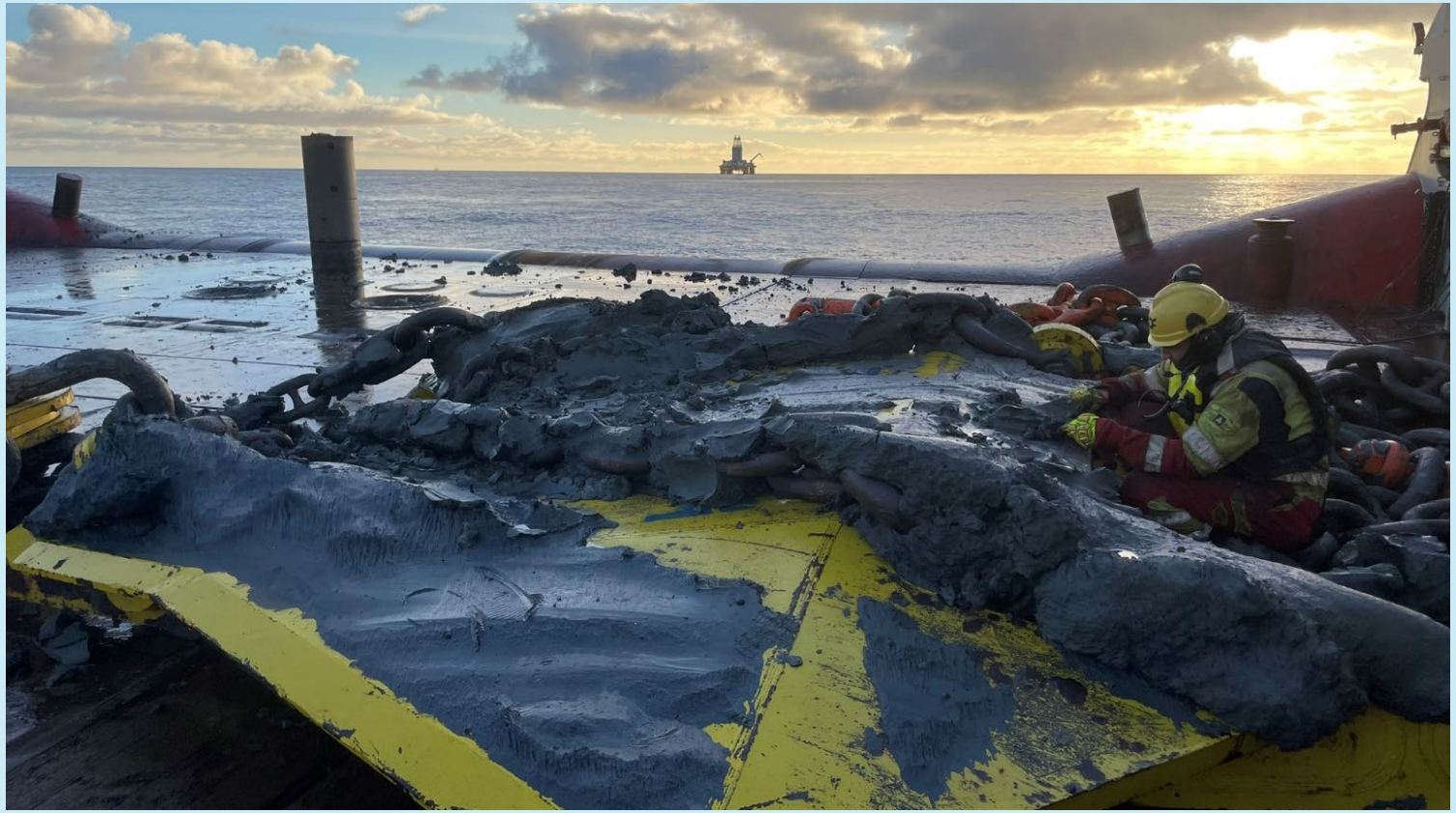
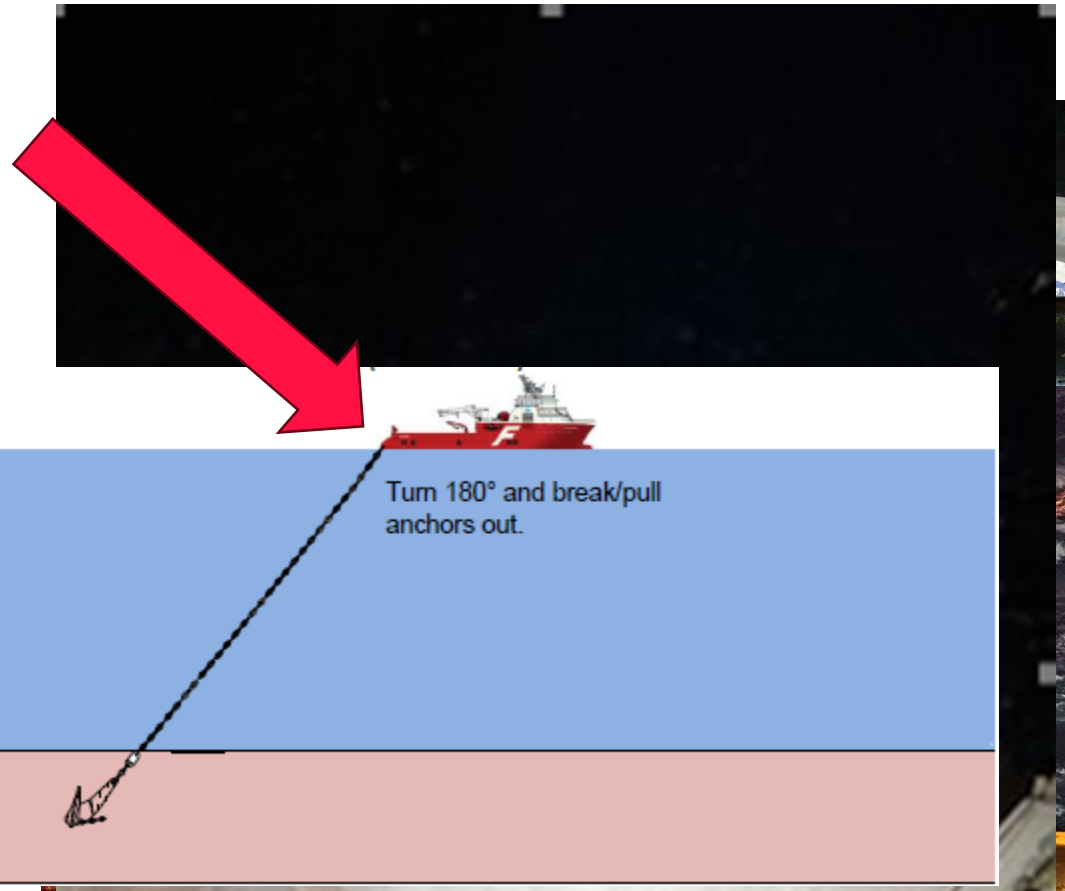
Full-scale test of the Stevmanta® VLA at Troll Field

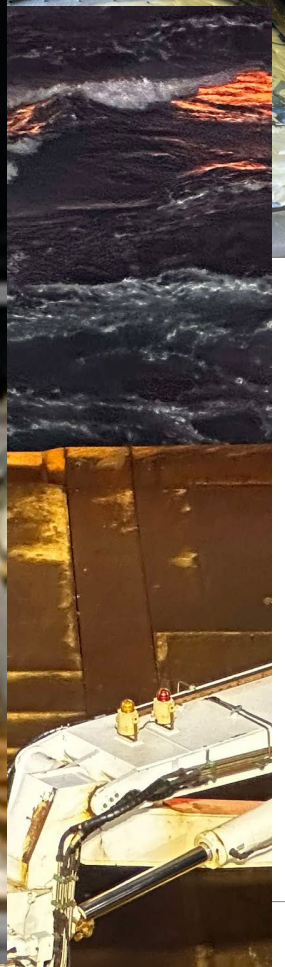
Marine Operasjoner i Praksis,
Bergen, 24 April 2025



Background

- Several linebreaks over the past 8 years.
- Most likely due to handling of chain during recovery operations.





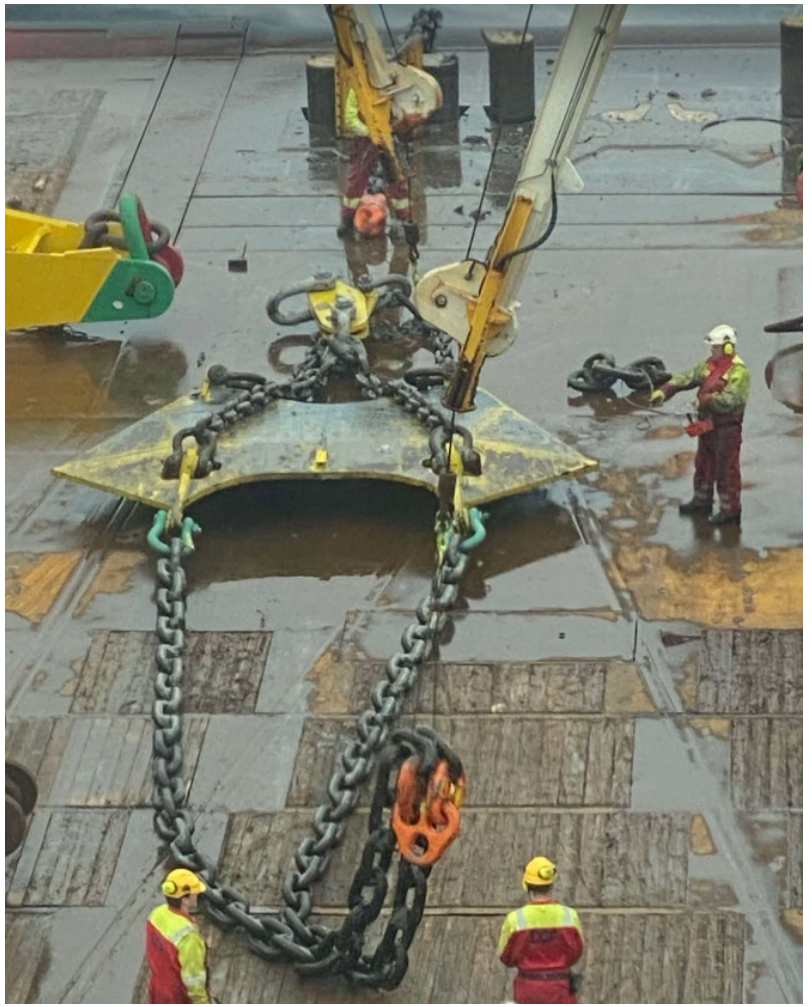
- Needed to find a solution to the problem

