DIGIN in sand

New tool to asses installation and capacity for drag embedded anchors in sand

Innovation idea for Offshore Infrastructure and Technology

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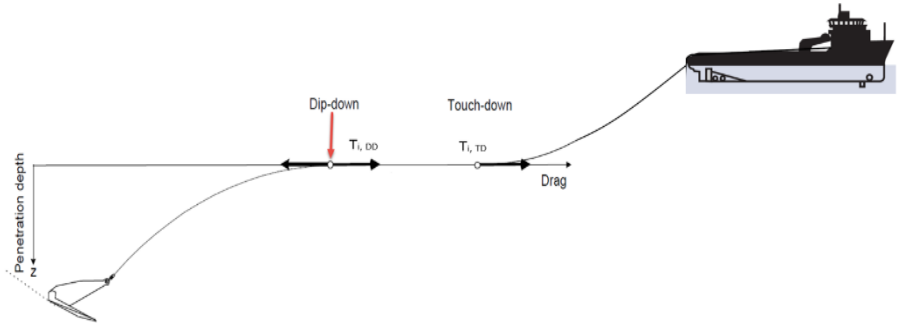
Customer problem:

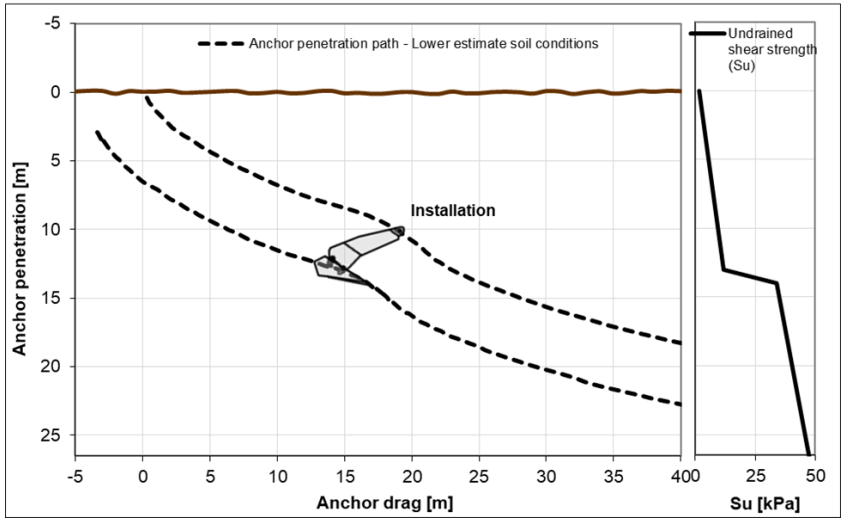
- During the installation of Drag Embedded Anchors (DEAs), the contractor is required to load test the anchor to the ULS load and hold the load for 15 minutes.
- For high loads, this load testing often results in damaged equipment and mooring line. This is a known problem for O&G rigs that many customers have communicated to DNV (Aker BP, Equinor, Vår Energi, Oddfjell Drilling, Intermoor ++).
- For the expected development of the floating wind market, this problem will fore sure increase as the anchor loads for floating wind are much larger than in O&G, and the numbers of anchors to be installed for floating wind will be significantly higher.
- It may not be feasible to load test up to the design load.



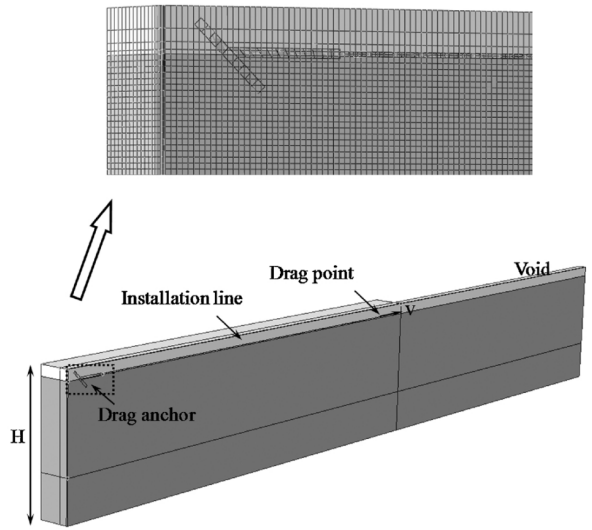
Solution:

