



TWIND – Mooring System Design

06/07/2021

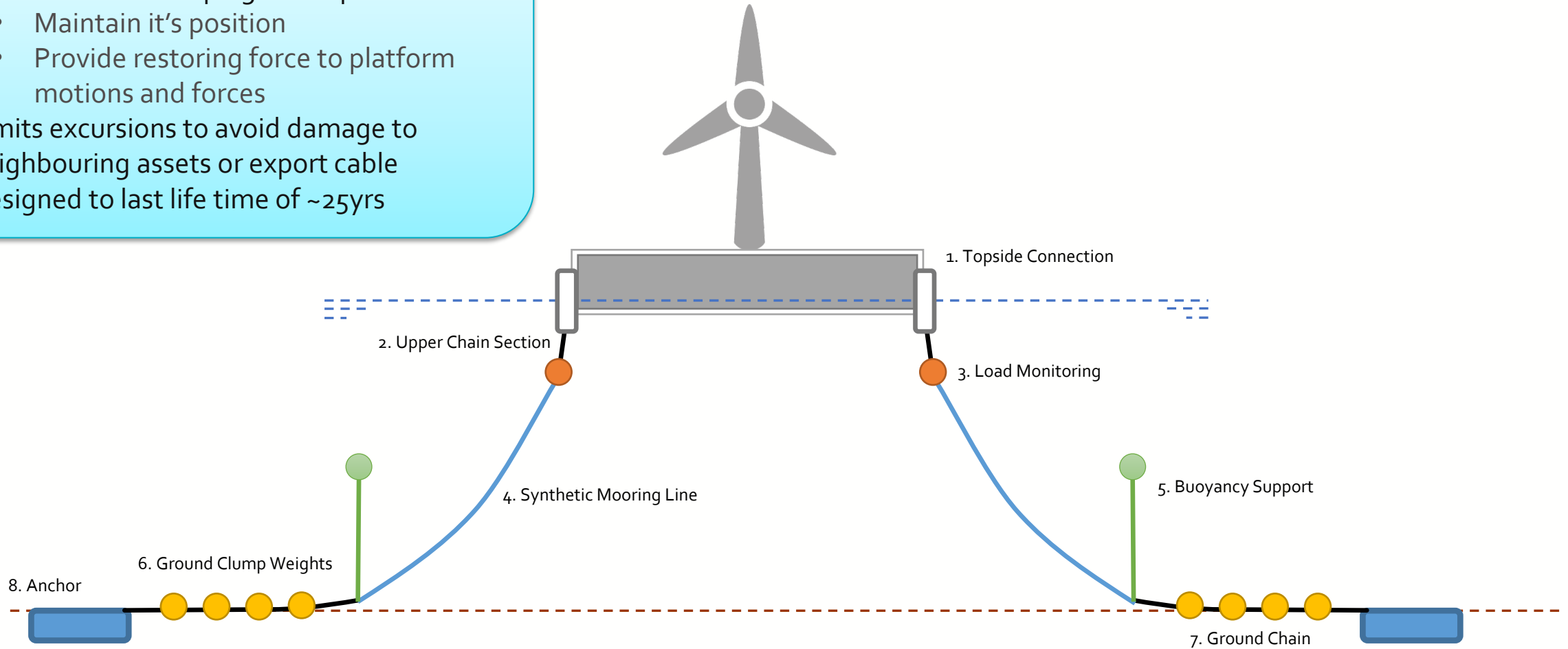
Alistair Lee

Agenda

- What is a mooring system?
- Brief mooring theory
- Tools used
- Design parameters
- Inspiration - Existing mooring systems
- Standard components
- Mooring materials
- Future advancements

What is a mooring system?

- Enables station keeping of the platform
 - Maintain it's position
 - Provide restoring force to platform motions and forces
- Limits excursions to avoid damage to neighbouring assets or export cable
- Designed to last life time of ~25yrs

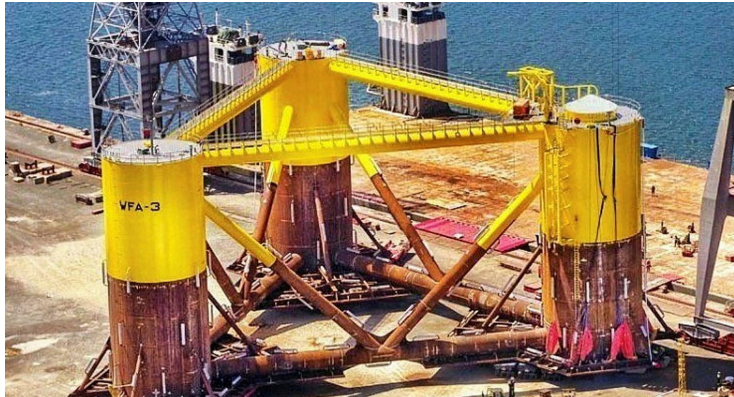


$$F(t) = \underbrace{C_M \rho V \dot{v}(t)}_{\text{Inertia}} + \underbrace{C_D \frac{1}{2} \rho A v(t) |v(t)|}_{\text{Drag}}$$

