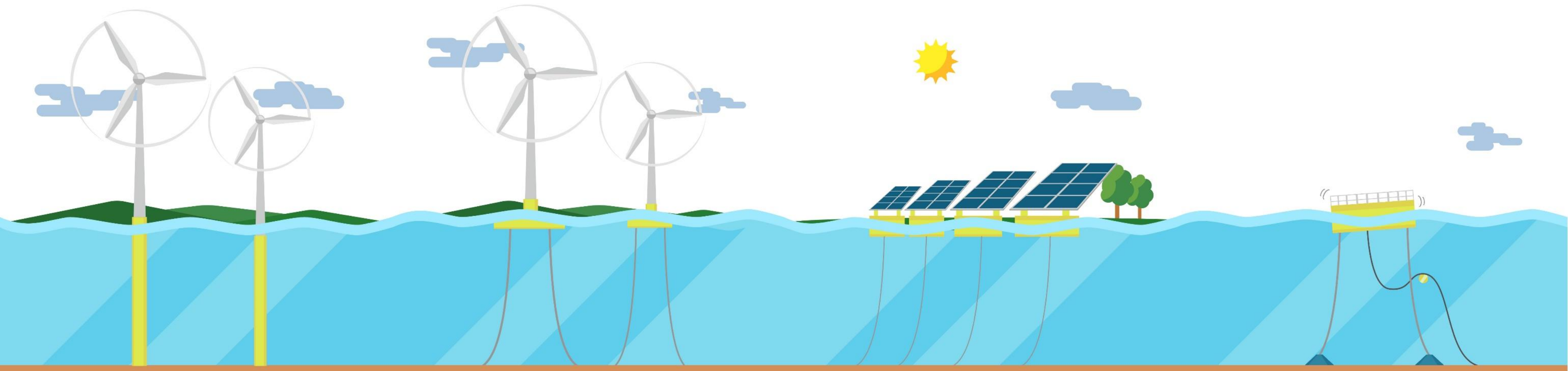
Engineering Services



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28/01/2022

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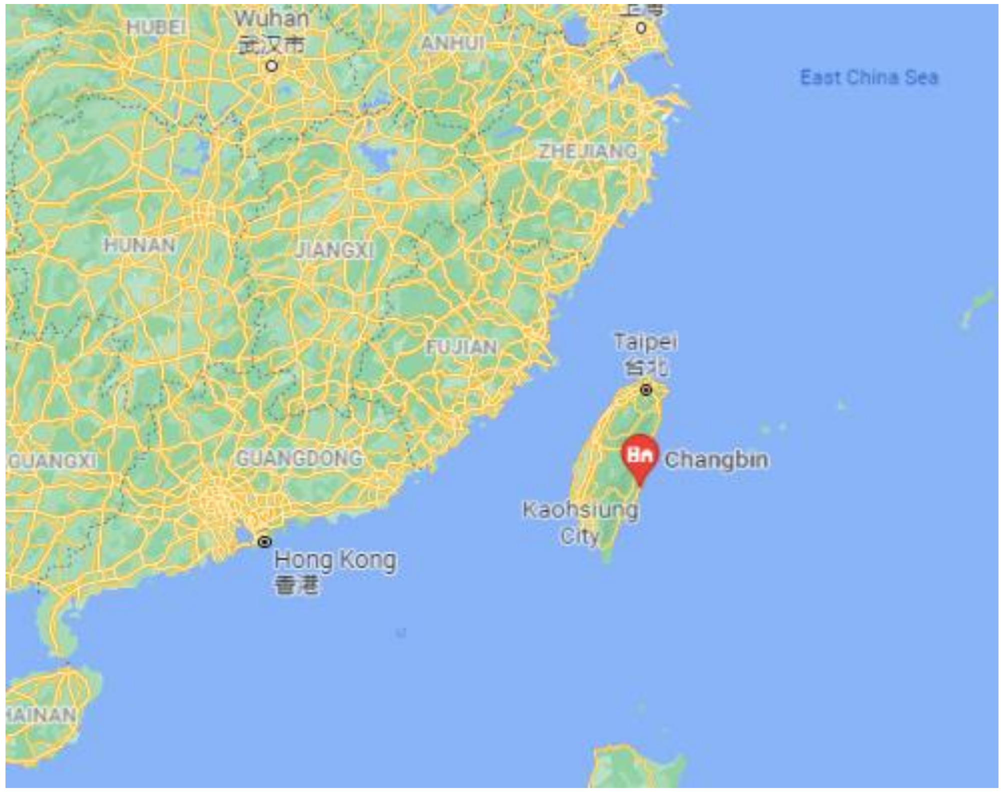
Agenda

- Site data
- Wind farm layout and elements definition
- Reduce model adjustment
- TRUSS modeling
- Mooring modeling
- Pile / Pile ring interaction
- Aluminium fatigue

Site data



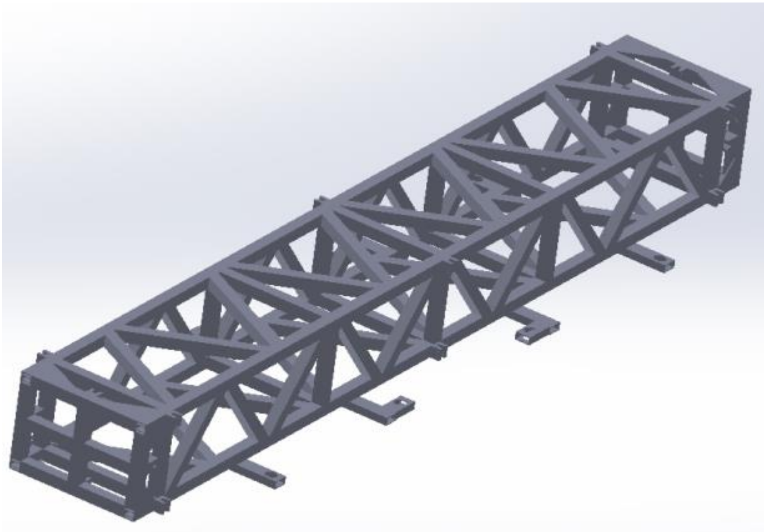
<u>For Numerical calibration</u>

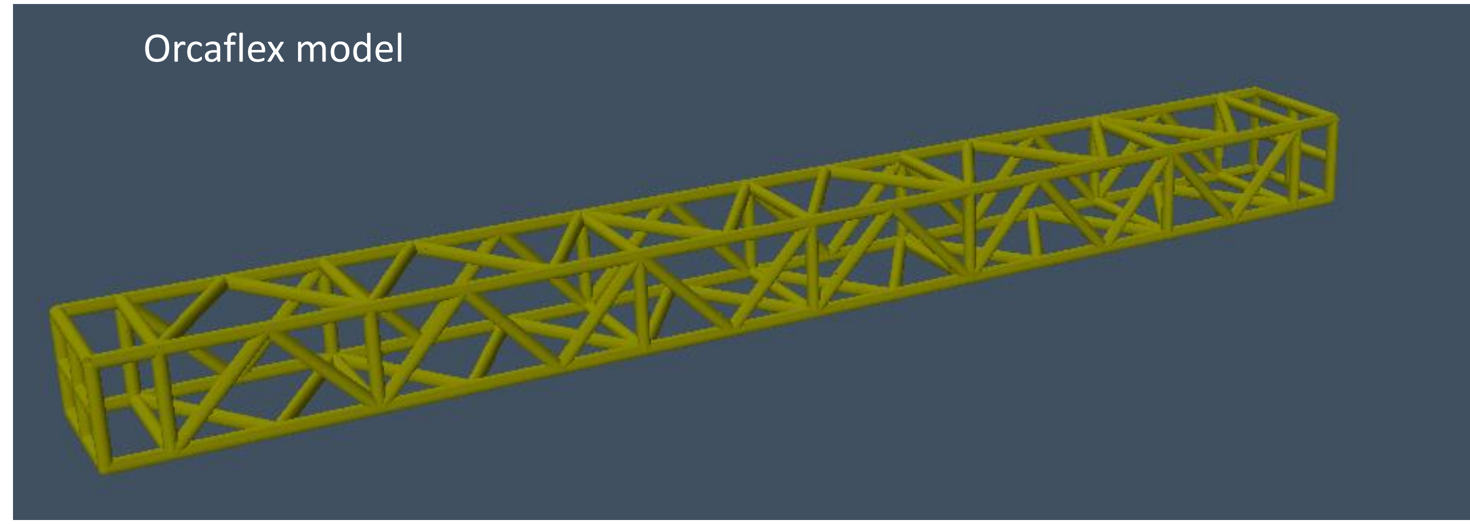
Storm events (wind/wave/tide/current)

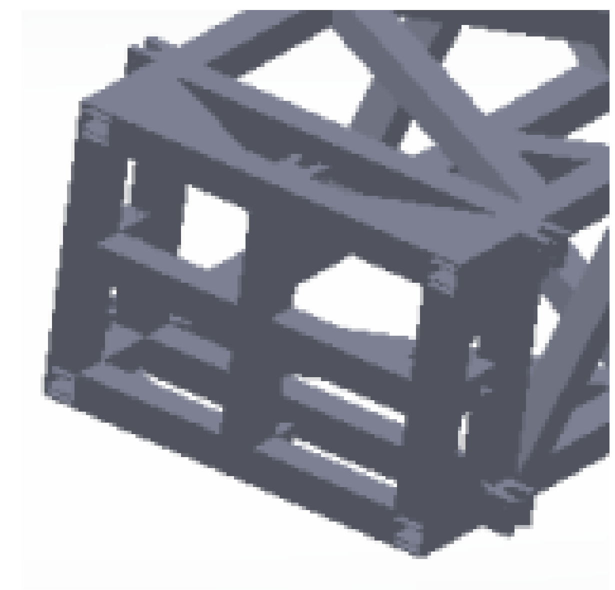
<u>For fatigue analysis</u>

Wind/windir & fetch => Hs/Tp = > H/T => Orcaflex => S design

TRUSS modeling







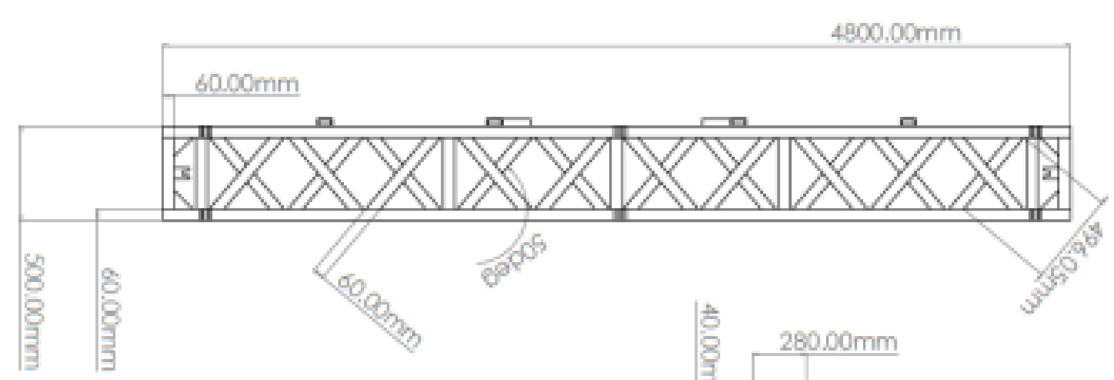
6.3 Truss assumptions

- Beam properties
  - Square 60x60
  - Isotropic inertia
  - I = 617 867 mm4
- Extremity beam section : to be discussed
- Gussets neglected
- Additional weight to be considered
  - Beam model : 200 kg
  - Input data : 320 kg (including buoy connection, gussets…)

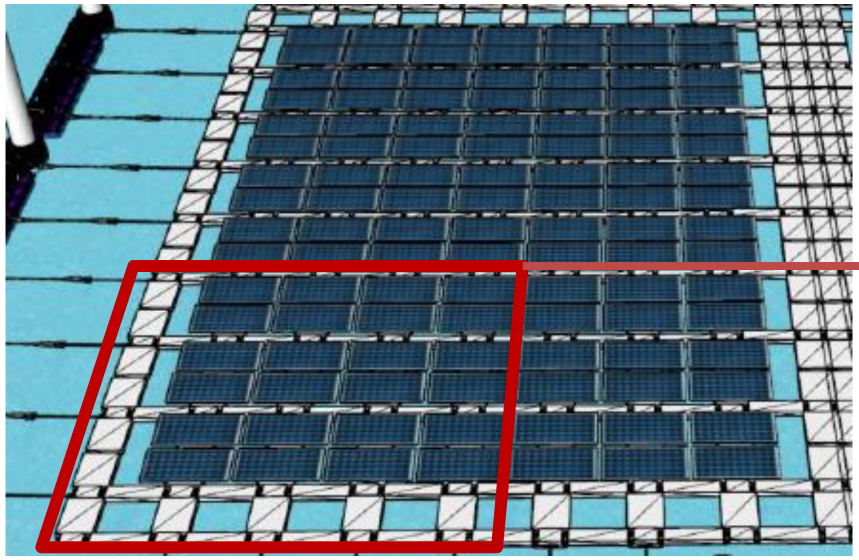
South truss

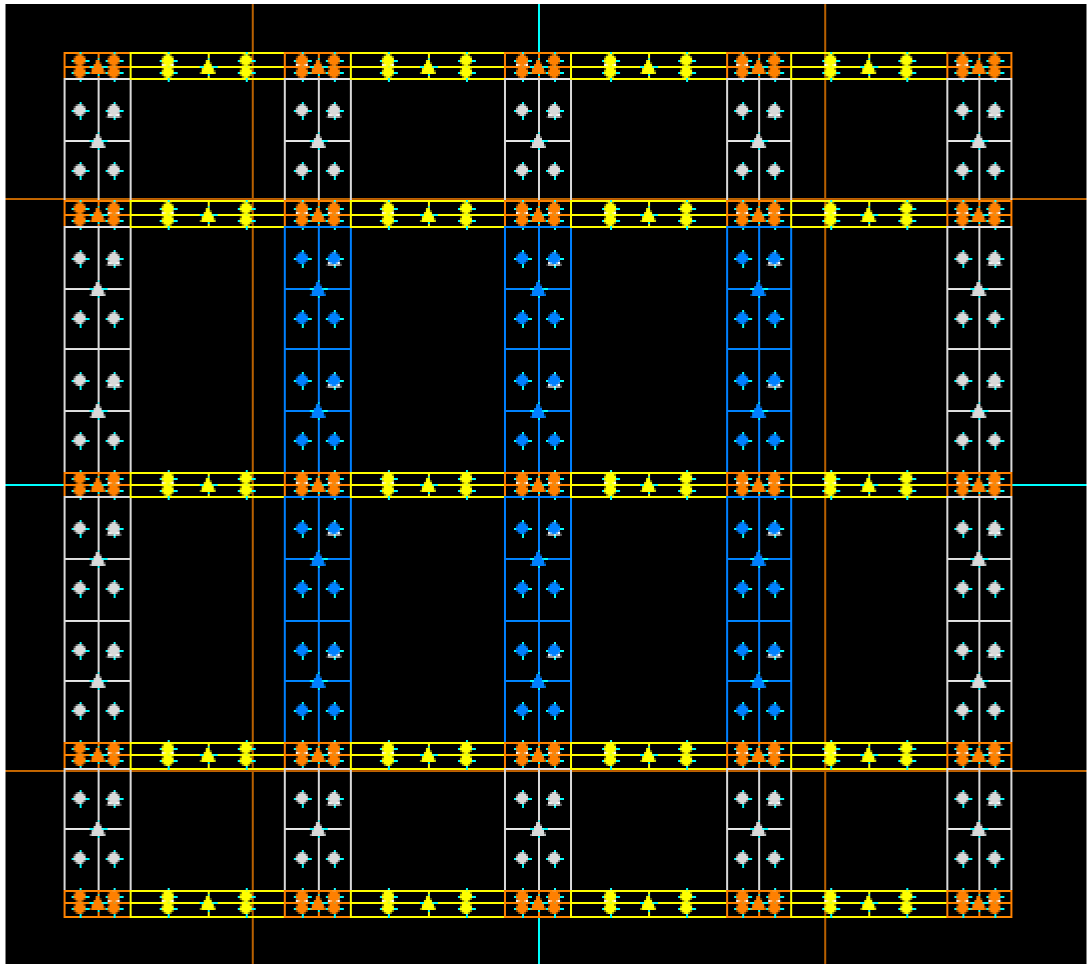
Two models :