- If the anchor capacity can be documented by analyses, the load test requirement can be relaxed.
- For clay sites DNV developed the DIGIN tool in the 90's applicable for clay sites. Today we perform about 20-30 DIGINs each year.
- For sand sites there are currently no calculation tool available.
- Therefore, DNV want to develop a finite element tool that can predict DEA capacity in sand which will help the customers to reduce the installation cost.
- The tool will utilize the CEL approach available in Abaqus to model the entire installation process including anchor, chain and soil undergoing large soil displacements.

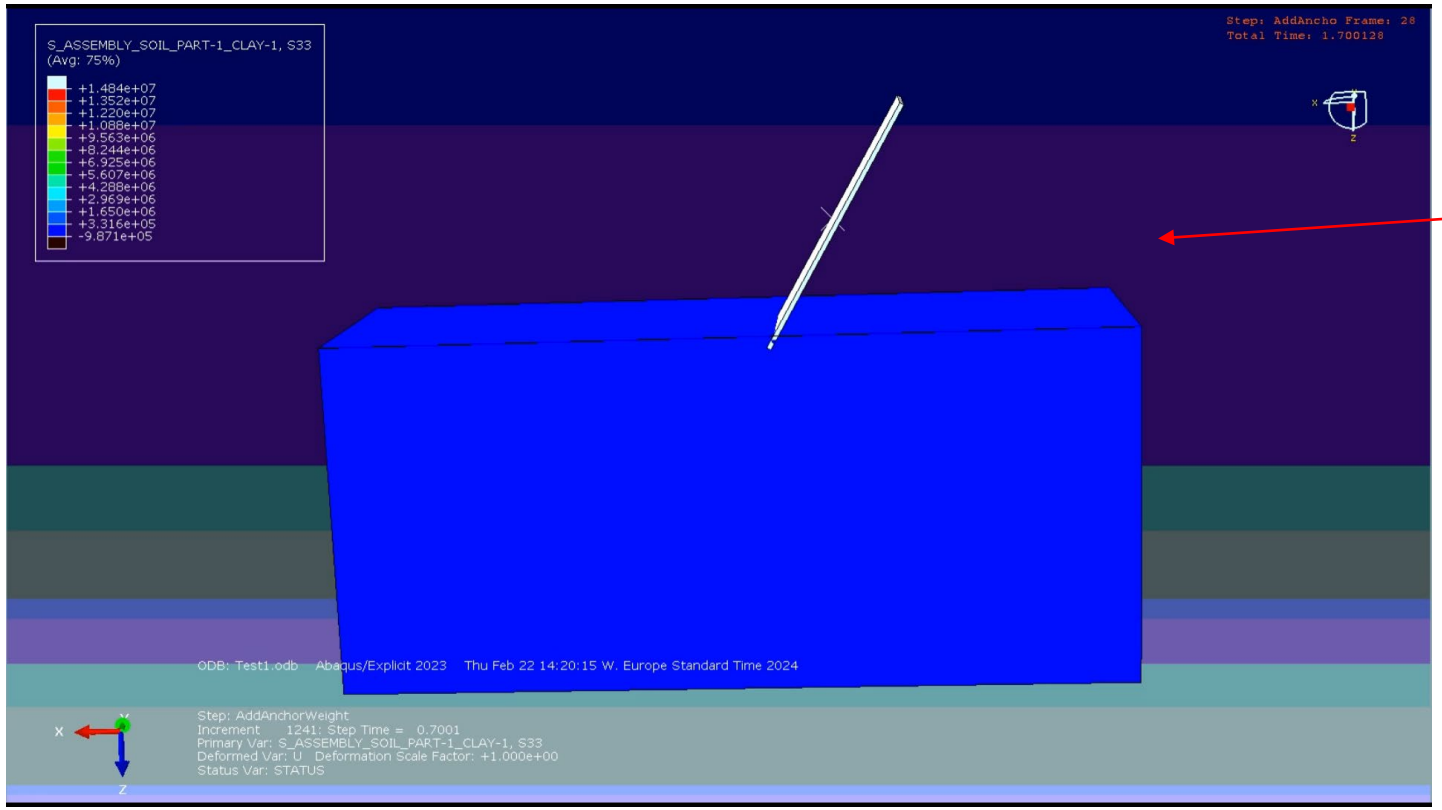
DIGIN:



CEL approach:



Preliminary analyses with simple “plate anchor”



- Currently: Have established model with simple plate anchor
- Next step: Include model of the Bruce Dennla anchor

Market need (From 2023)

- PSA are supporting this initiative (Meeting held 01.04.20
- A number of customers have expressed their i eloping this tool
  - (Meeting 12.01.2023 with Odfjell Drilling BP, Intermoor)
  - Seminar Ålesund 18th -19th of A
  - Visit from Intermoor UK .2023)
- We are also i with several of the companies regarding establishing a project with the goal to 301 "Design and installation of fluke anchors" to cater for the coming develop of the floating wind market. We also wish to include the development of this tool in the project.

No money, no funny, your sonny

Ground Investigation for Floating Turbines [GIFT JIP]

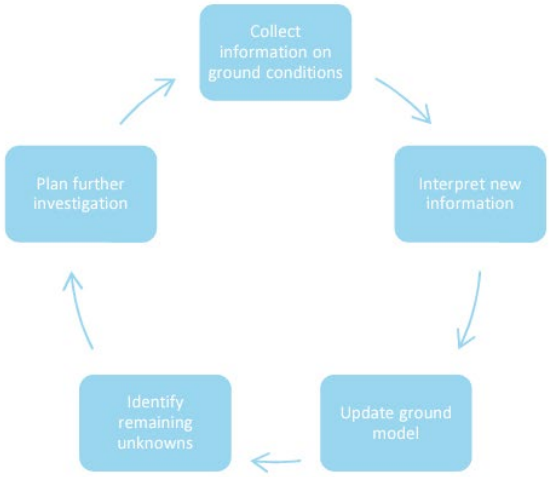
"What type and extent of ground investigation is needed to produce reliable, certifiable and installable anchoring designs for floating wind turbines?"

JIP Aim:

- Reduce GI costs in the industry
- Reduce potential mitigation related costs
- Help industry standardise/optimise anchor design and fabrication

JIP Objectives:

- Move away from geotechnical GI per anchor towards Environmental Class design as in DNV-ST-0119
- DNV-RP to optimise Environmental Class – accepted by DNV ST 0119



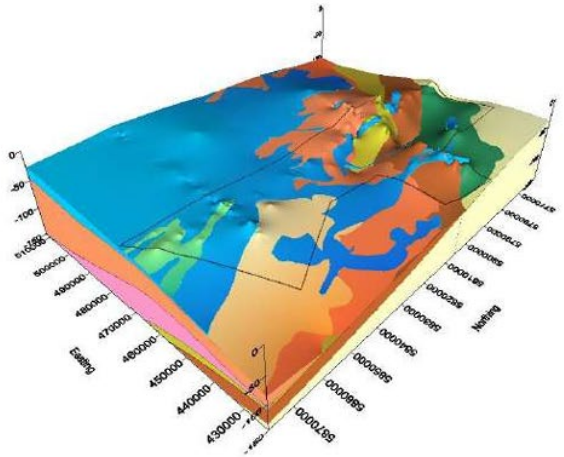


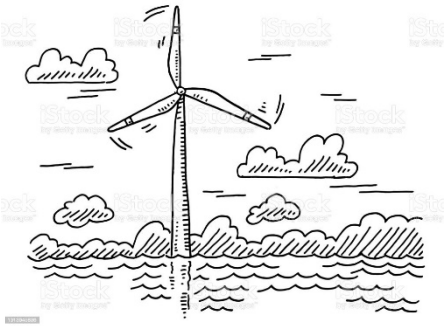
Figure 1-1 Process of ground model development

