SINTEF RESEARCH ON OFFSHORE WIND

Øyvind Hellan, VP Research, SINTEF Ocean

Scandinavia's largest independent research organization

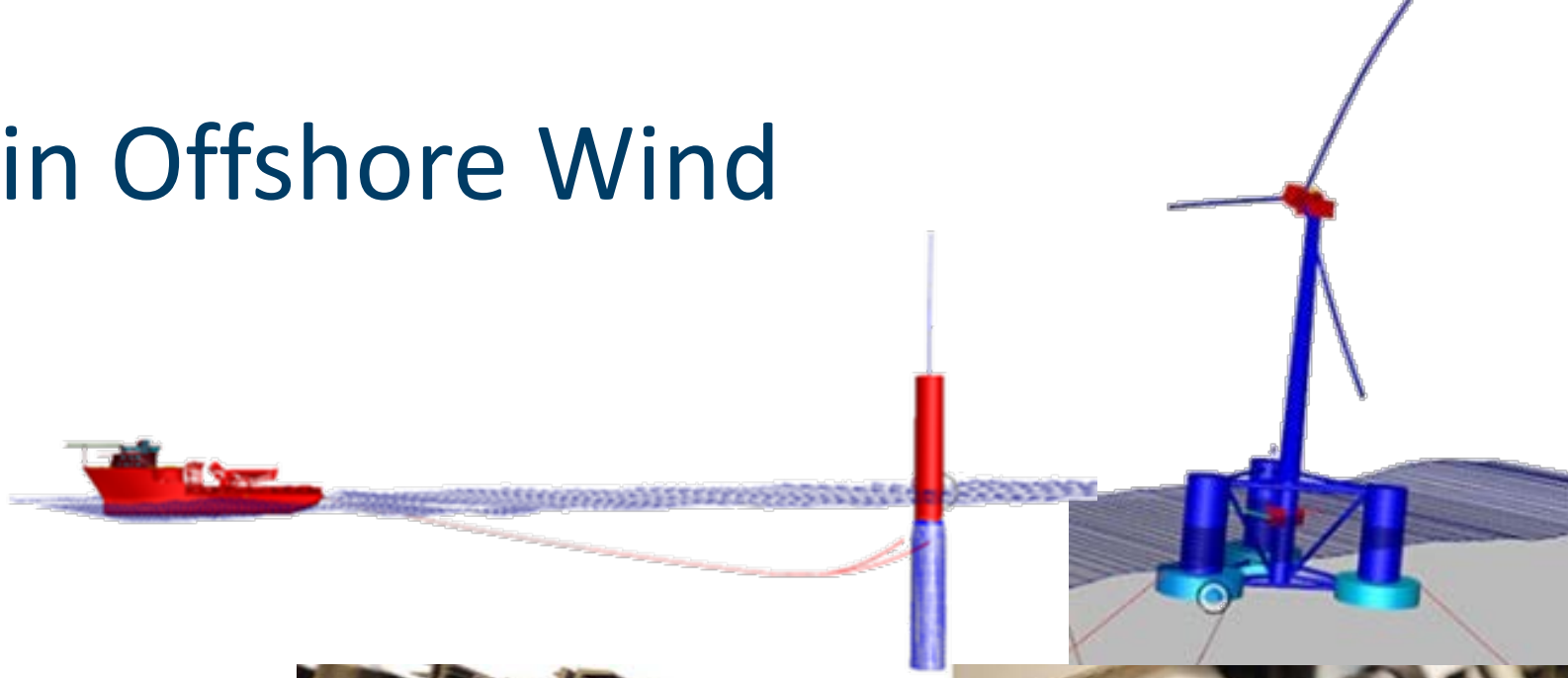
NOK 3,2 billion
Revenues

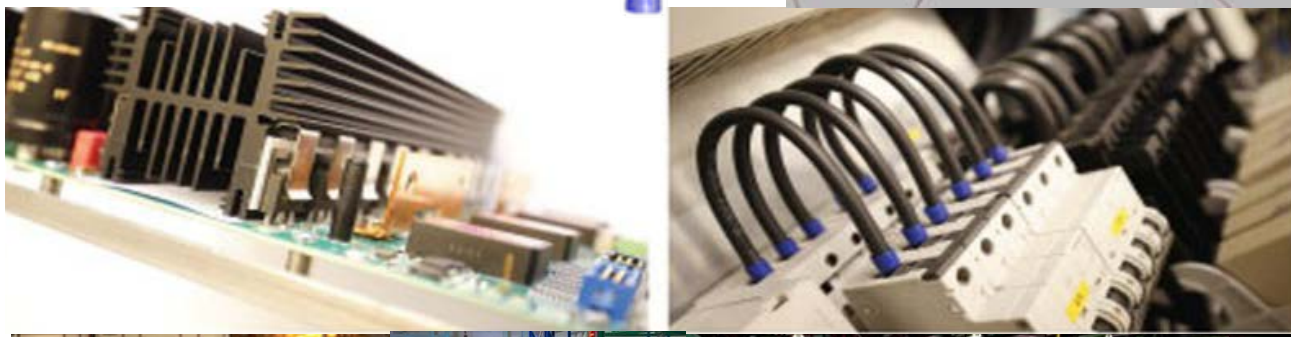
NOK 500 MILL
International sales

SINTEF

SINTEF research in Offshore Wind

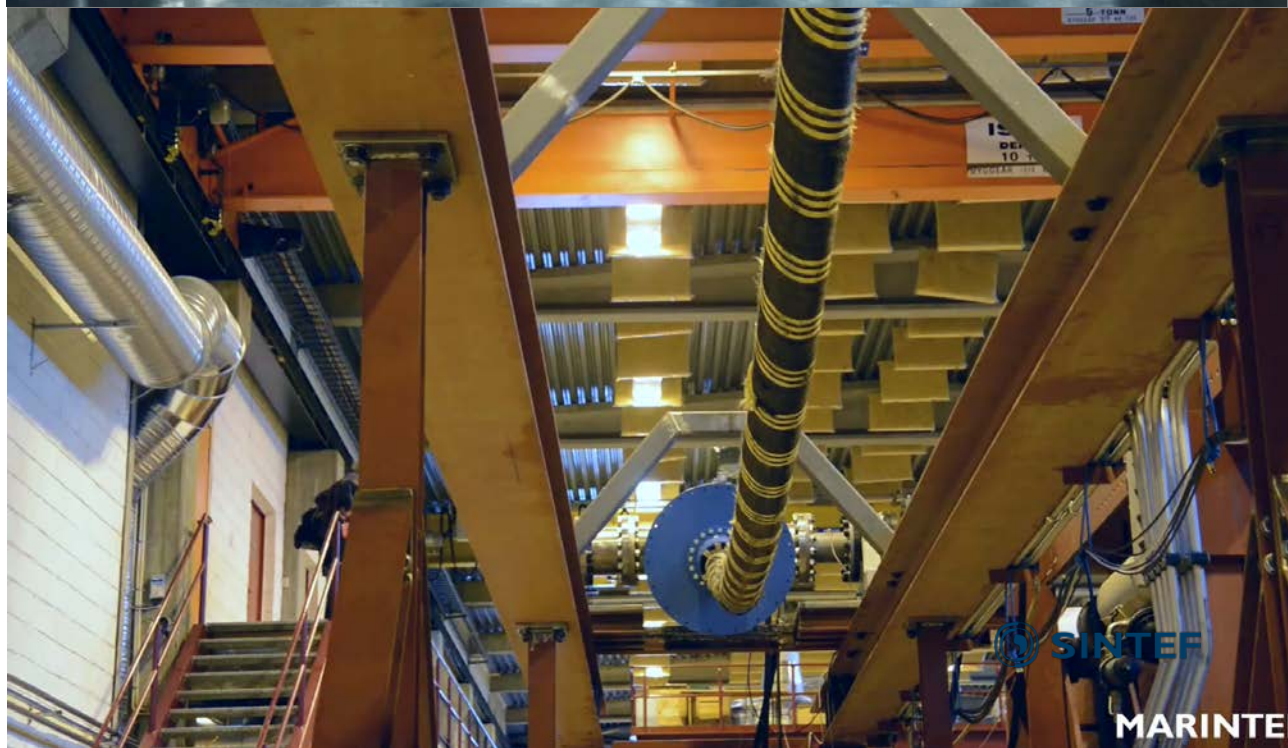
- Substructures
- Control systems
- Grid connection
- Logistics, O&M
- Marine operations
- Materials