- cad : 3.9m
- Documentation : 4.8 m



Farm modeling

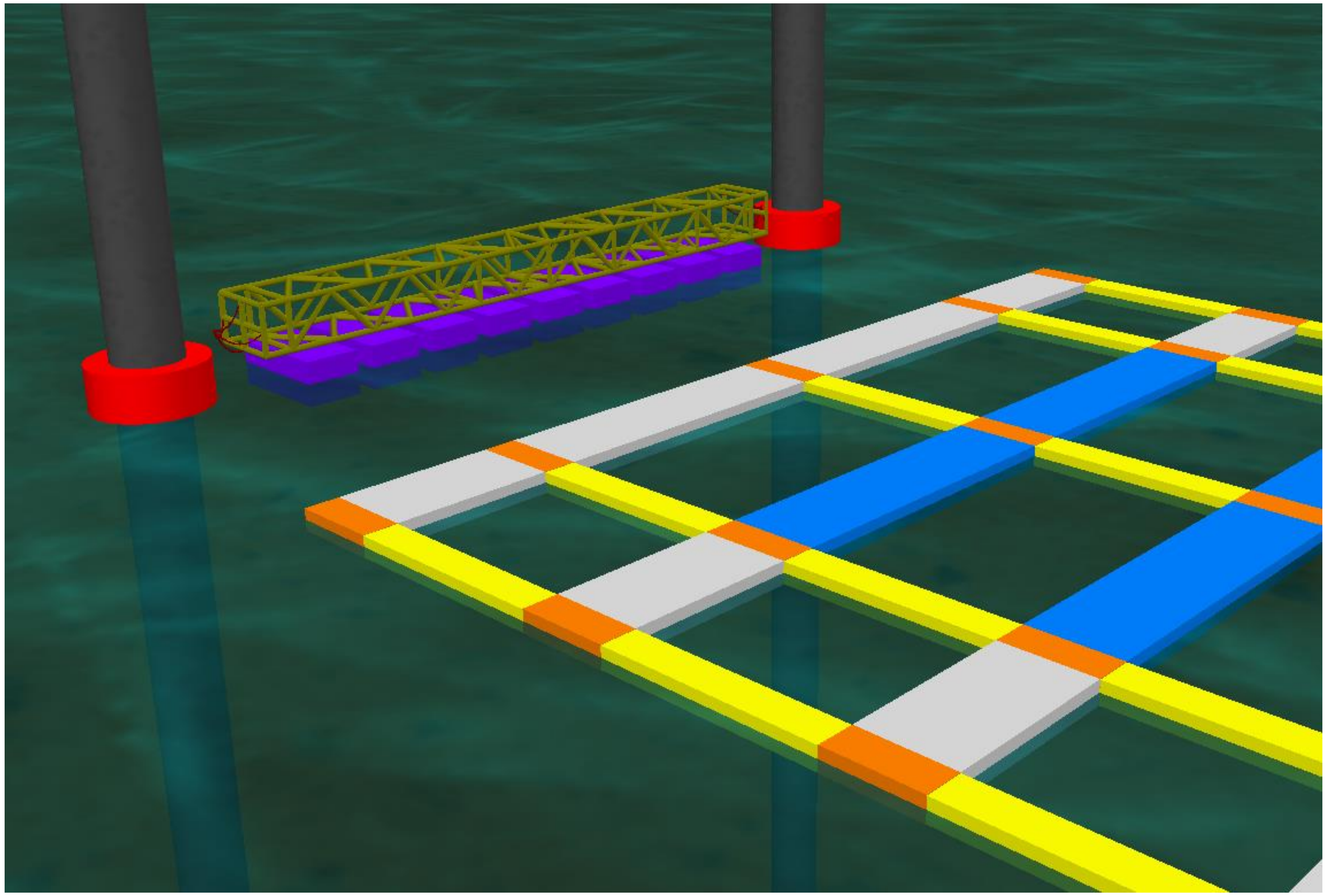


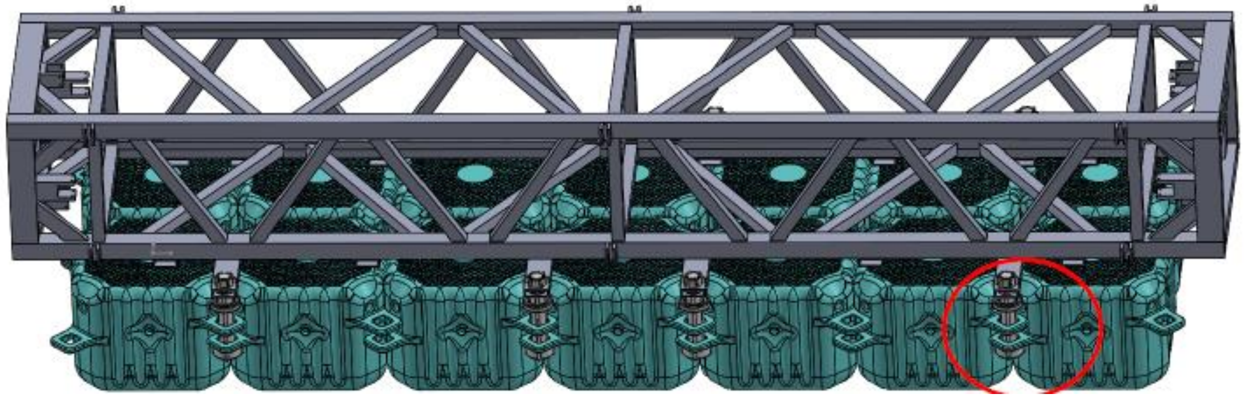


Buoyancy tool
One buoyancy module = 5 buoys

Global modelling

To be added:
South truss (4.8m or 3.9m)
Mooring lines (characteristics to be defined)





SCOPE REMINDER

ETUDE N°002-22	**Taiwan Truss fatigue analysis**
DONNEES D'ENTREES	- Meeting avec les équipes C&T - Description du système : plans, matériaux, devis de masse - Description détaillée du treillis (materiaux, section, inerties)

SCOPE	1. Modélisation sous Orcaflex
	  a. Truss modélisé sous formes de lignes avec connexions pour pouvoir accéder aux efforts en différents nœuds
	    i. Recherche de caractéristiques en fatigue de l'aluminium (SN curves)
	  b. Modélisation simplifiée de la ferme pour imposer des efforts/mouvements vers l'ancrage
	  c. Modélisation des lignes d'ancrage entre truss et ferme
	  d. Modélisation des connexions aux piliers béton
	2. Sensibilité sur la construction du modèle
	  a. Taille de la ferme
	  b. Hypothèse concernant la connexion avec les piliers béton
	  c. Efforts de vent et efforts des vagues
	3. Définition d'une liste de cas de charges
	  a. Prise en compte des données du site et établissement d'une liste réduite
	  b. Vagues seules et/ou Vagues + vent en fonction du point 2.c
	4. Simulations et résultats
	  a. Simulations temporelles dans Orcaflex
	  b. Calcul en fatigue en différents points du truss
	    i. Endommagement
	    ii. Durée de vie
	  c. Sortie d'une base de donnée compatible S-design dans le cas vagues seules
	(si besoin de sensibilité ultérieurs sur les données de site, ou courbes SN)

LIVRABLES	- Modèles Orcaflex (.dat) de l'étude - Rapport d'analyse incluant la méthodologie et les résultats de l'étude
PLANNING	3 semaines
NOMBRE DE JOURS	**10 jours**
DECOMPTE JOURS 2022	4 jours (Etude Ancrage alernatif avec bouées, en cours).
PRINCIPE DE TARIFICATION	Application d'un taux dégressif sur l'année ▪ 0-25 jours / an : 800 €/jour ▪ 25-75 jours / an : 700 €/jour ▪ >75 jours / an : 650 €/jour ▪ Le décompte des jours est réalisé sur la base d'une année calendaire. ▪ Facturation tous les 2 mois réalisée sur un tarif moyen de 700 €HT/jour. ▪ Régularisation bi-annuelle en fonction du nombre de jours consommés ▪ En cas de trop perçu lors de la régularisation bi-annuelle, une régularisation sera proposée sous forme d'avoir pour les études à venir.

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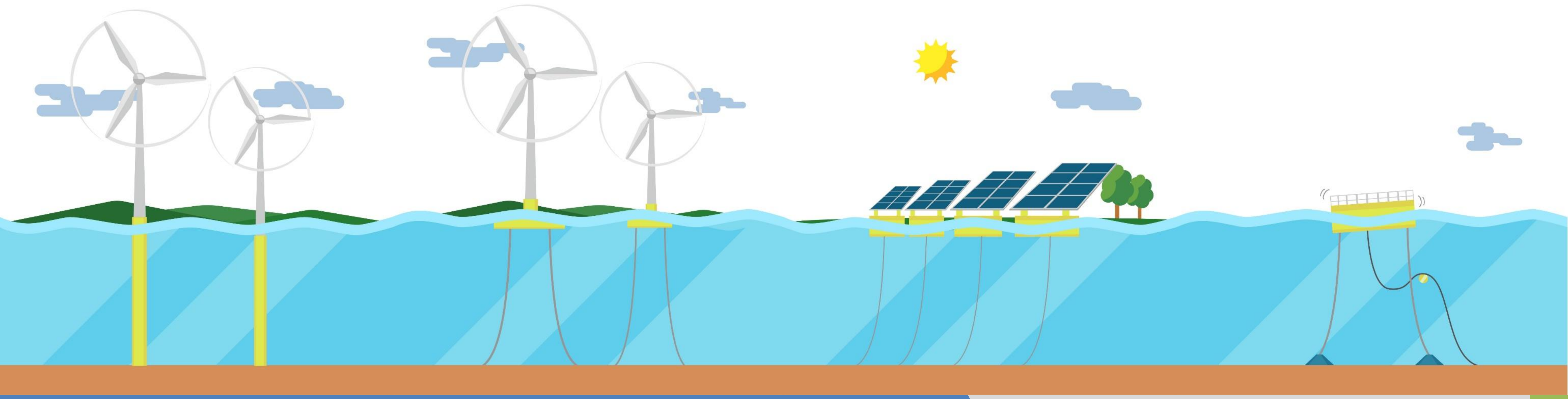

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Agenda

- Site data
- Wind farm layout and elements definition
- Reduce model adjustment
- TRUSS modeling
- Mooring modeling

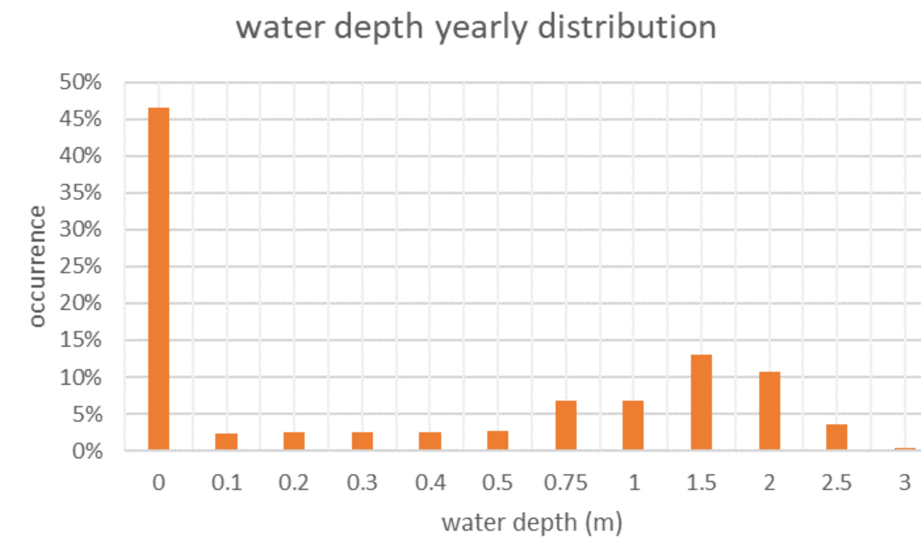
Site Data

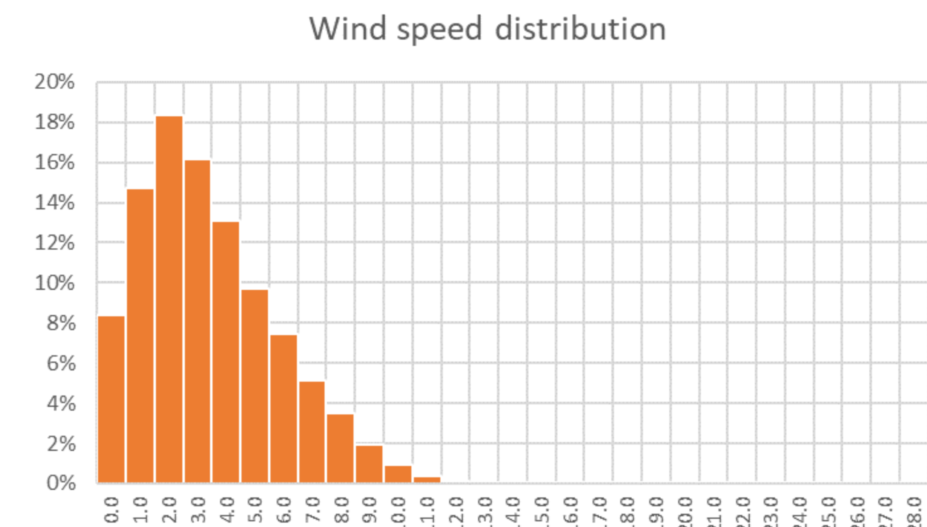
Water depth

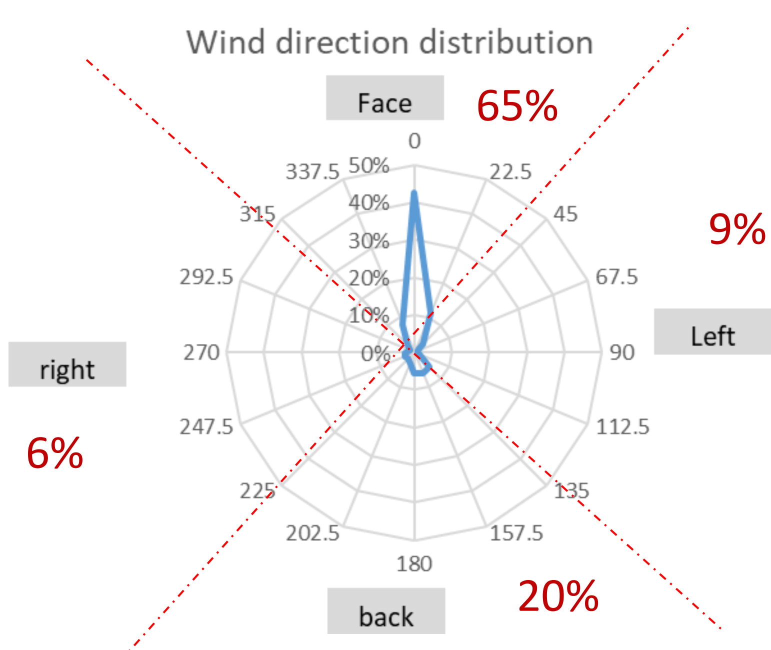
- 50 % time with water depth less than draft (7 cm)

