Nov 2024

RTDT Laboratories AG

Aerosense

Aero-structural monitoring and diagnostics

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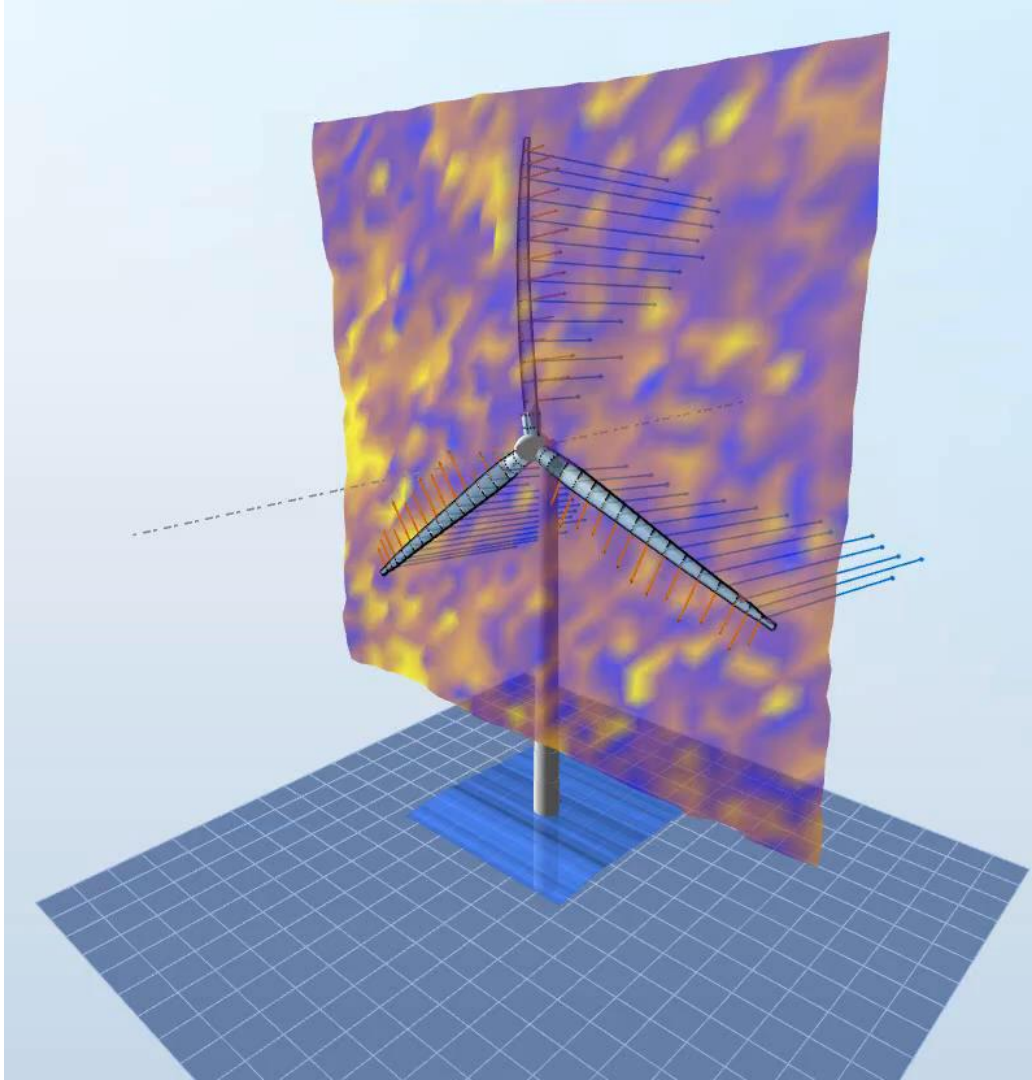
Very difficult to measure the full flow field in front of wind turbines – in high resolution and in real-time.

