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## Design and Installation of Synthetic Rope Moorings

Moorings and Anchor Conference & Workshop



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  - Synthetic Rope Moorings
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## Tadek Overview

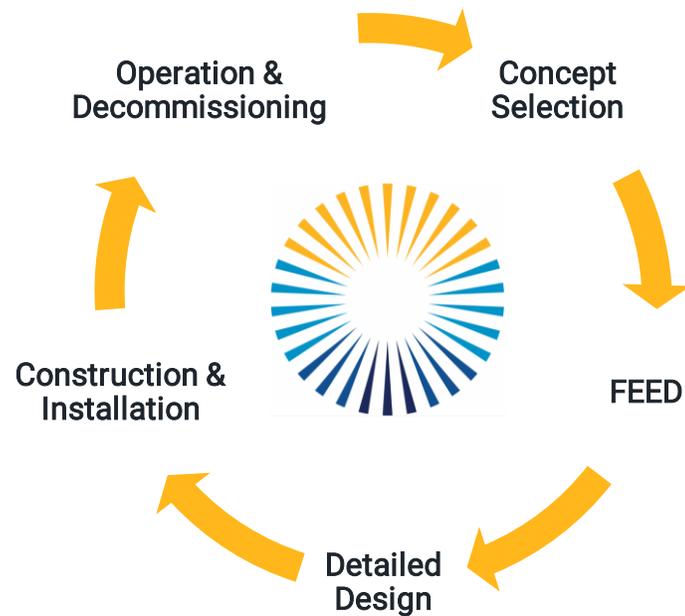
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# Introduction to Tadek

## Tadek

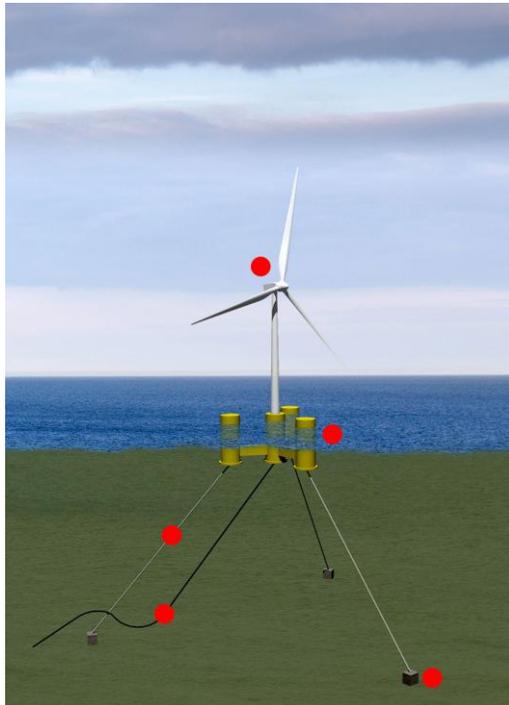
- Dynamic design & engineering consultancy established 2010.
- HQ in Woking, UK with a team of ~35 permanent staff.
- Over 300 projects worldwide (Europe, Africa, Americas, APAC).
- Expertise in traditional O&G to cutting edge renewable energy.
- Specialist partners (e.g. CFD, Geotech).
- ISO9001 Quality Management Certified UKAS BAB.



# Capabilities

## Advisory

- Field Development
- Owners Engineering
- Risk Analysis
- Technical Due Diligence



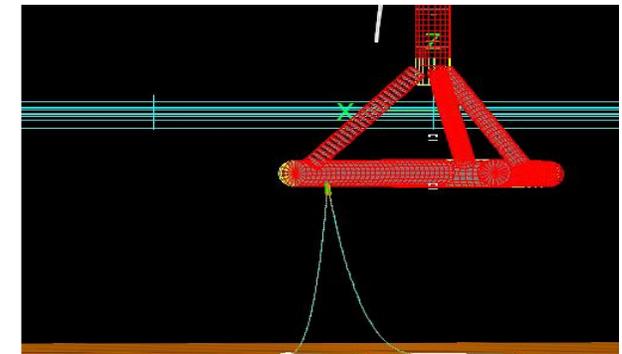
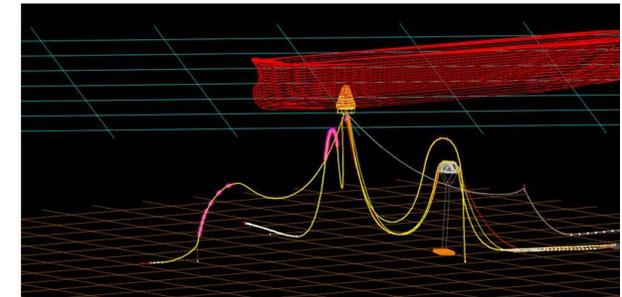
## Ocean Projects

