Honeymooring 2.0

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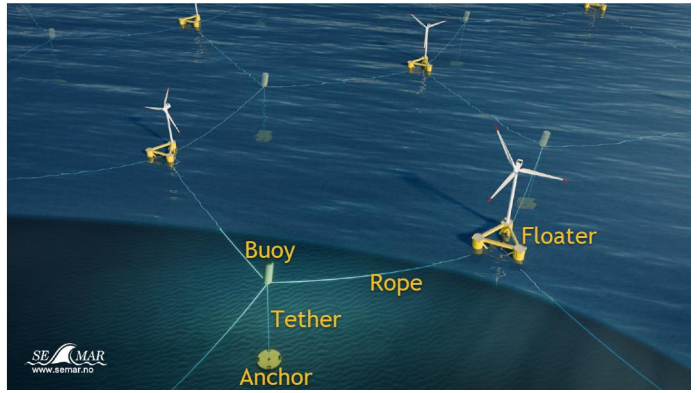
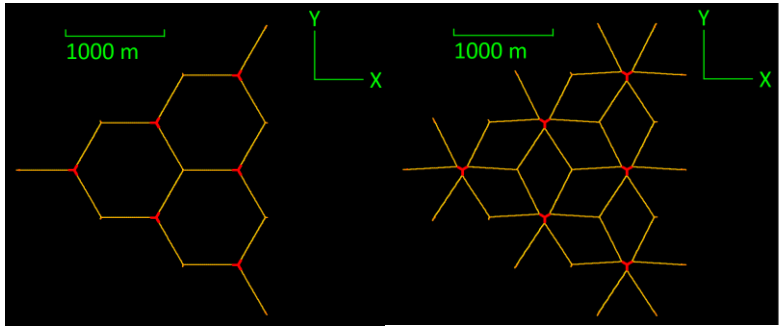
EERA Deepwind Conference 2025

SEMAR

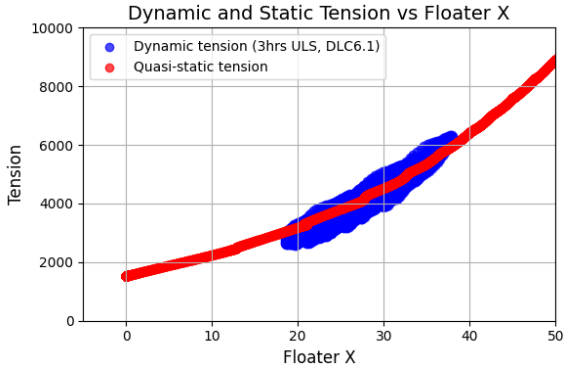
Presentation outline



1. Honeymooring introduction



2. Honeymooring reference designs

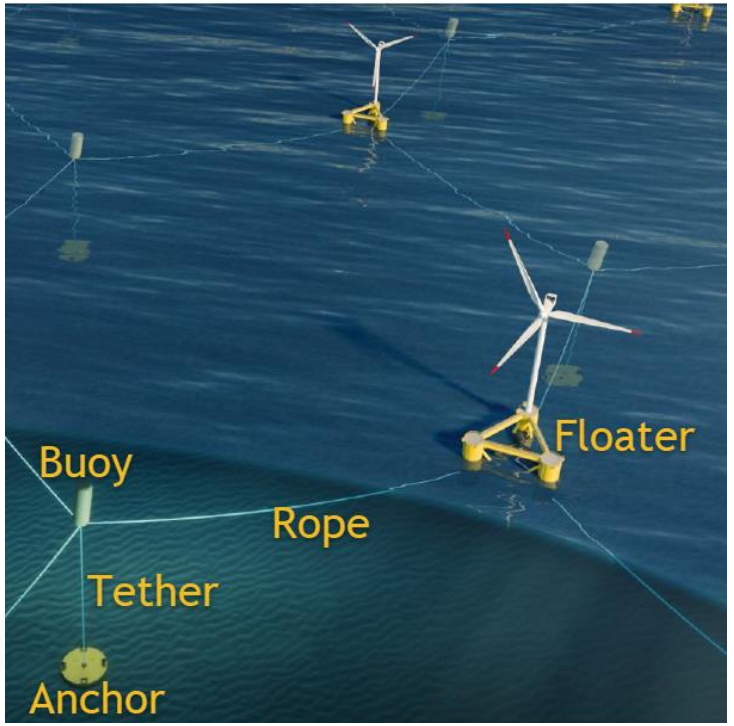


3. Analysis results

A Game Changer for Floating Wind Park Developers

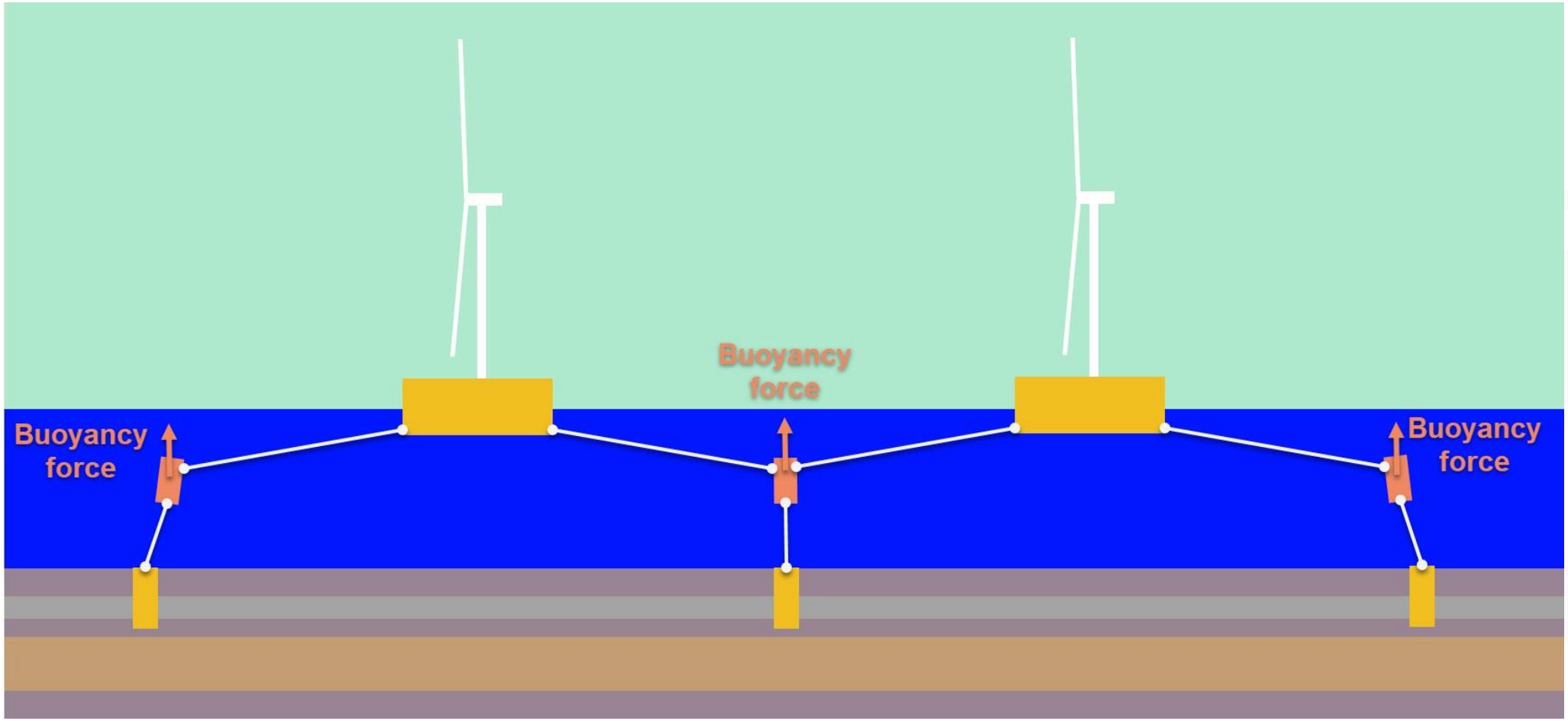
Honeymooring is a grid solution for sustainable planning of floating wind parks to minimize cost and environmental impact, and maximize area utilization.

- Reduce cost vs traditional mooring solutions
- Simplify interface with FWT both contractually and technically
- May allow for integrated mooring and power cable solutions
- Reduce seabed footprint vs traditional mooring solutions
- Allow for fishing activities within the wind park
- No seabed damage from mooring lines or chains
- Allow for less schedule risk with pre-installation and testing of mooring

