Engineering Fit-For-Purpose Dyneema® Ropes for the Stiesdal TetraSpar Demonstrator

Binay Patel, Business Development Manager, Americas, DSM

Collaborators:
Rigo Bosman, Mooring Rope Specialist, DSM
Alberto Leão, Sales Manager, Lankhorst Ropes
Rasmus Hovgaard, Project Engineer, Dynamica Ropes
Patrick Falk Nybroe, Project Engineer, Stiesdal Offshore Technologies A/S

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TetraSpar Demonstrator

- World's first industrialized offshore foundation
- Commissioned & fully operational in 200-meter water depth since mid-2021
- Competitive advantages:
  - Lean manufacturing
  - Lean assembly
  - Streamlined installation
  - **Material efficiency (today's focus)**
    - **Optimal use of materials to lower total system costs**

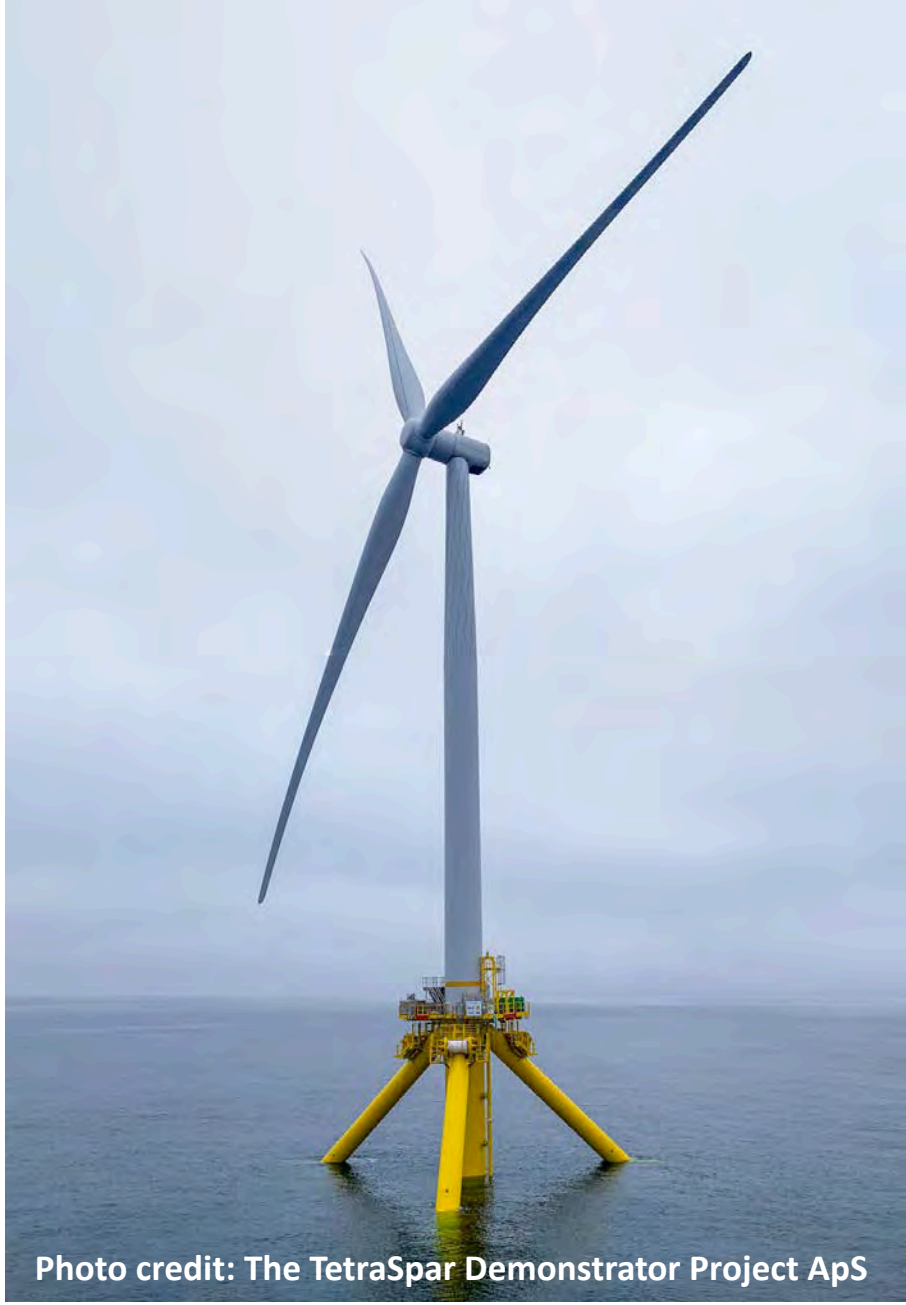
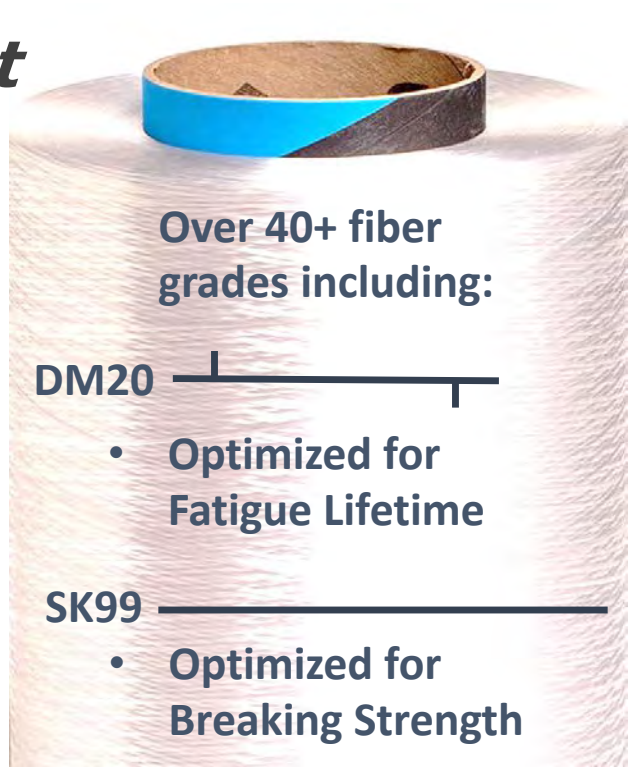


