



Horizontal directional drilling

Pipeline installation by pulling or pushing

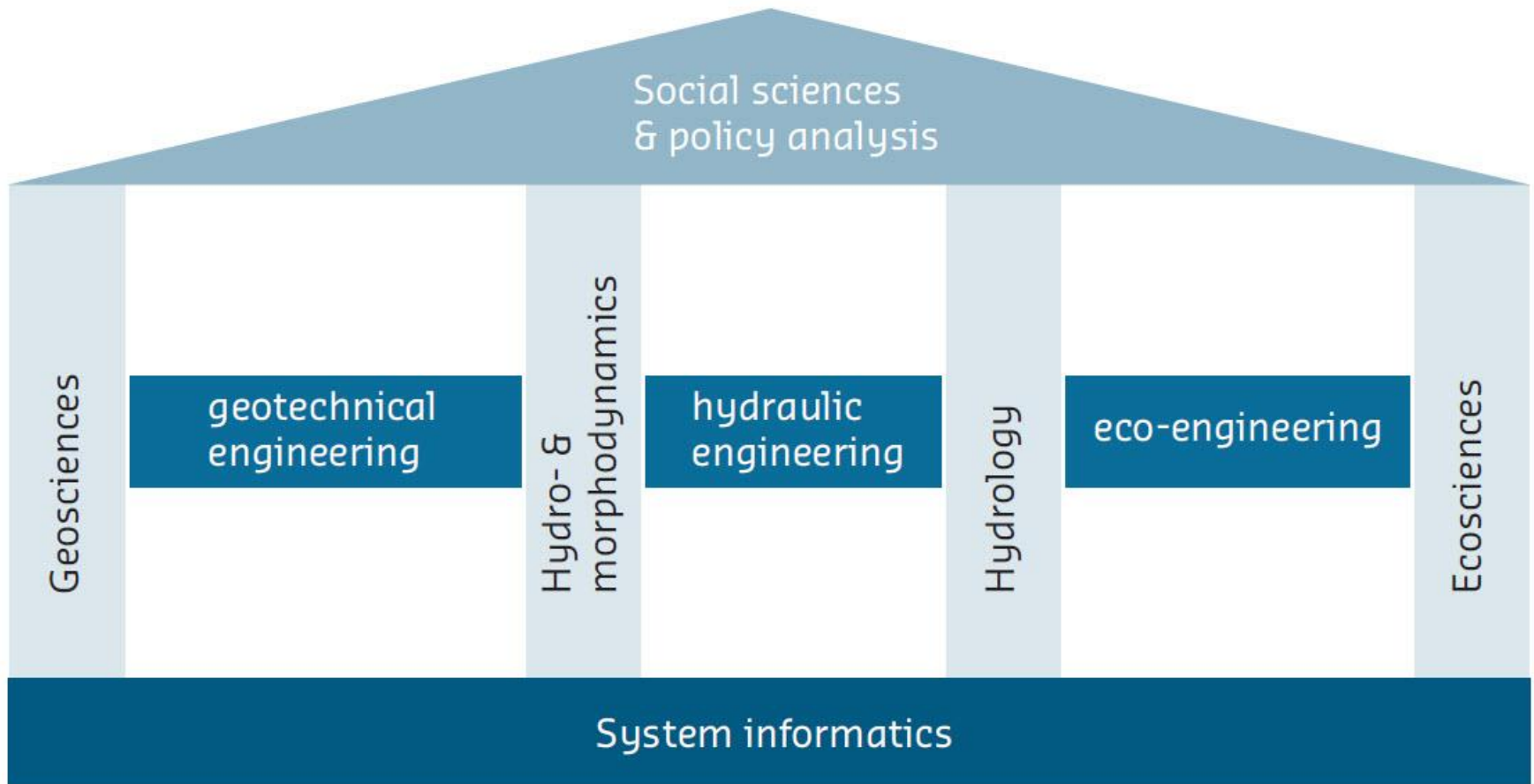
Henk Kruse and Jorn Stoelinga



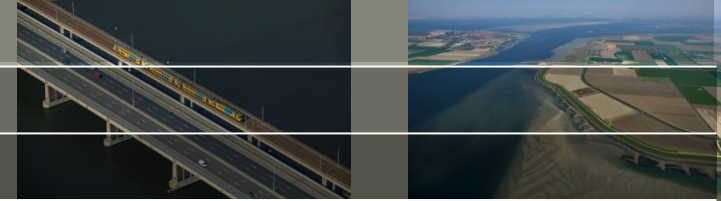
LMR DRILLING

Ein Unternehmen der Ludwig Freytag Gruppe

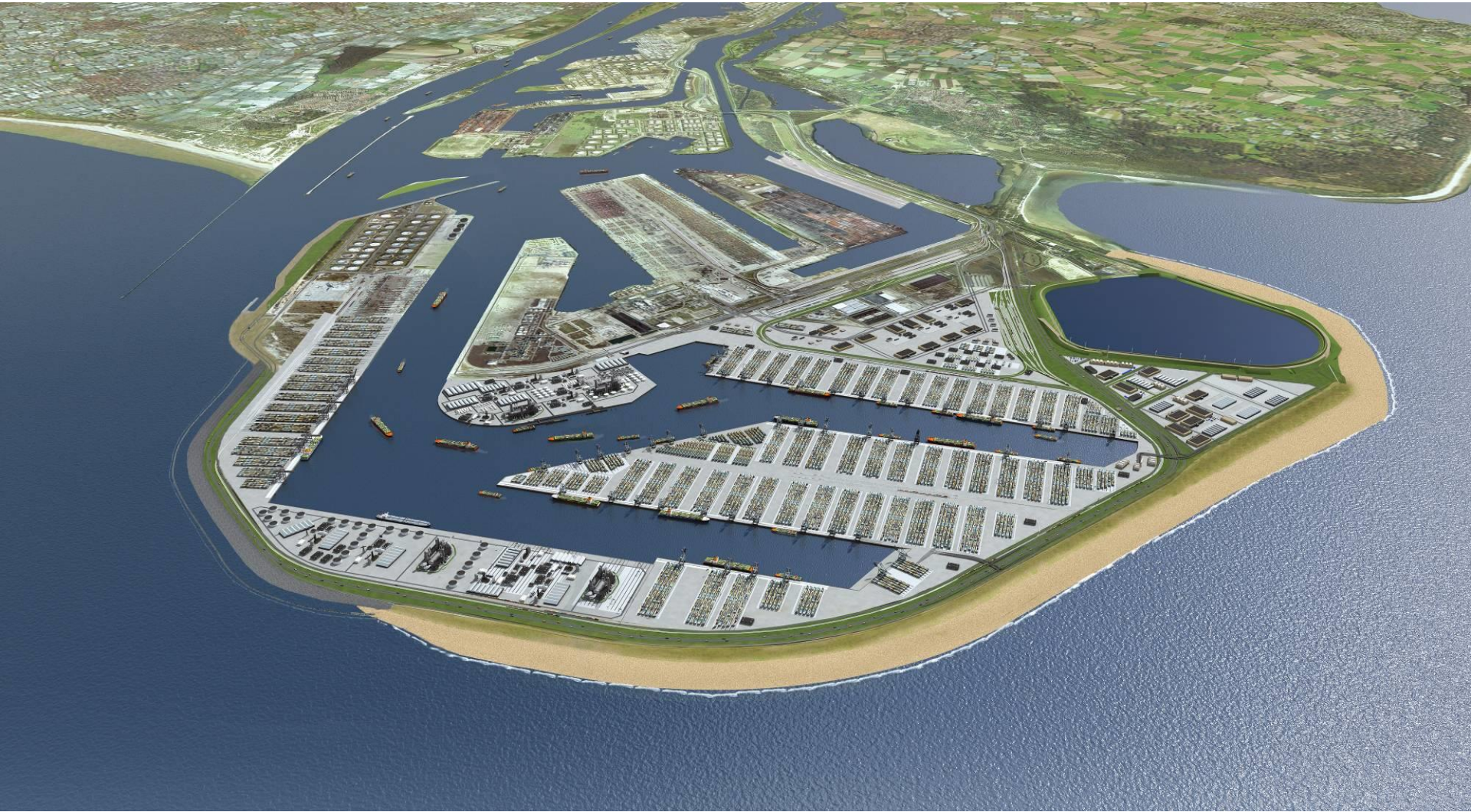
Deltares is a Dutch National Institute



Research and consultancy



Design of the extension of the harbour in Rotterdam



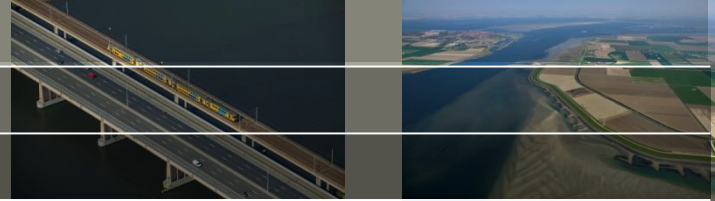
Horizontal directional drilling

Horizontal directional drilling is the most used trenchless method for pipeline installation.