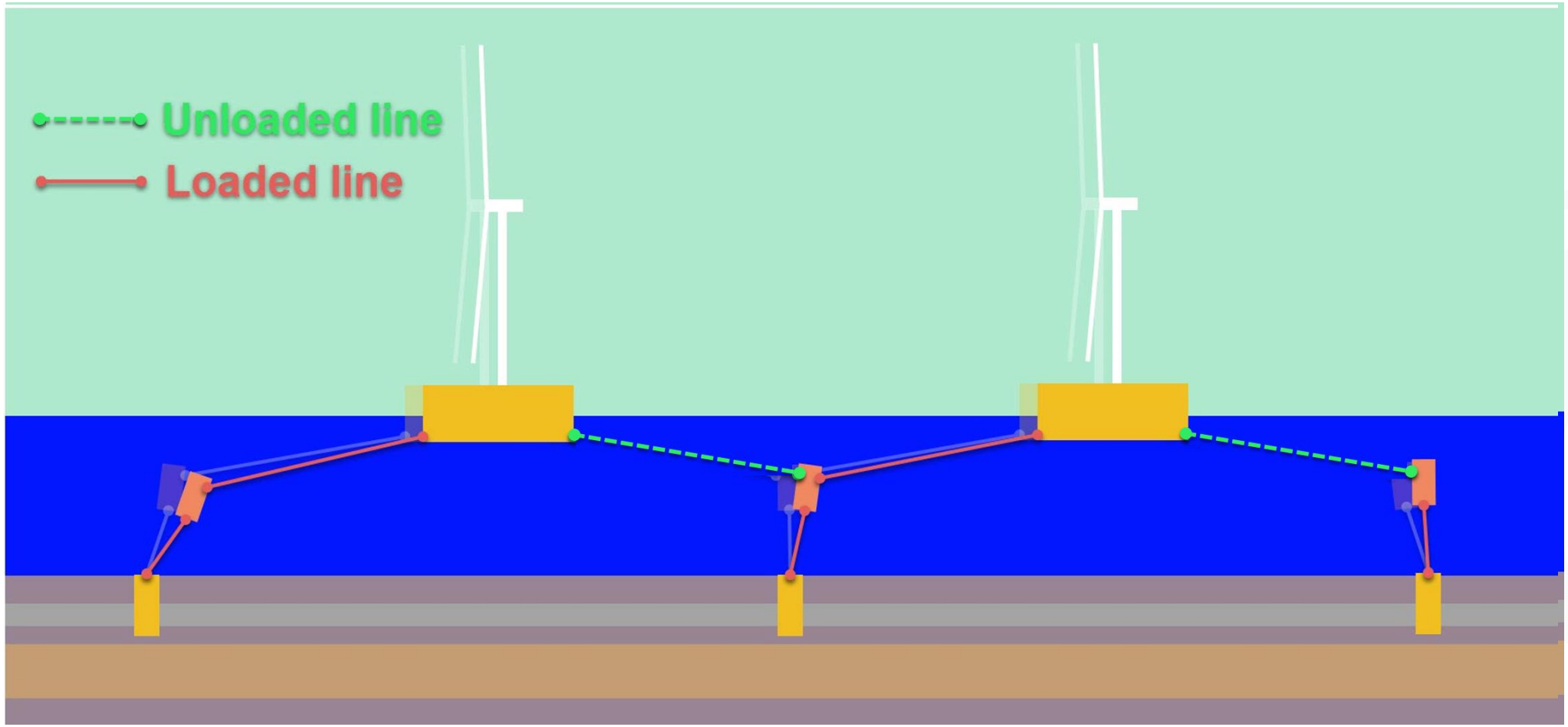


SE MAR

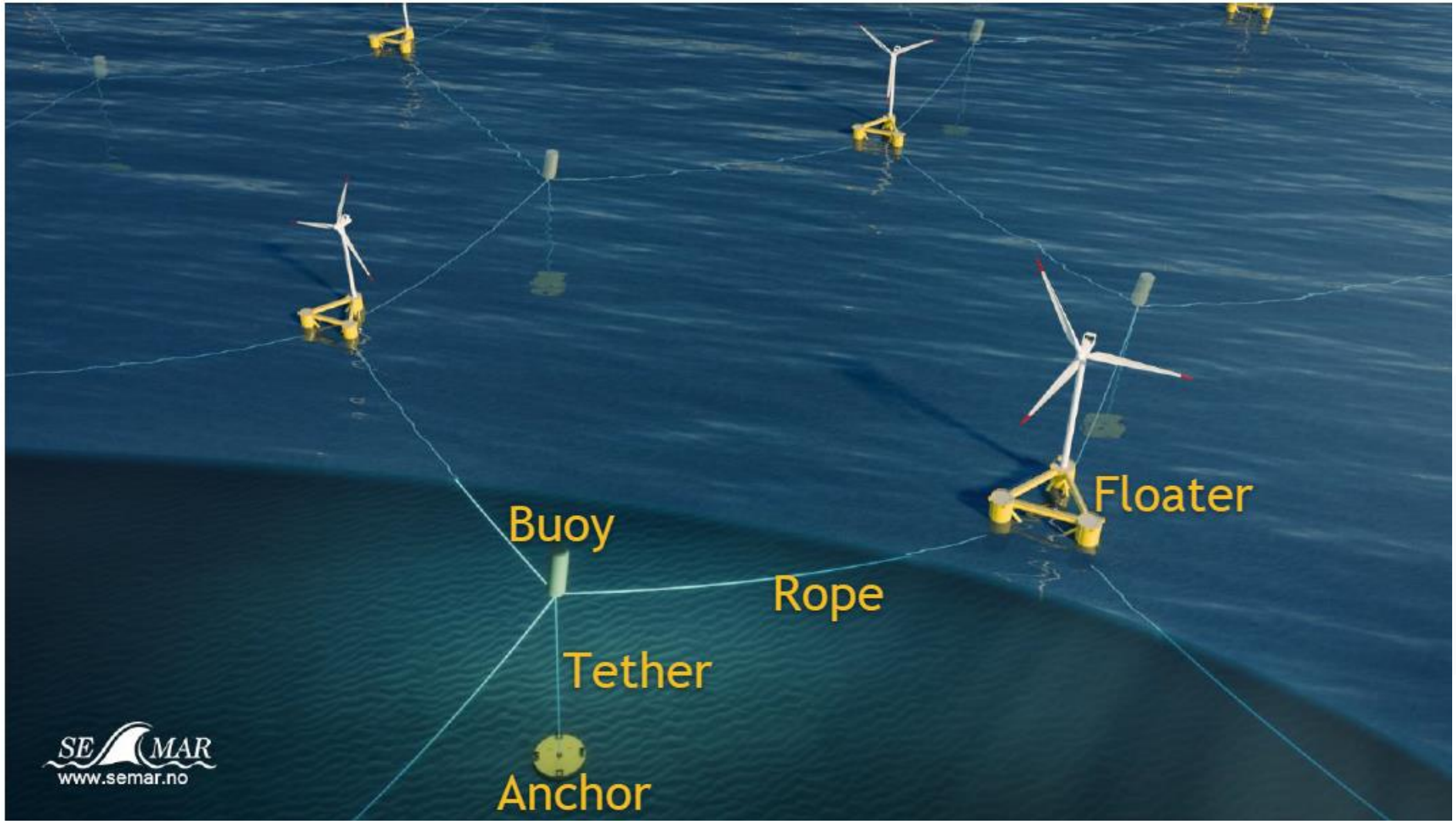
Saves cost by providing anchor-sharing & load reduction



Buoys acts as load reduction devices, and are shared by up to 3 FWT



Standardized components with simple interfaces



Cluster-philosophy

"Real life" Yield-Test-Case – South Korea

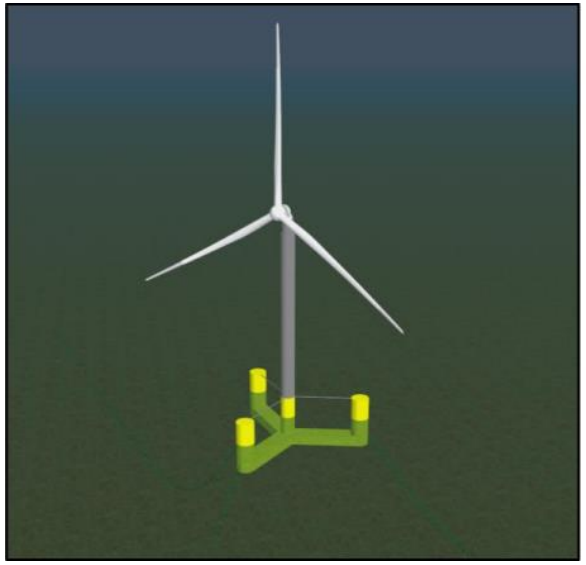
Ref. **Vind AI** (Vake-models: TurbOPark/ Jensen):

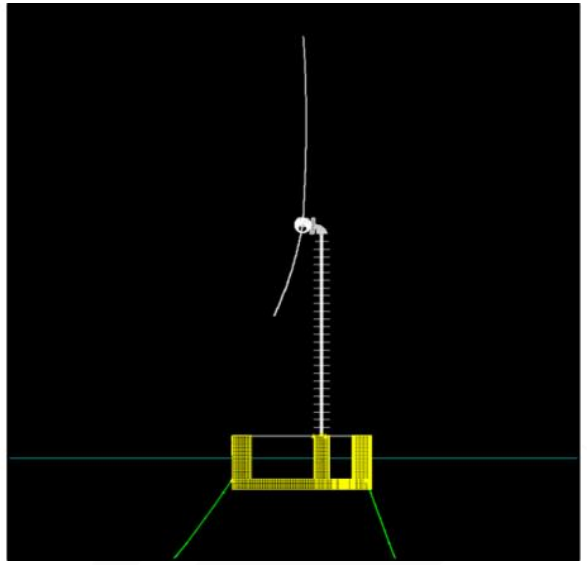
- No of turbines: 54
- Turbine rating: 15 MW
- Clusters give 75% free area

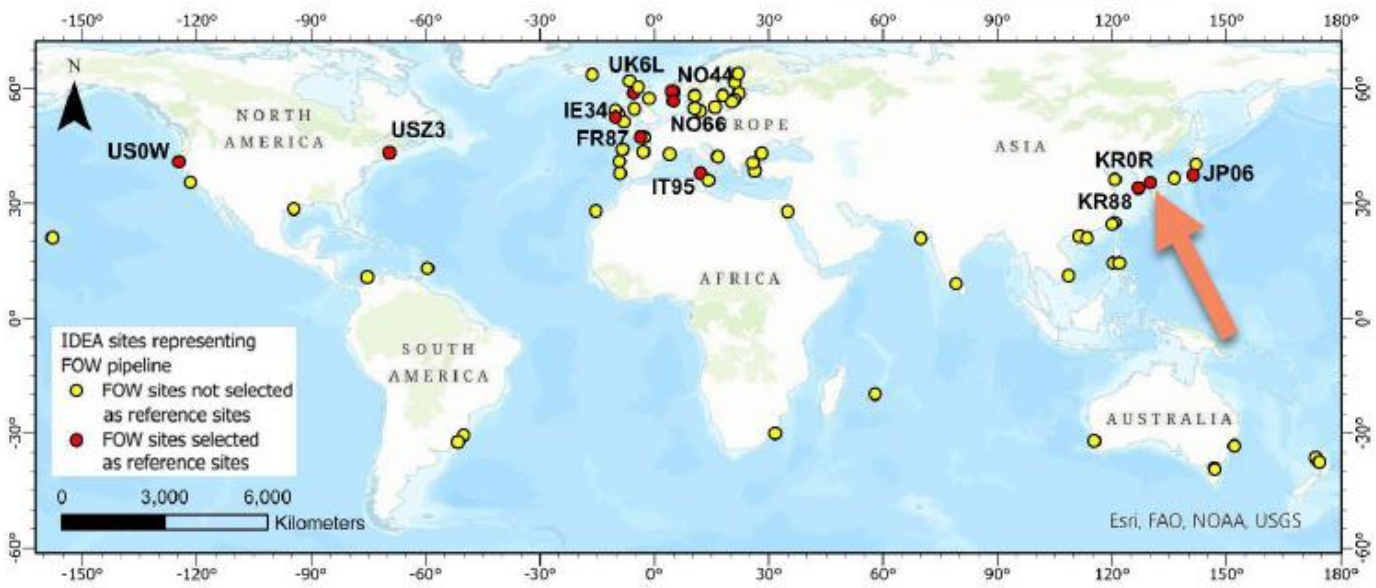
Spacing:	~8 Rotor-diameters	4 Rotor-diameters
Wind rose	Planned polyester layout	Honeymooring compact clusters
Analysis version	4.9.0	4.9.0
PARK		
Area	155 km²	155 km²
Total sub area	23 km²	118 km²
PRODUCTION		
Capacity	810 MW	810 MW
Capacity factor	42.3 %	42.3 %
Net energy	3007 GWh	3003 GWh
Total wake loss	13.2 %	13.3 %

Honeymooring reference designs
Design basis summary

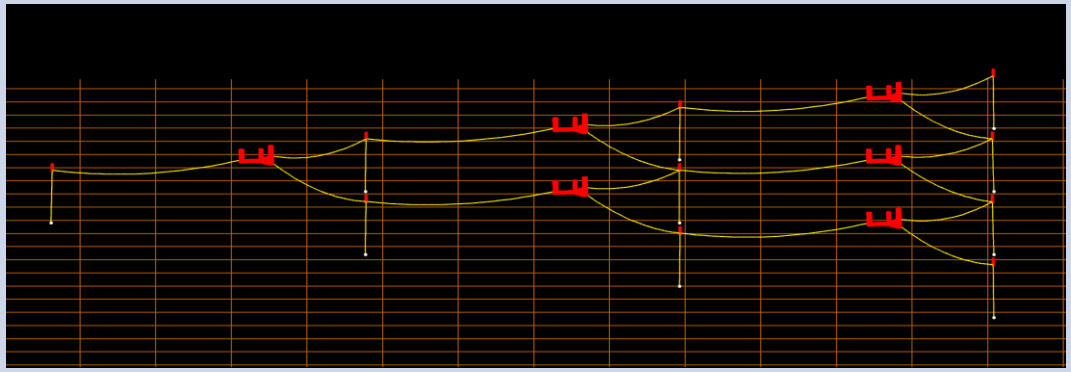
- IEA 15MW RWT
  - Drag-disk modelling tuned for idling
- VolturnUS-S semi-sub
  - As provided by Orcina+current
- Ulsan (Korea) site
  - 188m depth
  - Hs_max=11.18m, Current=1.63m/s
  - Wind=42.16m/s@100m, TI=0.14
  - Assume omnidirectional
- Assume ULS driven: DLC 6.1
- Consequence Class 1
  - Td=1.3*Tmean+1.75*Tdyn
- 6 floaters in a cluster
- 4D spacing