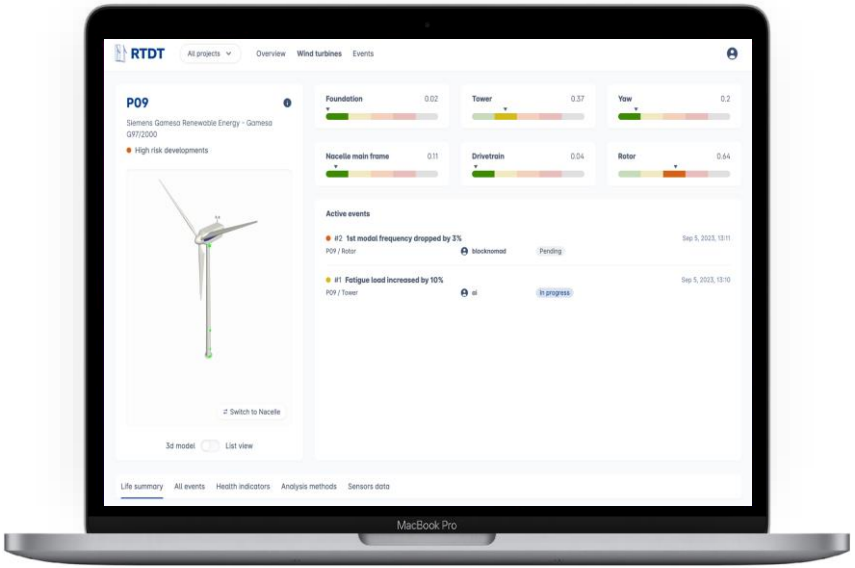


About | RTDT

Digital doctor for wind turbines

Aerosense ®
Multi-sensor node

Holistic Aero-Structural
Health Diagnostics Software



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Blade data capture with Aerosense (patent filed)

Flexible 3D printed enclosure with embedded micro-electronics sensors, installed in minutes

Measures aerodynamic pressure, vibrations, strain, acoustics, and temperature in a single node

Wireless & self-sufficient onboard power (solar-powered)

Proprietary models for rotor diagnostics and control

Aerosense on wind turbines for aero-structural diagnostics

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Physics

Aero-structural dynamics

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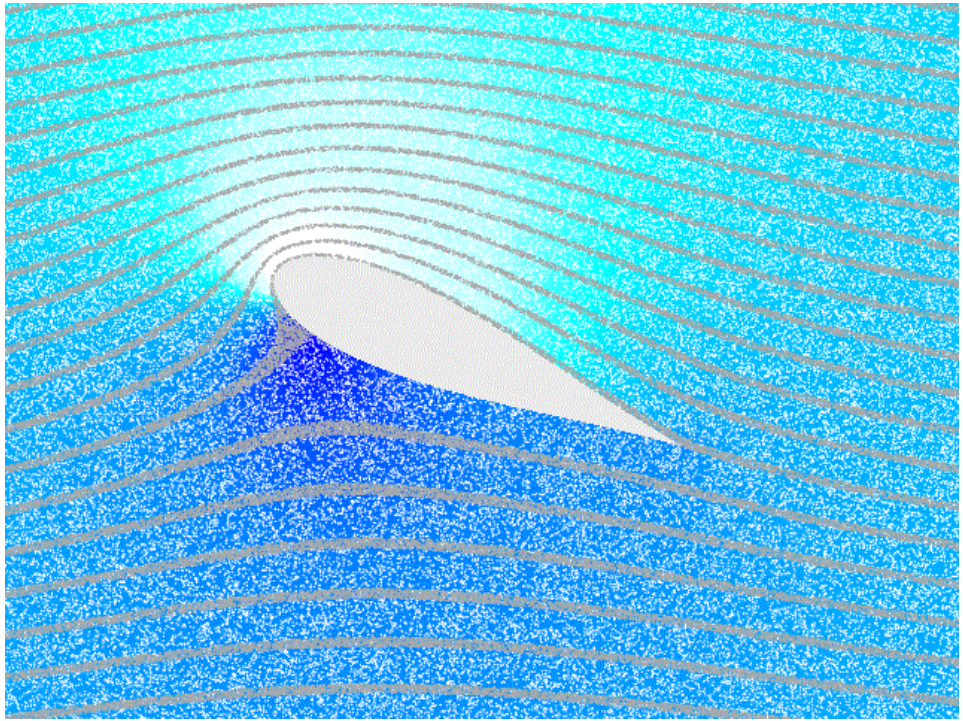
Airfoil aerodynamics