- **In the Past, pipelines were installed by pull back**
- **In the Future forward pipeline installation will be carried out more often**

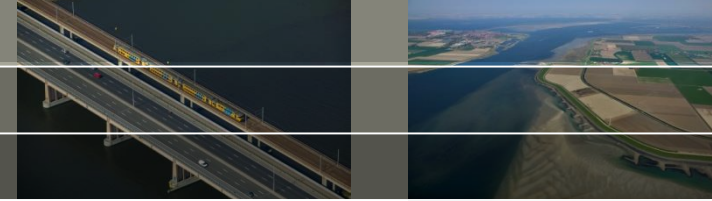


Pull back operation

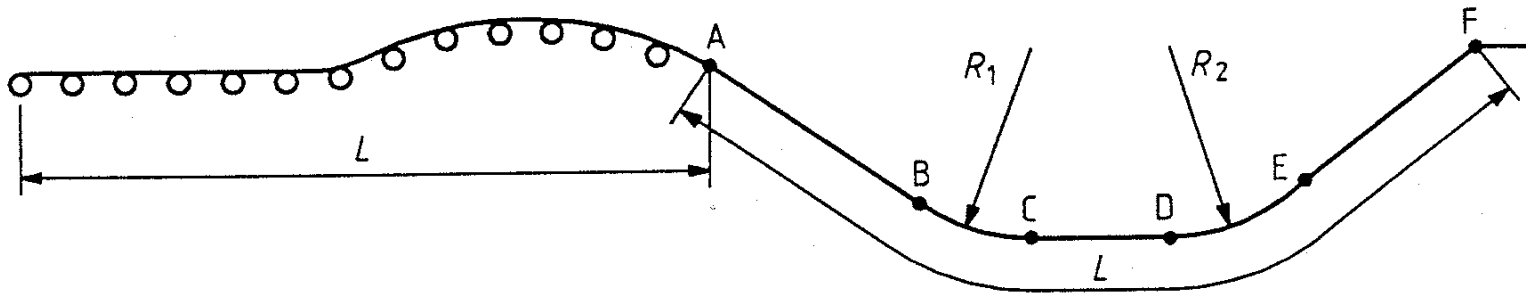


- Standard prediction model to calculate the pulling force is available
- The model ‘works well’ but has several shortcomings
 - Independent soil type
 - No influence of the shape of the borehole
 - Application of overall safety factor
- Ballasting of the pipeline is important

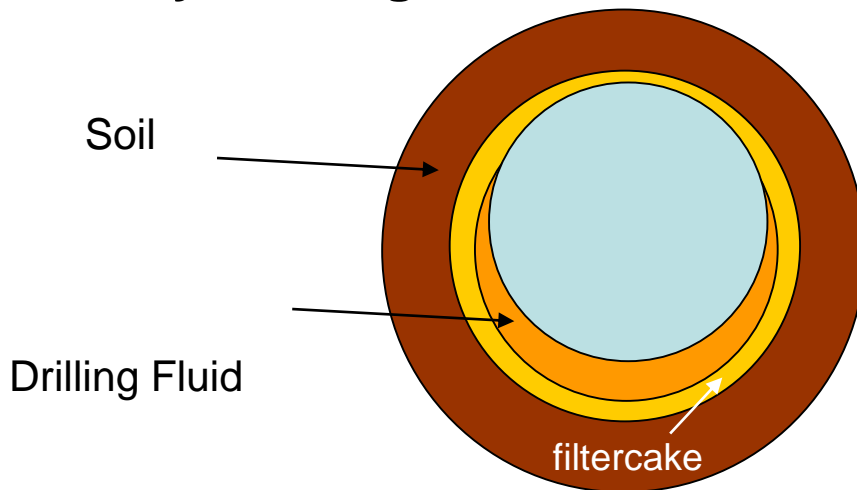
Pulling force calculation



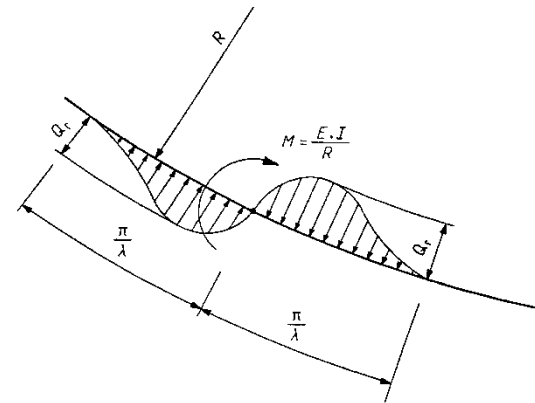
Simple prediction model based on downhole mechanisms