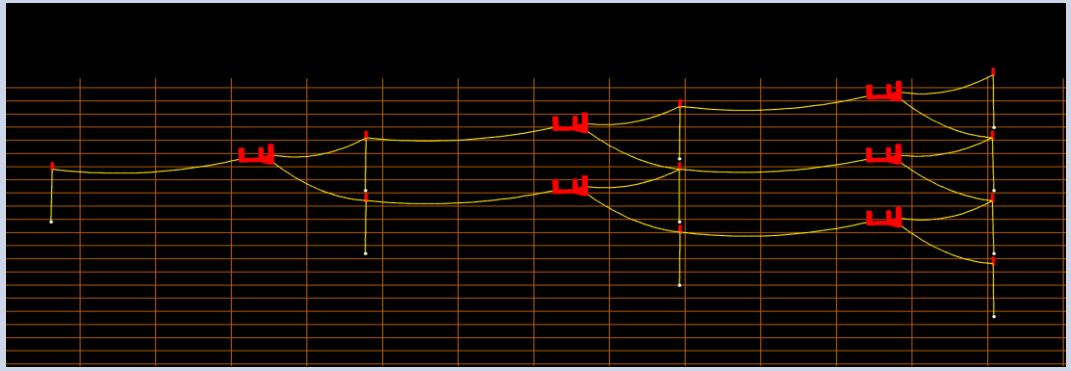
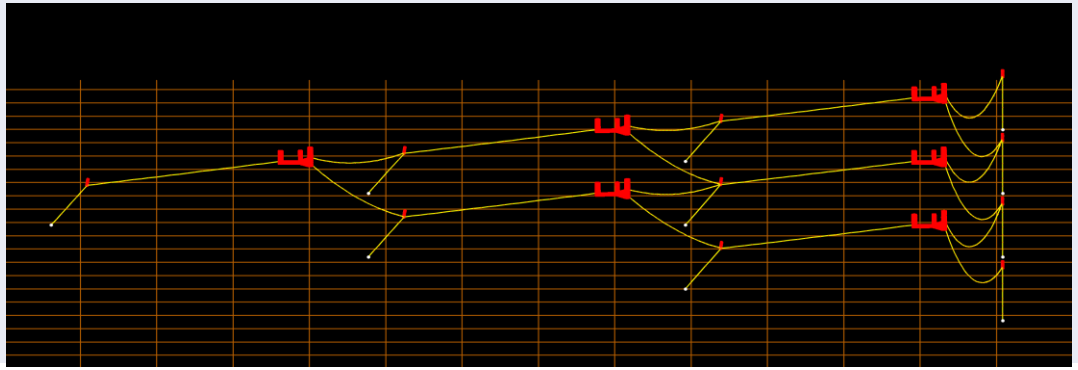




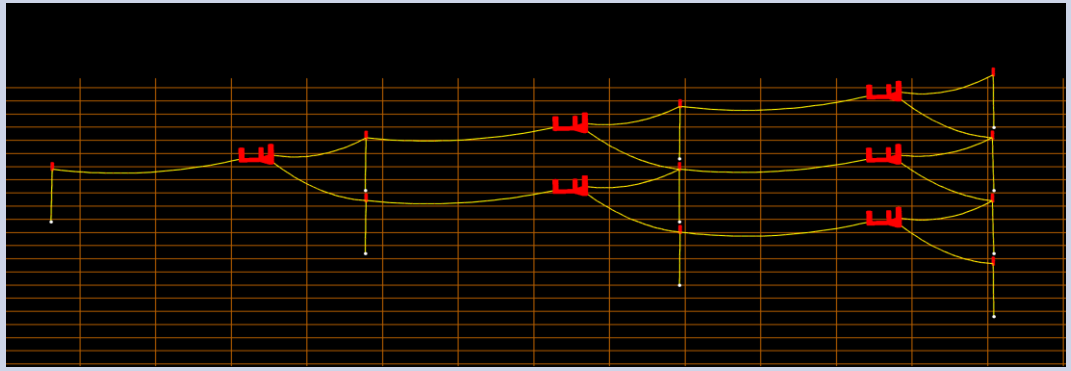
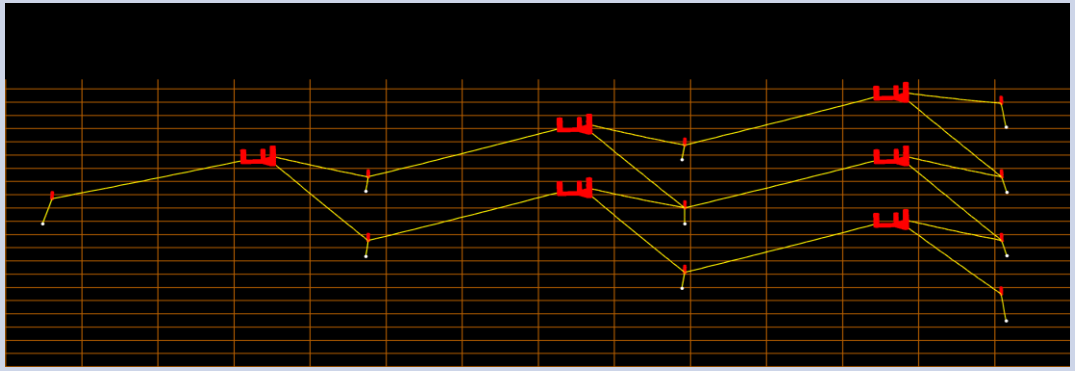
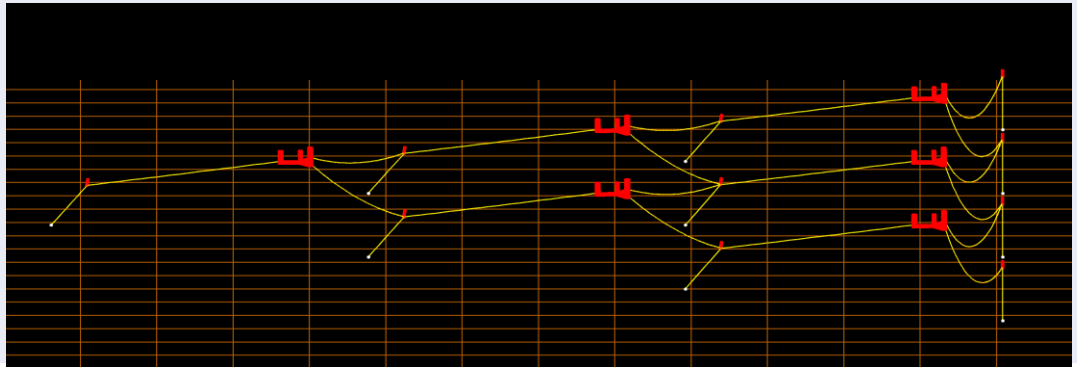
Here is the original Honeymooring

Applied force per floater	Honeymooring 1.0	Honeymooring 2.0
0 kN		
3500kN		

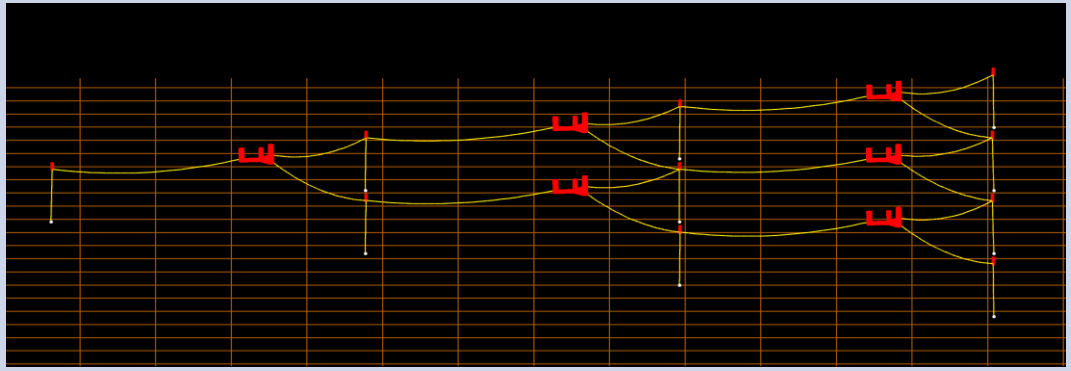
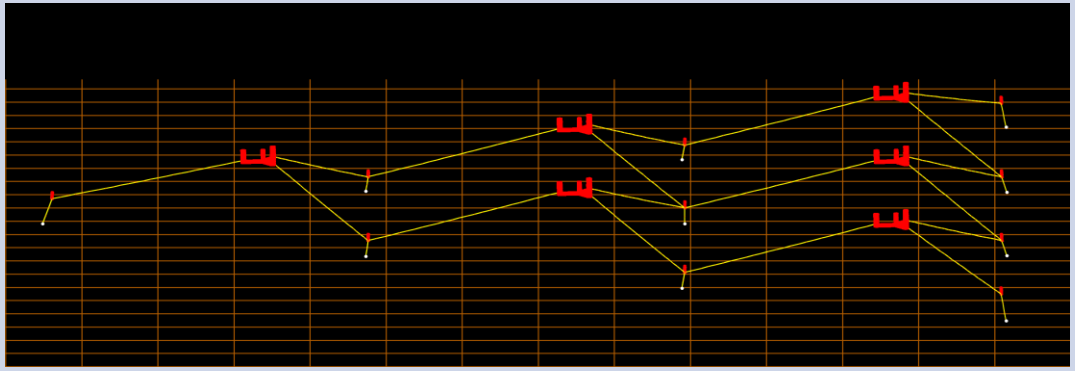
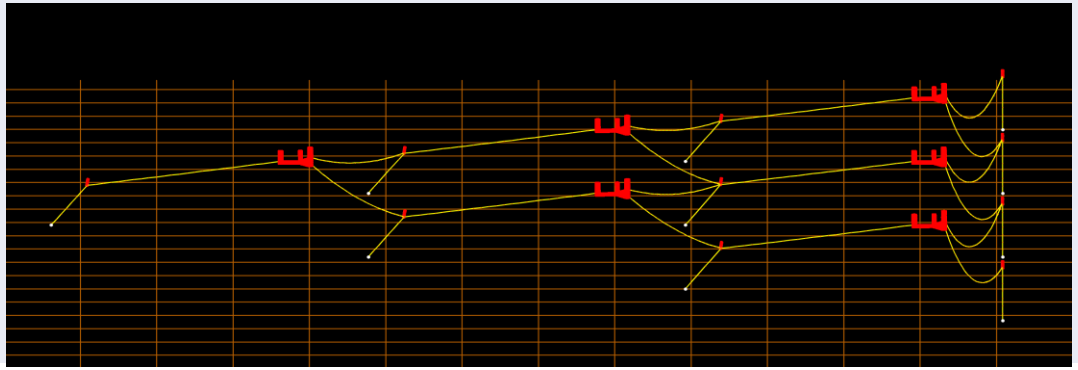
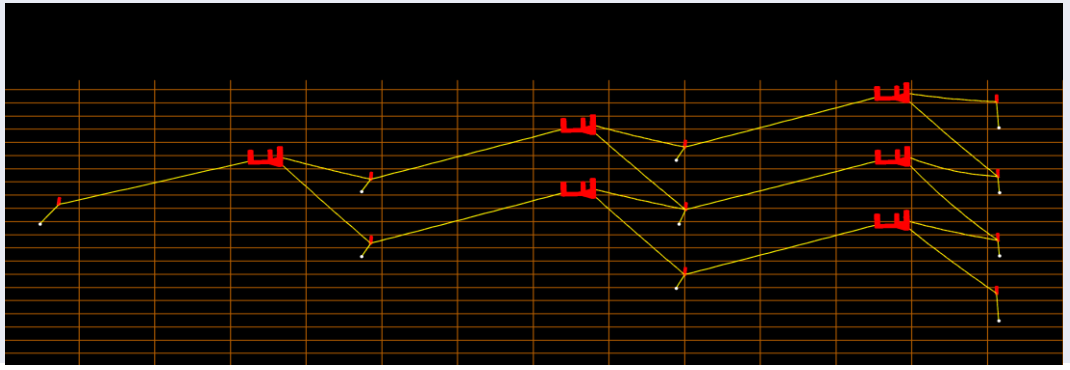
When loaded, it very got large offsets, which not everyone were too happy about

Applied force per floater	Honeymooring 1.0	Honeymooring 2.0
0 kN		
3500kN		

Honeymooring 2.0 has shorter tethers and pretension

Applied force per floater	Honeymooring 1.0	Honeymooring 2.0
0 kN		
3500kN		

Honeymooring 2.0 can satisfy all requirements on offset, seabed clearance, yaw stiffness, and so on

