



# ACCURATE FATIGUE ASSESSMENT AT ALL DESIGN STAGES APPLICATION TO STAR 1 SEMI-SUB FOWT

WindEurope Annual Event - Floating Structures and Components

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# SAIPEM AT A GLANCE

Saipem is an advanced technological and engineering platform for the design, construction and operation of safe and sustainable complex infrastructure and plants.

Saipem has always been oriented towards technological innovation and is currently committed, alongside its clients, on the frontline of energy transition with increasingly digitalised tools, technologies and processes that were devised from the outset with environmental sustainability in mind.

It is listed on the Milan stock exchange. It operates in over 60 countries around the world with 32 thousand employees from 130 different nationalities.



**7.3 B€**

REVENUE 2020

**> 32,000**

EMPLOYEES

**> 130**

FROM DIFFERENT  
NATIONALITIES

**25 B€**

BACKLOG 2020 FY

**2,660**

ACTIVE PATENTS

# FATIGUE DESIGN: NOT A LATE-STAGE ADJUSTMENT

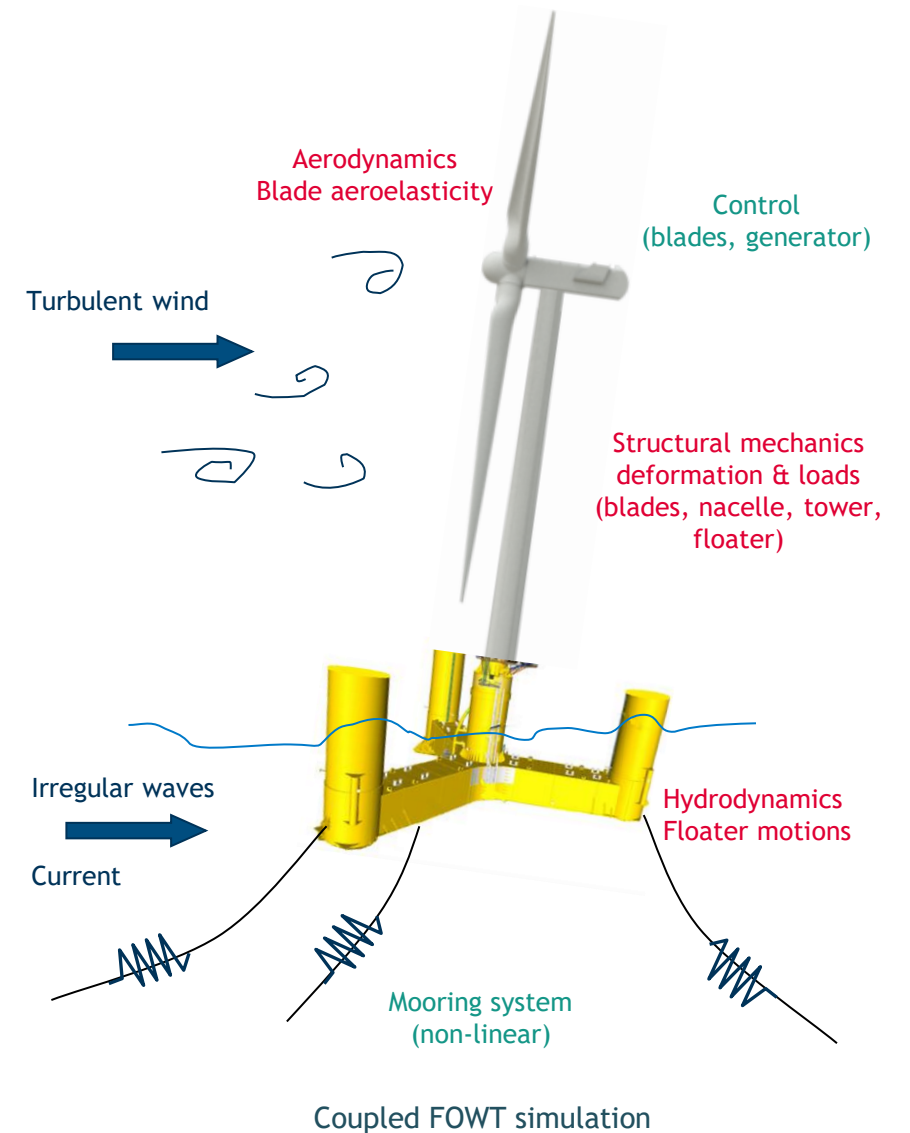
## Why early fatigue assessment?