We operate some of the world's most advanced energy and marine technology laboratoeries

- Ocean Basin
- Wind Tunnel
- Power cable and risers' lab
- Smart Grid lab
- Material labs



We work in close partnership with NTNU

- Strategic and operational cooperation since 1950
- Joint use of laboratories and equipment
- Cooperation covers research projects, research centers and teaching

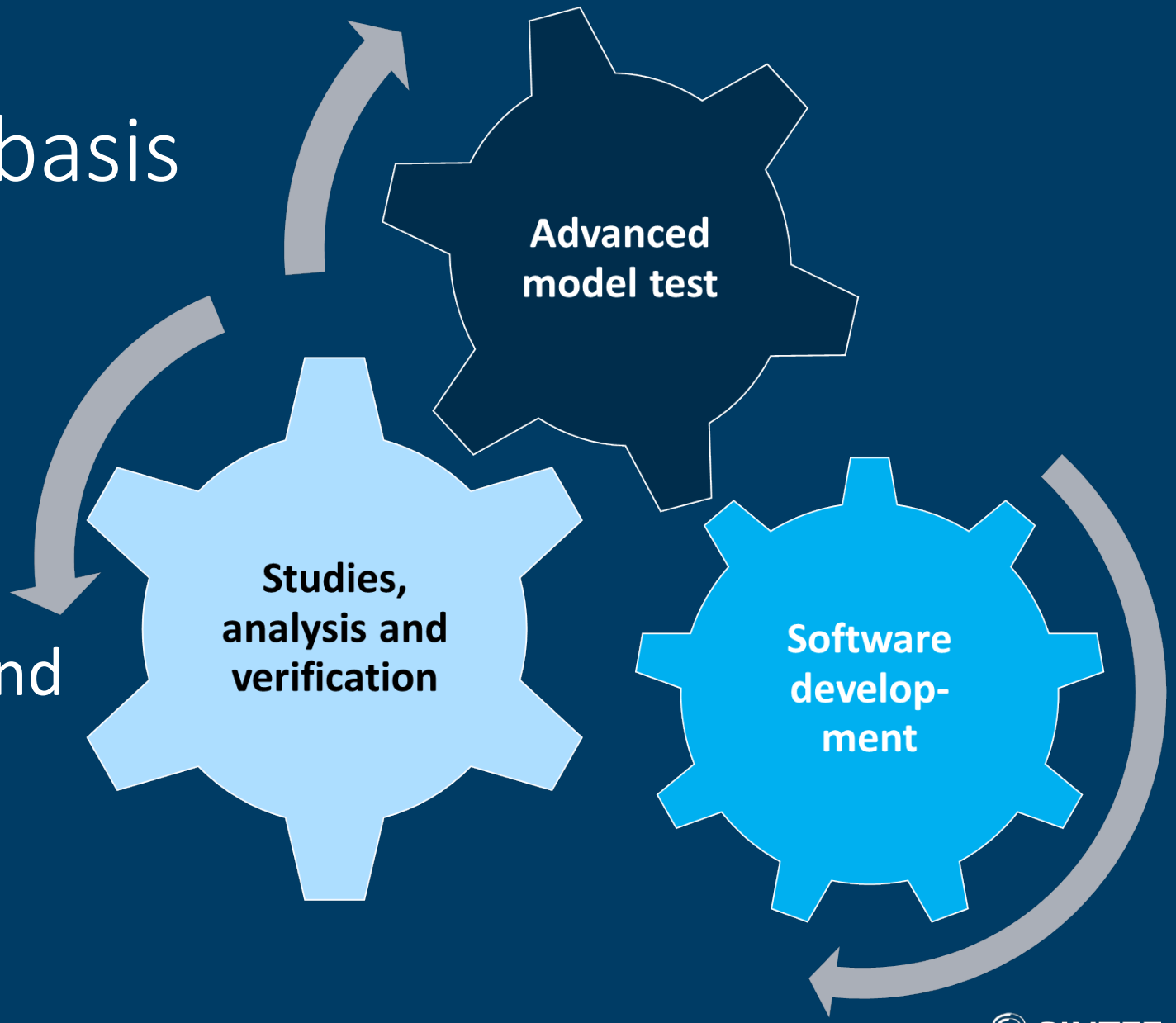
SINTEF

The largest marine technology research and education centre in the western world

- Graduating 120-140 M.Sc,. and 15-20 Ph.D. every year within marine technology.
- Hosting two successive *centres of excellence in* Norway.
- Hosting four successive *centres of research-based innovation* in Norway

Our fundamental basis

We offer a
unique combination of
world-class laboratories,
software development and
engineering competence



SINTEF

A strong portfolio of R&D projects

H2020

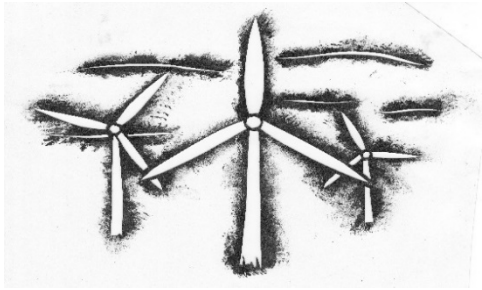
- Lifes50+ (2015-2018)
- BestPaths
- TotalControl

EU FP7:

- DeepWind (2010-2014)
- LEANWIND (2013-2016)

