R&D Webinar - AFOSS-DC Project Outcomes

Designing the electrical substations of the future

With the financial support of:

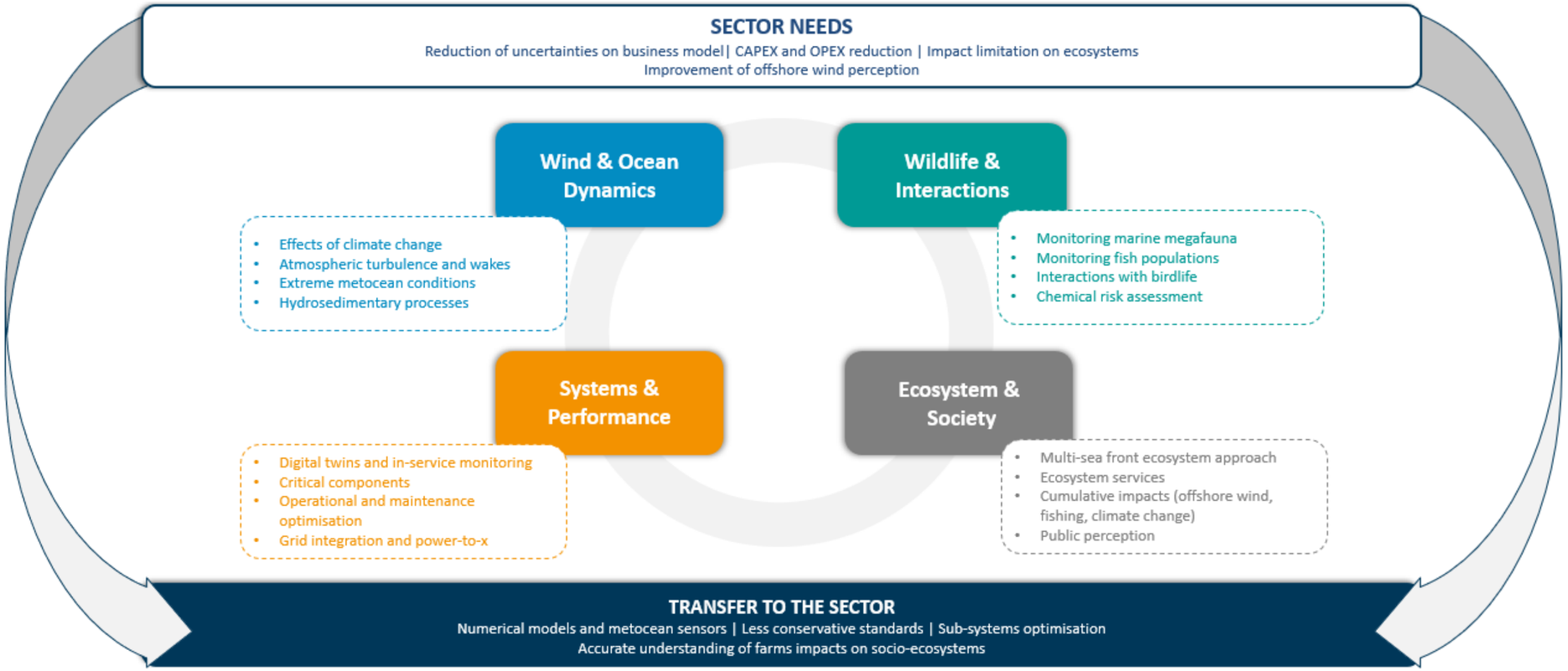
Using TLP technology for Floating Offshore Sub-Station : feedback on design and basin test campaign

Agenda

- Presentation of France Energies Marines
- TLP concept : reminder of the technology and potential advantages for FOSS
- Design : specification and results
- Basin test campaign
- Conclusion / outcomes

France Energies Marines

- FEM (France Energy Marine) is the French Research and Innovation Institute dedicated to Offshore Wind.



TLP concept

TLP concept : Potential advantages and drawbacks for FOSS

- TLP means *Tension-leg Platform.*

Comparatively to *Semi-submersible* platform, the « mooring » lines called **tether/tendons** are vertically moored.

Here are the potential advantages/drawbacks of such a technology :

- **Advantages** :
  - Reduce vertical movements (and maybe accelerations ?) which can be beneficial for both electrical equipments and cables
- **Drawbacks** :
  - Nonlinear effects (springing/ringing) to be taken into account
  - Installation might be more complicated than other technology

TLP Design

Design objectives and floater specification

- **Main objectives** of this TLP design work :
  - Provide a **basic design** which can be validated early to start the scale model construction for the basin tests
  - Satisfy the design criteria with comfortable margin, given the early stage and associated hypothesis

- **Environmental conditions** :
  - 3 water depths : **400 m (base case),** 150 m and 1000 m
  - **100-yrp wave data (Atlantic coast)**
  - 100-yrp wind speed @10 m
  - 10-yrp surface current speed

- Main **design criteria** :
  - Adapt to topside mass and dimensions
  - Maximum dimension to ease construction and installation
  - **Positive airgap** during any lifecycle phase and keel emergence superior to 3m
  - Stability requirements following DNV-OS-C301 (for free floating phase) and DNV-OS-C205
  - Maximum acceleration levels (for electrical equipment) and horizontal offset (for cables)

	Maximum dimensions
Maximum Length	200 m
Maximum Width	58 m
Maximum Height	66 m
Maximum Draft at yard	9 m

