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FEAC

ENGINEERING | REALIZE YOUR DIGITAL TWIN

Digital twins & numerical simulation of Wind turbines

www.feacomp.com

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CONTENT

About Us

About Us

Consulting Projects

Delivering multi-physics simulation services covering the entire product development process.

Software Distribution

Smart Solution, Software & Technology Partner of SIEMENS DISW.

Training & Support

Certified Training Partner

Software Development

PITHIA, a unique simulation software

Engineering Expertise

Covering the entire product development process.

Aerospace/Aeronautics
Marine
Oil & Gas
Bioengineering
Construction
Renewable Energy
Accelerator Magnets

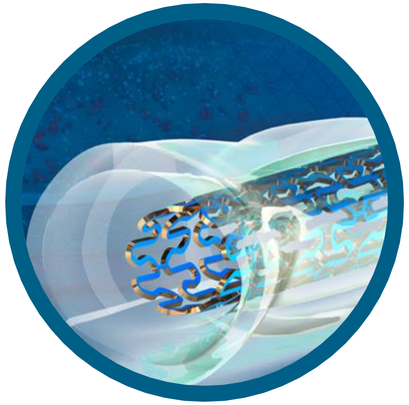
Realize your Digital Twin

Some indicative projects

CERN's 11T magnet

Credit: Airbus Defence and Space
Source: ESA website (link)
Collaboration with INASCO

ESA's Juice Mission



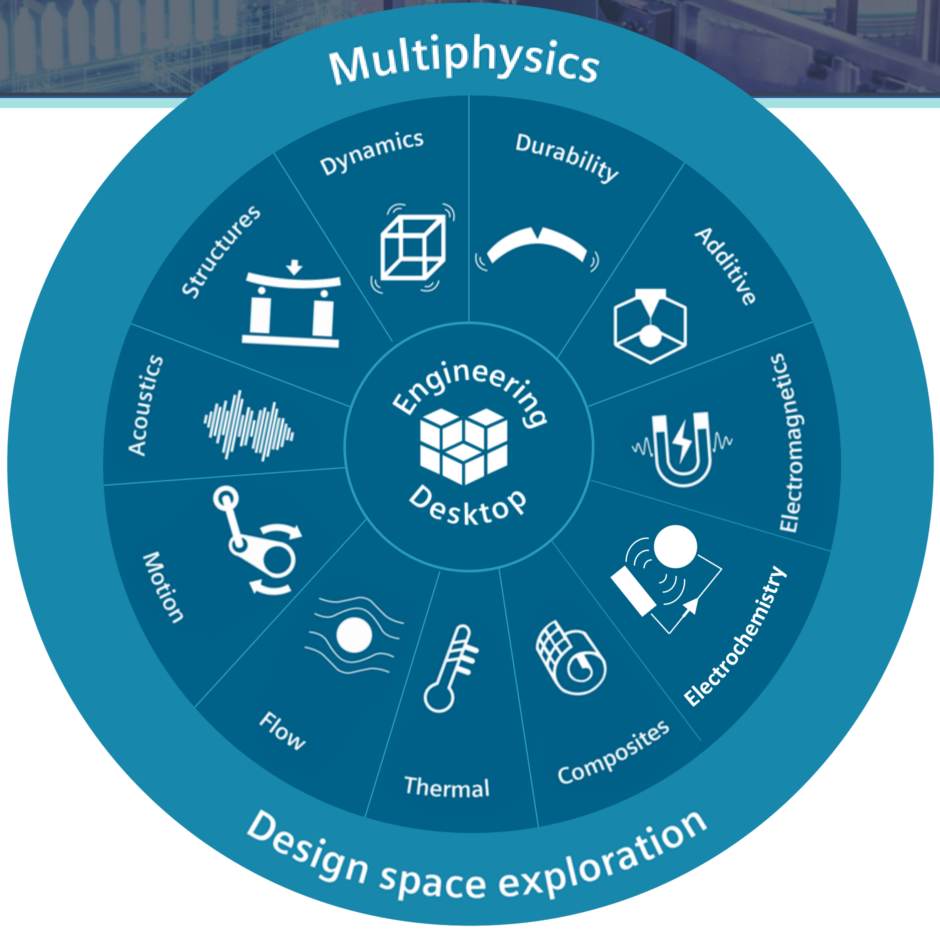
Coronary Stent

Vessel's Scrubber

Car's Engine

Some Of Our Partners And Clients

SIEMENS Simcenter



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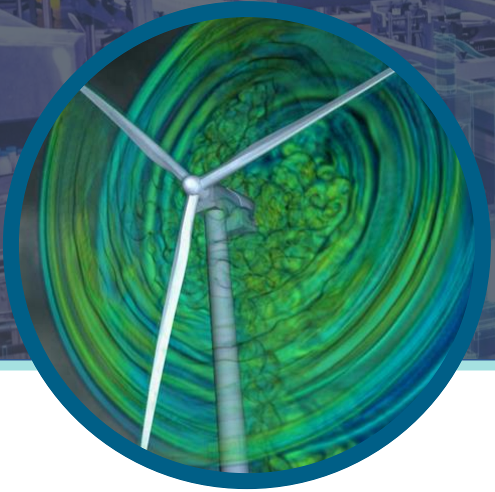
Main Siemens Tools

Simcenter 3D

Simcenter 3D is a fully integrated simulation platform for design, modeling, simulating and analyzing complex engineering products and Multiphysics simulations.



Star-CCM+

STAR-CCM+ software delivers accurate and efficient multidisciplinary technologies in the field of Computational Fluid Dynamics**.**

Amesim & gProms

Simcenter Amesim allows the virtual assesment and performance optimizion of mechatronic systems.

gProms is a unified modelling and solution platform focusing on chemical reactions & operations.

Heeds

Modelling and simulation of various operating conditions. Design space exploration and design optimization.

Pithia-CP

PITHIA-CP is FEAC's powerful and unique solution for Cathodic protection computer aided engineering, integrated and available as an addon module to the Siemens Simcenter 3D software.

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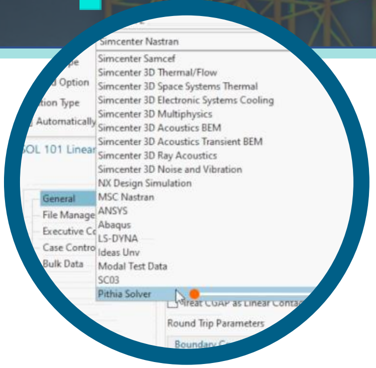
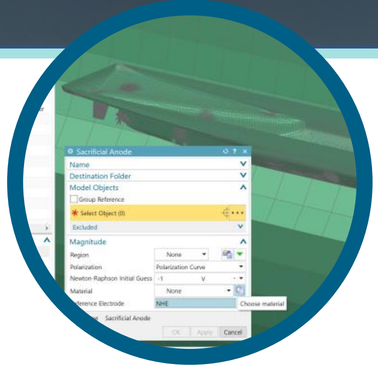
PITHIA-CP for Cathodic Protection



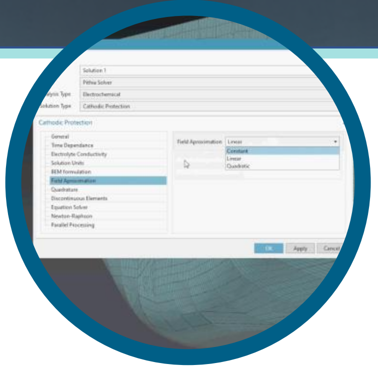
Add-on module to SIEMENS Simcenter 3D



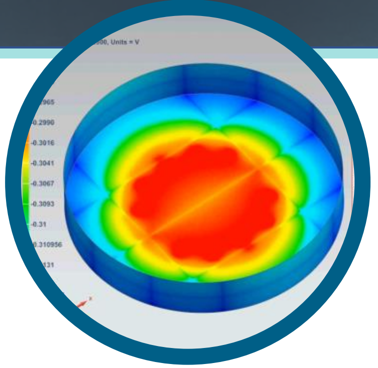
Sacrificial Anode CP (SACP)

Impressed Current CP (SACP)

Material Library



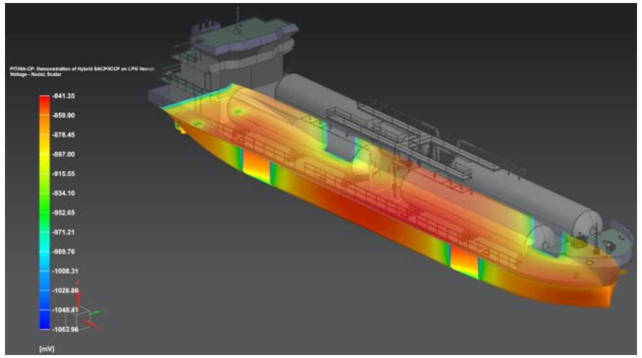
Accelerated BEM Solver

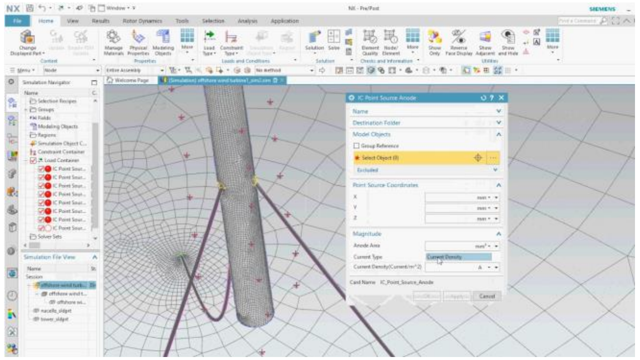


Best-in-class Modeling Environment

COMPETITIVE ADVANTAGES

- Accurate results
- User Experience
- Intuitive Workflow
- Fast solver
- Complex Models
- Low Hardware Requirements





Workshop 1: Numerical simulations for Wind Turbine Engineering Problems

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SIEMENS Training

[Patras – FEAC Engineering]

[Athens – Siemens CUBE]

https://feacomp.com/training/

FEAC's Timeline
Main Milestones

2014

Beginning of everything…

1st Award in ANSYS HALL OF FAME COMPETITION

Participating in Several Start-Up incubators & accelerators

2015

Active member of the Start-Up Community

Building Company's Reputation

Projects

2016

Joint Venture with Dept. of Mechanical Engineering – Patra's University for the Development of PITHIA

&

Projects

2017

1. FEAC announces Partnership with Siemens PLM Software
2. FEAC selected as the 1st Greek SME for CERN's BIC to co-develop PITHIA
3. FEAC as one of the 1st Greek Companies participating in ESA's space mission

2020

Integration of FEAC's solver, PITHIA, in SIEMENS simulation platform

&

Projects

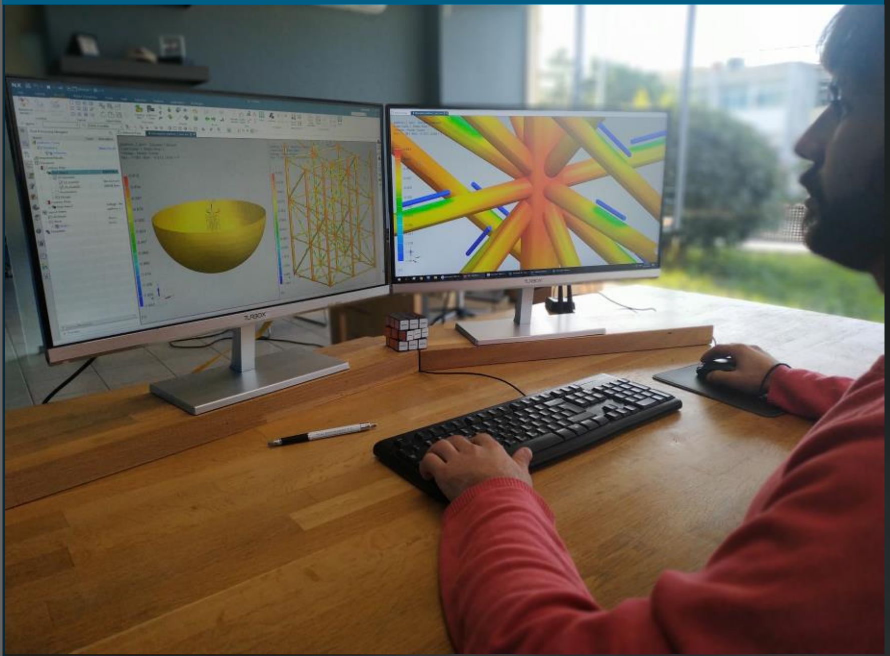
2021

Projects

&

participation in R&D consortia

Company



Ph.D. & M.Sc. Engineers

Broad Portfolio of Engineering Services including Structural, CFD, Thermal, Electromagnetics analysis

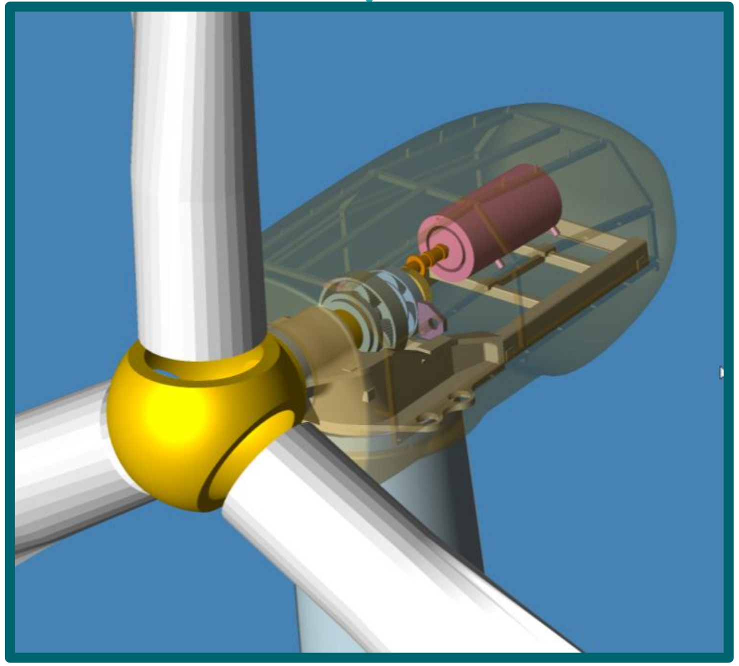
Numerous Scientific Publications

Globally recognized in the technical and scientific community

One Global Award - Two National Awards

Holistic Digital twin

Ideation



Realization

Utilization

FEAC's Expertise

Holistic Digital Twin Approach

Structural Performance:
Structural analysis

Computational Fluid Dynamics Performance:
Fluid dynamics analysis

NVH & Acoustic Performance:
e.g. Sound Vibration Analysis

Thermal Management:
Thermal Analysis

Electromagnetic Performance:
Electromagnetic Analysis

System Performance system:
e.g. 1D-3D co-simulation

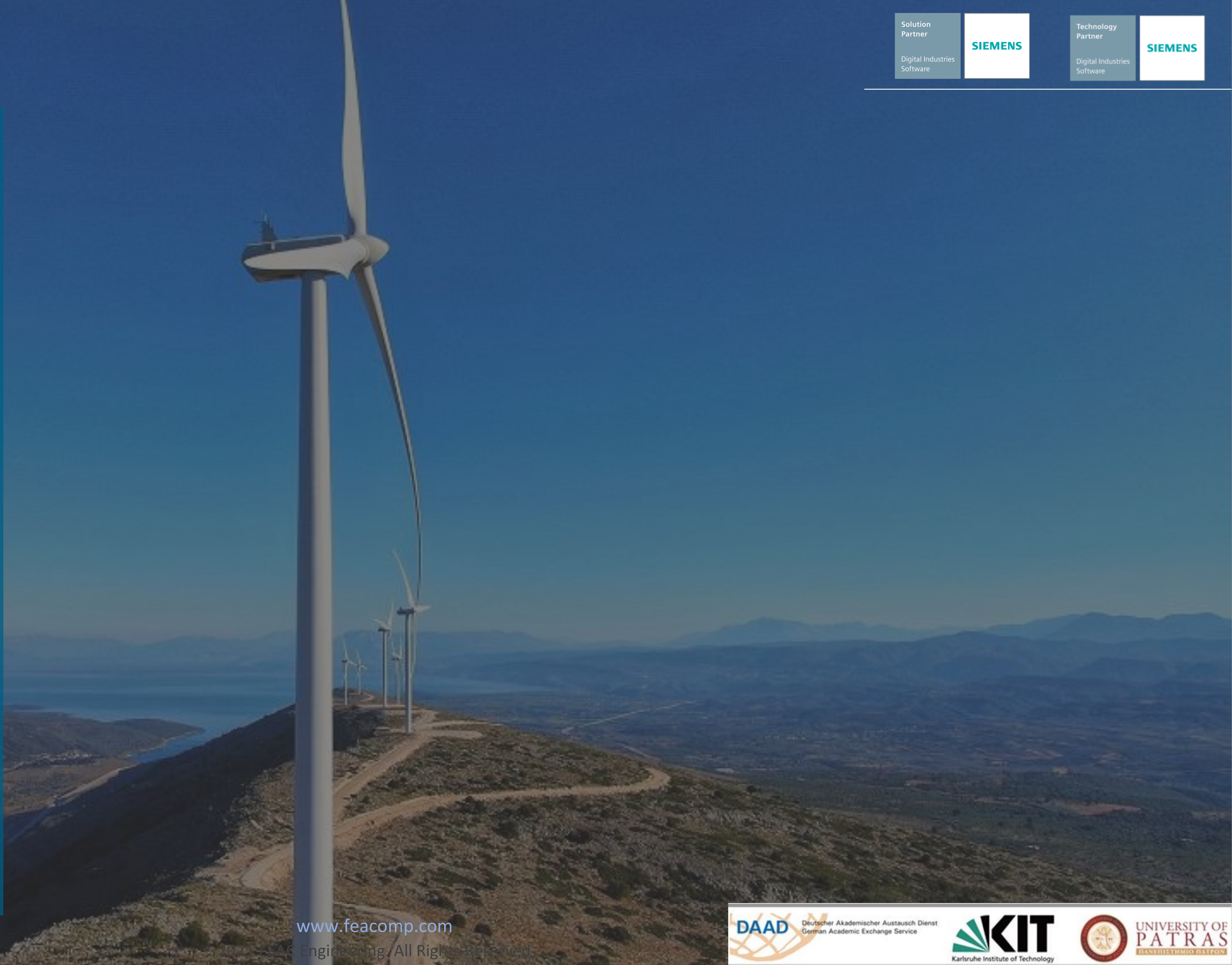
Cathodic Protection:
Development of cathodic protection

Multiphysics Analysis:
Test-CAE correlation

Verification & Certification

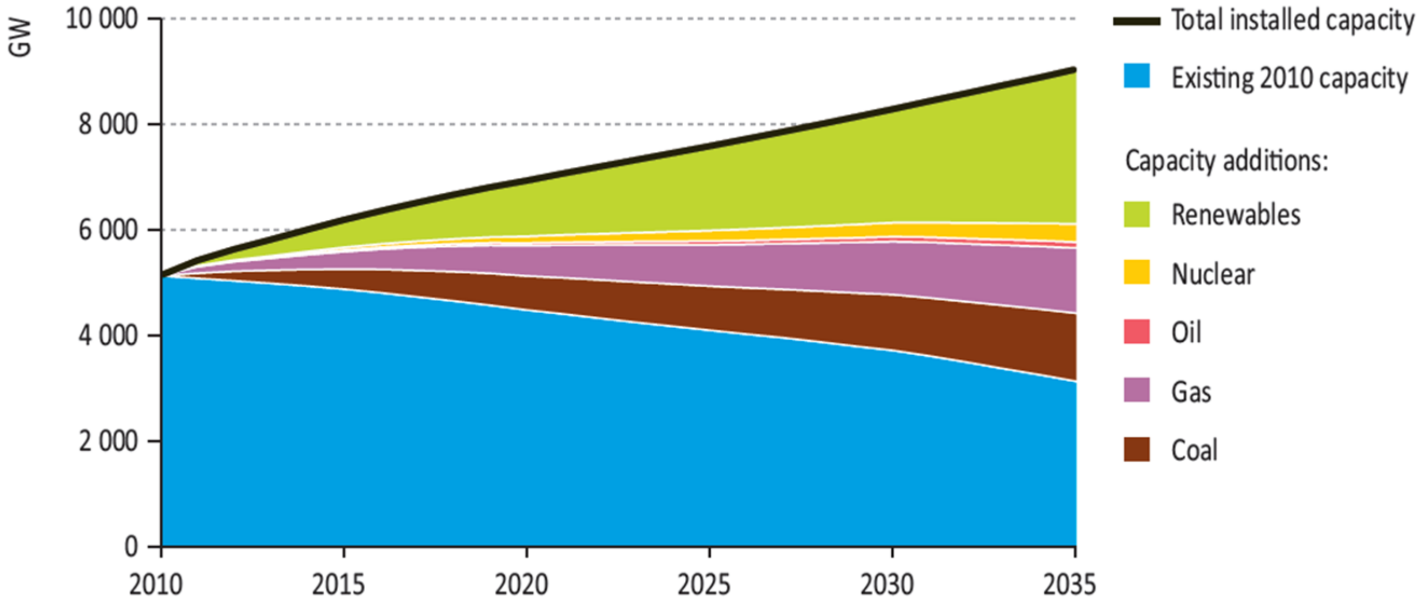
Wind Turbines

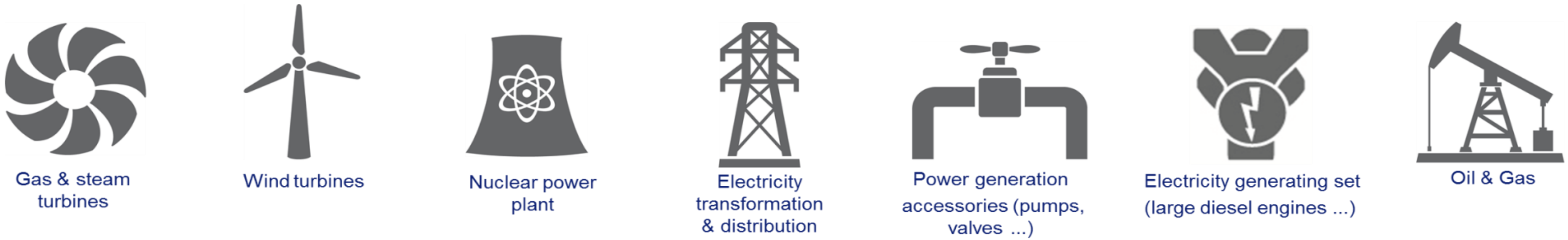
1. Introduction



General trends in the Energy Sector

- Increased environmental concerns
  - Environmental care
  - Lowering NOx and other pollutants
  - Decreasing noise levels
- Need for higher efficiency
- Keeping installations alive for a longer time and limit maintenance costs
- Peaks in energy demand and intermittent power generation demands energy storage





What is a WT?

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How does it work?

CONTENT

Wind Turbines

2. Trends

The Changes in the Wind Energy Landscape

Shift to Offshore Wind Farms

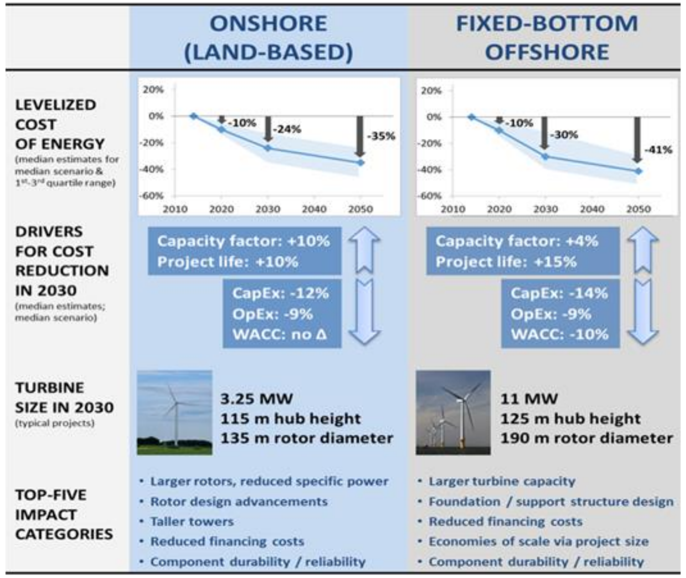
Logistical & technical challenges

The race to maximum energy harvesting leads to large offshore wind farms.

Wind Power Costs Reduced

Rethink business model

The need to reduce the LCOE points to larger turbines, larger wind parks and longer lifetimes.