- Floating wind systems tend to have fatigue-governed parts
- Existence of “vicious cycles” in design
- Can impact structure mass by up to 30%

## Why via coupled simulation?

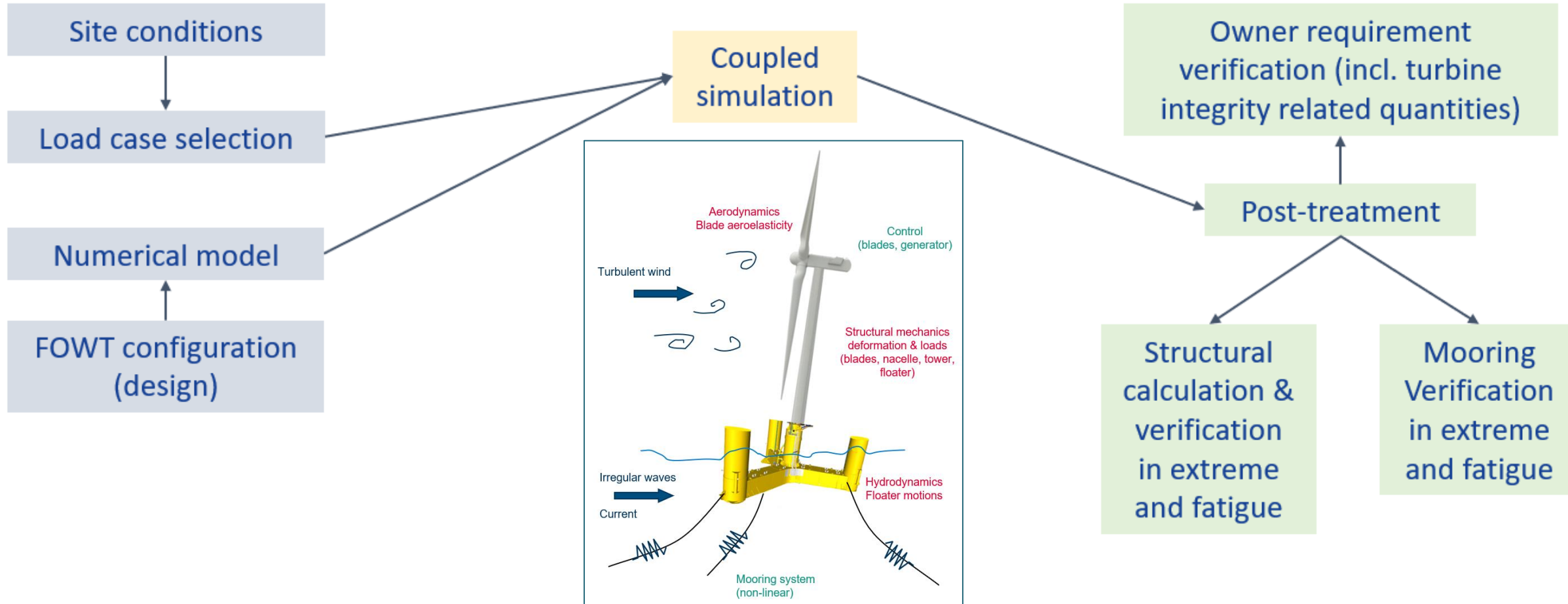
- Cyclic loads are mainly a combination of wave and turbine loads
- The two above components emerge from coupled dynamics