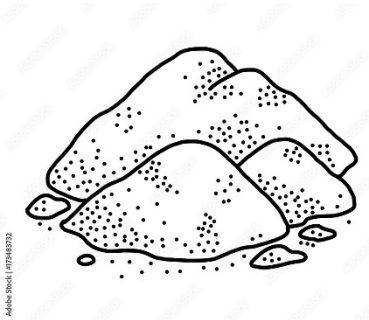
How:

- Greater focus on and increased confidence in ground modelling
- Optimise geophysical surveys: data inversion → correlations with geotechnical parameters, 3D?
- Relevant (and latest) anchor types for defined soil provinces/Env. Class
- Case studies - both simple and complex / extreme cases. Worldwide

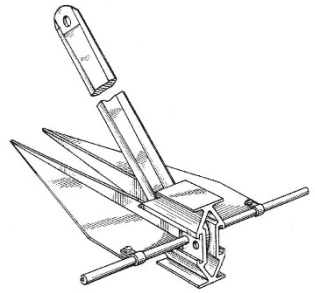
Hurra sangen

1)
Vi vil synge hurra sangen vår (Hurra Hurra)
For alt som trygt ned på havbunnen står (Hurra Hurra)
Er det grus leire silt eller sand, (Siltig sand)
Er det akkurat det som vi kan (Det som vi kan)
Har du erroderte soner,
kan vi spare millioner
Har du kalkholdig jord,
Så blir regningen stor!





2)
Alt som ligger og dupper i sjø (Hurra Hurra)
Det er Veritas daglige brød (Hurra Hurra)
Selv med to konsekvens klasse trinn (Klasse trinn)
Får det juling av strøm, bølger og vind (bølger og vind)
Vi kan regne på alt mulig
Laplace, Euler og Bernoulli
Kraften den blir nok stor
Mye større enn du tror!



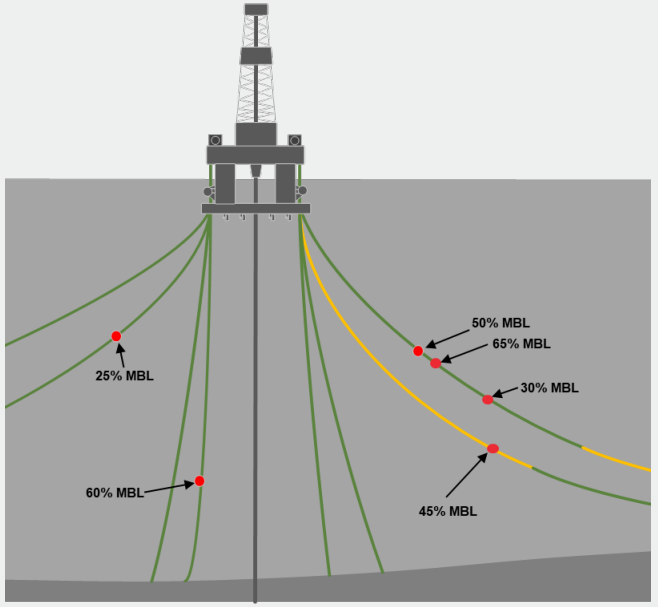
Why the focus on recovery loads and chain handling...

Equipment integrity

- High strength mooring chain defects are very hard to detect – inspection may not uncover all (low PoD)
- Doubt increases need for inspection
- Inspection increases cost

Rig mooring integrity

- The situation to be avoided: - multiple weakened undetected chain links/components present in the system