Photo credit: The TetraSpar Demonstrator Project ApS

How can Dyneema® fibers help Stiesdal achieve lower LCOE?

- **Facilitate structural light-weighting – *getting the steel out***
  - with keel lines made with Dyneema® DM20
- **Ensuring mooring integrity – *proving safety & reliability***
  - with GAMA98® mooring lines made with Dyneema® DM20
- **Flexible deployment – *adjusting to operational changes***
  - with winch lines made with Dyneema® SK99



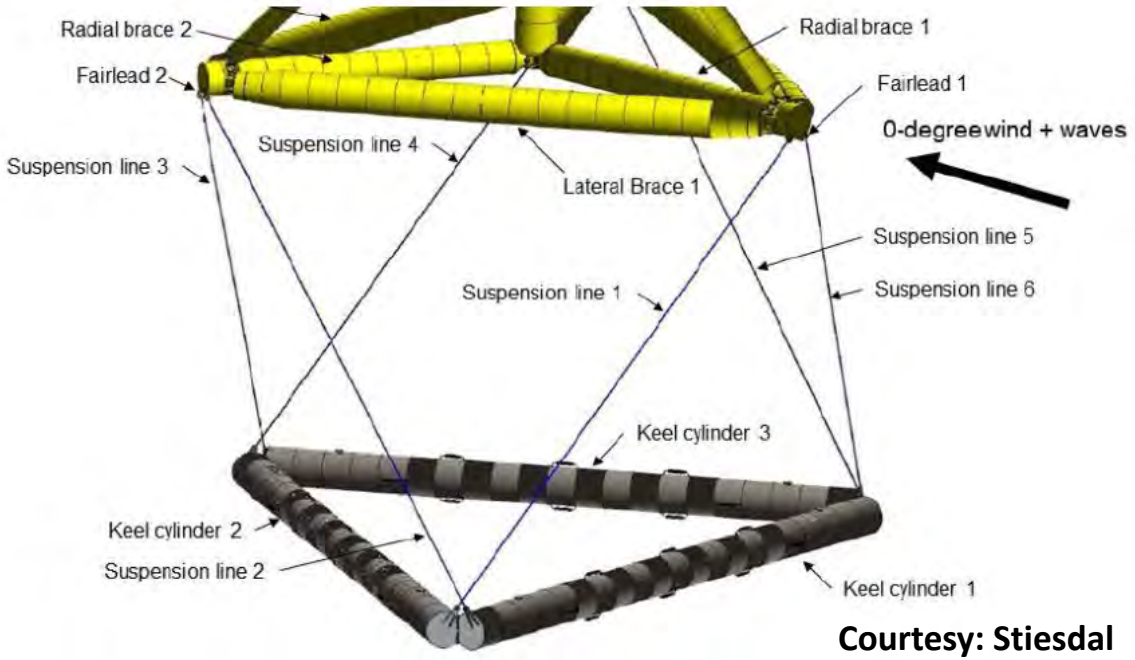
Facilitating Structural Light-Weighting

Winch lines made with Dyneema® SK99

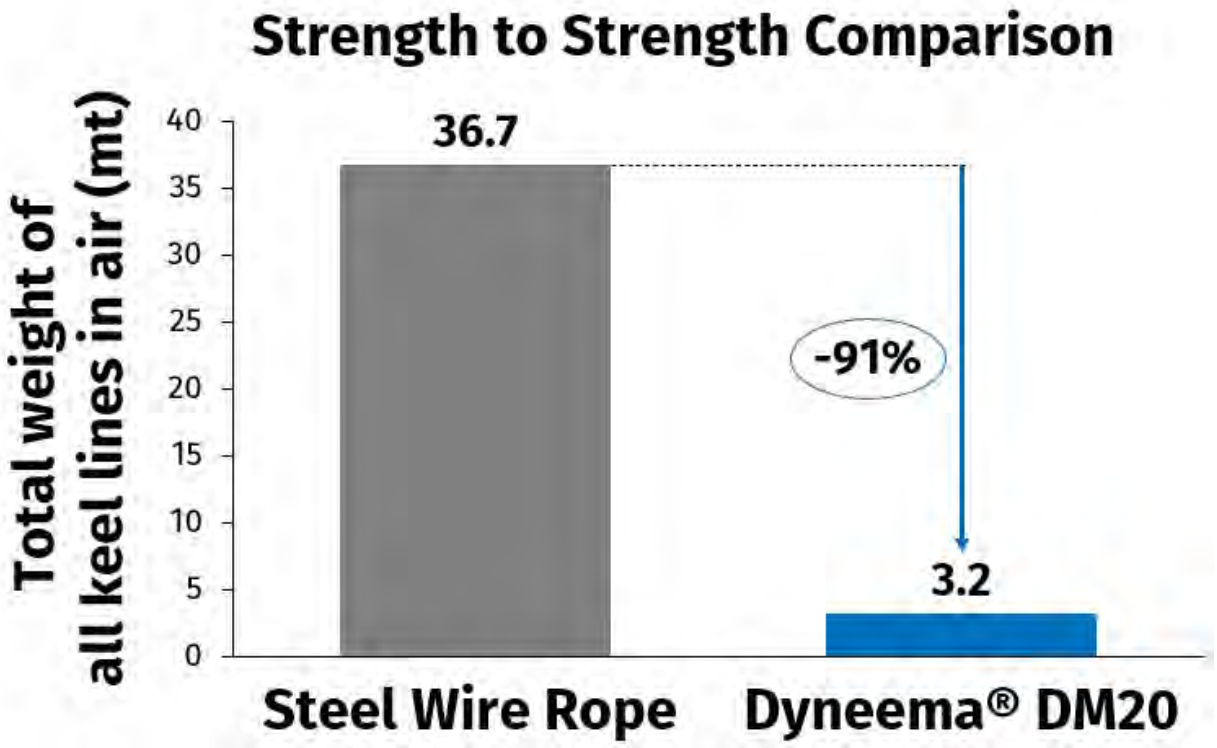
Keel lines made with Dyneema® DM20

Photo credit: Dock90

Total Weight of Keel Lines Reduced by 91%



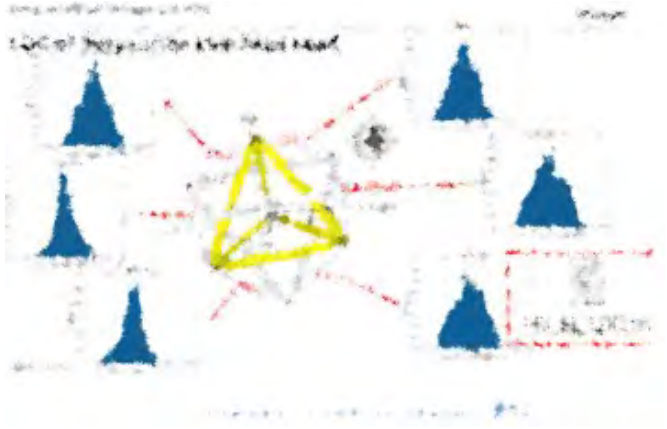
Courtesy: Stiesdal



- When submerged, Dyneema® is neutrally buoyant – saving 30+ mt of extra buoyancy