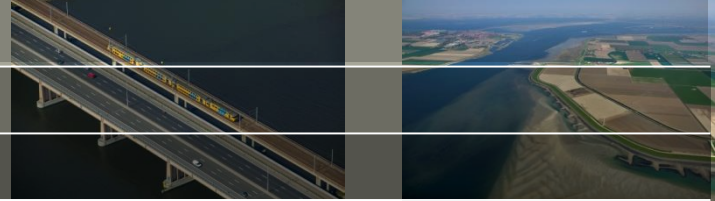
Buoyant weight



Soil reaction in the curves



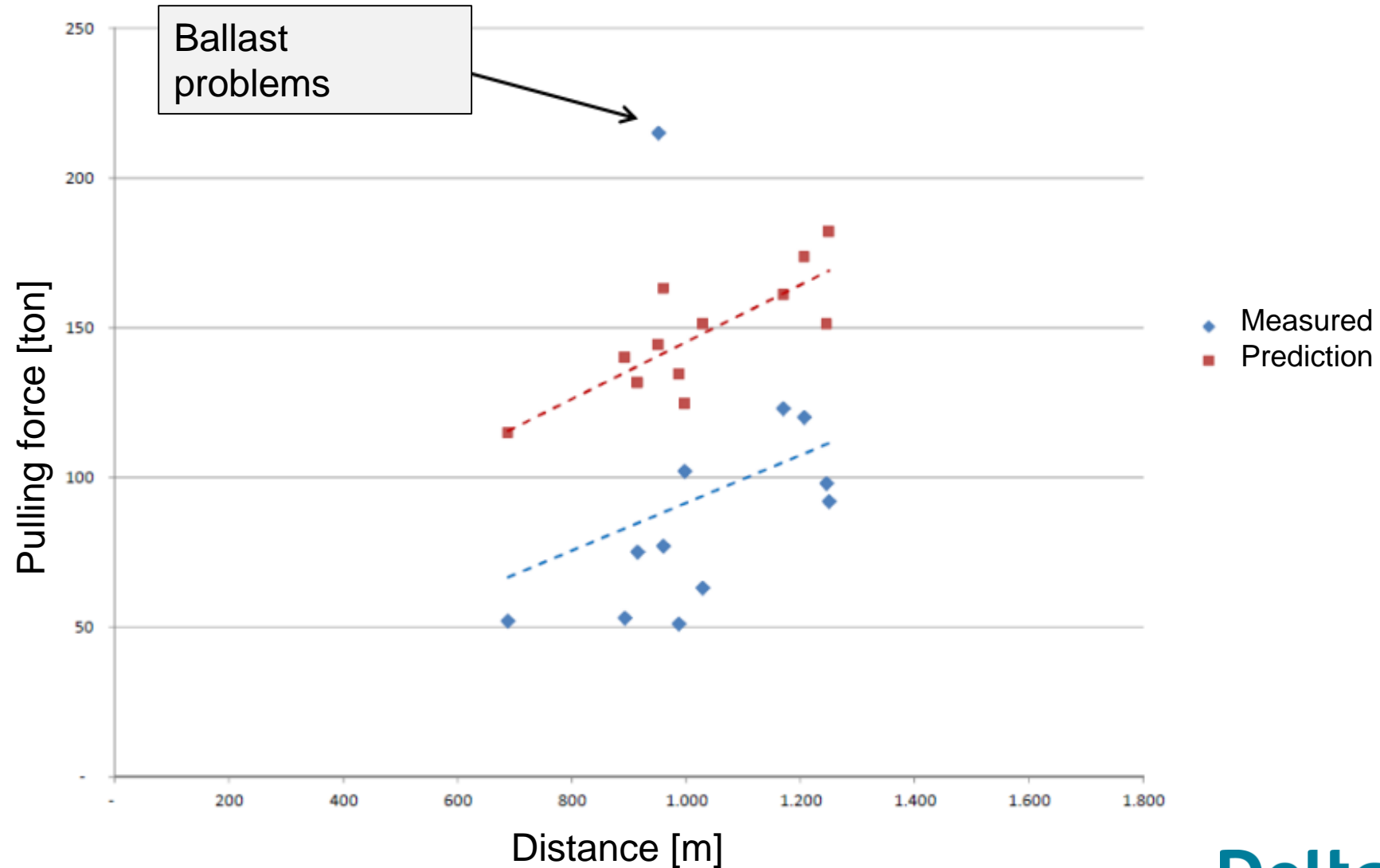
Buoyant weight



Ballasting techniques have been improved



Pulling forces lower than predictions



Shape of the Borehole important for pull back

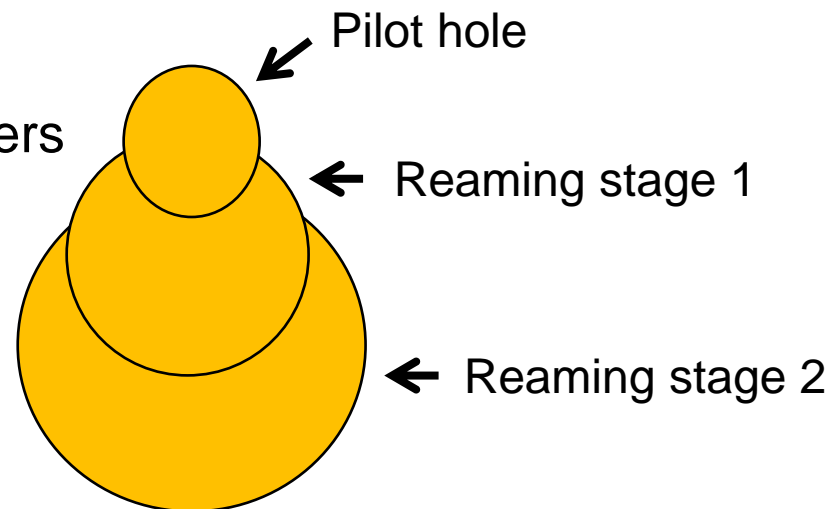
- Axial shape of the borehole.