Norwegian Research Council

- WAS-XL (2017 – 2020)
- HVDCpro
- OPWIND
- WindSense (2012-2014)
- FAROFF (2012-2014)
- Deep sea offshore wind turbine technology (2007-2009)
- NOWITECH (2009-2017)



Advanced software for offshore wind

Workflow

SIMA – Analysis of Marine operations and Floating systems
ShipX – Integrated tool for ship design

Marine operations

SIMO – Simulation of marine operations

Platform loads and responses, mooring system analysis

MULDIF – Hydrodynamic analysis
SIMO – Floater motion and station keeping
RIFLEX – Global FEM analysis of slender structures
SIMO/RIFLEX – Coupled floater and mooring analysis
NIRWANA – Structural analysis of fixed platforms
MIMOSA – A mooring system analysis tool
WINDOPT – Optimization tool for FOWT

Power Cable

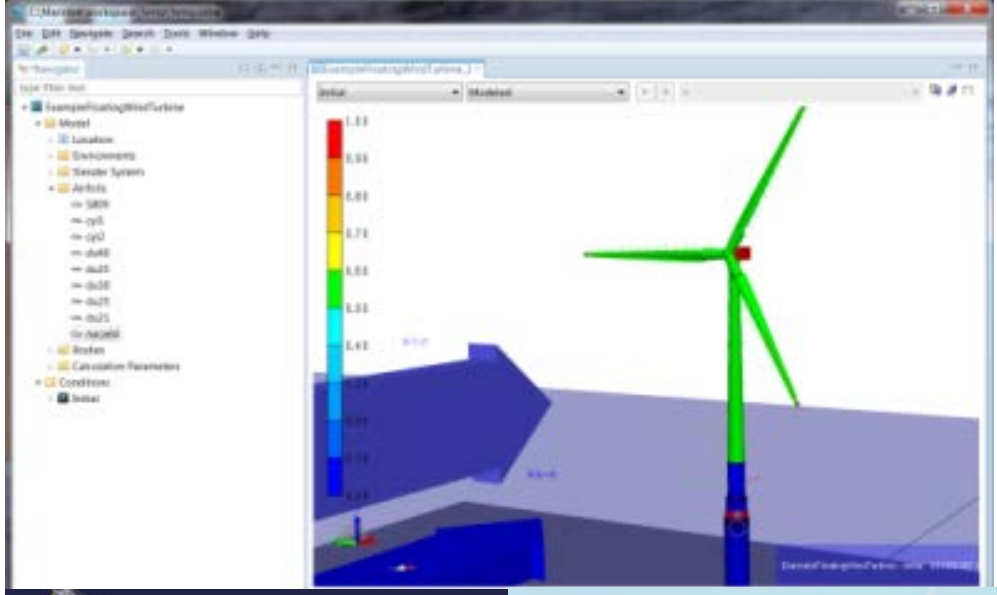
UFLEX2D – Local stress and fatigue analysis of subsea power cables
UFLEX3D – 3D stress and fatigue analysis of subsea power cables
SIMLA – Offshore power cable route optimization and installation analysis
VIVANA – Vortex induced vibrations

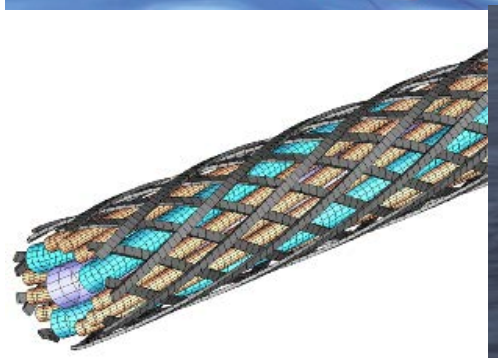
Vessel performance

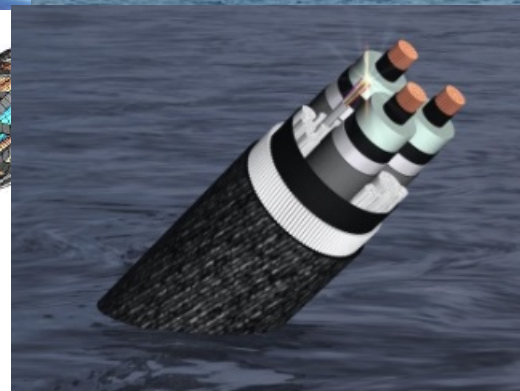
ShipX/VERES – Sea keeping and ship performance

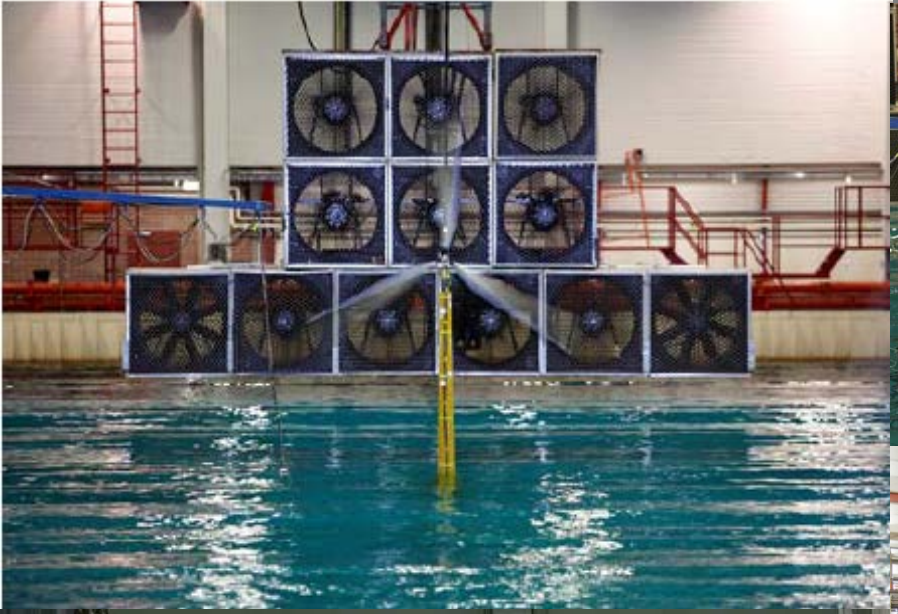
Vessel fleet optimization

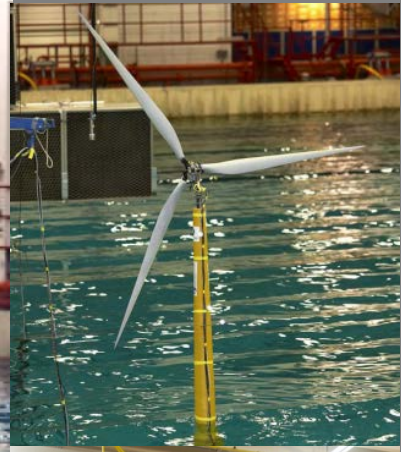
Routing and scheduling model of maintenance operations on an offshore wind farm
Vessel fleet size and mix optimization model