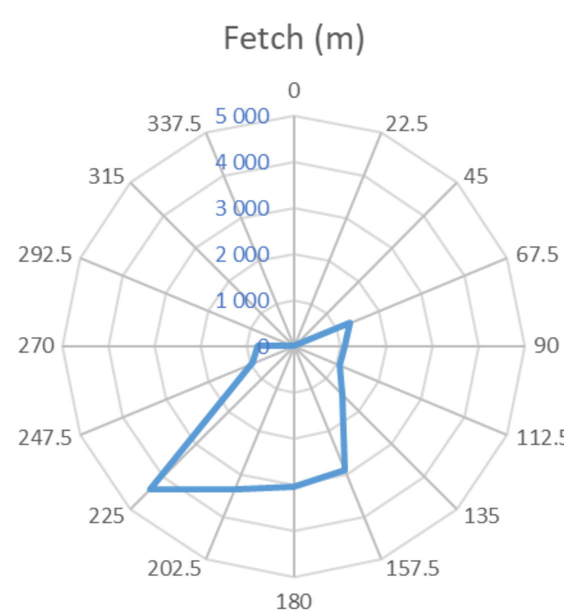
Wind speed and direction distribution

- 70% occurrence in -45° to +45° sector with 0m fetch
- 20% in back sector with 180 m fetch
- Largest fetch in south-west sector (low occurrences)

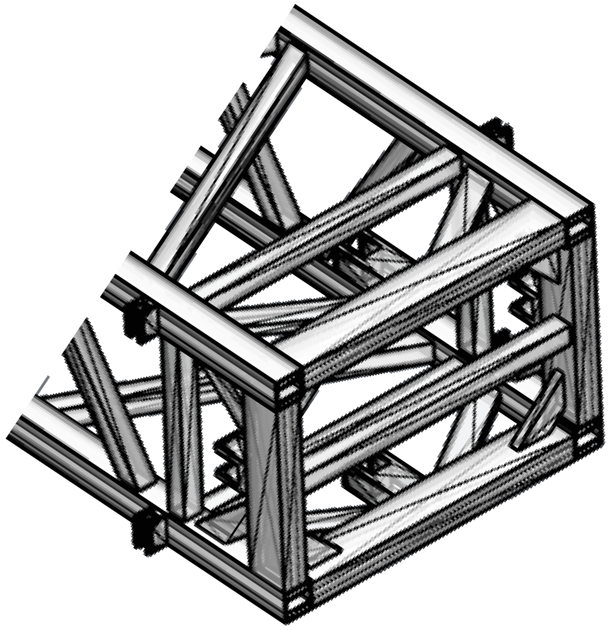


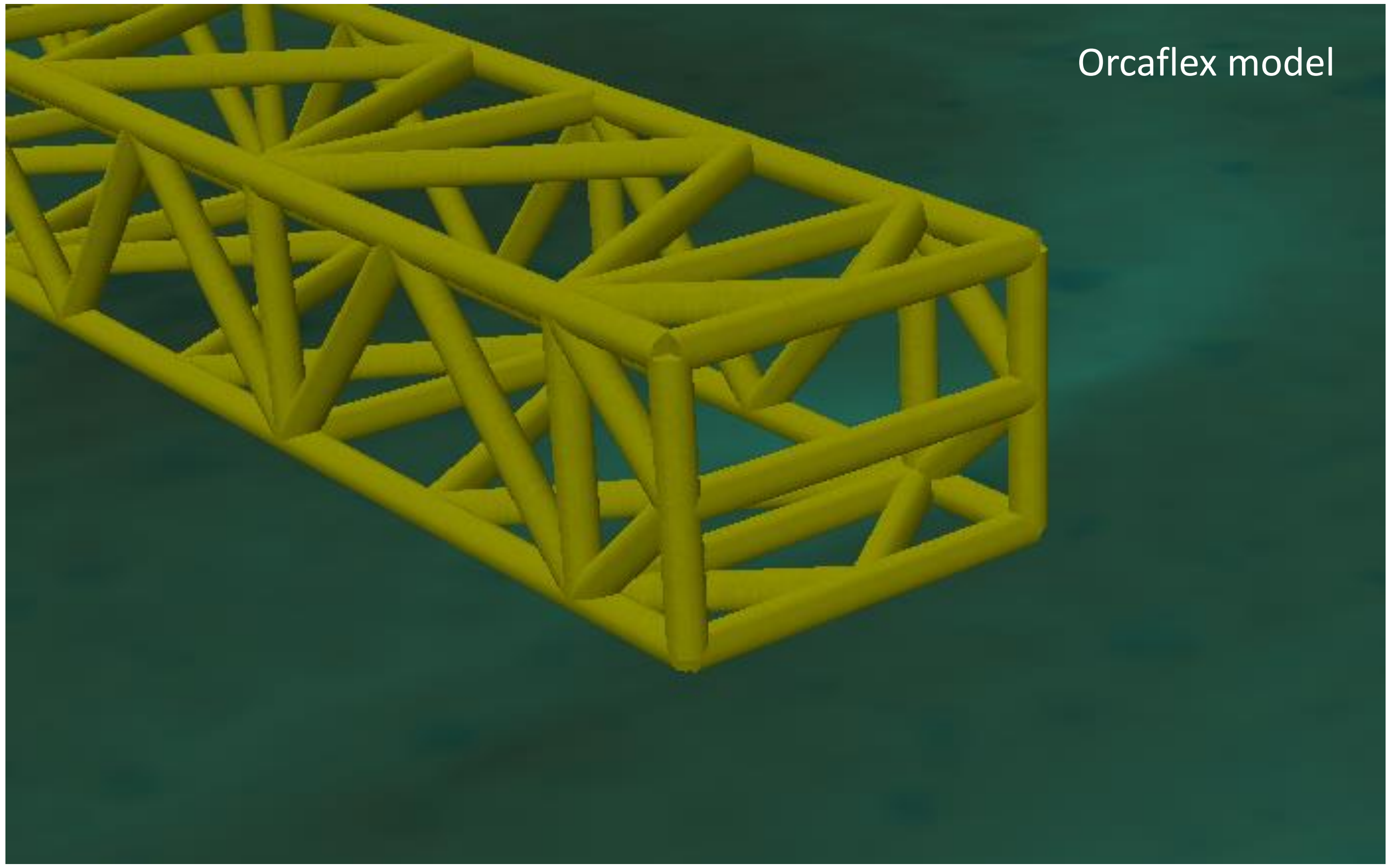






TRUSS modeling

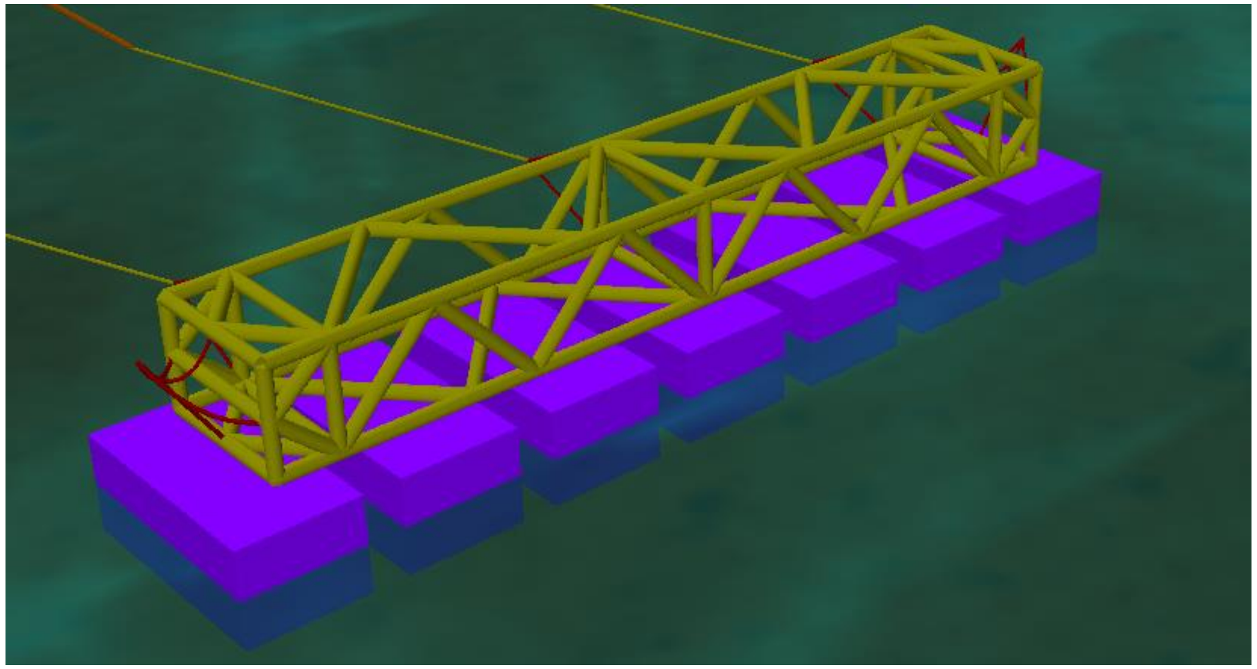




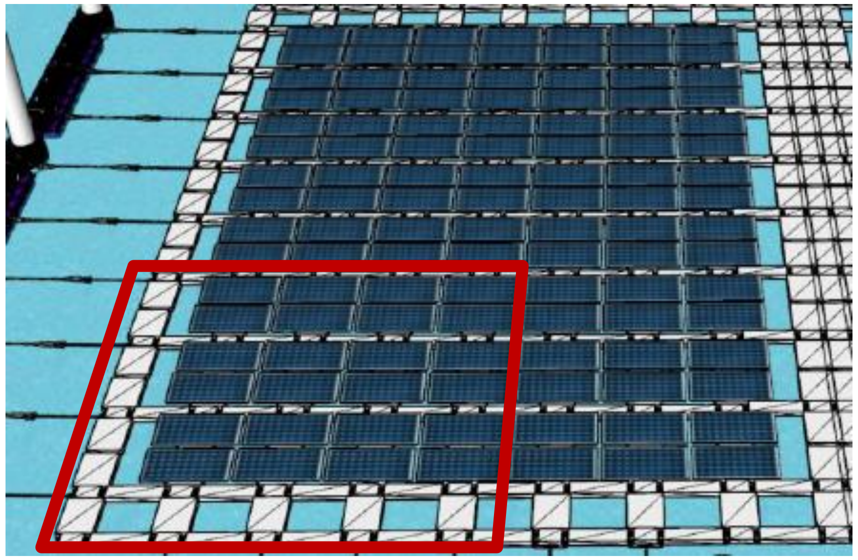
6.3 Truss : Model update
- Vertical end bar removal
- End bracings added
- Additional weight to be considered
    - Beam model : 200 kg
    - Input data : 250 kg (including buoy connection, gussets…)
    - => material density increase

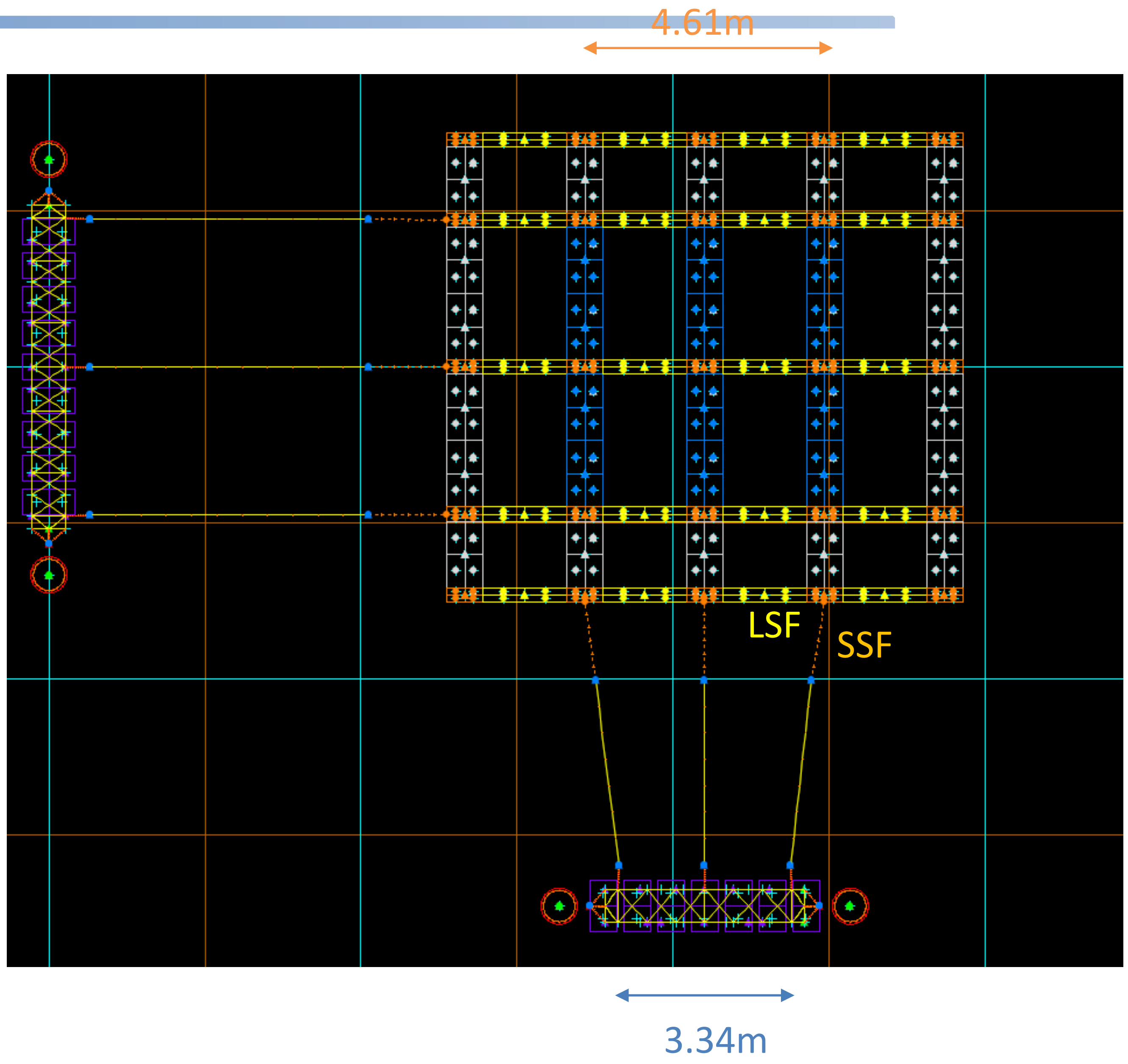
South truss

Two models :
- 3.9 m version
- Additional weight to be considered
    - Beam model : 120 kg
    - Input data : 150 kg (including buoy connection, gussets…)
    - => material density increase