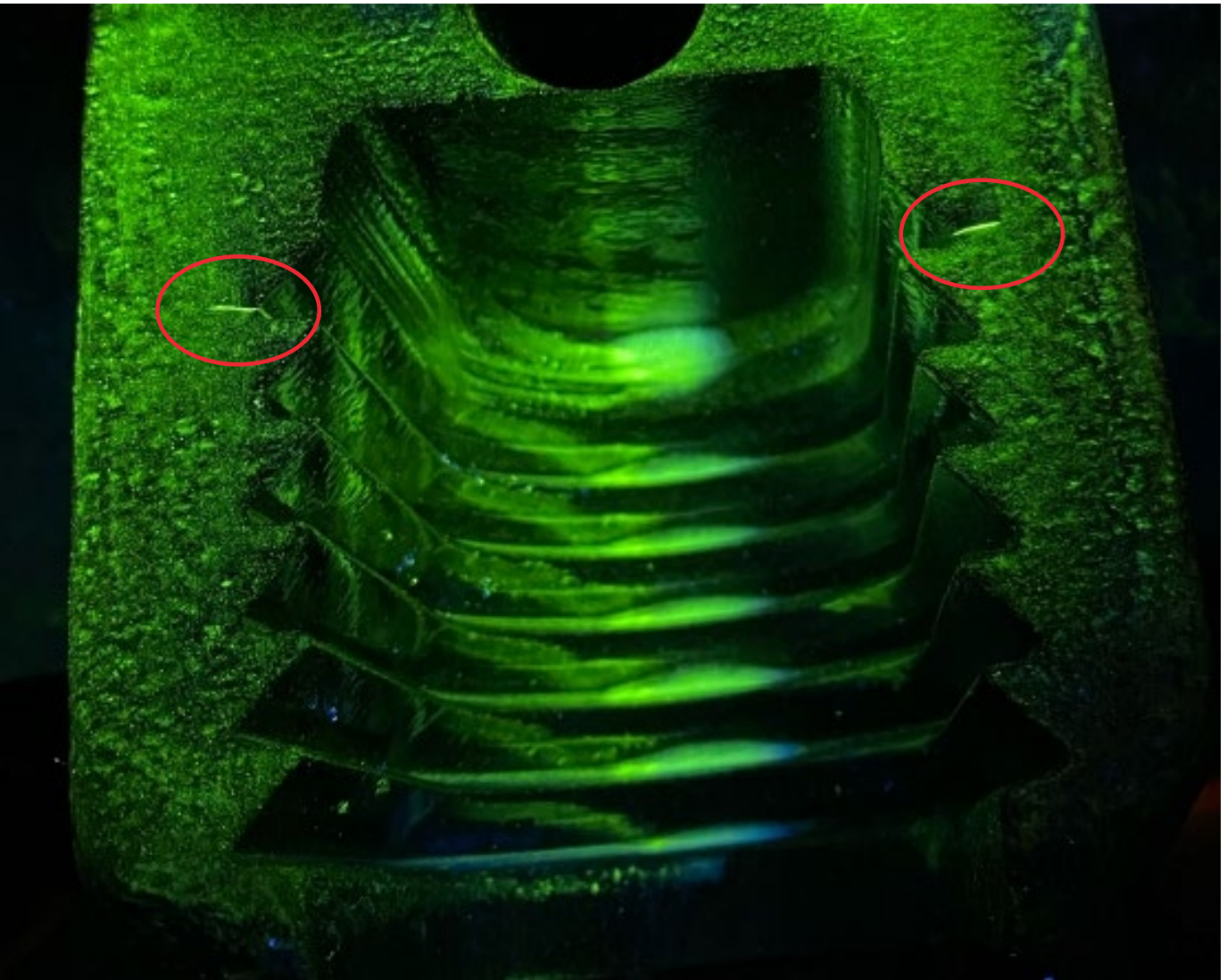


Deck crew safety

- Components failing under normal handling/low loads – unexpectedly
- Failures at “safe load” is a risk for personnel