Applied force per floater	Honeymooring 1.0	Honeymooring 2.0
0 kN		
3500kN		

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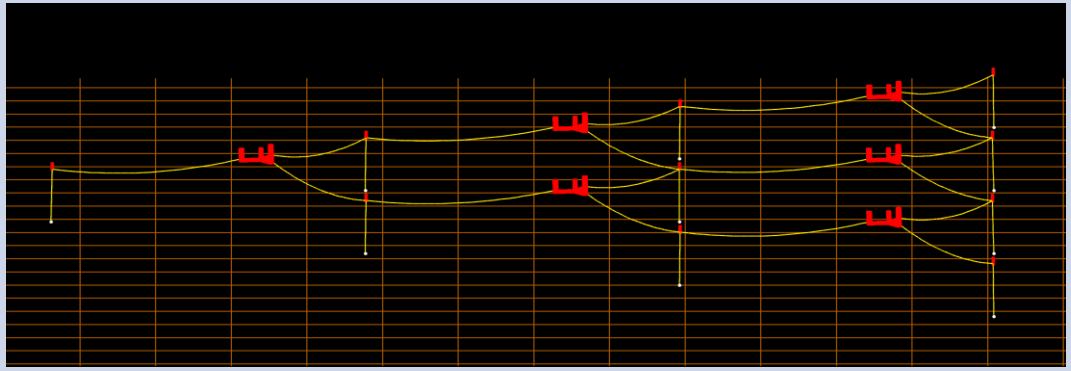
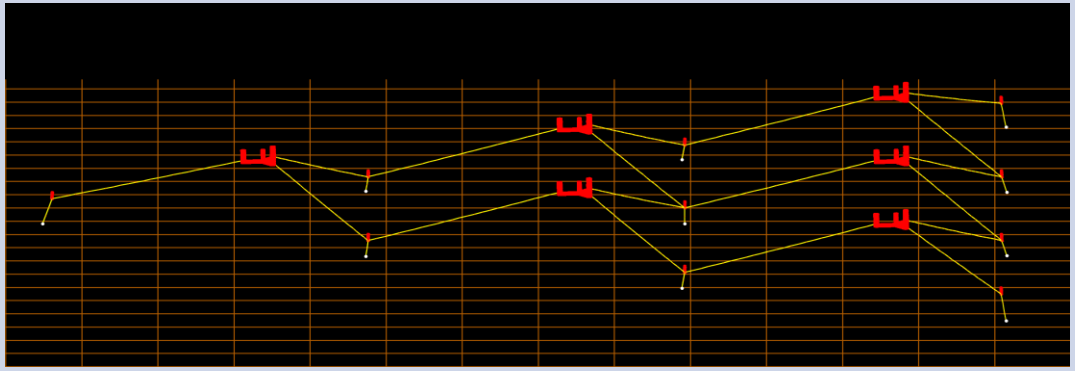
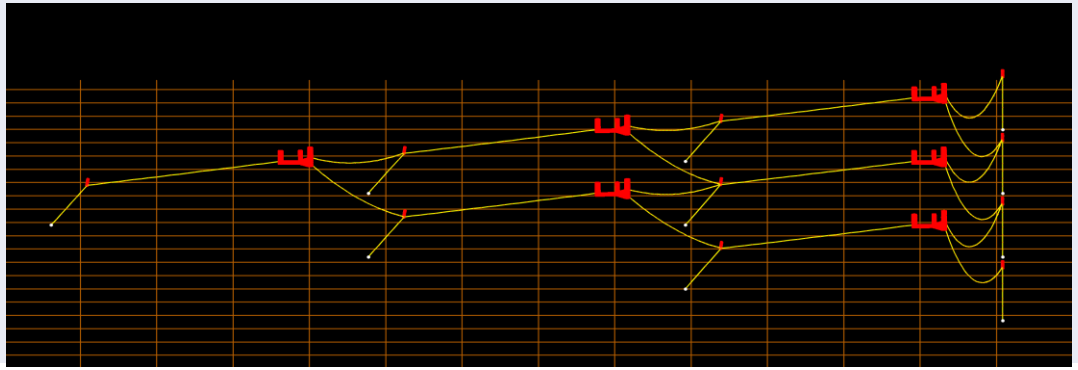
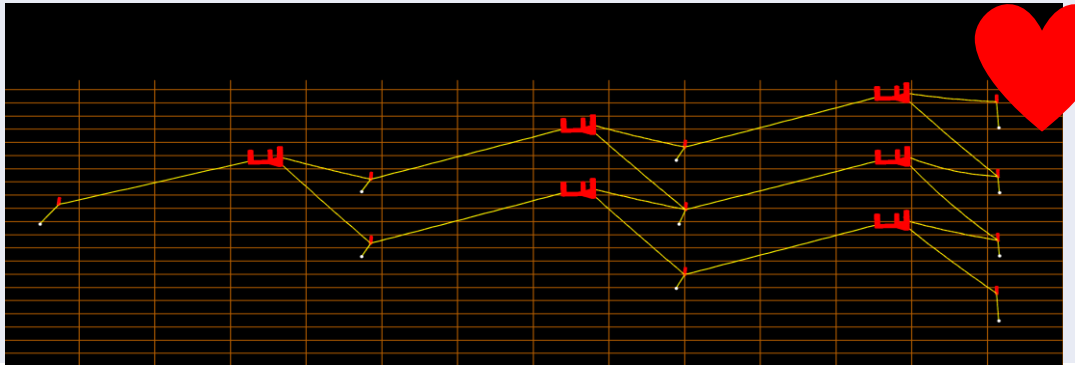
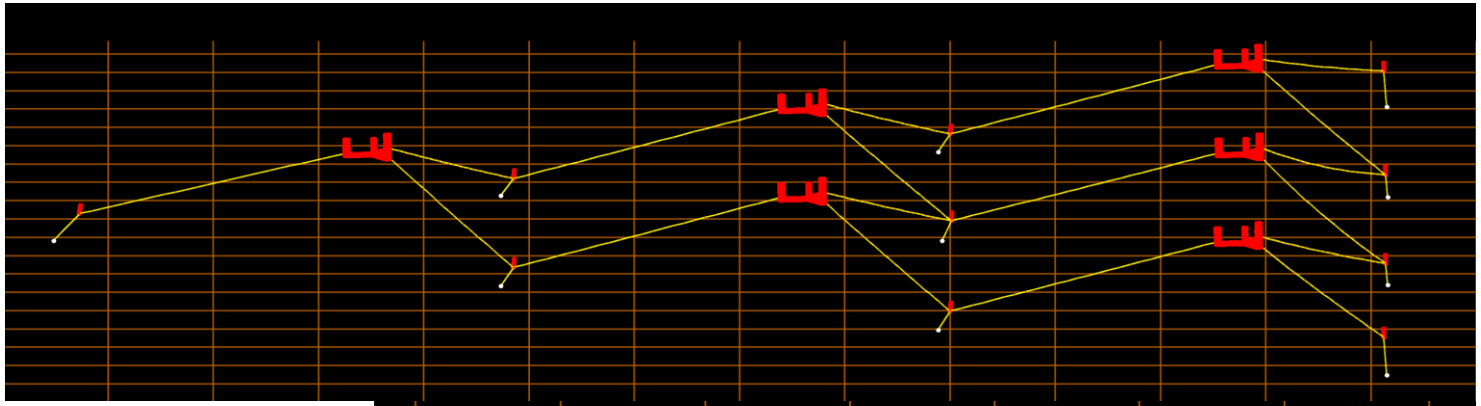
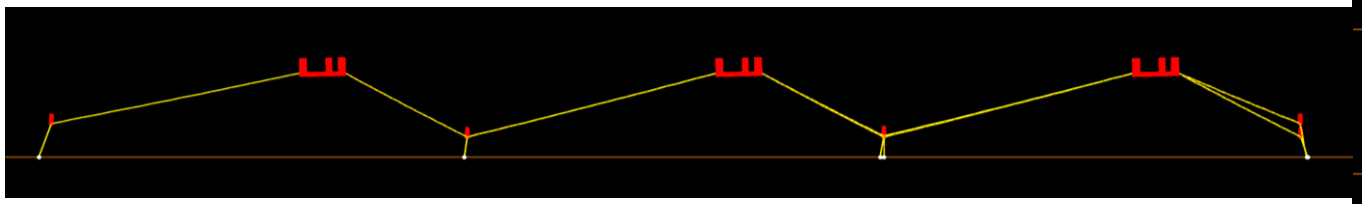
0 kN		
3500kN		

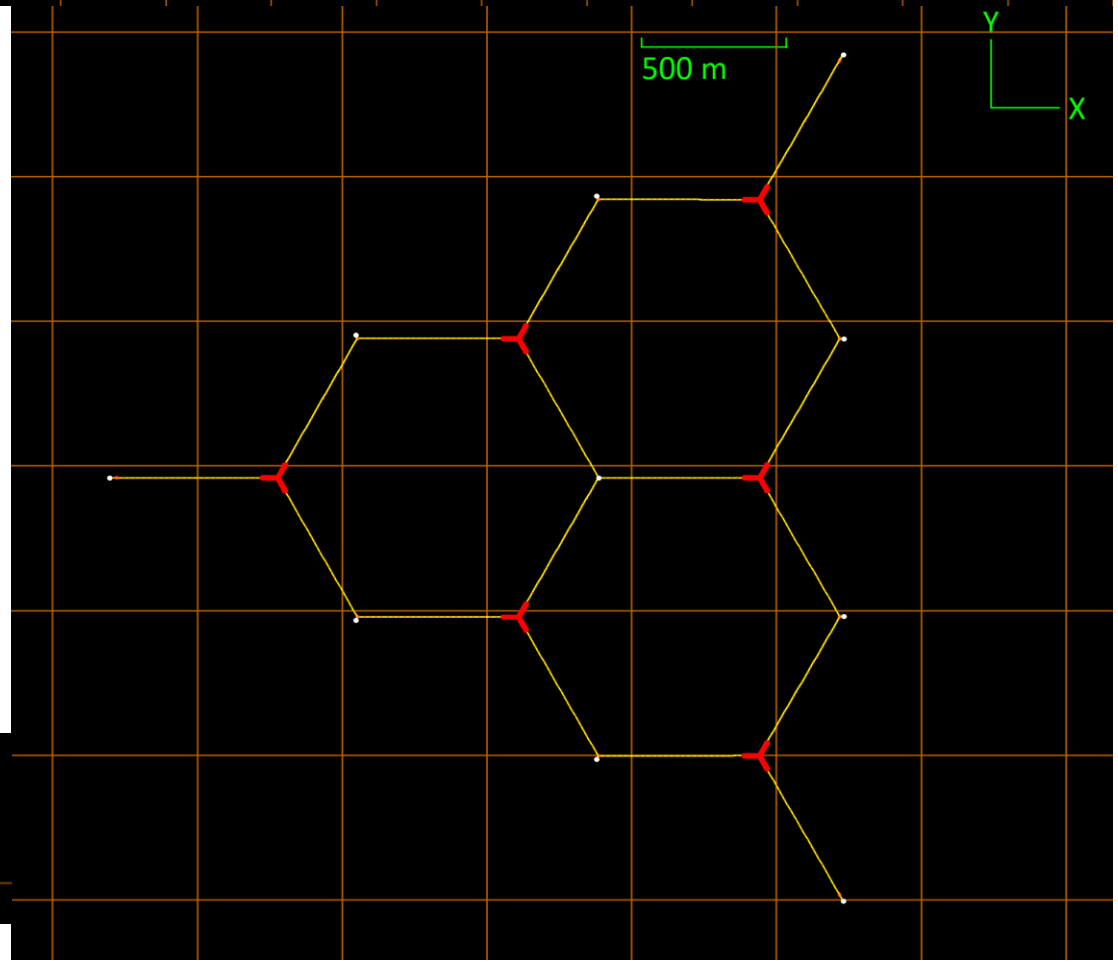
Honeymooring reference design 3 lines



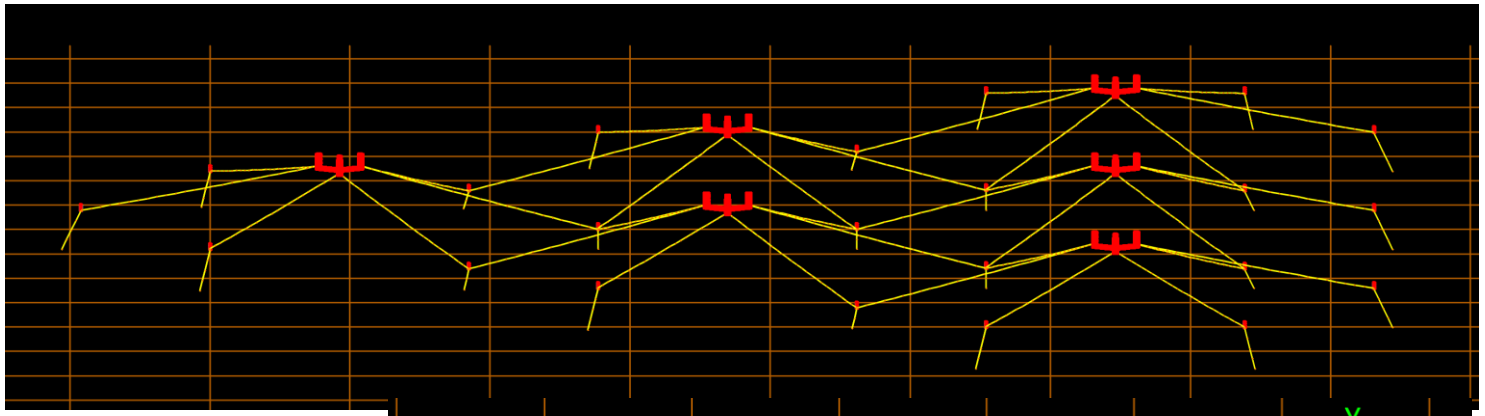
Parameter	Value
No of anchors/tethers/buoys	10 (1.67 per floater)
No of horisontal lines	18 (3 per floater)
Buoy net buoyancy	400 ton
Pretension	150 ton
Rope length	Ca 500m
Tether length	Ca 50m (80m)
Line MBL	1200ton