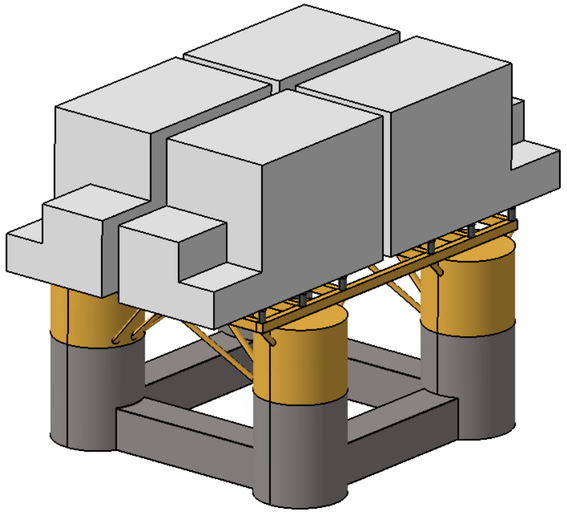
FOSS Maximum allowable dimensions

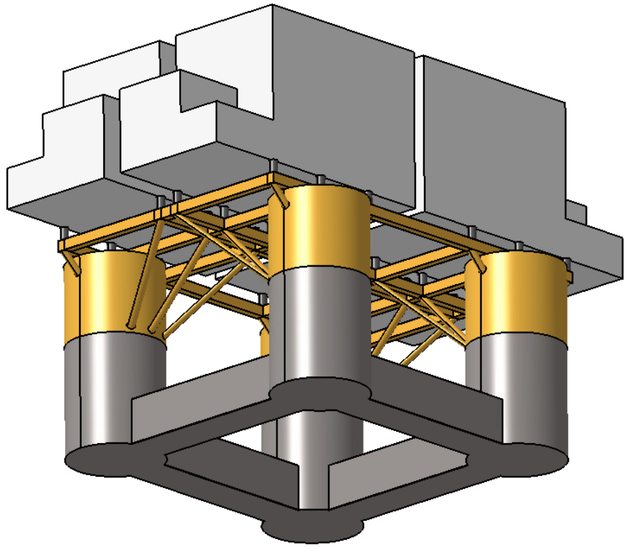
	Maximum allowable motion
Horizontal acceleration	4.0 m/s²
Vertical acceleration	3.5 m/s²
Tilt angle	15 deg
Horizontal offset	Max (30 m ; 10% of water depth)

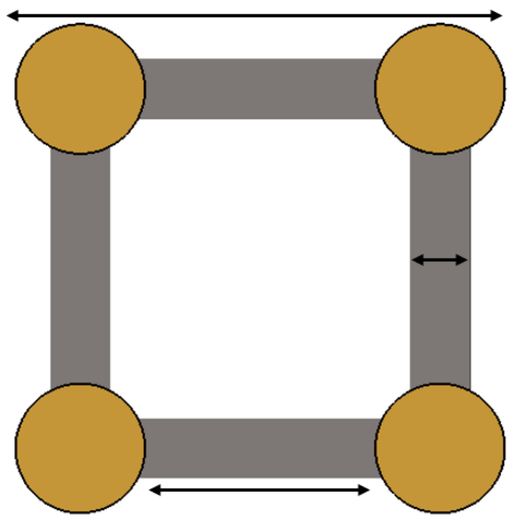
FOSS Maximum allowable motions

Design results : Geometry and mass

- TLP global geometry (floater and transition piece) :







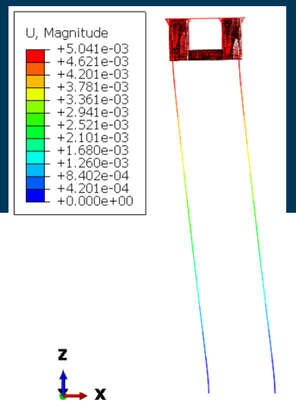
- Draft : 26 m (in place), 20 m (towing)
- Mass estimation :

Element	Mass (te)	VCG (m)
TP (no margin for welding)	3 032	43.0
Hull (no margin for welding)	13 335	15.6
Ballasted hull with TP	18 192	18.7

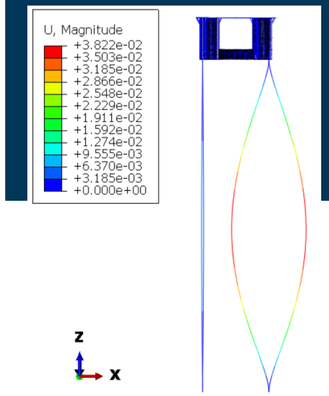
NB: this design is preliminary and should be optimized in a detailed design

Design results : Structural studies

- Both static and dynamic structural analysis have been conductued :
  - Von mises crtieria have been passed
  - Modes up to 100 have analyzed and compared to topside structural modes
  - Thickness inside of the main elements the hull have been definied → mass weight report has been updated !



Mode 1



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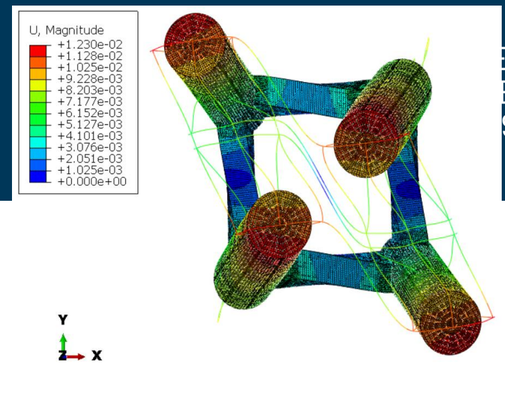

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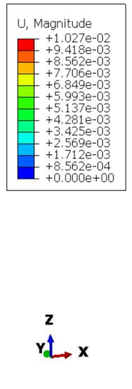

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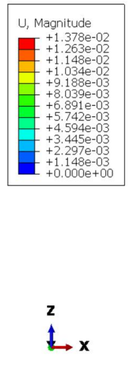

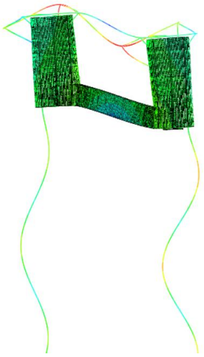

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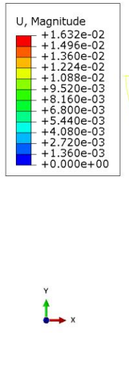