Stevmanta plate anchor – test, May 2023

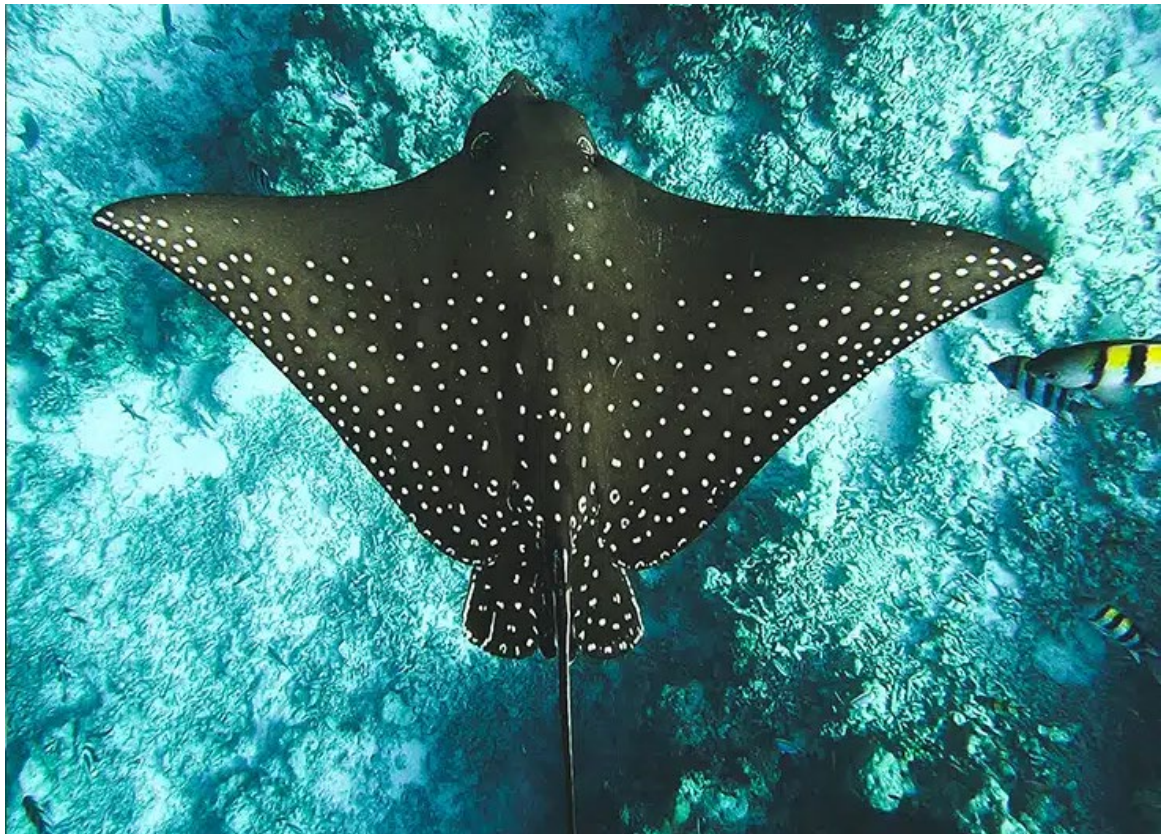
- I had three requirement to the test.
- It is needed to show that we could install the anchor, just as efficient as the MK6.
- Low recovery loads
- No harm to chain

- Conclusion was that the test went VERY well.
- Needed to get DNV onboard.

- New test ☺



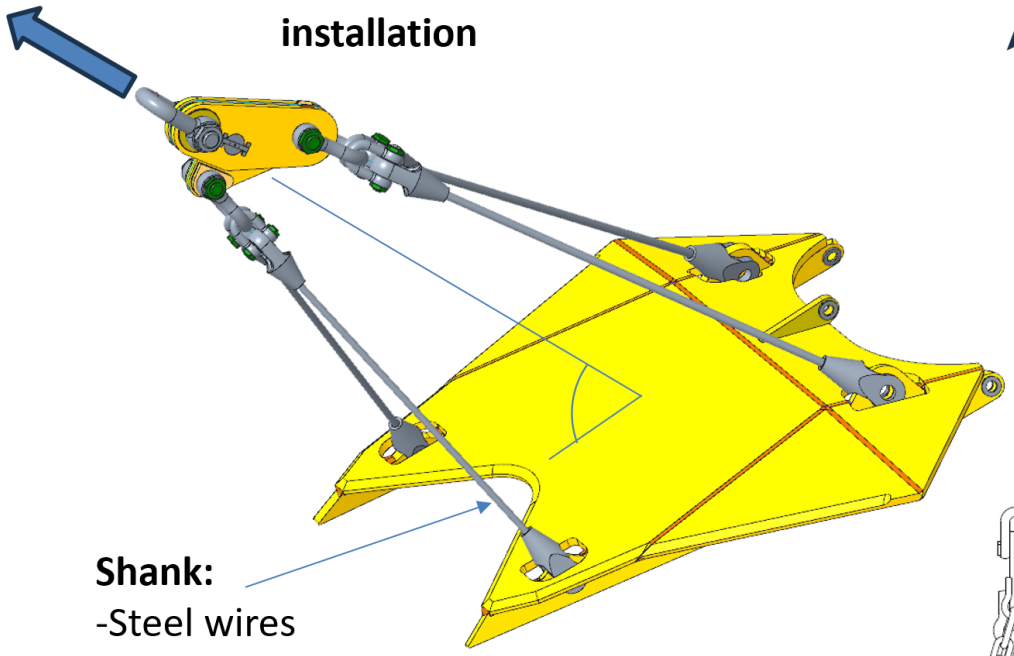
STEVMANTA® VLA

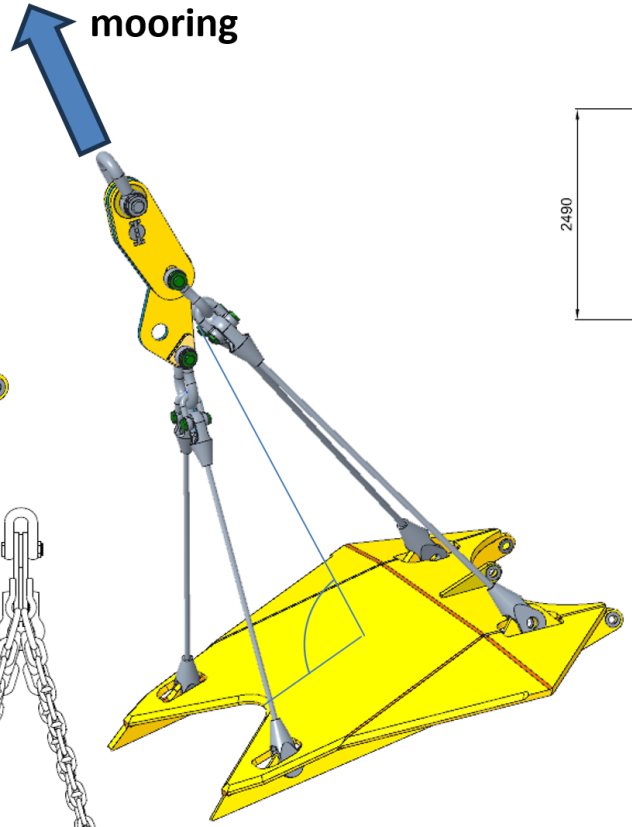


CHARACTERISTICS OF THE STEVMANTA® VLA

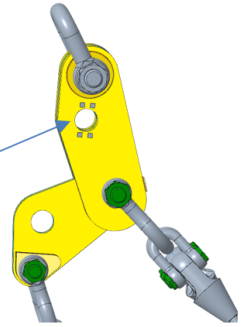
- Suitable for soft clay and cohesive silt soil conditions
- Supports large vertical and horizontal loads
- Best choice for semi-taut and taut leg moorings
- Installed like a conventional drag embedment anchor
- Easy anchor recovery