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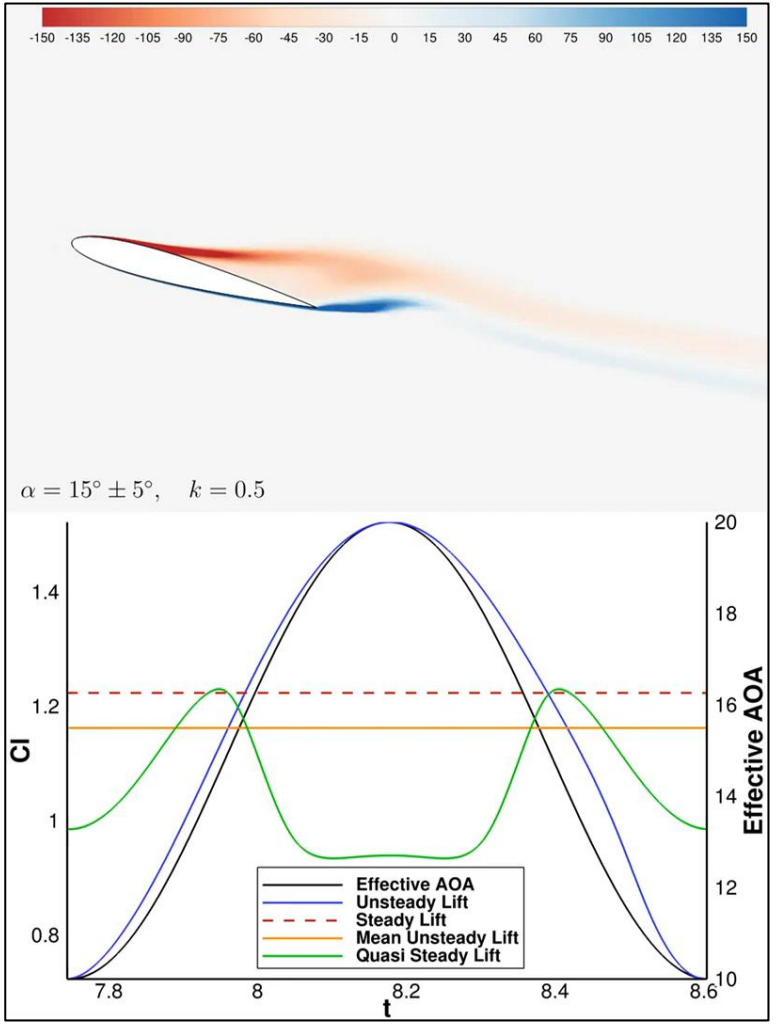
Aerodynamic Forces on an airfoil