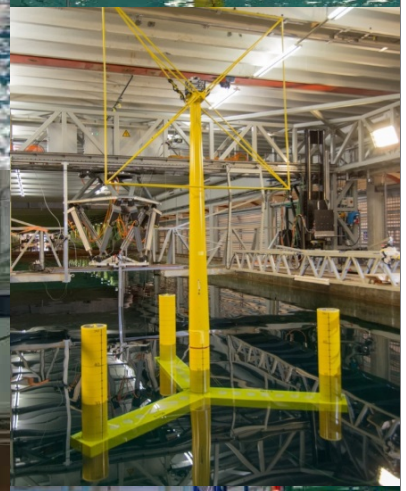


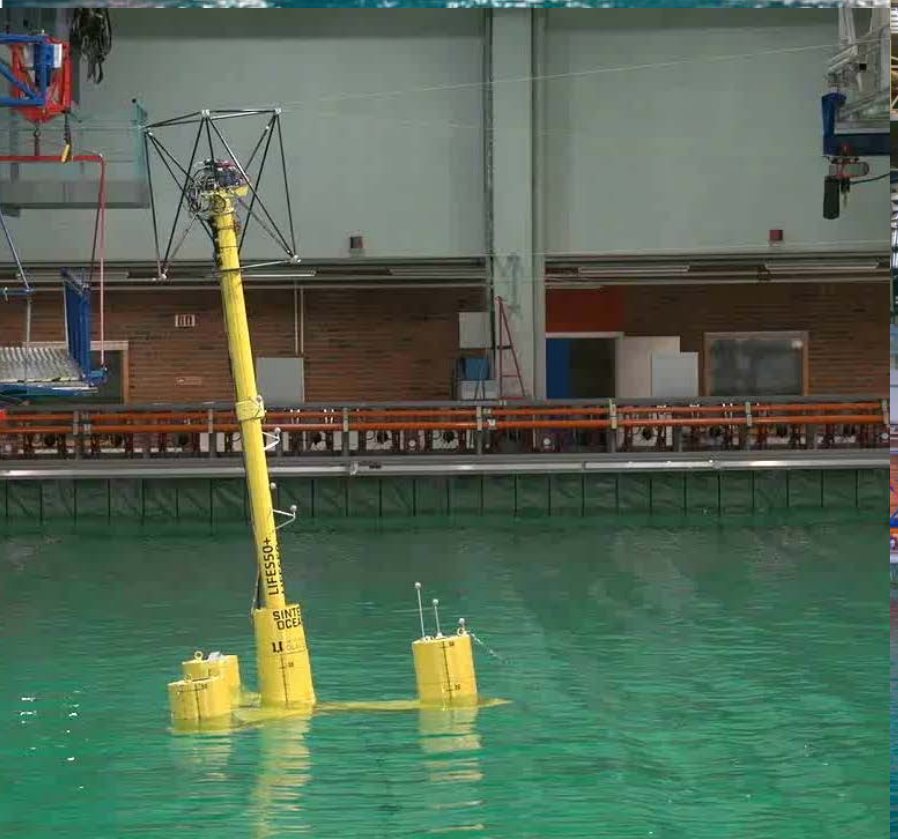


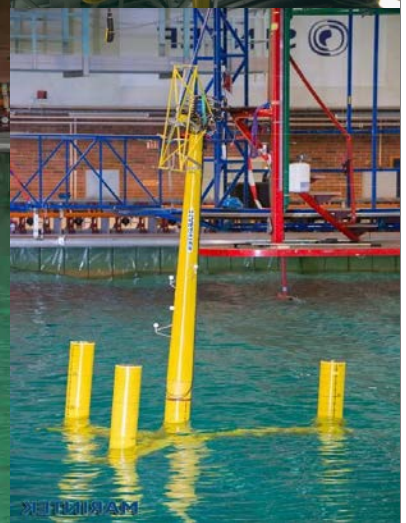












Advanced model testing for offshore wind

Hybrid testing
(hardware-in-loop testing)

Integrated testing / verification of

- Control system
- Sub-structure
- Wind
- Waves
- Current
- Soil

SINTEF

”Excellence in the science base is not enough.

It is essential to have the capacity to translate knowledge into new products, processes and services.”

From ”Life Sciences and Biotechnology.
A strategy for Europe”

SINTEF

Specific projects / concept development

SPAR

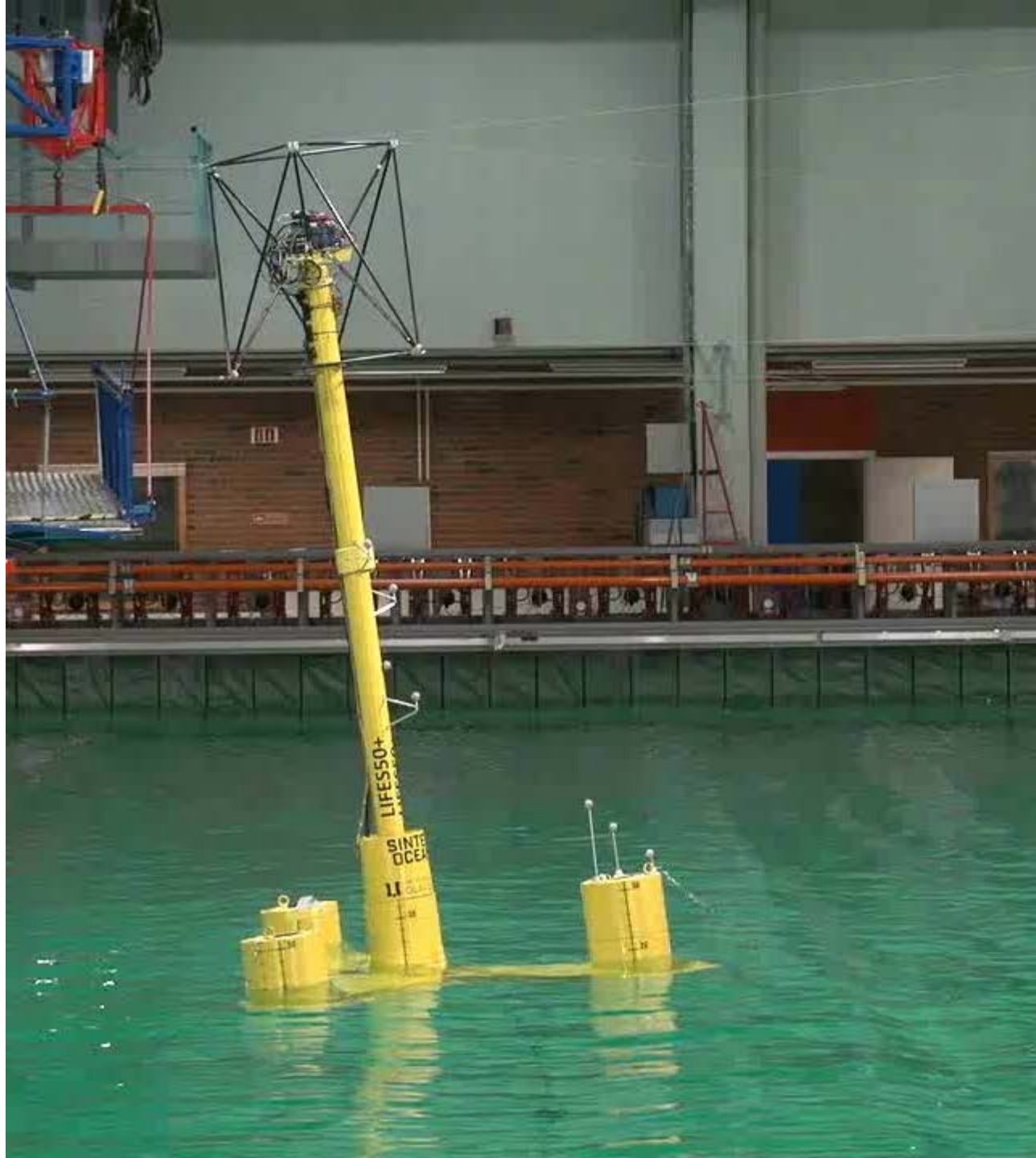
- **HyWind Demo**
- **HyWind Scottland**