Quality of the drilling line depends on steering of the drilling head

- Tangential shape of the borehole

Determined by the interaction of the downhole drilling tools and the soil.

Often loose soils and heavy reamers are a Risk factor for the creation of irregular boreholes



Drilling line : Steering using the Gyroscope

Guidance input: desired drill-path

Dead
Reckoning
based
Guidance



Driller

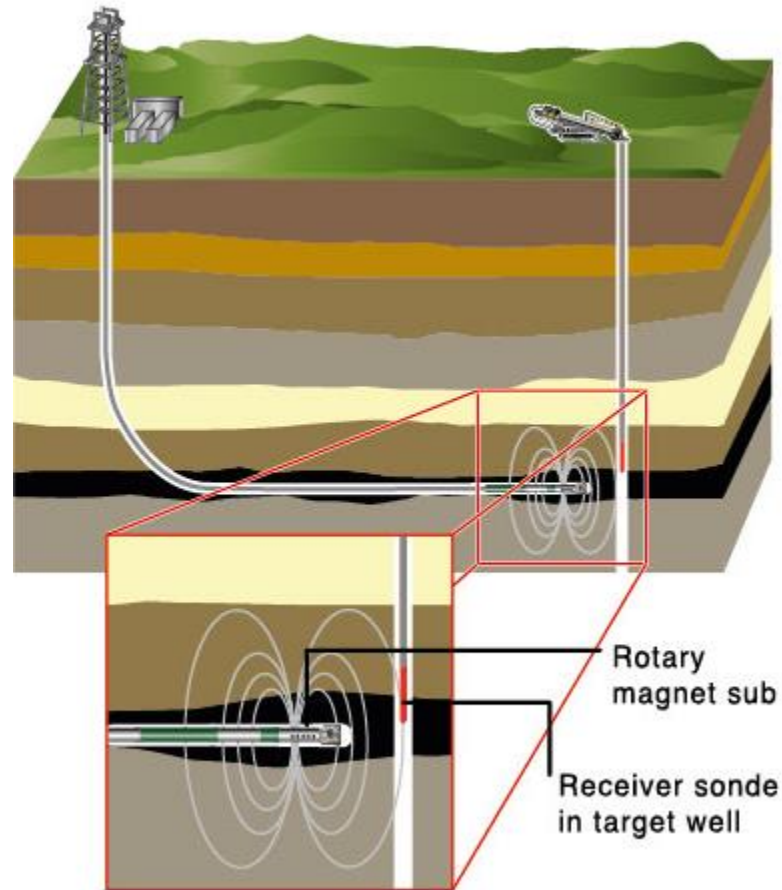
Measured input: real drill-path



Optical Gyro System



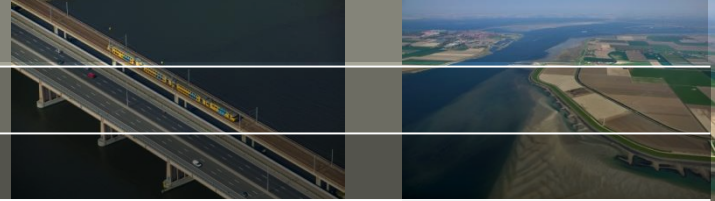
Drilling line Steering Magnetic system



The AC Beacon



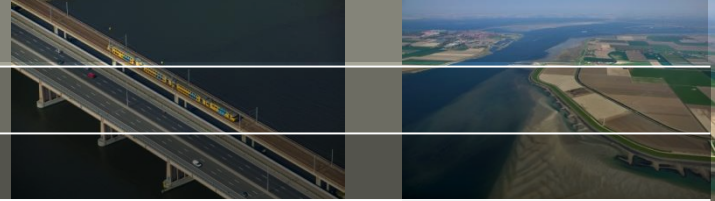
The drilling line control



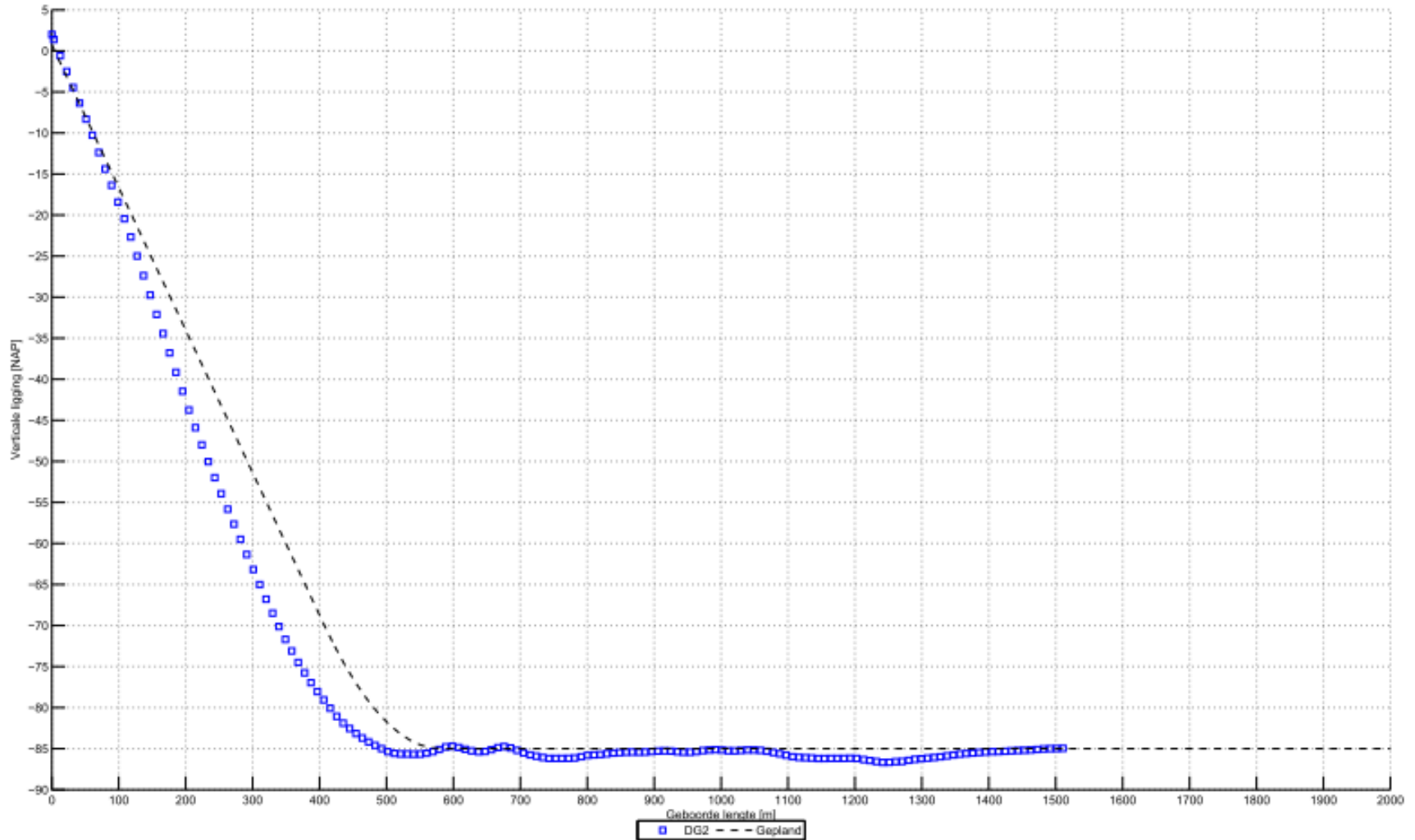