- Meeting breaking strength requirement is only the first step

Regaining Design Freedom

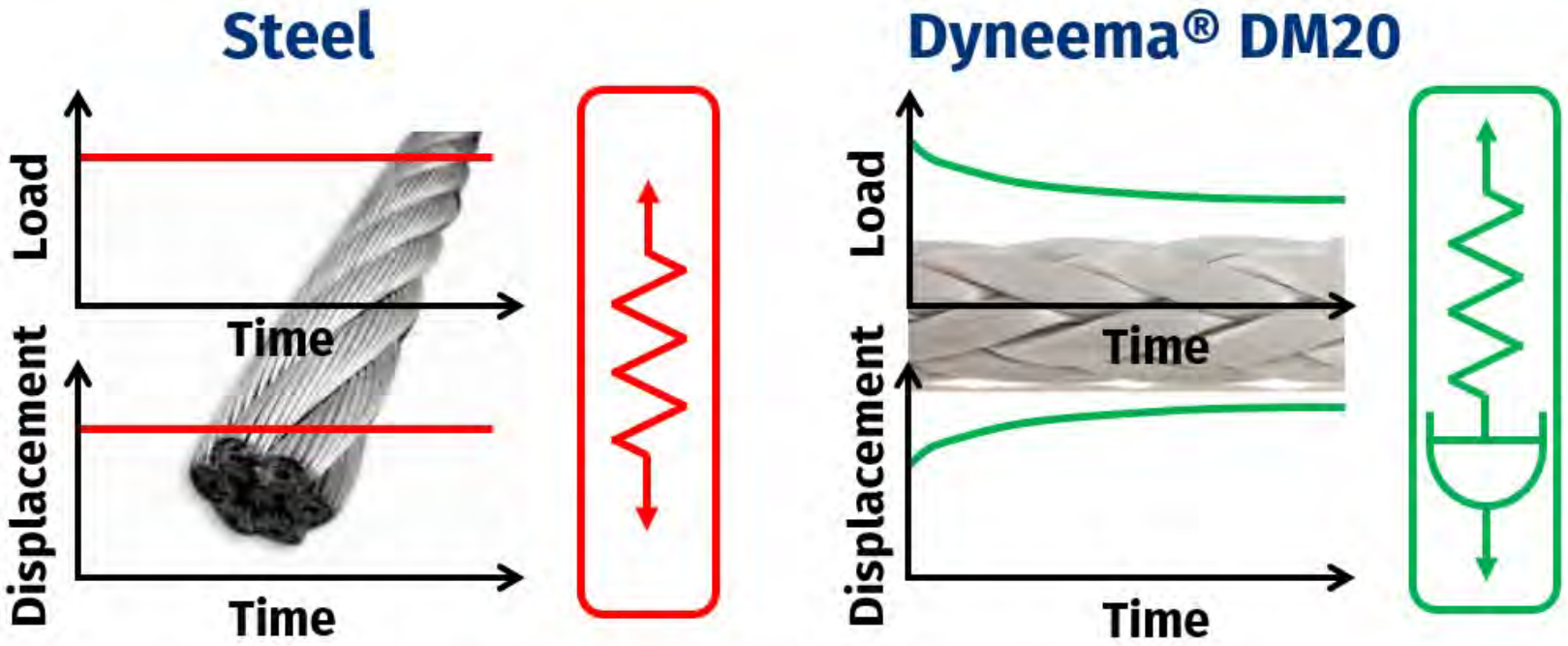
- Today there is no standard for synthetic keel lines - *How can we validate the system holding capacity for the keel lines?*
- DSM has developed an engineering method for achieving safe & reliable rope performance for offshore applications
- Ropes developed with the engineering method are certification-ready via DNV