SEMI

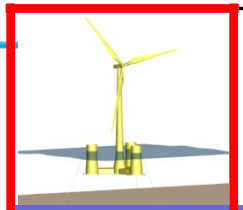
- NOWITECH semi
- OO Star
- Nautilus

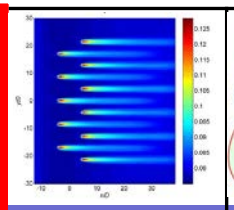
Mono-piles

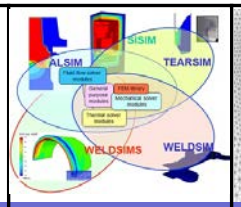
- Borssele
- **Dudgeon** 7 m O.D.
- NREL 5 MW concept 7 m O.D.
- DTU 10 MW concept 9, 11 m O.D.



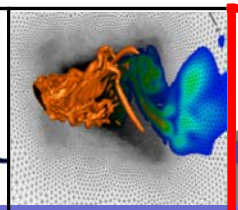
NOWITECH: 40 innovations, 3 commercial spin-offs, Net present value > 5 000 MEUR*

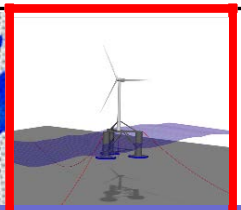

3Dfloat integrated model *TRL7*

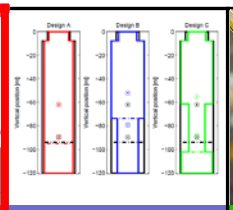

3DWind park wake model *TRL6*



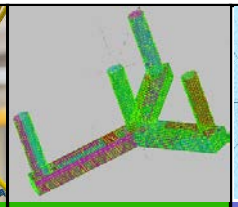
INVALS general purpose optimization *TRL8*

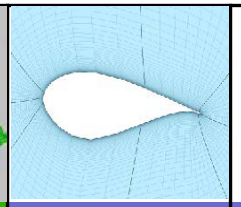

Commercial grade rotor CFD *TRL5*


SIMO-RIFLEX *TRL7*


WindOpt *TRL4*


Real time hybrid model test in ocean basin *TRL5*

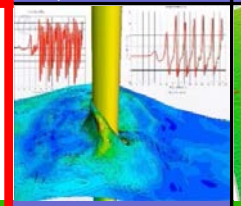

Novel floater *TRL5*

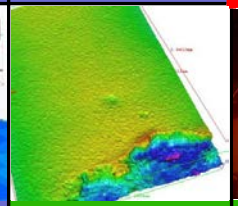

Variational Multiscale Error Estimator *TRL3*


www.IFEM.no *TRL3*


ASHES (SIMIS AS) www.ashes.no *TRL7*

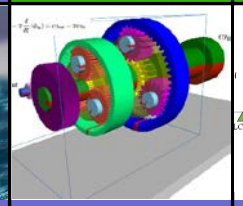

Seawatch Wind Lidar Buoy *TRL9*

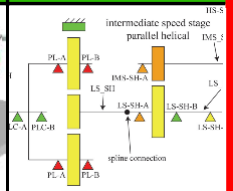

CFD simulation *TRL5*


Droplet erosion resistant blade coatings *TRL3*

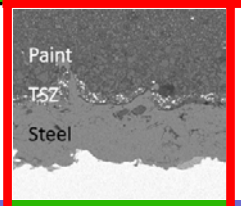

Droplet erosion testing *TRL5*


Fleet optimization *TRL5*

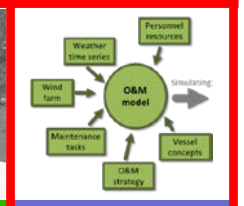

Gearbox fault detection *TRL3*



Gearbox vulnerability map *TRL3*

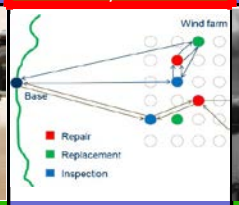


Dual layer corrosion protection coatings *TRL5*



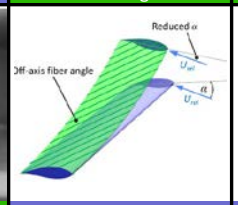
NOWIcob *TRL6*


REACT/Remote Presence (www.emip.no) *TRL5*

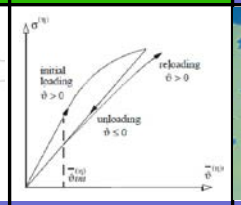


Routing and scheduling *TRL2*


Thermally sprayed SiC coatings *TRL5*



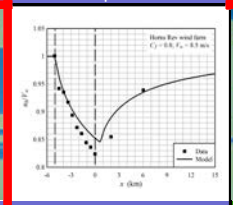
Buckling resistant blades *TRL3*



Fatigue damage simulation *TRL4*

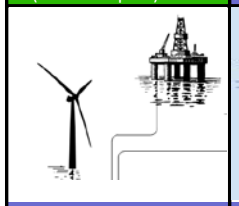
PSST Power System Simulation *TRL5*

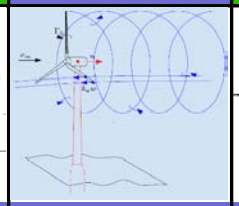
NetOp network optimization *TRL4*

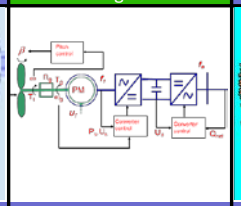

Viper Estimate Energy Output from OWF *TRL4*

Smartgrid Lab HVDC grid *TRL4*

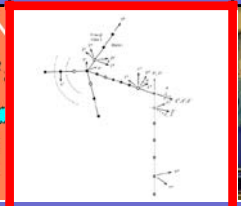
Control of multi-terminal HVDC grid *TRL4*