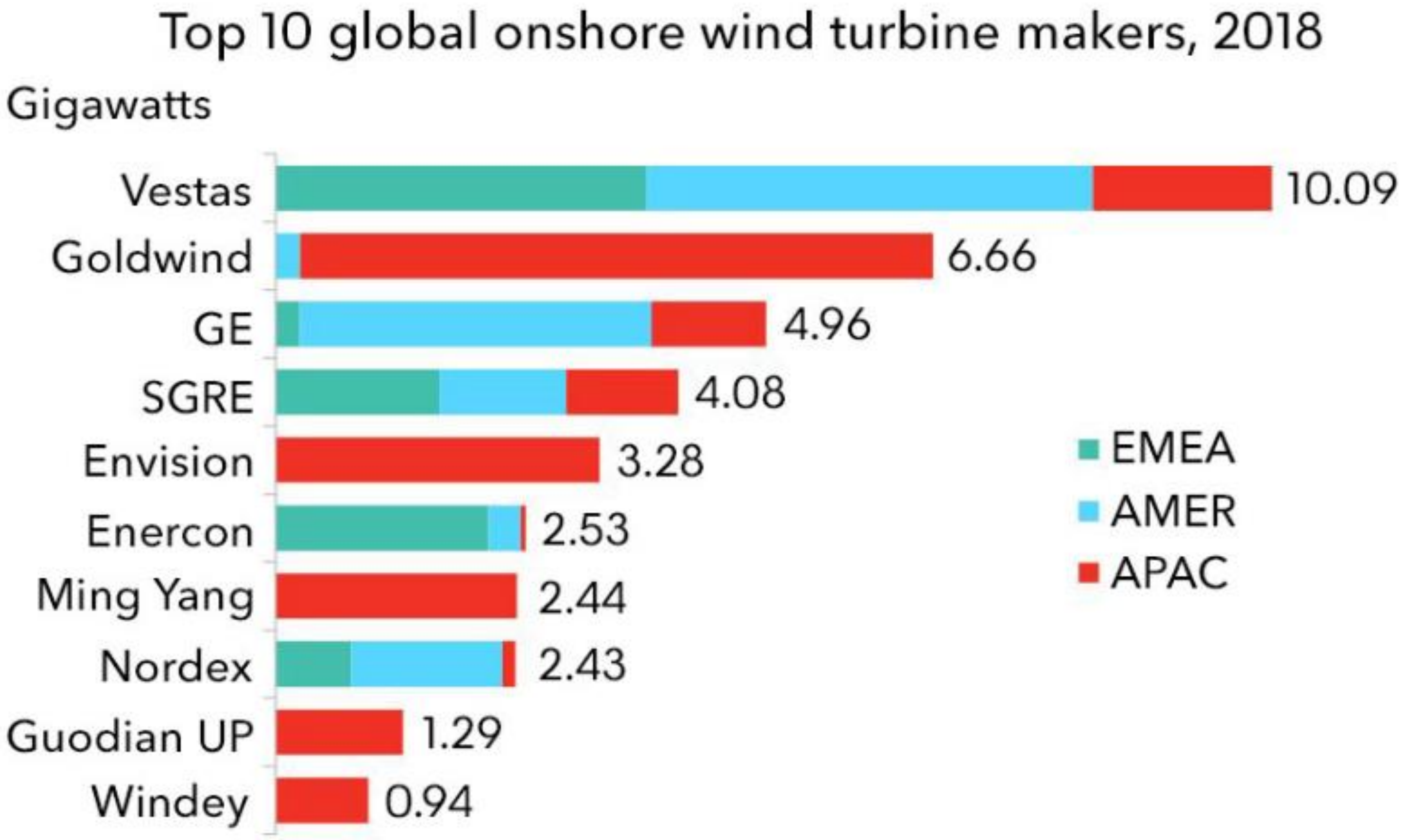
Source: Berkeley Lab, Energy Analysis and Environmental Impacts Division

Technology progresses

Race towards bigger turbines

10MW (MHI-V), 12MW (GE), 14MW (SGRE), …. requires new and reliable technology. This leads to consolidation amongst the turbine makers. In 2019 the big 4 wind OEMs covered 55% of the market!

Stakeholders



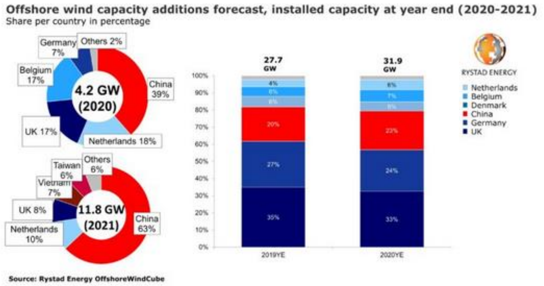
Source: BloombergNEF. Notes: Only includes onshore wind capacity. Total fully commissioned onshore wind capacity in 2018 was 45.4GW. SGRE is Siemens Gamesa Renewable Energy.

OFFSHORE

Rystad Energy: Global Installed Offshore Wind Capacity to Grow by 37% in 2021

February 4, 2021, by Adrijana Buljan

The world's installed offshore wind capacity rose by 15 per cent in 2020, despite the COVID-19 pandemic, and this year will see a 37 per cent growth in global installed offshore wind capacity, according to Rystad Energy.



Source: Rystad Energy

Major contributor to both last year's and this year's growth is China. The country is expected to ramp up its offshore wind installation this year since after 2021 it will begin phasing out feed-in-tariffs, and many developers are therefore pushing to complete projects during the coming period.

Last year ended with 31.9 GW of installed offshore wind capacity, 15 per cent more compared to 27.7 GW at the end of 2019, with China accounting for 39 per cent of the additions, followed by the Netherlands (18 per cent) and the UK (17 per cent).

Rystad Energy expects the global installed offshore wind capacity to further increase by 11.8 GW in 2021, a 37 per cent increase compared to 2020, where China will continue to lead the new capacity additions, accounting for 63 per cent of the expected growth.

"China had a construction backlog of more than 10 GW going into 2020, and Chinese developers are racing to reach maximum commissioning by the end of the year in order to claim full feed-in-tariffs. This means 2021 is going to see major capacity additions, particularly since some projects initially scheduled for commissioning in 2020 ended up slipping into 2021", said **Alexander Fløtre**, Rystad Energy's Product Manager for Offshore Wind.

Commitment Strong in Europe and U.S. Despite Delays

Related news

Offshore Wind Faces Installation Vessel Shortage – Rystad Energy
2 months ago

SGRE Reports FY2020 Drop in Revenues, Doubled Offshore Wind Order Intake
3 months ago

Offshore Wind Investments to Swell in 2021 with New Markets
about 1 month ago

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MBCC GROUP
Offshore Wind Business Development Manager EU
MBCC Group

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Time for Offshore Wind to Wake Up to Full Benefits of Digitalisation

January 29, 2021, by Adrijana Buljan

*The following article is a guest post by **Jonas Corné**, CEO at **Greenbyte**, a provider of asset management solutions. The article examines digitalisation in the offshore wind sector, the necessity of it and current challenges that hinder using digitalised solutions to advance offshore wind projects.*

Despite the global disruption caused by the COVID pandemic, 2020 was a springboard for global offshore wind development. In Europe, the European Commission's 'offshore renewable energy strategy' targeted a 25-fold expansion of its offshore wind capacity by 2050, committing to significant investment in ports, grid connections and the wider supply chain to effectively support the sector's growth.

However, there is one key area in the EU's offshore strategy that, despite being crucial to the scaling up of green energy, is noticeably lacking in detail: digitalisation.

Too often, the development and implementation of advanced digital infrastructure and artificial intelligence (AI) has been seen as a 'nice-to-have' by the offshore wind sector, which means that some significant advances have gone under the radar. Indeed, AI algorithms are now capable of providing more than just a way to reduce operations and maintenance (O&M) costs, with new technologies able to stabilise central grids and increase electricity dispatch efficiency already available on the market.

In spite of its rapid growth, offshore wind has not managed to keep up with innovation in digital technologies, with many European offshore owners continuing to rely on outdated in-house data management systems.

This lack of understanding around digitalisation's potential benefits is also reflected at a company level. In a 2019 ORE Catapult survey, 94% of respondents agreed that the offshore wind industry was not extracting the full value of data and digital technologies as effectively as it could. In spite of its rapid growth, offshore wind has not managed to keep up with innovation in digital technologies, with many European offshore owners continuing to rely on outdated in-house data management systems.

Related news

Ramboll Tests Digital Twin Tech at Wikinger OWF
about 1 month ago

Siemens Gamesa Commissions Motion Comfort Monitoring Tool
about 1 month ago

Harren & Partner Buys Wind Lift I Jack-Up Vessel, Launches SAL Renewables
24 days ago

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Recruitment Consultant – Offshore Renewables
UTM Consultants

MBCC GROUP
Offshore Wind Business Development Manager EU

Biden Sets The Stage For An Offshore Wind Energy Boom

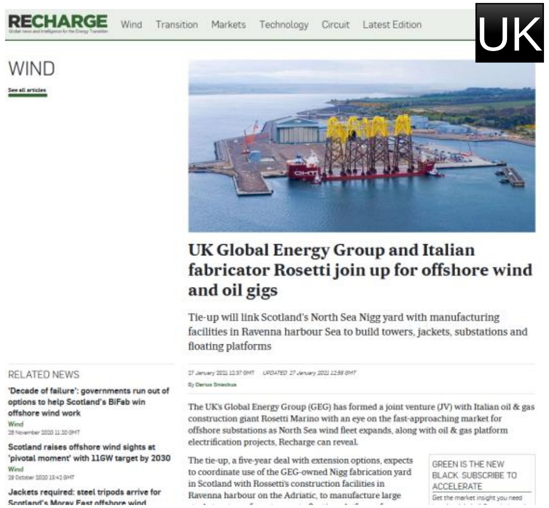
By Tsvetana Paraskova - Feb 14, 2021, 4:00 PM CST

The U-turn of the U.S. Administration's energy policies under President Joe Biden sets the stage for a flourishing U.S. offshore wind industry, as the federal government looks to speed up environmental reviews to make offshore wind a significant contributor to the new clean energy goals. In the United States, offshore wind hasn't really taken off, with just two small offshore wind farms in operation with less than 50 megawatts (MW) of combined capacity. To compare, Europe has 113 offshore wind farms in 12 countries installed, with 25 gigawatts (GW) of total offshore wind capacity.

The U.S. is smashing records in onshore wind, solar, and storage installations, with records for each of those in 2020, according to the American Clean Power Association.

But offshore wind has been considerably lagging behind, also because of lengthy environmental reviews from federal agencies and the weighing of pros and cons of having offshore wind installations within sight of beaches or in areas of commercial fishing.

Near-future Opportunities all-around the globe



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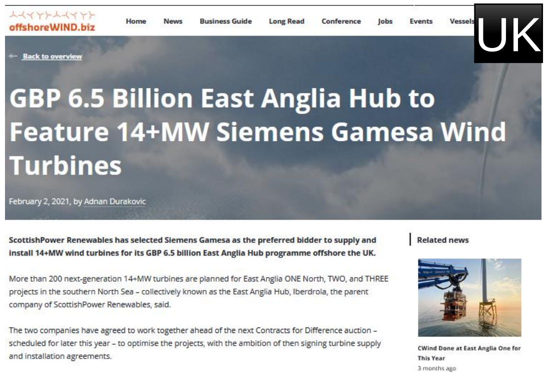

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Near-future Opportunities all-around the globe

USA

BP Officially Enters Offshore Wind

February 1, 2021, by Adrijana Buljan

BP and Equinor have closed the transaction for BP's acquisition of a 50 per cent interest in the Empire Wind and Beacon Wind projects off the U.S. east coast.

The closing of the transaction marks BP's official entry into offshore wind.

link

Taiwan

Back to overview

Boskalis and MENCK Team Up Offshore Taiwan

WIND FARM UPDATE

January 25, 2021, by Adnan Durakovic

Pile-driving specialist MENCK has won a contract to support Boskalis with the foundation piling activities on the Changfang and Xidao offshore wind farm in Taiwan.

This involves the piling of 186 pin piles for the 62 three-legged jacket foundations being installed over two campaigns in 2021 and 2022 in water depths of up to 40 metres, Acteon, MENCK's parent company, said.

MENCK will be providing a piling hammer spread including two 1200 KJ hammers with associated powerpacks and winches for the project.

"Providing services on this project is a significant achievement within the Taiwanese region where we are continuously increasing our presence through equipment development, strategic partnerships and deployment of localised personnel," **LJ Pan**, Taiwan country manager at Acteon, said.

"Our track-record is growing and is enhanced by Acteon's partnership with DWTEK in Taiwan. DWTEK will assist us with local suppliers, importation/customs and personnel work permits and Visas."

Back in 2019, Boskalis established a joint venture to transport and install the jacket foundations and the accompanying pin piles at the 589 MW Changfang and Xidao project.

link

USA

US Hits Pause Button on Oil & Gas Leasing, Doubles 2030 Offshore Wind Target

January 28, 2021, by Adrijana Buljan

U.S. President Joe Biden signed a new Executive Order on 27 January, directing the Department of the Interior to identify steps that can be taken to double offshore wind energy production by 2030 and to pause entering into new oil and natural gas leases on public lands and in federal waters.

link

Croatia

Back to overview

Croatian Oil & Gas Company Eyeing Offshore Wind in Adriatic Sea

BUSINESS & FINANCE

January 27, 2021, by Adrijana Buljan

Croatian oil and gas company INA-INDUSTRIJA NAFTE, d.d. (INA) plans to diversify into renewable energy and is specifically considering offshore wind and solar energy developments in the country.

At an energy conference held on 26 January, INA's Director of Strategic Operations and Public Affairs, Hrvoje Glavaš, said that INA would first start with solar energy and the installation of pilot solar projects at its own industrial facilities.

The company is considering offshore wind projects in the Adriatic Sea and sees great potential for using this technology off the Croatian coast, where it already operates gas fields, according to Glavaš.

In 2018, when the Italian oil and gas company Eni announced it was leaving the upstream sector in Croatia with the sale of Eni Croatia b.v. to INA, the Croatian company became the owner and operator of the Northern Adriatic and Marica gas fields.

One of the renewable energy sources INA is now also looking into is geothermal energy.

link

Italy

Italy on pole in race for first Mediterranean offshore wind

The 30MW bottom-fixed project off Taranto will likely be fully operational in 2020, beating three French floating pilot arrays

Italy's – and likely the Mediterranean's – first offshore wind project, a 30MW nearshore array off the southern Italian town of Taranto, has reached financial close, consultancy Mott MacDonald said.

link

Poland

Breaking: Polish Parliament Passes Offshore Wind Act

January 13, 2021, by Adnan Durakovic

link

France

French Offshore Wind Tender Enters Competitive Dialogue Stage

January 25, 2021, by Adnan Durakovic

link

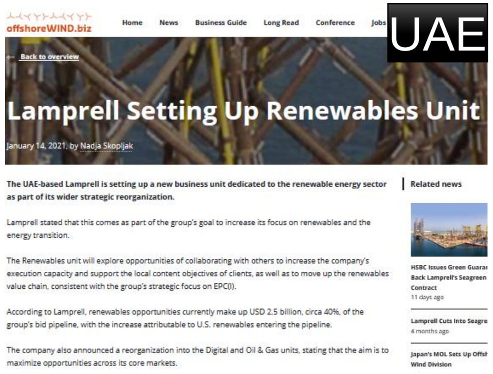
Greece

Greece Opens Public Consultation on Offshore Wind Legislative Framework

January 22, 2021, by Adrijana Buljan

link

UAE



Lamprell Setting Up Renewables Unit

January 14, 2021, by Nadja Skopljak

link

South Korea

South Korean Pair to Develop Offshore Wind Substation

GRID CONNECTION

January 20, 2021, by Nadja Skopljak

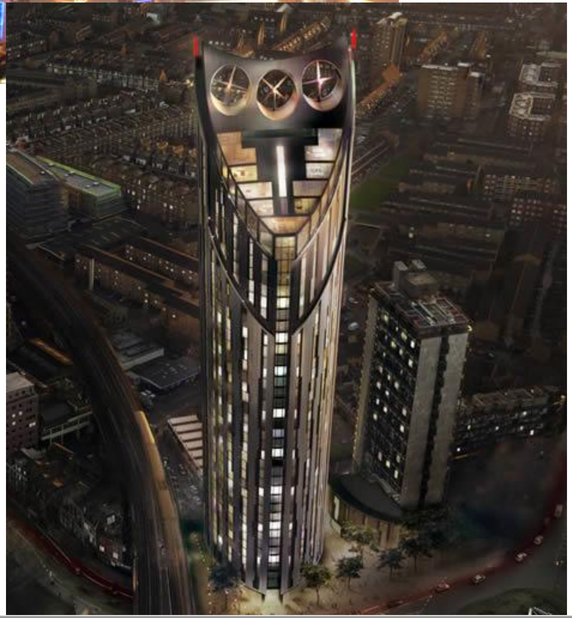
Daewoo Shipbuilding & Marine Engineering (DSME) and Korea Electric Power Corporation Engineering & Construction (KEPCO E&C) have signed a Memorandum of Understanding (MoU) to develop an offshore wind substation.

Source: DSME

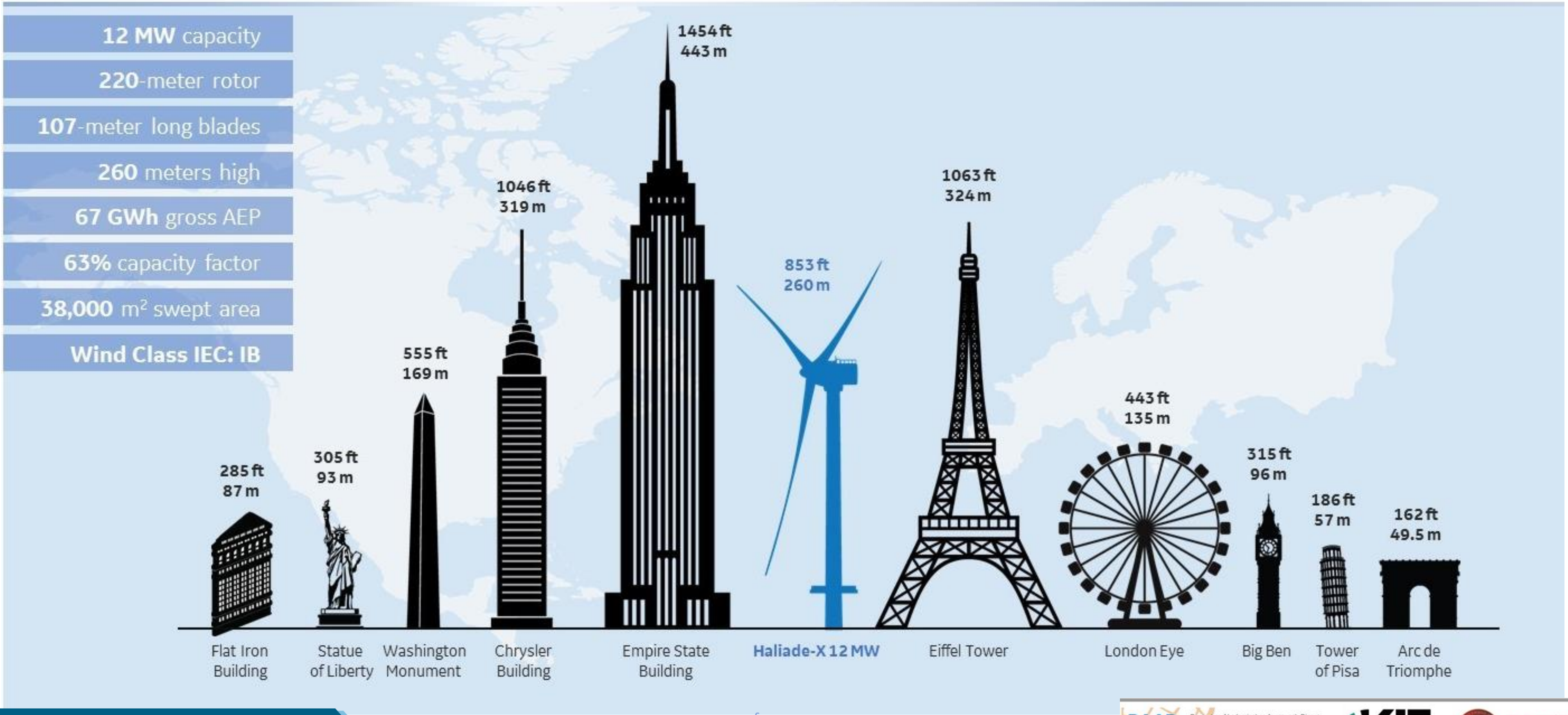
The South Korean companies plan to jointly research and develop the offshore substation both for the shallow and deep waters, as well as further expand their business targets to the overseas market.

link

Different Designs



Size is constantly increasing

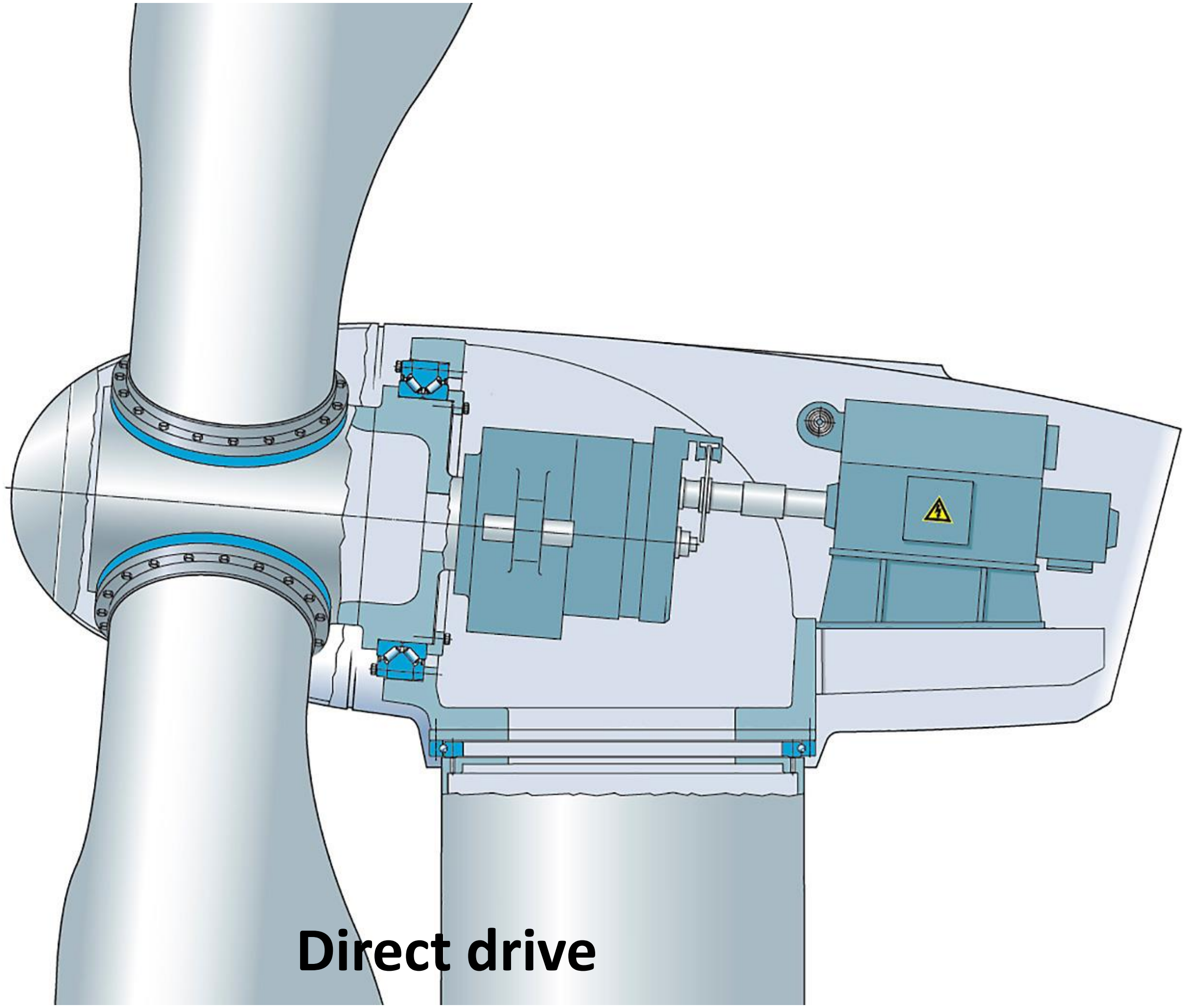


Biggest Wind Turbine

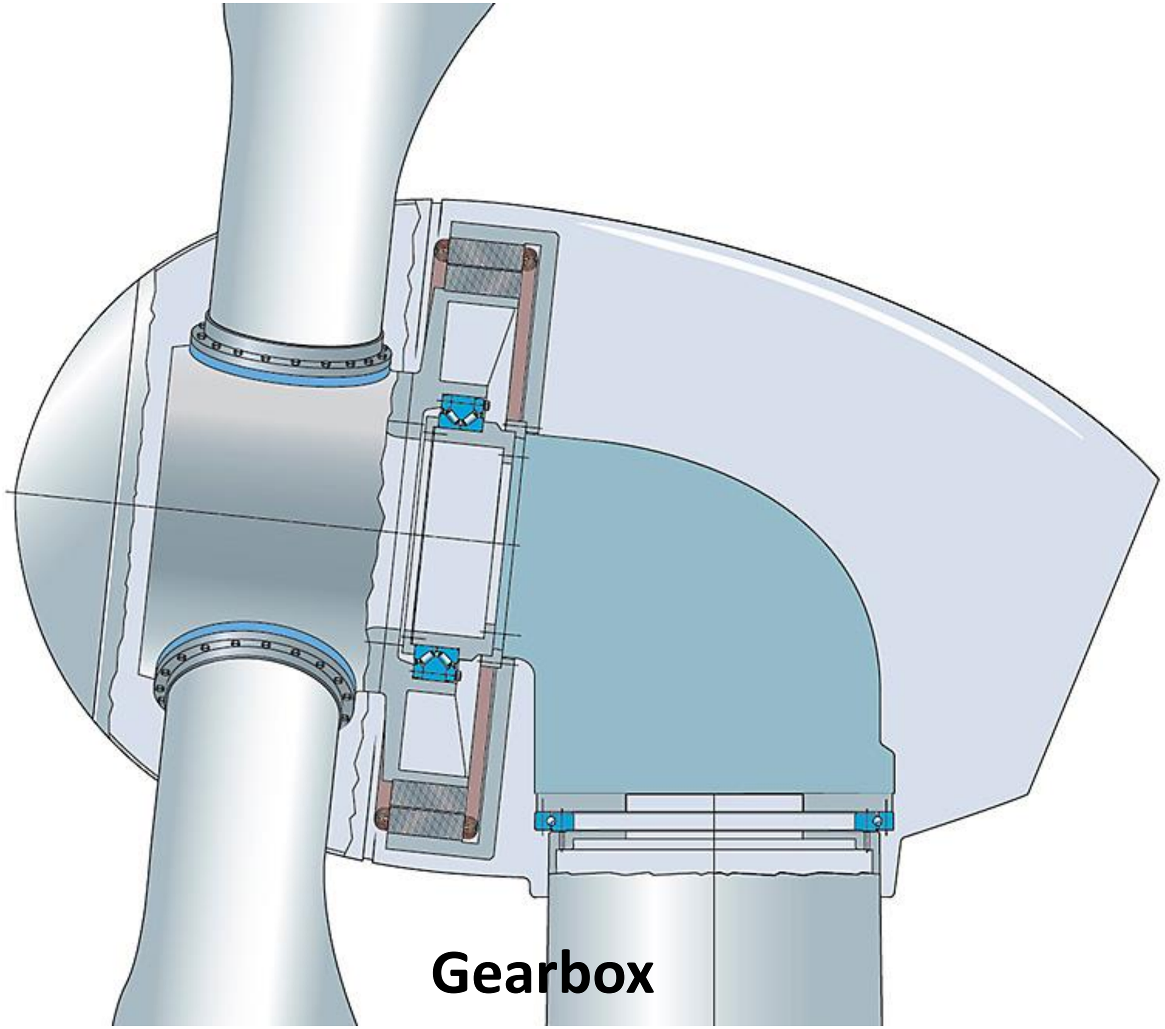
2021 – GE Haliade-X (12-13MW)

2022 – SIEMENS Gamesa SG 14- 222DD (14-15 MW)