TetraSpar Assurance Case:

- **<u>Reduced</u>** full-scale testing facilitated by:
  - Fatigue performance modeling
  - Scaled testing (Ex. bending fatigue)
  - Splice integrity testing for end terminations

Leveraging the Full Potential of Synthetics



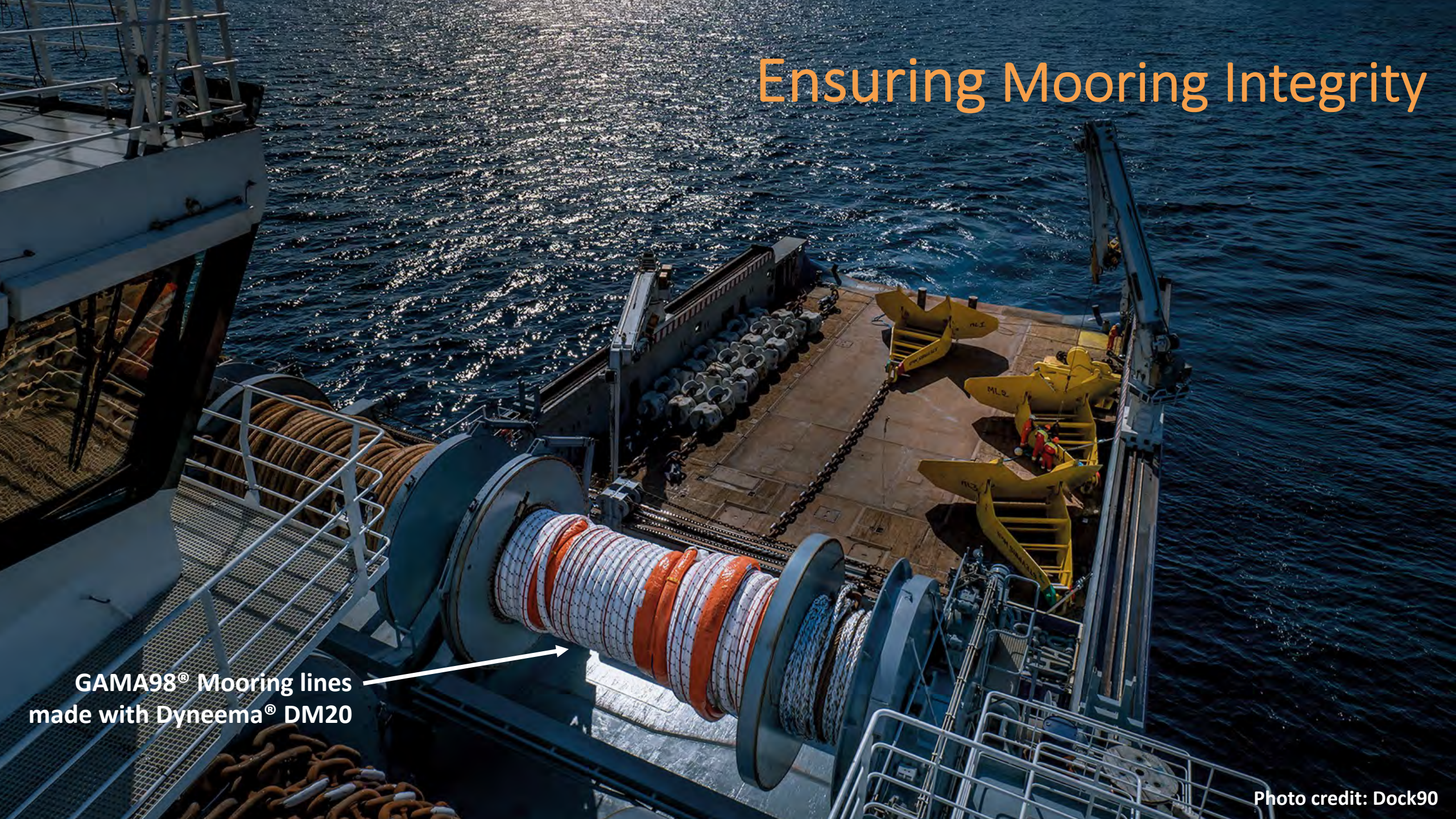
Elastic Response: Deformation and load are directly proportional.