THE TWO MODES OF STEVMANTA® VLA

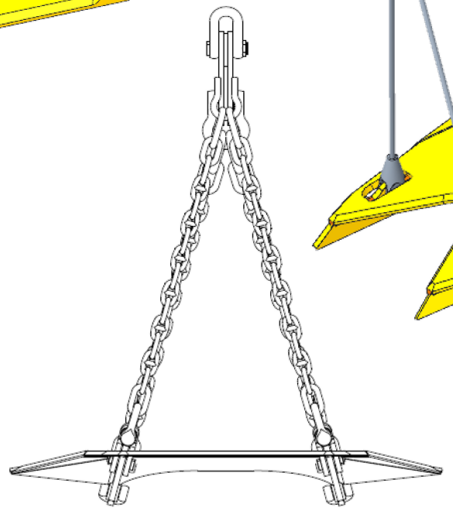


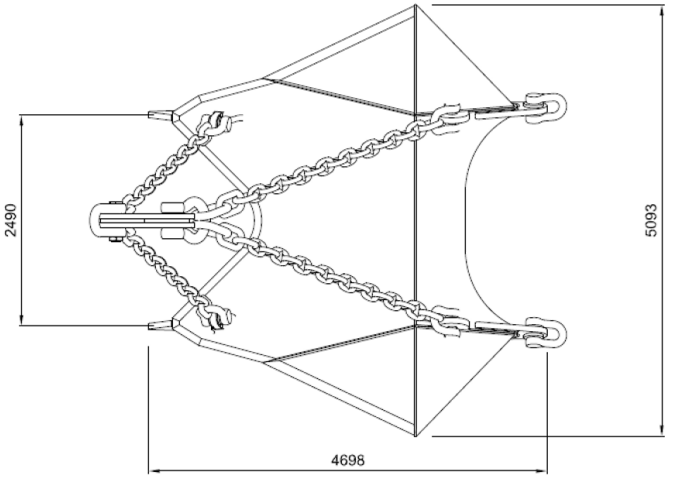


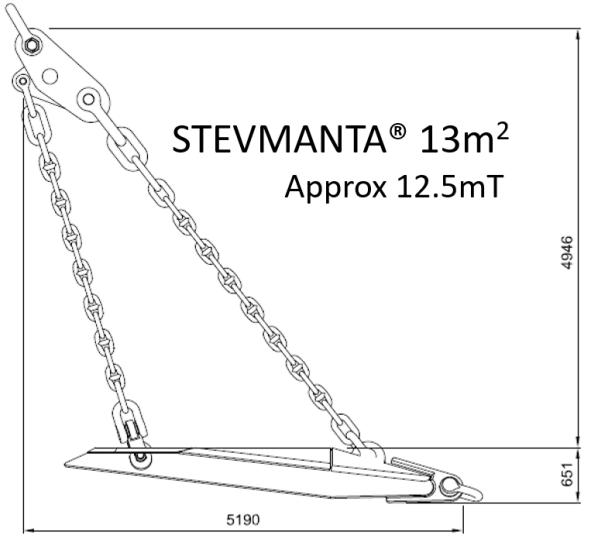
Shank:
-Steel wires
-chain



Angle Adjuster
Shear pin

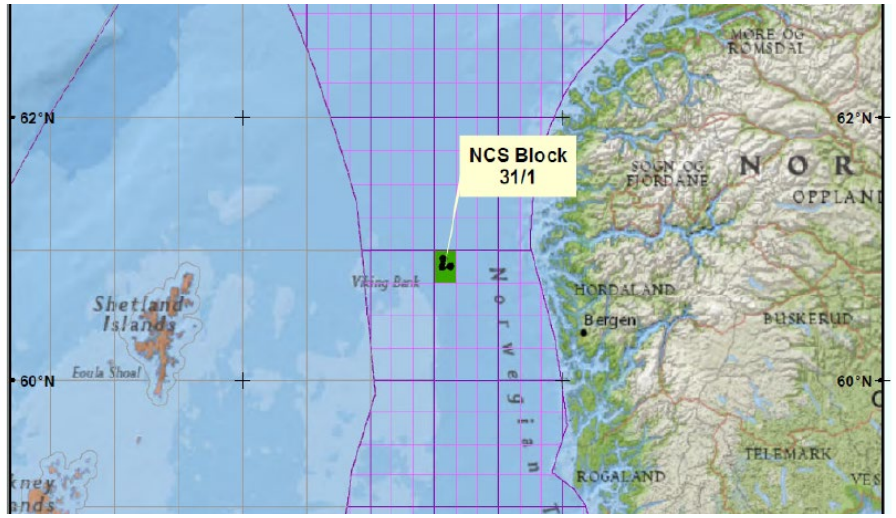






STEVMANTA® VLA 13M² TEST OVERVIEW

- **Location:** Ringand, Troll Field
- **No of Tests:** 3 in total
- **Two types of tests:** Fixed Pin and Shear Pin Breakage
- **Data Collection Tools:** Star Oddi & ADAPS
- **Water depth:** 290m



SOIL CONDITIONS AT RINGAND

- **Soil Description:**

  Extremely low to medium strength sandy Clay.

- **Shear Strength:**

  Includes low, high and best estimates (2 to 57kPa)

- **Plasticity Index:**

  $I_p = 23$

- **Submerged Unit Weight:**

  $\gamma' = 7.1 – 8.5\ kN/m^3$

DATA COLLECTION TOOLS: STAR ODDI & ADAPS

- ***ADAPS (Anchor Depth and Positioning System):***

Measures position, pitch and roll along with depth of penetration during tension steps.

- ***STAR Oddi Sensor:***

Logs test results, data to be processed after retrieval of the anchor together with AHV tension log.

TWO TYPES OF TESTS

Test 1 & 2: Fixed Pin Tests

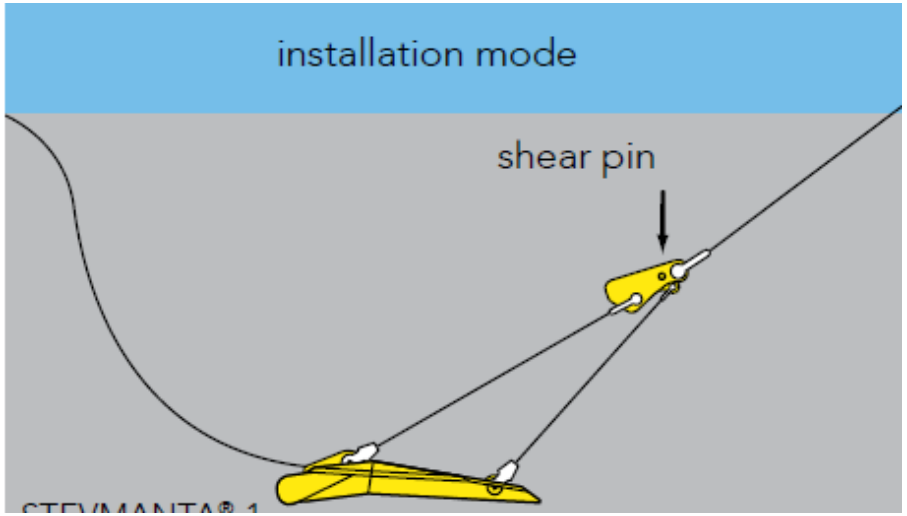
Stepwise Installation w/ data collection at every step.

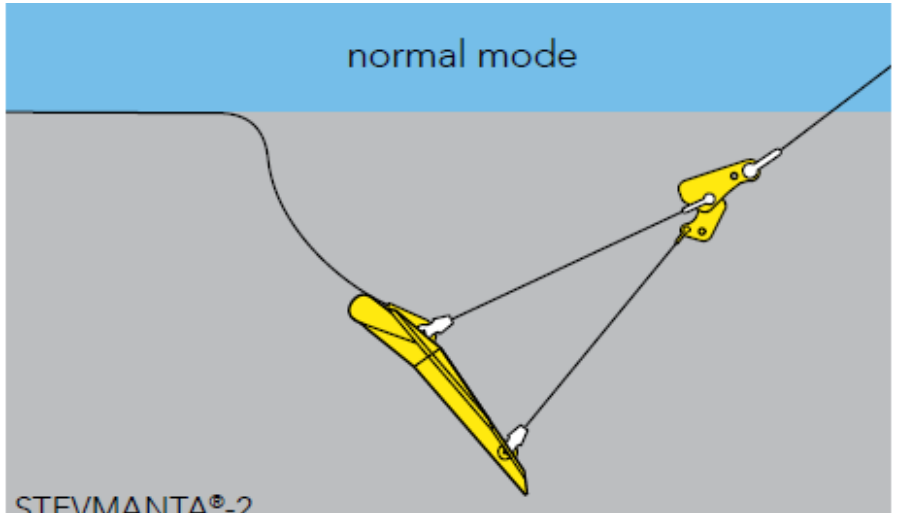
Retrieval w/ bridle tail.

Test 3: Shear pin breakage test (120mT)

Continuous pull until shear pin breakage.

Retrieval of anchor by overloading.





DNV's scope of work

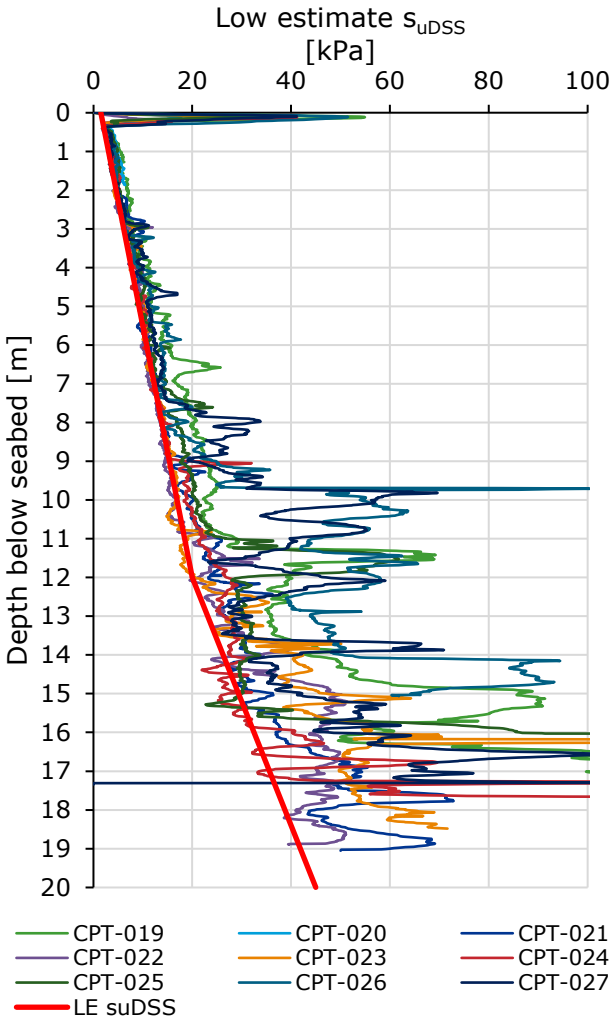
Calibrate predictive calculations with test results:

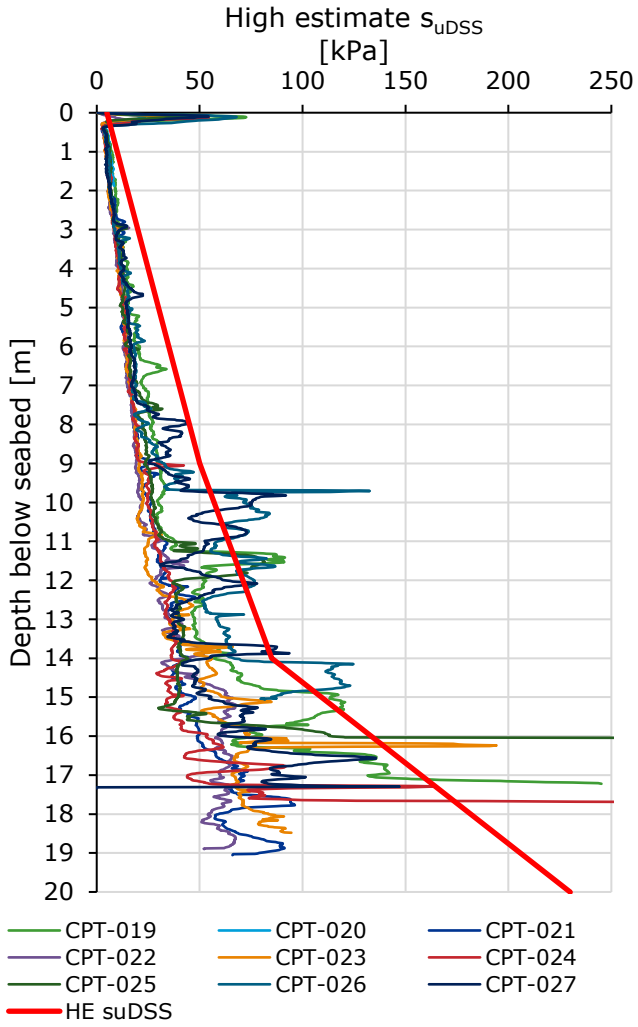
- DIGIN – anchor capacity and behaviour
- PLAXIS (3D FEM) – anchor capacity