Transmission



Direct drive



Gearbox

Onshore vs. Offshore

- Onshore Wind Turbines
  - withstand higher turbulence (landscape)
  - limited tip speed (Noise regulation)

- Offshore Wind Turbine
  - Different type of foundations
  - Very expensive to install
  - Expensive to maintain

Onshore vs. Offshore installation

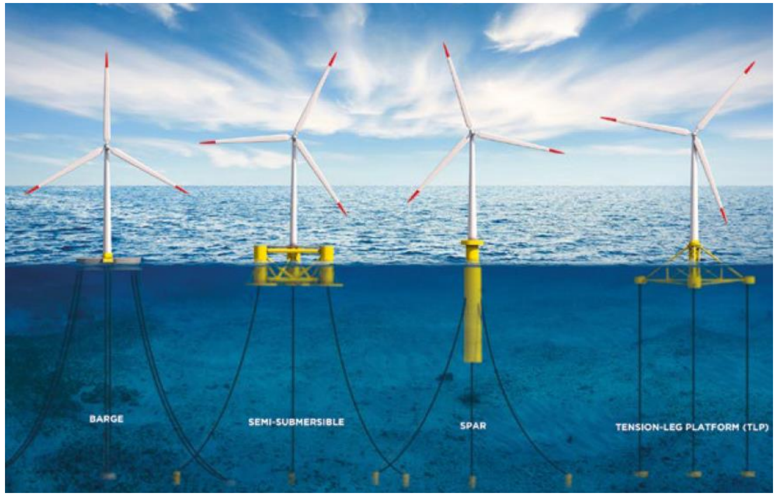
- Onshore Wind Turbines

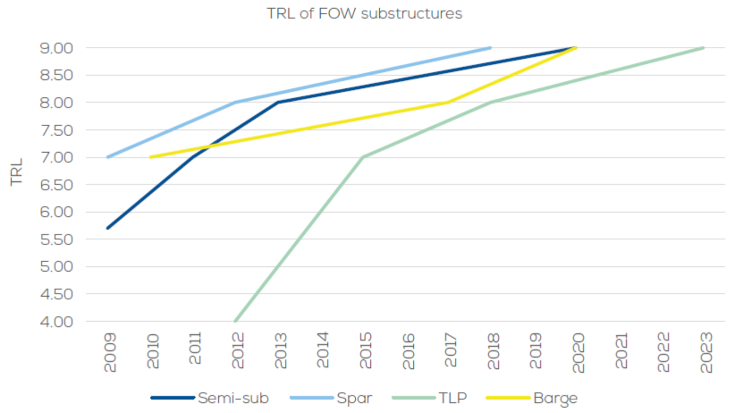
- Offshore Wind Turbine

Onshore vs. Offshore installation

- Onshore Wind Turbines

- Offshore Wind Turbine





Source: The Crown Estate[1] and WindEurope

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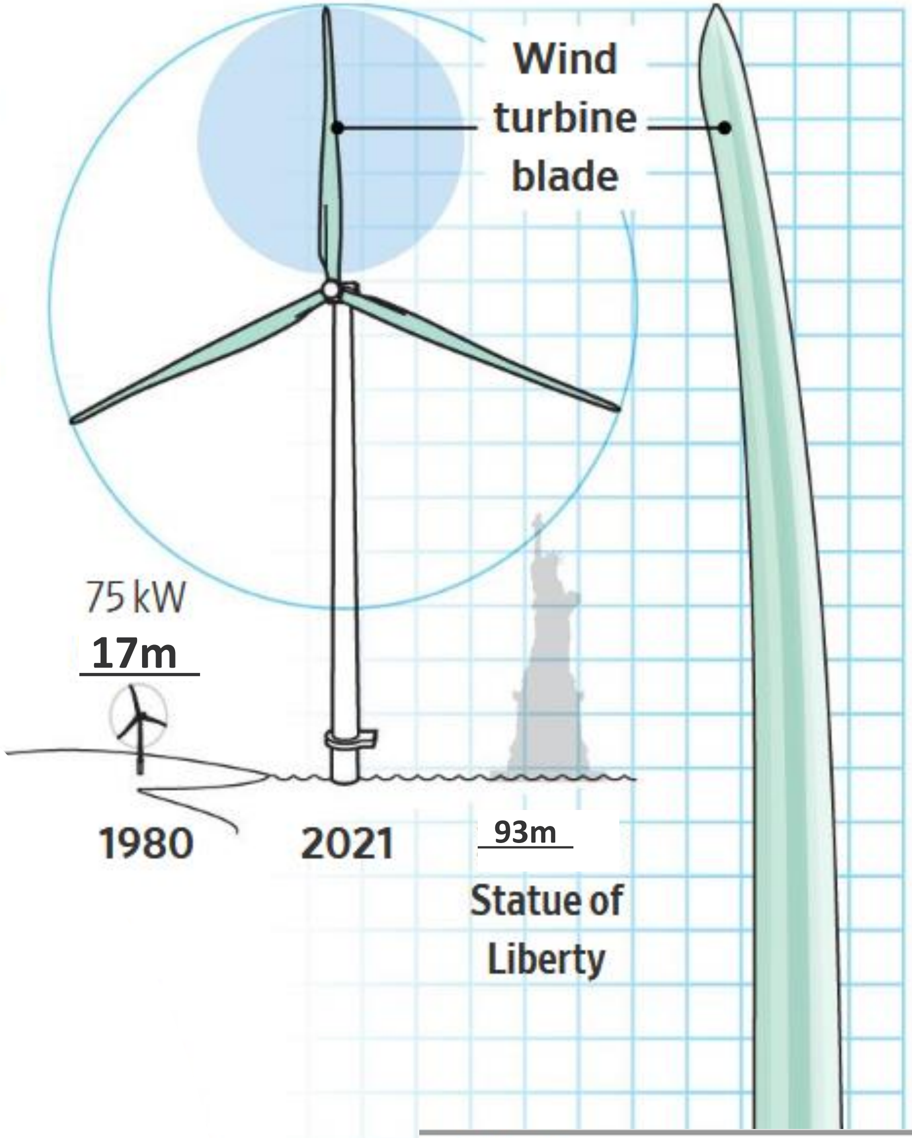
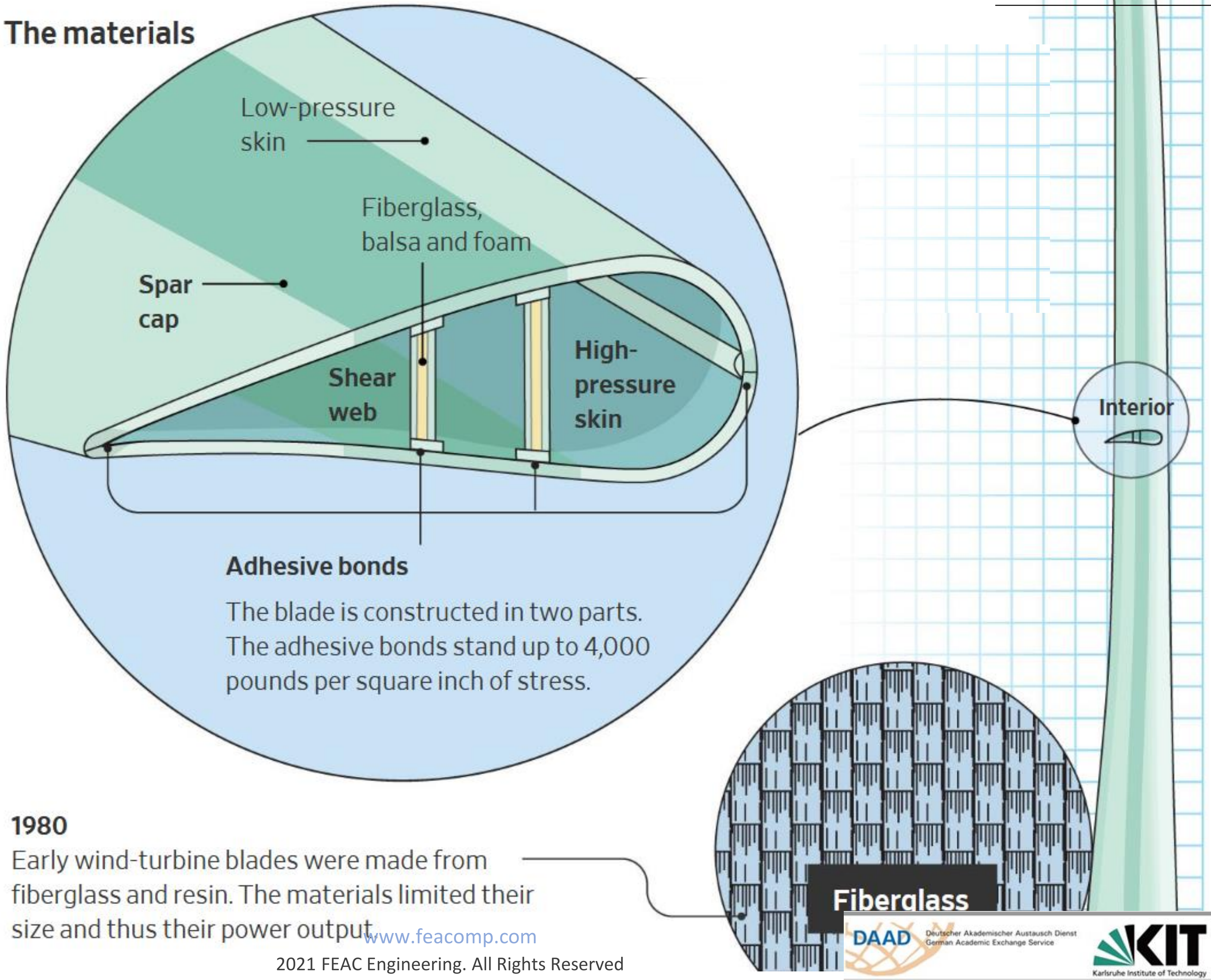
Technology is the key to success

3. Tools

The size

Forty years ago typical wind-turbine blades were around **8m long.** Today, with lighter materials, the blades have reached **107m,** , longer than the Statue of Liberty is tall, and are packed with new technology.





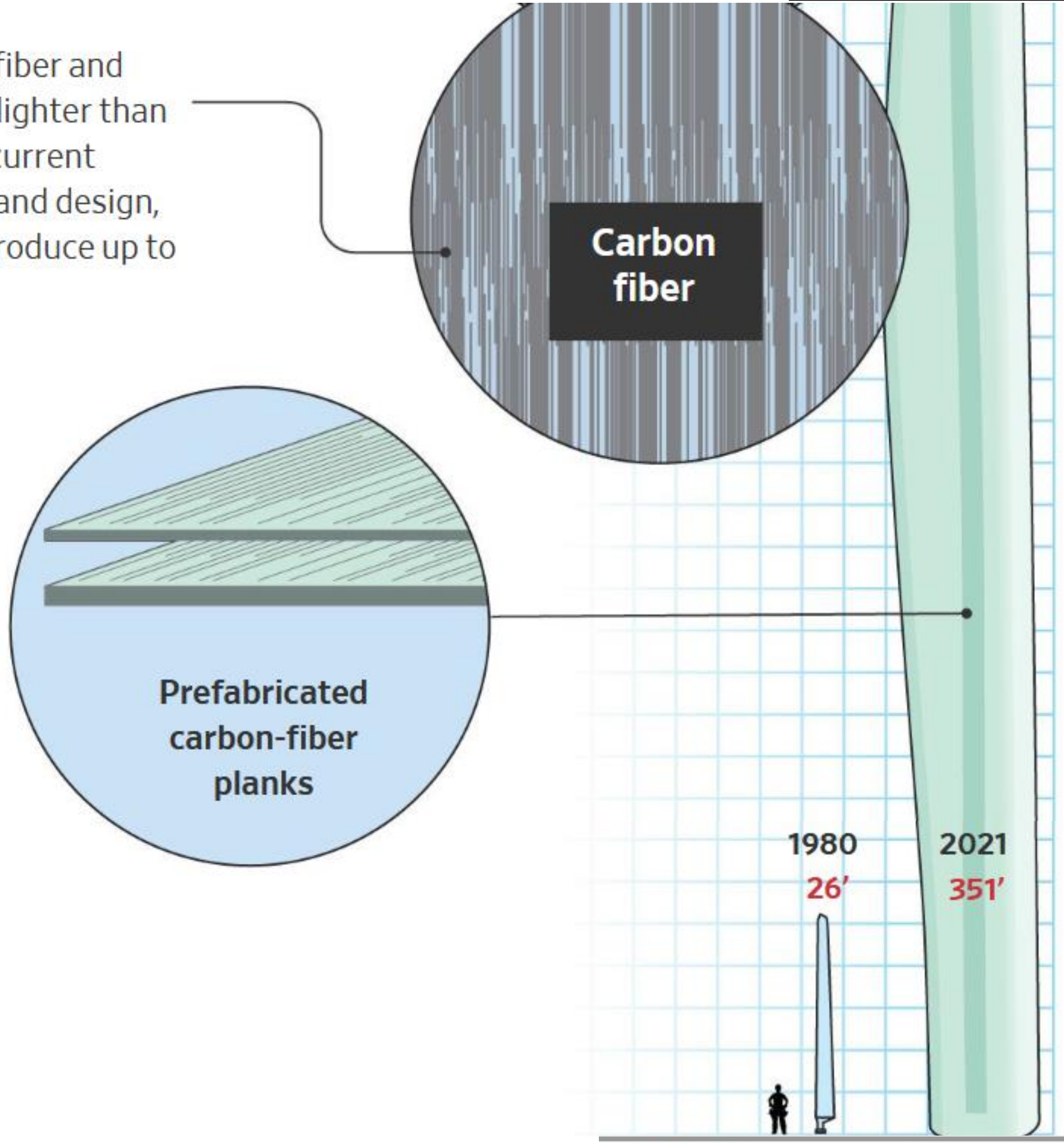
The materials
Low-pressure skin
Fiberglass, balsa and foam
Spar cap
Shear web
High-pressure skin
Interior
Adhesive bonds
The blade is constructed in two parts. The adhesive bonds stand up to 4,000 pounds per square inch of stress.
1980
Early wind-turbine blades were made from fiberglass and resin. The materials limited their size and thus their power output.
Fiberglass

2021

Modern blades, made from carbon fiber and other advanced materials, are 90% lighter than 1980s blades would be if scaled to current turbine sizes. Because of their size and design, turbines with the new blades can produce up to 15,000 kW of energy.

Spar cap

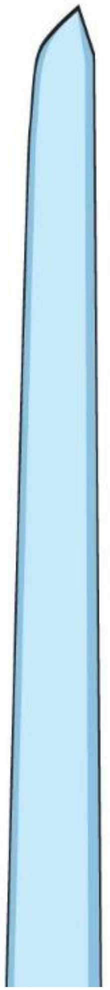
This section of the blade takes an enormous amount of stress. It is now reinforced with a carbon-fiber strip the entire length of the span for strength. Sometimes the strip is made with carbon-fiber planks instead of cloth.



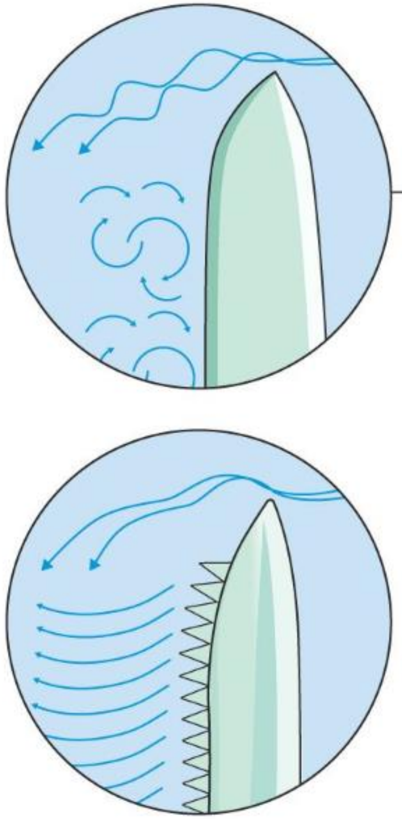
The shape

Innovations for the modern wind-turbine blades include higher strength that can withstand more stress, bend-twist coupling to reduce loads, and aerodynamic improvements to the blade tip for noise mitigation.

1980



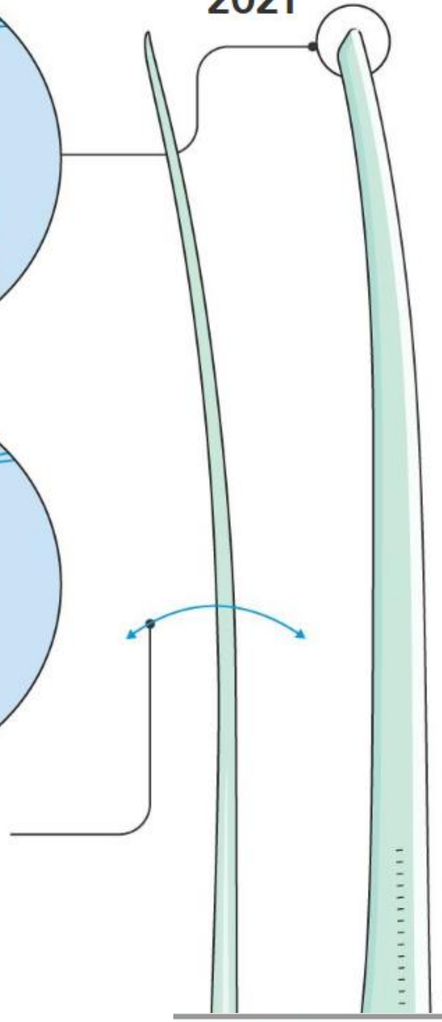
Blade tip
Since the blade tip moves faster than the blade nearest the hub, more noise is generated on the tip.

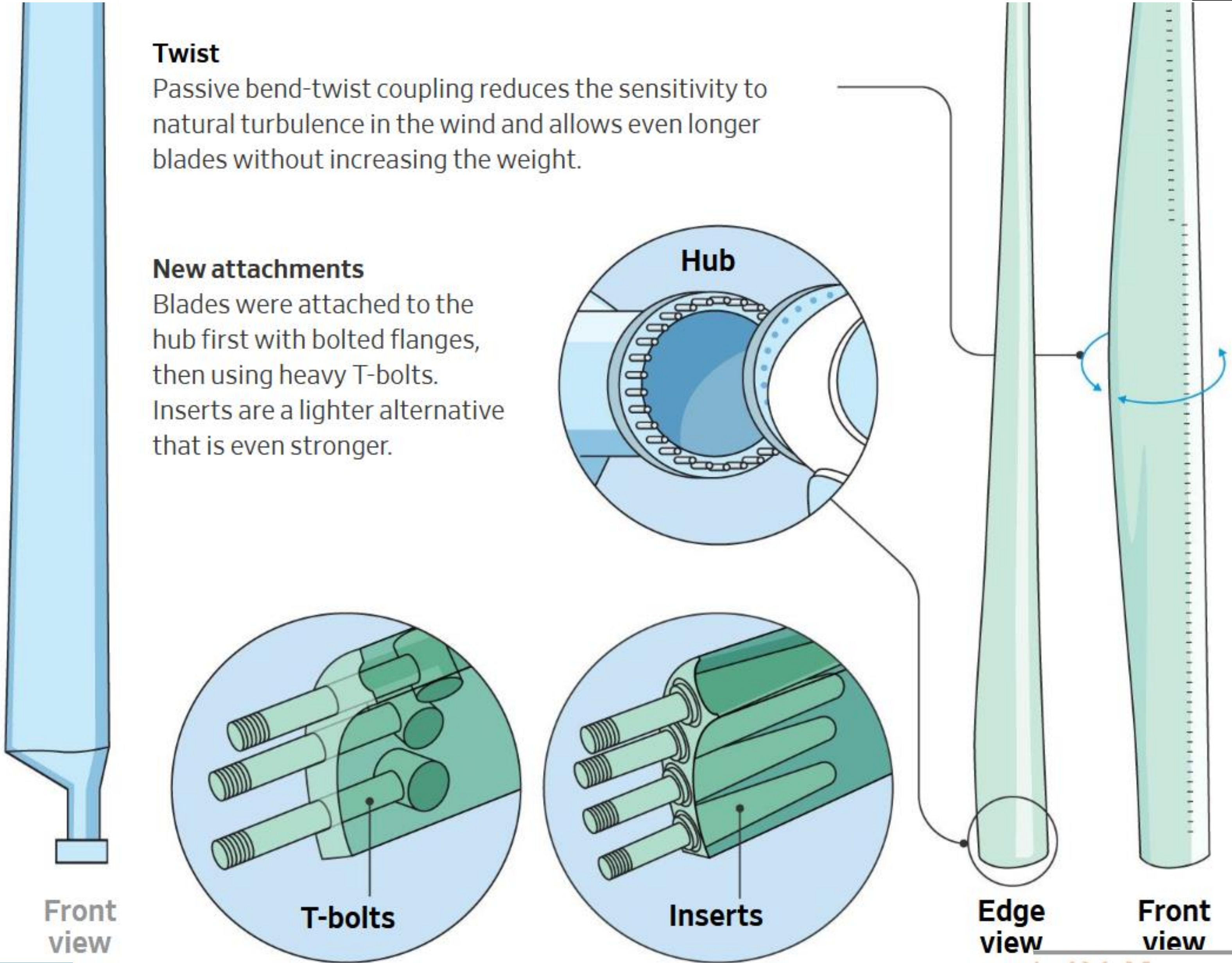


Tip shape
Rounded tips and serrated edges make blades quieter.

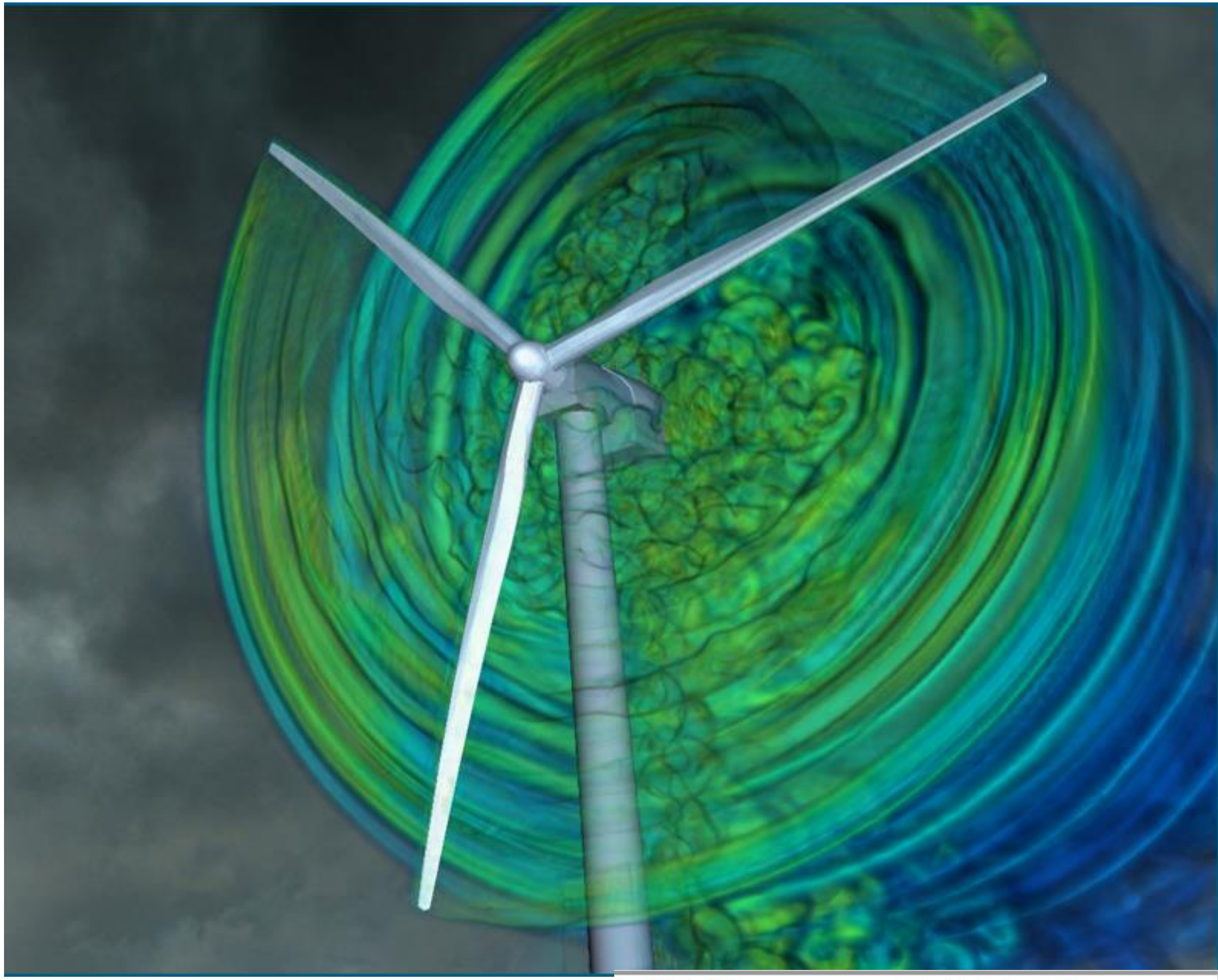
Bend
Greater swept area captures more wind, but requires longer blades that are more slender and flexible in bending. Manufacturing in a bend in the blade (known as a pre-bend) allows more room to deflect while avoiding contact with the tower.