Viscoelastic Response: Over time deformation can increase and loads can decrease.

- 50% of load sharing capability occurs in 1st hour

- TetraSpar Keel Lines: length differences within the rope construction are reduced

Ensuring Mooring Integrity

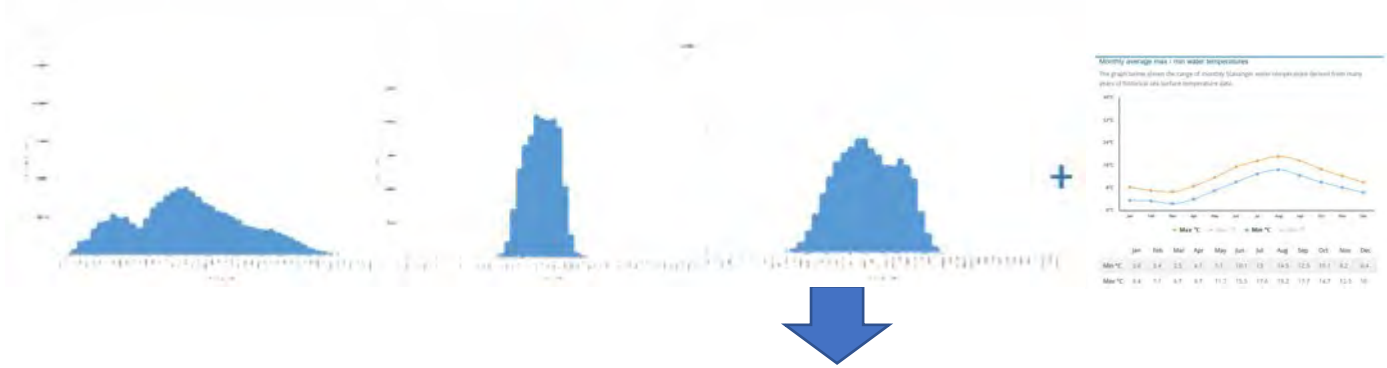


GAMA98® Mooring lines
made with Dyneema® DM20

Photo credit: Dock90

Assuring Mooring Performance over a 25-year Operational Life