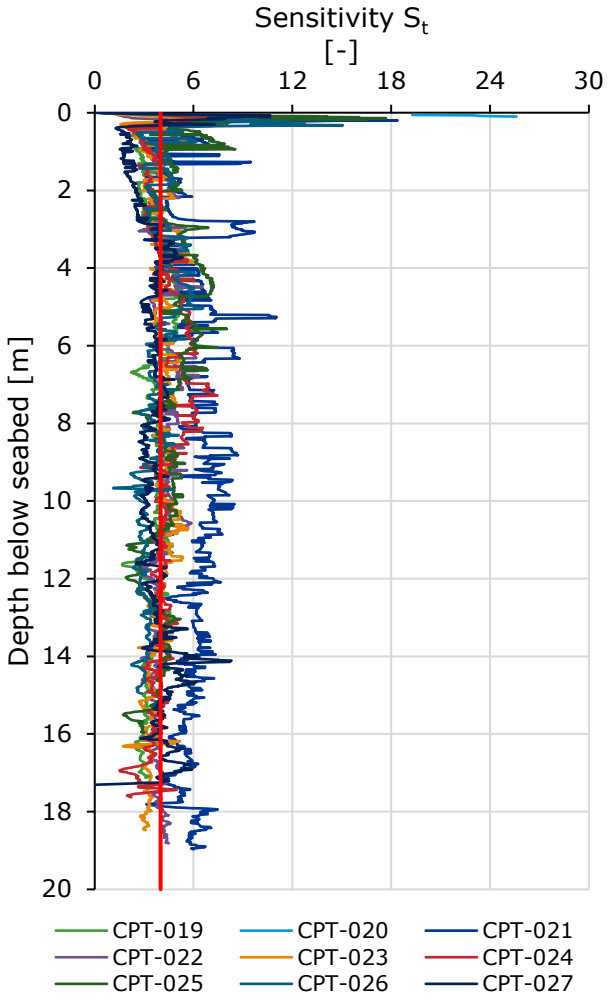
Daniel Gartha Hammer

Thursday, April 24, 2025

Soil Profiles

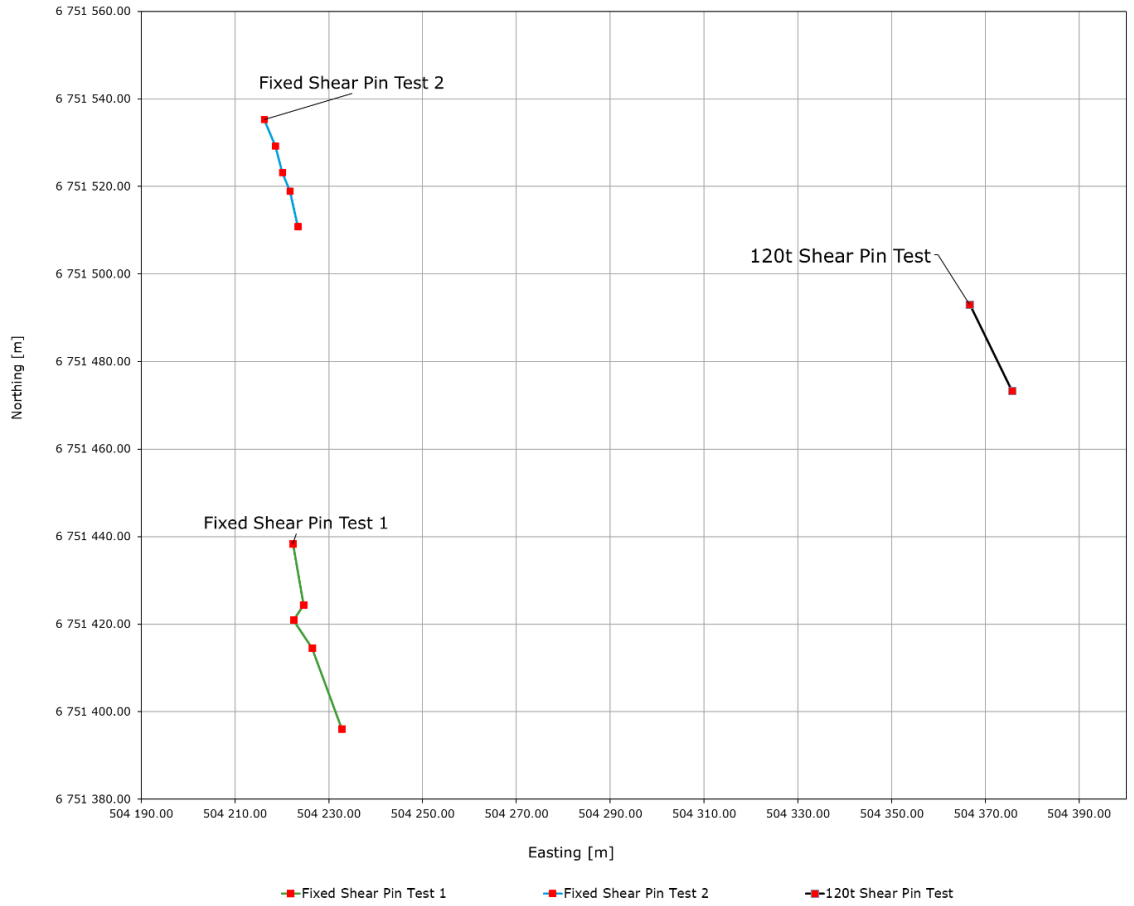




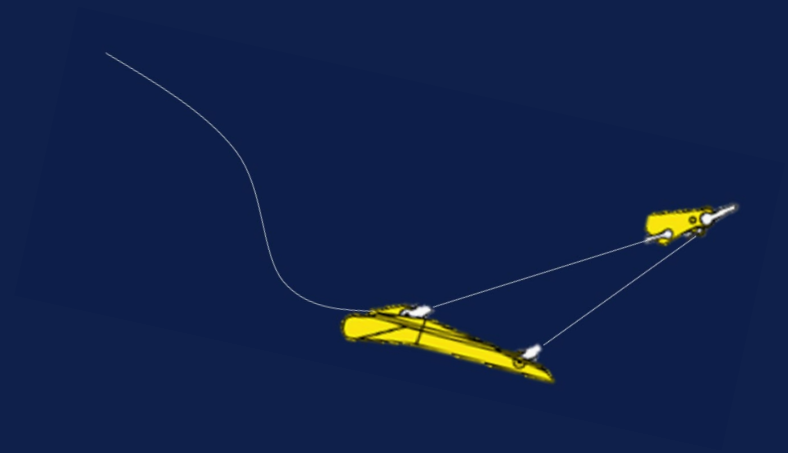


Data used for Calibration

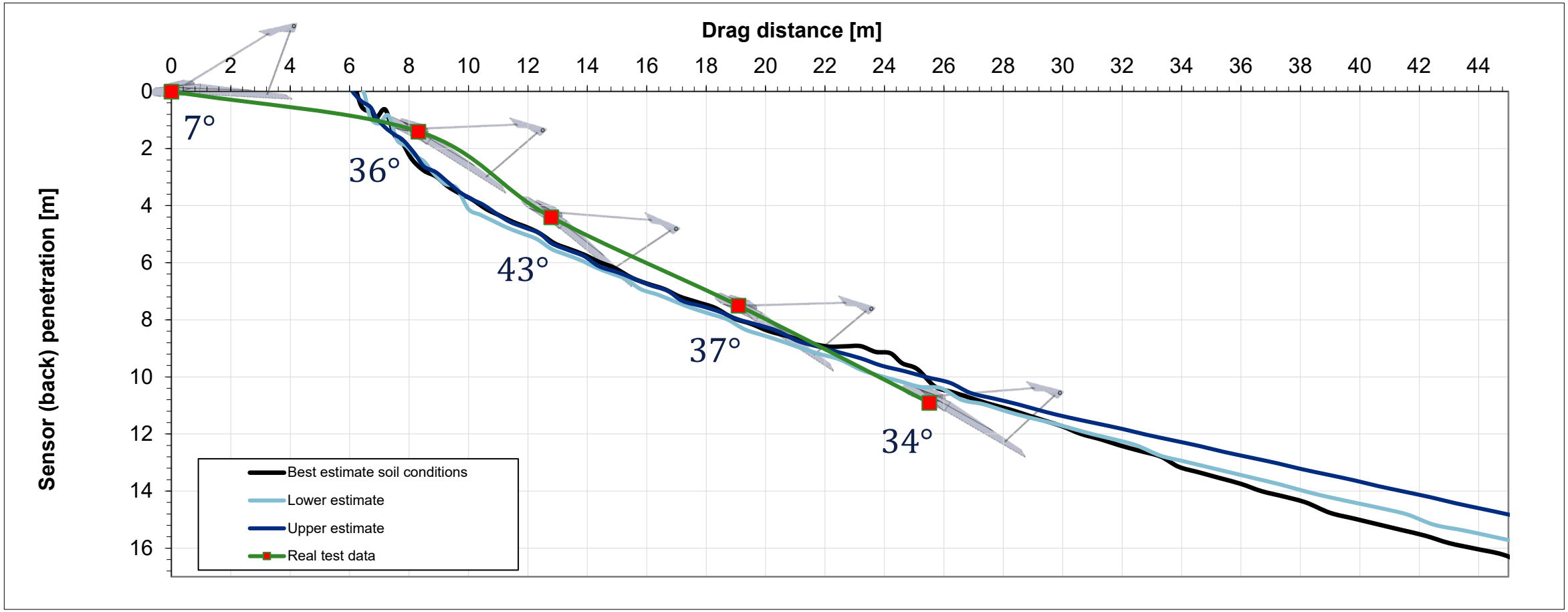
- Positioning and depth from ADAPS sensor
  - Drag and penetration of anchor
- Tilt from Star ODDI sensor
  - Rotation of anchor
- Winch tensions from winch logs
  - Winch tension over time