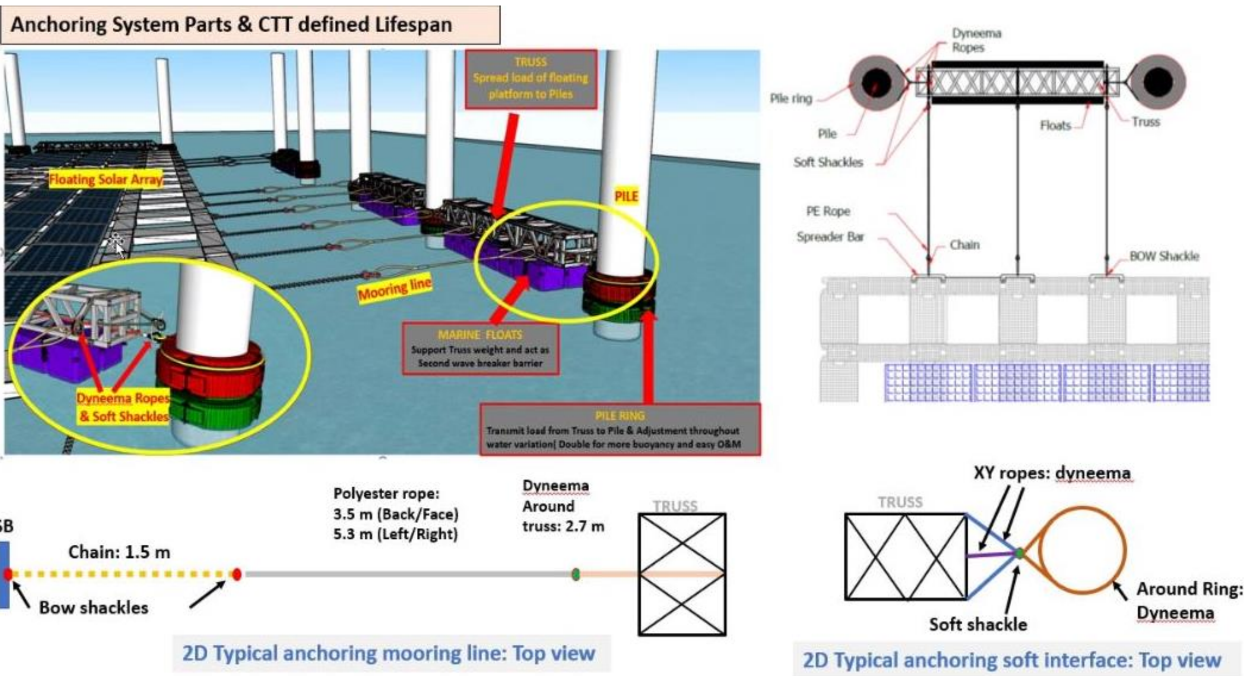
Farm modeling

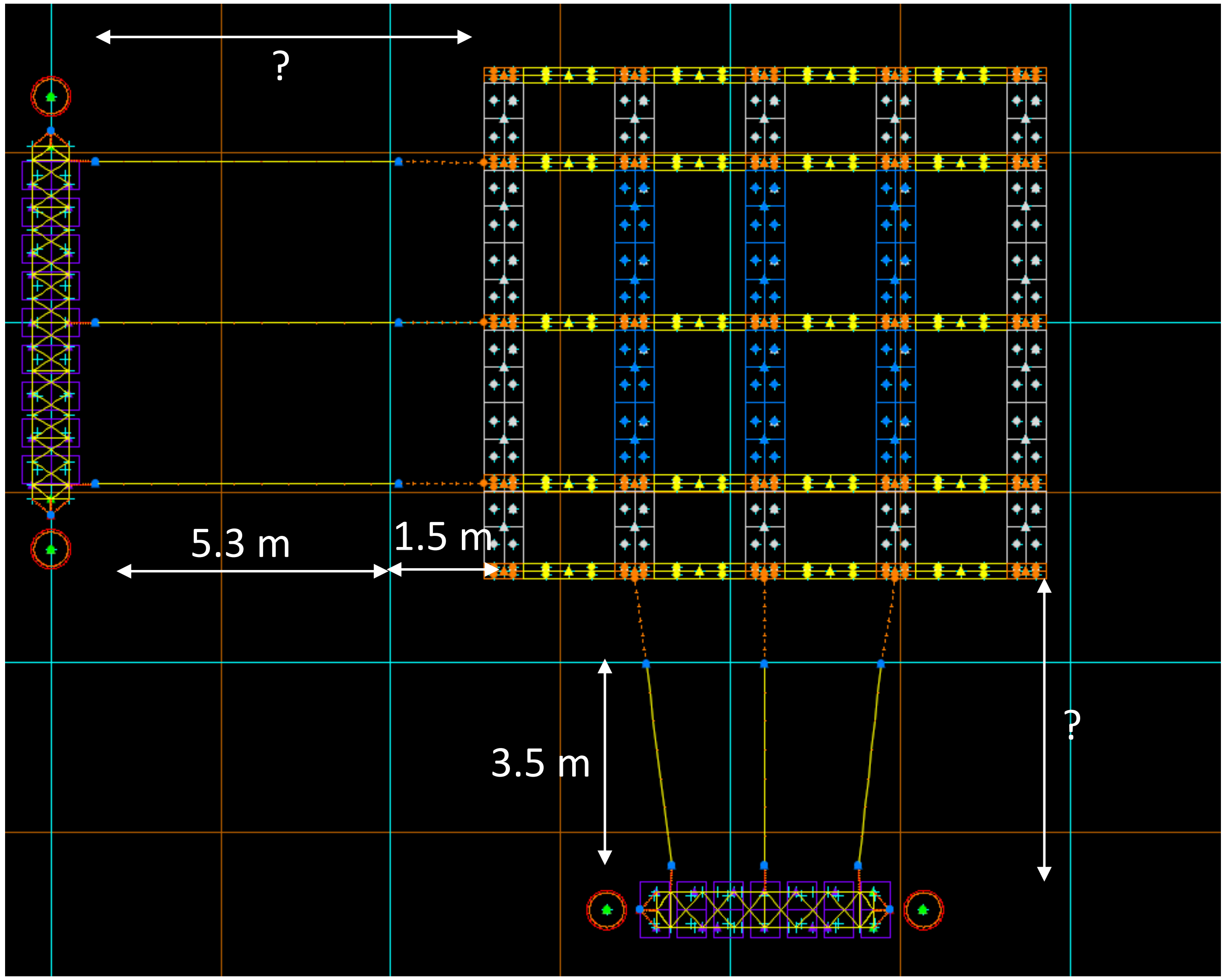




Difference in line spacing with 3.9m Truss

Farm modeling

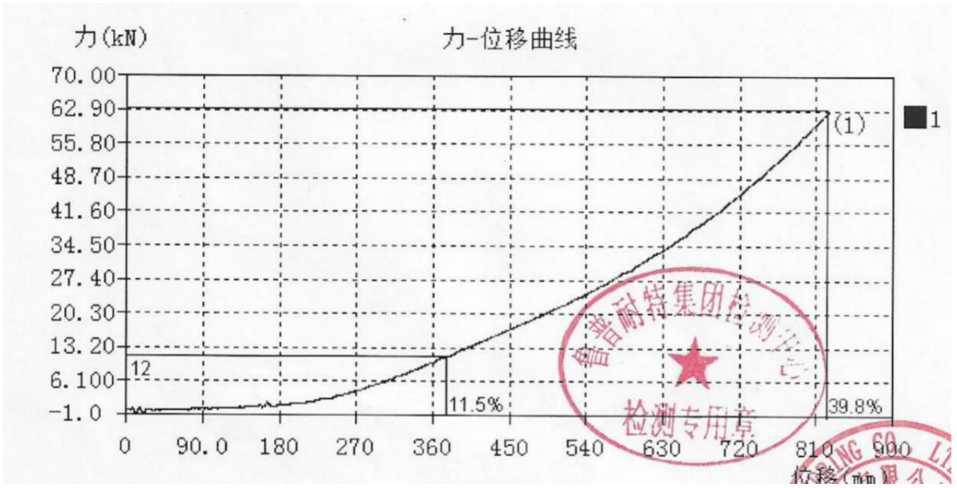


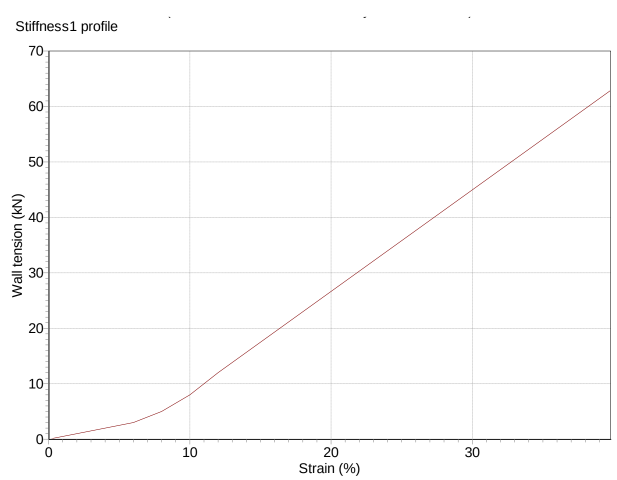


- Chain : 12 mm in 316L SWL 1.7 t
- Polyester rope : selected to have 12% elongation at 12 kN (EA 100 kN) and user defined stiffness curve

Horizontal distances between farm and truss

- To be calibrated
- Tension at equilibrium in the mooring lines

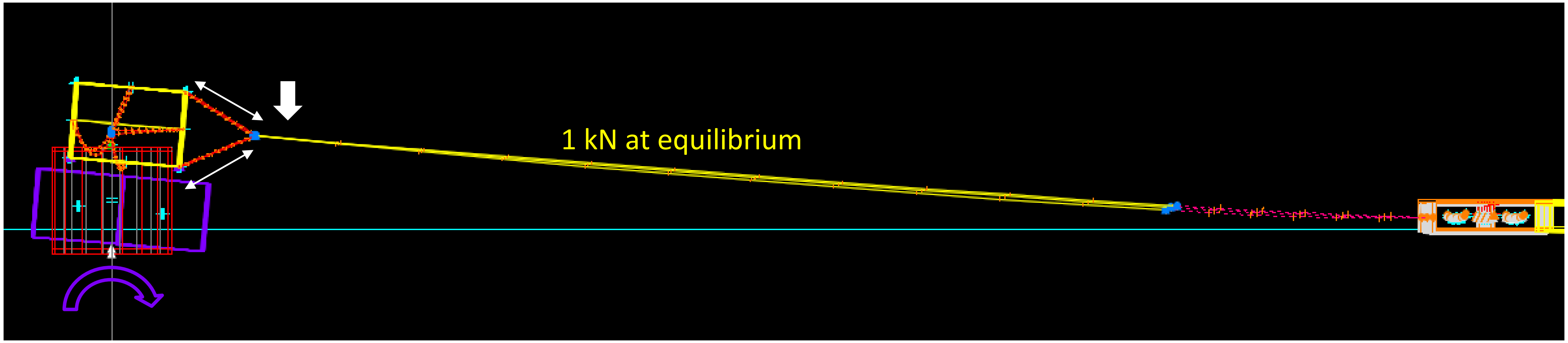


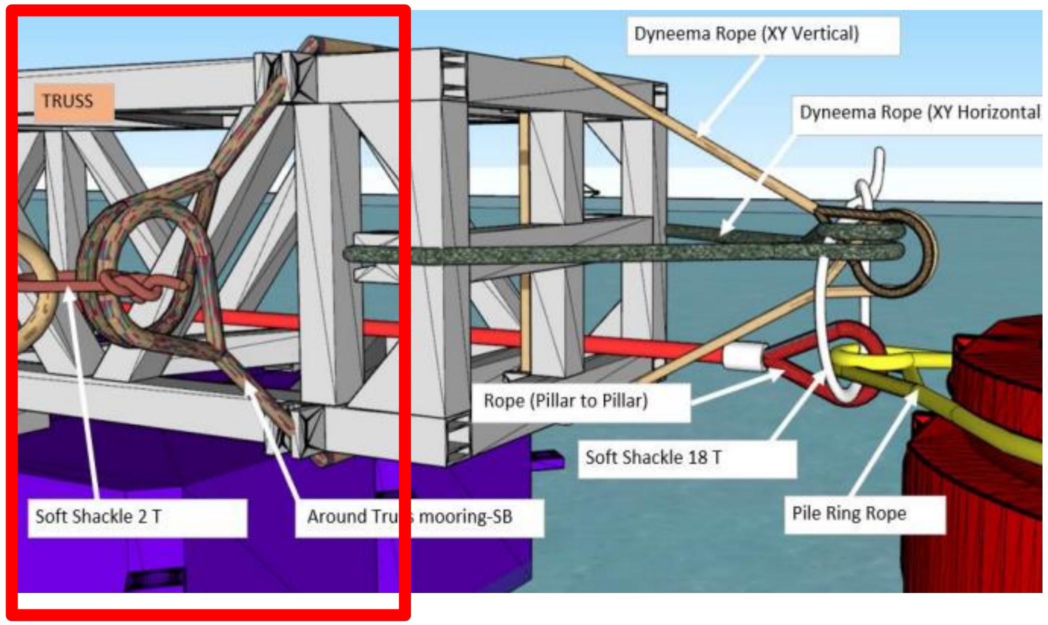


Global modelling

Sling around truss assumption to be tested

- Free rotation around truss
- Line length difference





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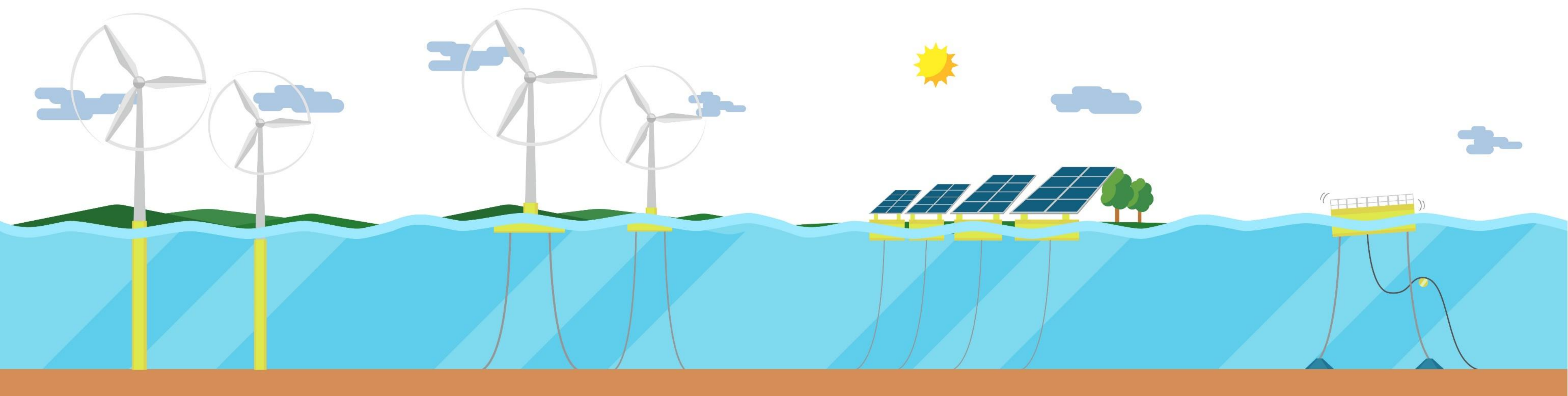