MBL = Minimum Breaking Load



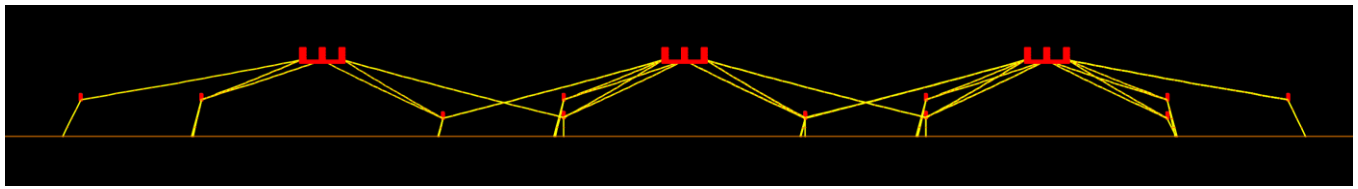


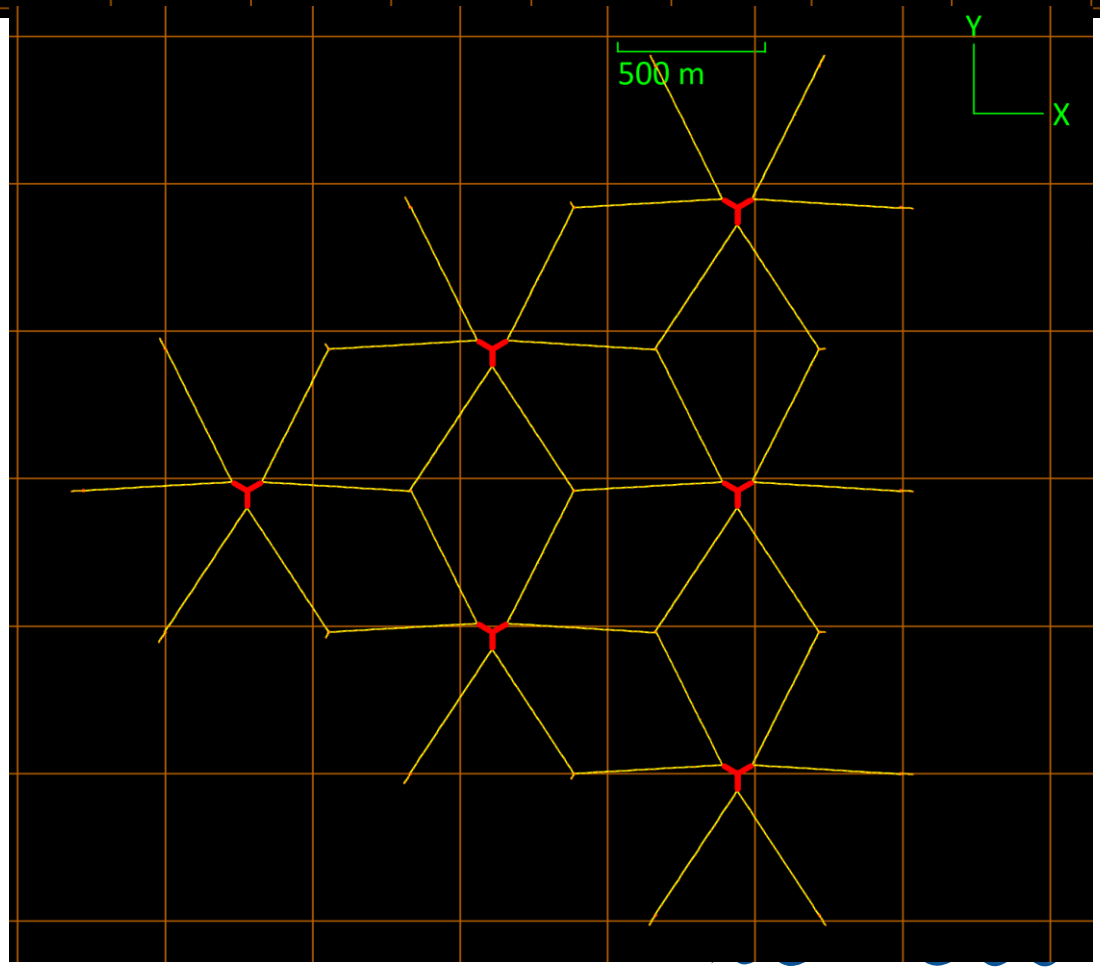
Honeymooring reference design 6 lines



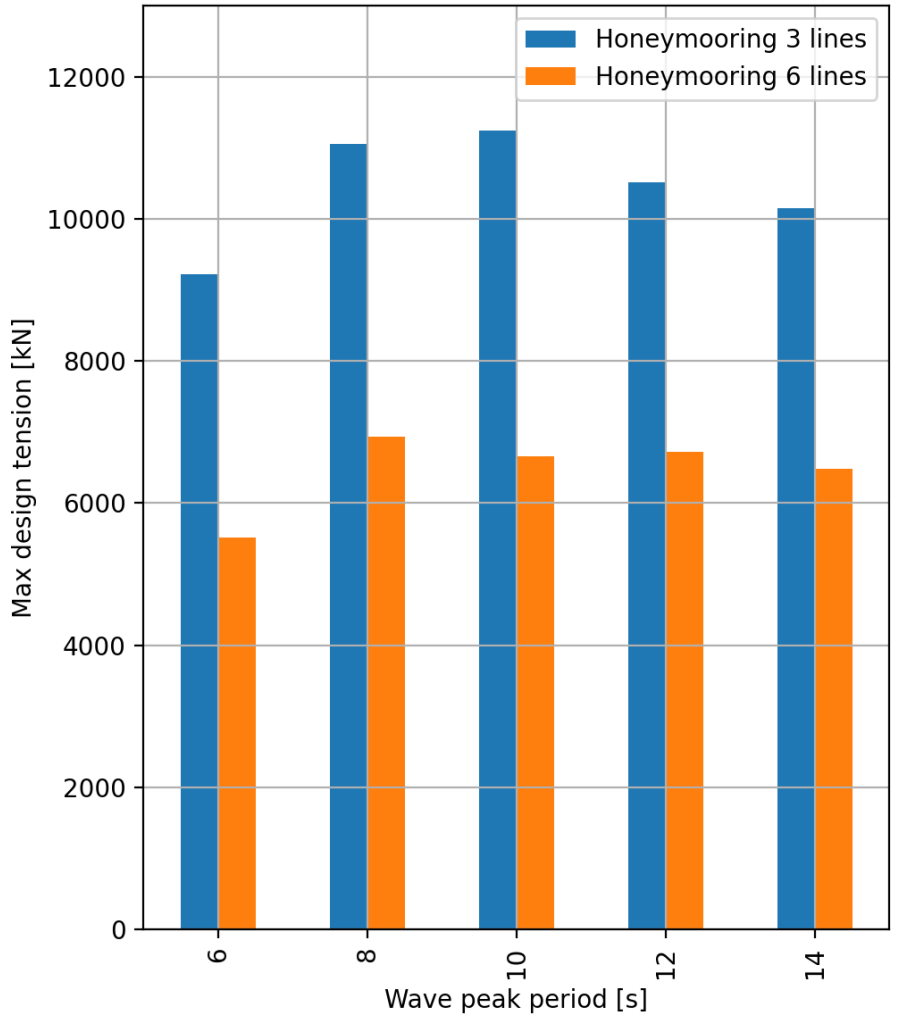
Parameter	Value
No of anchors/tethers/buoys	22 (3.67 per floater)
No of horisontal lines	36 (6 per floater)
Buoy net buoyancy	200 ton
Pretension	100 ton
Rope length	Ca 500m
Tether length	50m (95m)
Line MBL	800ton

MBL = Minimum Breaking Load

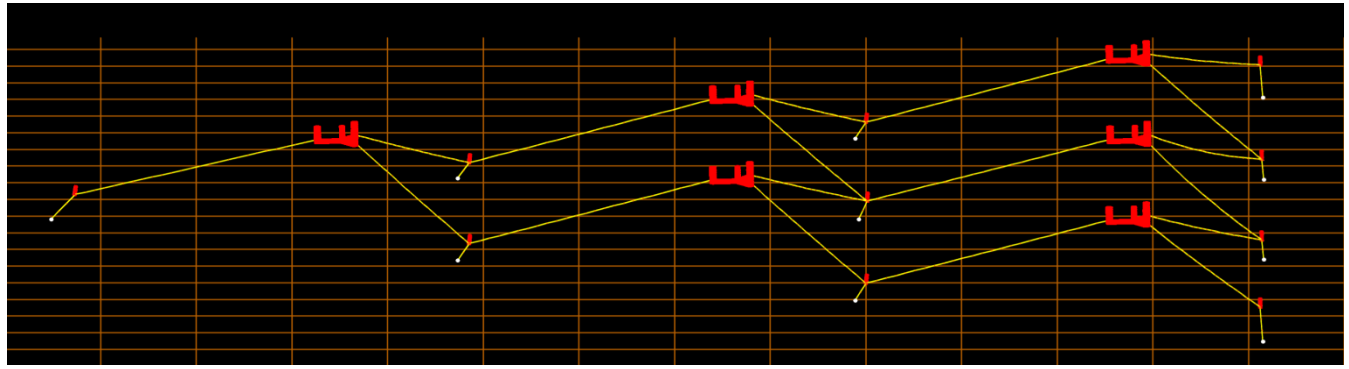




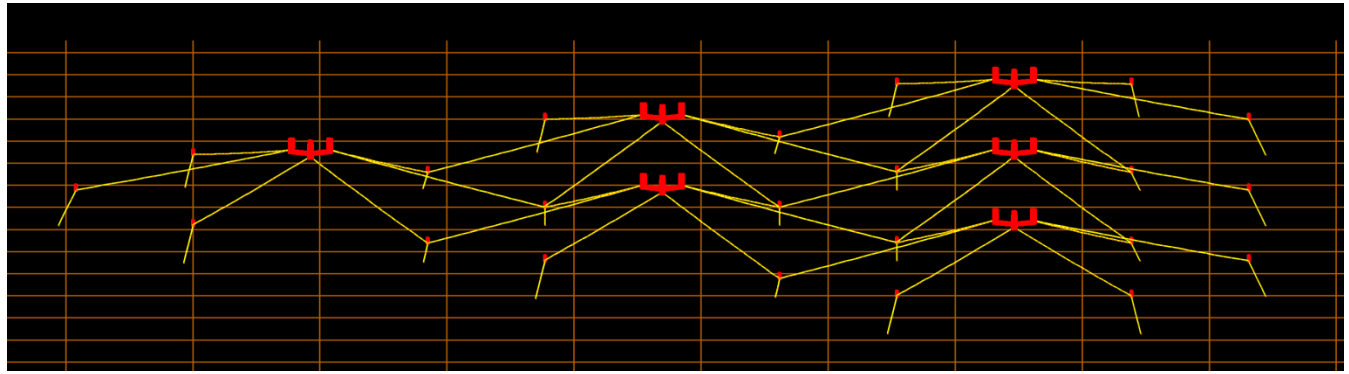
Max design tension occurs at wave period 8-10s