2021

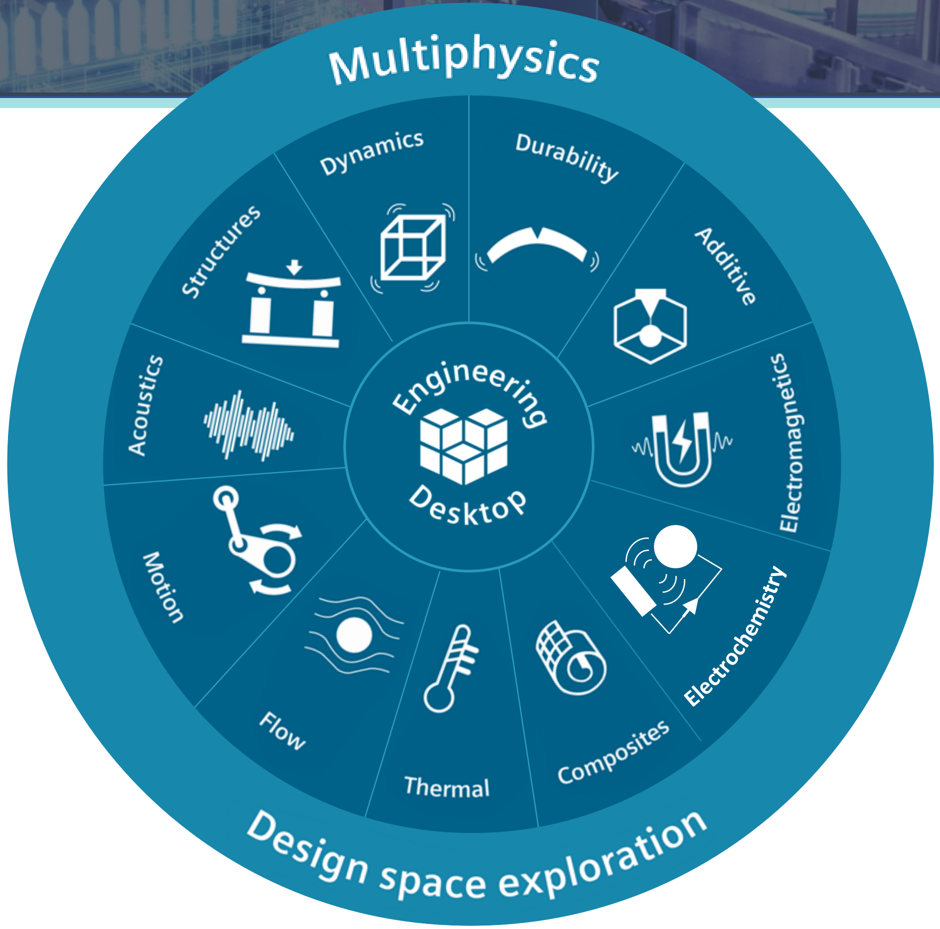



Twist
Passive bend-twist coupling reduces the sensitivity to natural turbulence in the wind and allows even longer blades without increasing the weight.
New attachments
Blades were attached to the hub first with bolted flanges, then using heavy T-bolts. Inserts are a lighter alternative that is even stronger.
Hub
T-bolts
Inserts
Front view
Edge view
Front view

\+
the right tools



SIEMENS Simcenter



Wind Turbines

4. Digital Twins

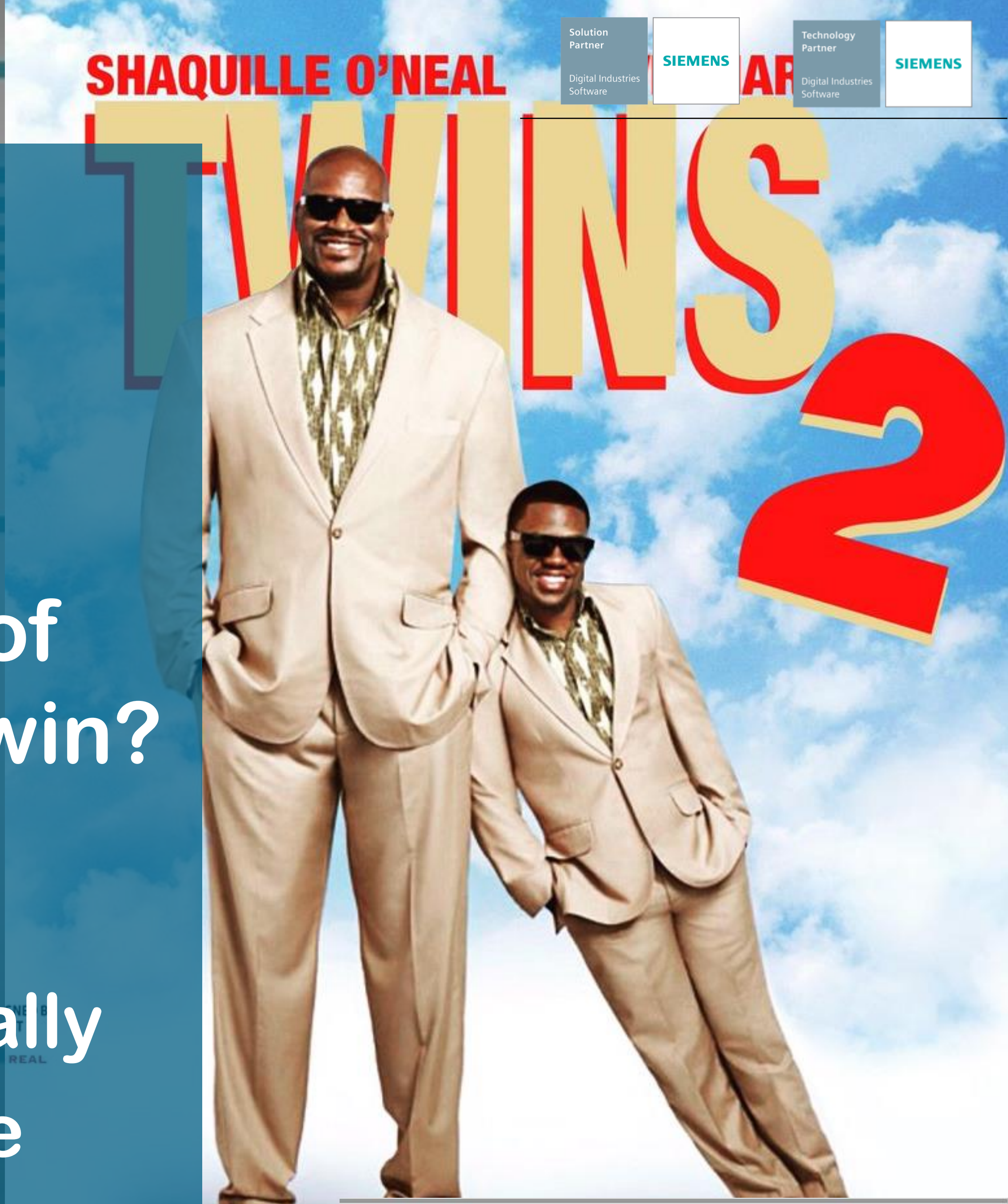
TWINS

100% Identical
100% Different

Value of Digital Twin?

...not really

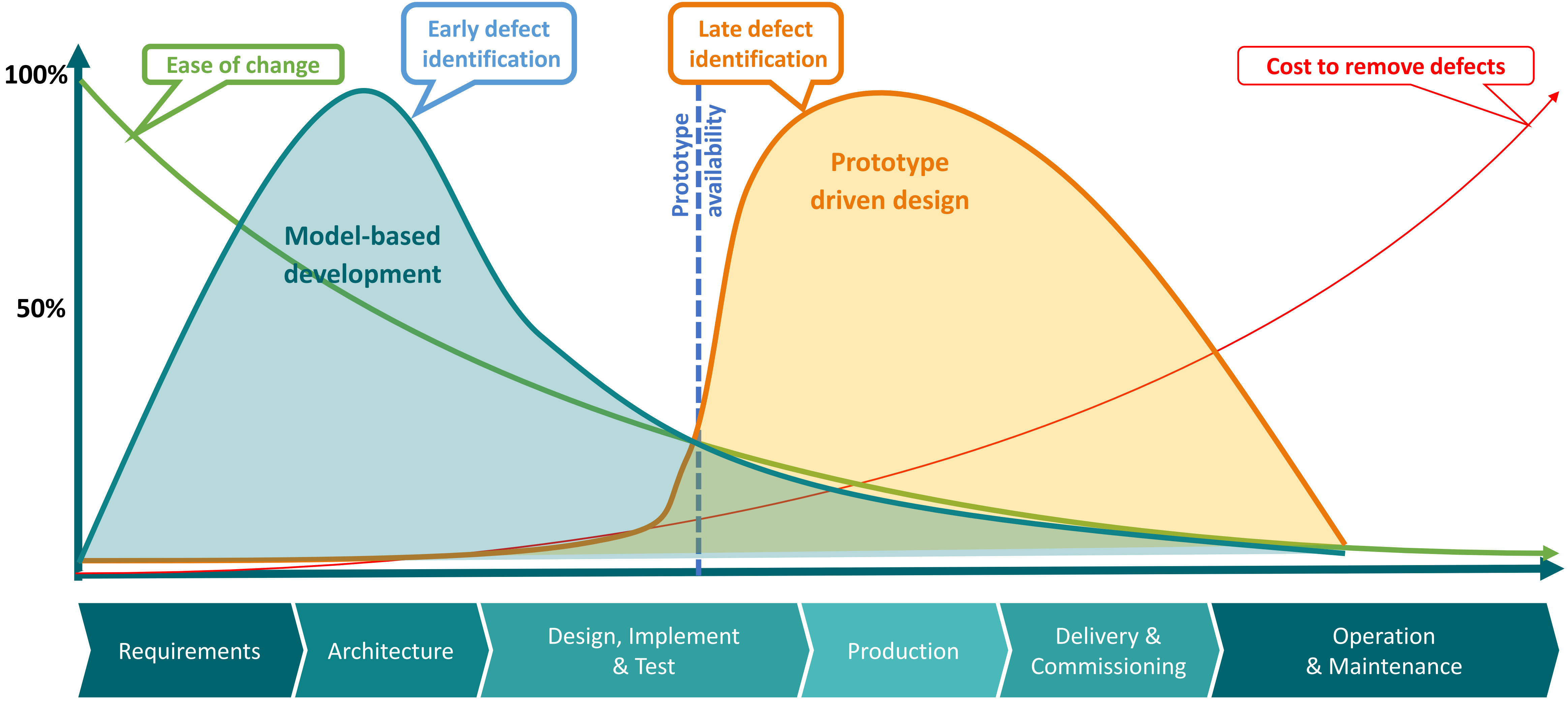
...huge



Digital Twins are the future

Model Based Development

Reducing the development costs, time and risks via simulation



- Wind Loads
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- Offshore
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- Wind Farms
- Materials
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- Acoustics
- Optimization
- Vibrations
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….Siemens Portfolio Tool…

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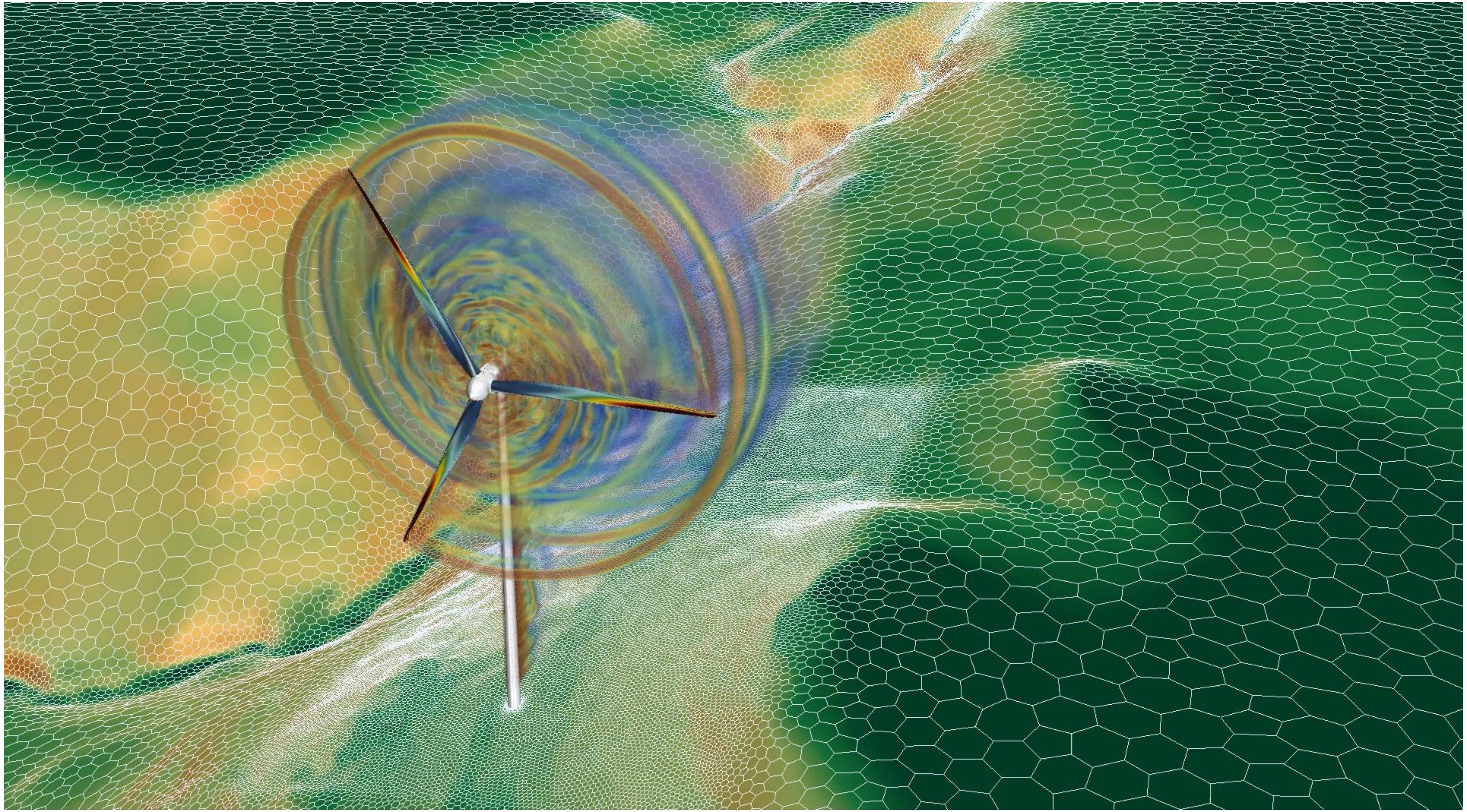
Star-CCM+



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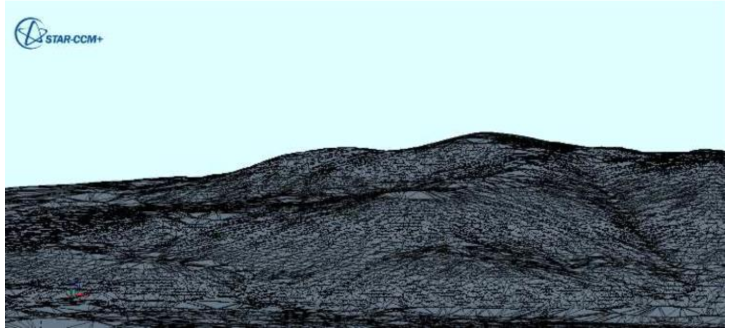

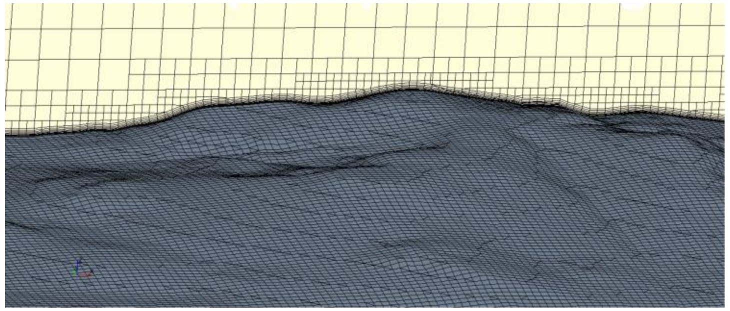

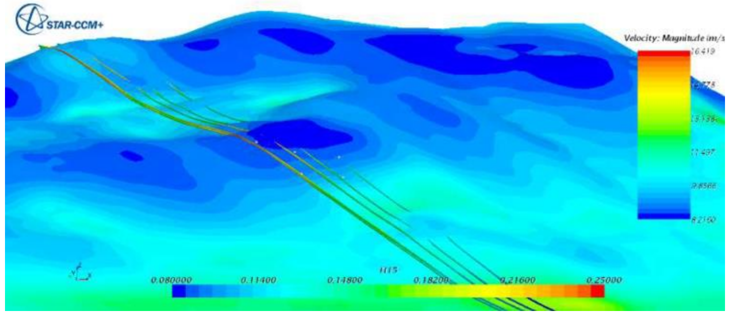

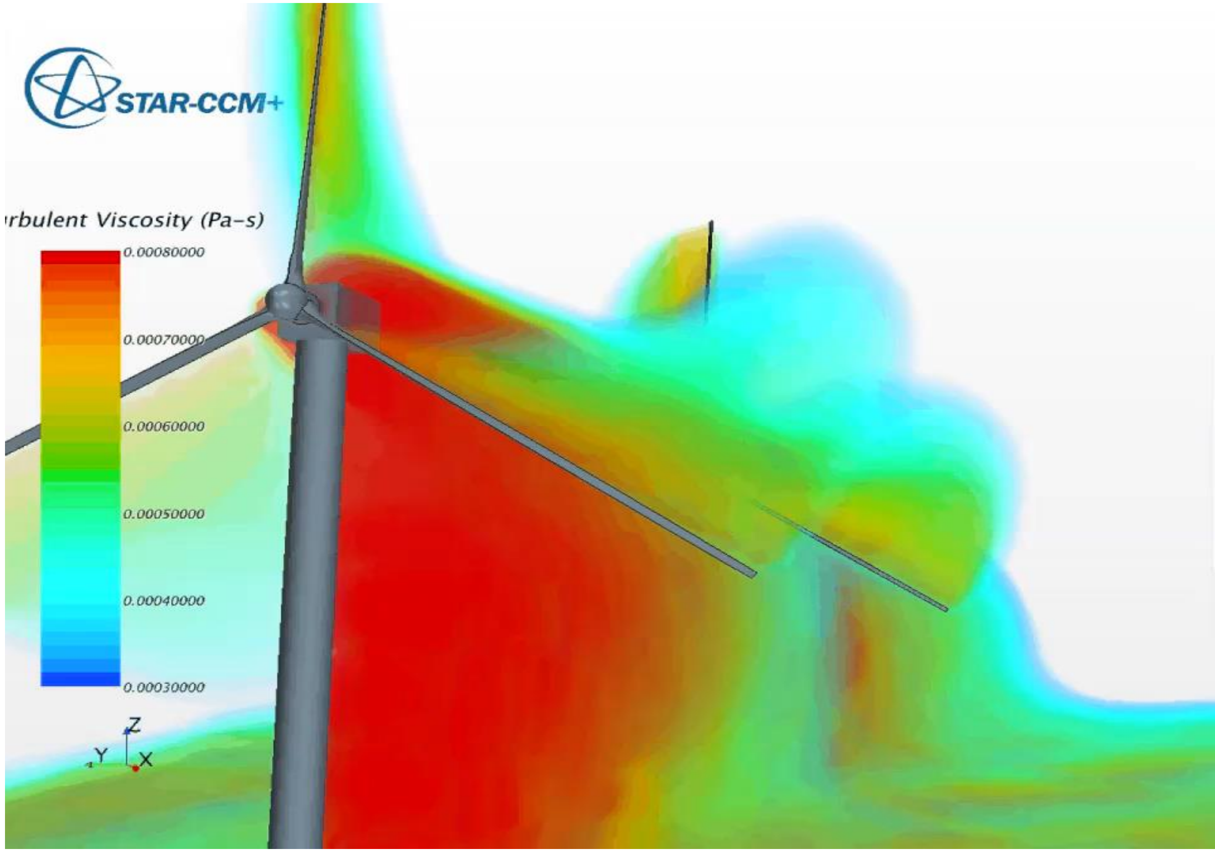

Star-CCM+

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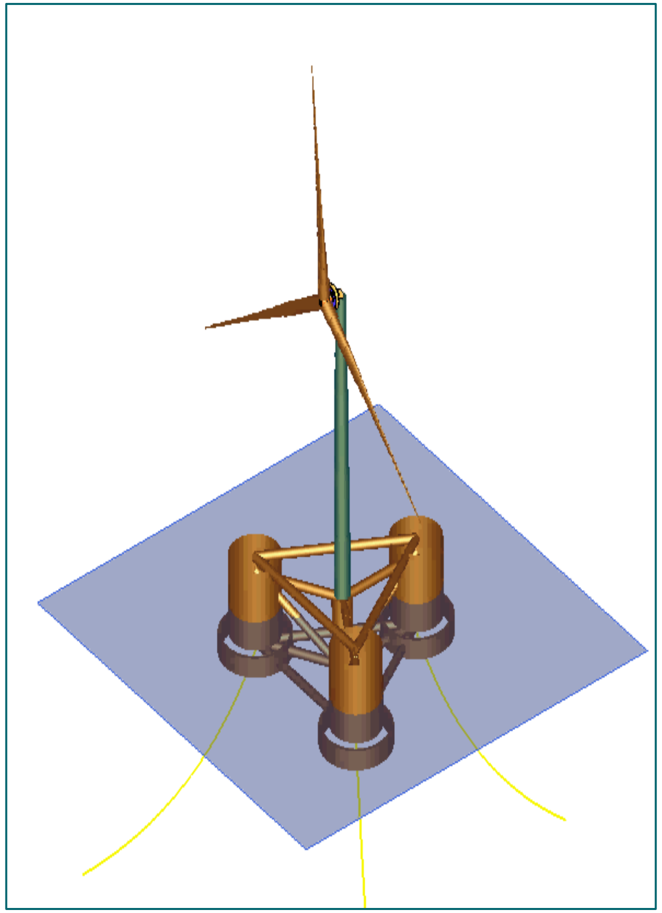

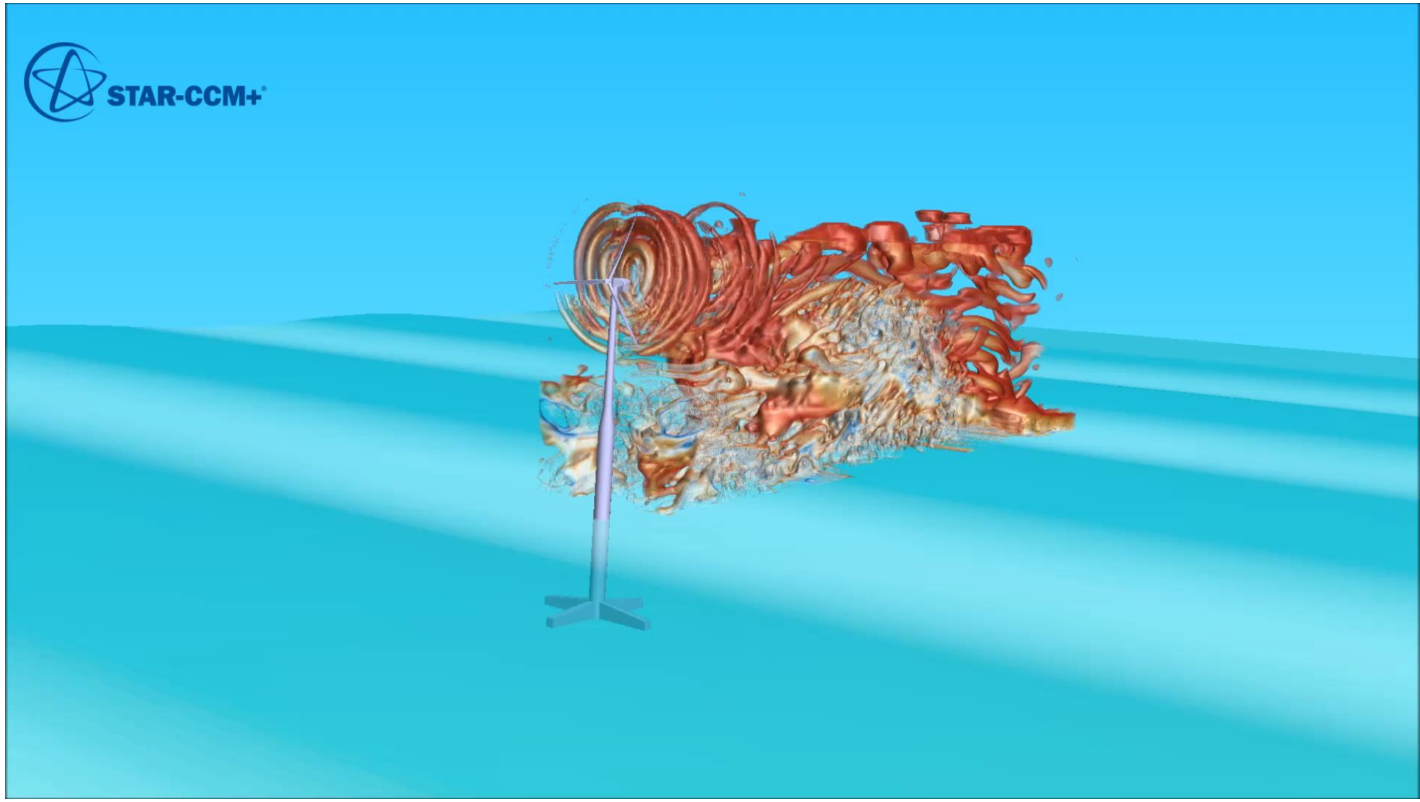

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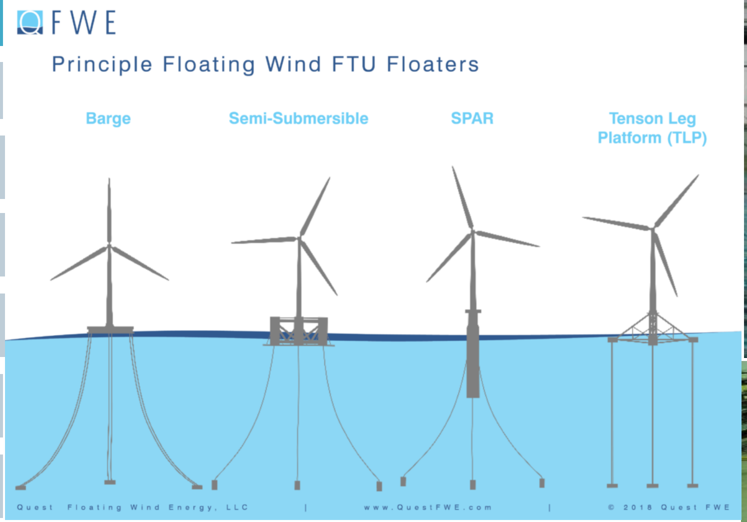
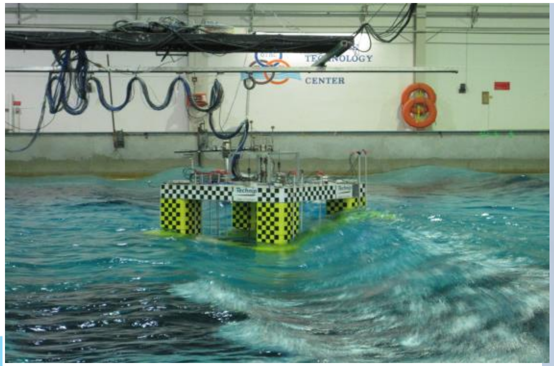
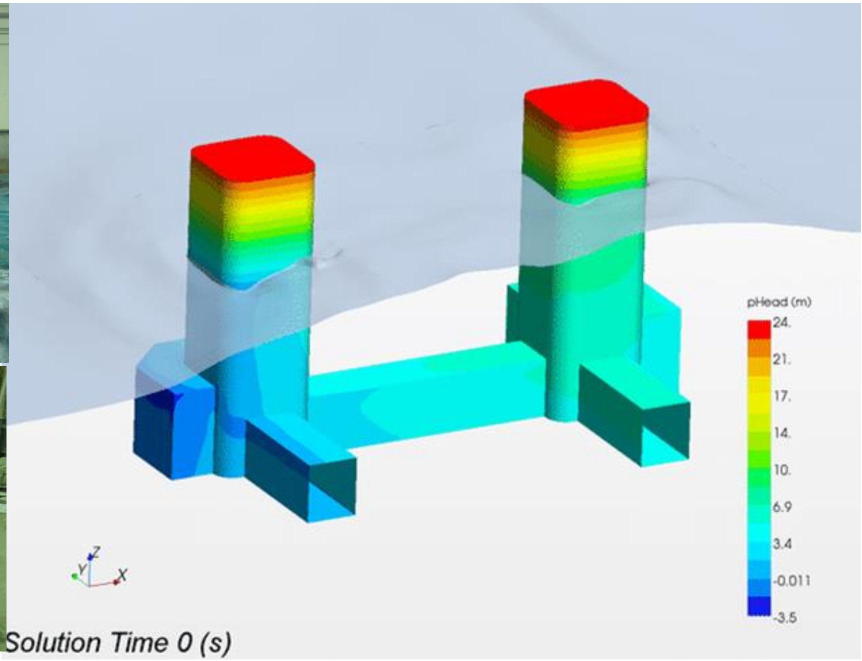
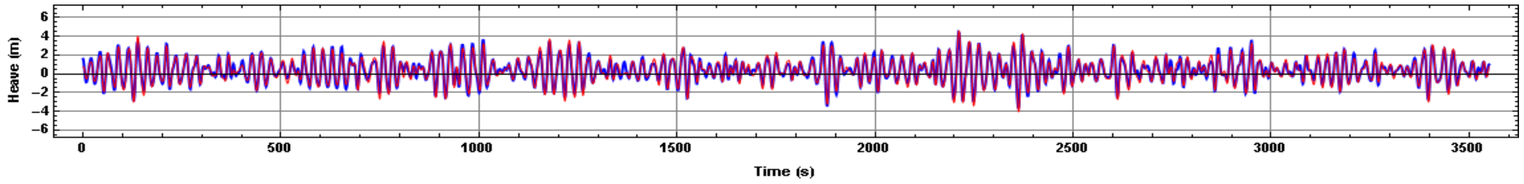
Floating Offshore Semisubmersible Development