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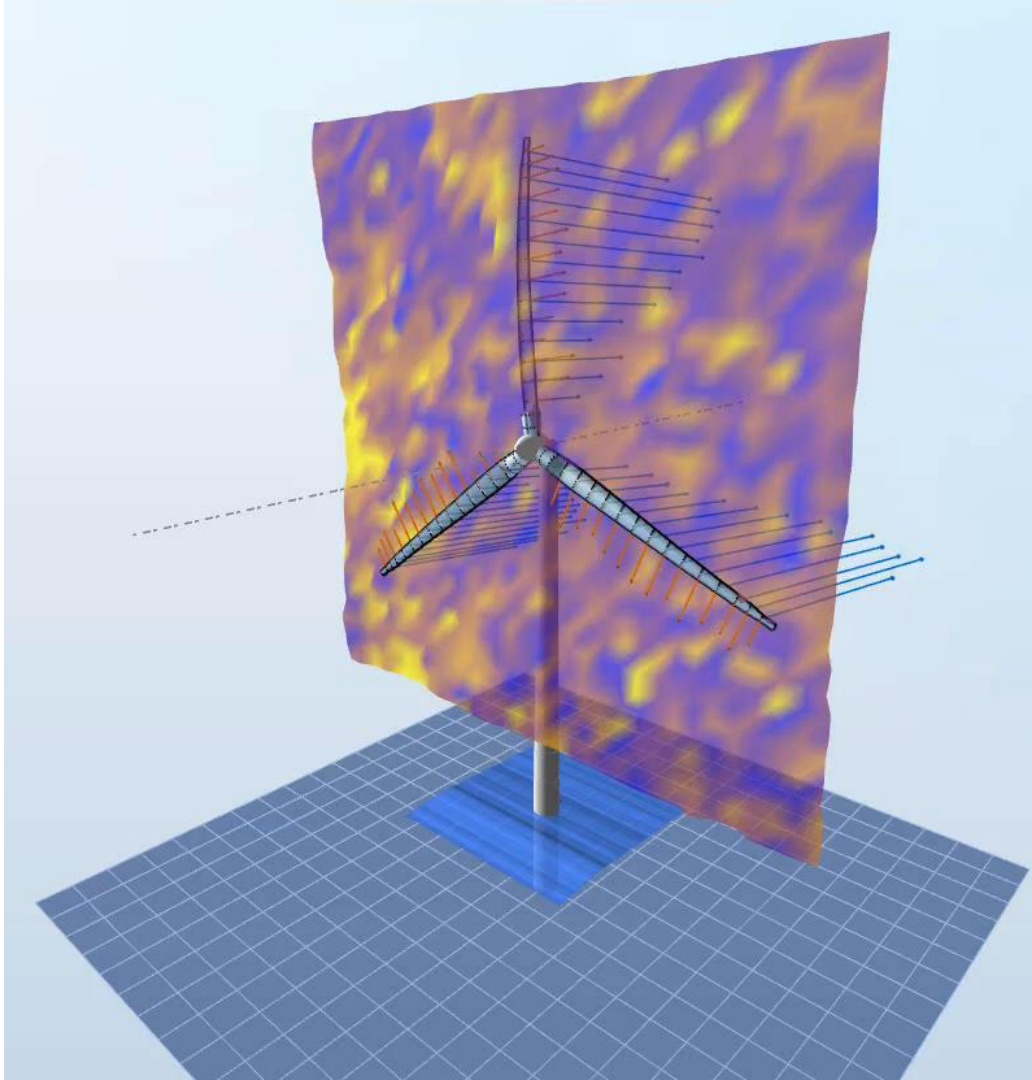
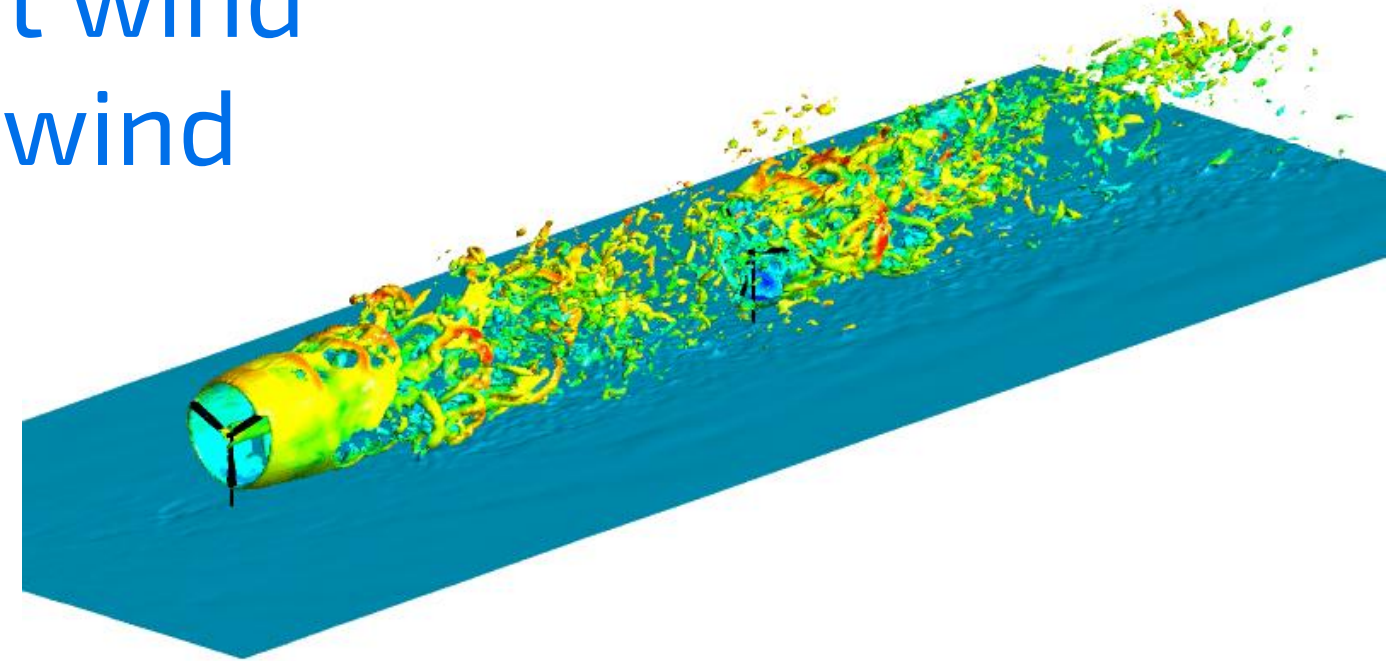
Turbulent wind field in front of the rotor