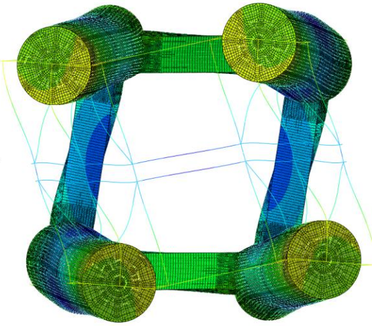

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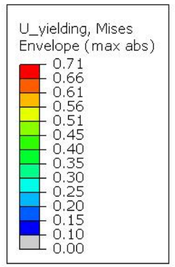
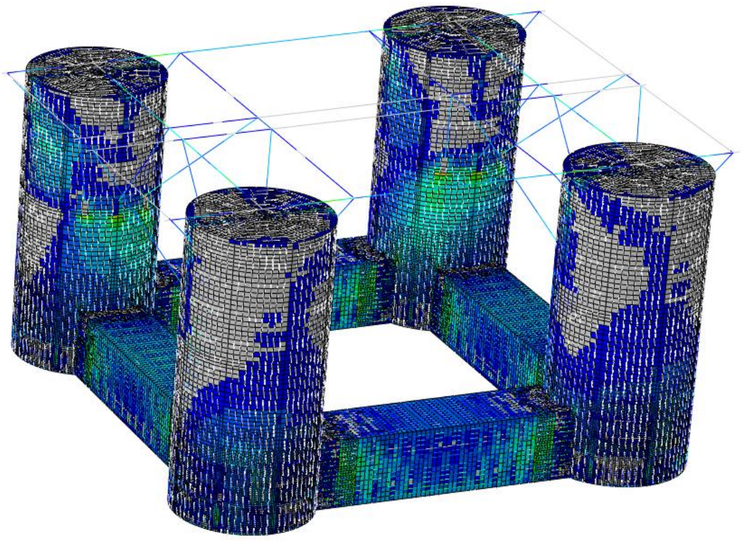
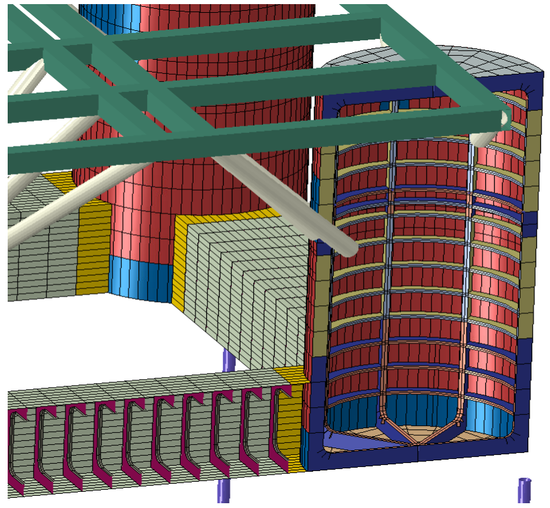




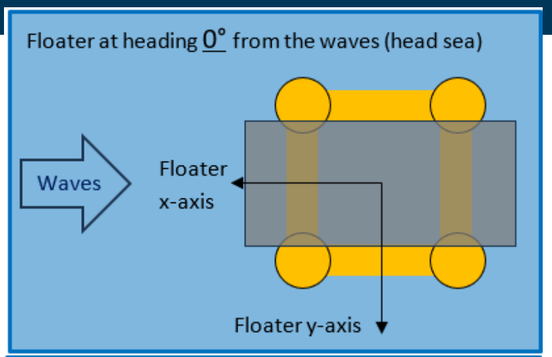
Equilibrium

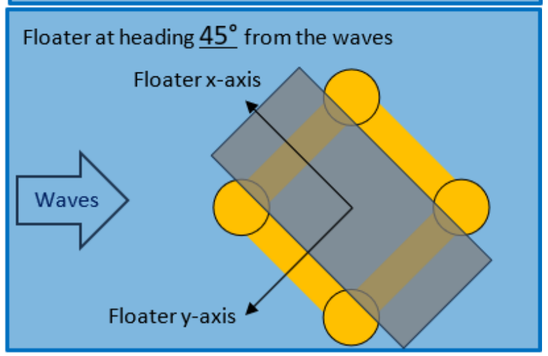


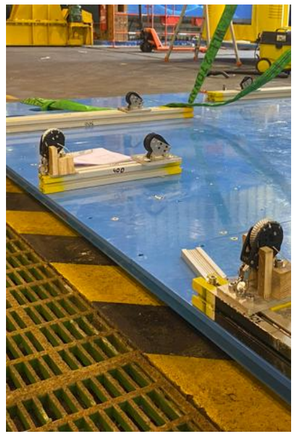
TLP Basin test campaign

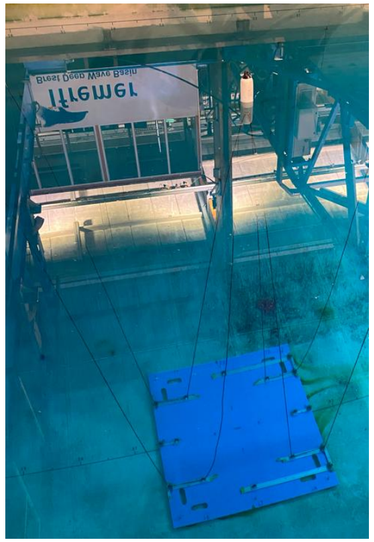
Basin test campaign preparation : objectives/program, mock-up design and instrumentation (1/2)

- Main Objectives :
  - Assess whether non-linear effects are present in the system response in the wave conditions considered
  - Provide experimental results for this platform concept:
    - **Tendons' tension and platform motions and accelerations** to evaluate the accuracy of the numerical analysis
    - **Free-surface elevation and resulting air-gap** to evaluate the accuracy of numerical assessment
    - To assess the sensitivity of the global response to the tendons' stiffness or water depth.
- Scale 1:50, Froude scaling.
- Test program (over 200 tests during 3 weeks)
  - Still water tests: pull-out and decays.
  - Regular waves tests, at 0° and 45°, 3 tendons stiffness for 3 different water depths
  - Irregular waves tests, at 0° and 45°, 3 tendons stiffness for 3 different water depths
  - Focused waves tests, at 0° and 45°, 3 tendons stiffness for 3 different water depths