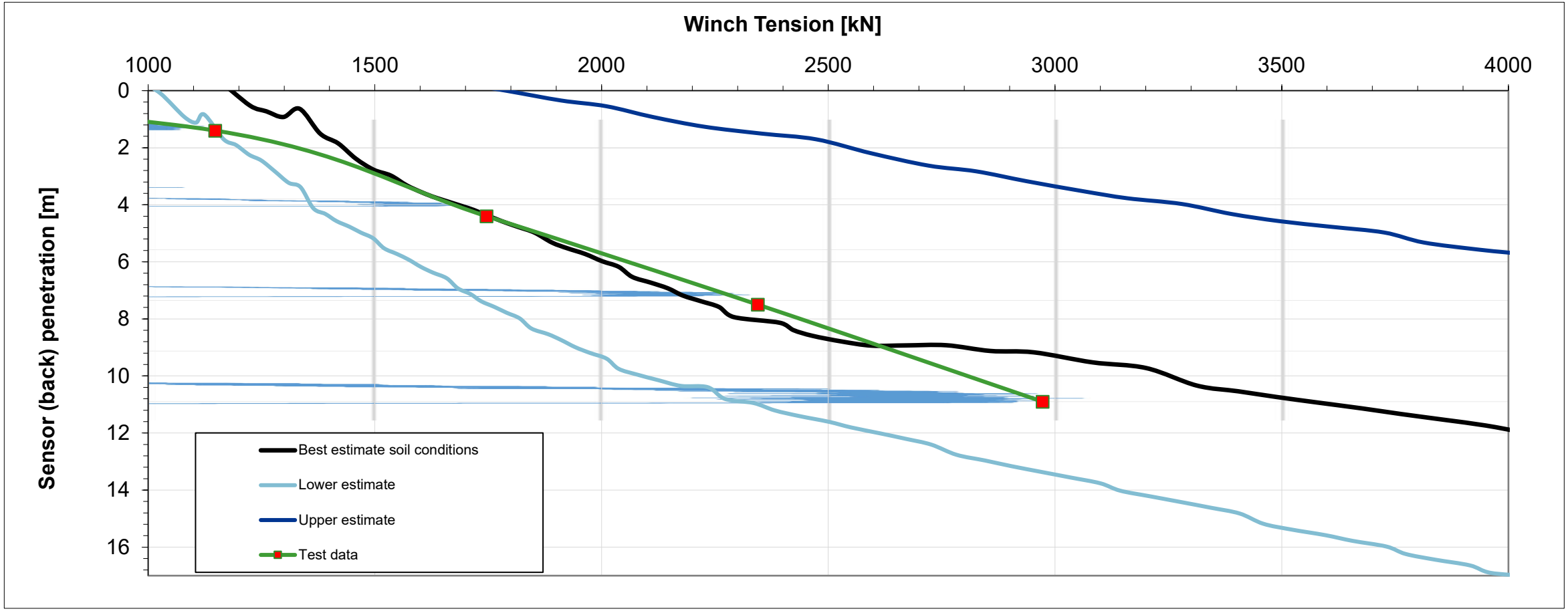
Fixed Shear Pin Analysis



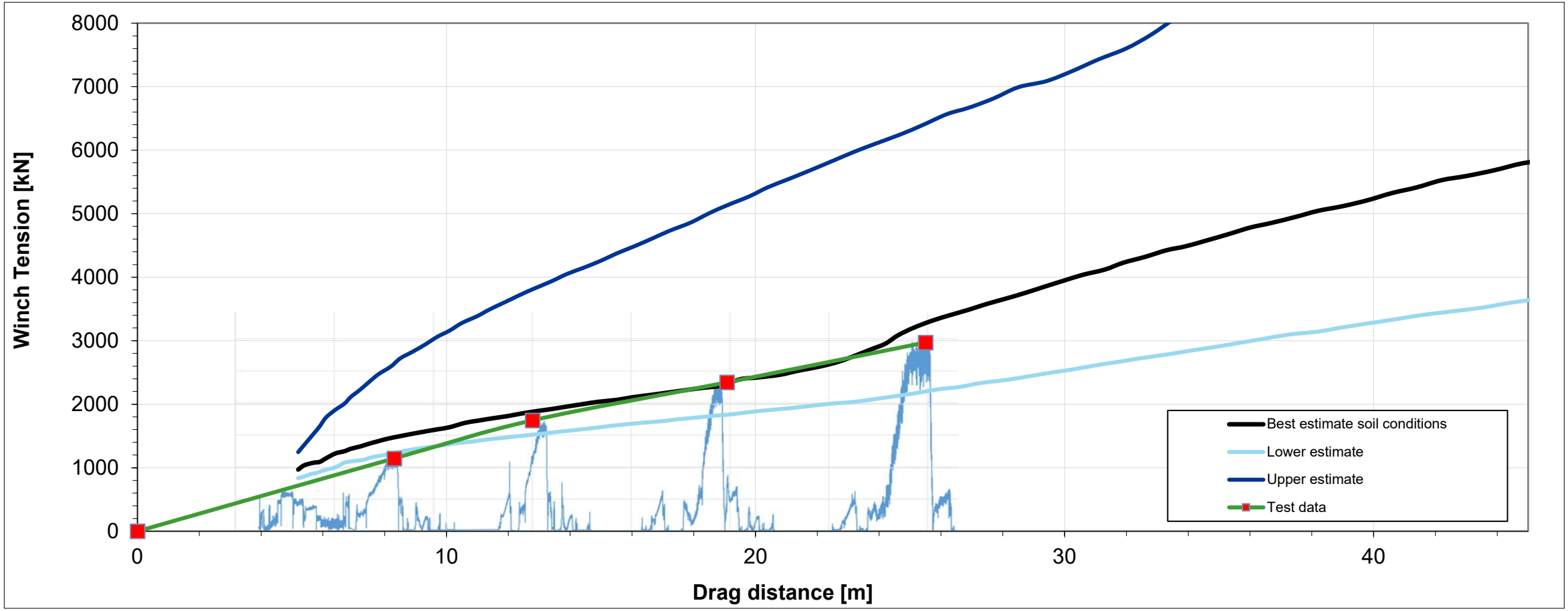
DIGIN Calculations – Penetration Path



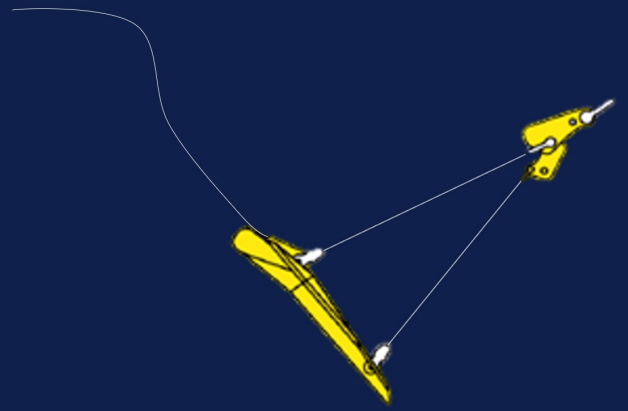
DIGIN Calculations – Penetration versus Winch Tension



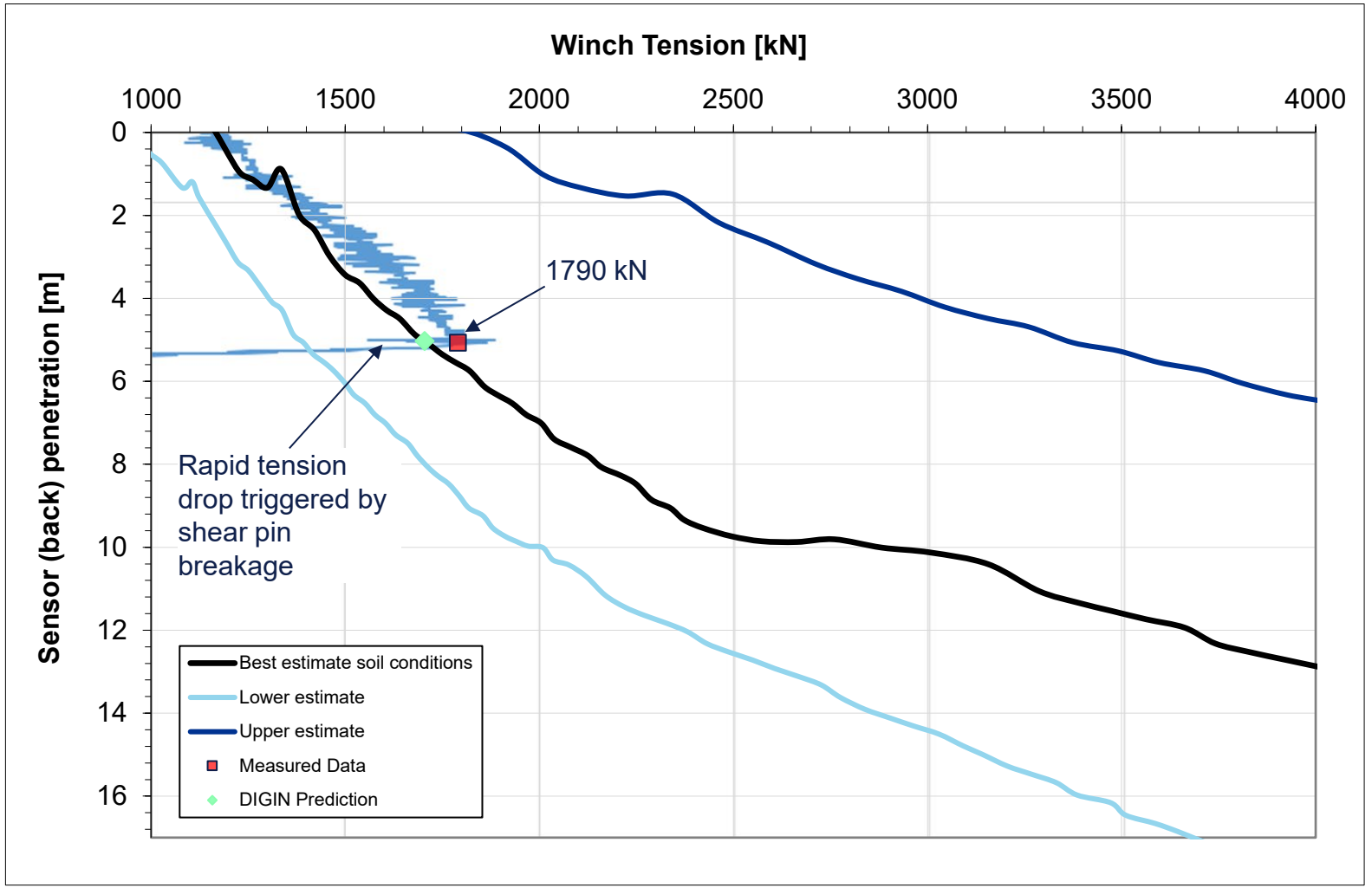
DIGIN Calculations – Drag versus Winch Tension



