A floating electrical substation is shown in the center of the image. It consists of a yellow, rectangular platform with a central vertical column. The column is white and supports a horizontal arm with three long, thin, white blades. The platform is floating on a dark blue sea with small waves. The sky is overcast with grey clouds.

Floating electrical
substation
modelling in
extreme wave
environment



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INTRODUCTION TO FLOATING SUBSTATION

Harvest more wind power

Wind turbine farms further from coast, deeper water, more severe wave

Electrical losses in exporting electricity to shore

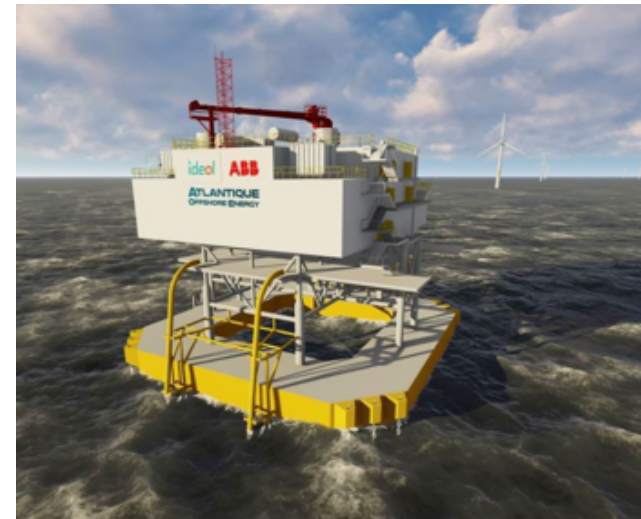
Higher voltage to reduce losses

Electrical substation to convert voltage (ex: 33kV or 66kV to 220kV)

Floating electrical substation

Ideal

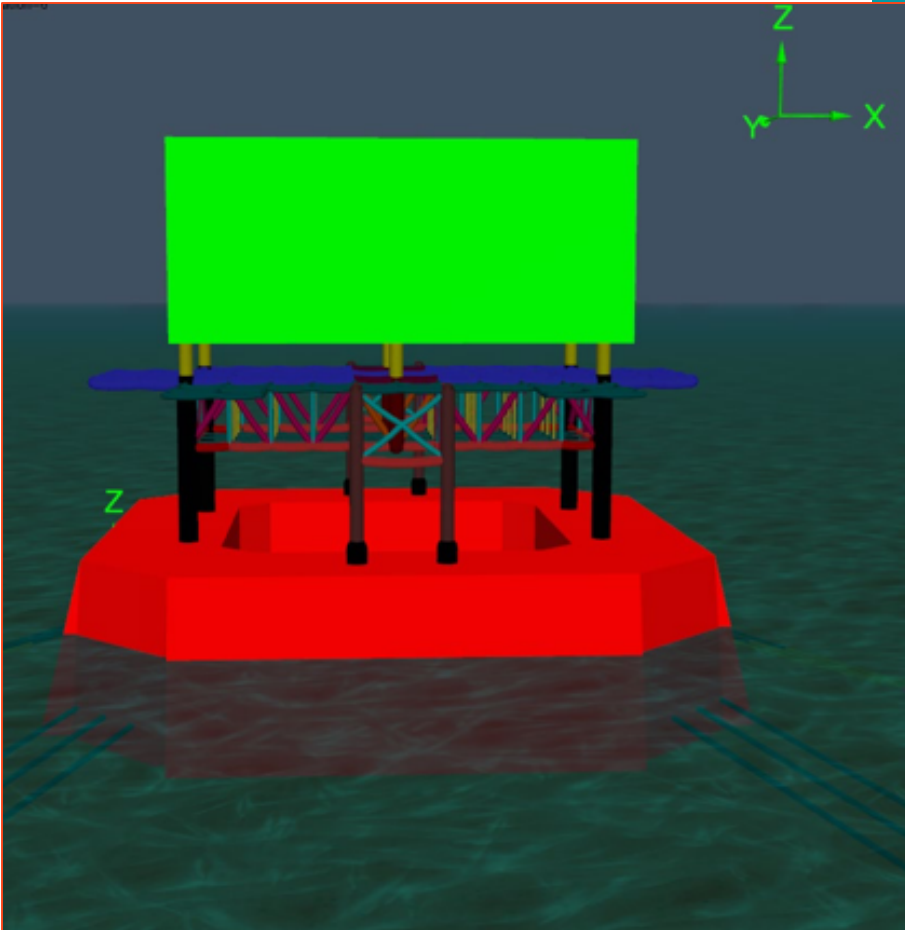
Develop the efficient, well-adapted and robust floater to any site