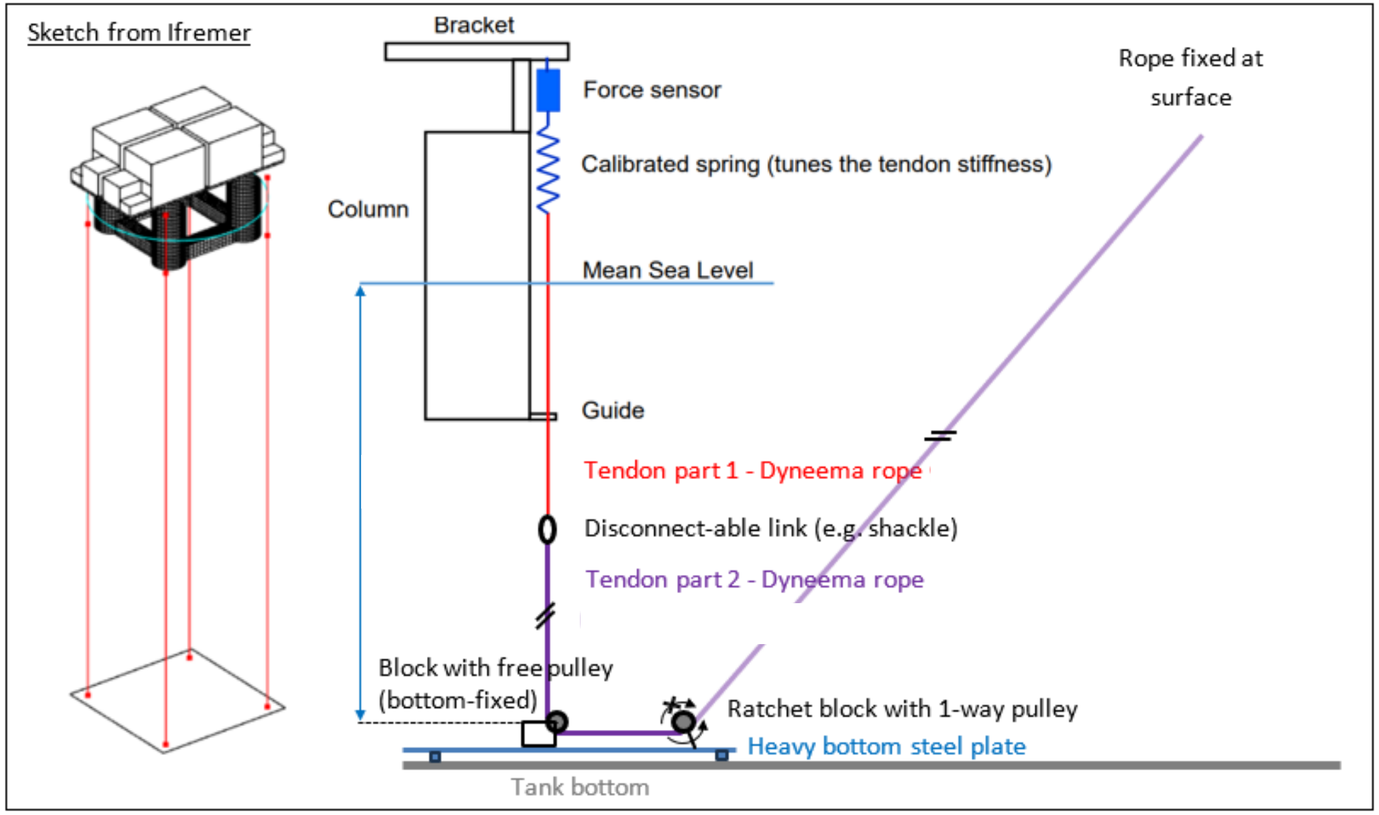


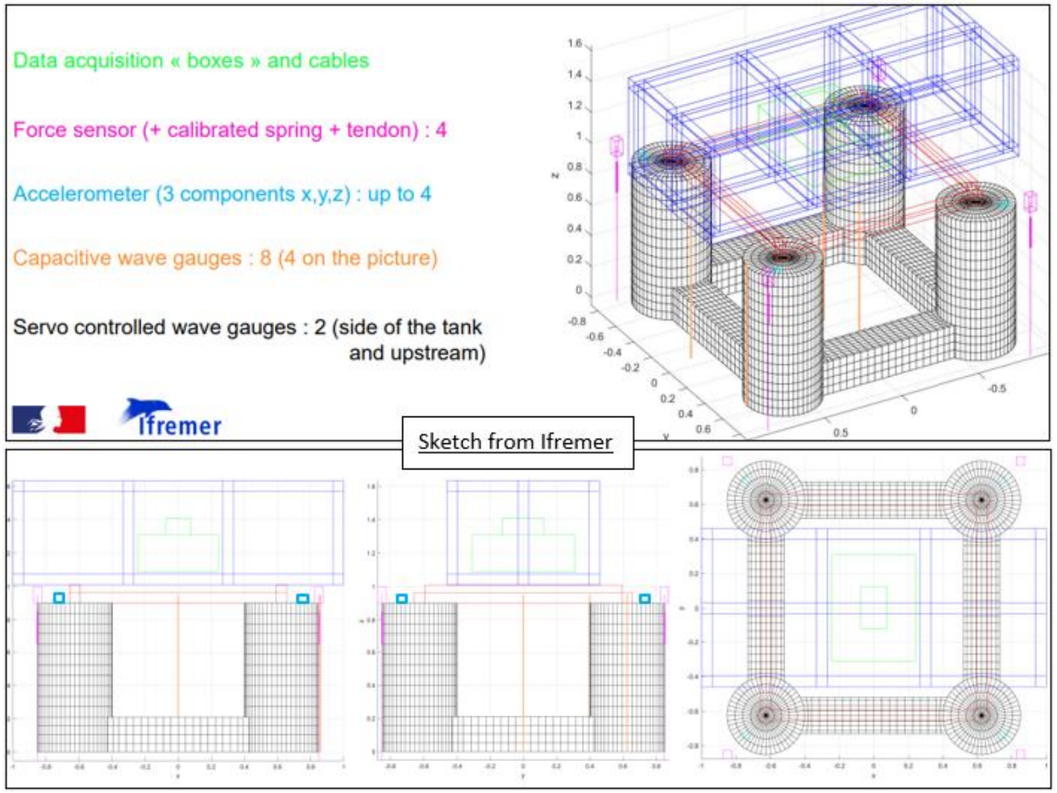




Basin test campaign preparation : objectives/program, , mock-up design and instrumentation (2/2)