- Project Management
- Project Planning
- Project Engineering
- QHSE

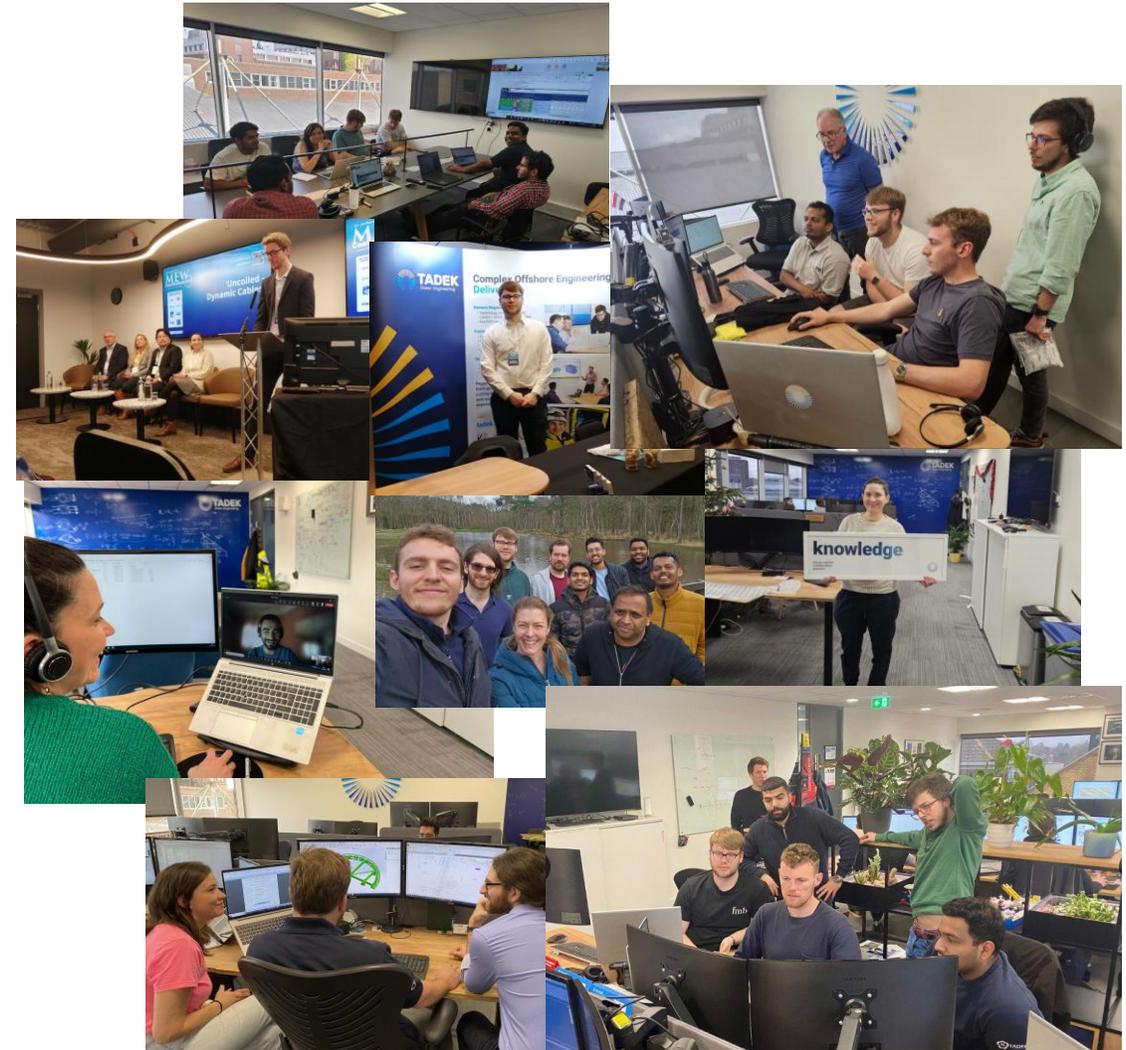
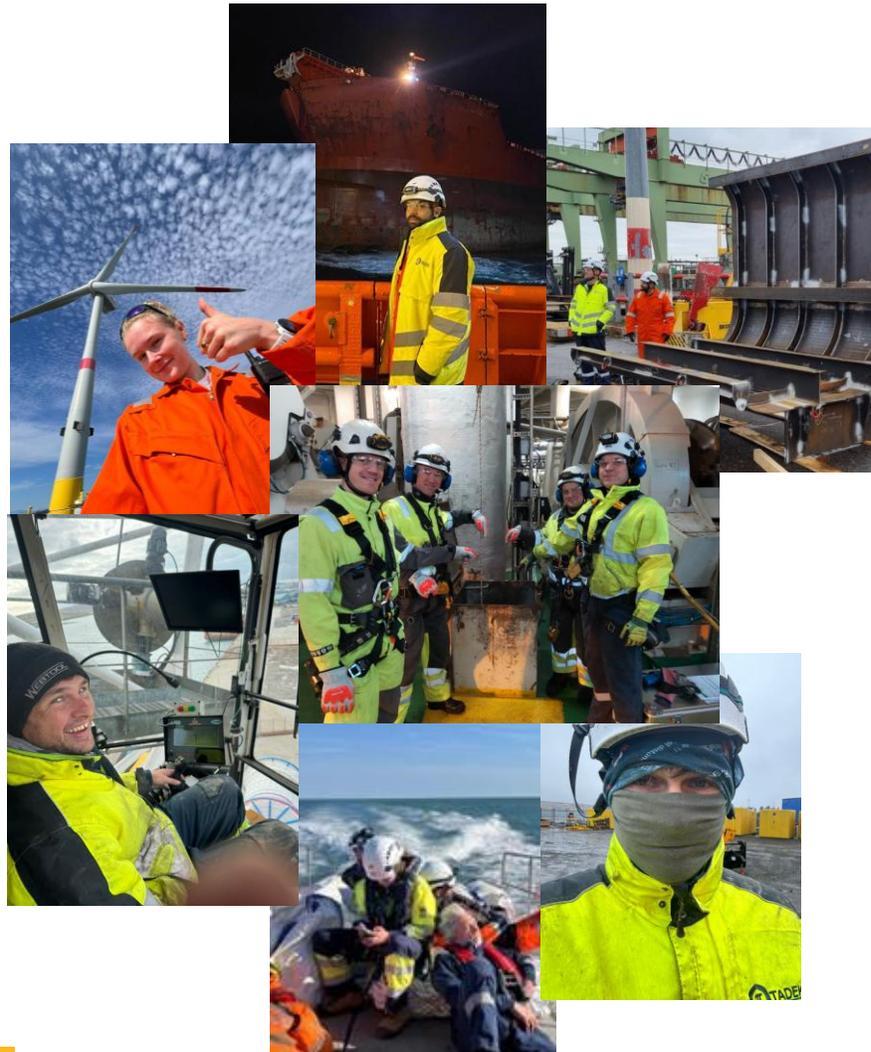