Wind Supply to Oil & Gas *TRL3*


Turbine control *TRL3*

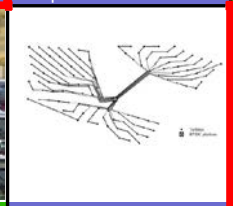

Wind turbine electrical interaction *TRL4*

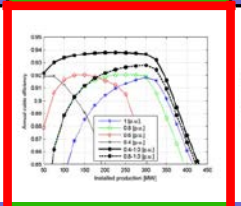

Network Reduction *TRL3*

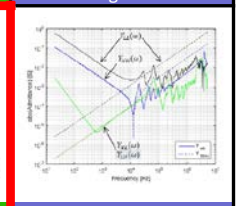

STAS Linear State-Space W.P. Plant Analysis *TRL4*


PM generator magnetic vibrations *TRL4*


PM generator integrated design *TRL3*


Wind farm collection grid optimization *TRL2*

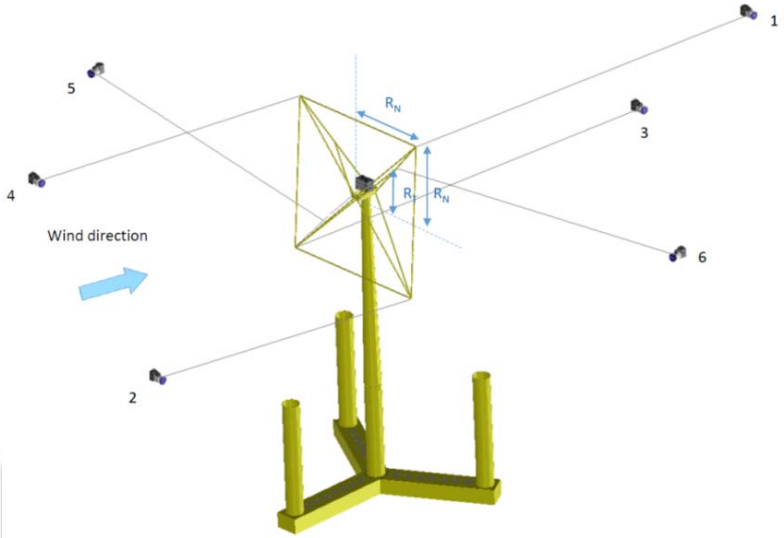

Long distance AC transmission *TRL3*

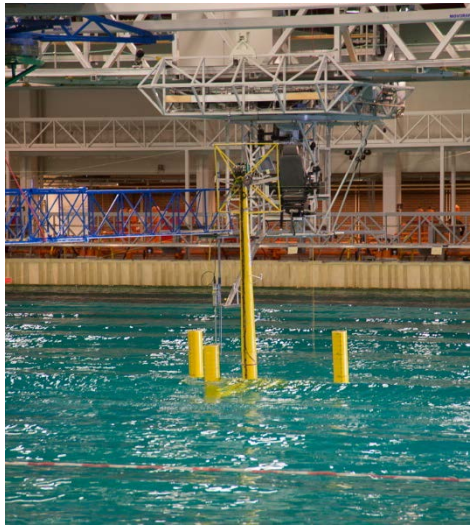

Wideband model of wind farm collection grid *TRL2*

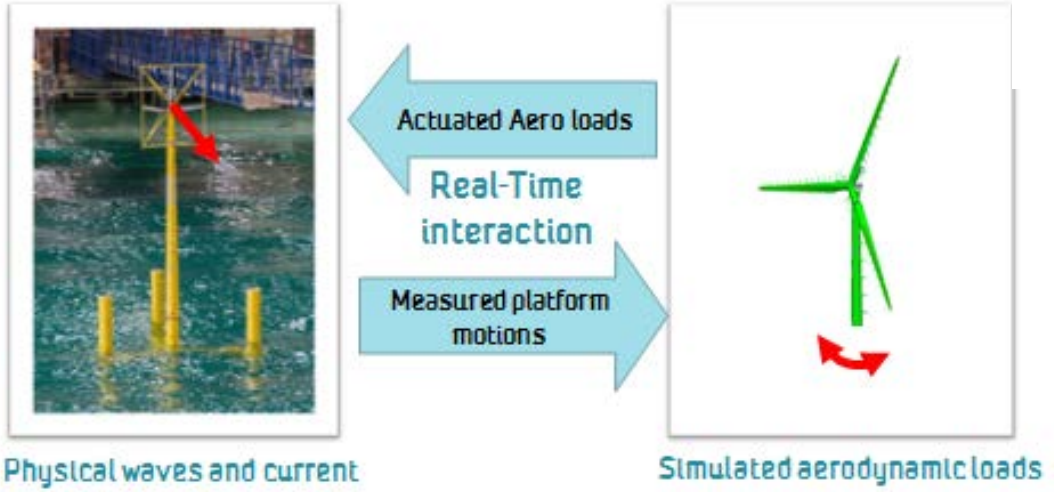
SINTEF Ocean Innovation example:
- cutting edge testing capability: real-time hybrid testing

Testing offshore wind turbines is challenging due to conflicts in scaling laws:

Wind loads scales differently than wave loads







SINTEF Ocean together with NTNU have developed a new method for testing offshore wind turbines:

Combine experiments with real time simulation

SINTEF

Real-Time Hybrid Model (ReaTHM®) testing

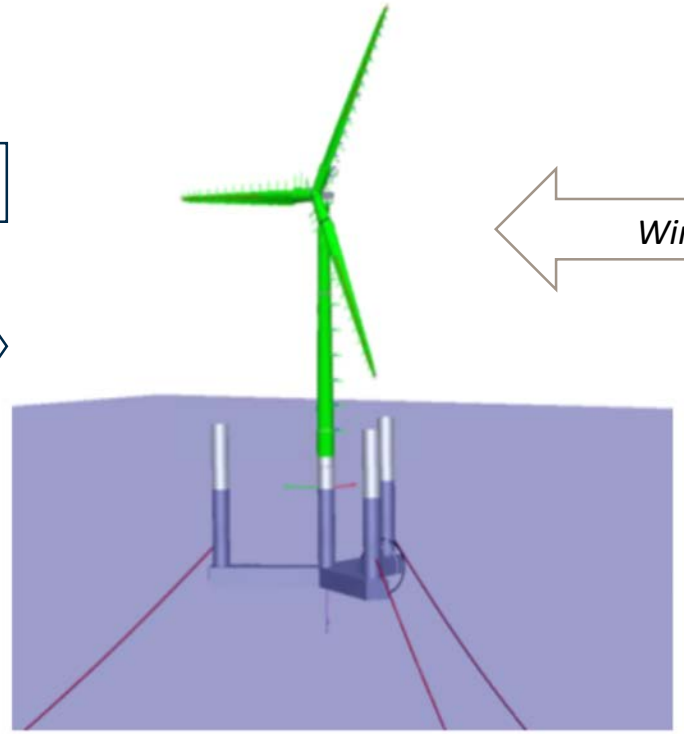
Model testing
(Ocean Basin)