Inertia

Drag

$$K_c = 2\pi \frac{A}{D}$$



$KC < 8$

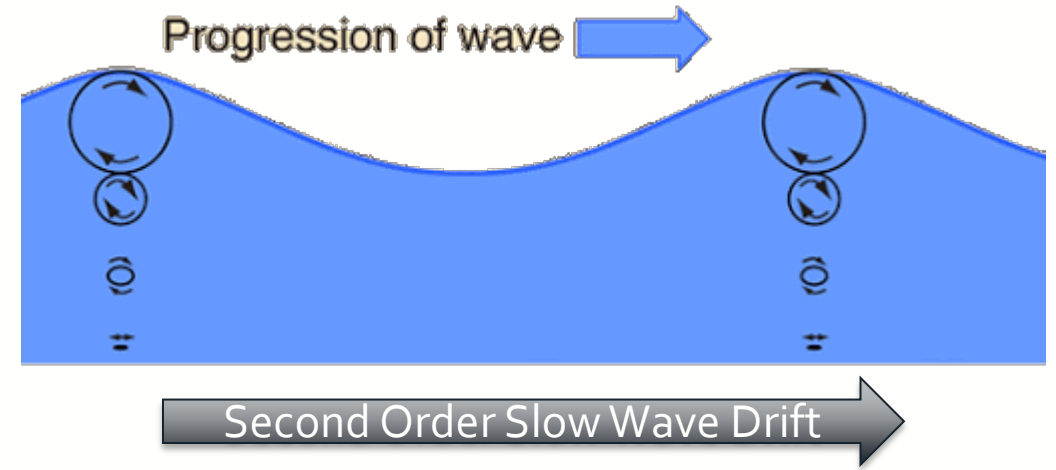


Inertia
Dominated

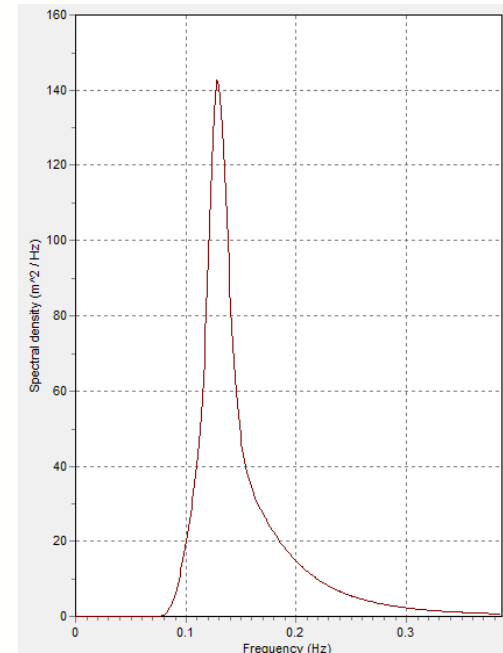
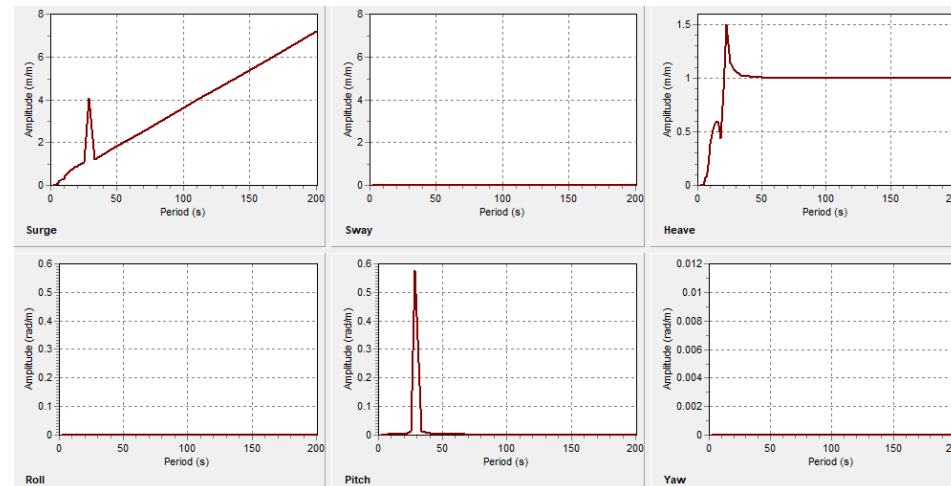
$KC > 25$