Shear pin breakage analysis



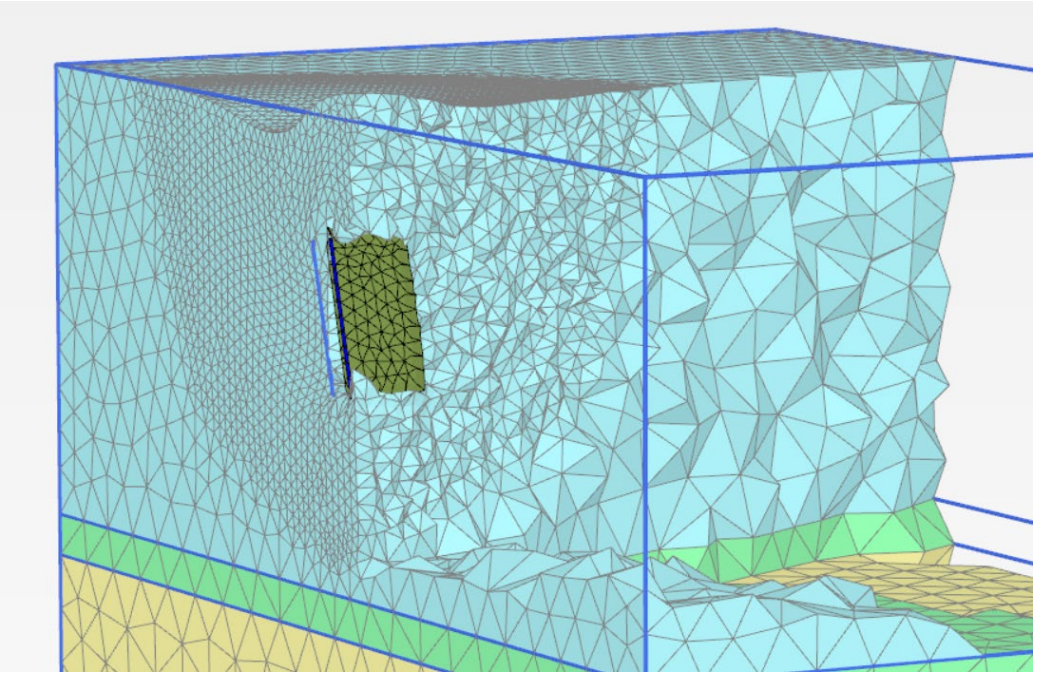
DIGIN Calculation – Before Shear Pin Breakage

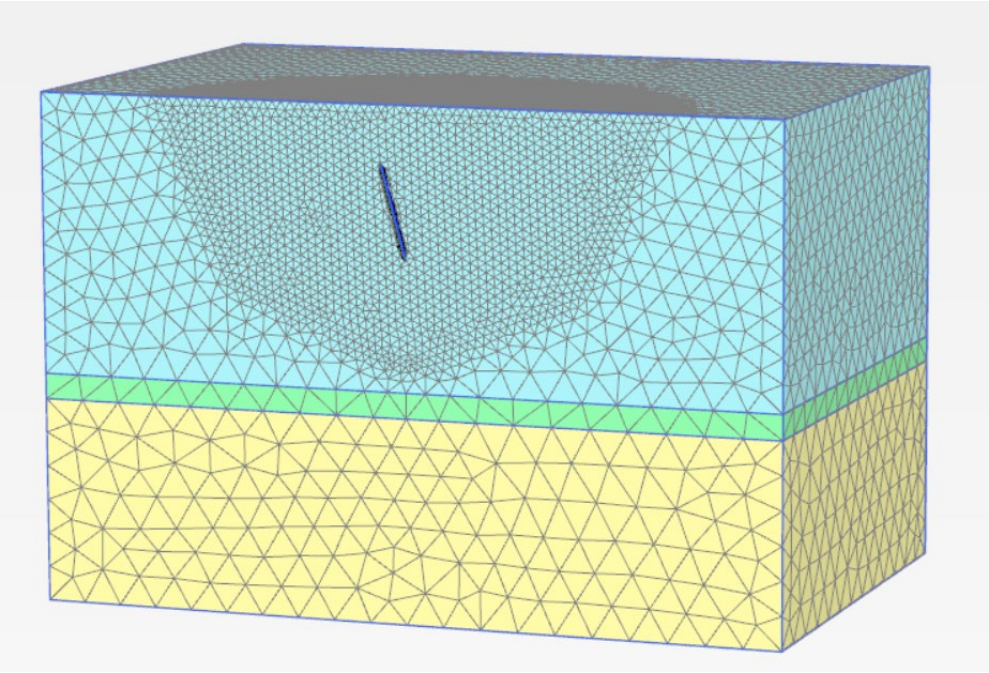


DIGIN Results	
Shear Pin breakage [t]	120
Shear Pin breakage [kN]	1177
Winch tension [kN]	1704
Tip penetration [m]	7.06
Sensor penetration [m]	5.03

FEM Calculations – After Shear Pin Breakage

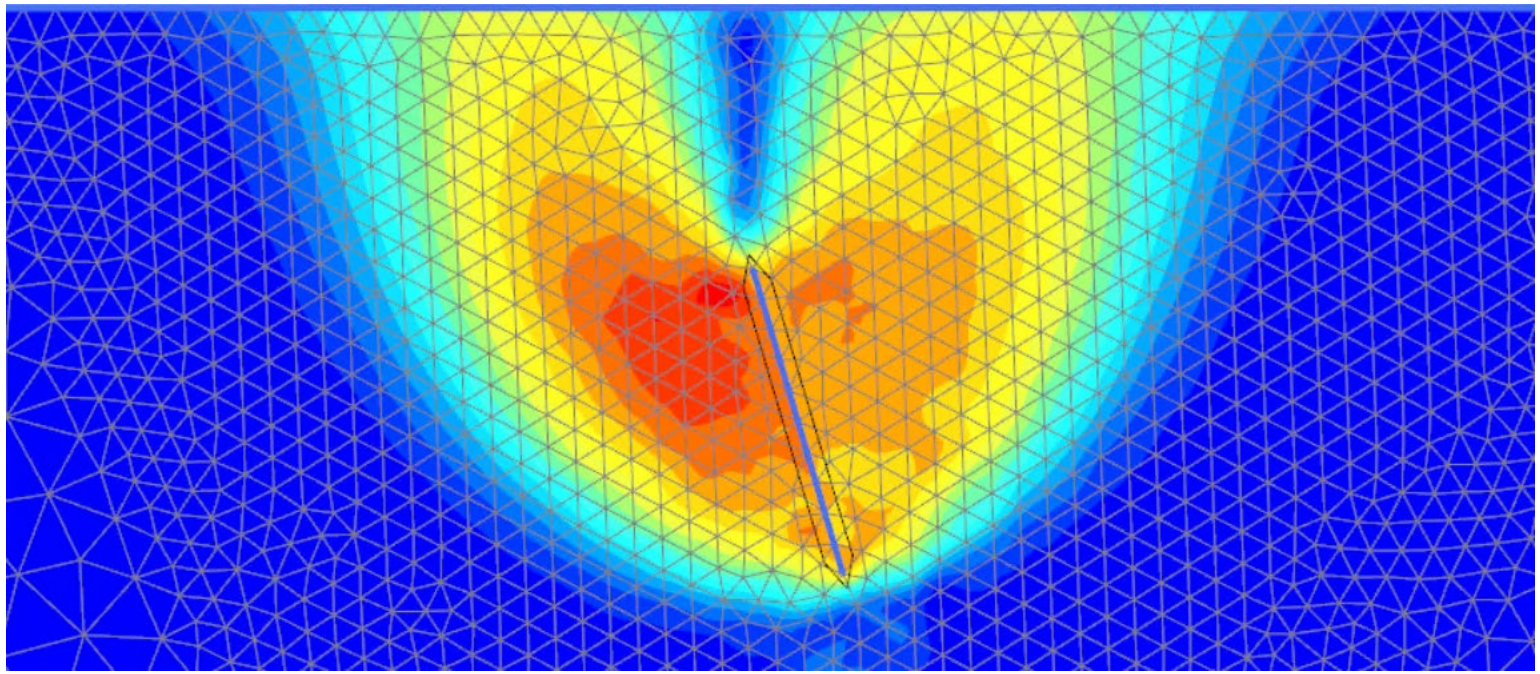
- Number of elements: ≈ 130 500
- For small displacements only
- Anchor angle and penetration depth from DIGIN assumed for calculations