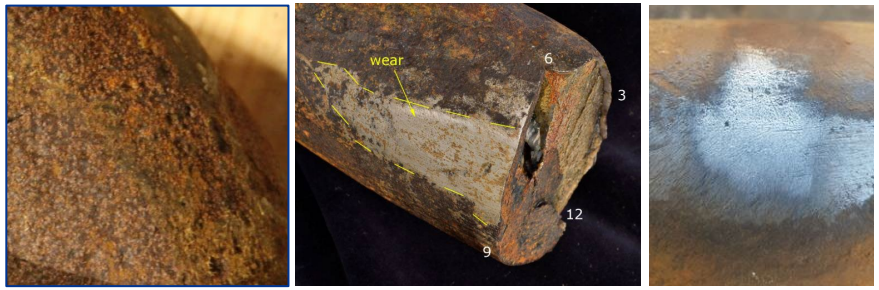
Video: courtesy of Equinor

Probability of Detection (PoD)…

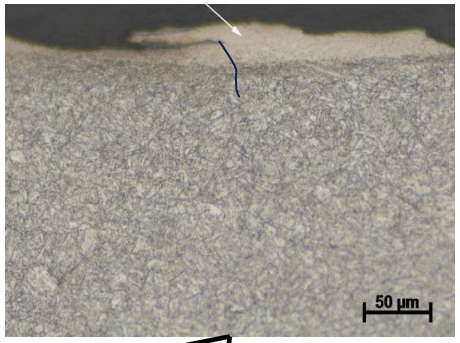


The Solution is not more inspection…but *Less Damage*

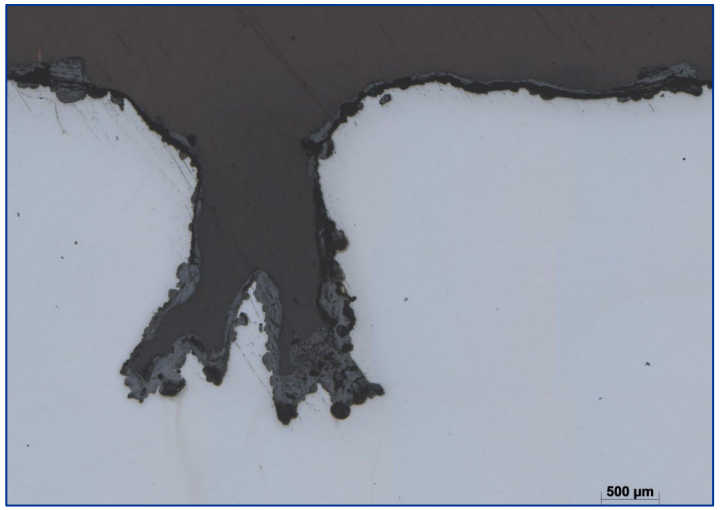
- Fatigue & Cracks – the mechanism



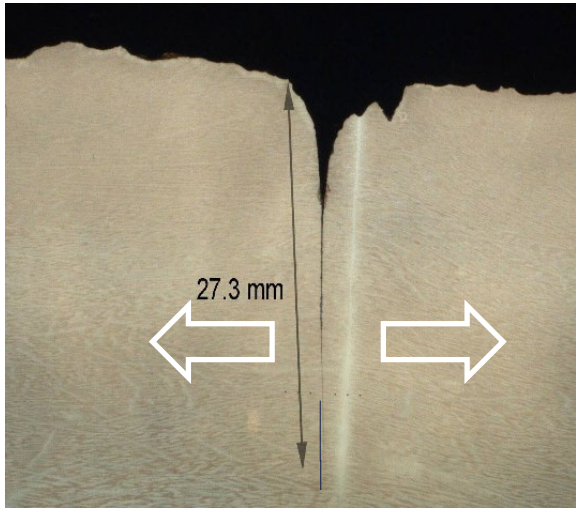
Various imperfections and other damage may act as crack starters



An initial crack is blunted by corrosion, as no more high loads are applied



An initial crack is subject to repeatedly high loading/utilization – crack grows and fatigue capacity is further reduced