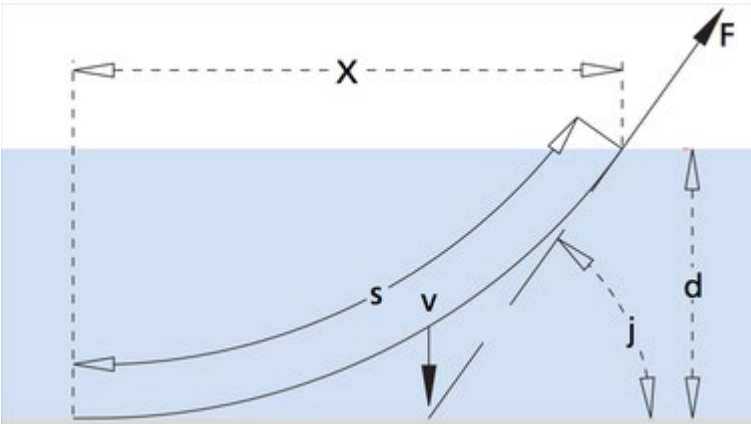
Drag
Dominated



Diffraction Analysis



Hand calculations



$$S = \sqrt{d \cdot \left(\frac{2 \cdot F}{w} - d \right)}$$

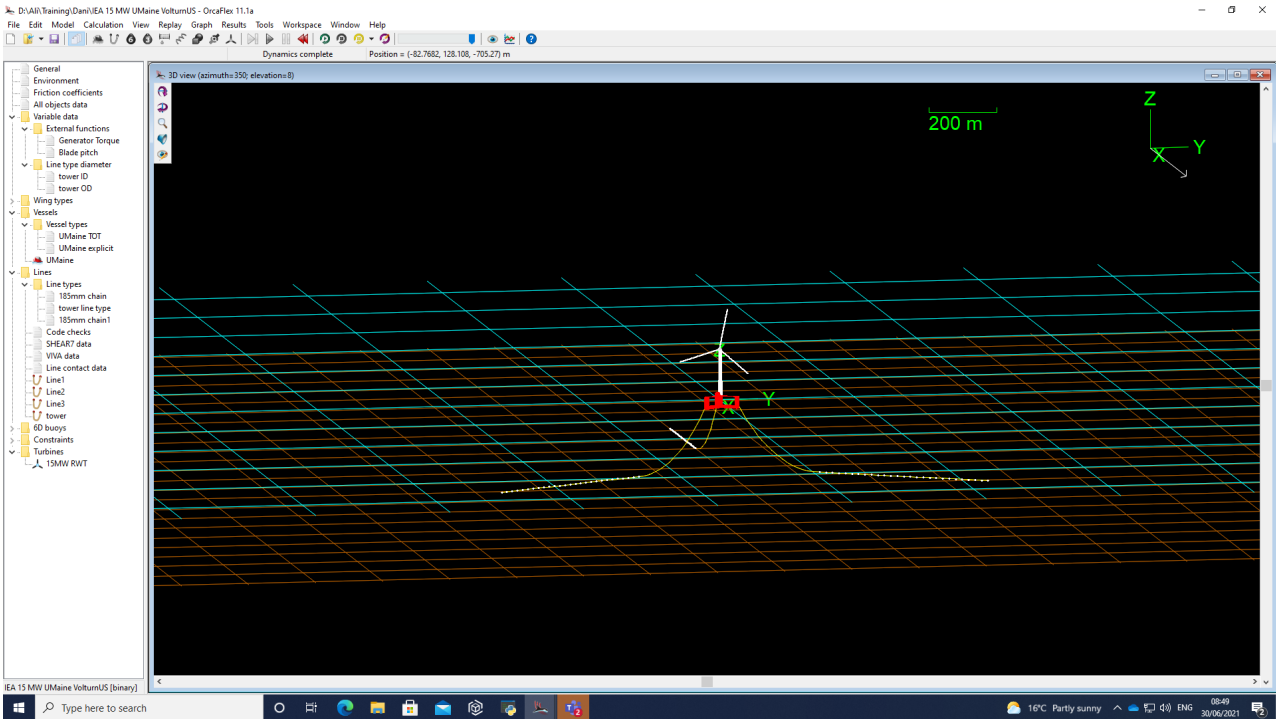
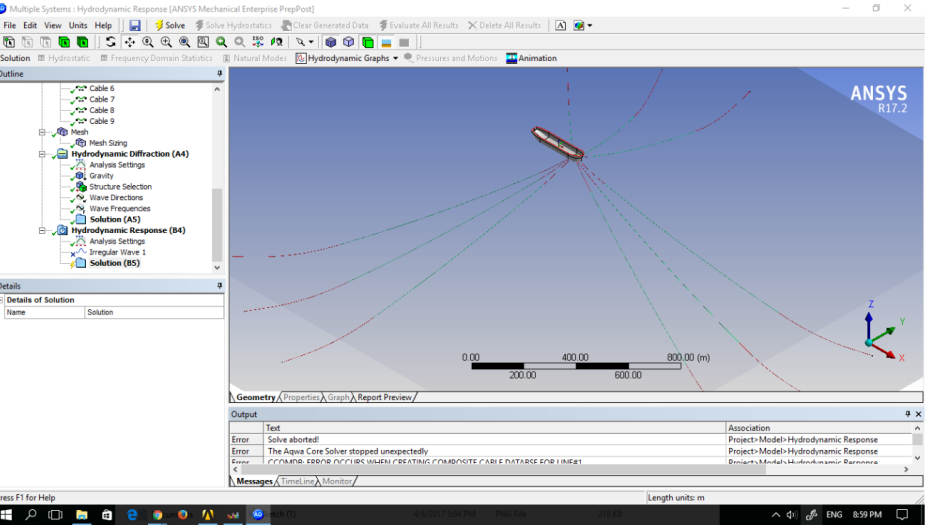
$$X = \left(\frac{F}{w} - d \right) \cdot \ln \left(\frac{S + \frac{F}{w}}{\frac{F}{w} - d} \right)$$