Comparison of Heave Response (Blue : Model Test, Red : CFD)



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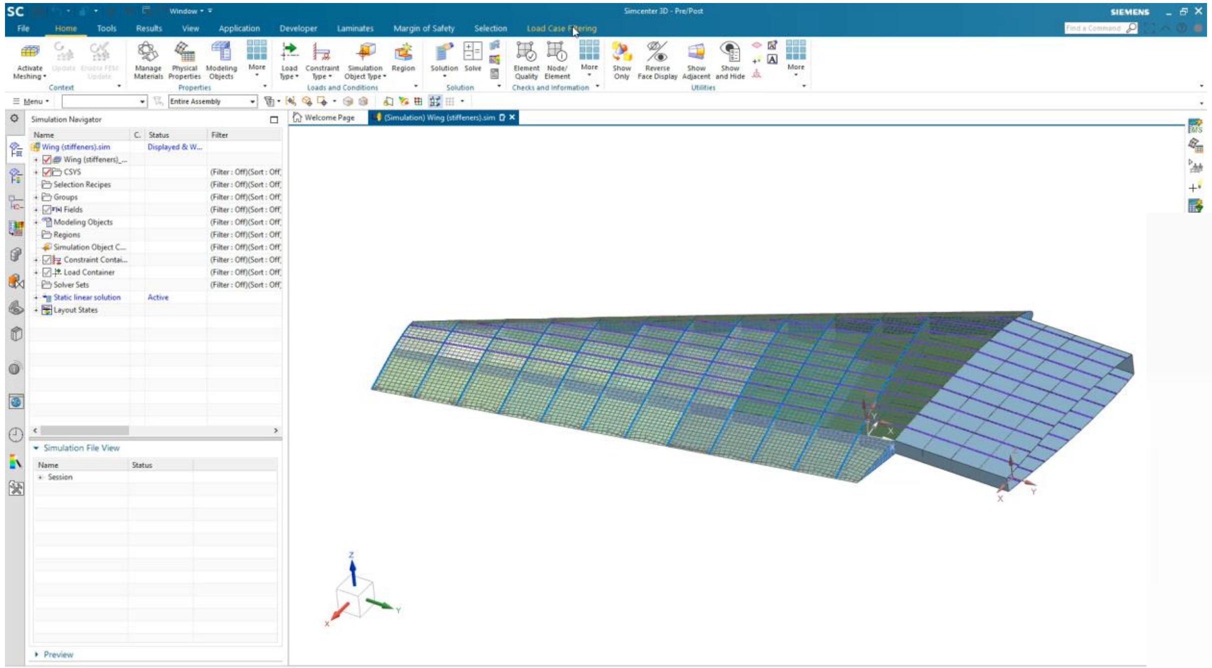

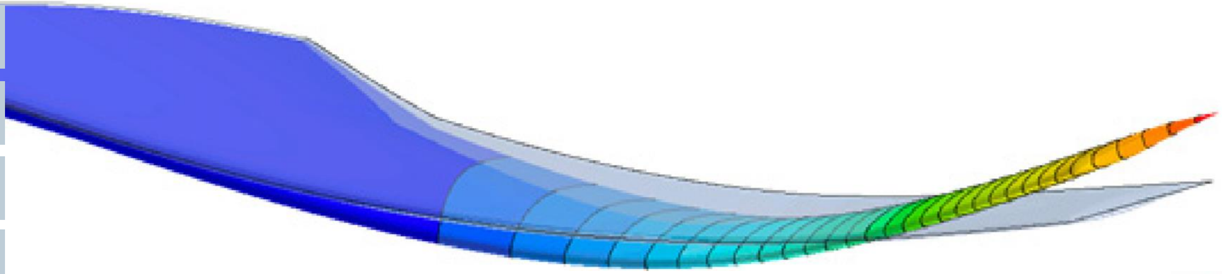

Workshop 1: Numerical simulations for Wind Turbine Engineering Problems

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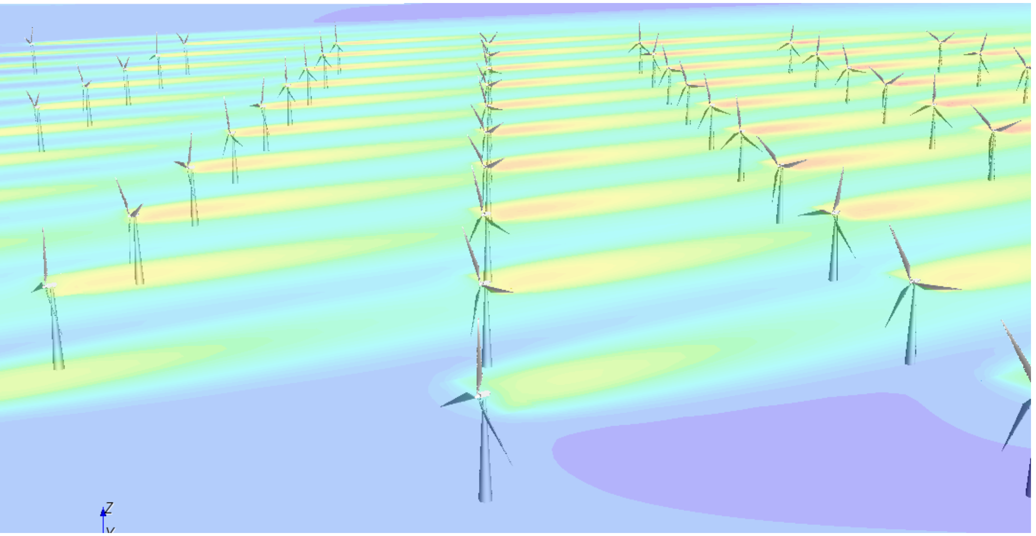

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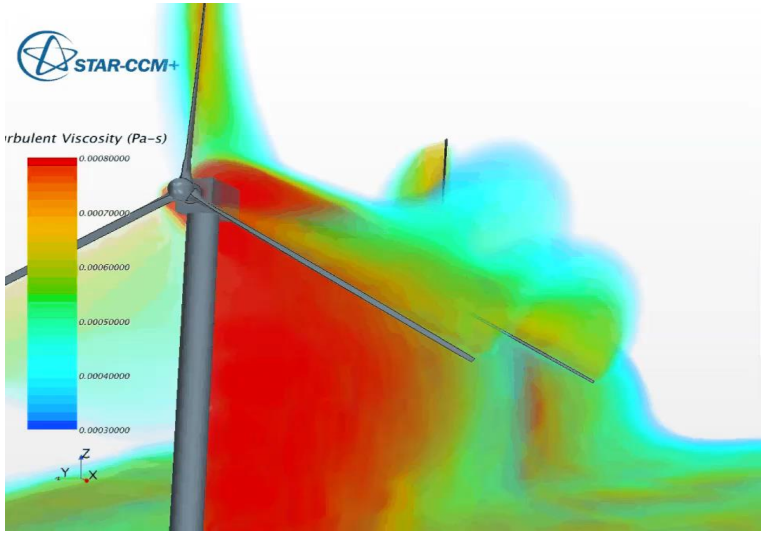

Challenges

- **Improve annual power of a wind farm**
- **Maximize Annual Energy Produced (AEP)**

Constraints

- **Terrain and multi-turbine wakes effects**

Design variables

- **Location of each turbine**

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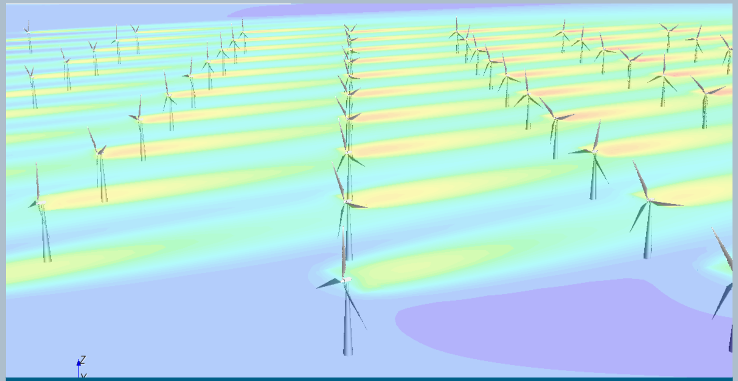
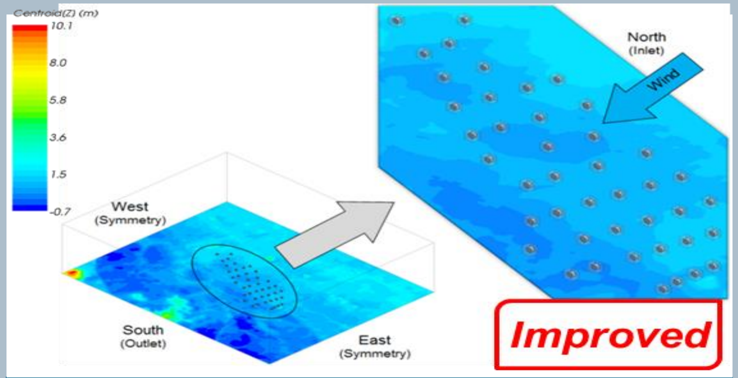
Star-CCM+ & HEEDS

Aero-dynamic simulation in combination with design exploration



Wake effect in caused neighboring turbines



Optimized layout of turbine locations

- **Detailed analysis in Simcenter STAR-CCM+**
- **Terrain and multi-turbine wake effects were causing energy output to suffer**
- **A design exploration process was initiated to identify a new layout of turbines**

"Increased Annual Energy Production (AEP) by 8.5% compared to the original design"

Could vertical wind turbines finally have their day, and be the future for wind farms?

Joshua S Hill 5 May 2021 8

Share Tweet in 0

A new study published last month by researchers at Oxford Brookes University in England has raised the possibility that traditional propeller wind turbines be replaced by more compact and efficient vertical wind turbines.

The standard wind turbine is the three-blade propeller wind turbine, also known as a Horizontal Axis Wind Turbine (HAWT), and are generally assumed to be the future of wind energy technology, in both onshore and offshore projects.

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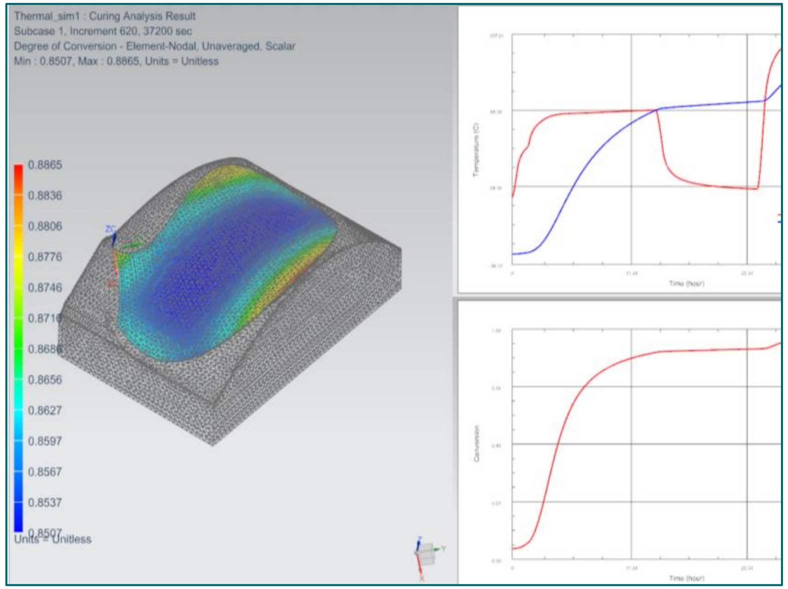

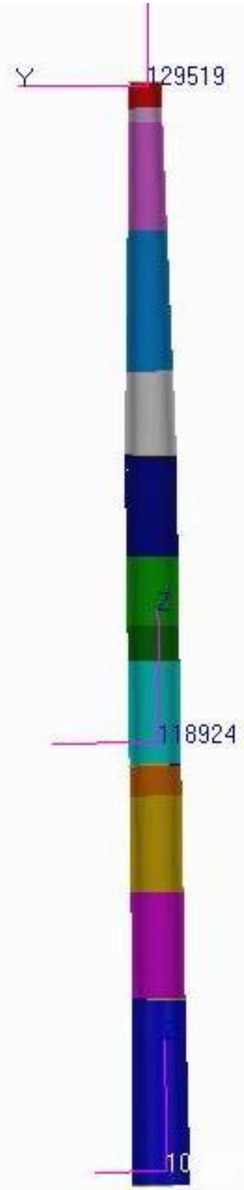

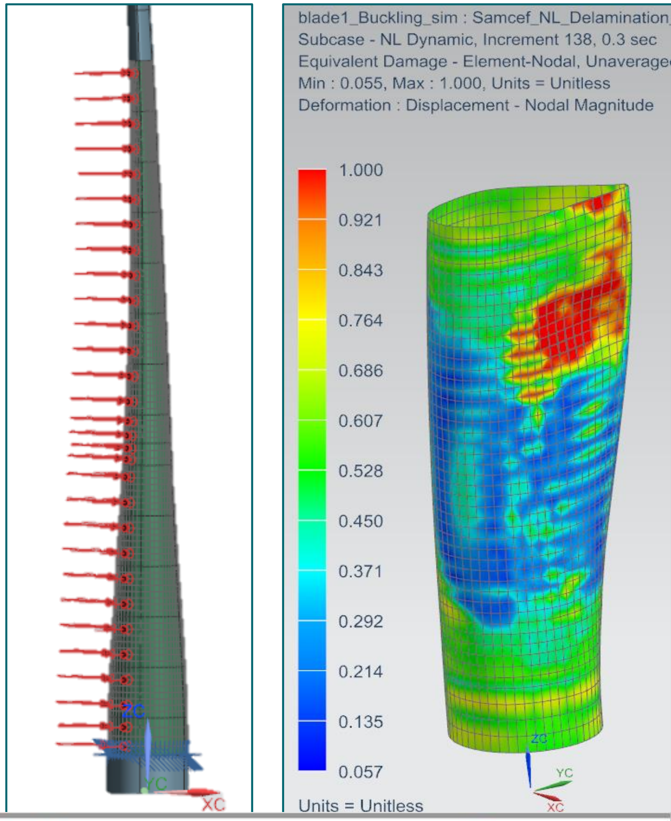

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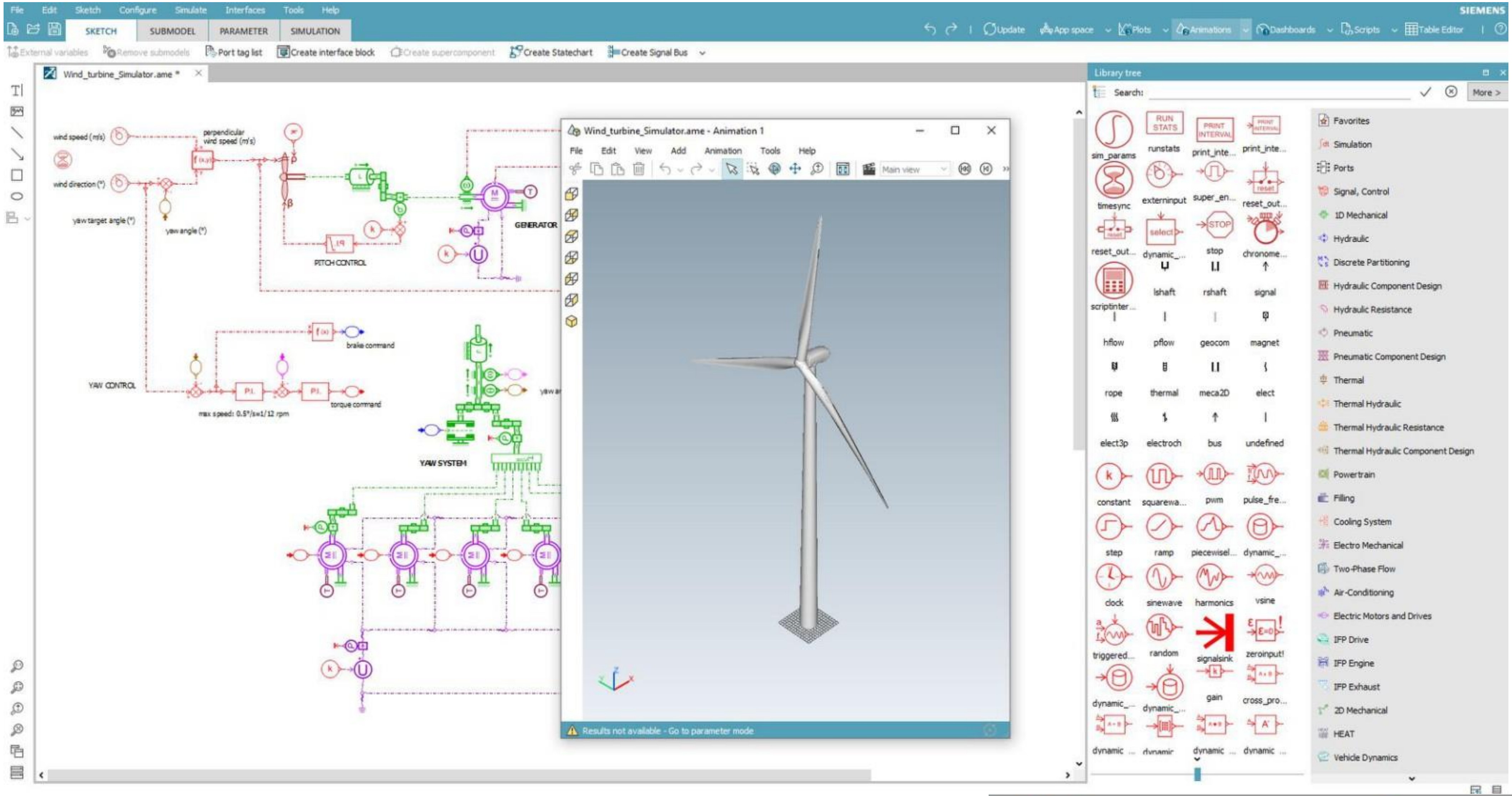

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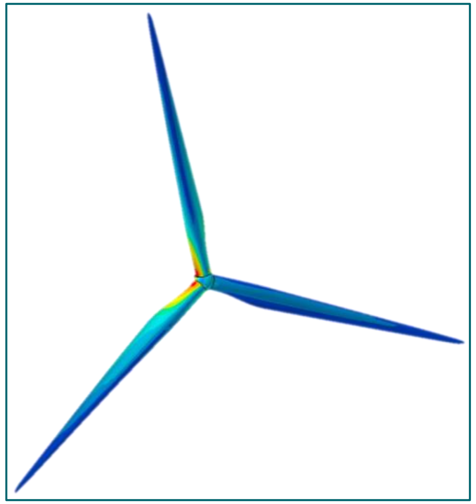

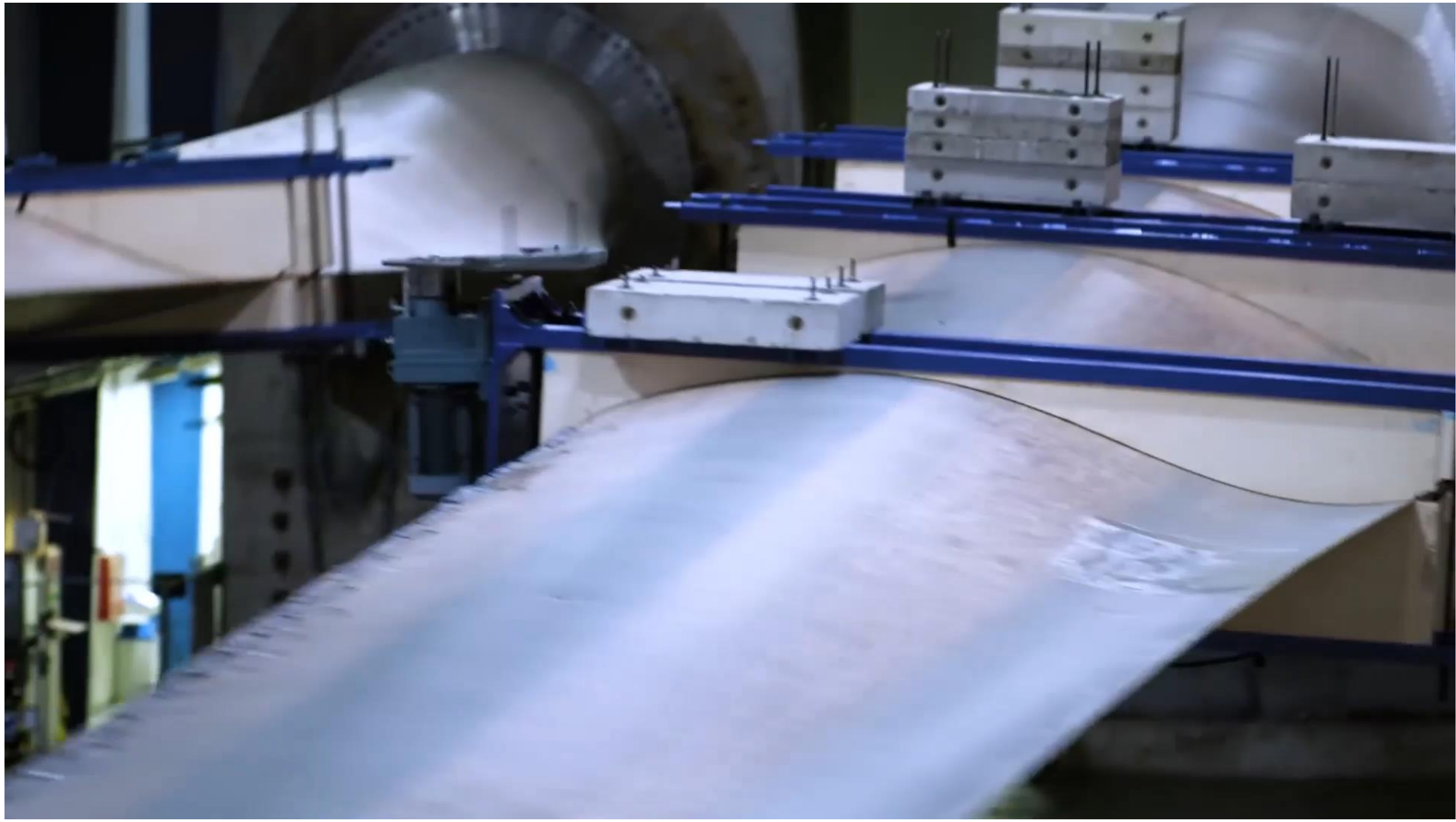

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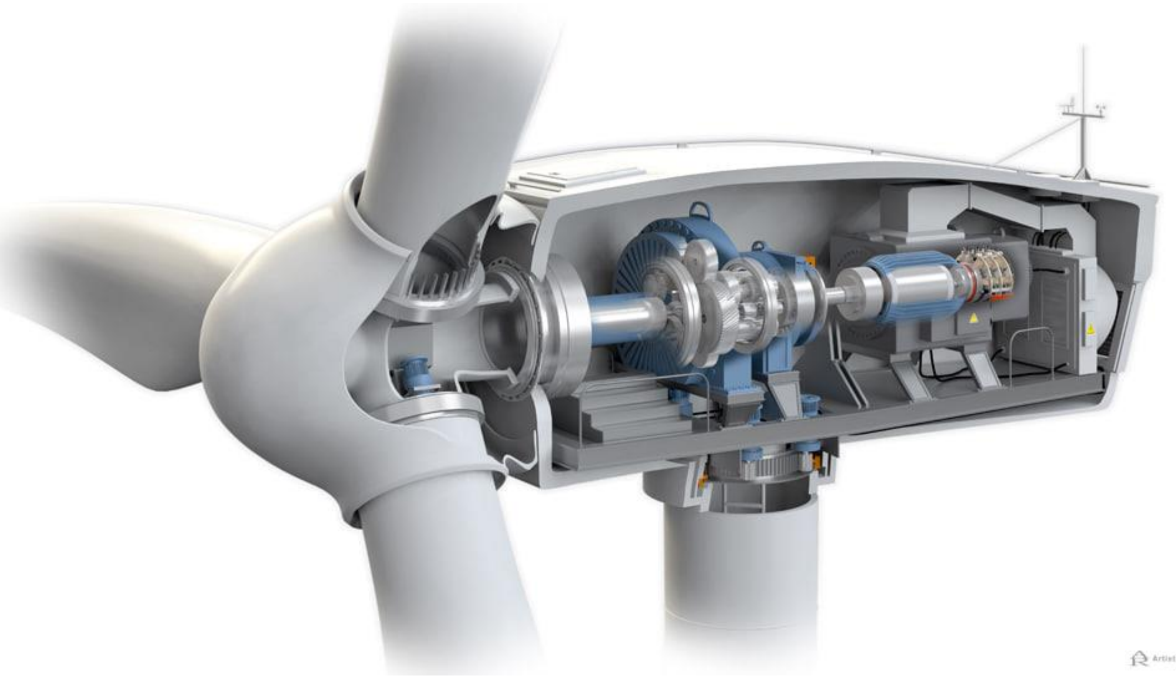