Turbulent wind field in a wind farm



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The Challenge

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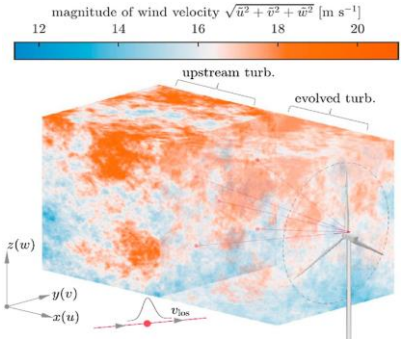
Overview of the physical process

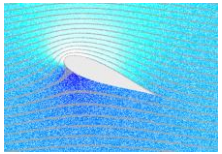
INPUT

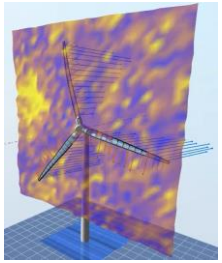
Turbulent wind field



PHYSICAL PROCESS

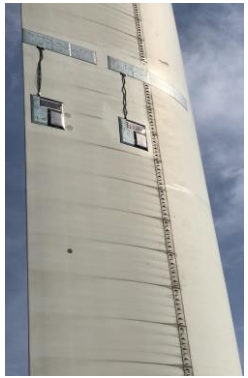
Rotor coupled aero-structural dynamics

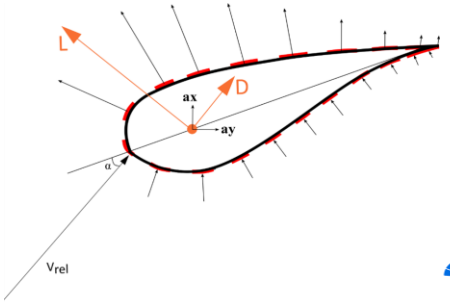




AEROSENSE (measureable) OUTPUT

$Acc_x(x,t)$
$Acc_y(x,t)$
$Acc_z(x,t)$
$F_N(x,t)$
$F_T(x,t)$
$\alpha(x,t)$
$V_{rel}(x,t)$