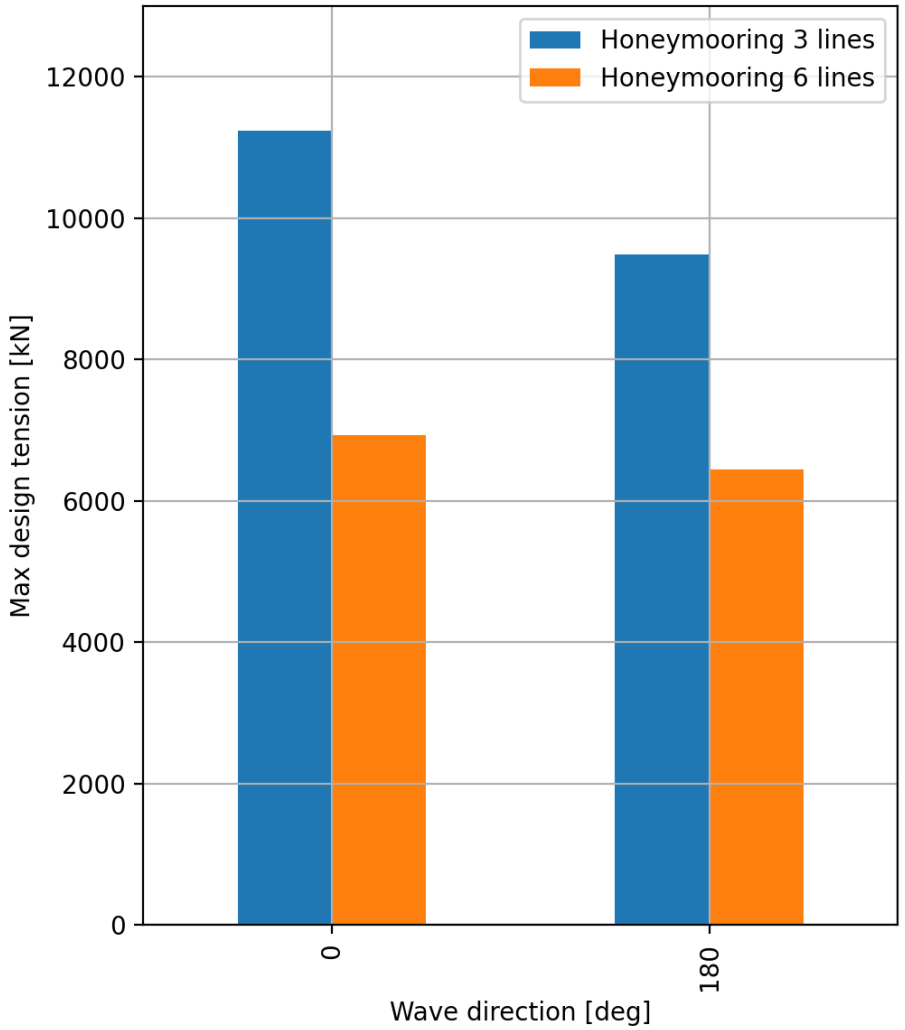
3 lines: MBL=1200ton



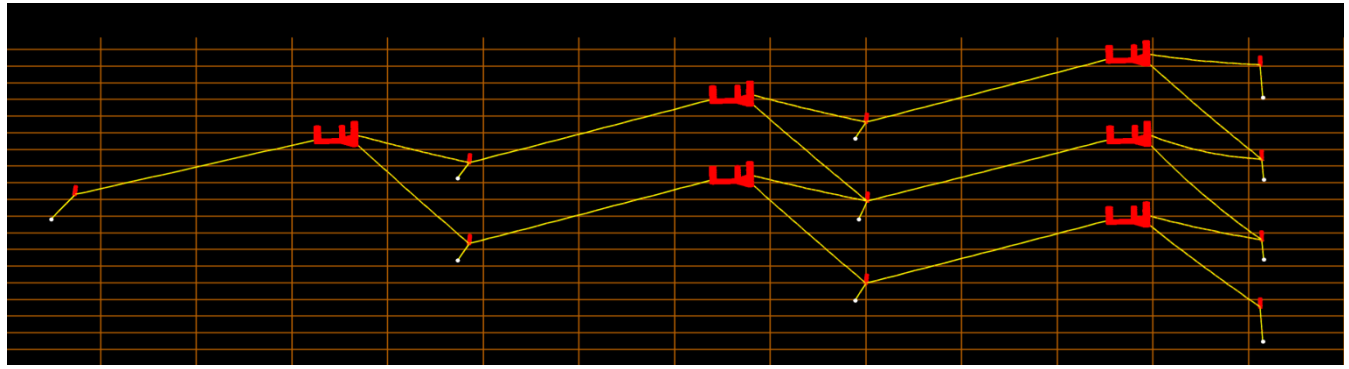
6 lines: MBL=800ton



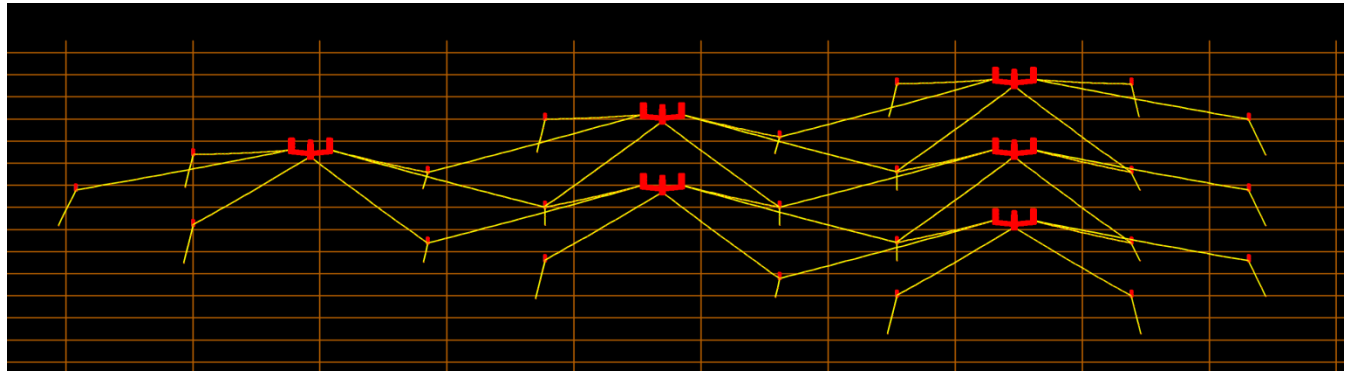
…and when the load is aligned with one line



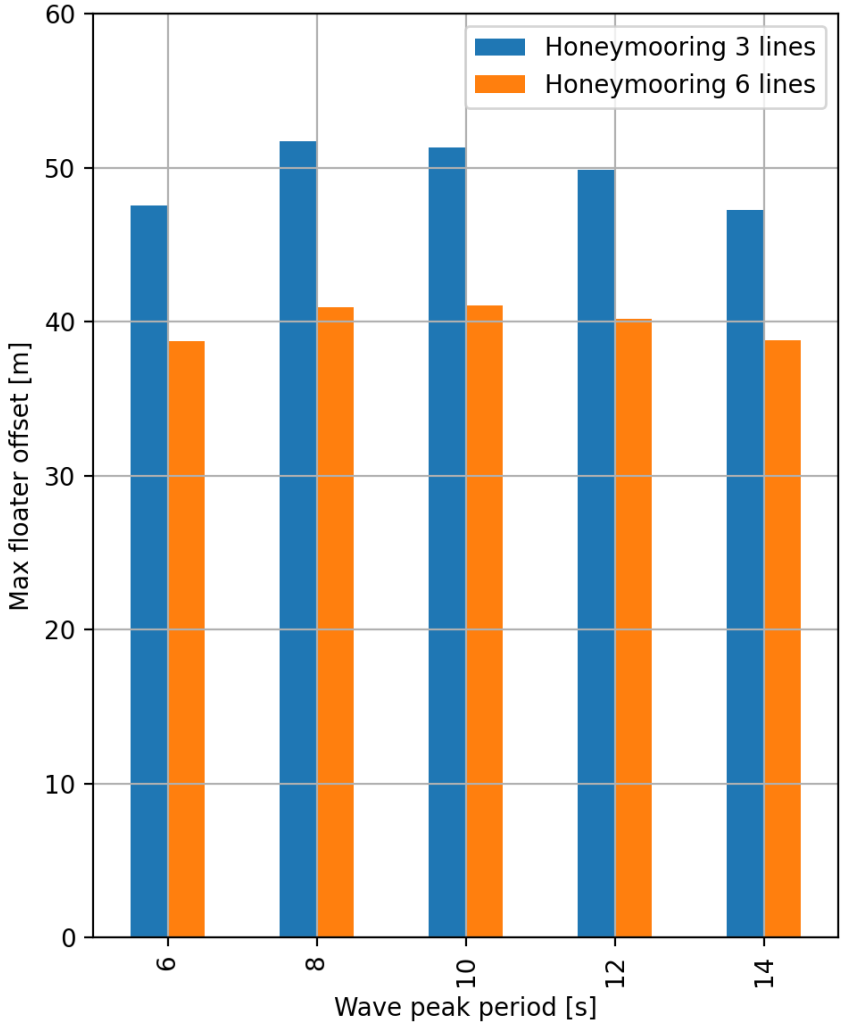
3 lines: MBL=1200ton



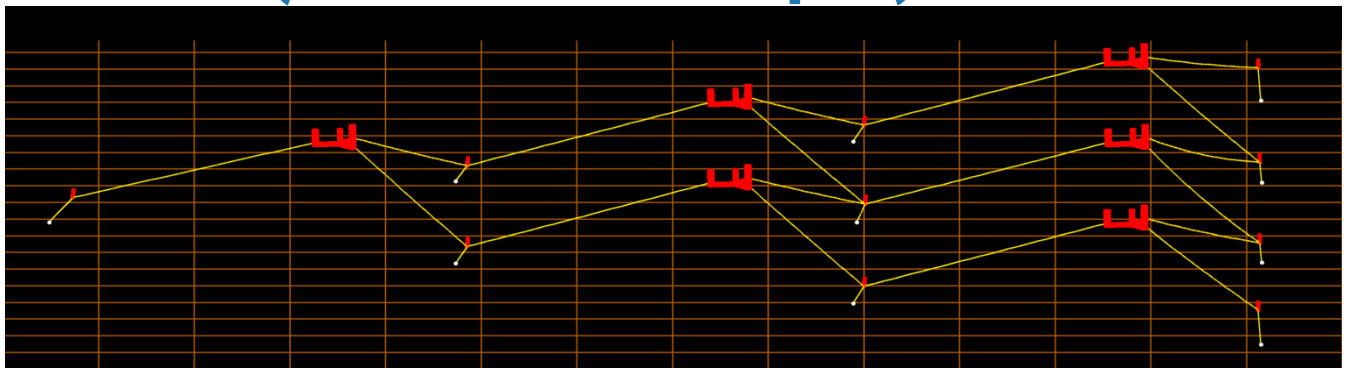
6 lines: MBL=800ton



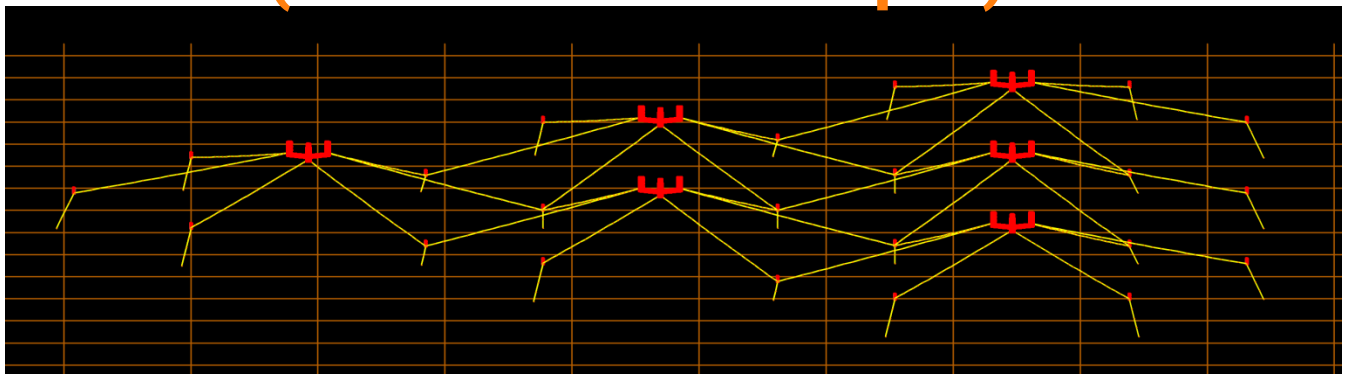
Offset is well below 30% of water depth (188m)