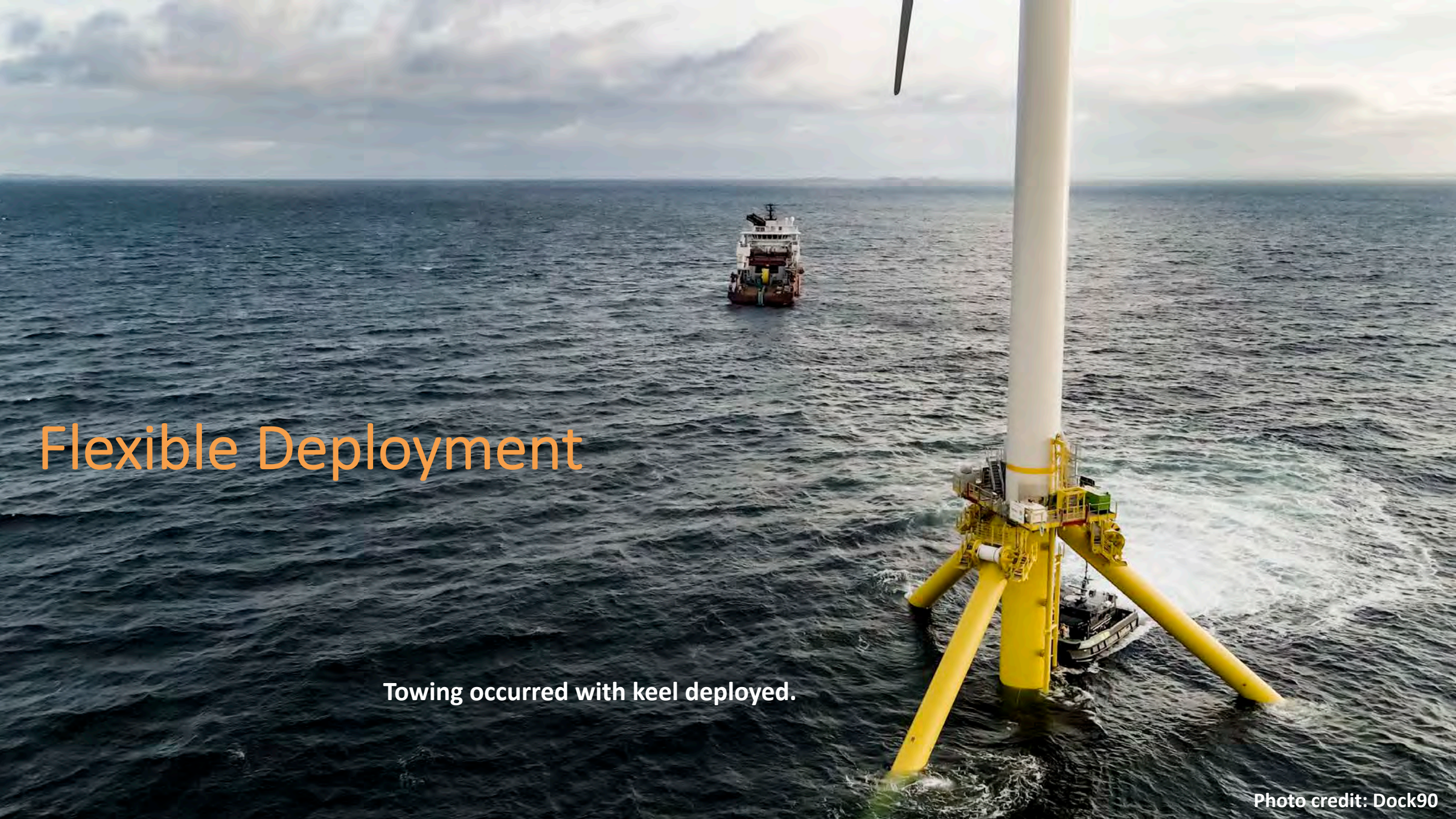
- Defined the worst-case environmental conditions:
  - Gather inputs on the maximum loads
  - Applied at maximum temperatures
  - For 25 years of operational life
  - Following DNV & ABS guidelines



- Utilized DSM's Fatigue Performance Model with core-equations certified by DNV.

- Results: **Negligible creep deformation (<0.1%) on all three GAMA98® mooring lines made with Dyneema® DM20.**