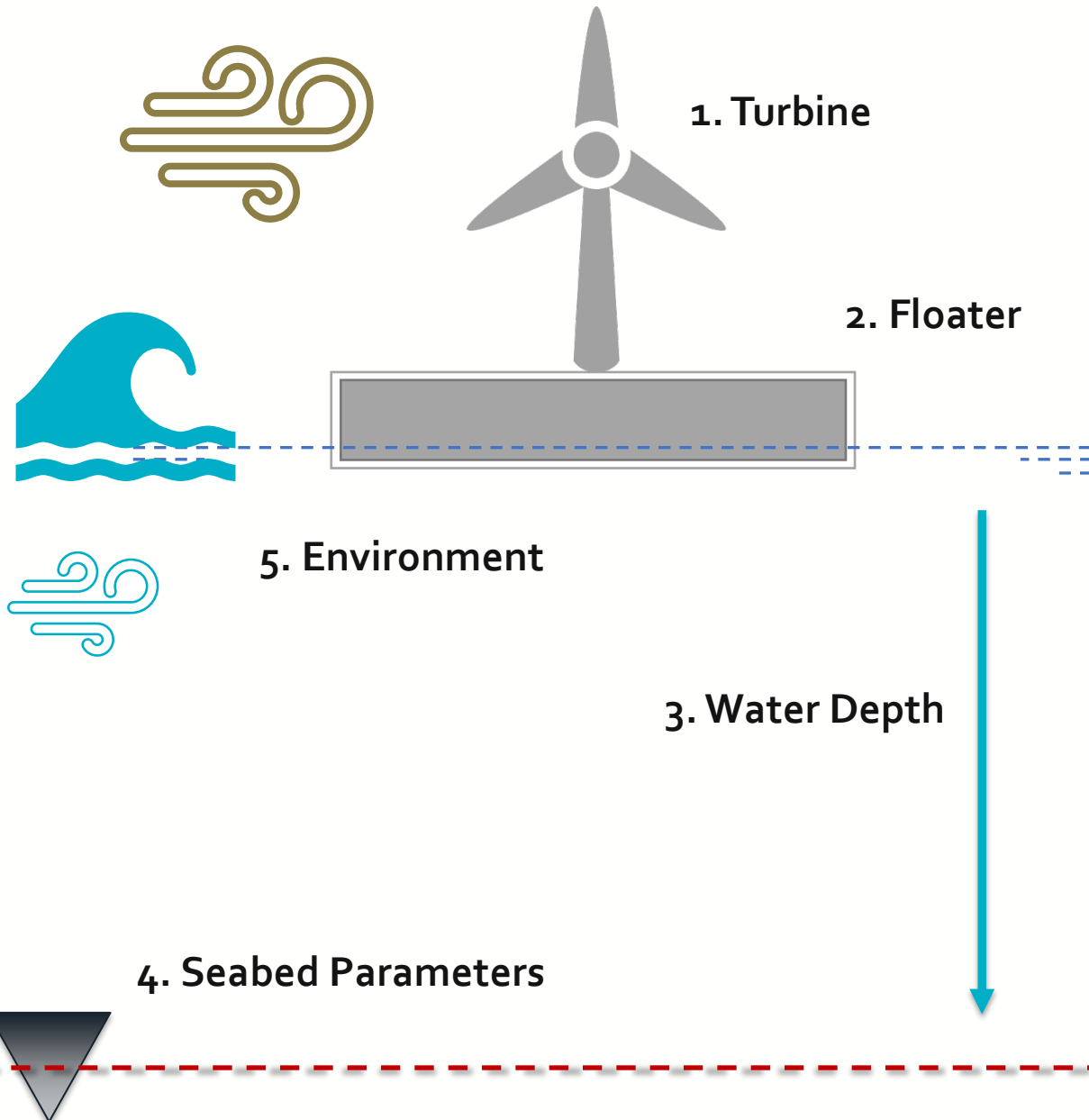
$$V = w \cdot S$$



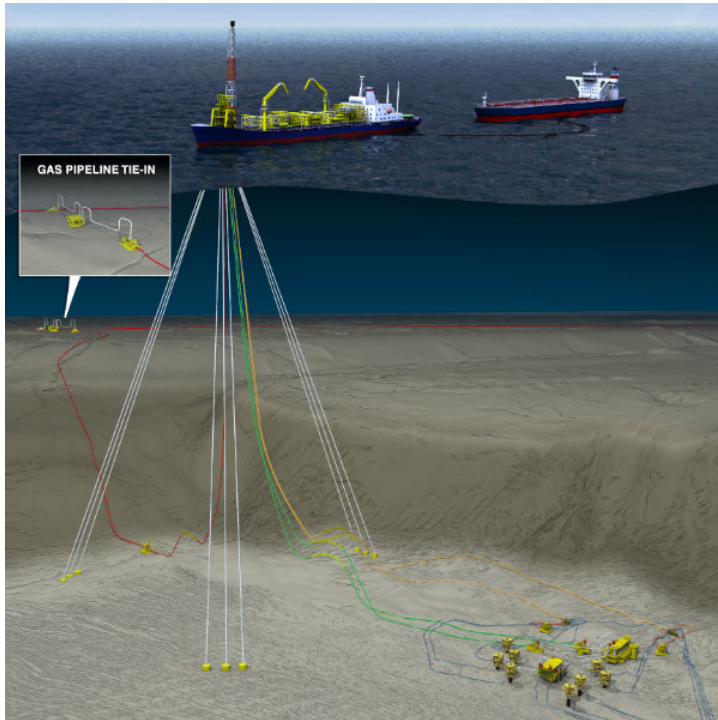
Orcina - OrcaFlex

ANSYS – Aqwa





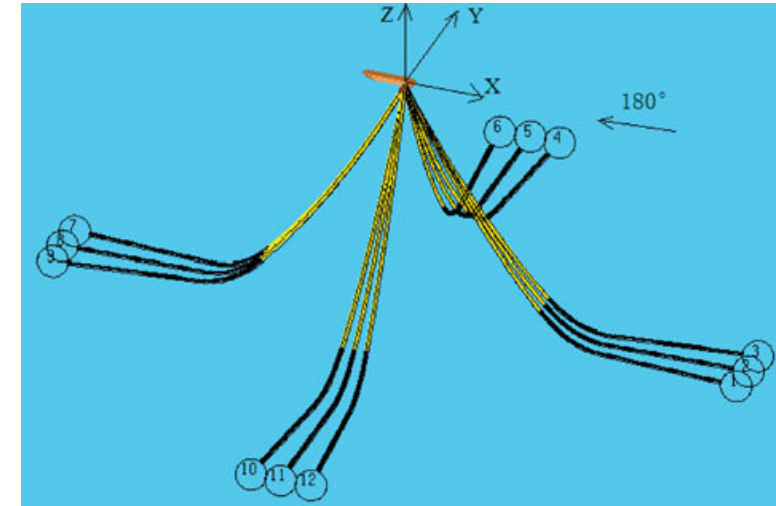
1. Stop platform from drifting away
2. What load path can the anchors handle?
3. Ensure platform can survive design life in chosen environment
 1. ULS
 2. ALS
 3. FLS
4. Reduce platform excursion
5. Prevent snatch loads on platform
6. Prevent anchor uplift (if using drag anchors)
7. Cost of mooring lines and anchor
8. Installation complexity and cost
9. Mooring line integrity