Waves & current

Actuated rotor **loads**

Measured platform **motions**

Aero simulation
(NREL's FAST code)



Wind

SINTEF

Advantages of ReaTHM® testing

- Realistic and **controlled** aerodynamic loads
  - Direct access to complete platform dynamics, power takeout, etc…
  - Facilitates calibration of hydrodynamic. models
- Possibility to test extreme conditions
  - Extreme environmental conditions
    - coherent wind gusts
    - wind shifts
    - wind-wave misalignement
- Emergency shutdown and associated transients

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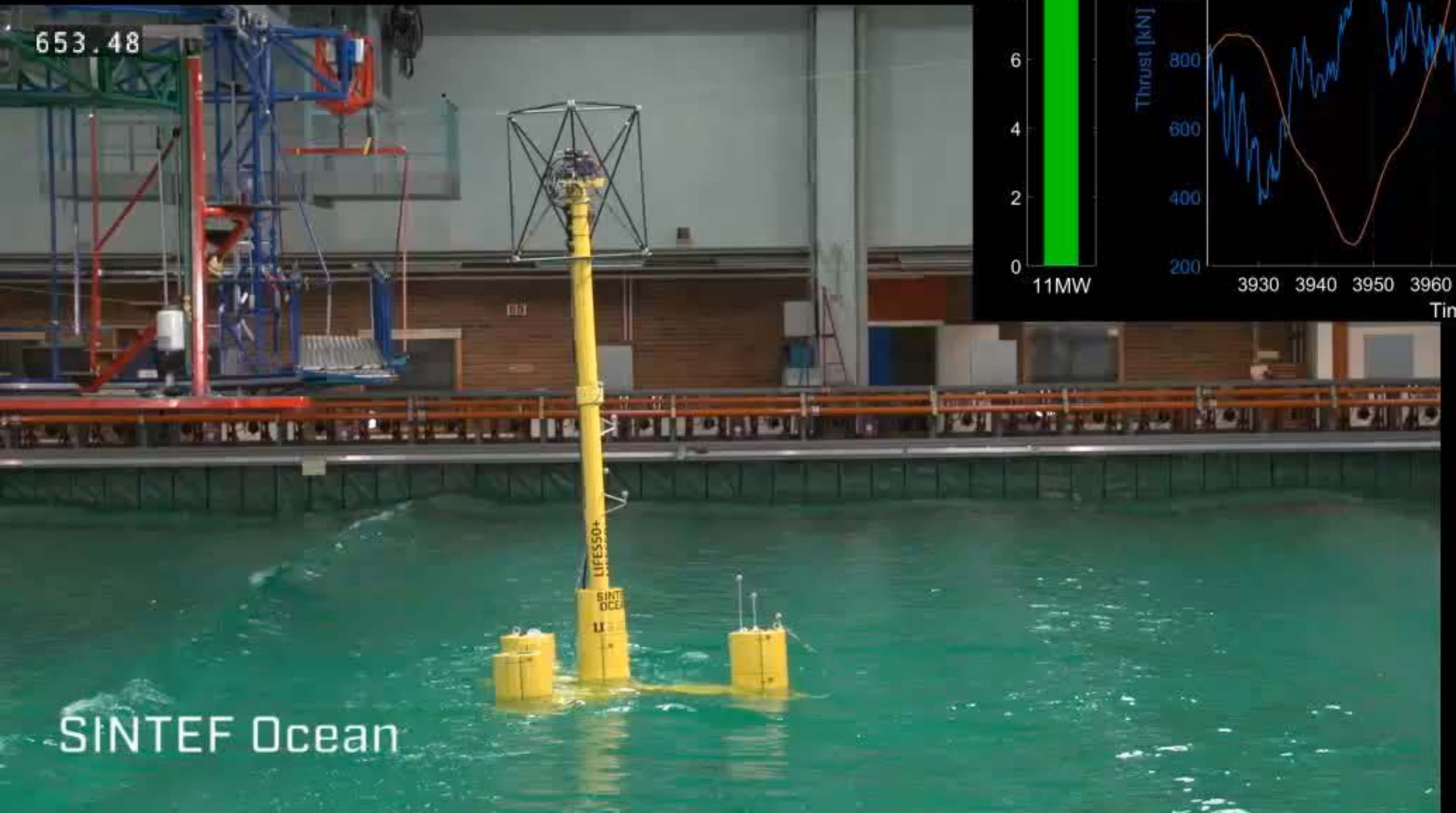
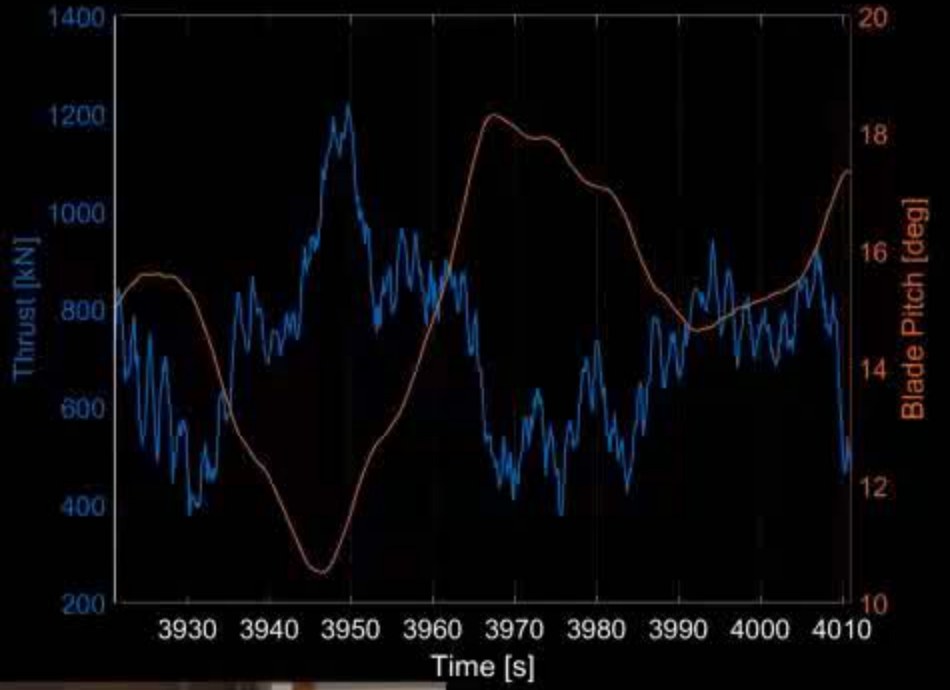
Real-Time Hybrid Model test with