Flexible Deployment

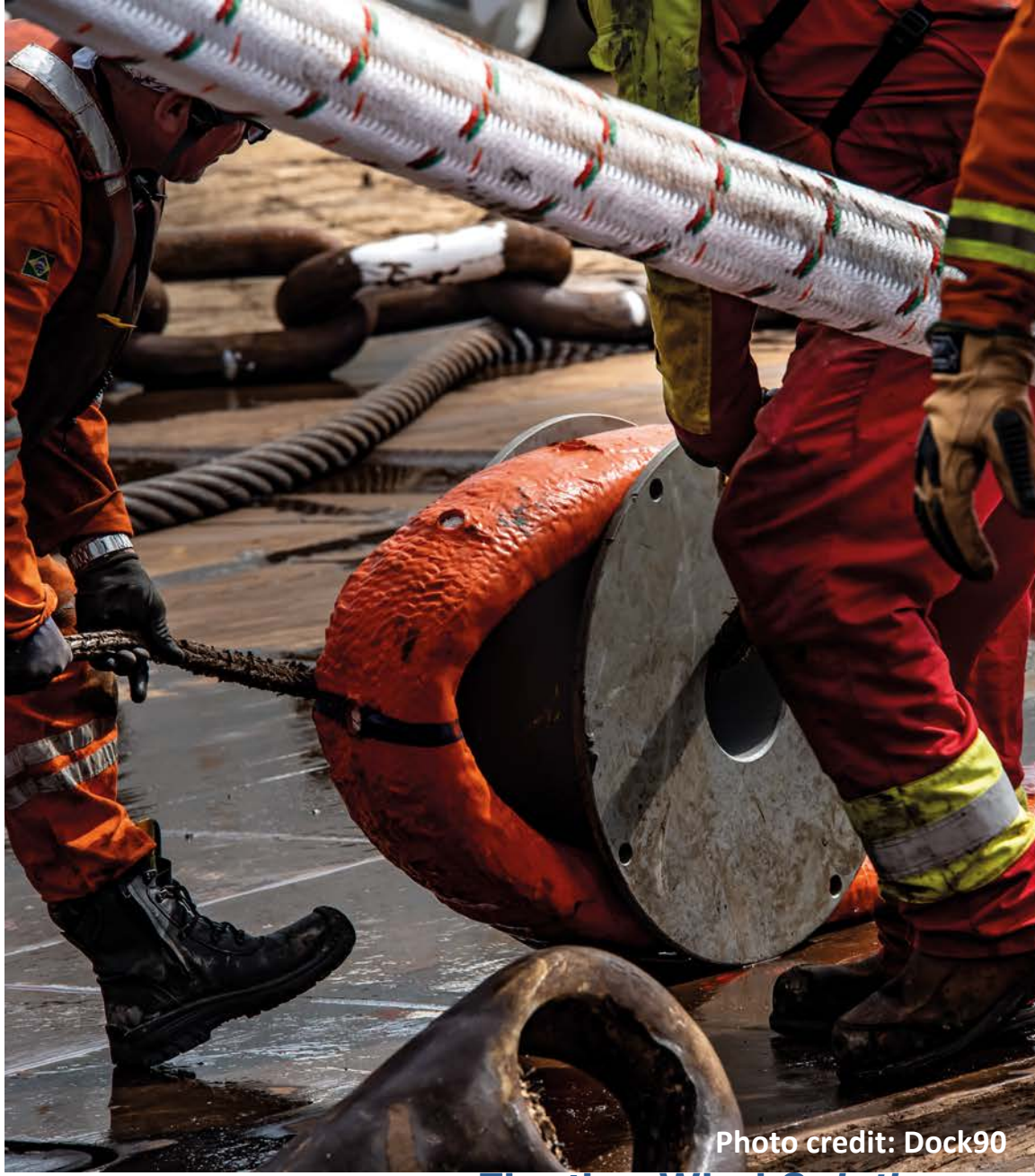


Towing occurred with keel deployed.

Photo credit: Dock90

Adapting to Operational Needs

- Reduced rope diameter ~15% by utilizing Dyneema® SK99 fiber to accommodate an existing winch assembly.
- Decision to tow floater with keel deployed supported by optimal deflection system.
- Positive buoyancy allows mooring pre-lay to form an arch thereby avoiding contact with the sea floor.



Transitioning to Commercial Scale

- Designing components based on lifetime
  - Ex: Reusing winching lines to install all floaters for a wind farm (or multiple wind farms!).
- Material availability is not a bottleneck
  - Upwards of 10,000 km of Dyneema® SK78 vessel mooring lines are in use today.
- Optimizing installation plans
  - Ex: No pre-stretching sequence for GAMA98® mooring lines (waiver via ABS)
  - Ex: Using smaller (local) vessels to accommodate port infrastructure constraints.


Photo credit: Dock90

Thank You