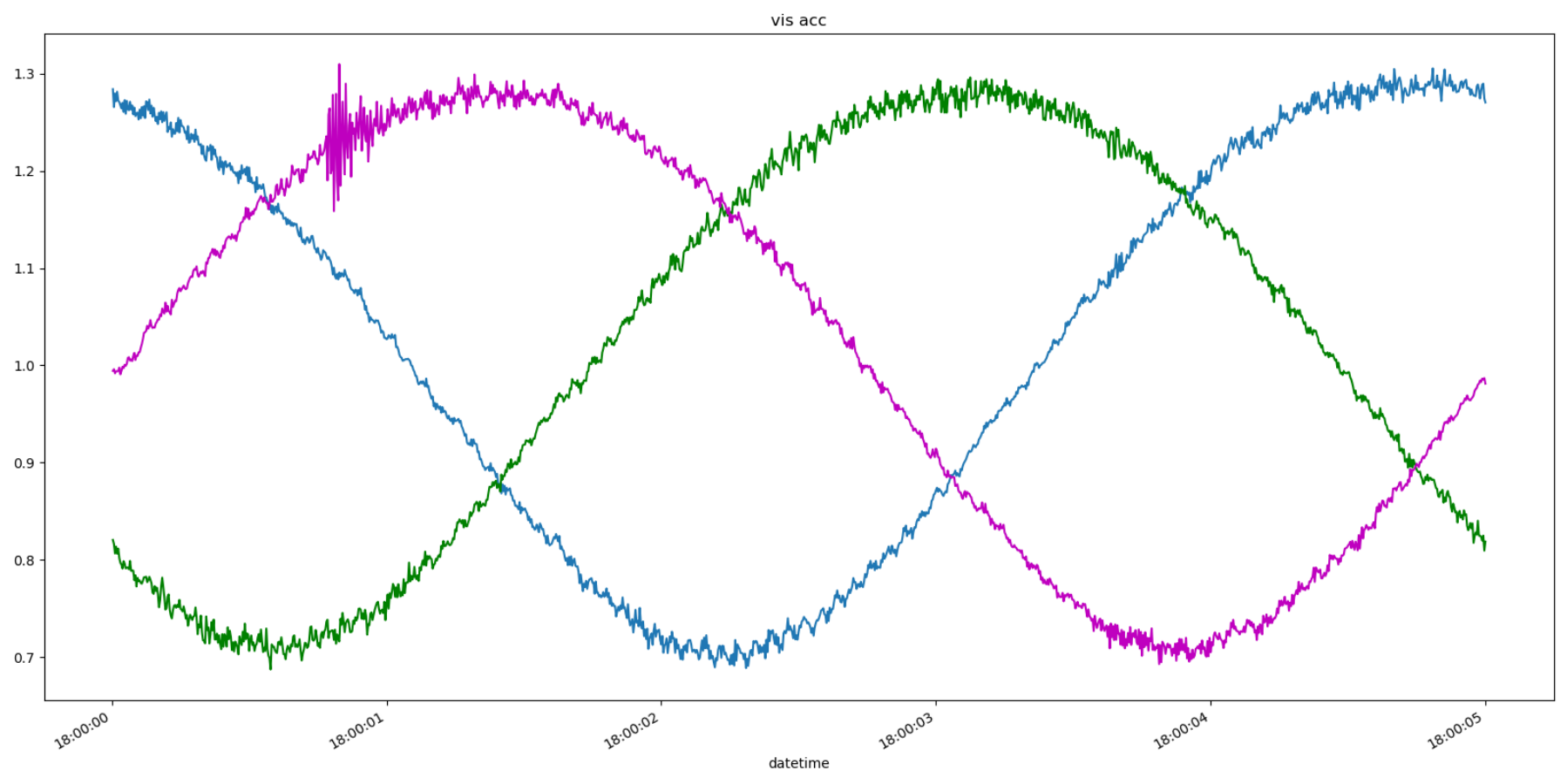
Ventus Patent



R1 = 2m.
R2 = max out in blade

G-force measurement in 3 blades using Ventus TripleCMAS sensor node - during 1 Rotor RPM:

Blade 1 **Blade 2** **Blade 3**



ALGORITHMS EXAMPLES:

Wind speed

Turbulence Intensity

Wind Direction

Yaw Misalignment

Wake

Flap wise bending & Edgewise blade bending *(Individual blade aerodynamic efficiency)*

Blade twisting – *(Blade behaviour, Wake monitoring)*

Relative Blade Pitch Misalignment

Rotor Aerodynamic Imbalance

Icing detection

Blade hit by Lightning strike

Movement in top of tower

Orientation of rotor in stopped position

RPM and Rotor Overspeed detection

Monitoring cut-in, cut-out and re-cut-in

Speed and behaviour of Blade pitch angle changes

Heavy Rain and Hail Detection

Movements in foundations

Punctual shocks in blade structure

TripleCMAS = Winning solution at Launch Academy UK Organized and evaluated by ORE Catapult and SIEMENS Gamesa

"The panel were unanimous in their support; they were impressed by how you [Ventus Engineering GmbH] answered the Sensors challenge with a comprehensive solution that could cover multiple challenges in one package, offering clear advantages over incumbent technologies."

Andrew Tipping, Commercialization Manager, ORE Catapult.

SIEMENS Gamesa RENEWABLE ENERGY

CATAPULT Offshore Renewable Energy

THANK YOU FOR YOUR ATTENTION!

TÜV AUSTRIA ZERTIFIZIERT TÜV AUSTRIA CERT GMBH
EN ISO 9001 20100223014051
ISO 45001 20116223014052

RENEWABLES CERTIFICATION DNV STATEMENT MB-DNV-SE-0439-08423

Austria (HQ)
Ventus Engineering GmbH
Simmeringer Hauptstraße 101/1-6/327,
1110 Vienna,
Austria

Austria
Ventus Wind Services GmbH
Simmeringer Hauptstraße 101 /1-6/326
1110 – Vienna
Austria

Denmark
Ventus Wind Services A/S
Vesterballevej 27,
7000 Fredericia
Denmark

Scotland
Ventus Wind Services UK Ltd.
101 Rose Street South Lane,
Edinburgh, EH2 3JG,
Scotland

Poland
Ventus Wind Services Sp. z o.o.
Ul. Mściwoja 9-5 Gdynia,
pomorskie, 81-361
Poland

India
Ventus Wind Services (India) Pvt Ltd
19/ Union Park, Pali Hill, Khar (West),
Mumbai, Mumbai City, Maharashtra,
India, 400052

sales@ventus.group | www.ventus.group