Stones¹



Perdido^{2,3}



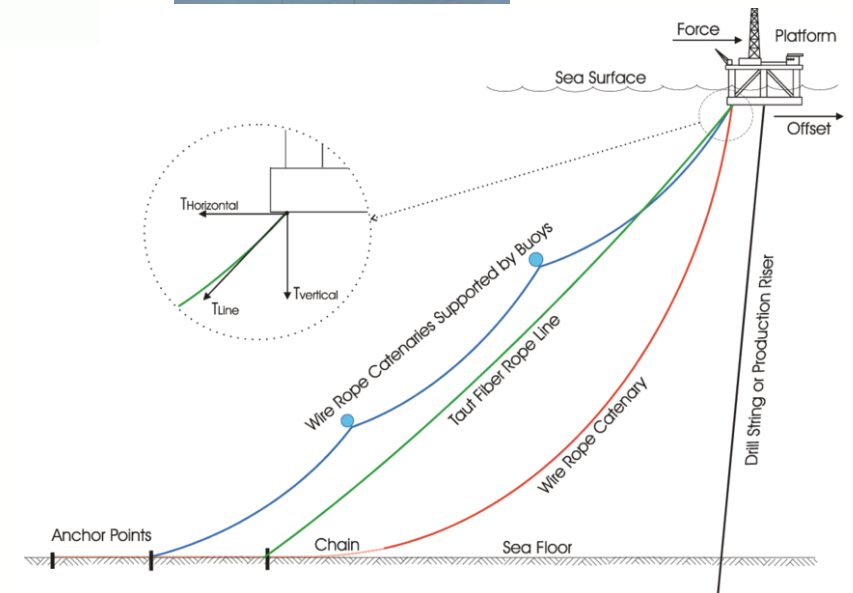
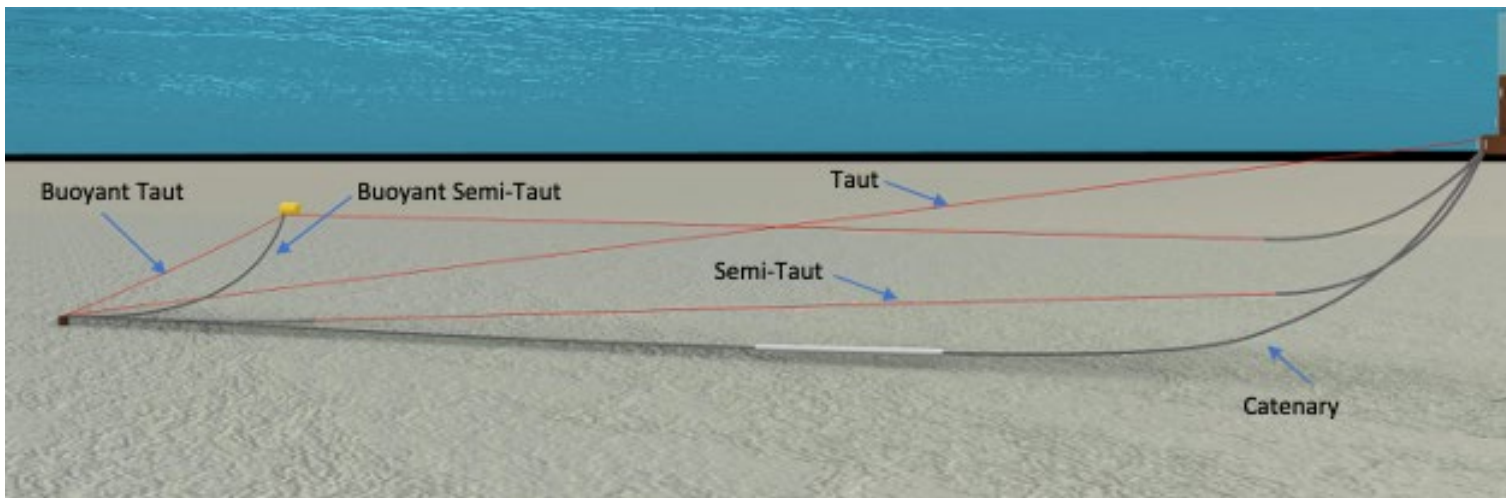
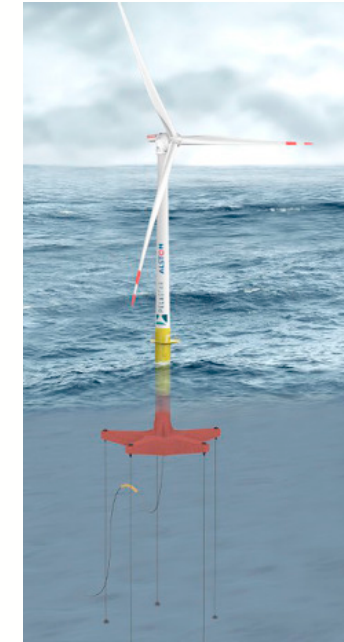
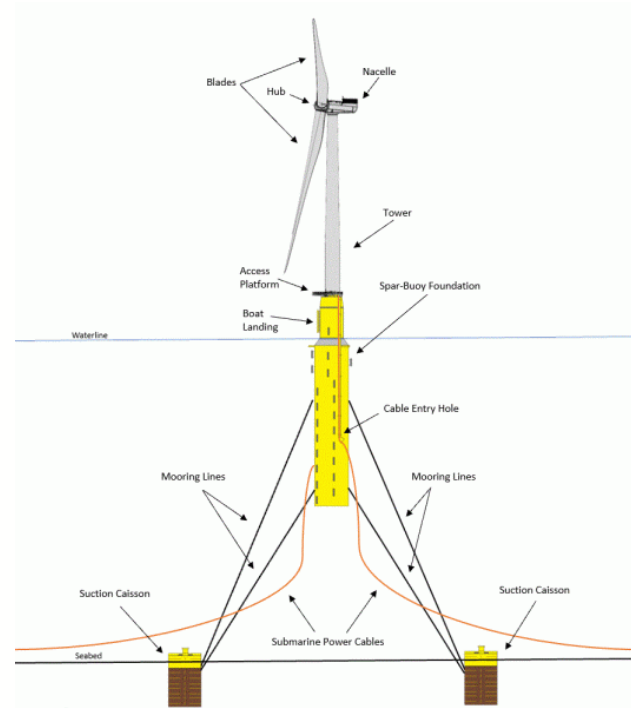
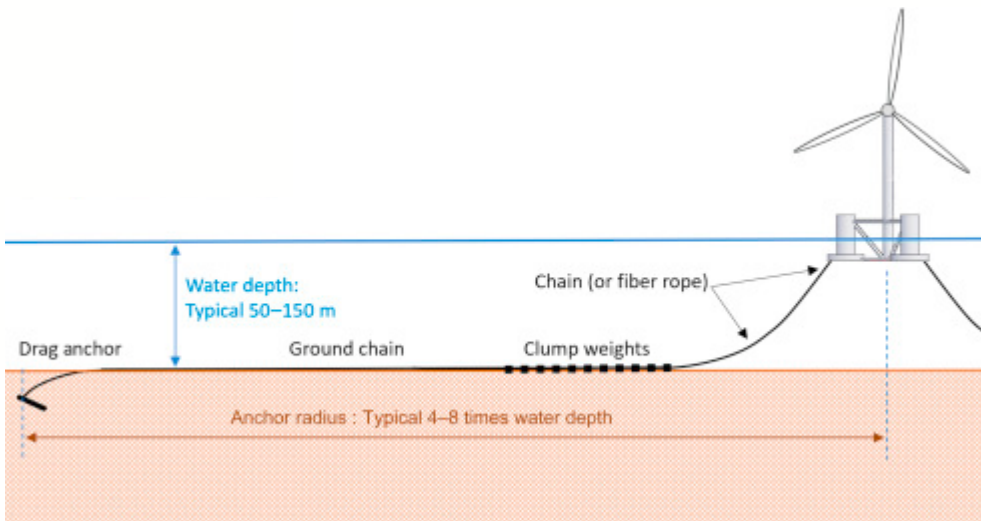
- Extensive experience from O&G industry
- A lot of inspiration can be taken and lessons learned
- Design parameters vary compared to FOW
- Many more assets for FOW = more mooring lines