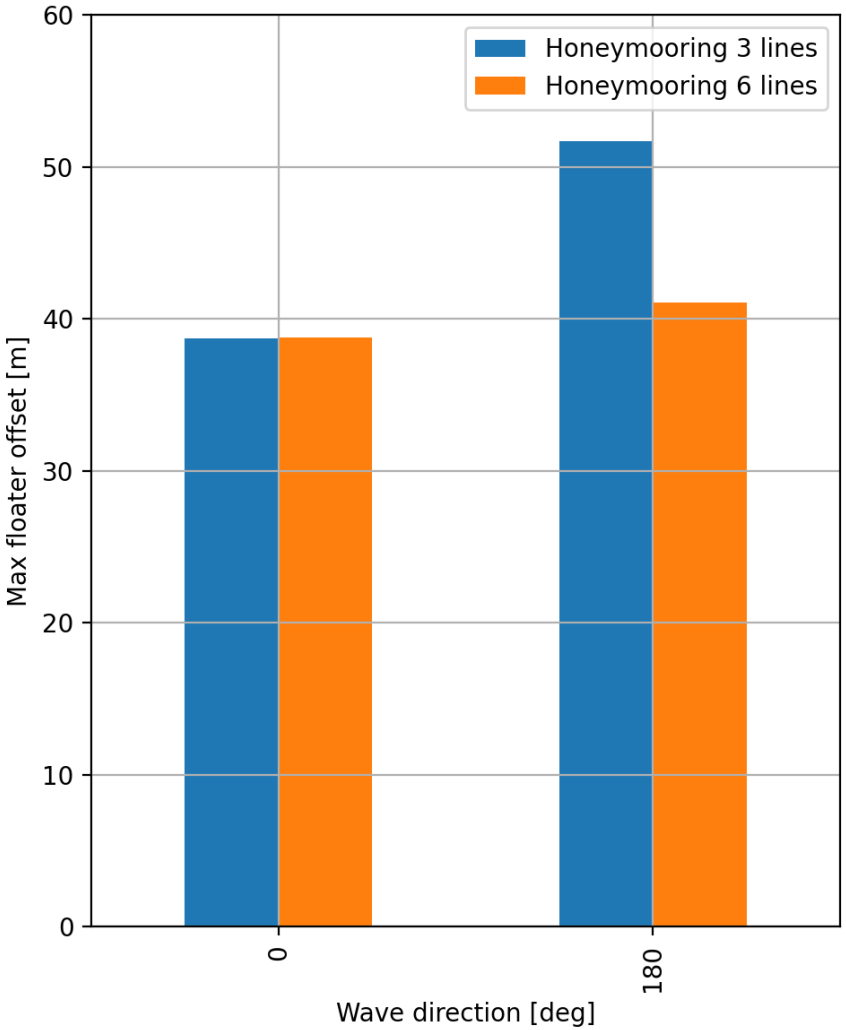
3 lines (Offset=27% depth)



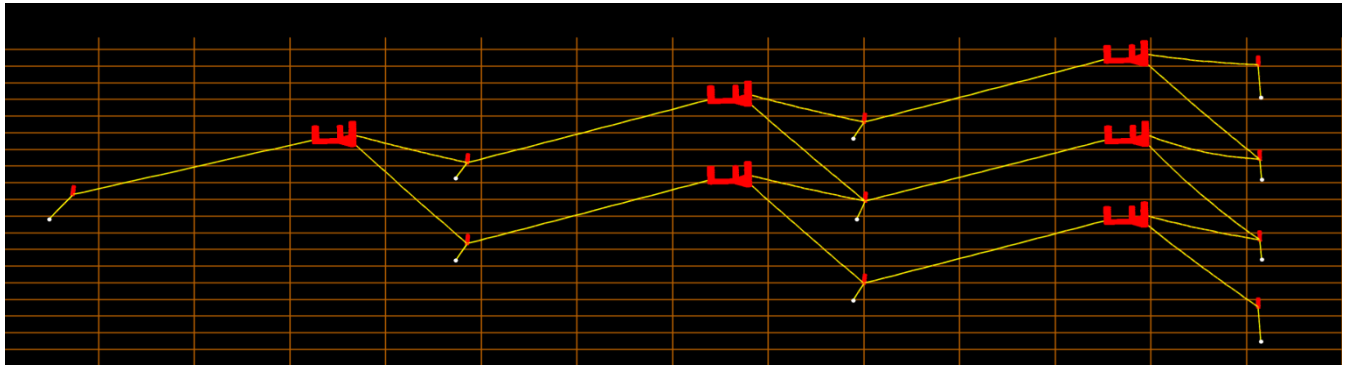
6 lines (Offset=22% of depth)



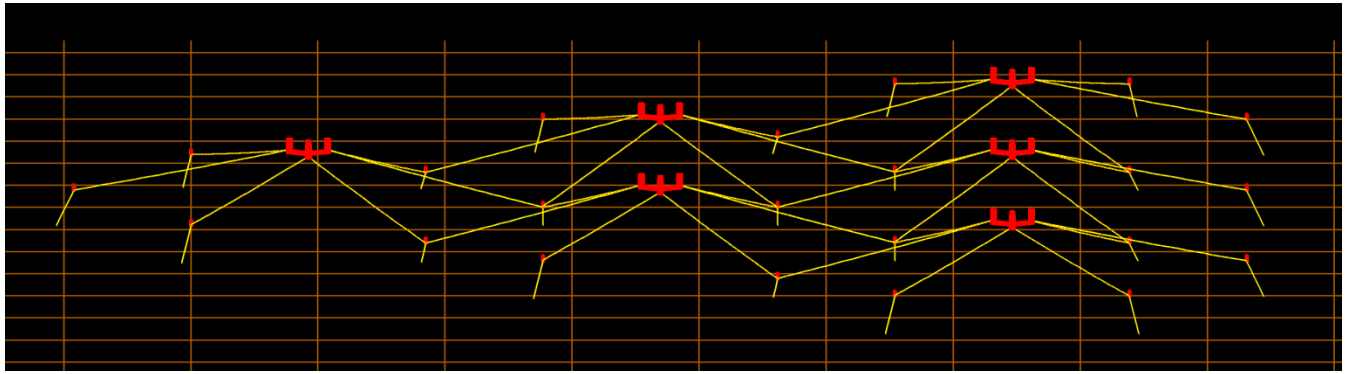
…and largest when the load acts between two lines