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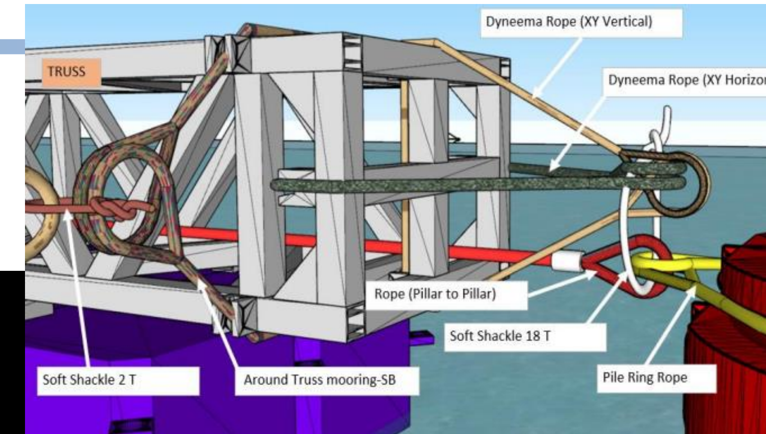
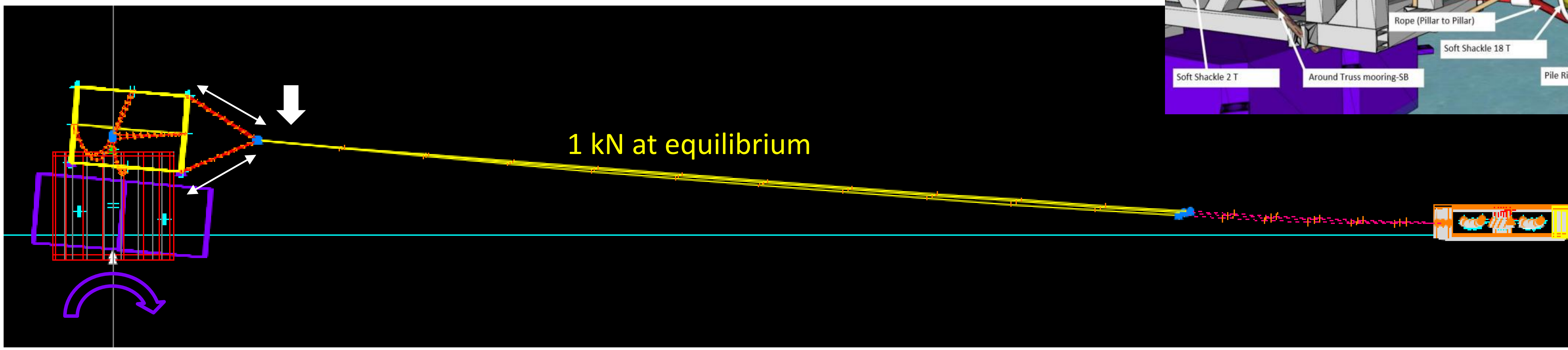
Agenda

- Mooring line assumption
- Farm modelling sensitivity
- Wind/waves sensitivity
- Site data and List of simulations

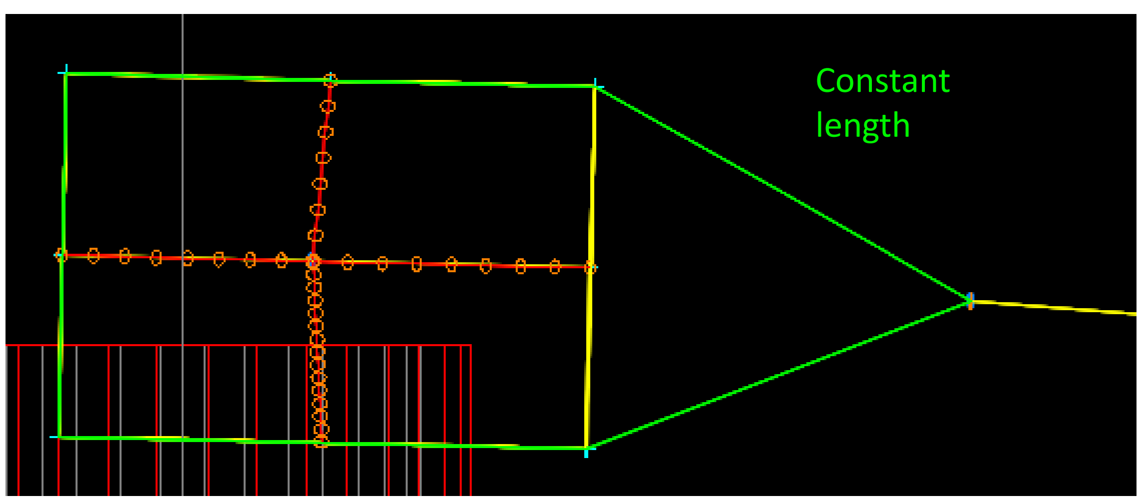
Global modelling

Sling around truss assumption to be tested
- Free rotation around truss
- Line length difference



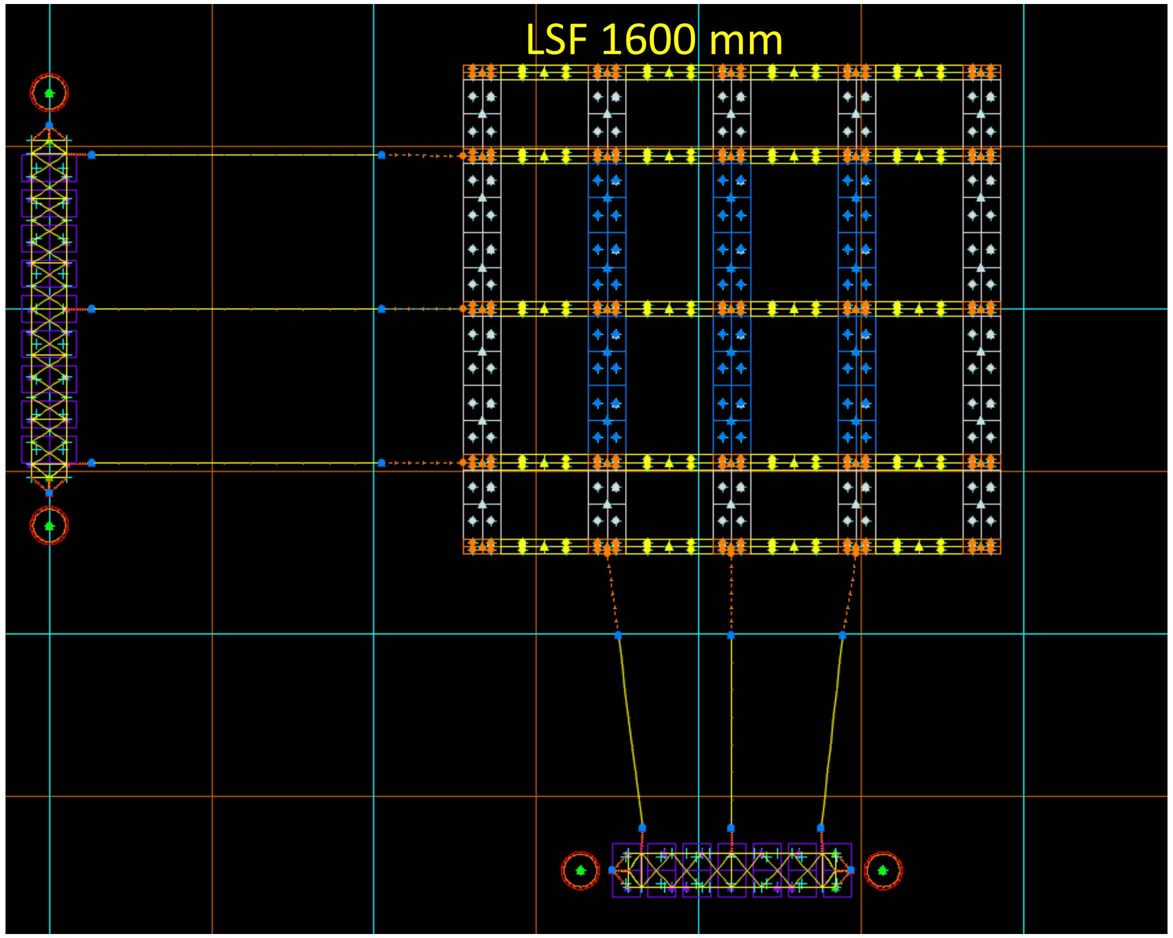


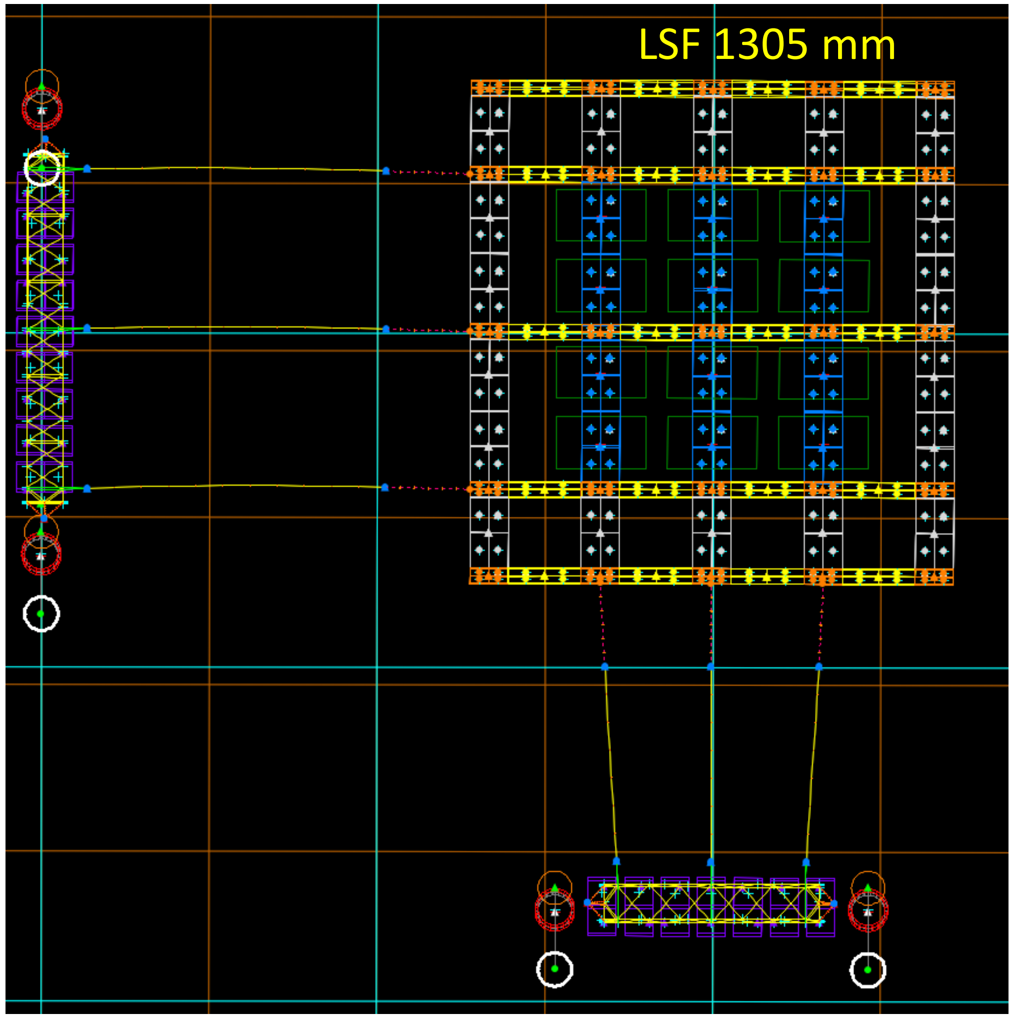
Assumption changed with a slinding winch (constant length, with dynema stiffness)