1 - <https://www.offshore-technology.com/wp-content/uploads/image-digitalinsightresearch/Archive/nri/offshore/Stones.jpg>

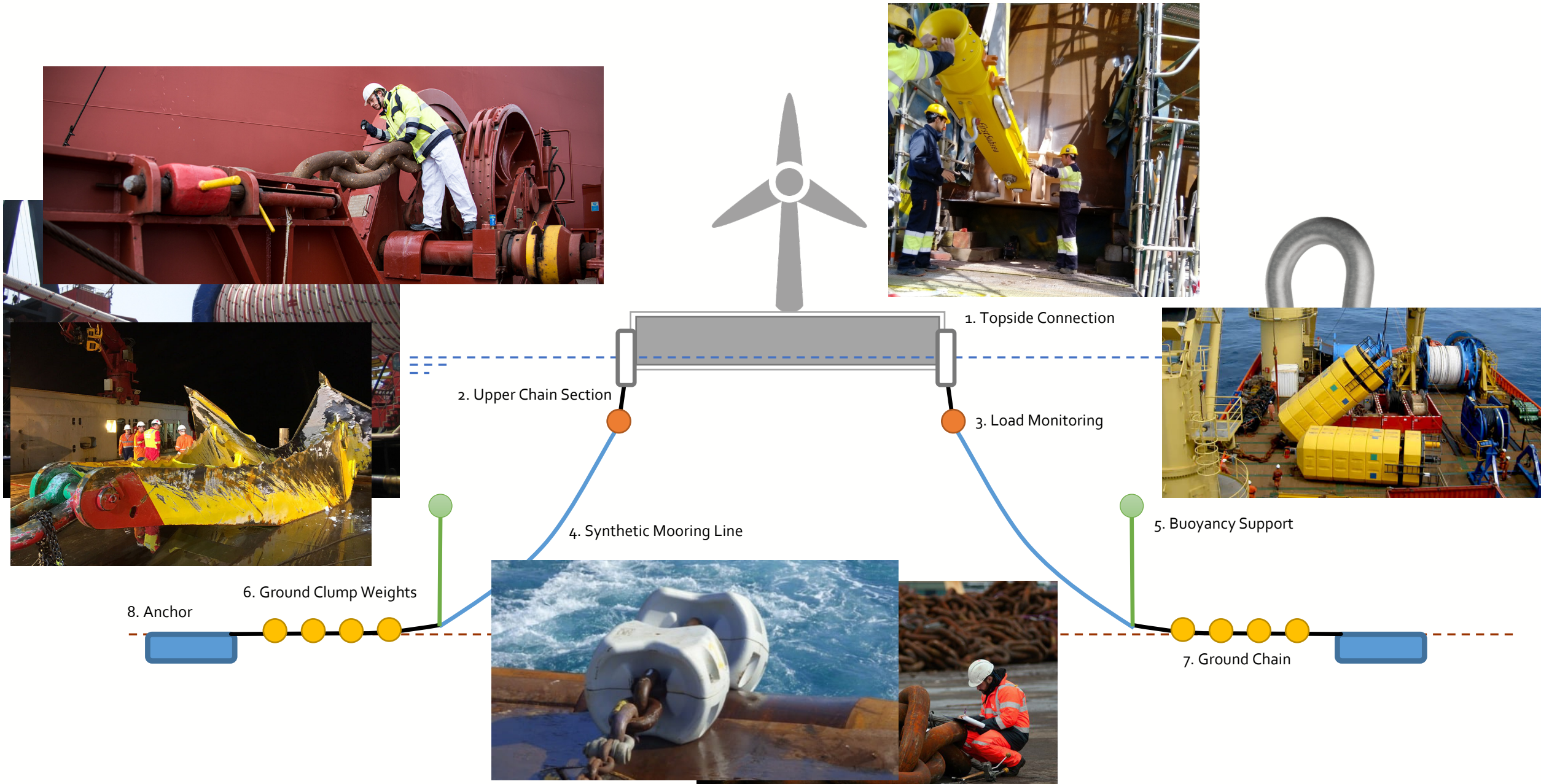
2 - <https://www.popularmechnics.com/technology/infrastructure/g2926/7-of-the-biggest-offshore-structures/>

3 - <https://www.offshore-mag.com/field-development/article/16758212/shells-perdido-sets-mooring-record>

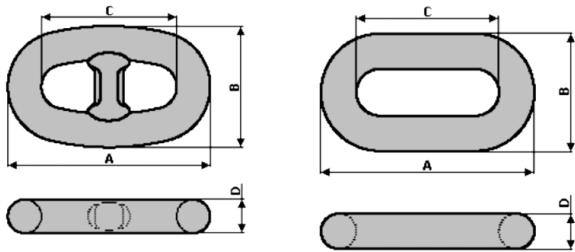
Different mooring types



Standard components



Chain

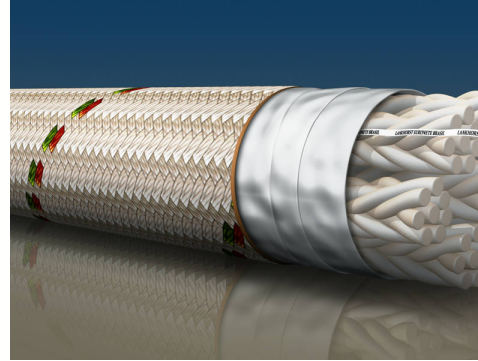


(a) Stud-Link

(b) Studless Chain

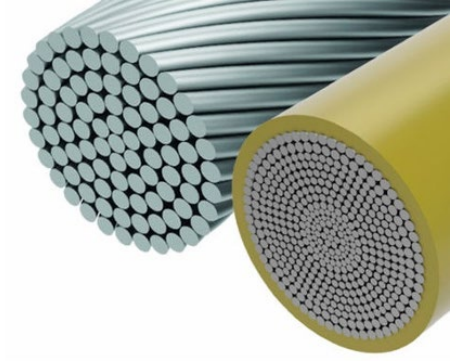
- Stud or studless
- Varying grades, usually R₃ or R₄
- Current maximum of 185mm
- High MBL and fatigue strength
- Very heavy (~700kg per link)