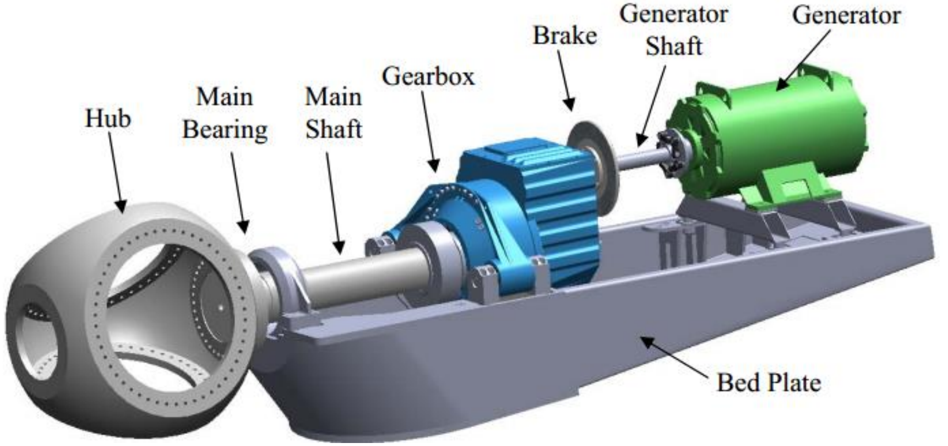

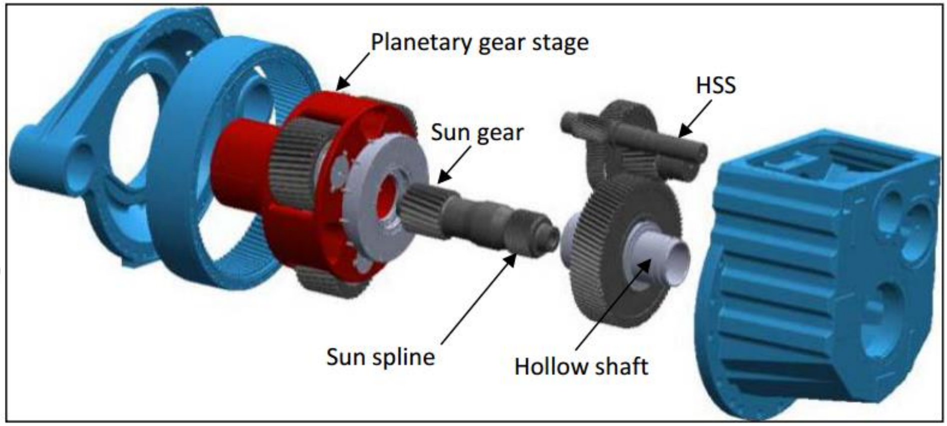

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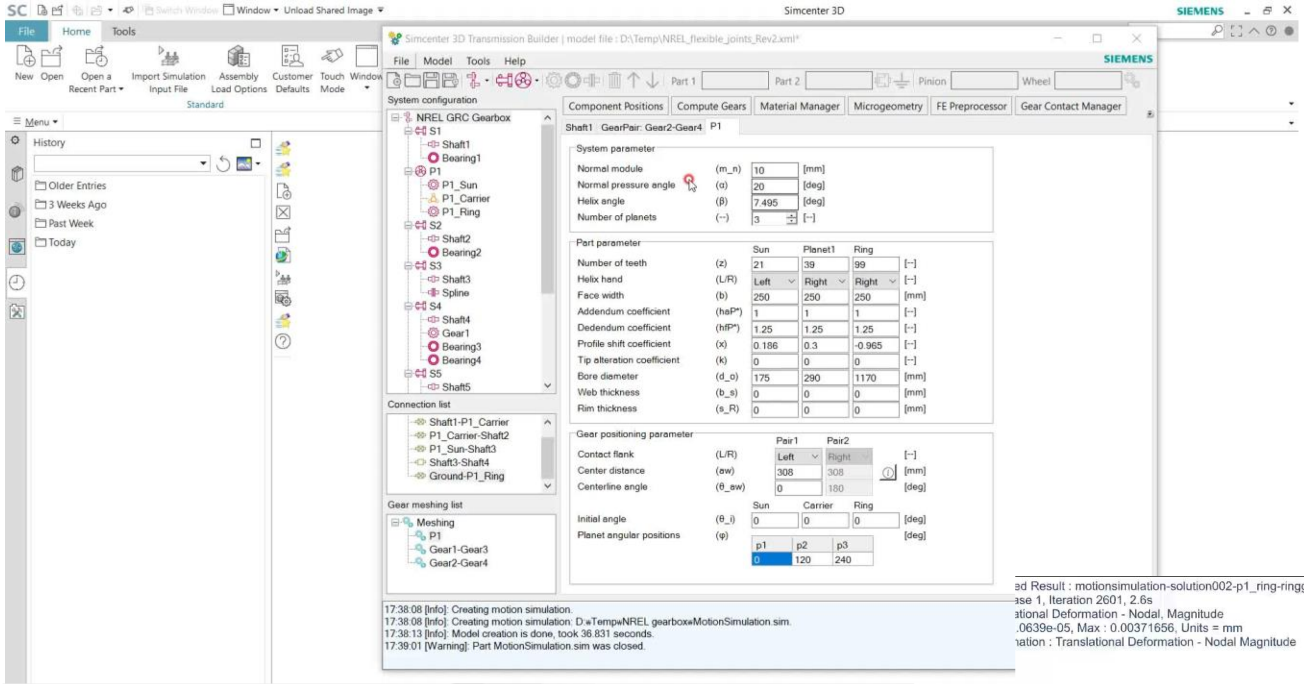

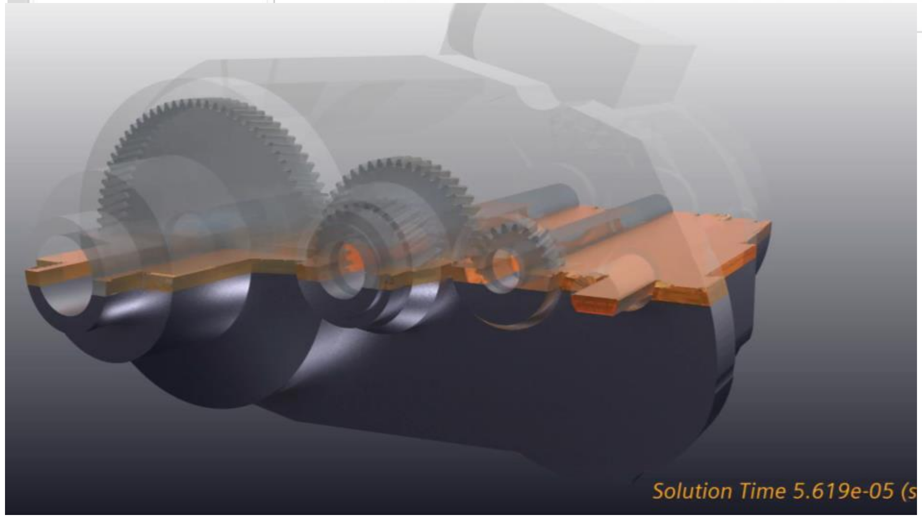

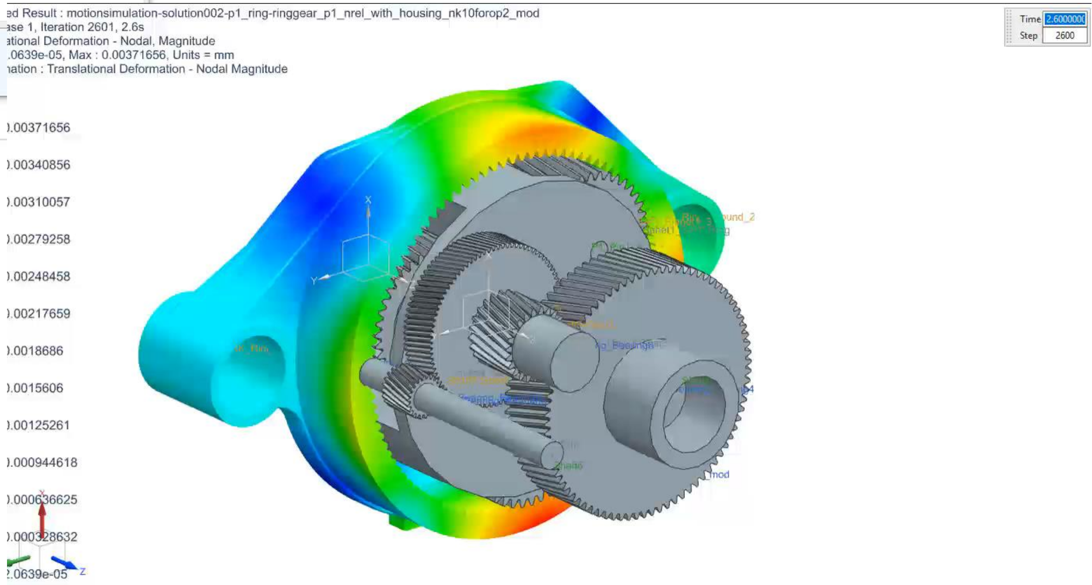

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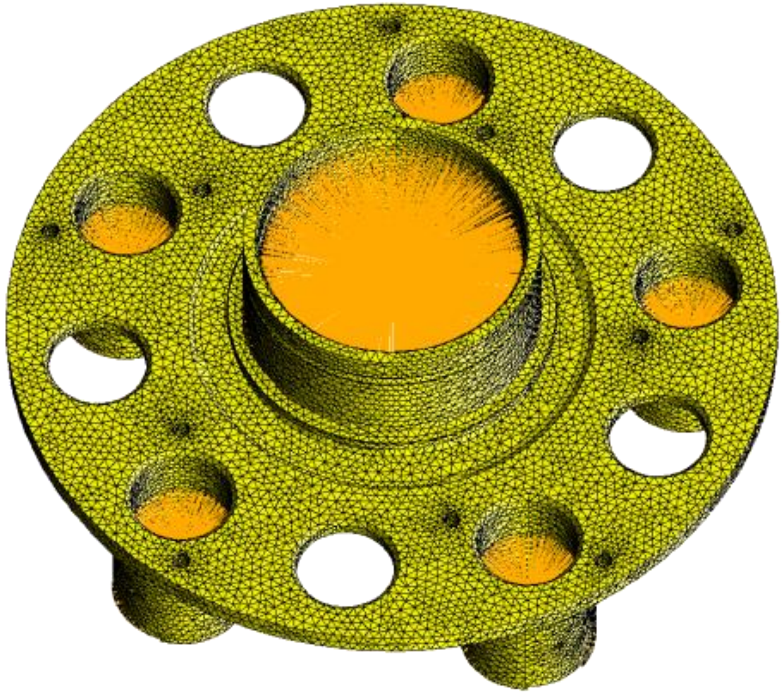
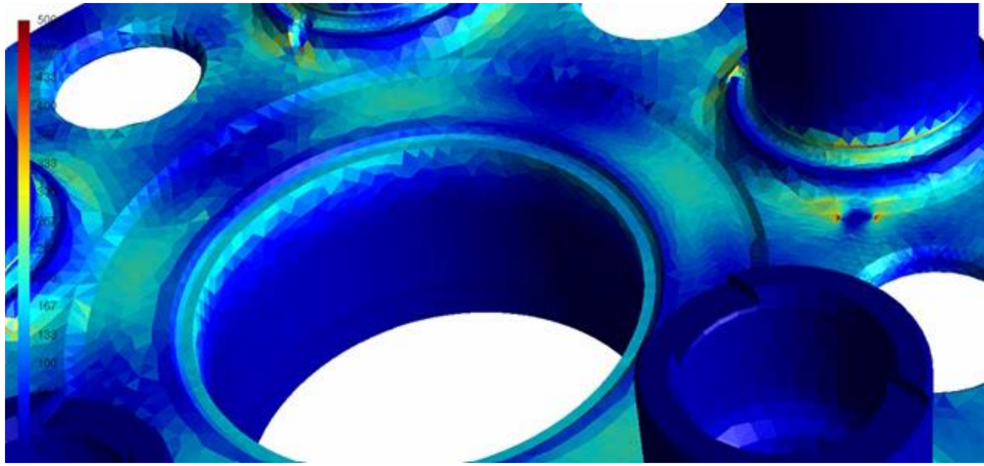


With courtesy of Eurocopter



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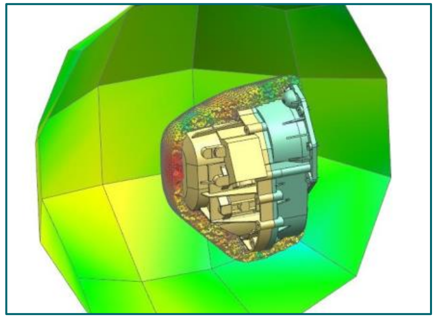


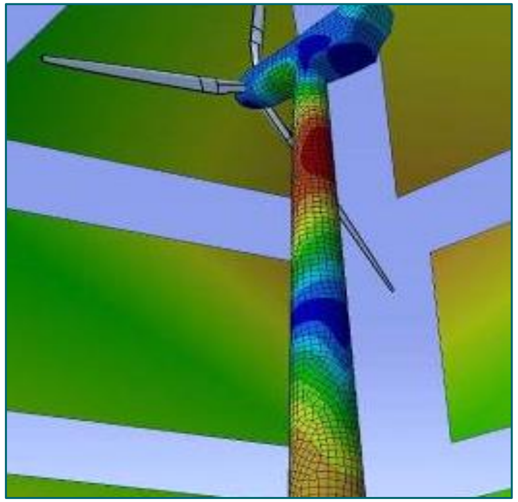
Noise radiation

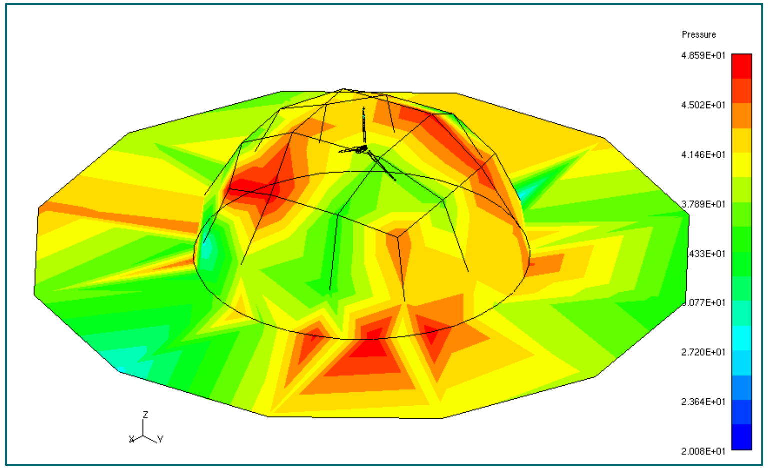
Transmission loss

Enclosures

Acoustic scattering

Acoustics modeling

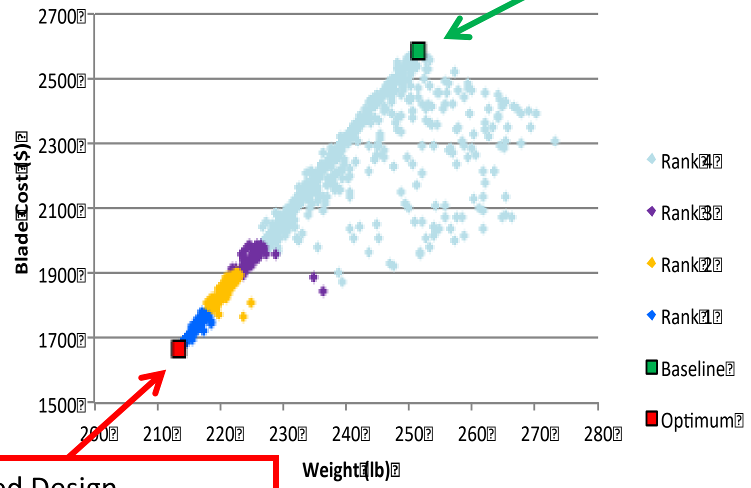




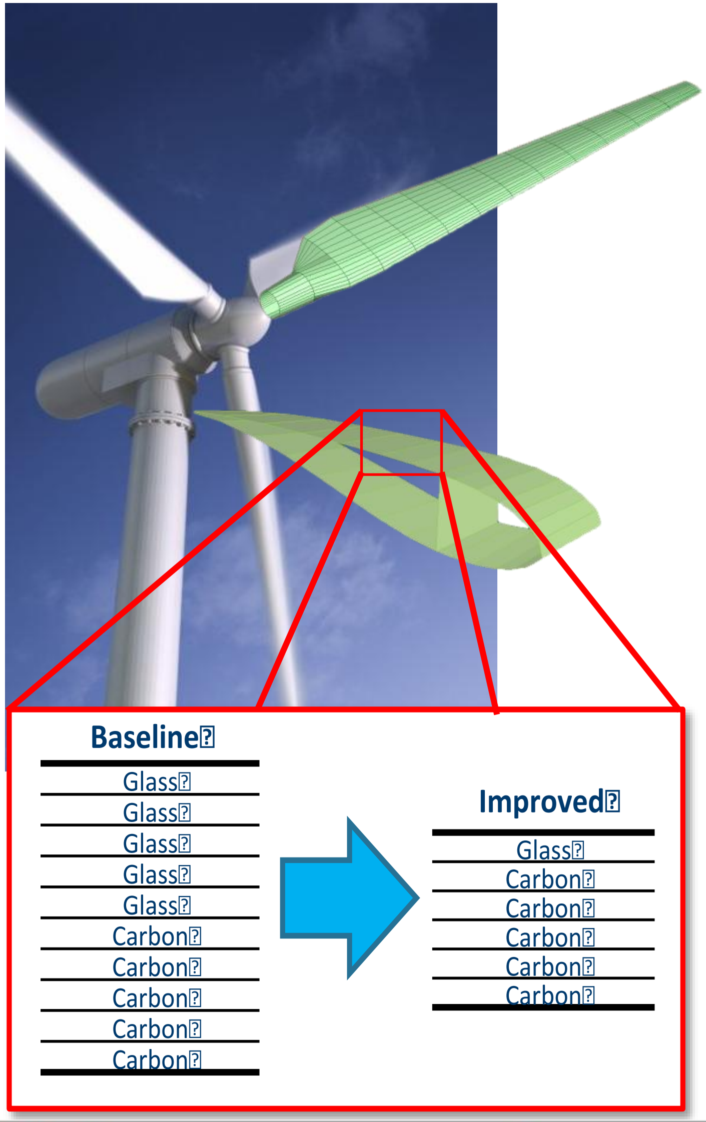
Simcenter 3D & HEEDS

- Challenge:
  - Maximize wind energy KWh produced
  - Minimize blade weight and power production cost
  - Constraints
    - Laminate failure, deformation, mode separation
  - Design variables
    - Laminate lay-up, scale of blade
- Results:
  - Reduced blade cost by 36%
  - Increased performance by 26%

Initial Baseline Design



Improved Design



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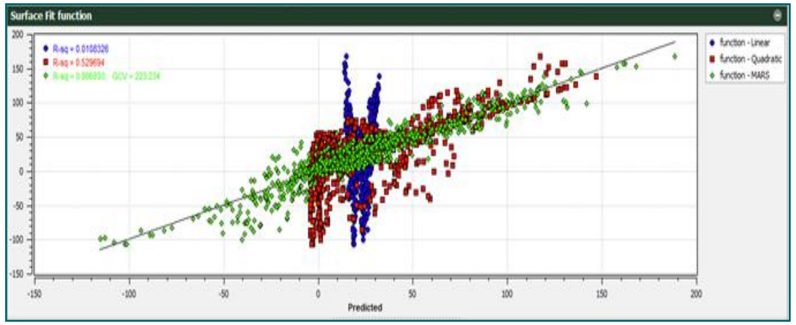