The drilling line at the exit point



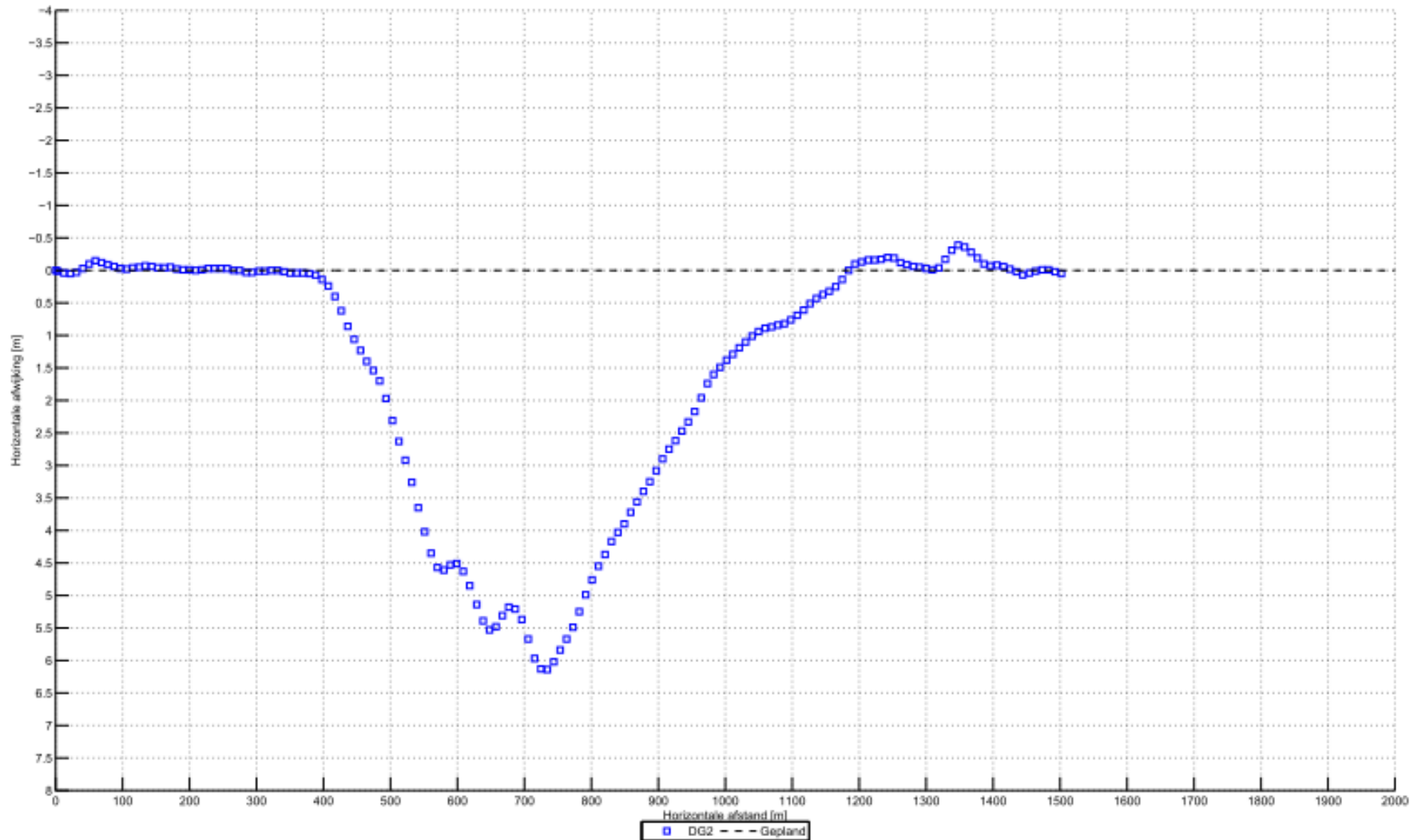
Exit point



Drilling line in between entry and exit point

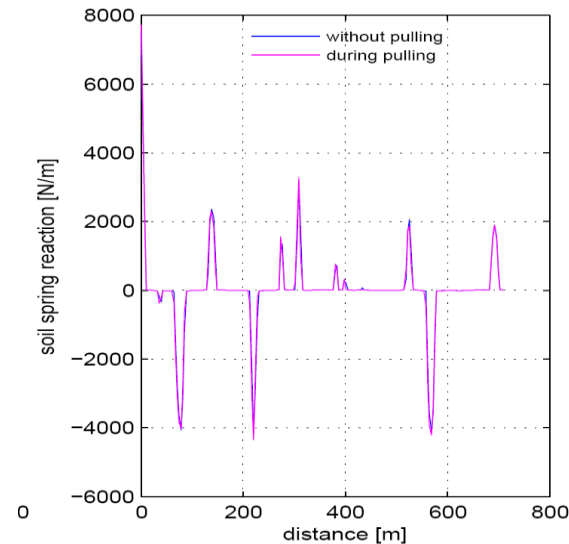


Drilling line in between entry and exit point



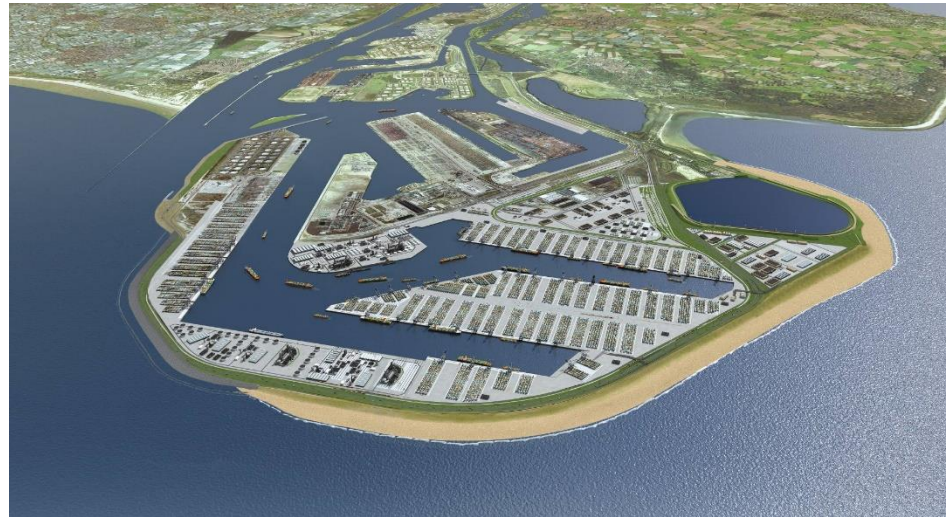
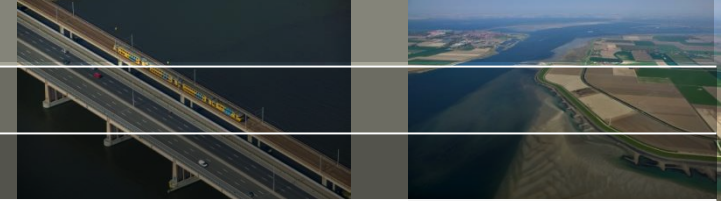
Monitoring of drilling line required