Need for quick tooling chain to afford computing fatigue early on



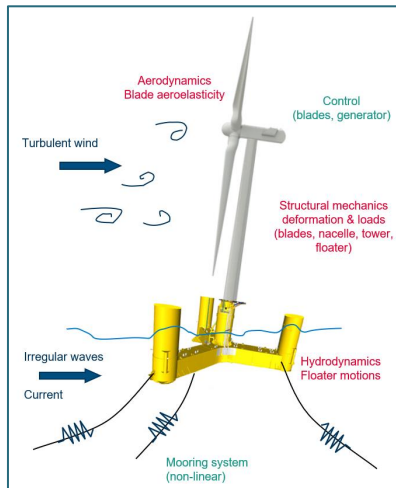
# FATIGUE DESIGN AT ALL STEPS

With Integrated Modular Calculation Chain



# FATIGUE SIMULATION METHODOLOGY

## Coupled simulation



~1000h FLS simulated time  
@ 3P response sampling

Tens of millions time stamps

Output time series

Mooring cyclic loads: conventional ✓

## Structural cyclic loads:

- Local stress time history needed
  - *Commercial FEM workbenches computationally heavy for early phases* ✗
- ↓
- In-house integrated solution **Genesea**:
    - Since 2014: qualified ✓
    - Efficient calculation chain ✓
    - Proven also with turbine OEM coupled runs ✓

~ 100 Times more efficient than standard software chain  
**Viable since early phases**

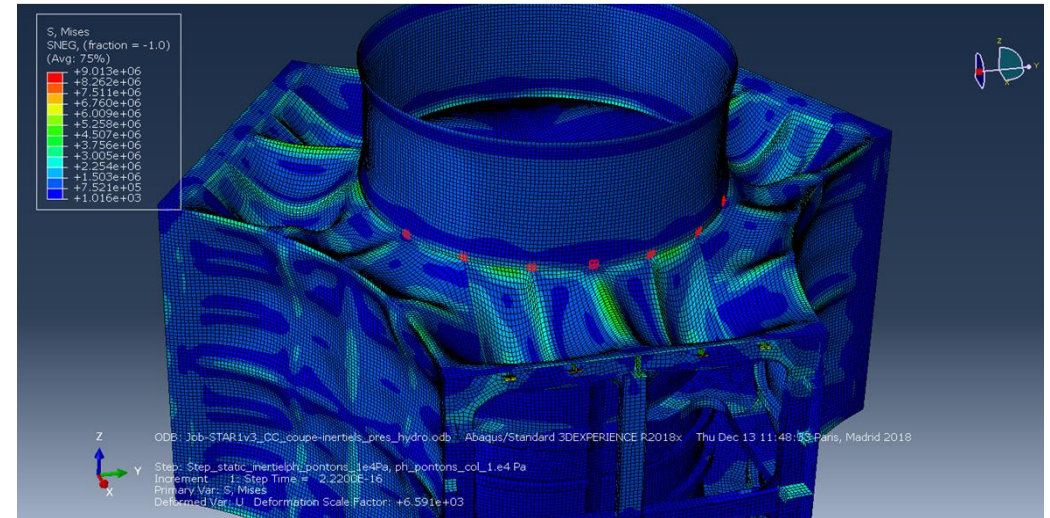


## Enabled by segmented model:

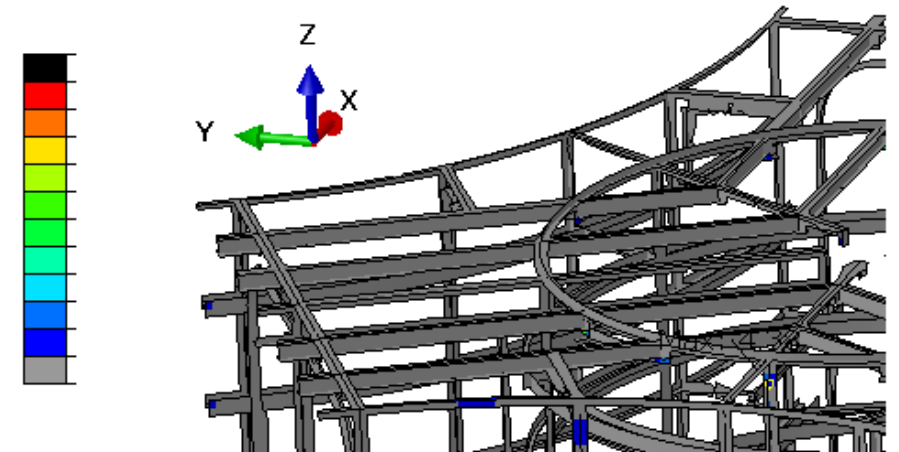
- Full Morison, DNV-validated approach
- Structural beams integrated in the Load Analysis step
- Output: internal loading