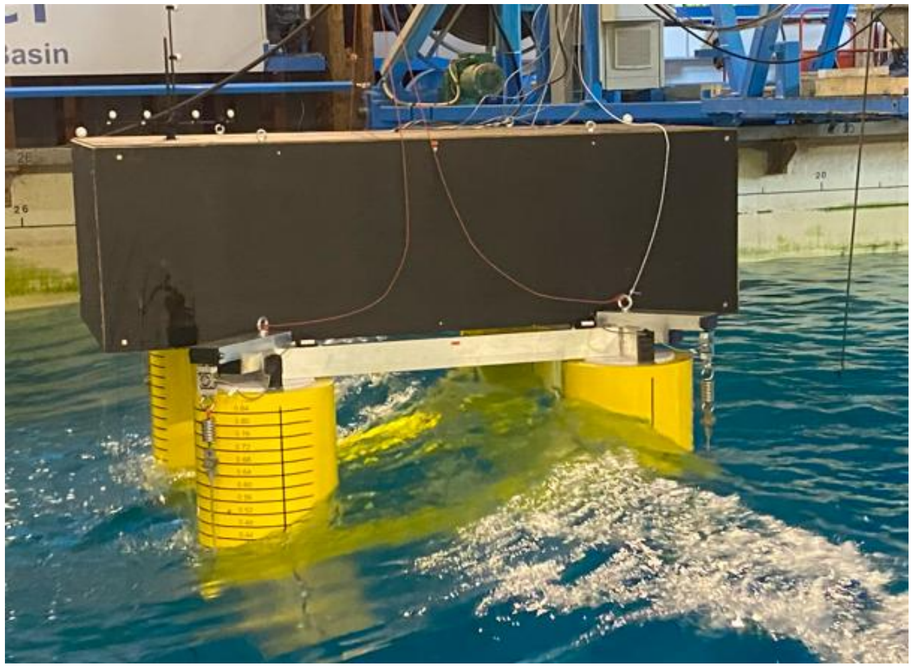
- Explanation of experimental design and instrumentation :

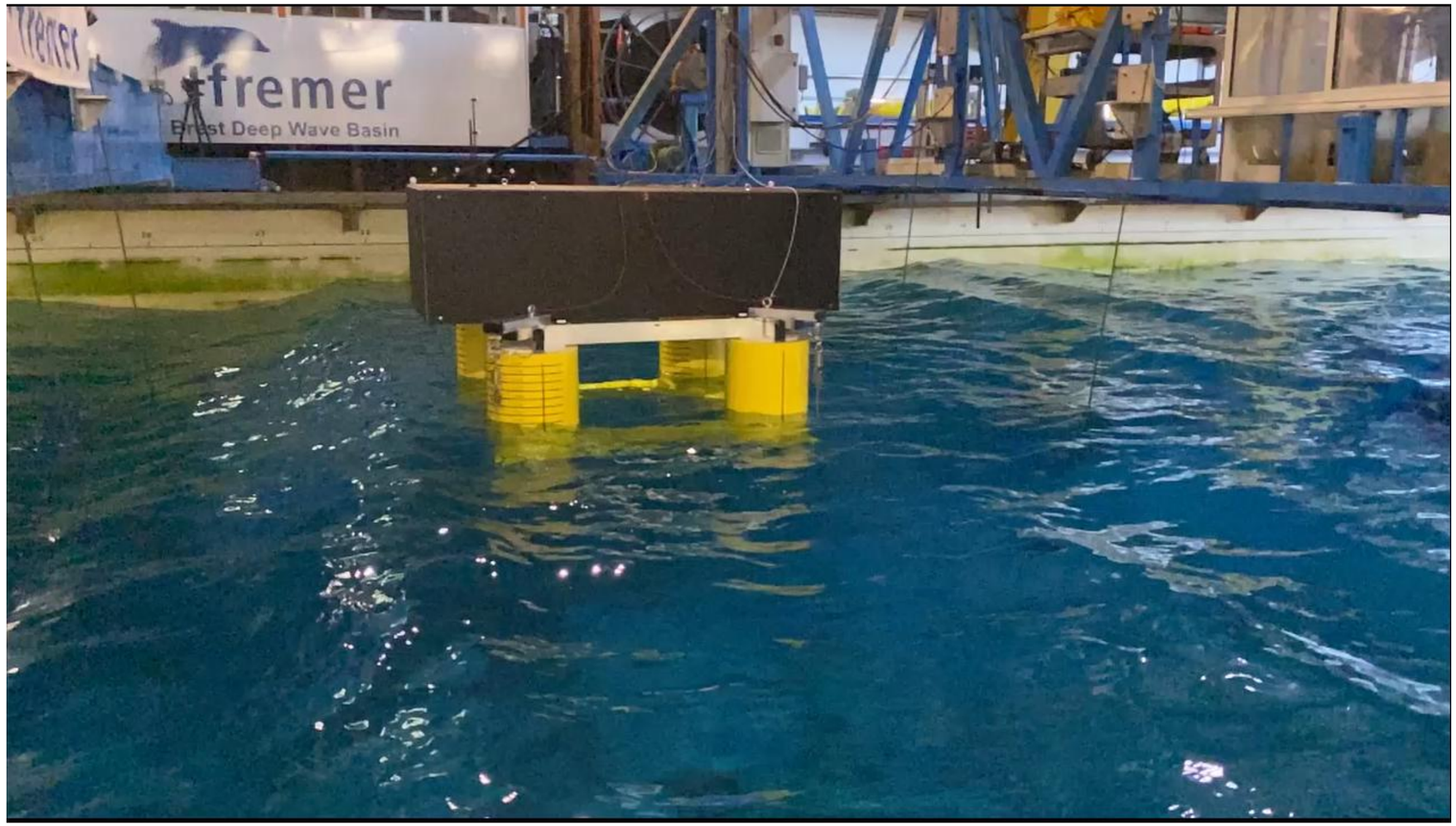




TLP basin tests – 100 yr storm

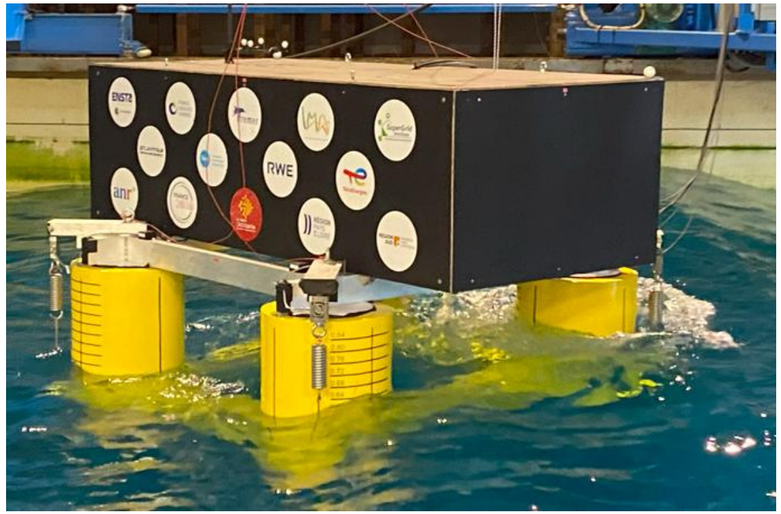
- 100-yr conditions, irregular waves Hs 13.9m, Tp 17s (test 063), 0deg, tendons stiffness 400m
  - « flat » motions