Global modelling

LSF update : 1305 mm





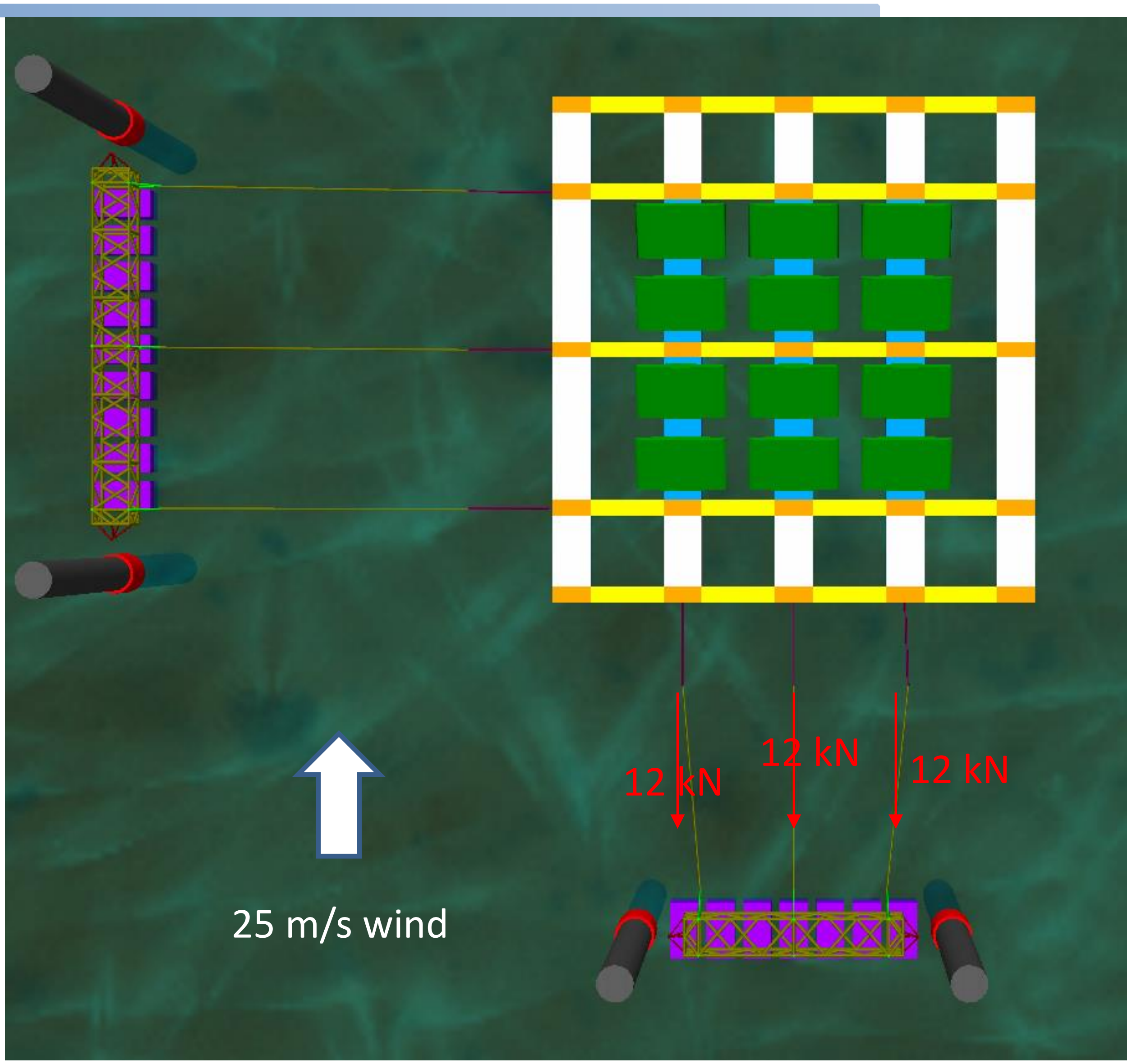
Wind load calibration

Maximum wind speed available in the data : 25 m/s

Use of wings on MSF buoys

Surface and drag coefficient calibrated to have

12 kN in mooring lines in extreme static wind (25m/s)

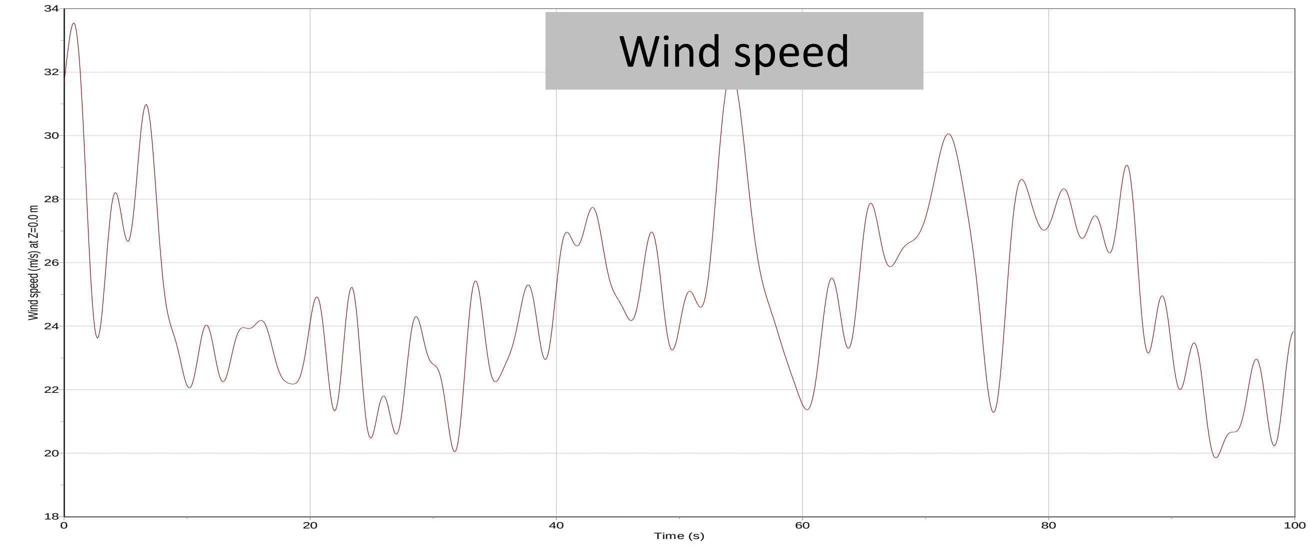


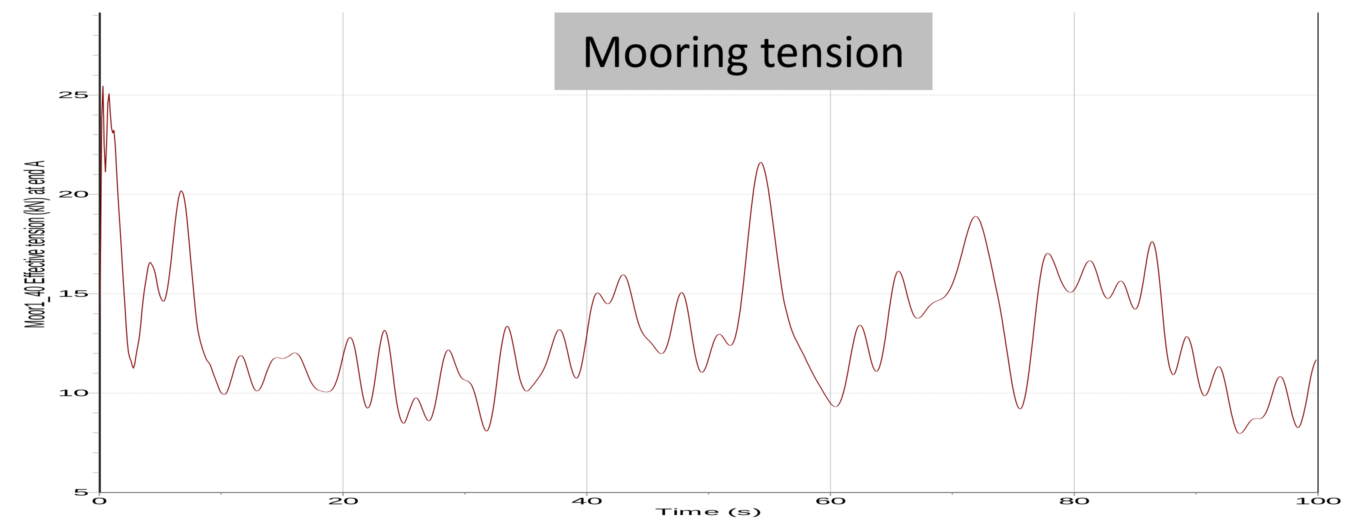
Wind load calibration

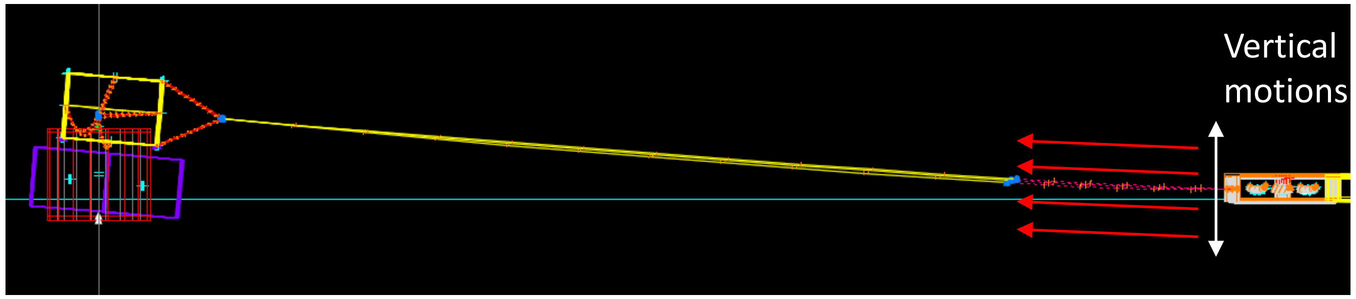
Turbulent wind time serie at 25 m/s

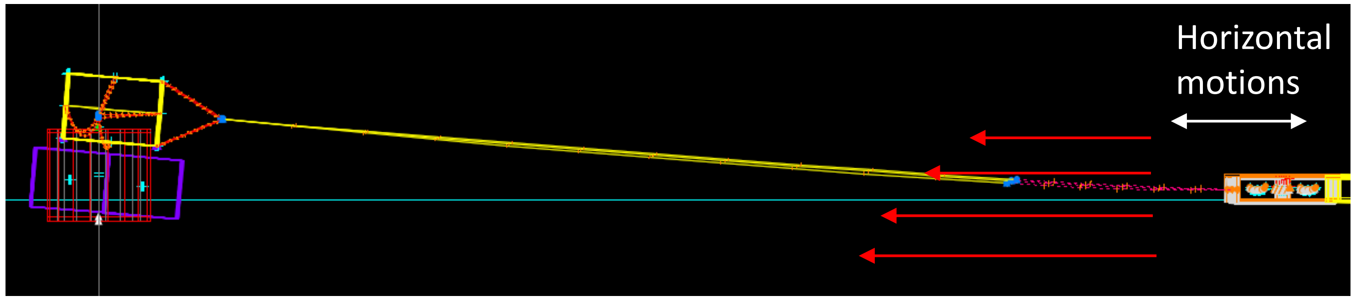
- Tension in mooring line directly linked to wind speed
- Very limited vertical motions in the farm
- No impact of farm vertical motions on tension applied to the truss through the mooring lines

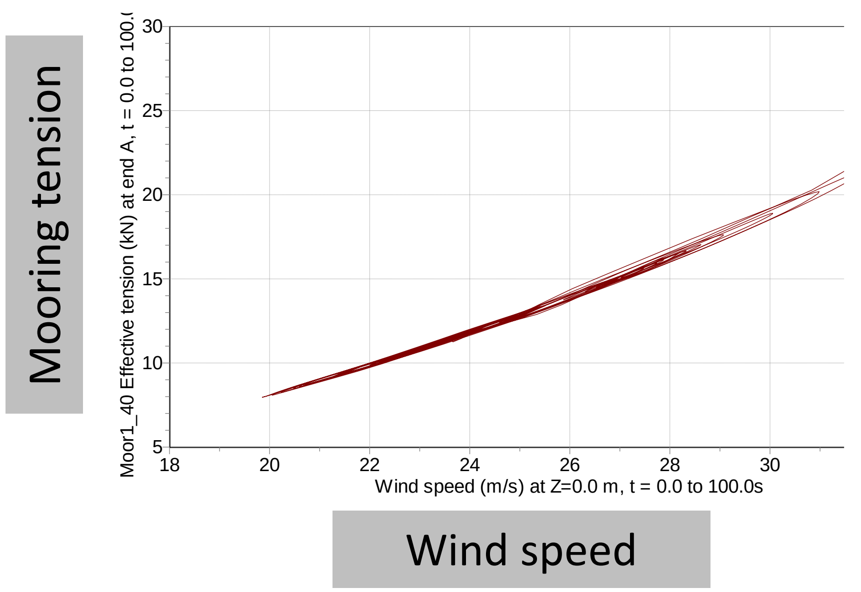
=> Assumption to model the farm as one single buoy with free motions in x, y