Atlantique Offshore Energy

- Adapt topside to floating constraints
- Select electrical equipment
- SeeOs solution

PRESENTATION OF THE FLOATING SUBSTATION



Compo

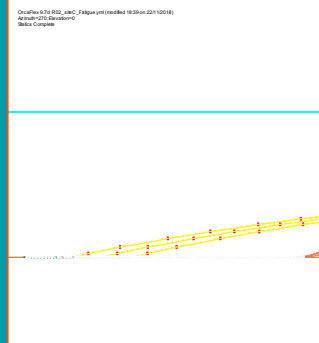
Topsid

Topsid

Square

Moori

Dynam



CHALLENGES TO MODEL FSS

Challenges

Conventional modelling dedicated to ship-like structure not relevant for floater with damping pool

Hyper static structure

Similar topside and hull dimensions -> transmission of hull deflection generated by wave loads to topside

-> Stiff topside on more flexible hull

Solutions

Time domain analysis

Model includes hull and topside support

TWO MODELS

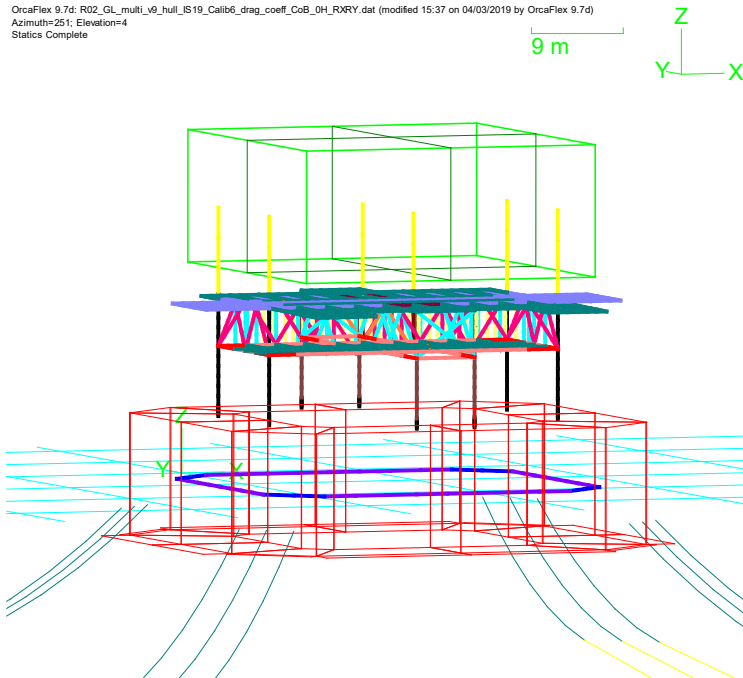
Hydro-structure model (OrcaFlex)

Multibody elastic hull with hydrodynamic data bases

Topside support as line elements

Environmental loads : wind & wave

Time domain simulation

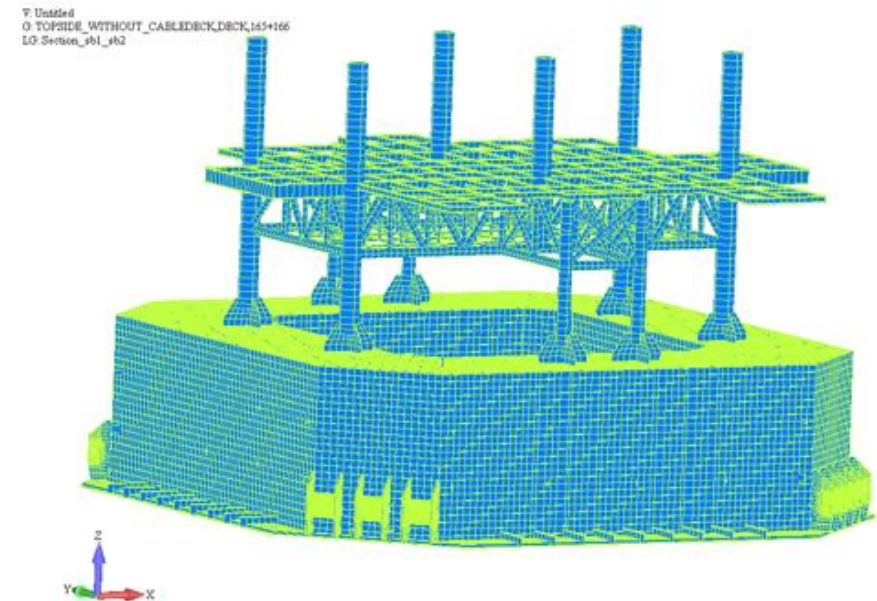


Definition of
critical instants
Export of loads

Structural model (FEMAP Nastran)