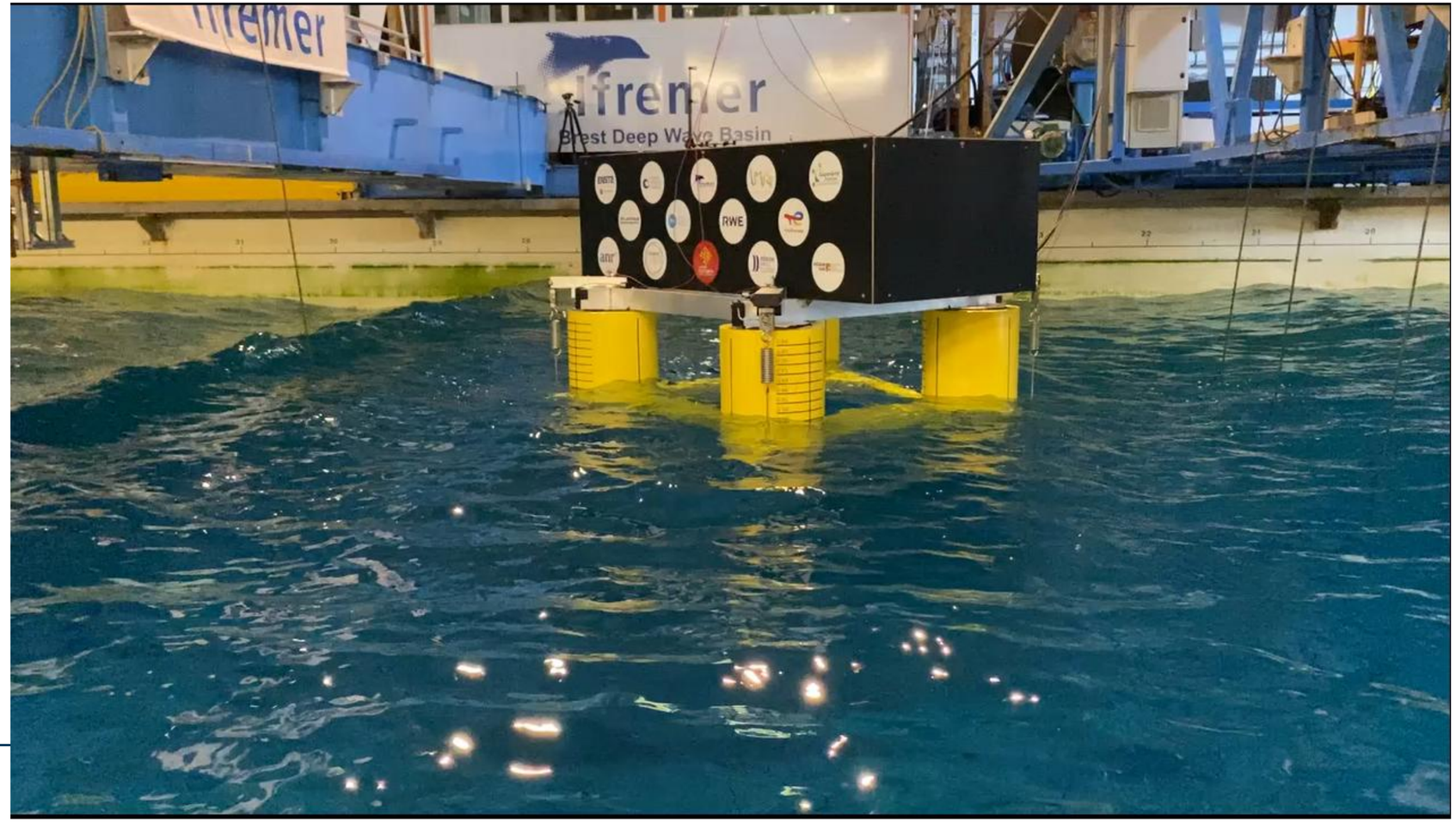




TLP basin tests – 100 yr storm

- 100-yr conditions, irregular waves Hs 13.9m, Tp 17s (test 214), 45deg, tendons stiffness 1000m
  - Visible pitch motion