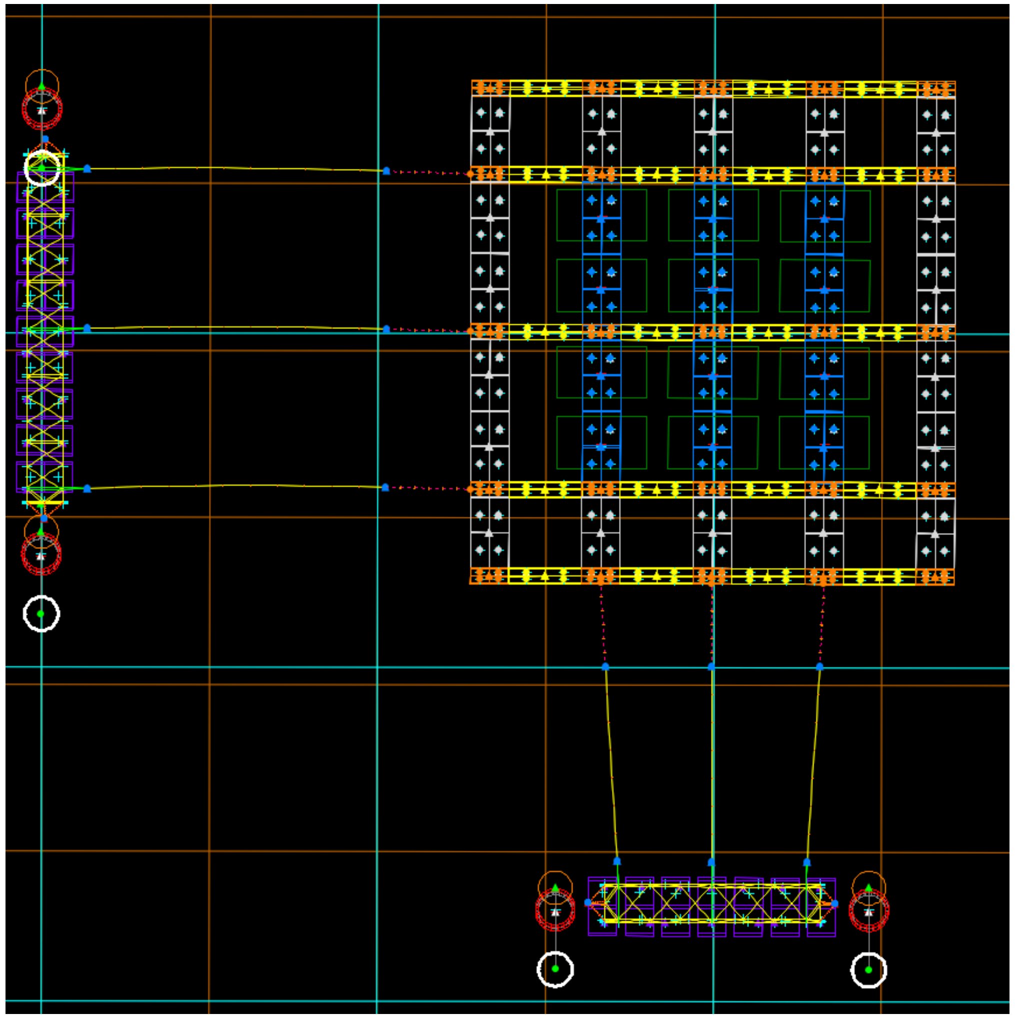


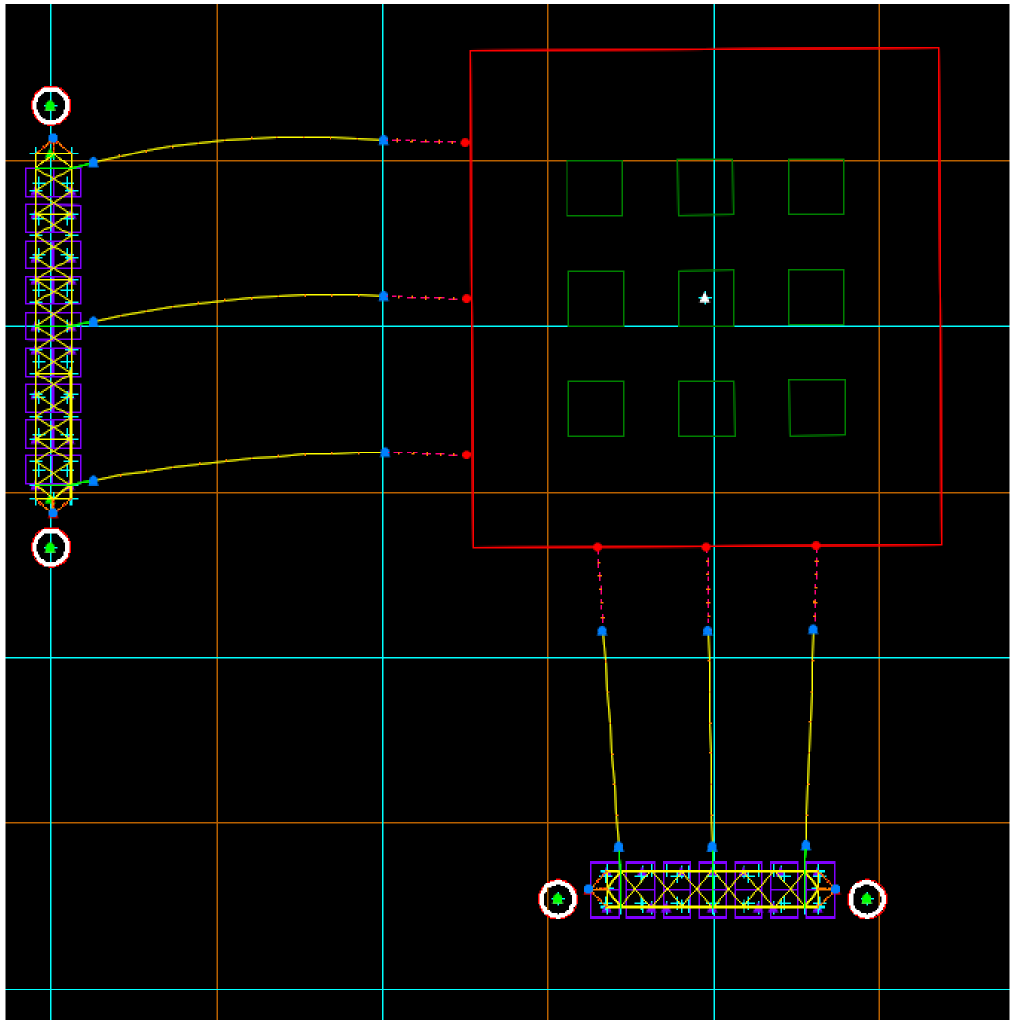






Wind load calibration





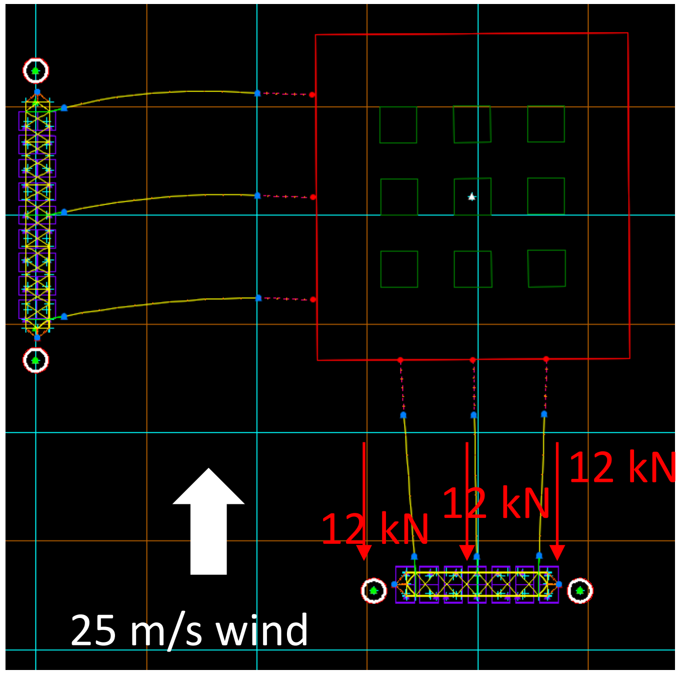
Farm

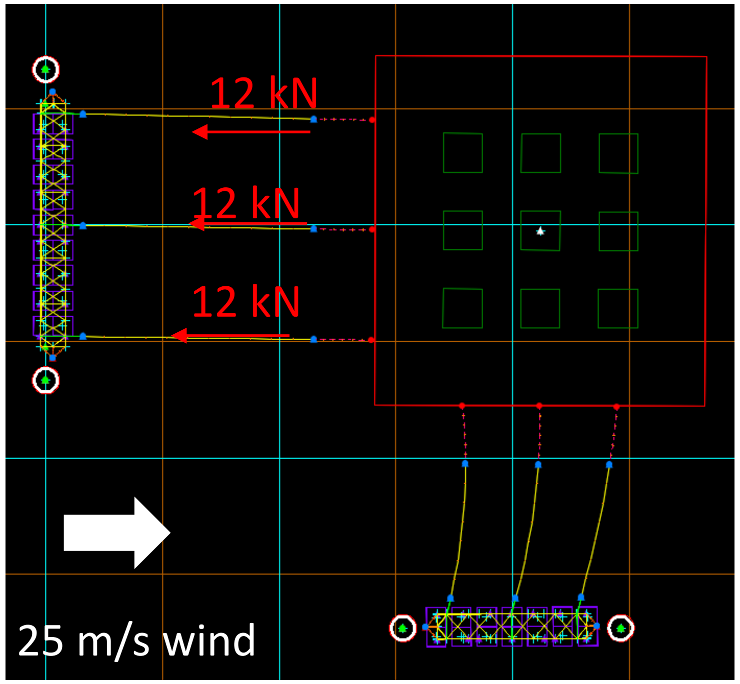
- connected to a boundary free
    - X
    - Y
- Wind loads through wings element

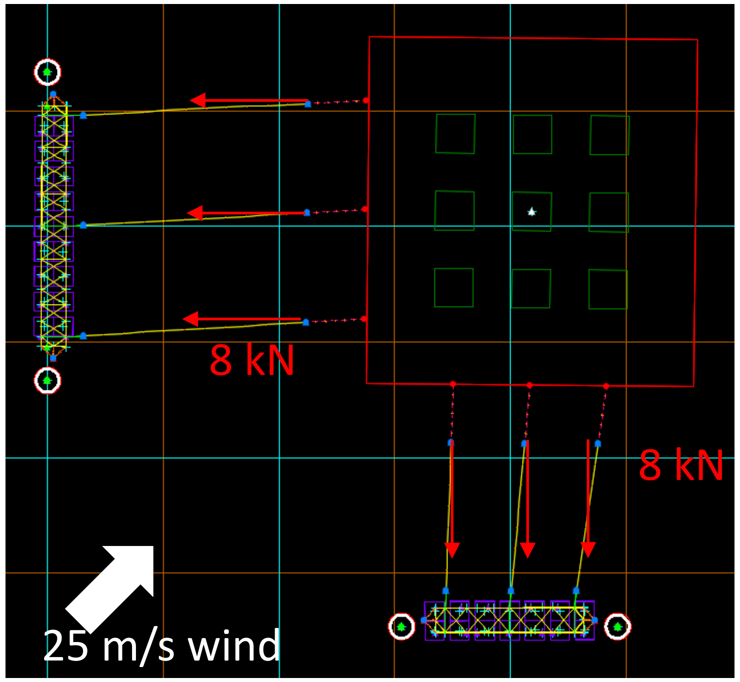
Wind load calibration

Assumption :

- same wind load at 0° and 90° to have 12kN in fairlead (even if wind loads in Est-West conditions should be lower)
- for same reference wind speed of 25m/s



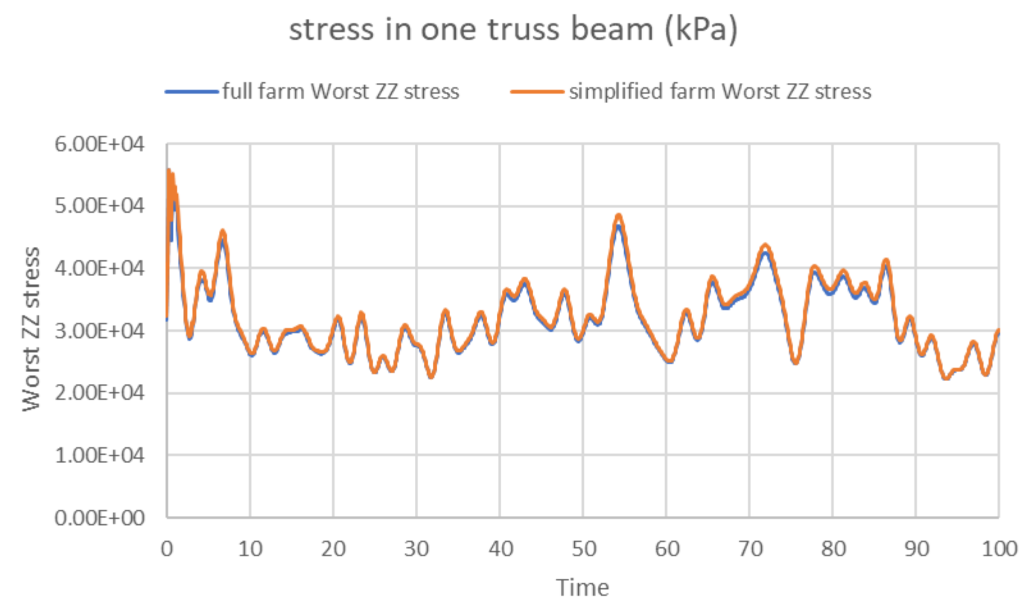




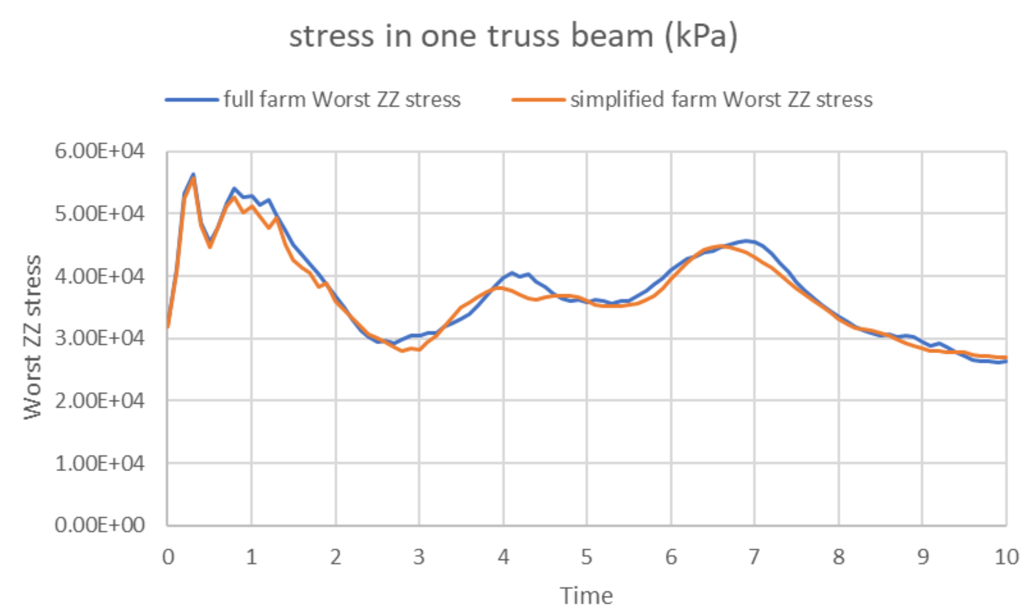
Wind load calibration

Comparison Full farm vs simplified farm

WIND ONLY



WIND + Wave



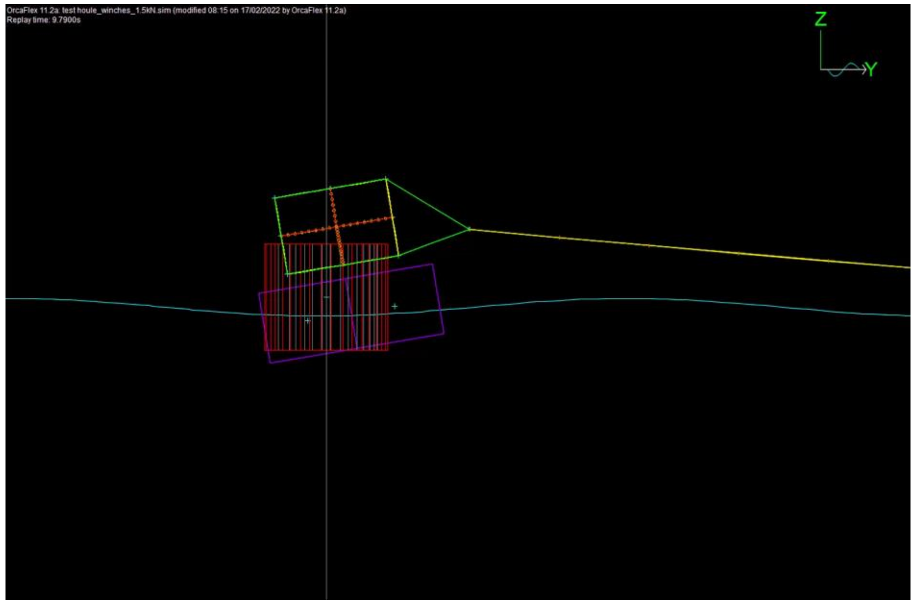
Same load level and variations
Assumption to use the simplified model