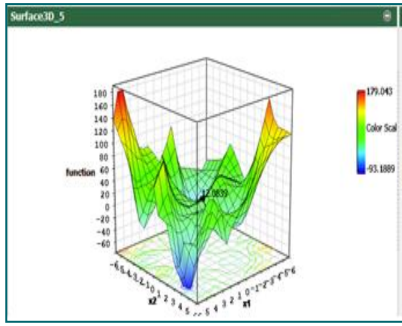

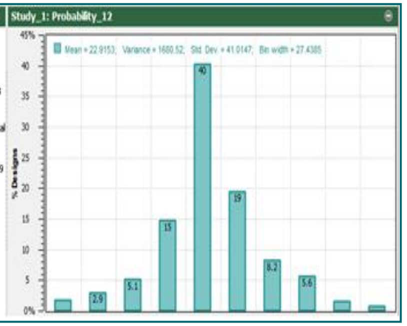

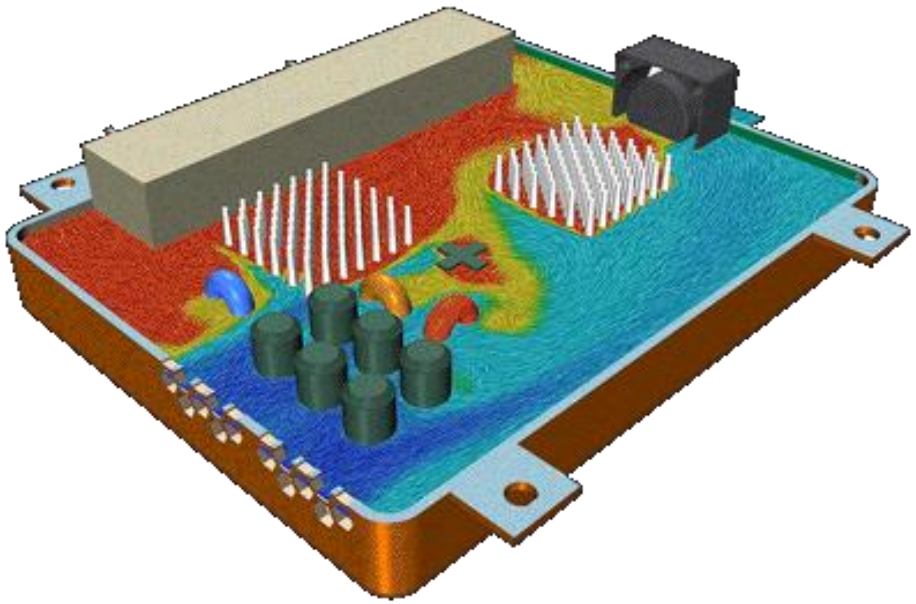

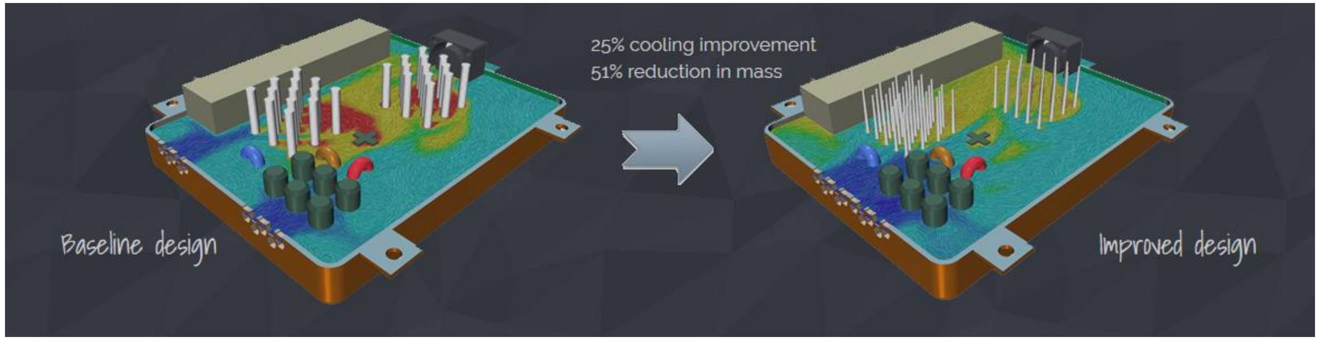

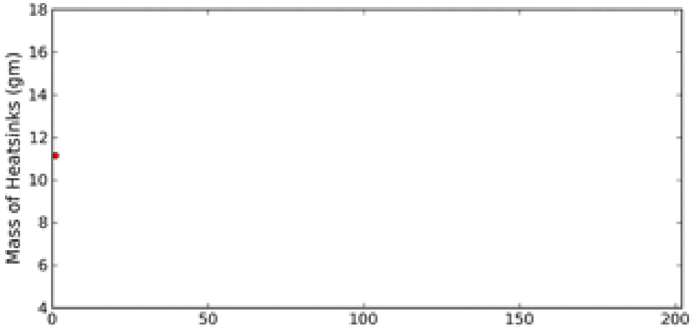

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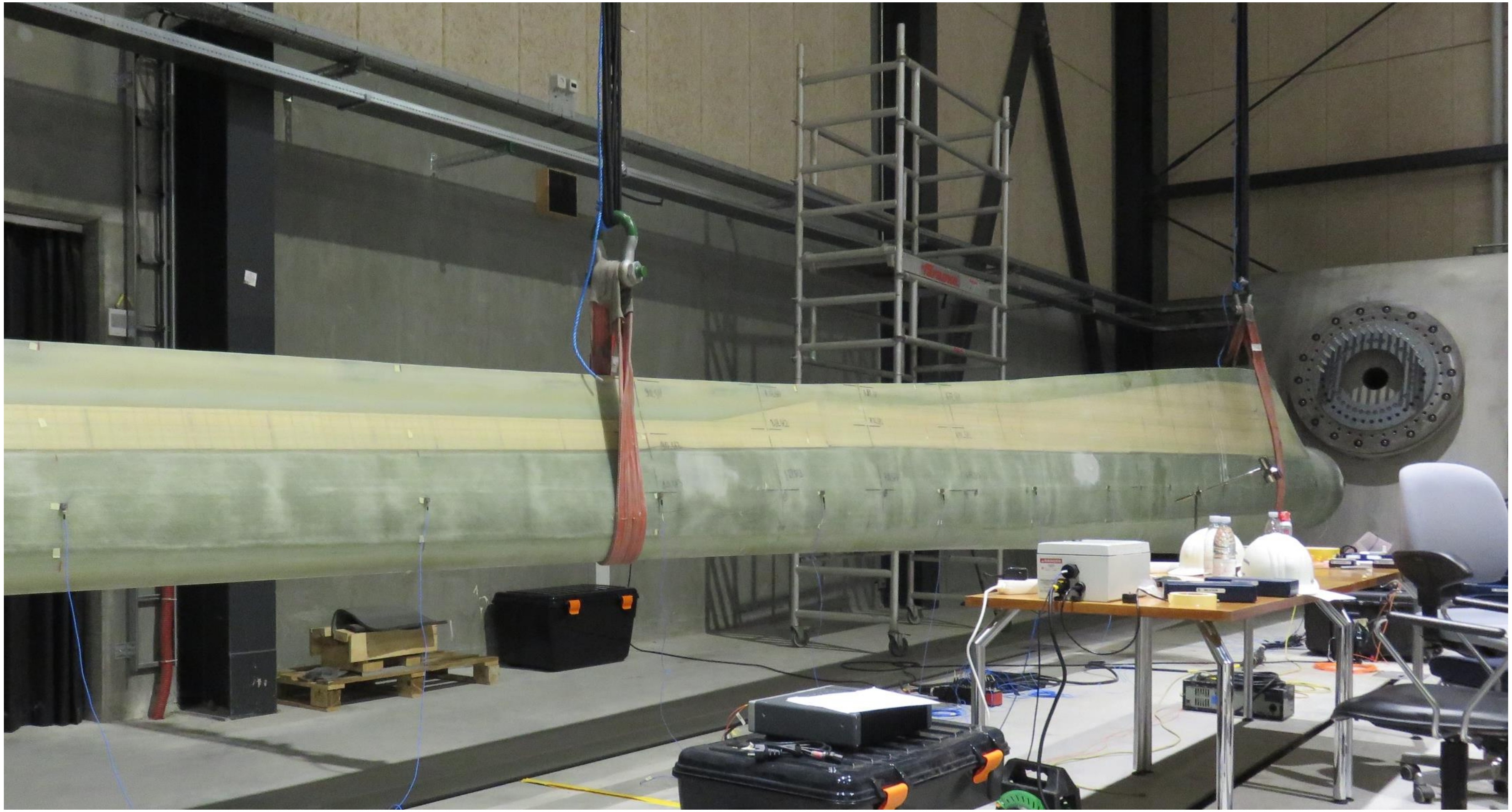
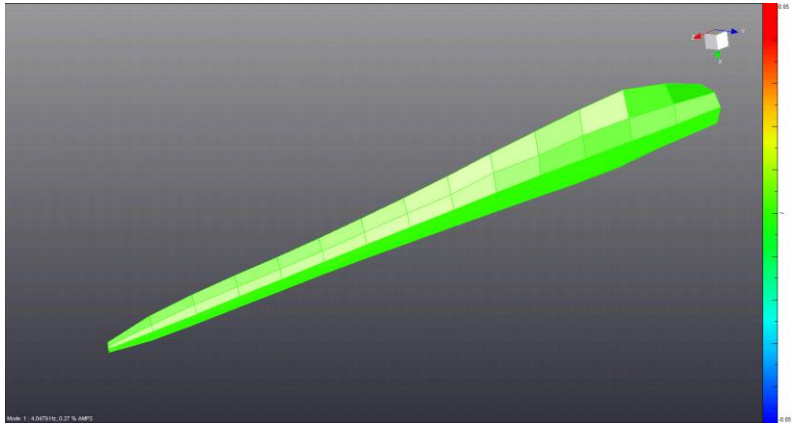
Free-free setup

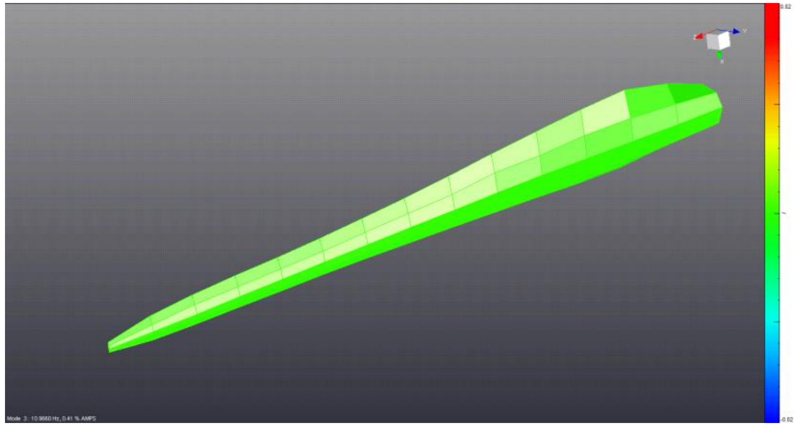


Experimental setup: Mode shapes



1st flap mode

4.05 Hz



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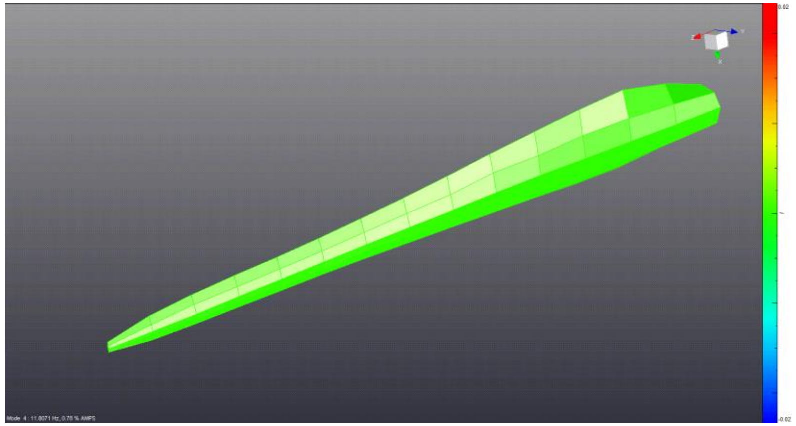
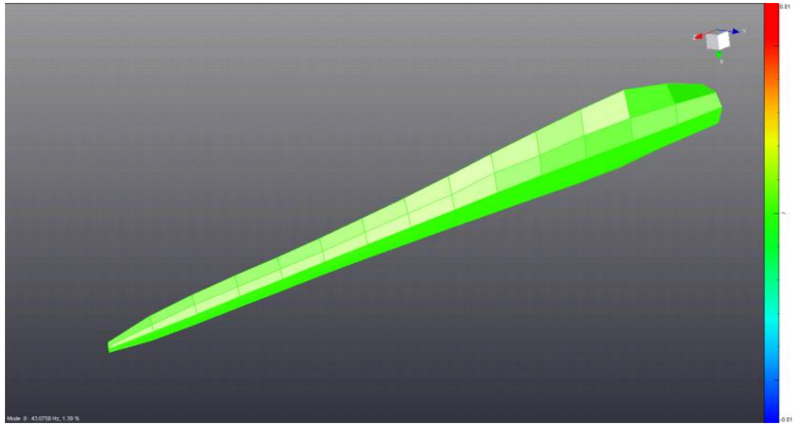


2nd flap mode

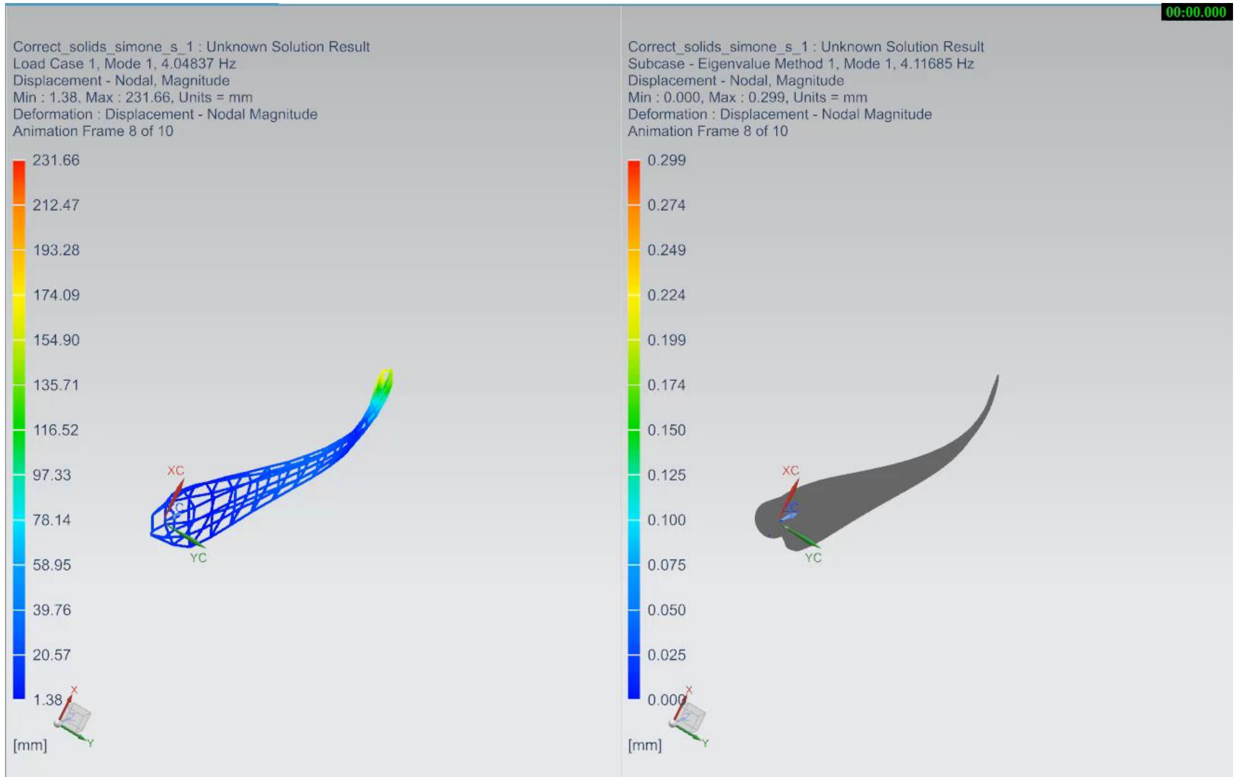
11.81 Hz

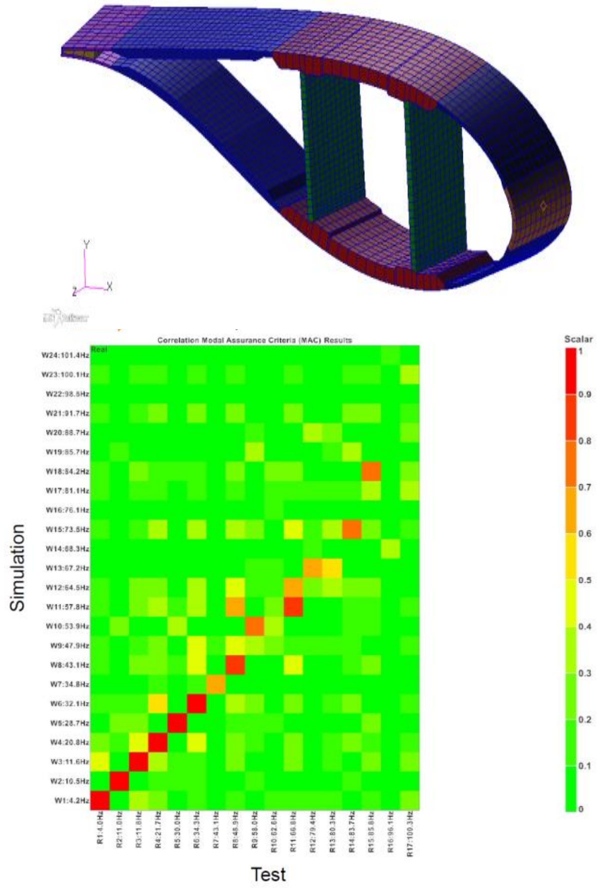


T

- Wind Loads
- Site assessment
- Offshore
- FSI/Aeroelastic.
- Wind Farms
- Materials
- System
- Durability
- Acoustics
- Optimization
- Vibrations
- Corrosion
- Thermal
- Wave propagat.
- Connection w. Land
- Cable Laying

3D FE simulation and correlation with the test





PITHIA-FSI

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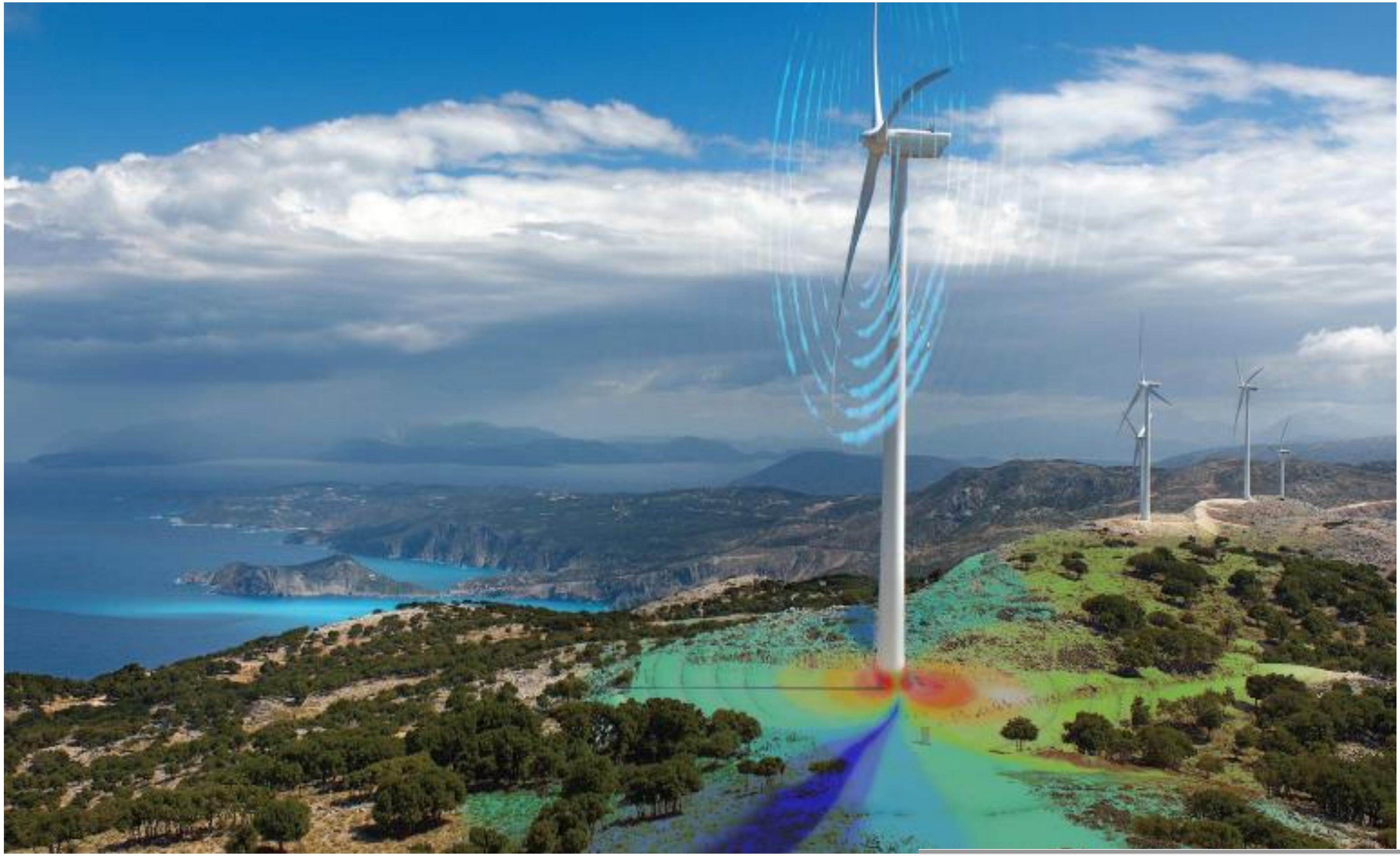

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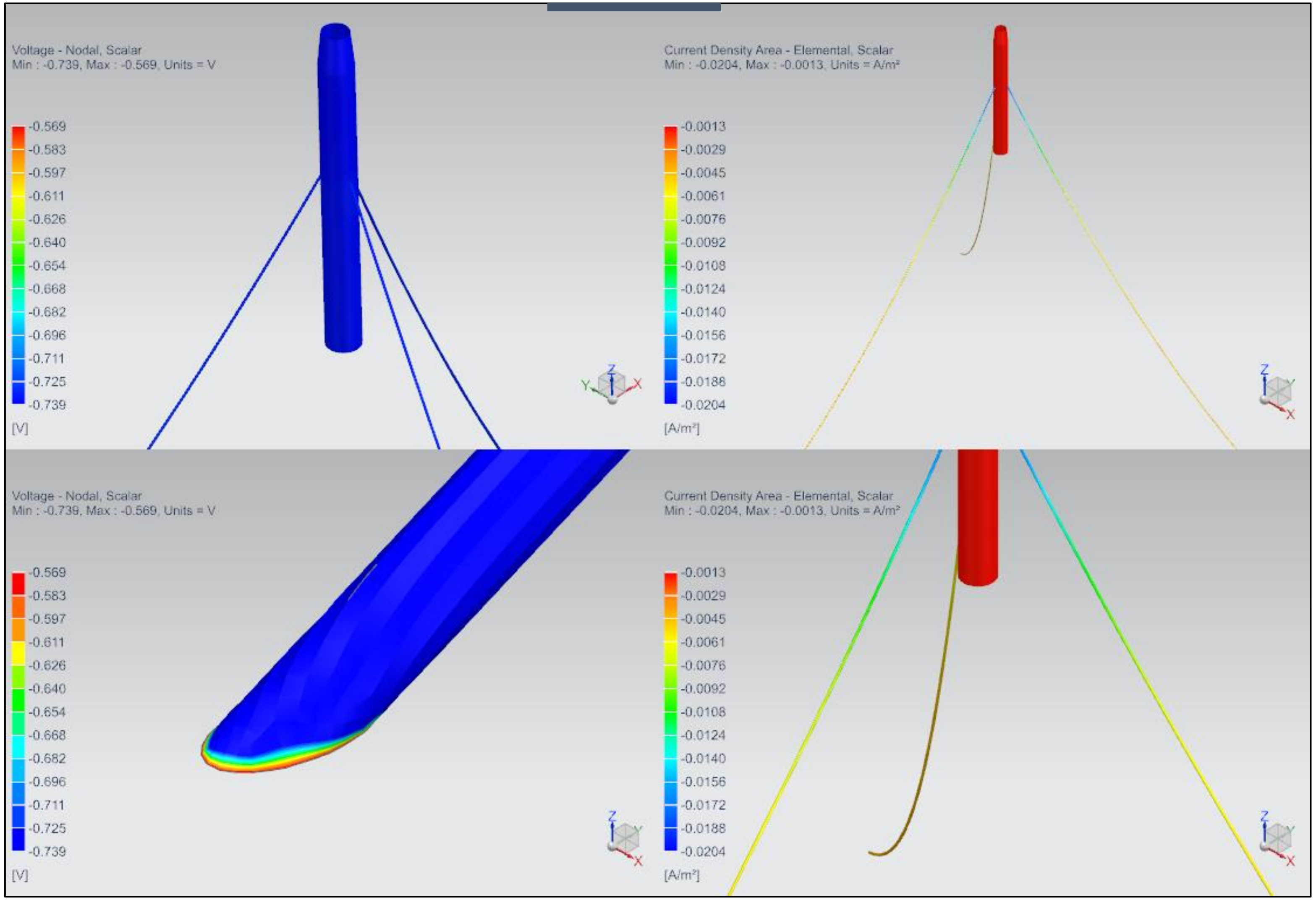
CP on an 145m-tall floating offshore wind turbine

PITHIA-CP



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Simcenter 3D

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- Optimization
- Vibrations
- Corrosion
- **Thermal**
- Wave propagat.
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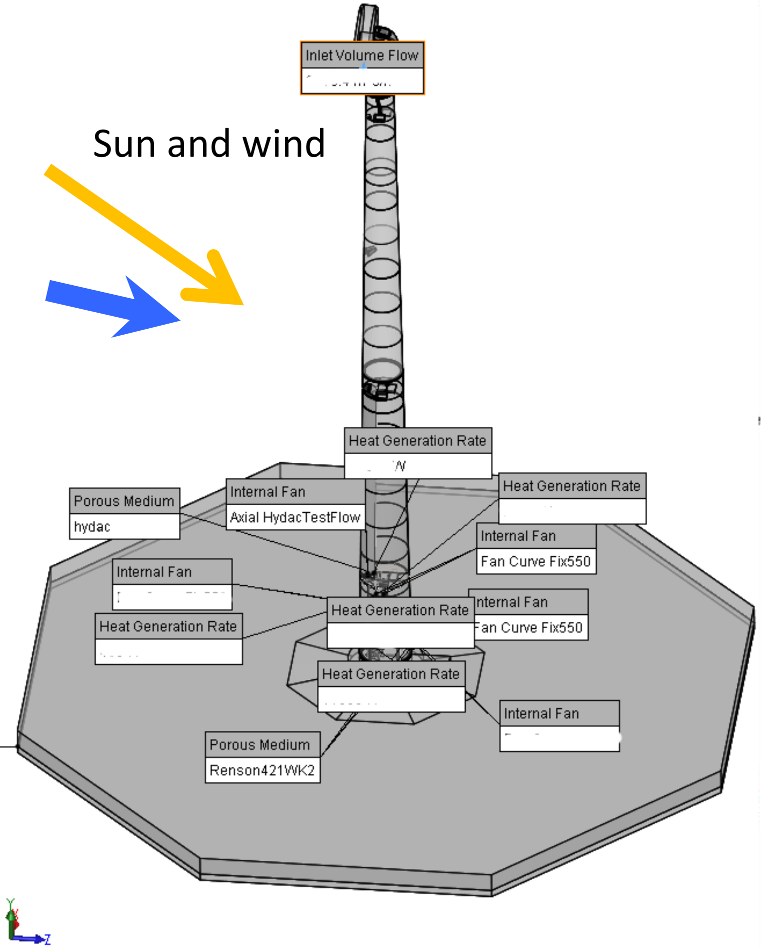
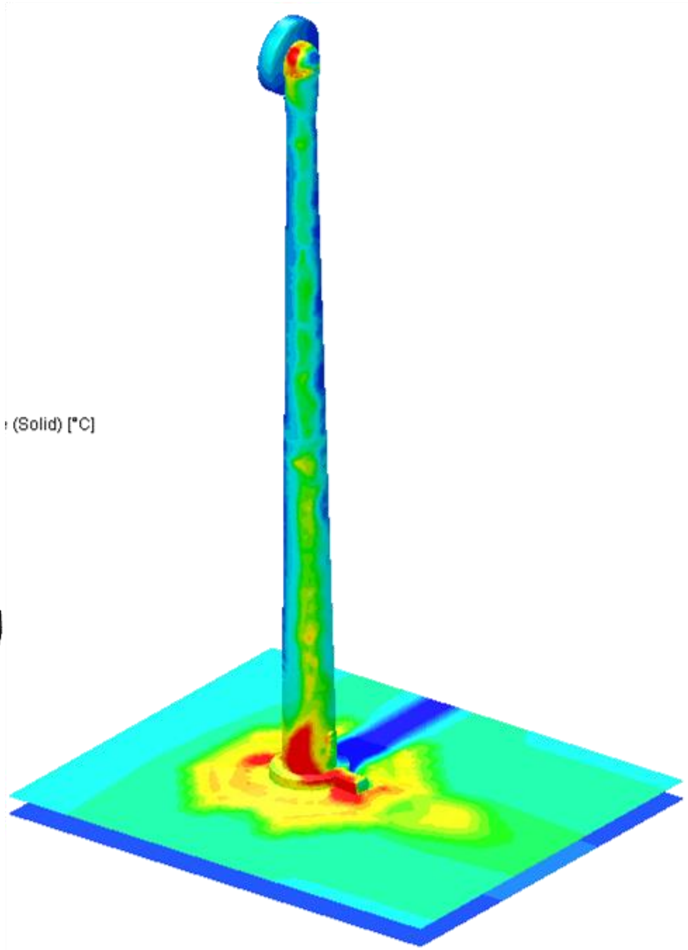
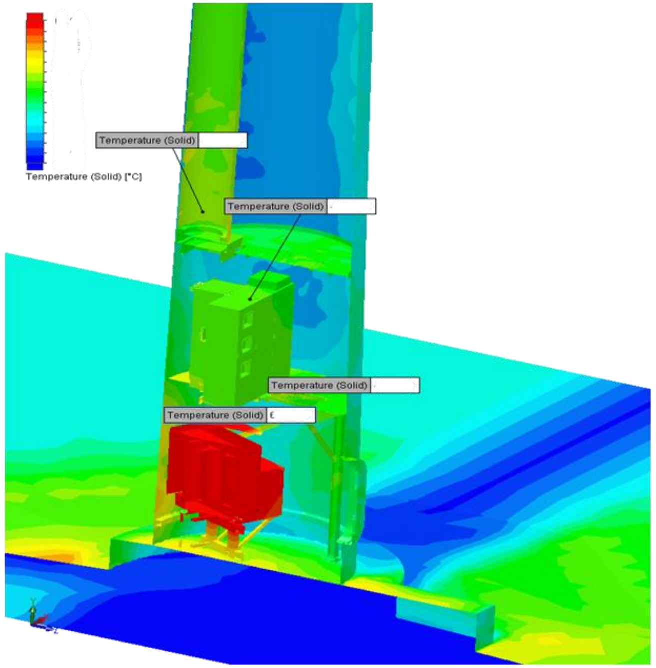
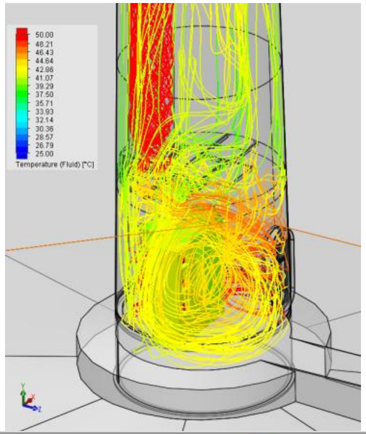
Sun and wind