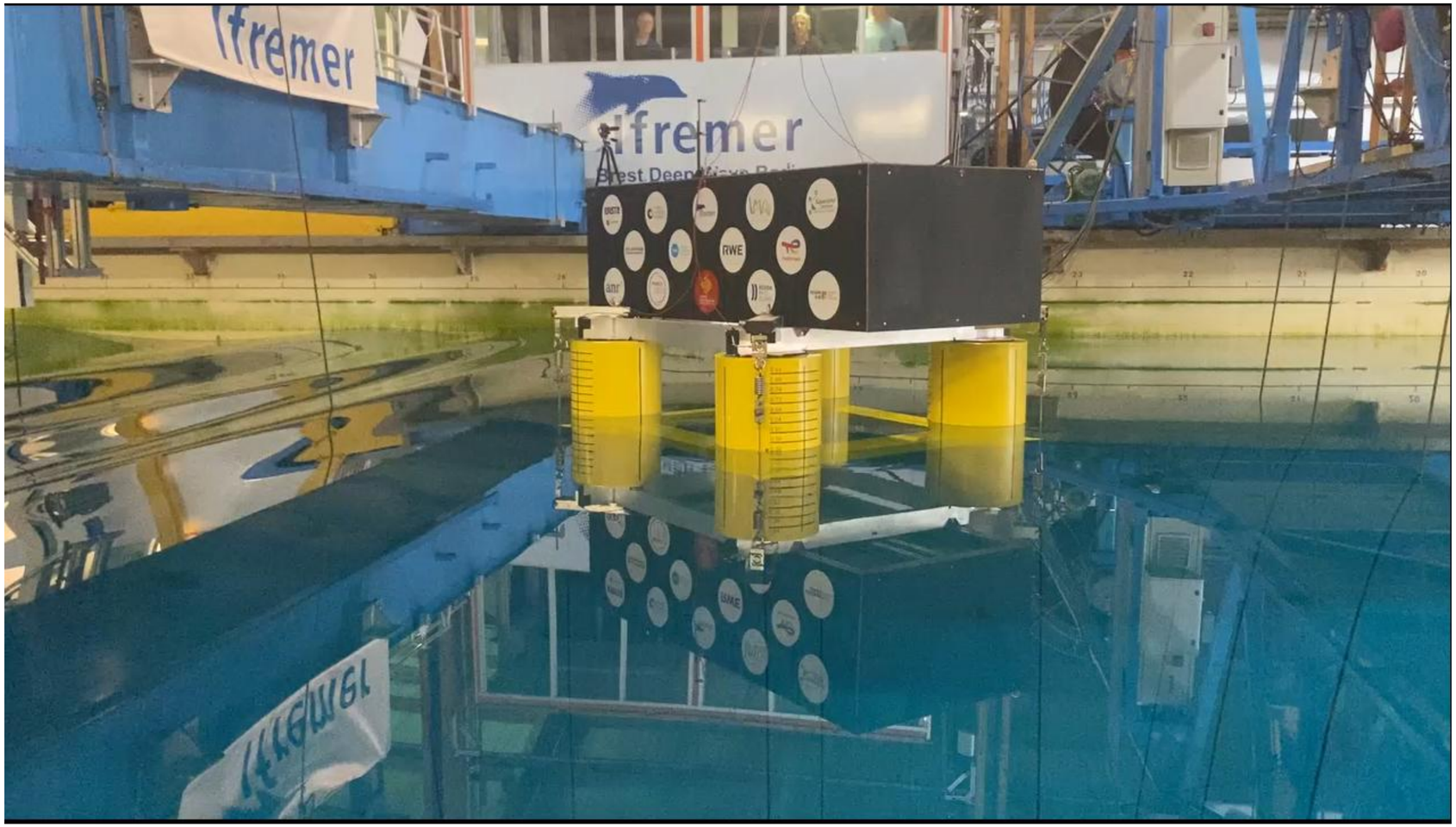
TLP basin tests – Focused waves

- Focused waves

Success in realization

Steep wave (not breaking)

Variation in « focus point »