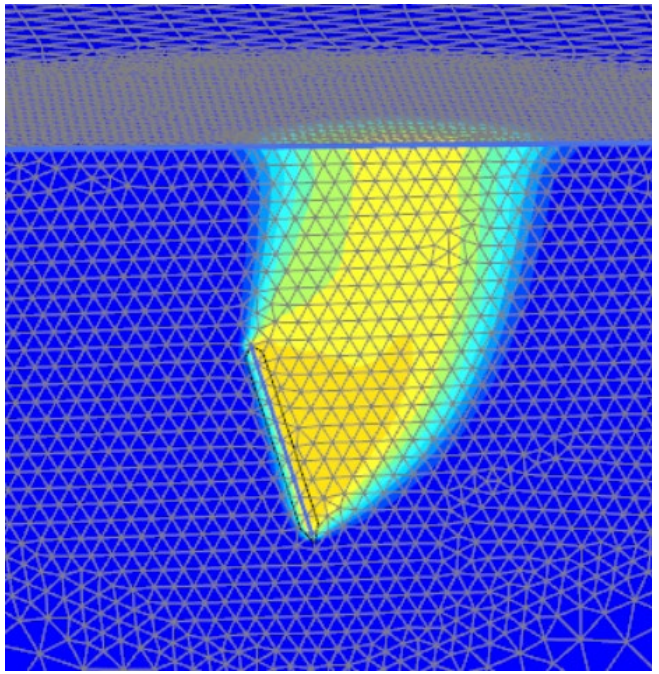


Failure Mode – After Shear Pin Breakage

NGI-ADP model

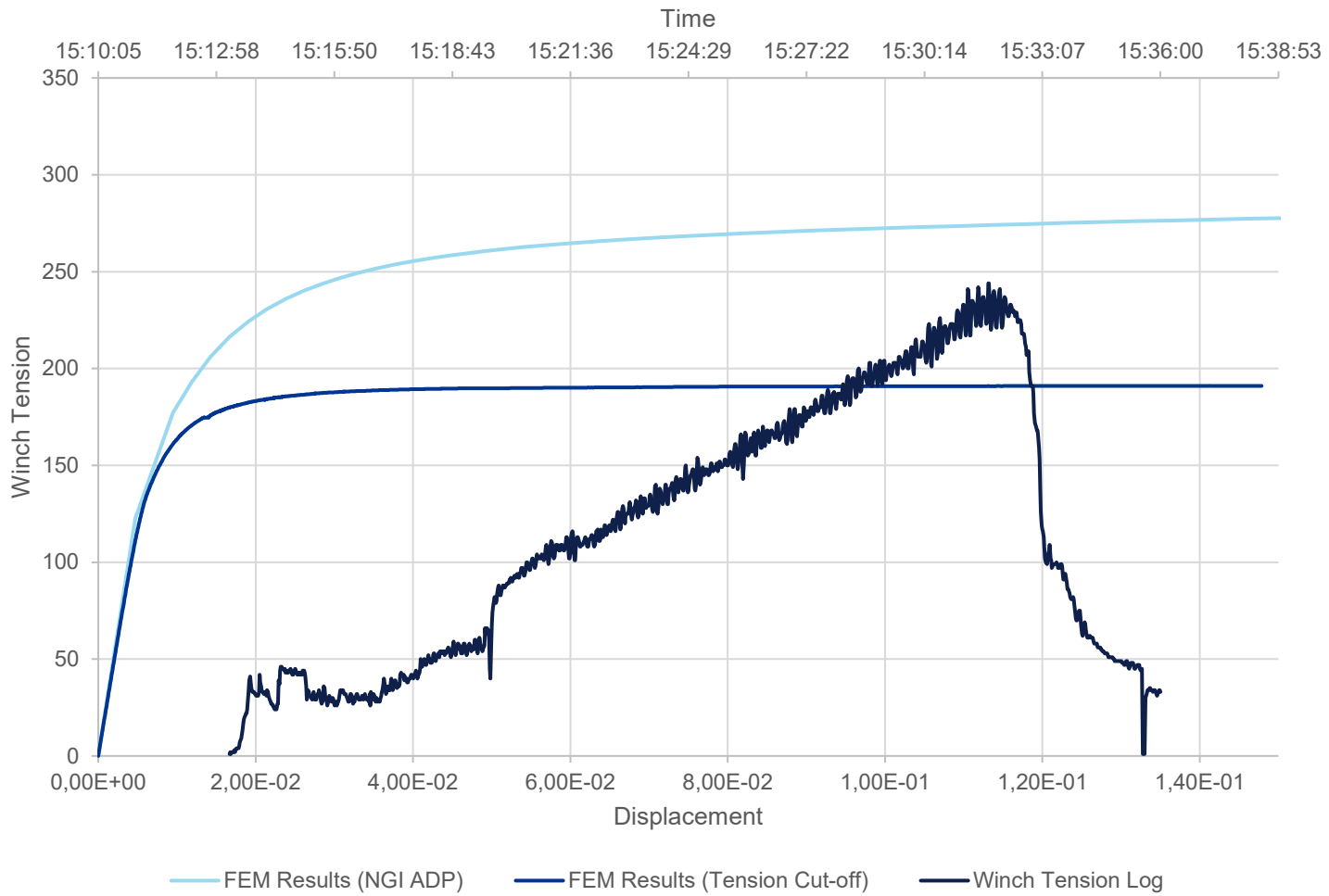


Tresca with tension cut-off



- Fluke angle of 71^{o} from DIGIN
- Tip depth of 7m

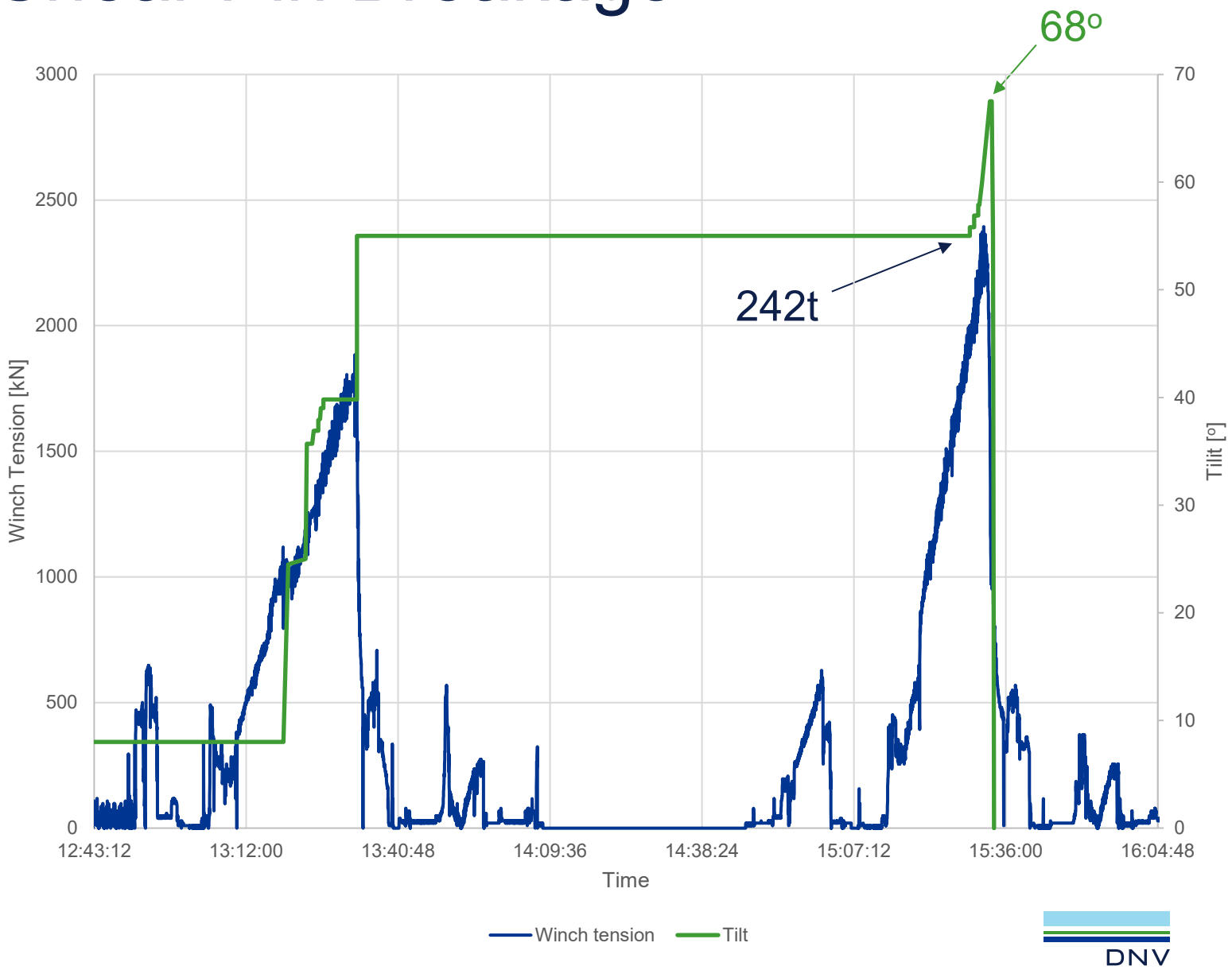
FEM versus Test Results



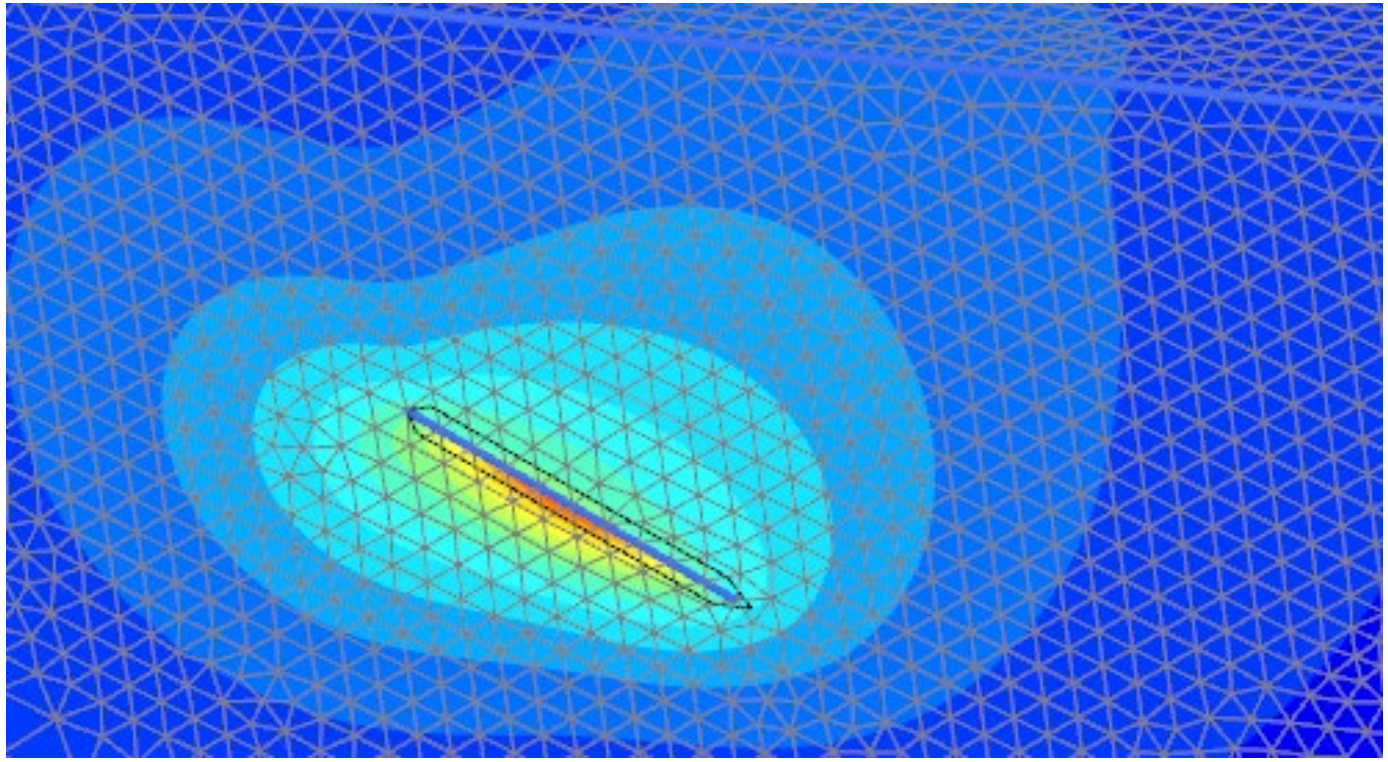
- FEM analysis
  - Overpredicts capacity by 20% with soil anisotropy
  - Underpredicts capacity by 16% with tension cut-off