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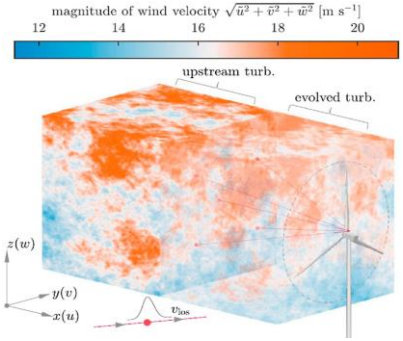
The challenge

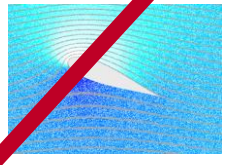
Reconstruct the 3D turbulent wind field using Aerosense data only

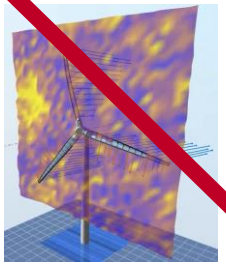
Turbulent wind field

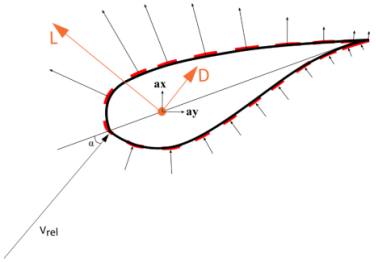
Rotor coupled aero-structural dynamics

$Acc_x(x,t)$
$Acc_y(x,t)$
$Acc_z(x,t)$
$F_N(x,t)$
$F_T(x,t)$
$\alpha(x,t)$
$V_{rel}(x,t)$