Synthetic Rope



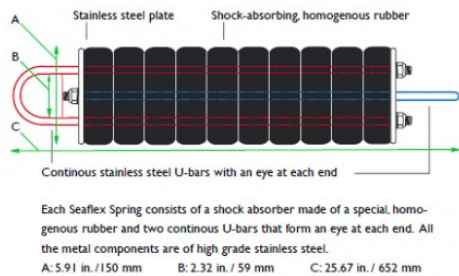
- HMPE, Polyester or Nylon
- Introduce compliance into system
- Very light (can be neutrally buoyant)
- High cost installation reels
- Not extensively proven for permanent moorings

Steel Wire

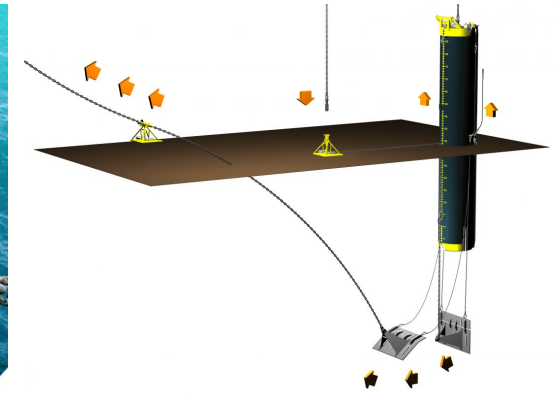
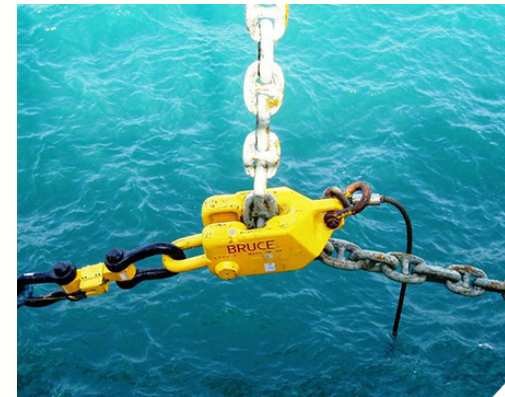
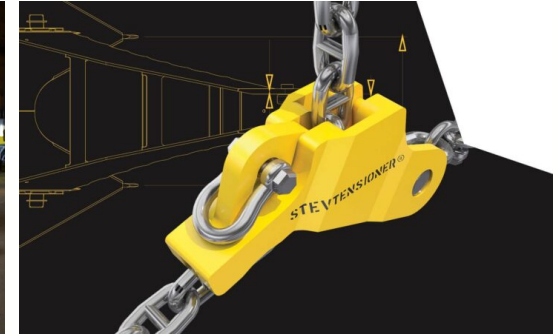


- Spiral strand wire rope
- Lighter than chain
- Well proven for FPSOs
- Potential use in catenary and taut systems

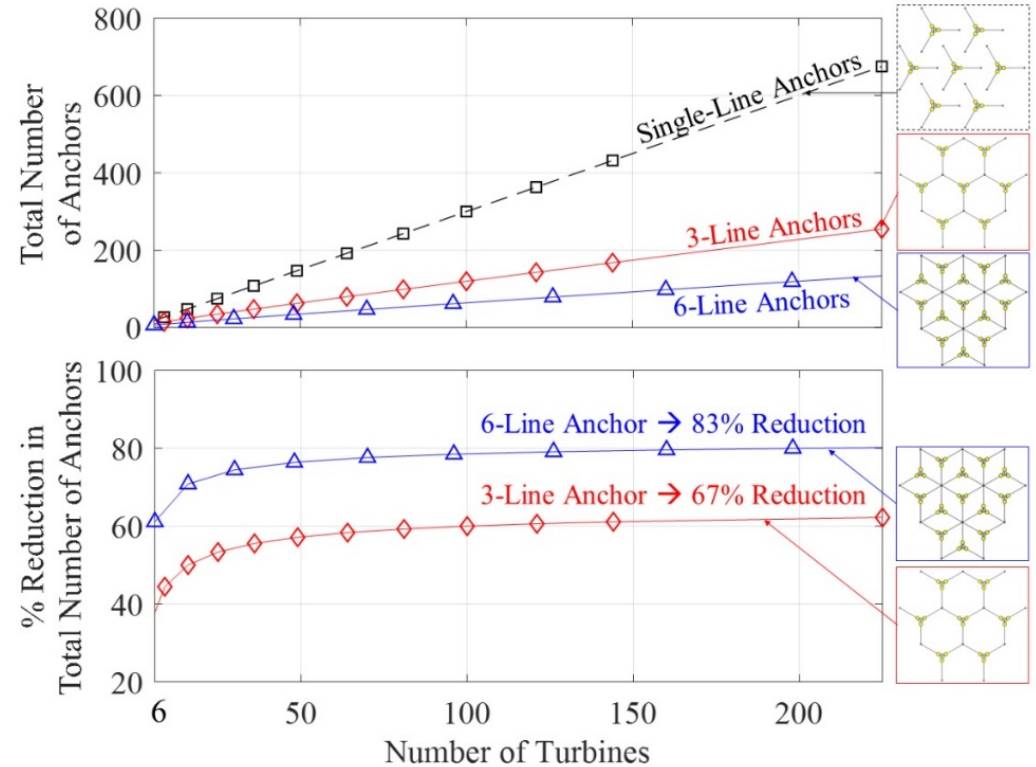
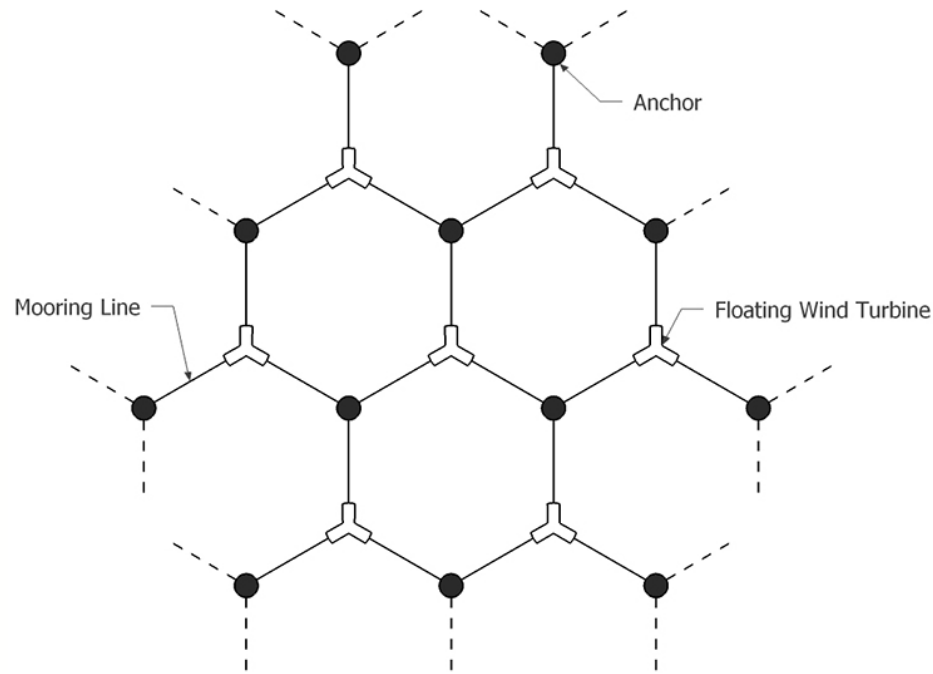
Load Reduction Devices