# STRUCTURAL FATIGUE DESIGN & VERIFICATION

- Considering fatigue in the design:
  - Time-domain fatigue structural analysis required
  
- Beam model completed by connections local sub-models
  - Advanced “stress intensification factors” (SIF) to decouple local and global analysis



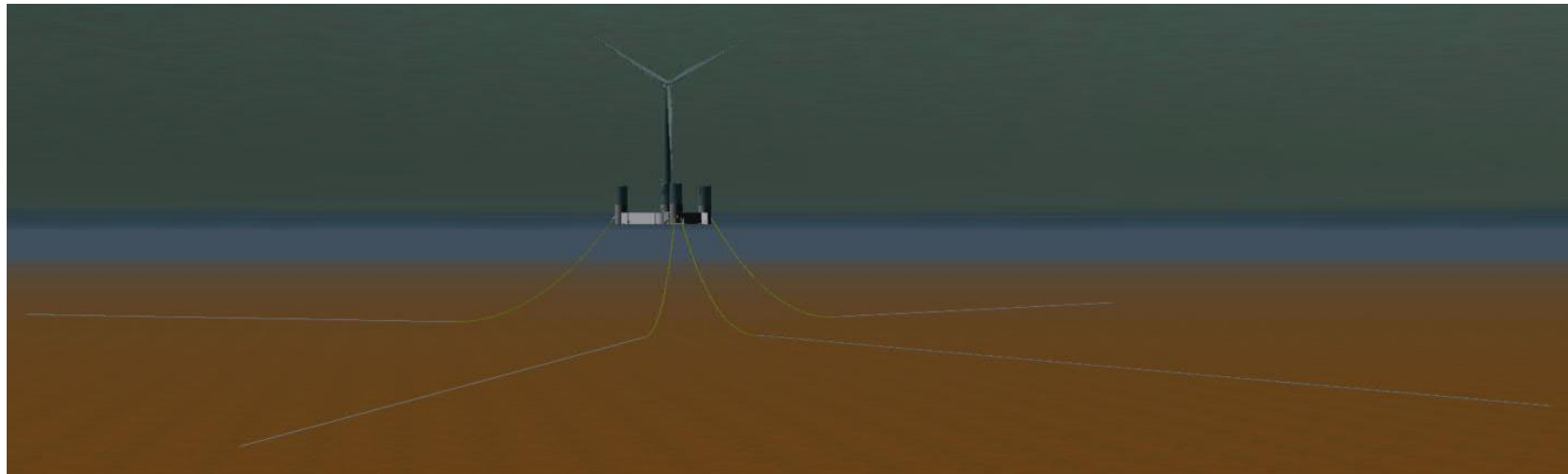
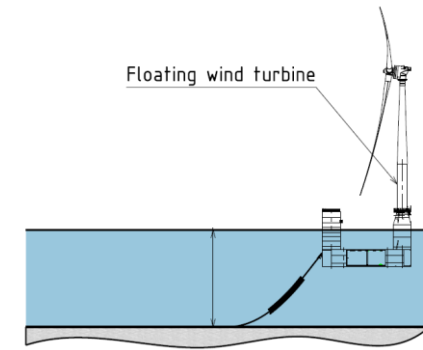
Allowing to deal with thousands of DLCs on all welds