## Ocean Engineering

- Naval Architecture
- SURF & Cables
- Design & Structural Engineering
- Installation Analysis
- Mooring, FOW & Floating Systems



# One Team – Two Disciplines



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**Synthetic Rope  
Moorings**

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# Synthetic Ropes in Offshore Energy

Synthetic ropes used traditionally in offshore energy projects with different conditions:



Deep water mooring of production platforms (polyester)



Tanker mooring to SPM systems (nylon)



Quayside and Ship-To-Ship mooring of tankers and LNGCs (HMPE)

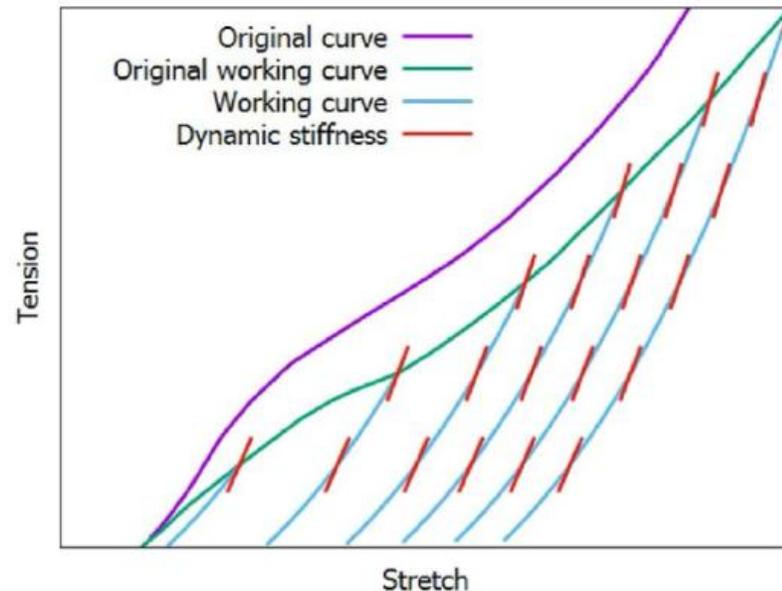
Increasingly the primary choice for the mooring systems of FOWTs because suitable to taut and semi-taut systems with advantages over catenary systems:

- Lighter weight
- Better compliance and load response
- Durability
- Low cost

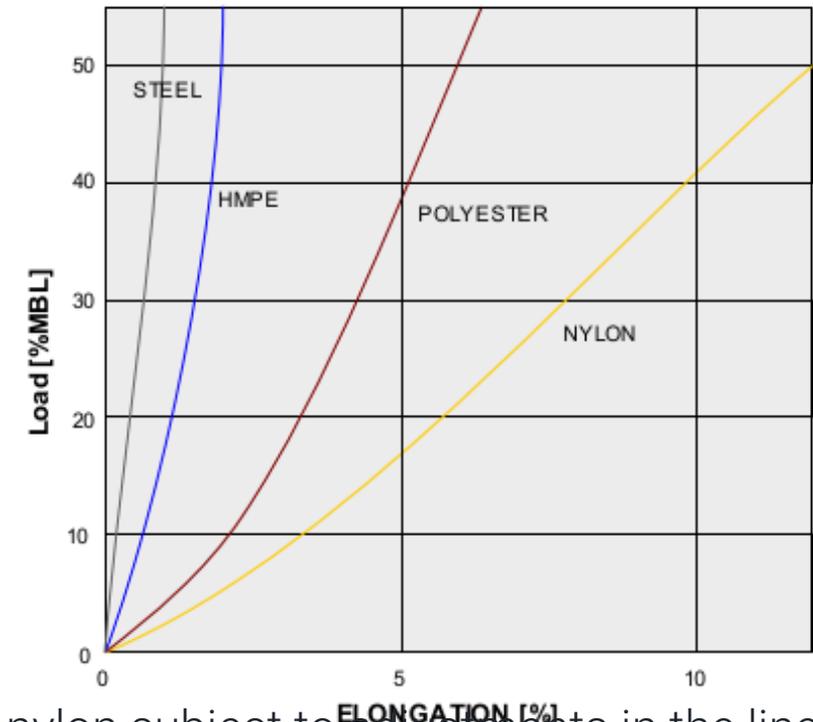
# Synthetic Rope Properties

Different types of synthetic ropes have different properties:

- HMPE -> high strength and high stiffness, creep-sensitive
- Polyester -> mid-range stiffness, limited creep, low cost
- Nylon -> large elongation, long-term usage not proven



DNV "Syrope" Model – Falkenberg et al., 2017



Courtesy of Bredon-Bekaert

- Both polyester and nylon subject to adjustments in the line length due to stretching
- Loading follow a hysteresis, according to the Syrope model
- Nylon prone to significant stretching after the hook-up, requiring different steps of re-tensioning operations