Global model: hull + topside support

Input data from hydrodynamic model

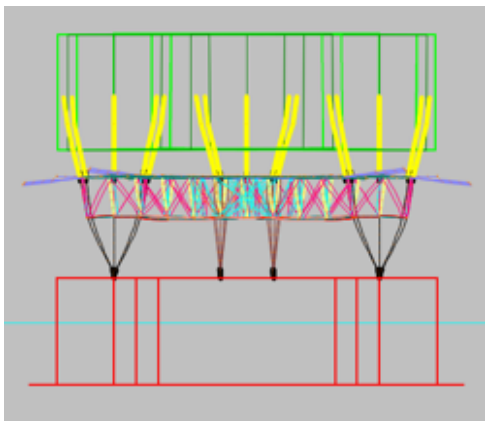


Verification on structural model
(yielding, buckling, pressure)

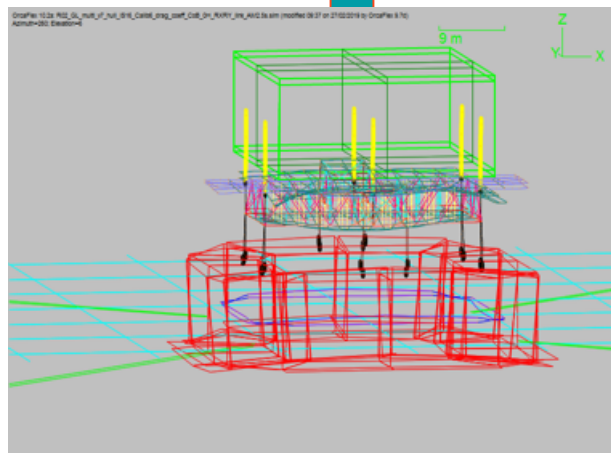
CHECK OF MODELS (1)

Hydro-structure model

Topside surge mode at 1.54Hz (floater fixed)



Example of modal coupling between hull and topside support at 6.9Hz



Structural model

Modal analysis

Topside surge mode at 1.59Hz (floater fixed)



CHECK OF MODELS (2)

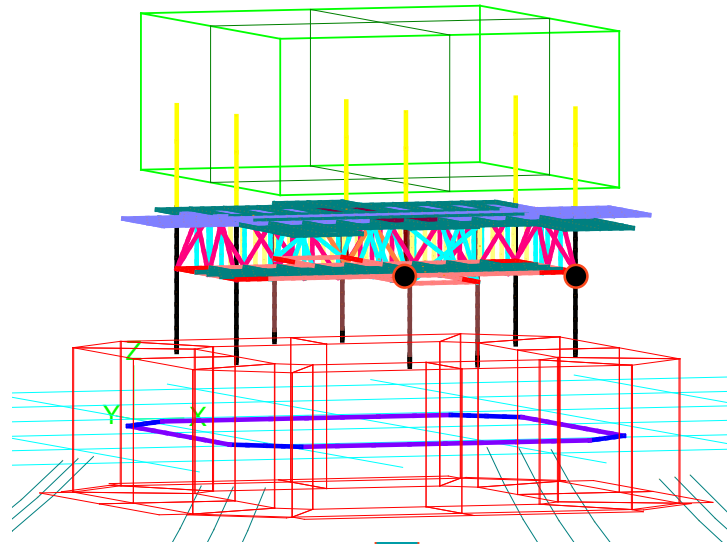
Hydro-structure model

Side column
 $F_z = -425 \text{ kN}$
 Fore column
 $F_z = -9.1 \text{ MN}$

Side column
 $F_x = 22 \text{ kN}$
 Fore column
 $F_x = 333 \text{ kN}$
 $M_y = -1750 \text{ kN.m}$

Structural model

Response under gravity



Side column
 $F_z = -475 \text{ kN}$ 11%
 Fore column
 $F_z = -9.0 \text{ MN}$ 1%

Response under horizontal unitary load 1MN at topside

Side column
 $F_x = 28 \text{ kN}$ 24%
 Fore column
 $F_x = 453 \text{ kN}$ 27%
 $M_y = -1538 \text{ kN}$ 12%