Installation Aids



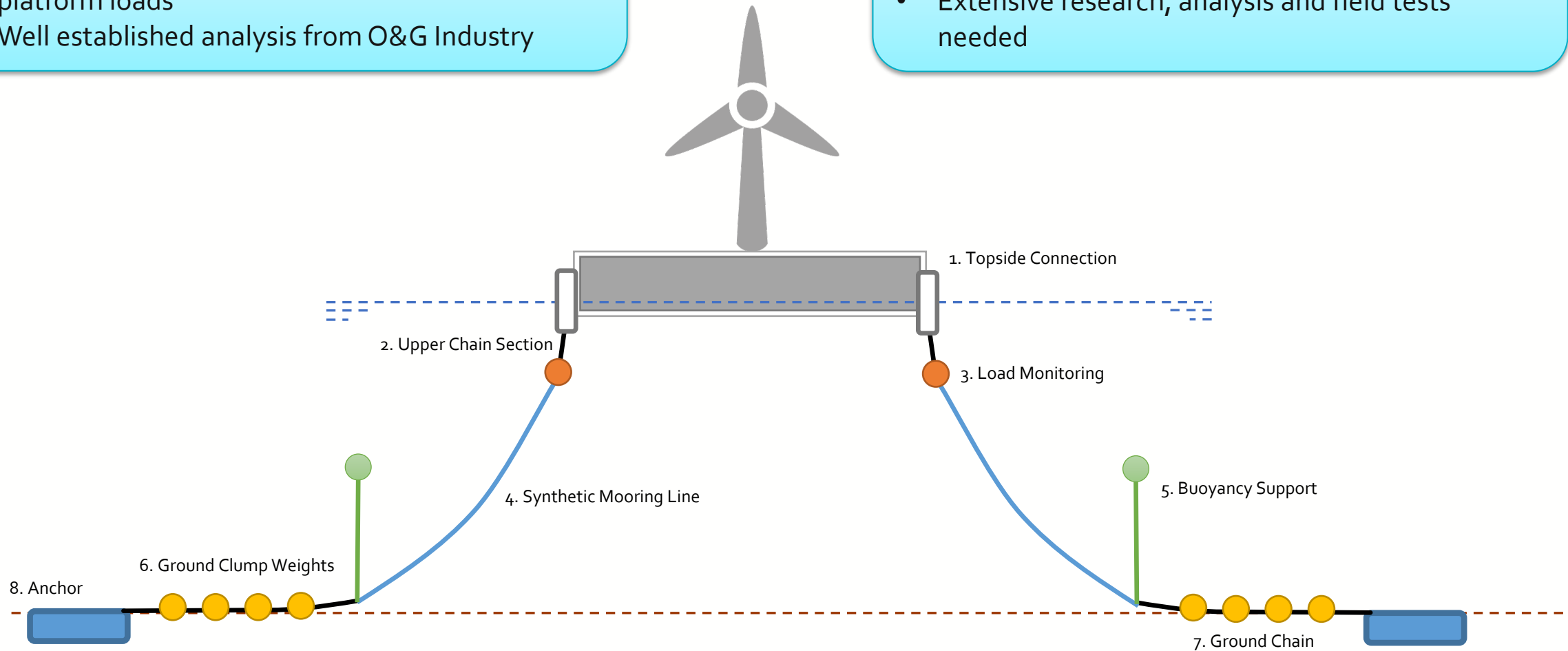
50 – 70% reduced peak load
30% reduced fatigue load



- Multiple mooring lines coming from the same anchor
- Anchor must be capable of taking multiple load paths
 - Suction caisson or pile anchor
- Reduce anchor fabrication and install
- Problems around failure
- More research needed

- Prevent platform excursions to prevent damage to export cable or surrounding assets
- Provide restoring forces and moments to platform loads
- Well established analysis from O&G Industry

- Lots of potential new advancements possible for FOW
- New design methodologies possible
- Extensive research, analysis and field tests needed



Contact us

Email us: info@ore.catapult.org.uk

Visit us: ore.catapult.org.uk

Engage with us:



GLASGOW | BLYTH | LEVENMOUTH | GRIMSBY | ABERDEEN | CORNWALL | LOWESTOFT | PEMBROKESHIRE | CHINA