Turbine in operating condition

IRR Wave H10.9m T15s - Wind NTM 18m/s

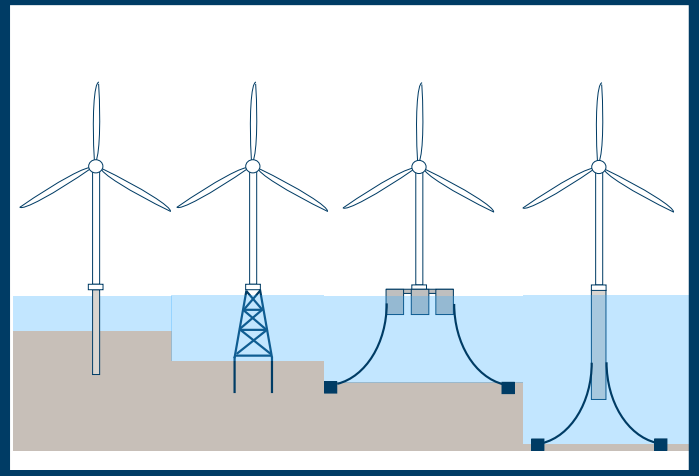




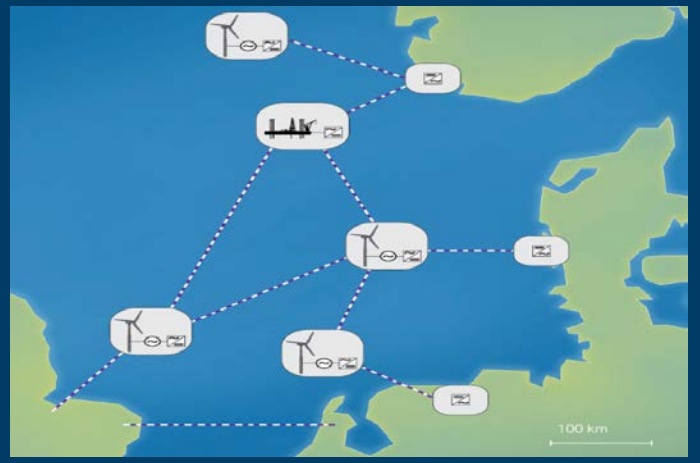
LIFES50+

DR. TECHN. OLAV OLSEN

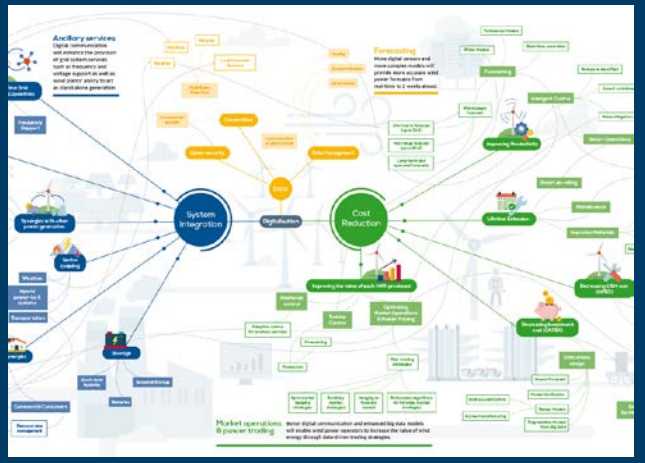
Further research priorities



- Support structures for larger turbines and/or deeper water
- Marine operations
- Materials



- Grid connection
- System integration
- Energy storage



- Asset management
- Wind farm control
- Digitalization

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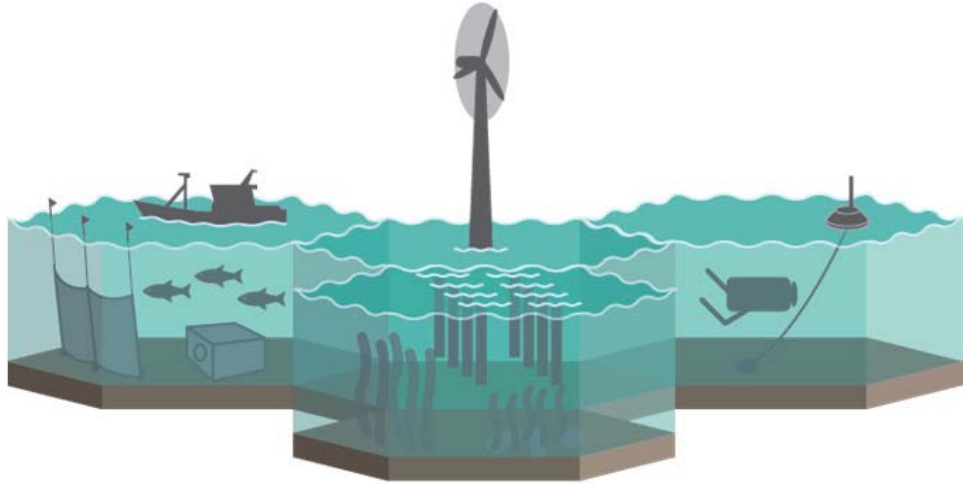
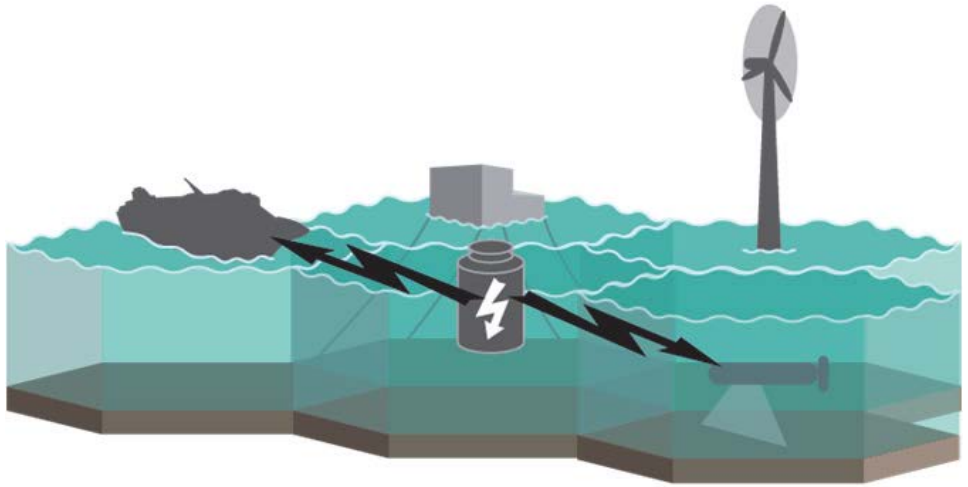
Blue sky outlook…

- New turbine / structure concepts
- Alternative methods for installation (and decommissioning?)
- Multi-use of ocean space (access to new areas ⇨ new operational models & Logistics)
- Offshore charging from renewable energy (mobile and stationary offshore users).
- Data analytics for asset optimization (energy opt. and maintenance).





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Technology for a better society