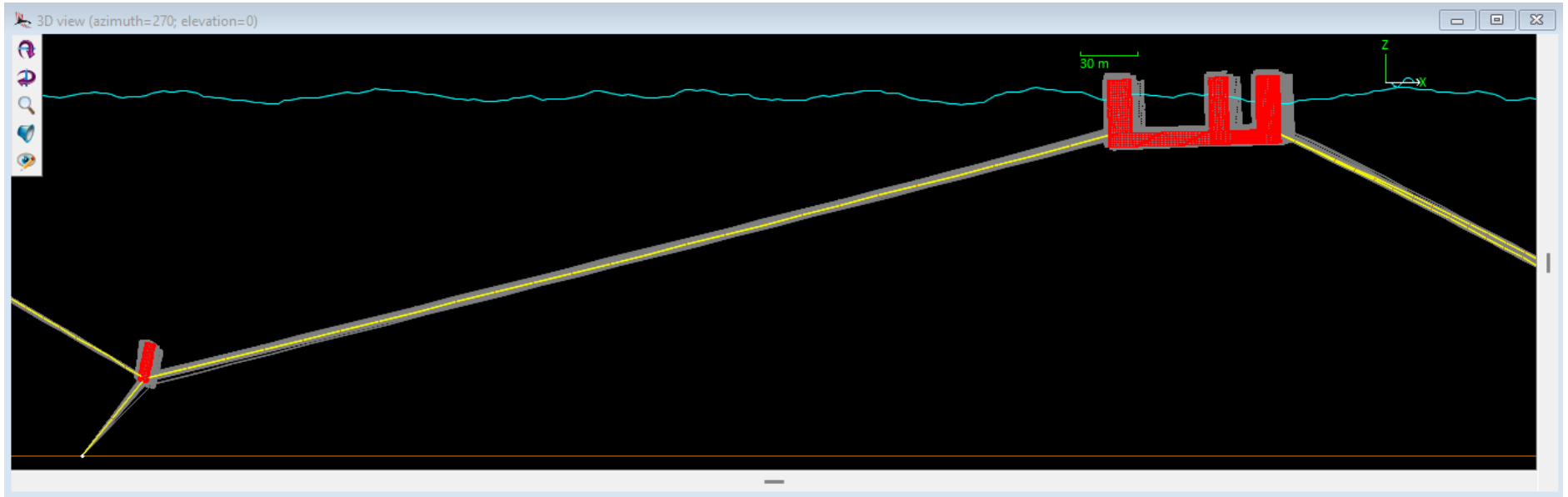
3 lines: Offset=52m

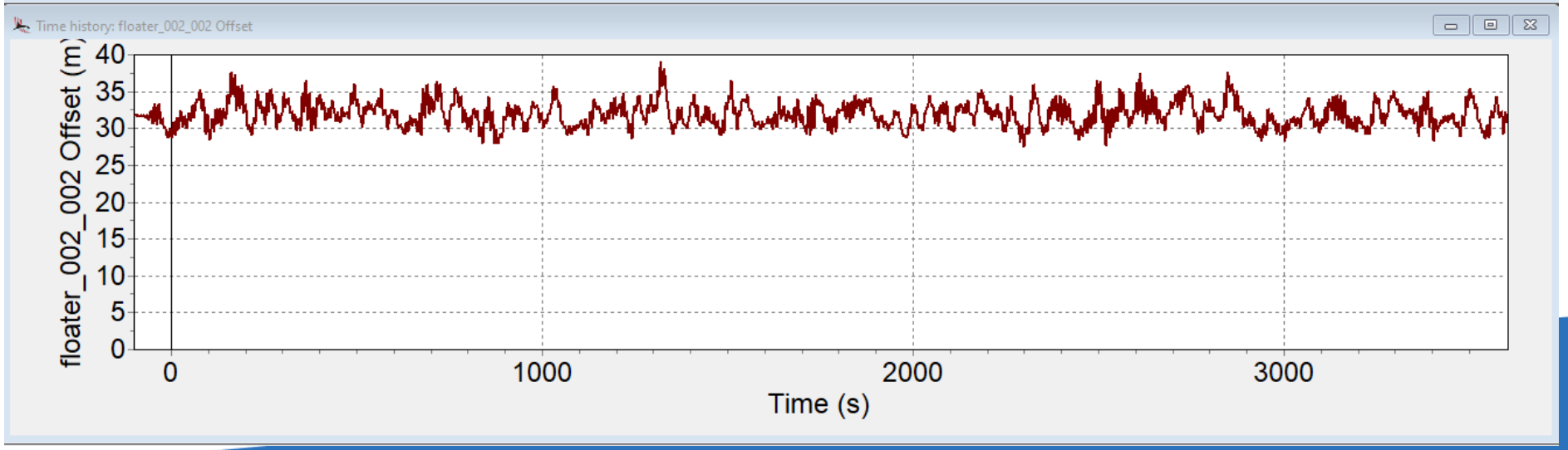


6 lines: Offset=41m



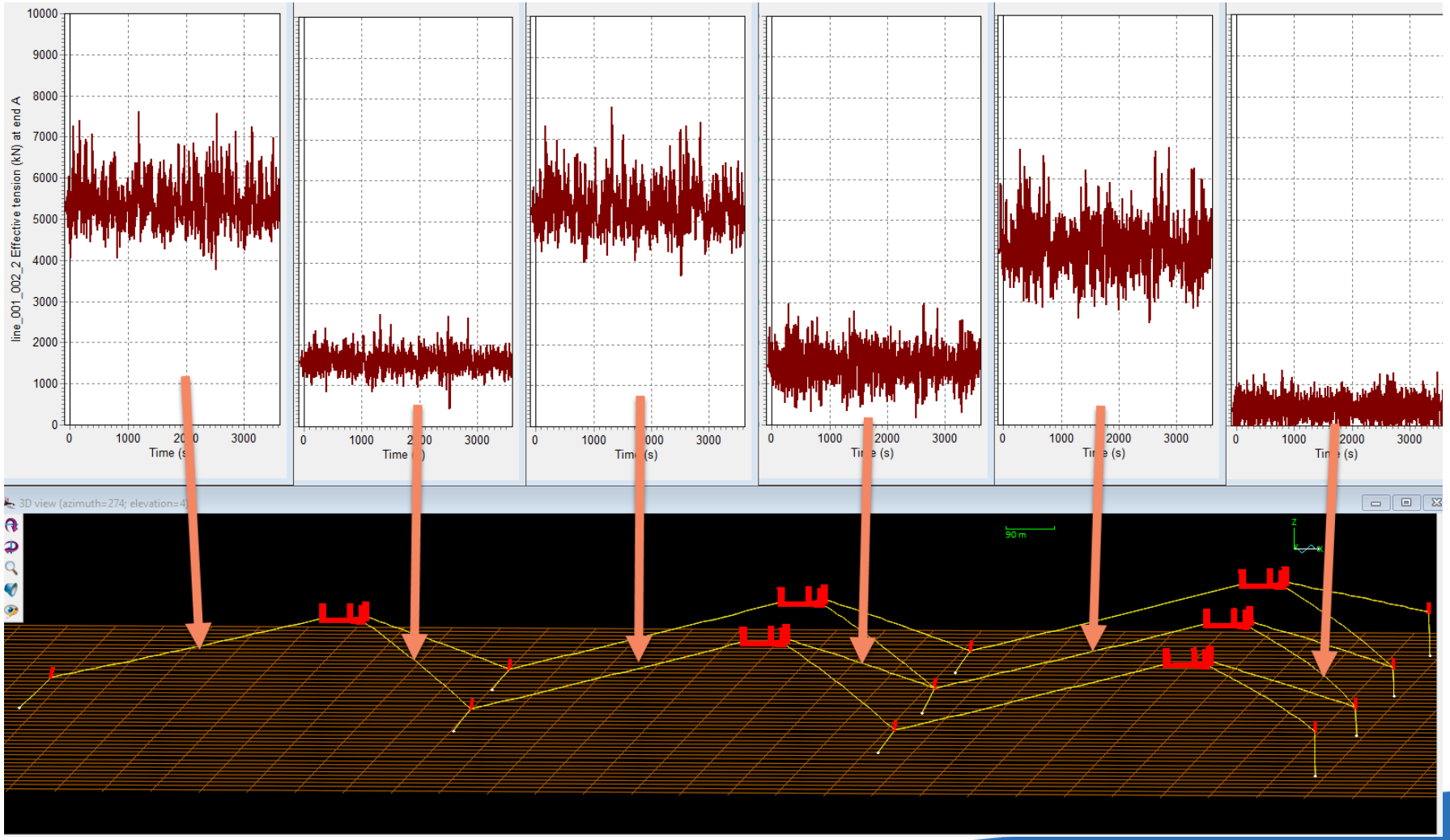
The floaters and buoys actually move very little during steady state conditions





3 lines
Tp=10s
Hs=9.2m
Dir=0deg
1hr

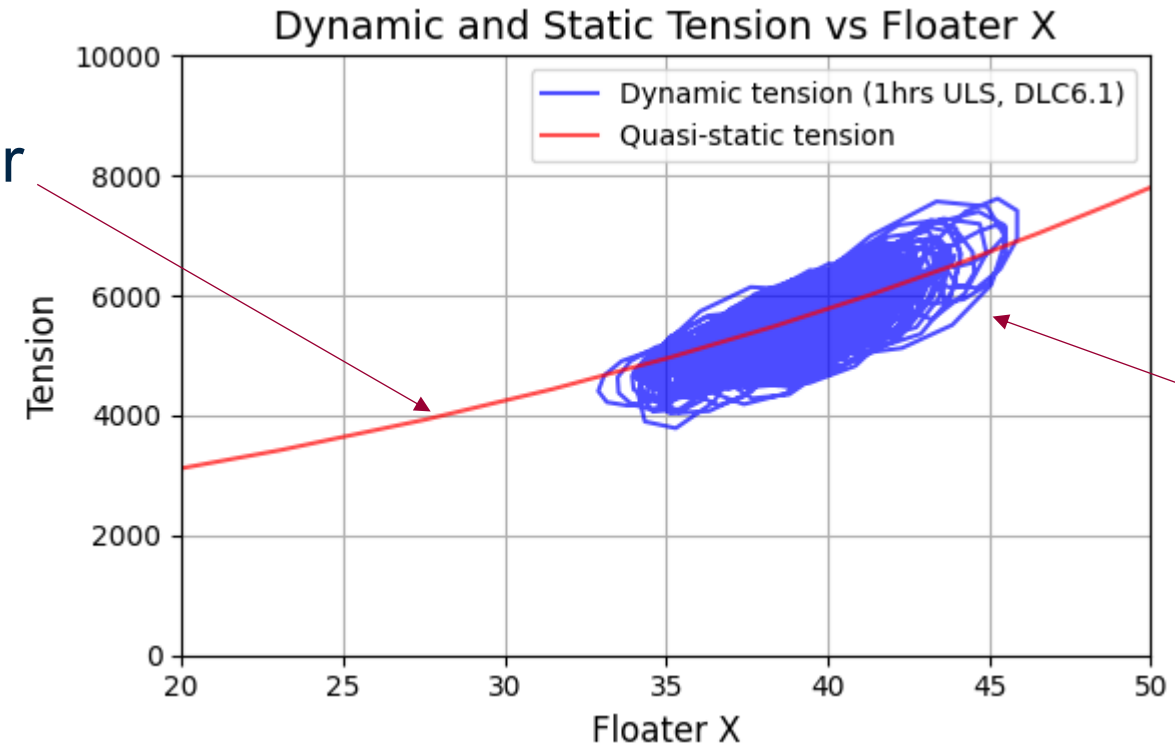
All upwind lines carry similar load



3 lines
Tp=10s
Hs=9.2m
Dir=0deg
1hr

Buoy & tether creates soft mooring

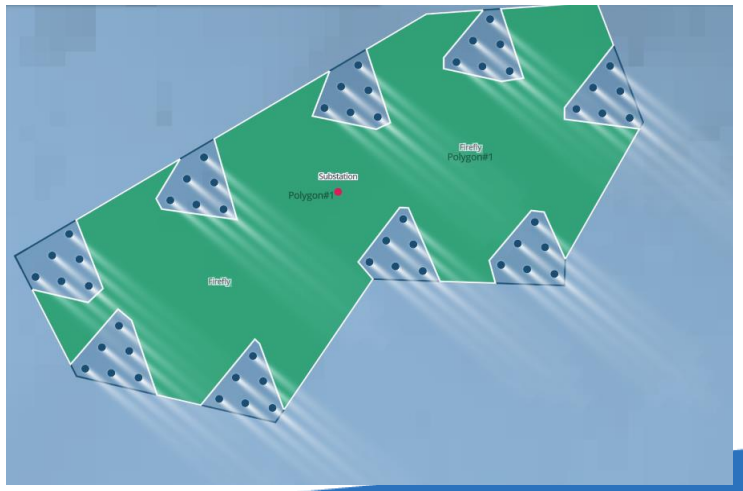
Very flat “restoring force curve” compared to taut or semi-taut mooring.



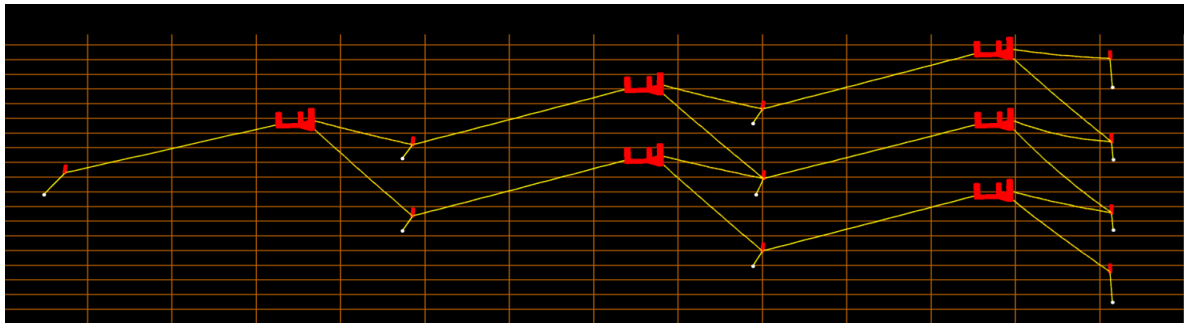
Dynamic tension behaviour due to buoy drag and inertia

Conclusions

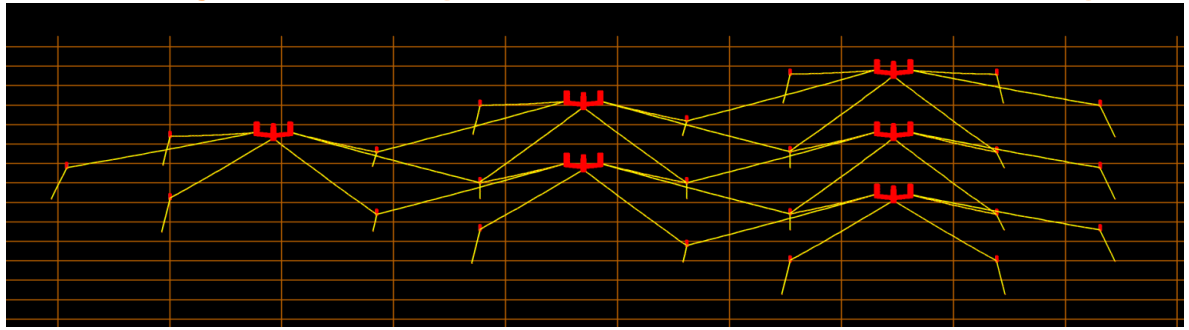
- Honeymooring is a grid solution for sustainable planning of floating wind parks
  - Benefits for cost, seabed, installation, cable, fishing, interfaces, etc
- Cluster layouts show promising results
- Two reference designs are presented



Honeymooring 3 line reference design



Honeymooring 6 line reference design



Extra slides

Feedback-CHALLENGES for Honeymooring 1.0

- **Low yaw-stiffness.** (Too low pretension)
- **Big off-set**
- **Line-contact with seabed**
- **M**aximum **E**stimated **L**oss. (progressive collapse concerns)
- **Low freedom to locate WTG** (wake-loss/ coexistence ++)
- **High HM-footprint with high wtg-spacing** (coexistence with fishing industry?)
- **Significant cost saving** relative to polyester with shared anchor**?**
- Can the Honeymooring principle be **very useful** for floating wind**?**
- **Our proposal: Honeymooring 2.0**:

Proposed ANSWERS : Honeymooring 2.0 :

- **Introduced pretension offer :**
  - **yaw-stiffness and**
  - **no Line-contact with seabed**
- **Acceptable off-set through deeper buoys**
- **Compact Standardized Cluster-philosophy offer :**
  - **Reduced M**aximum-**E**stimated-**L**oss - concerns
  - **HIGH freedom to locate each WTG-cluster** to optimize energy and coexistence.
  - **Increased potential for standardization**
  - **Very low wind-farm-footprint** offering significant improved coexistence