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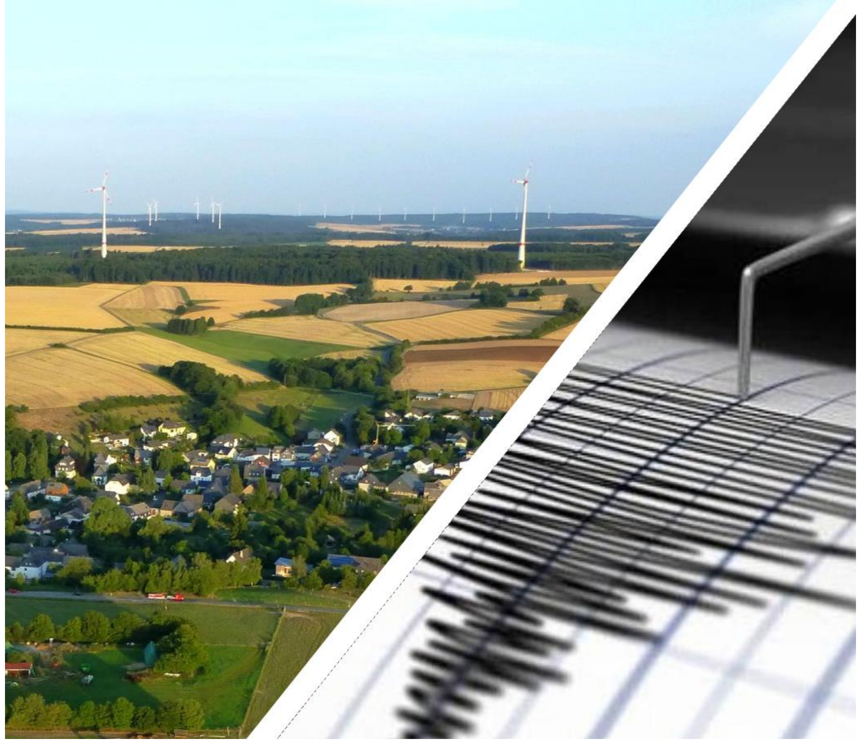
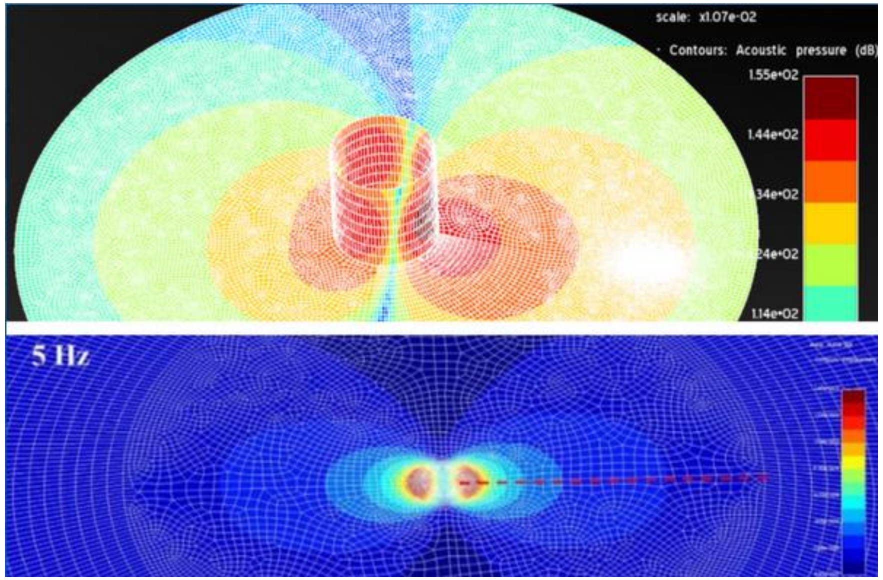
PITHIA-FSI

- Given the complexities associated with ship design and construction, the IMO Guidelines focus on primary sources of underwater noise, namely on propellers, hull form, on-board machinery, and various operational and maintenance recommendations such as hull cleaning. Additionally, piling operations performed during the installation of offshore wind turbines or the construction of bridges influence heavily the underwater life.



- Study of micro-seismic & infrasound noise generated by wind turbines. The waves are propagated through the air and soil possibly affecting nearby residences or Seismological/Earthquake data centers. The simulation handles effectively the fluid-soil-structure interaction (FSI) phenomenon.



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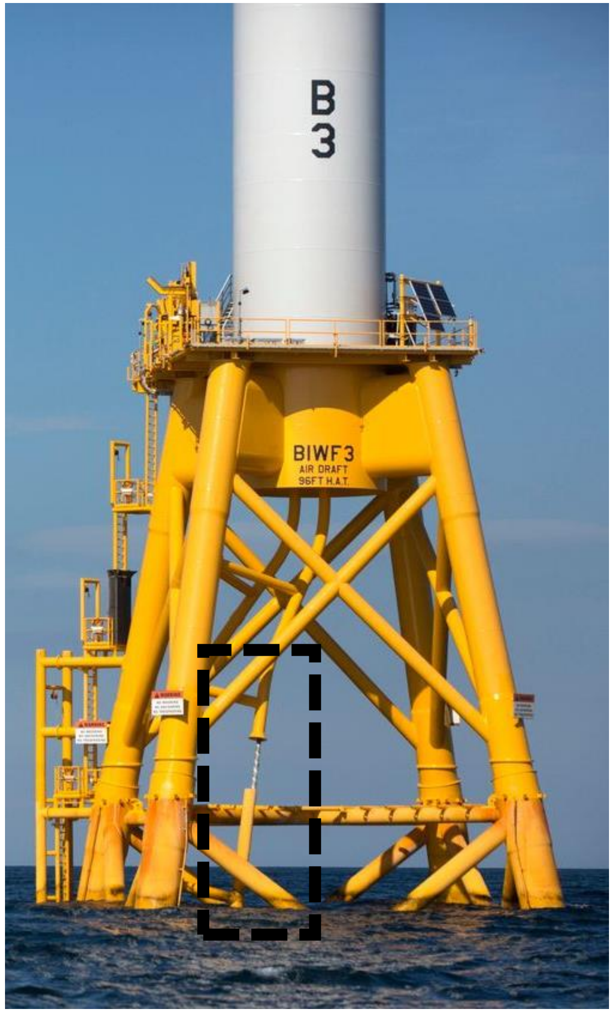
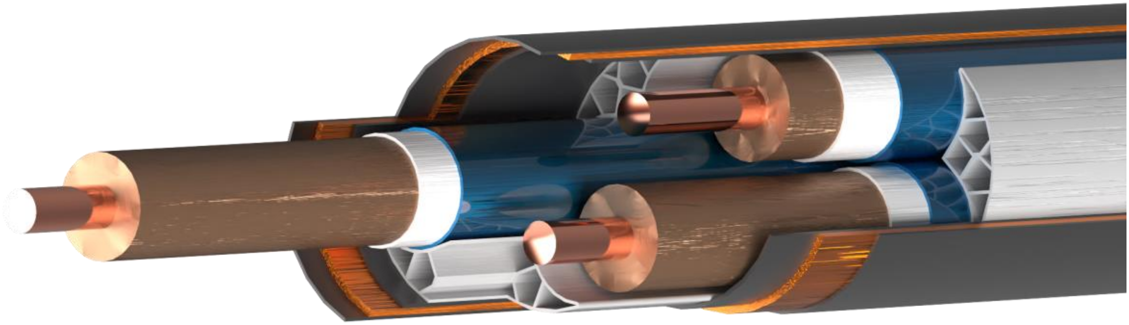
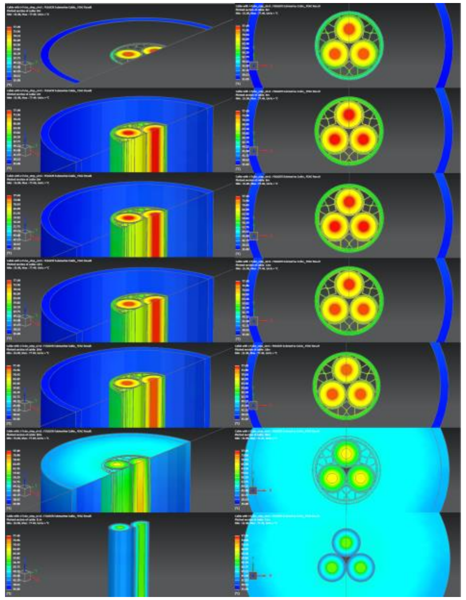
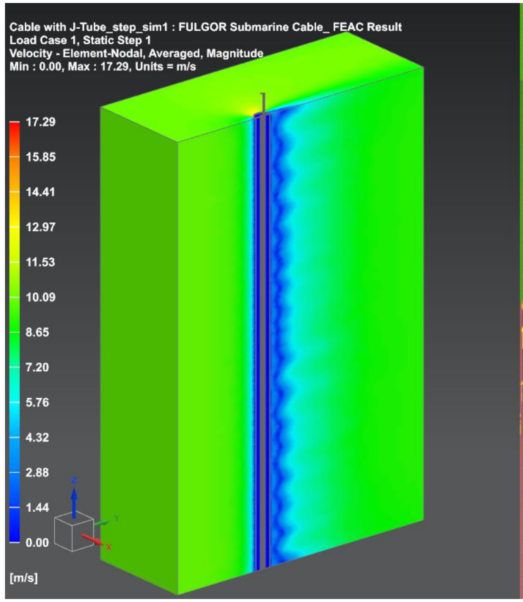
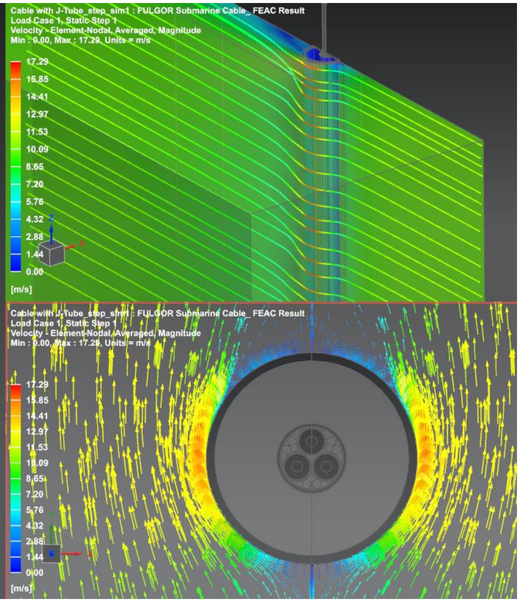




20-m long cable. Heat transfer through Conduction-Convection & Radiation







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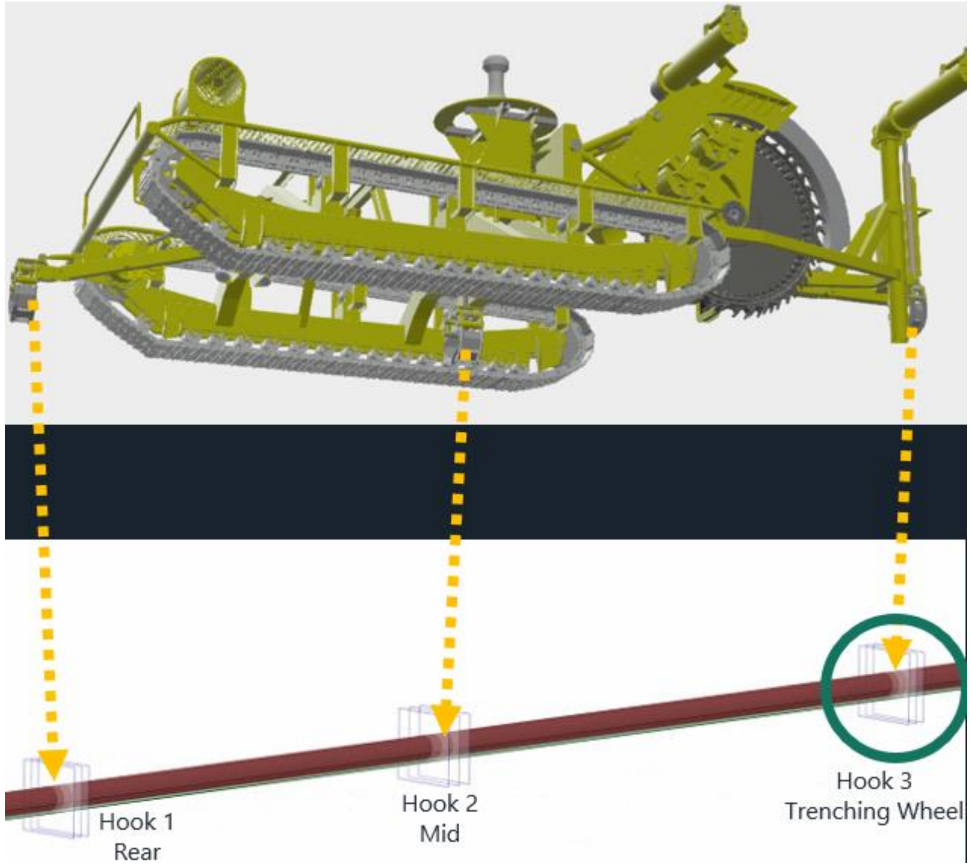
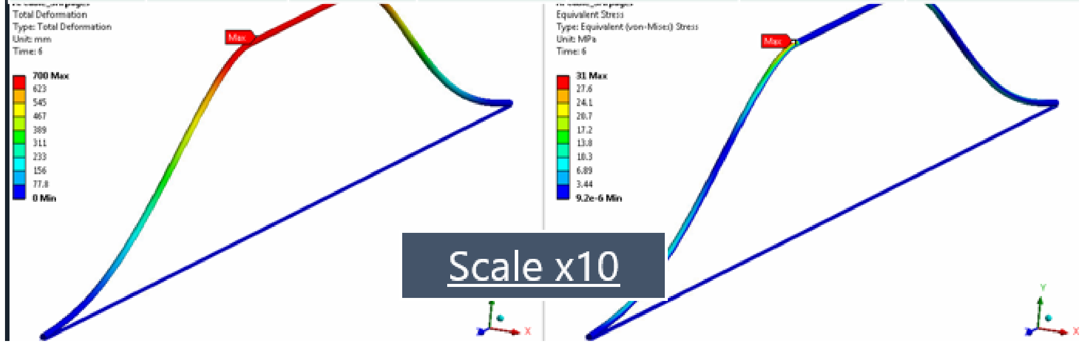


Lifting from 3 Lifting Points:

Pre-tension (per side)	Pre-tension (total)	Lifting	Equivalent Stress	Reaction Force Hook 1 REAR	Reaction Force Hook 2 Mid	Reaction Force Hook 3 TRENCHING WHEEL
0 kN	0 kN	700 mm	30.755 MPa	9160.90 N	2307.03 N	8973.60 N
1.25 kN	2.5 kN	700 mm	30.785 MPa	9160.95 N	2307.035 N	8973.61 N
2.5 kN	5 kN	700 mm	30.815 MPa	9160.97 N	2307.04 N	8973.62 N
5 kN	10 kN	700 mm	30.875 MPa	9161.00 N	2307.05 N	8973.64 N
7.5 kN	15 kN	700 mm	30.936 MPa	9161.10 N	2307.06 N	8973.66 N
10 kN	20 kN	700 mm	30.996 MPa	9161.20 N	2307.07 N	8973.67 N



CONTENT

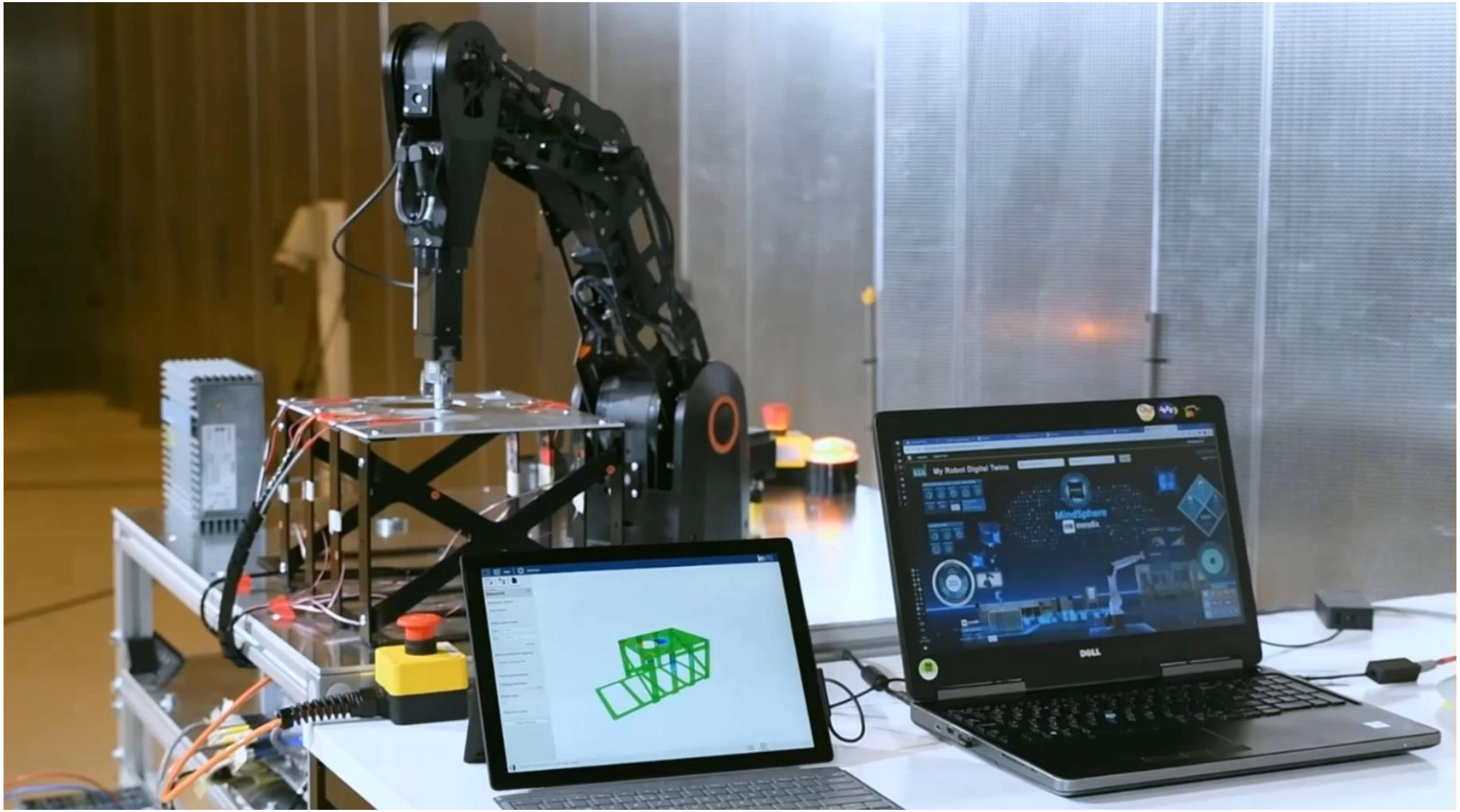
Executable Digital Twins

5. Real-time simulations?

What is an...

Executable (real-time) Digital Twin

Is a virtual representation connected to a physical product or process, used to understand, predict and <u>monitor</u> the physical counterpart’s performance characteristics. It provides simulation results in <u>real-time</u>.



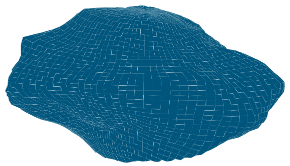
Executable Digital Twin: Definition

Connecting directly **virtual sensors** to Physical assets by **Physics based models**, measuring real sensors and using the data leads to **real time** prediction of quantities that were previously not measurable.

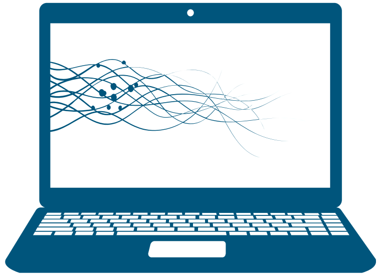
Physical assets

Create and validate

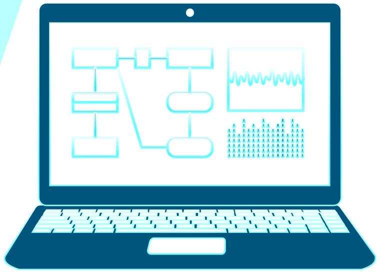
Create xDT Reduced Order Model



3D CAE



3D CFD



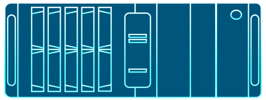
1D

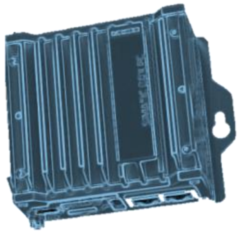
Test and Data driven

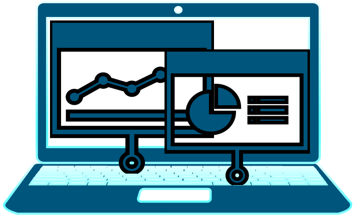
Package and deploy

XDT

Deploy xDT







Product Digital Twin — **Digital Product** *Engineering* — Predict and simulate the designed product

Production Digital Twin — **Digital Production** *Manufacturing/ Operations* — Predict and simulate the planned production line

Performance Digital Twin

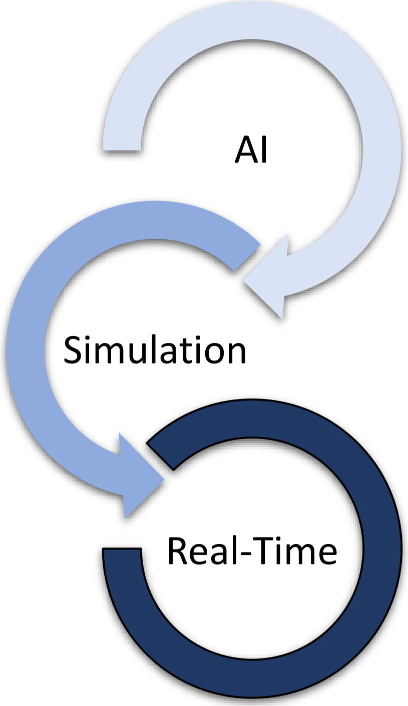
Real Production *Field Execution*
- Validate actual vs. expected
- Acquire real-time simulation data
- Test and monitor live performance

Real Product *Field Execution*
- Validate actual vs. expected
- Acquire real-time simulation data
- Track in-field use and performance

Simulation

Advantages/Disadvantages of Simulation

- (+) Can be explained and reconstructed
- (+) Describe Complex multiscale & multiphysics phenomena
- (-) Costly & Time Consuming
- (-) Only numerical experts can create well accurate simulation models



Artificial Intelligence

Advantages/Disadvantages of AI

- (+) Can be created easily and quickly with sufficient data
- (-) Can not describe accurately the physics of the system
- (-) Difficult to obtain enough training data
- (-) The mathematical context can not be modified by humans

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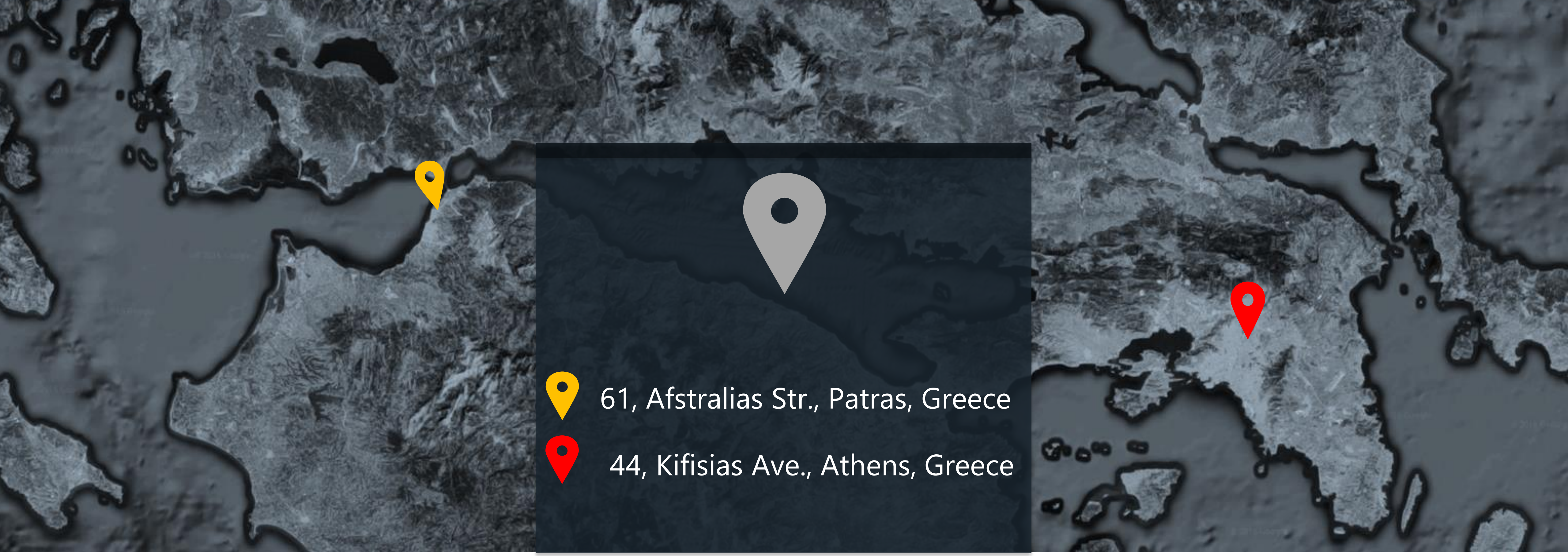

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