# Standards and Industry Guidance

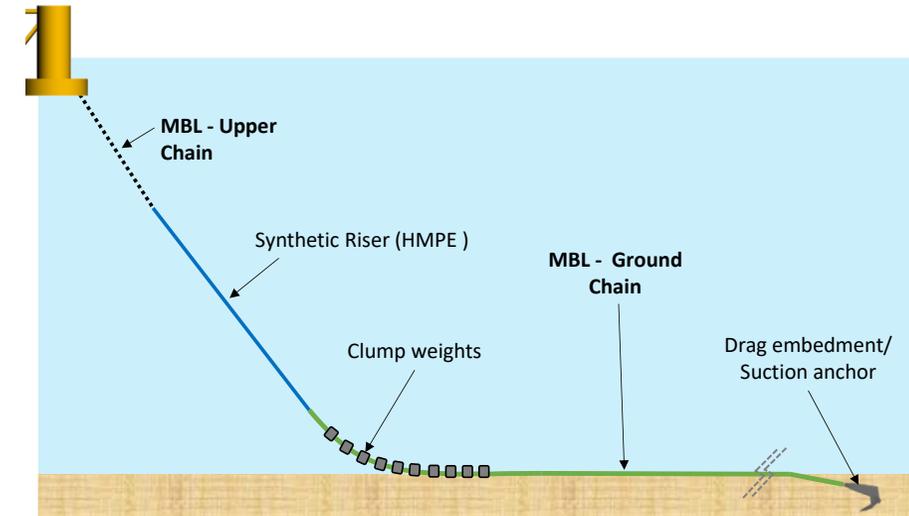
Most existing projects employ a hybrid mooring line design:

- Top steel segment (typically chain to facilitate length adjustment)
- Fibre rope segment/s (may be multiple for manufacturing and handling)
- Bottom steel segment (chain or wire to connect to the anchor)

Guidance from industry standards (ABS, BV, DNV) building on past O&G deep water experience aligned on:

- Dynamic stiffness formulation
- Protective cover against damage and particle ingress
- Creep monitoring for re-tensioning (where applicable)
- Avoidance of seabed contact
- Potential increase in SFs (e.g. BV and ClassNK)

Nylon suitability to permanent moorings still under investigation and qualification – most standards refer to polyester / HMPE as basecase



# Case Study – Design of Synthetic Moorings for FOWT

Design of a mooring system for a Floating Wind Semisubmersible, considering water depths of 70m and 120m

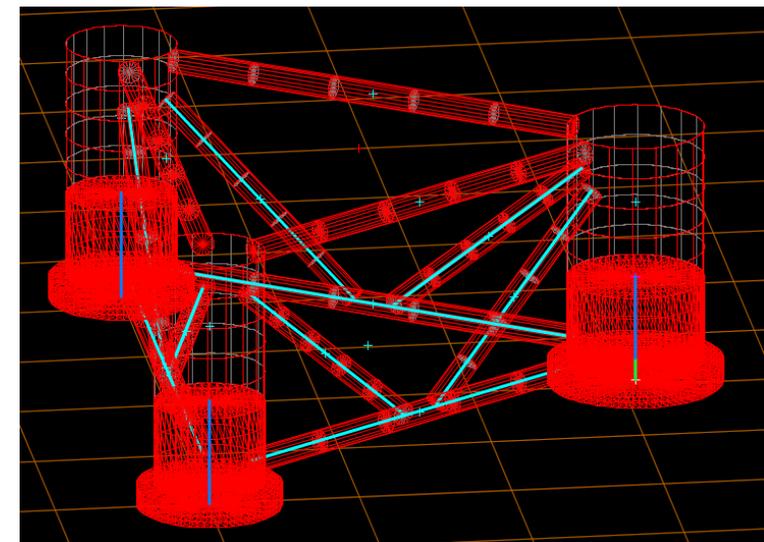
Main criteria:

- Design life of 30 years + 2yrs for installation / decom
- Mooring line loads SFs according to ABS
- Clearances of rope sections and buoyancy modules
- Max offsets within 40%WD

Asymmetric semisubmersible design with 3 columns, with corner WTG

Mooring hang-off below the heave plates

Loading Condition	Redundancy of the system	Design condition of the System	Safety Factor
Design Load Cases	Redundant	Intact	1.67
		Damaged condition with one broken line	1.25
	Non-redundant	Intact	2.00
Survival Load Cases	Redundant or Non-redundant	Intact	1.05



# Case Study – Design of Synthetic Moorings for FOWT

4-lines symmetrical mooring system

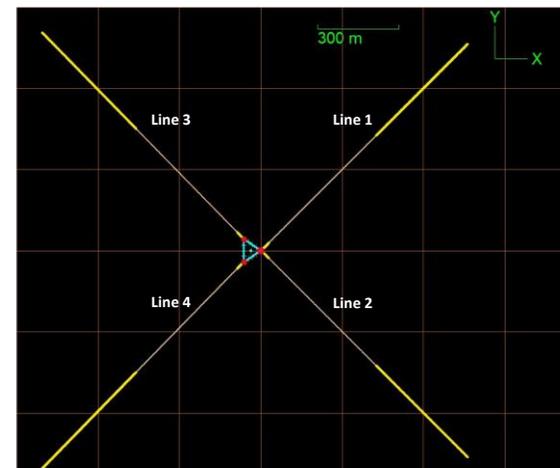
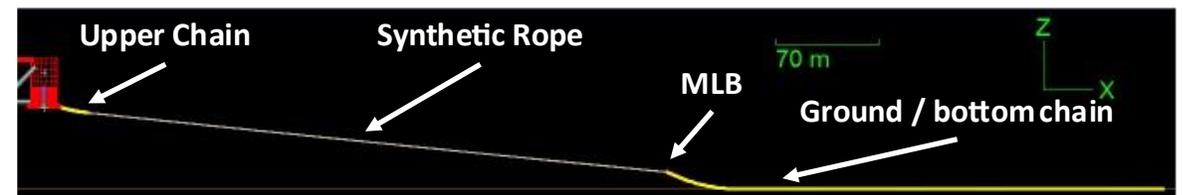
Requirement for minimum vertical uplift at the anchor leads to:

- Chain top section
- Synthetic Rope mid section (polyester / nylon)
- Chain bottom section to the anchor

Midline buoy of net buoyancy of 30t

Same components between water depths (254mm Polyester vs. 240mm Nylon)

- All designs comply with ULS criteria
- Nylon reduces loads with similar pretension
- System not fully redundant



Water Depth [m]	Synthetic Line type	Max Line Tension [kN]	SF
70	Nylon	7741	2.45
70	Polyester	9070	2.09
120	Nylon	7429	2.55
120	Polyester	8586	2.21

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## Installation and Hook-Up Procedures

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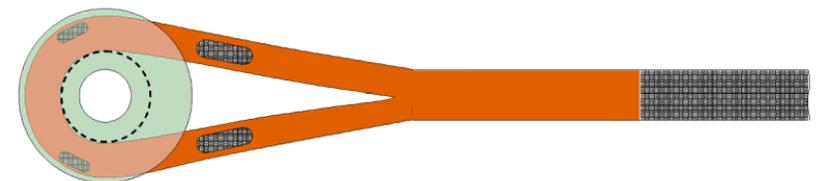
Moorings installation almost invariably involves anchors pre-laying -> Synthetic ropes often pre-laid with buoyancy elements to keep seabed clearance

Hook-up procedures with polyester or nylon may require applying tension for a long time (e.g. 60 mins) to achieve elongation:

- Example: Penguin FPSO applied cross-tensioning across opposite lines using chain stoppers
- FOW favours using in-line tensioners (when needed)

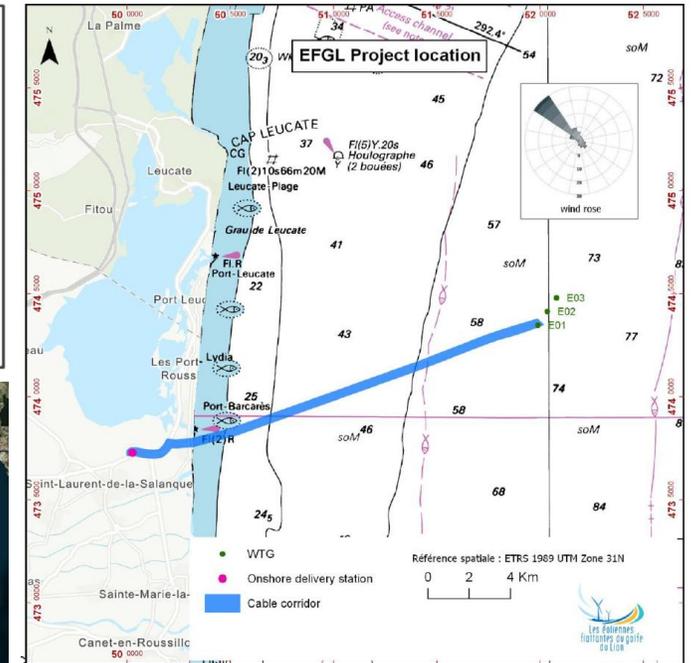
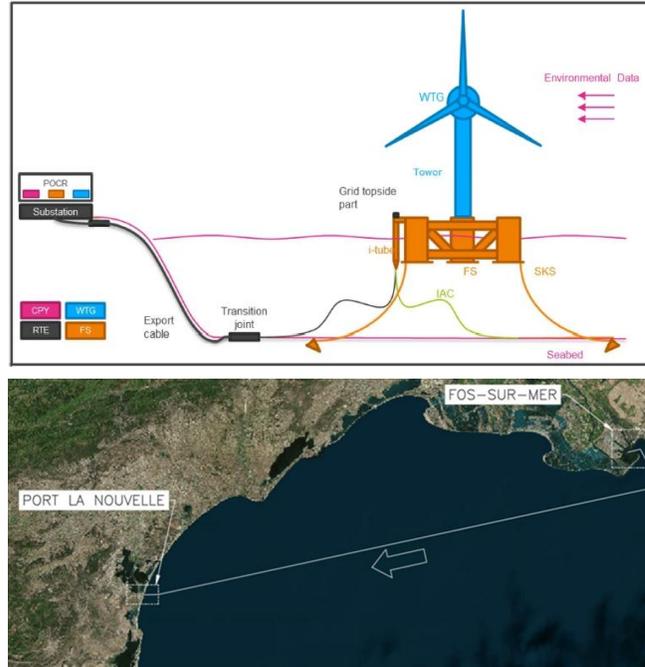
Fibre ropes often terminated with spliced eyes fitted on thimbles

Specialist solutions exist for quick connection (e.g. Balltec), some developed for FOW



## EFGL Project Overview

- 3x Floating Wind Turbines installed 16km offshore Leucate in Golfe du Lion, France
- Installation complete in summer 2025
- Principle Power WindFloat Floater
- Vestas 10MW Wind Turbine
- ~70m water depth
- Tadek worked with EPCI contractor Eiffage Metal and was involved in all operations below.