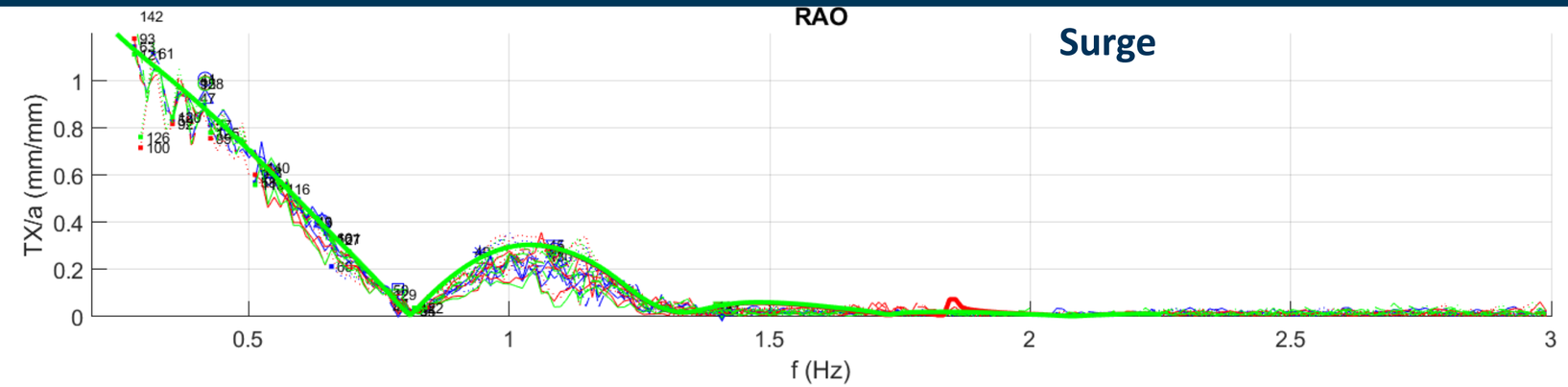
Basin test campaign : Motion RAOs

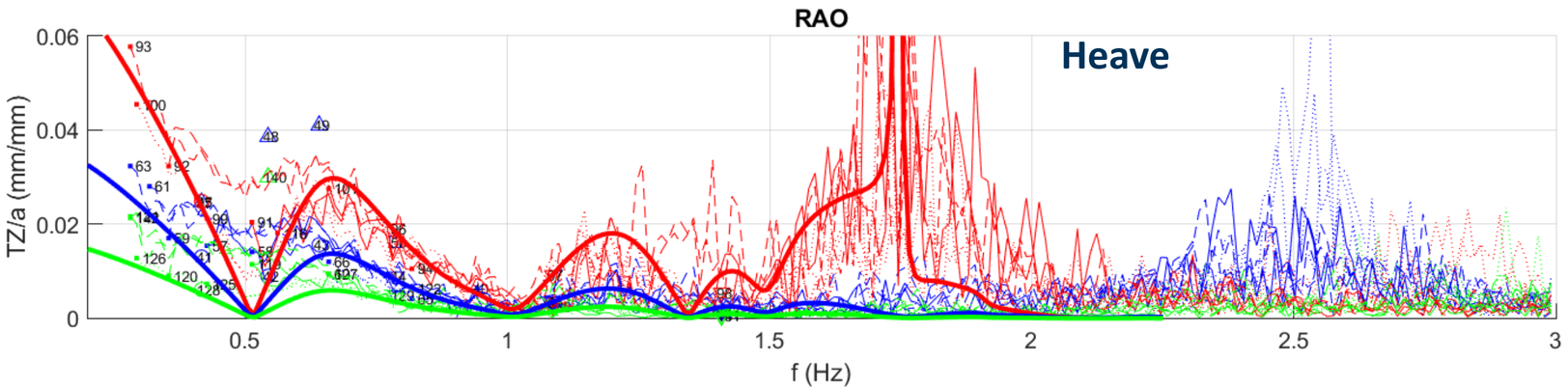
Model scale results

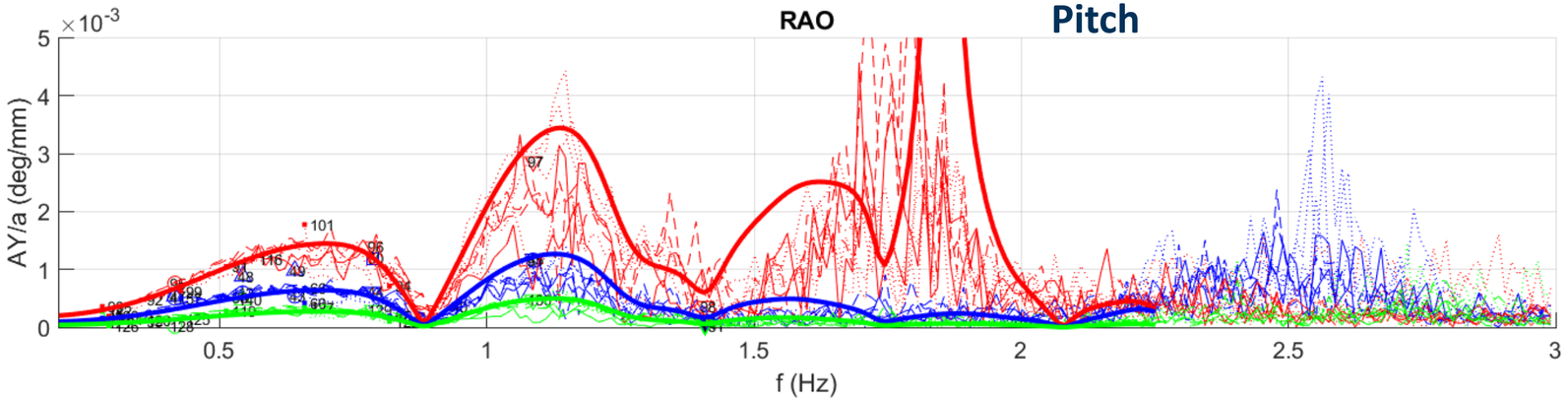
- Motions
- Transfer functions
- on regular and
- irregular waves
- Incidence = 0 °

150 m water depth
400 m water depth
1000 m water depth

Marker : regular waves
Lines : irregular waves
Thick lines : Hydrostar diffraction and radiation software





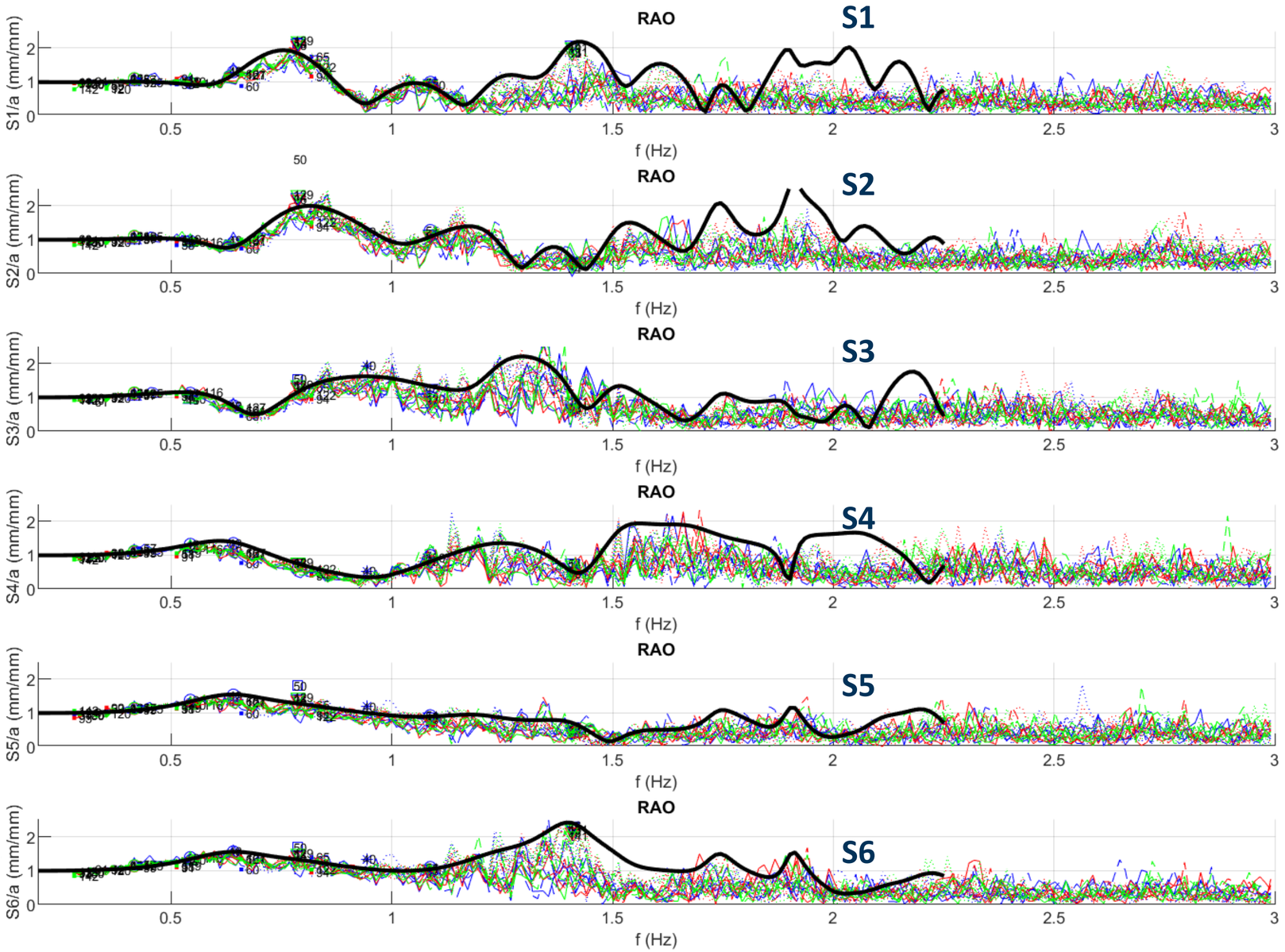


Basin test campaign : Free surface elevation RAOs

- Free surface elevations
- Transfer functions
- on regular and
- irregular wave
- Incidence = 0 °

150 m water depth
400 m water depth
1000 m water depth

Marker : regular waves
Lines : irregular waves
Thick lines : Hydrostar



Conclusion / outcomes

- **Basic design** (including structural design) have been sucessfully done and **all criteria of design have been met.**
- **Basin test campaign has been run** and **RAO** are **in accordance** with what has been calculated during design.
- **Non-linear effects have been identified** at certain wave conditions (focus waves)

Future work :

- Potential updates if weight estimation is updated
- Possible design updates if location hypothesis (Water depth / Metocean conditions) changes
- Continue analysis on non-linear effects on TLP basin test campaign
- The concepts (TLP / semi-sub') can be compared depending on the site/conditions

FRANCE ENERGIES MARINES

Thank you for your attention!