Waves behavior

Impact of hydrodynamic coefficients

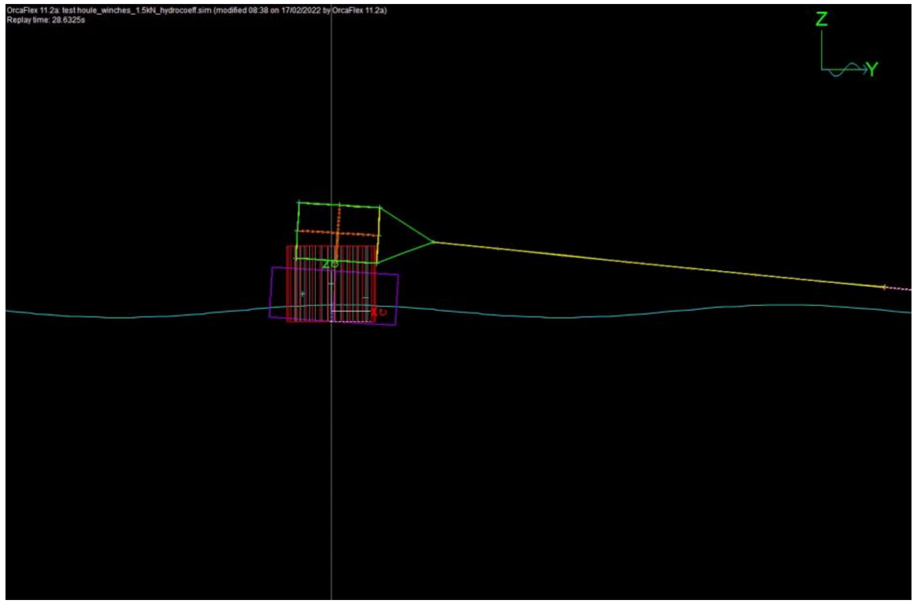
- No hydrodynamic coefficients on supporting buoys

No drag and added mass



Drag Cd=1

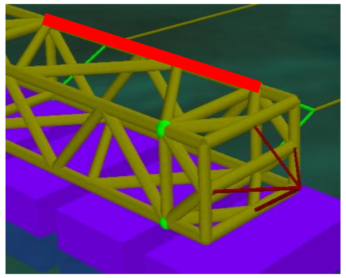
Added mass Ca = 1 (Cm=2)

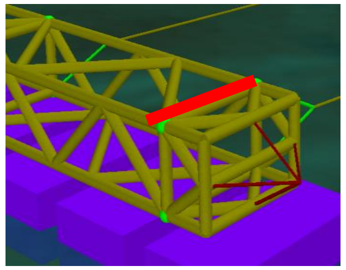


Wind load calibration

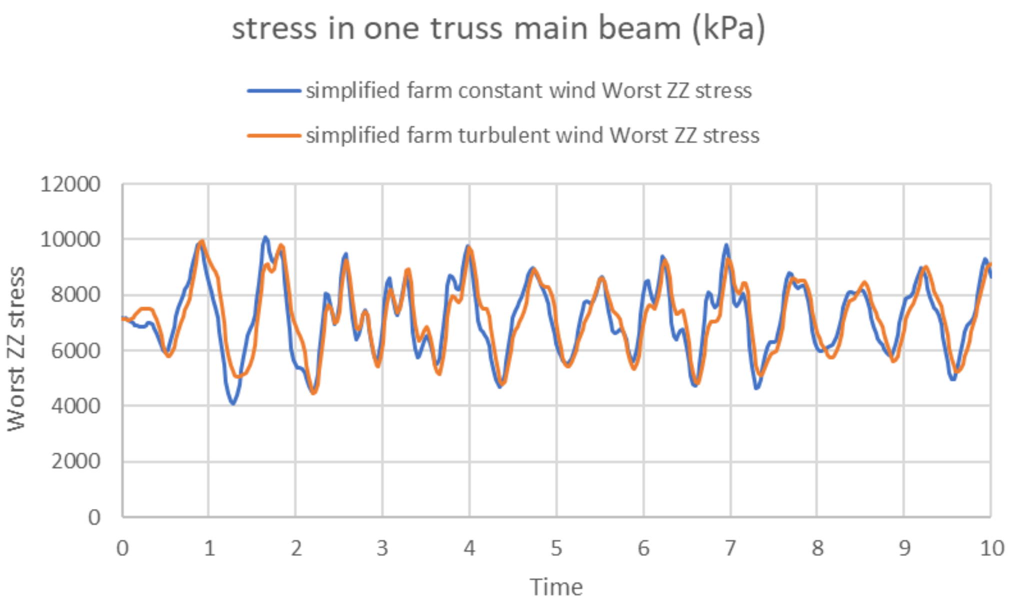
Comparison Constant wind vs Turbulent wind

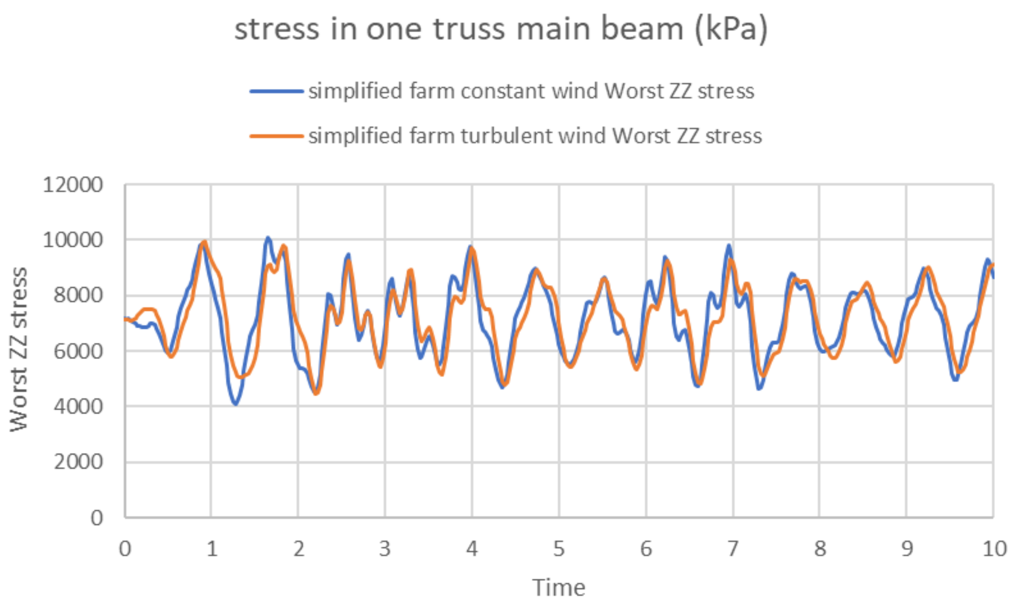
- Extreme conditions
    - 25 m/s wind speed
    - Wave H=0.1 m T=1.5s
- Average conditions
    - 3 m/s wind speed
    - Wave H=0.05 m T=0.75s



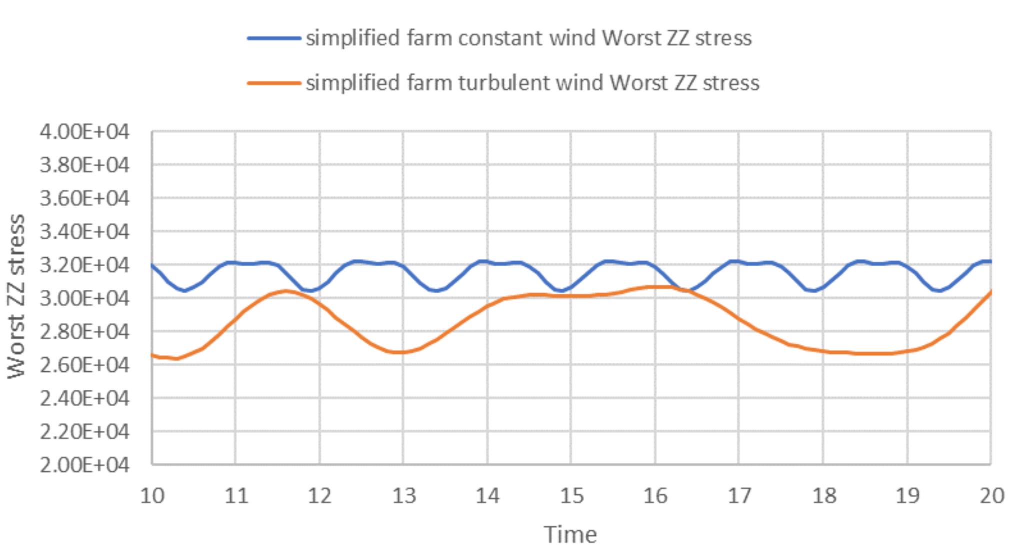


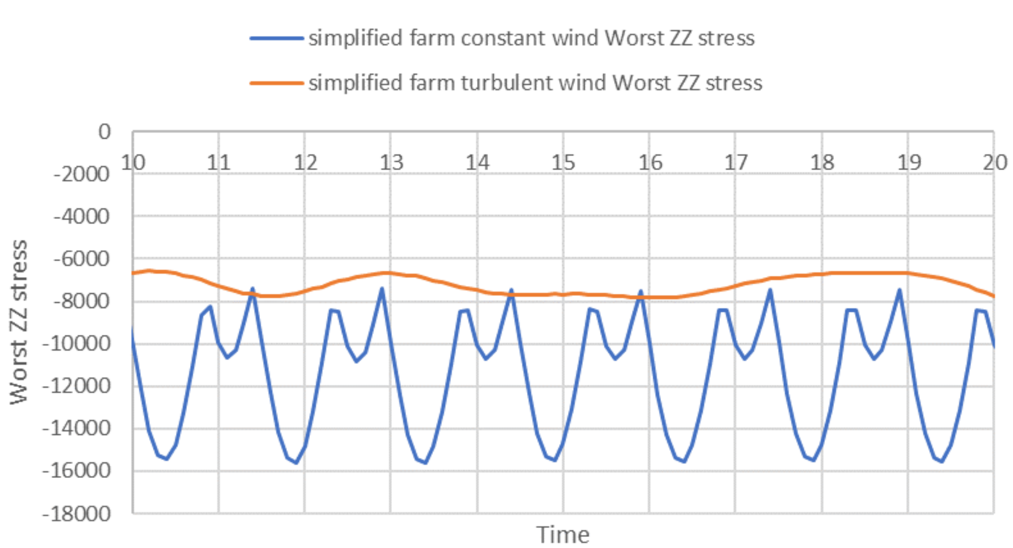
Average Wind





Extreme Wind



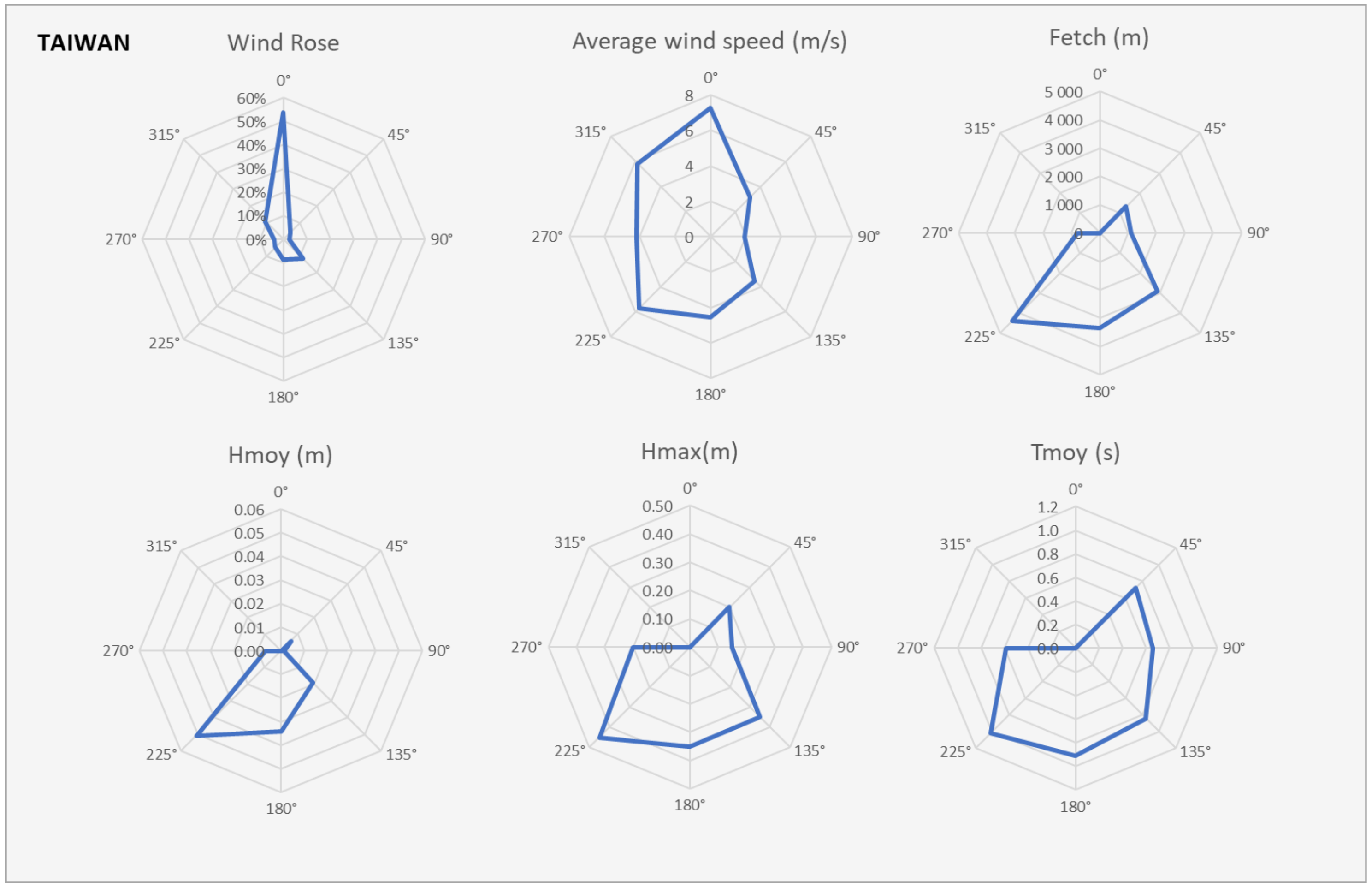


Site Data

Water depth

- 50 % time with water depth less than draft (7 cm)

Regular wave calculation as a function of
- **Wind speed and direction**
- **Fetch**



Site Data

8 load directions (0 to 360° with 45° steps)

Each direction is affected one simulation direction (0°, 45° or 90°)

16 wind speed with existing waves

Each wind speed associated to several regular waves

=> Total 2423 simulations