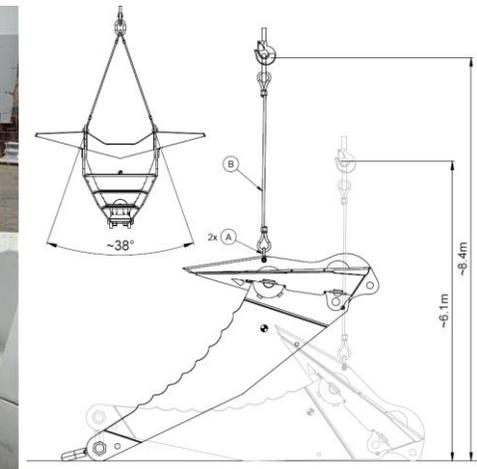
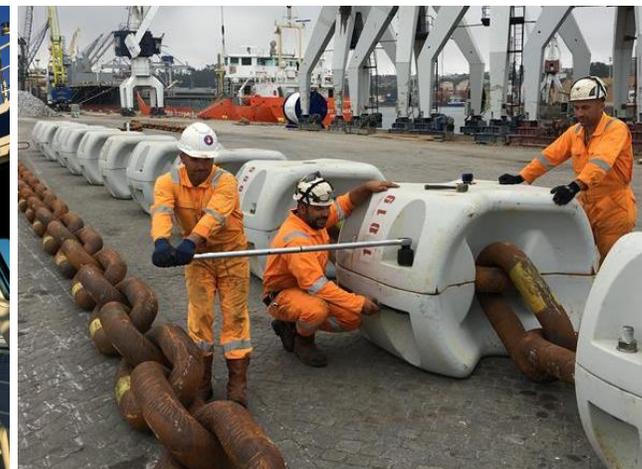
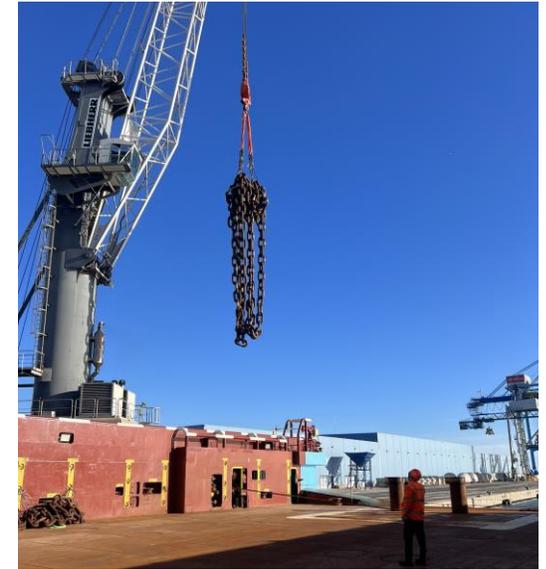


## Mobilisation Operations

- Prelay Equipment Mobilisation
- Drag Anchor Assembly
- Clump weight assembly
- Chain handling

## Tadek Input

- Mobilisation Planning & Documentations
- Traceability sheets
- On-Site assembly Supervision
- Lift planning
- Port interfacing



## Mooring Prelay Operations

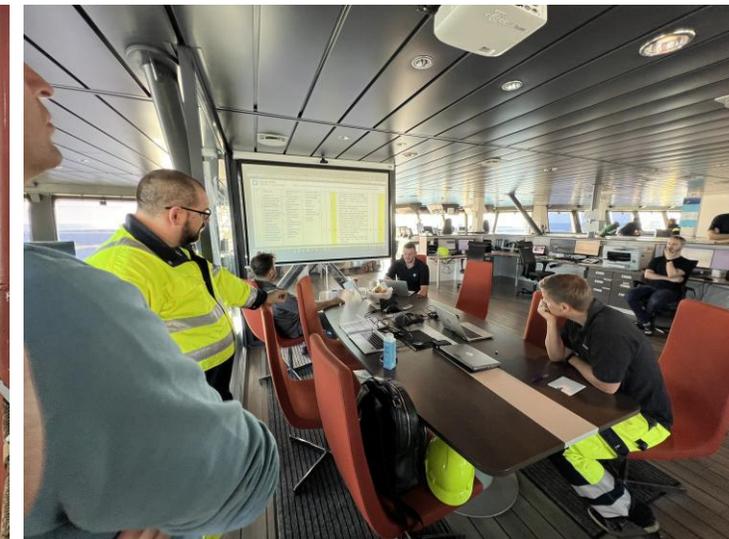
- Two phases of lines installation
  1. Drag anchors, clump weights & chain. Drag anchor proof loading (320t using Tandem Pull methodology)
  2. HMPE mooring line & PMC mandrel

## Tadek Input

- Mooring Prelay procedures
- As-built recording throughout operations
- Storyboards, site plans, deck layouts, task plans, lift plans
- On-site project engineering support

## Lessons Learned

- Vessel selection: gantry crane or aft deck crane would allow better equipment handling
- Learning curve with deploying certain components / installation aids / connections on deck
- Mooring system design / ground chain length very sensitive leading to lost time and potential risk
- Marine spread / timings were not complex – Phase 1 in 10 days, Phase 2 in 5.