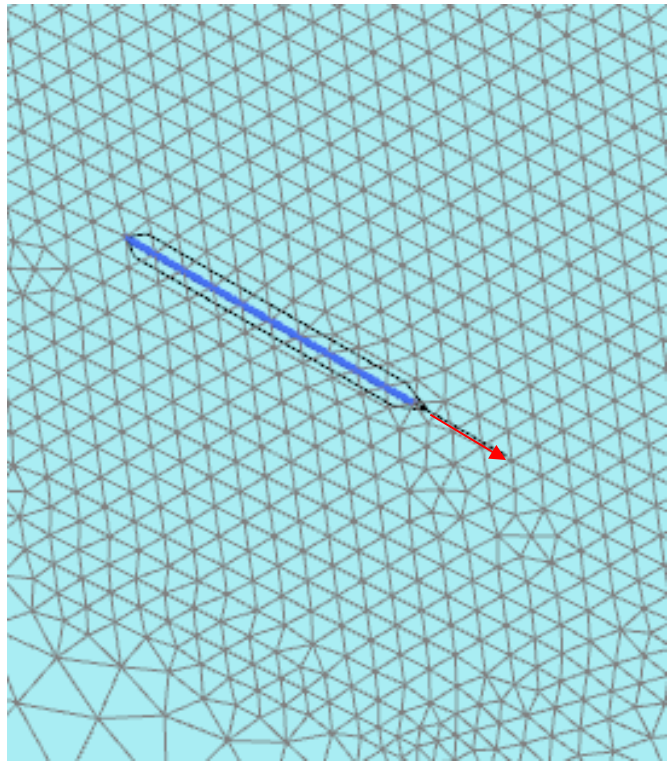
Test Results – After Shear Pin Breakage

- Up to 68º at failure (3º difference)
- Capacity increased by:
  - $\frac{242t}{185t} = 1.3$
  - 30% increased capacity



Fixed Shear Pin – Failure Mode





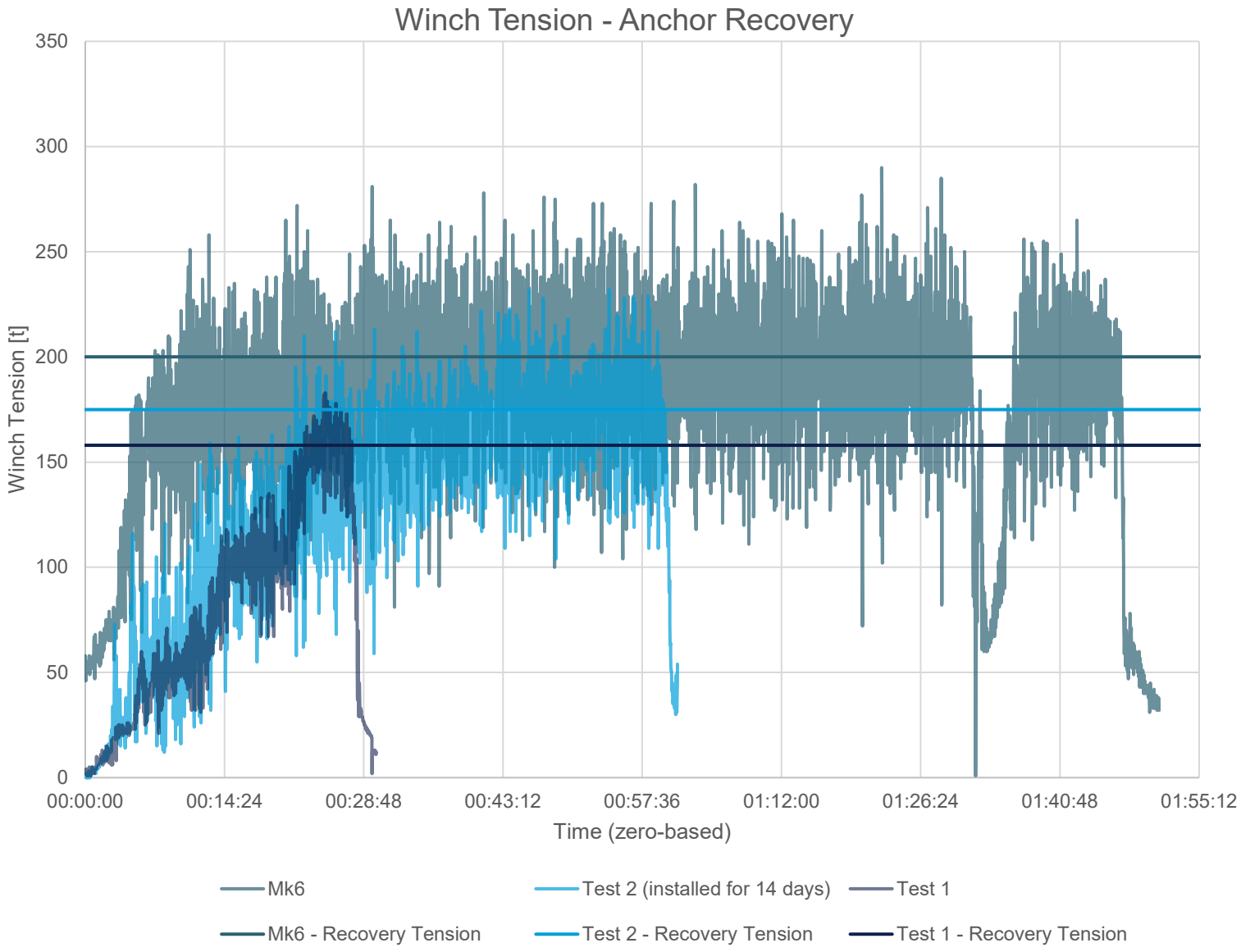
- (Failure defined as 15% strain)
- Because the shear pin mode carries a higher risk of anchor sliding out of the soil, we recommend higher safety factors than the fixed mode.

Anchor Retrieval

Anchor Retrieval

- Stevmanta tests
  - Installation tension = $295t$
  - Retrieval test 1 = $158t$
  - Retrieval test 2 (14 days) = $175t$

- Mk6 recovery:
  - Installation tension = $250t$
  - Retrieval = $200t$



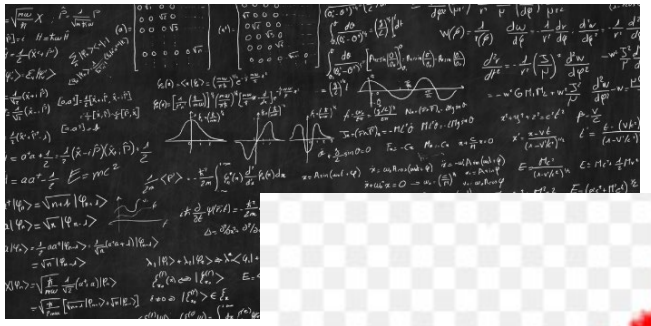
Summary

- DIGIN cannot model
  - Initial drag
  - Shear pin breakage

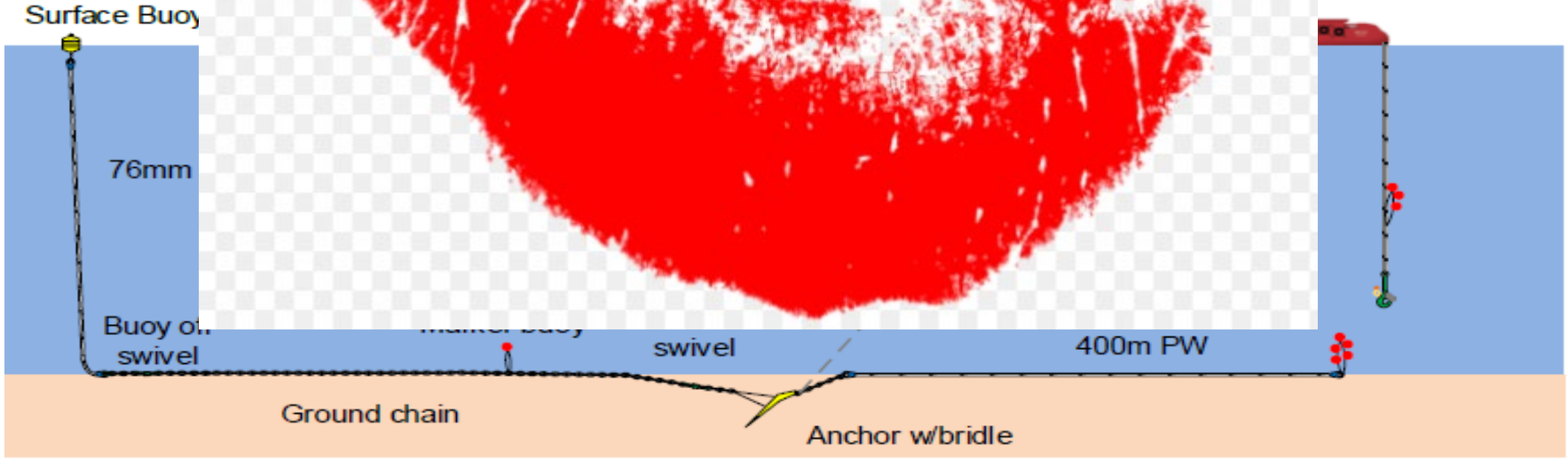
- What DIGIN can model
  - Penetration
  - Tensions
  - Relative drag

- Key Takeaways
  - Higher safety factors applied when shear pin is used
  - Add some space to account for initial drag
  - For FEM, do analysis both with and without tension cut-off
  - DNV approves

Next Steps



- It has been approved from DNV so the anchor can be utilized the same way as for the normal drag anchors
- Need to determine future locations for usage, to understand how many anchors we need available
- Operational aspect when it comes to both prelay and recovery
- Will this reduce linebreaks in the future?
- YES!!



Thank you for your attention!

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