# MOORING FATIGUE DESIGN & VERIFICATION

Methodologies and design developed from experience to consider specificities of mooring design for FOWT:

- Fatigue from WTG 3P
- Possible low / very-low depth situation
- Time-domain only
- Cost constraints / multiple floaters



# STAR 1 SEMI-SUBMERSIBLE SOLUTION

## Application Case

- Fatigue integrated in the design from early stage: e.g. transition piece, central column, connections...
- Successful convergence of fatigue and extreme design, acquiring **DNV Preliminary Design certification**
- Ready for turbine OEM interface: global behavior, frequency behavior...
- “ILA-based” design adaptation on a new project in 2 months



# CONCLUSIONS (1)

## For a de-risked project:

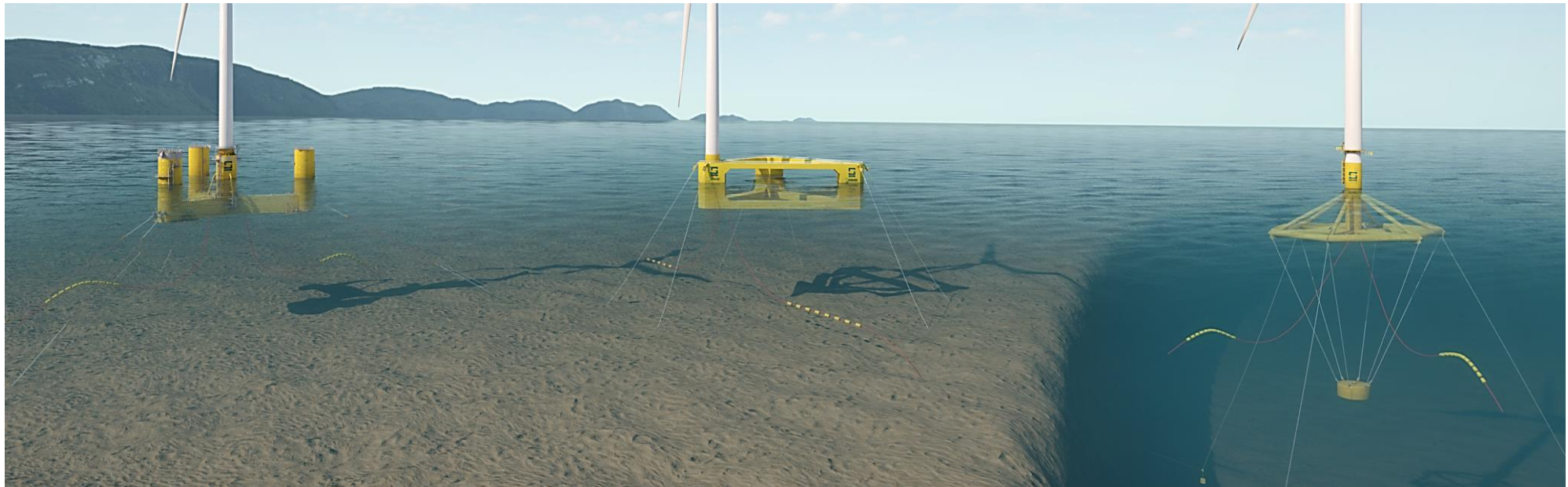
- Unlike for Oil & Gas, in FOWT engineering fatigue must be addressed at earliest stage  
**Impact on floater mass + WTG integration**
- Time-domain coupled simulation is the primary source of reliable fatigue data
- Organizing early WTG OEM involvement is key for fatigue design convergence

**Answered by SAIPEM's proven in-house software solutions**

## CONCLUSIONS (2)

### SAIPEM's floating solutions stem from presented methodology:

- STAR 1 and other concepts designed with fatigue in mind, expressly for harsh oceanic sites
- Robust mooring design (even for low-depth sites < 100m) without recurring to unconventional mooring components
- Avoidance of fatigue “vicious cycles”
- Track record at multi-MW scale with two major WTG OEMs: tens of thousands of coupled simulations, all post-treated down to local loads





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