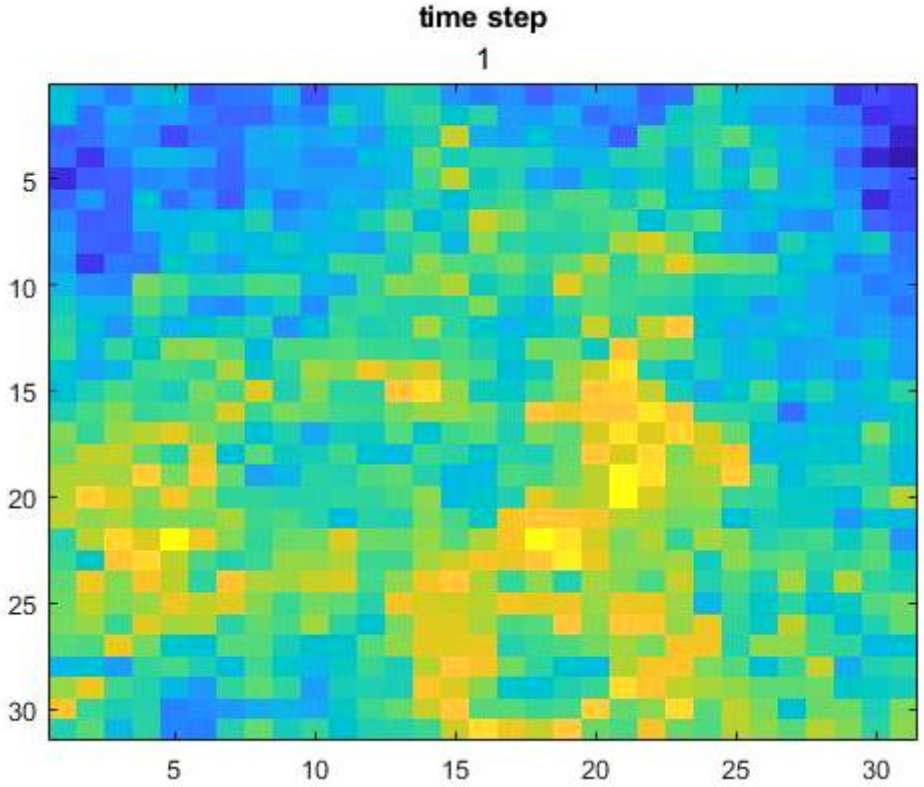








Data



Turbulent wind fields

Vmean = 6, 12, 20 m/s

Ti = 2, 10, 25%

12 realizations for each of the above combinations

Each wind field is made of 21x21 grid points

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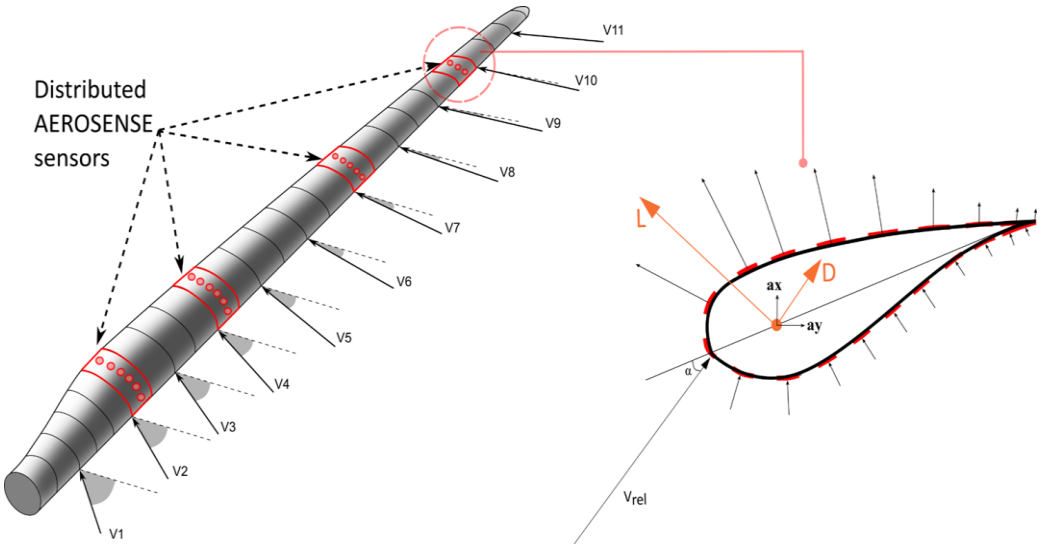
Data