## Offshore Tow to Site

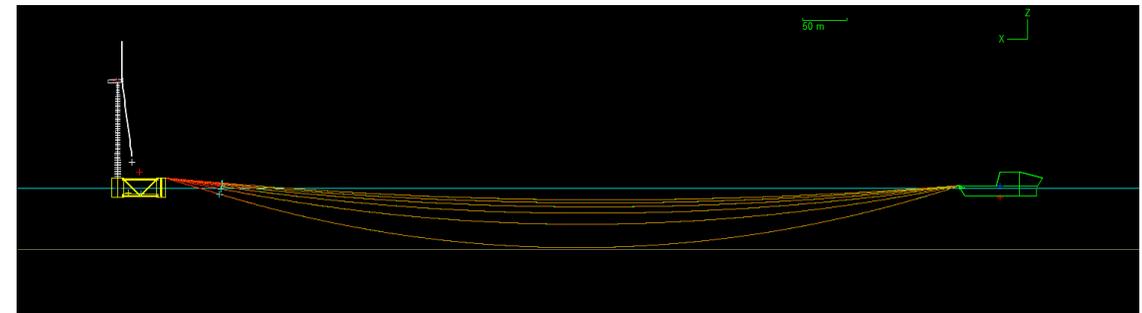
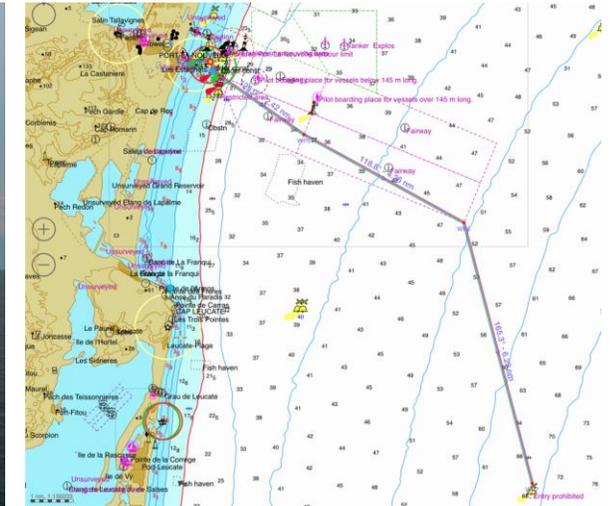
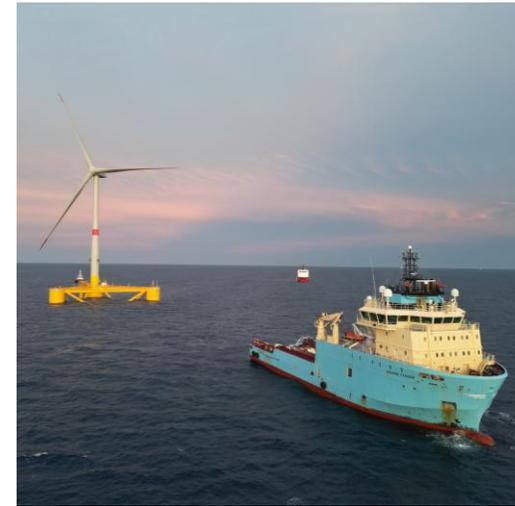
- Ballasting to installation draft & lift bag removal
- FWT towing from PLN to Installation Site
- Tow distance ~13nm

## Tadek Input

- Towing deliverables
- Bollard Pull & Towline Catenary calculations to DNV-ST-N001
- Marine spread specifications
- Tow Rigging Design & Draughting
- Passage planning with Master Mariners & local stakeholders
- Manoeuvre sketches and procedures
- Tow Manuals

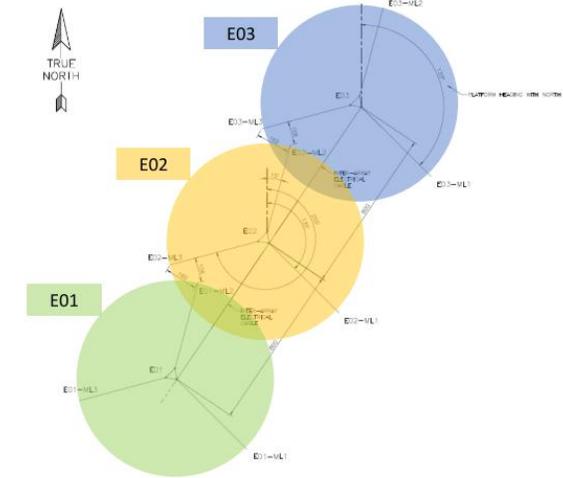
## Lessons Learned

- Technicians for onboard equipment on standby



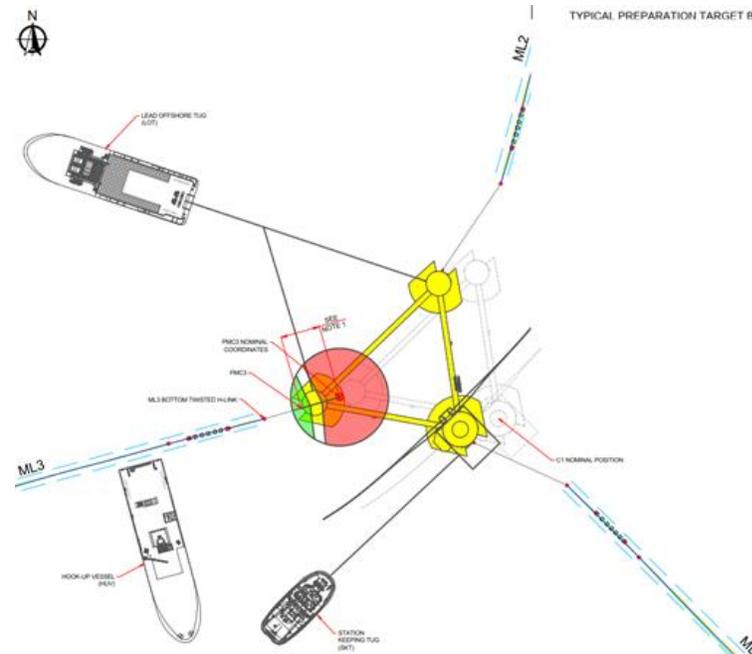
## Hook-up Operations

- Receptacle seafastening removal
- Pick up of pre-laid PMC mandrels
- Handshake of pre-laid moorings between vessel & FWT
- Pull-in of mandrels into receptacles on FWT columns