SIMULATION IN EXTREME WAVES

Sev
env
con
Wa
RP=
Tp=
spe
Wi
100
sur



EXTREME WAVE AND SLAMMING

Extreme waves

example: $H_{s_{3h,100y-RP}}=11.7\text{m}$ -> H_{\max} 21.8m crest to trough

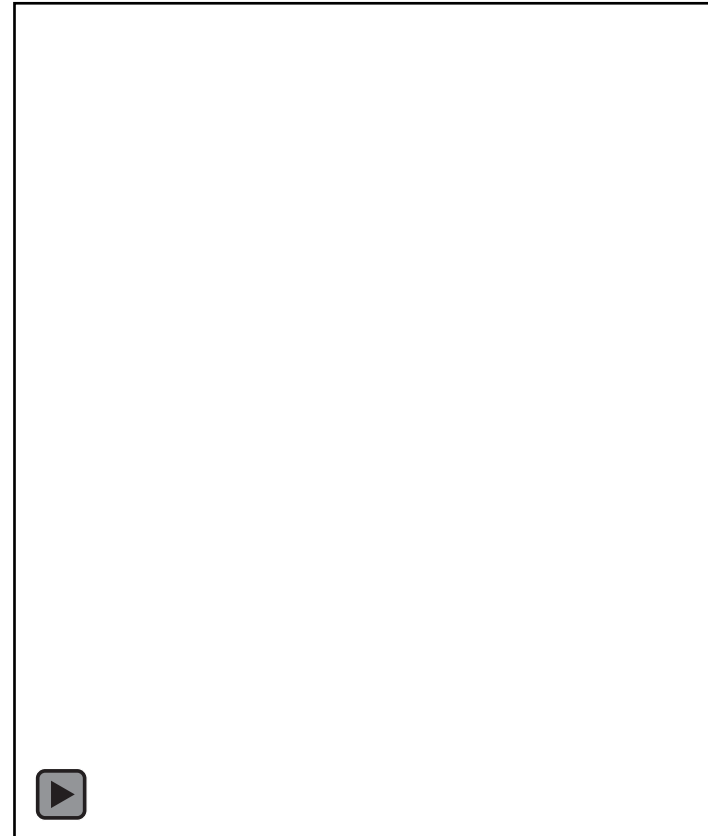
Slamming event is an impact of wave on the structure.

Slamming location

- Topside
 - > prevented by air gap
- Topside support (**columns**, decks)
 - > to account for
- Hull bottom
 - > prevented by floater draught
 - > basin test verification

Slamming on columns model

$$F = \frac{1}{2} \rho C_s S V_r^2$$



CONCLUSIONS

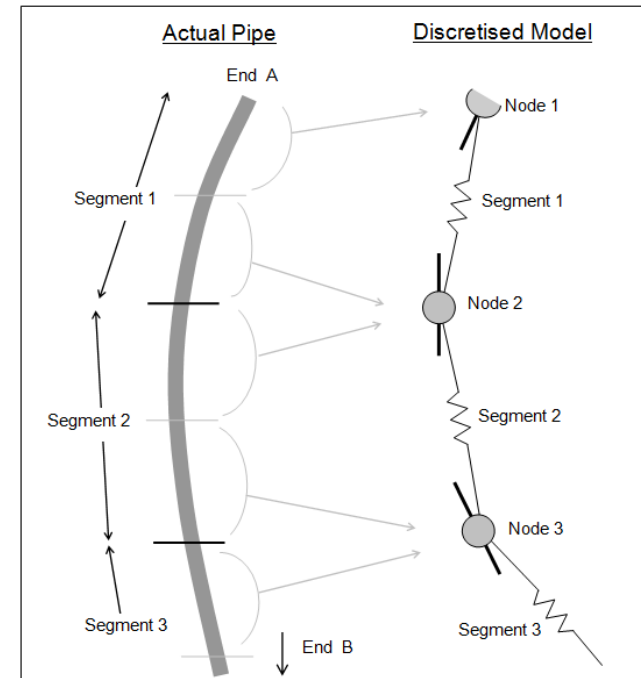
Good agreement of structural modal analysis

Calculation time of time domain model is significantly increased by this detailed modelling **x10**

Loads inside topside support difference caused by **different modelling approach** of finite element (sensitivity to element size)

Loads inside topside support **differ** considering **hull flexibility** with respect to fixed deck

Current work: Check in more details the **loads transmission** from topside to hull in extreme wave



OrcaFlex modelling of lines



THANK YOU FOR
YOUR ATTENTION

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