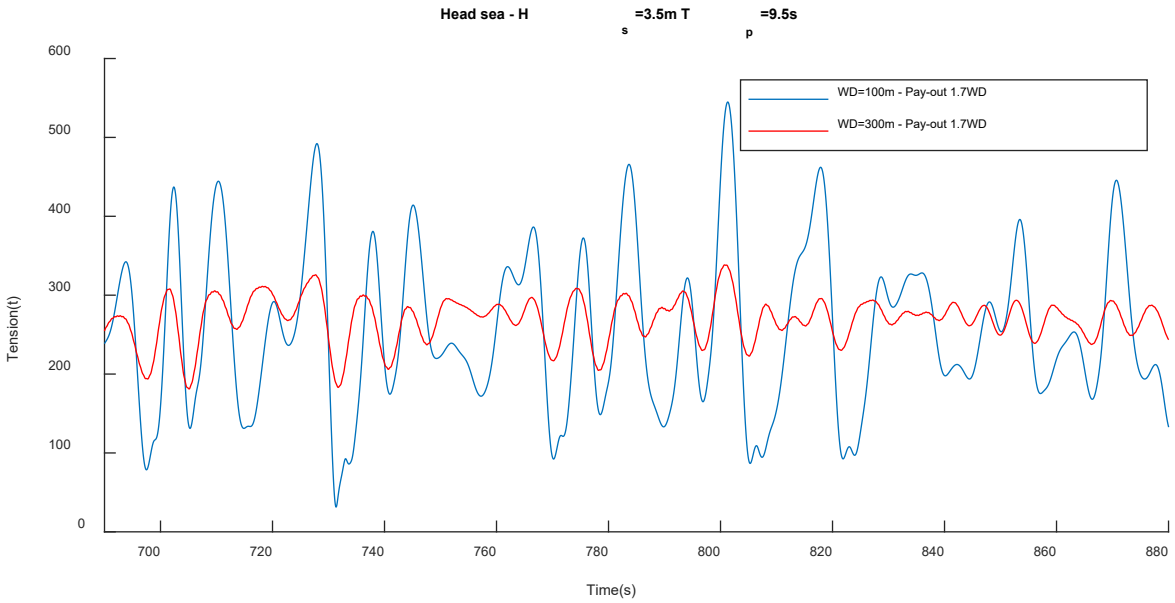
1. New inspection regime(s)

- Logging of loads + usage history
- targeted inspections

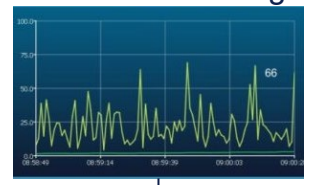
Recovery operations:

Actual line load vs. water-depth and pay-out vs. winch dynamic capability

(winch limitations often mitigated by applying winch brake - > high line loads)

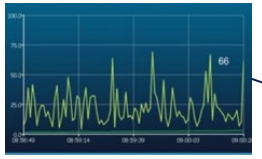


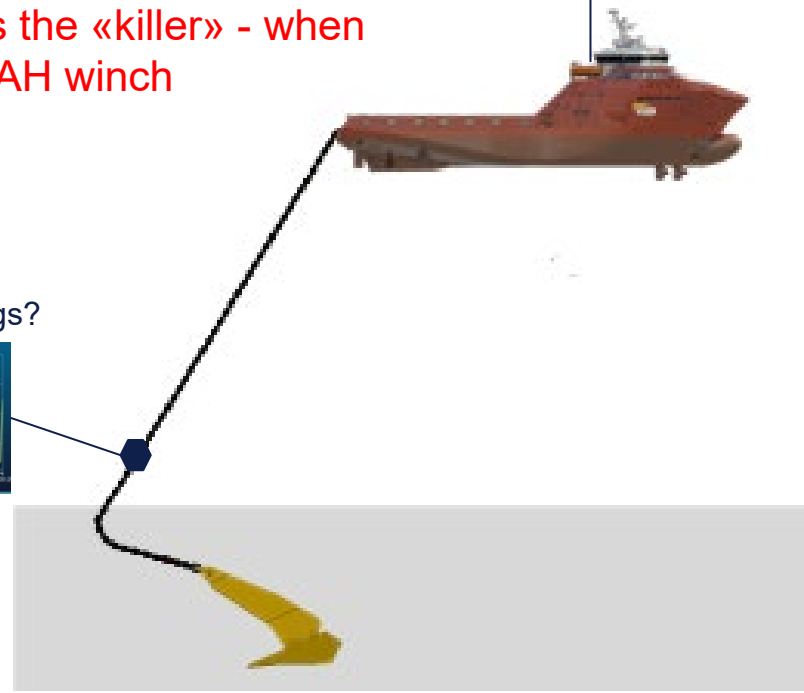
Winch load readings



Stern accelerations is the «killer» - when not compensated by AH winch

Load cell readings?





- Logging is to ensure we capture the loads and loading frequency over time and across operations
- Load history enables the equipment owner to select the components with highest risk of damage/cracks for correct type of inspection

NB - GRAPHS AND DATA COURTESY OF DELMAR SYSTEMS AS

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