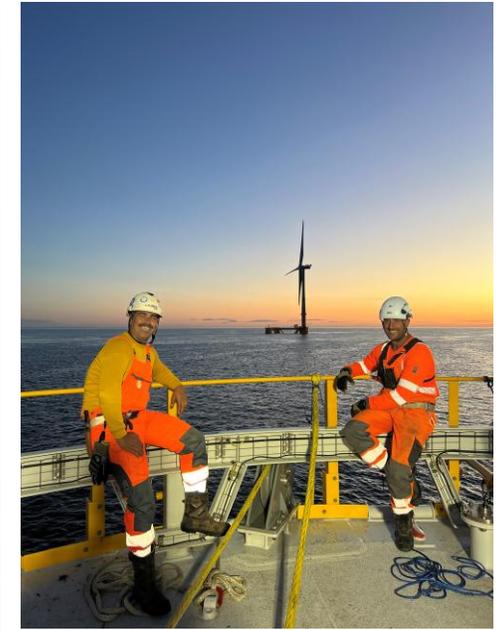
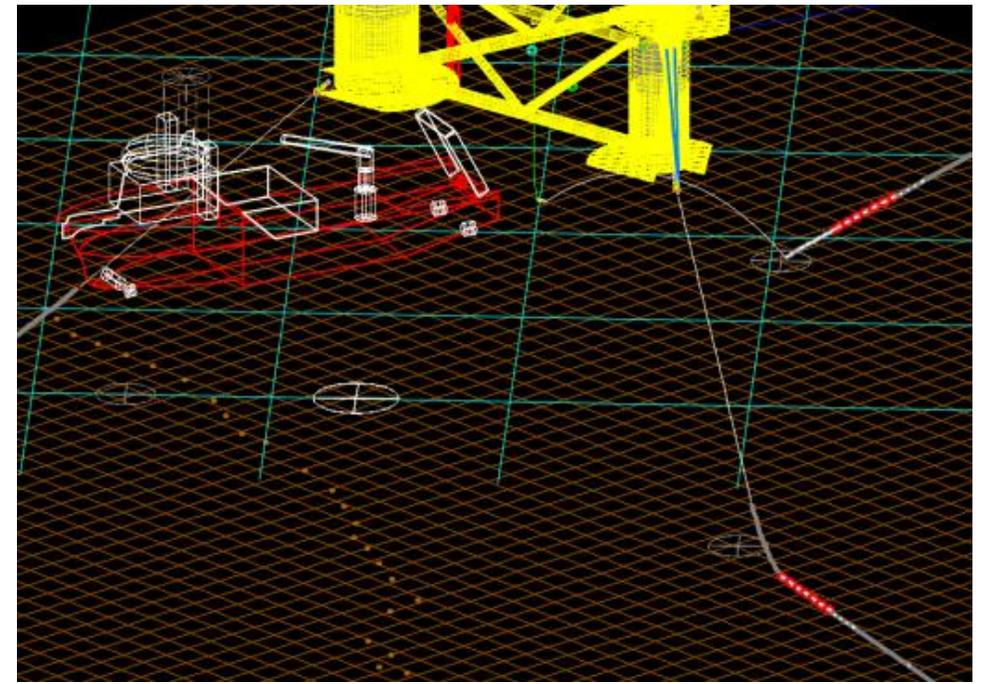
## Tadek Input

- Field drawings & storyboards
- Positioning guides / target boxes for installation
- Inputs from on-board winch, tug limitations, fairlead capacities, and environment
- ROV / survey spread interface
- Recording & reporting of as-built data
- On-site project engineering throughout the operations



## Hook-Up Lessons Learned

- PMC testing was important – adjustment rigging.
- Tight twist tolerances on HMPE ropes was difficult to achieve.
- Tadek design of installation aid to enhance operation.
- Weather buoy for weather monitoring.
- Crew Transfer limited operations.
- **Most efficient hook-ups on WindFloat platforms ever achieved !**



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## Conclusions and Perspectives

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# Conclusions and Perspectives

- Synthetic ropes can provide better performance than steel components and have already significant track record in specific applications
- Different types of synthetic rope with different properties, suitable for alternative applications (e.g. nylon for shallow water harsh environments, polyester for deep-water offshore moorings, HMPE for TLPs and mild)
- Industry standards note the importance of re-tensioning and avoidance of seabed contact, is this still relevant with novel solutions?
- Hybrid moorings with synthetic rope segments are technically feasible for floating wind and satisfy all design criteria in intact conditions
- Offshore installation is sensitive to the requirement for seabed clearance and may require bespoke components
- Tadek's experience shows that HMPE removes need for re-tensioning but subject to strict tolerances and requires careful monitoring of twisting
- Learning curves for floating wind mooring installation very steep -> potential of significant time savings in large scale wind farm
- Development of bespoke quick-release connectors and terminations enabler for smoother installations



**TADEK**  
Ocean Engineering

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**Naval Architects, Project Managers,  
Offshore & Subsea Engineers**

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