Aerosens output

$Acc_x(x,t)$
$Acc_y(x,t)$
$M_x(x,t)$
$M_y(x,t)$

$F_N(x,t)$
$F_T(x,t)$

$\alpha(x,t)$
$V_{rel}(x,t)$
$Pdynamic\ (x,t)$

9 locations along the span of each of the 3 blades

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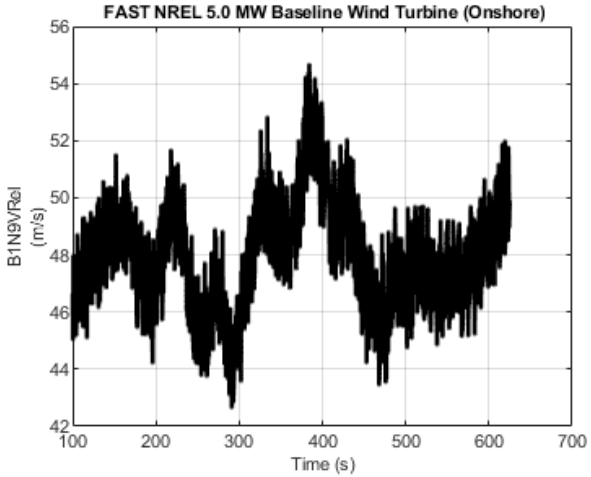
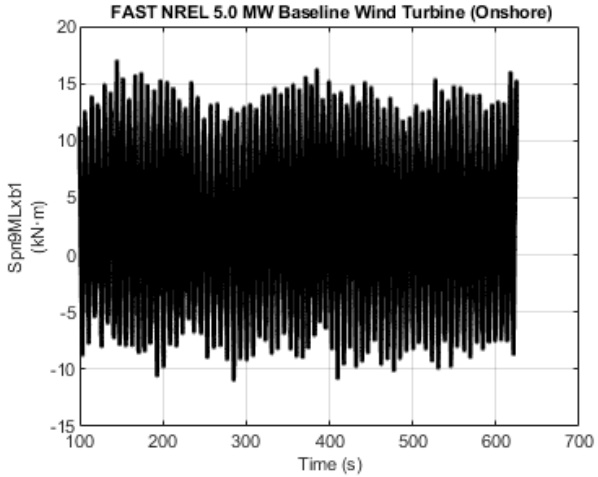
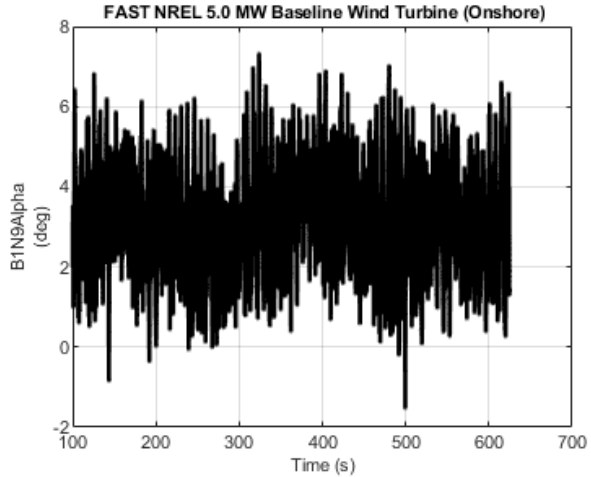
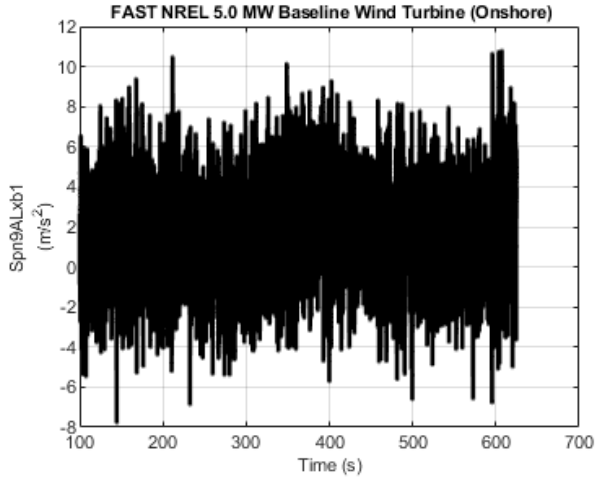
Data


FAST NREL 5.0 MW Baseline Wind Turbine (Onshore)
B1N9VRel (m/s)
Time (s)


FAST NREL 5.0 MW Baseline Wind Turbine (Onshore)
Spn9MLxb1 (kN·m)
Time (s)


FAST NREL 5.0 MW Baseline Wind Turbine (Onshore)
B1N9Alpha (deg)
Time (s)


FAST NREL 5.0 MW Baseline Wind Turbine (Onshore)
Spn9ALxb1 (m/s²)
Time (s)

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The Benefit

Why solve this challenge?

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Consequences of solving this problem

More effective real-time control of wind turbines = higher energy production

Lower uncertainty in estimating remaining useful life

More accurate load cases = better turbine design → lower CAPEX

Lower uncertainty in estimating the probability of failure = better insurance premiums

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Thank You!

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