- Friction increases considerably in irregular shaped boreholes



- *Avoiding so called dog legs by experienced drillers and sufficient soil investigation*
- *Avoiding a small bending radius by analyzing the measurement data from the pilot stage*
- *Continuation of the monitoring during reaming and or wiper trip*

Forward pipeline installation



- Landfall of offshore electricity cables
- Installation of 4 * 800 mm PE pipes for the cables
- Drillings carried out by LMR GmbH

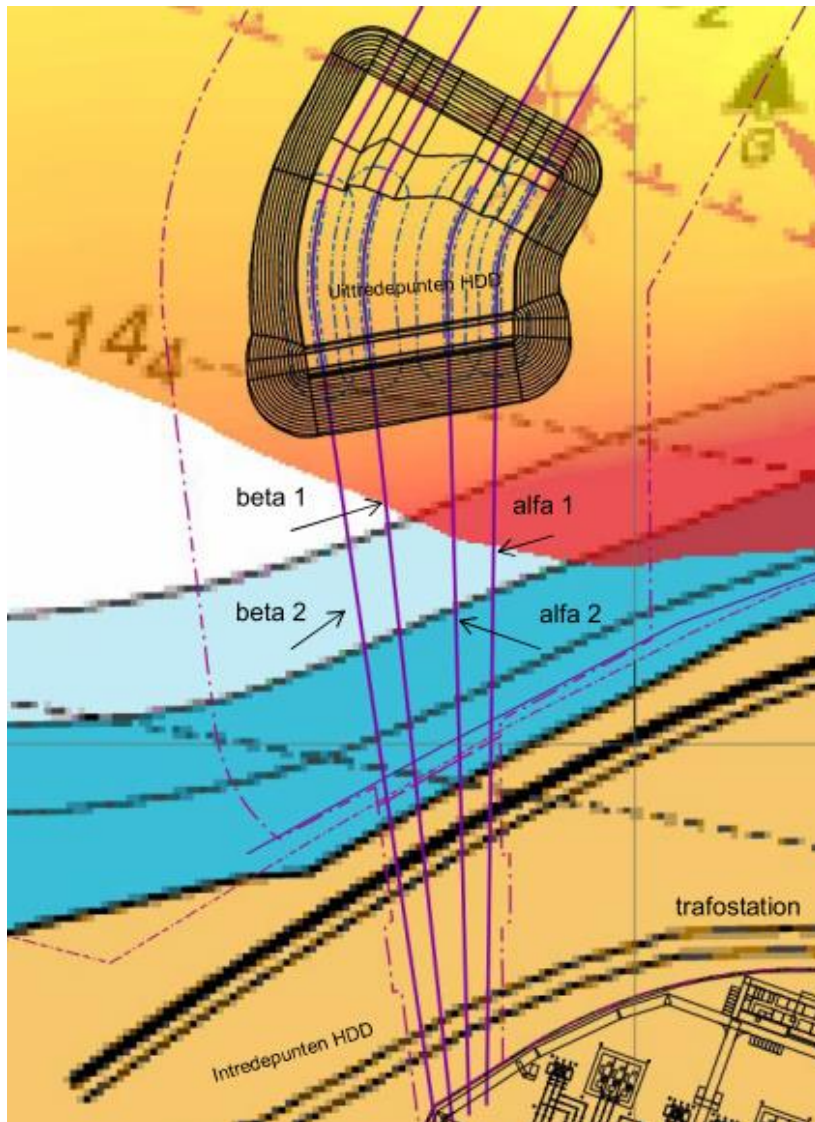


LMR DRILLING

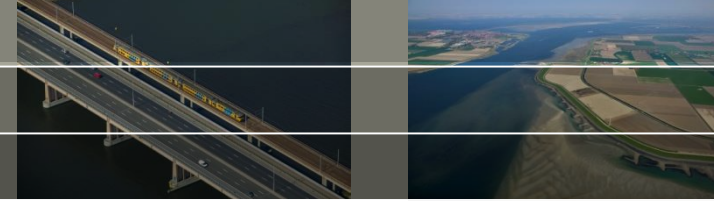
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Deltares

4 HDD's with exit points in a dredged pit



Drilling with forward reaming



- Exit point at a distance of 160 m from the sea dike
- Exit point in dredged pit with a slope angle of 1:5

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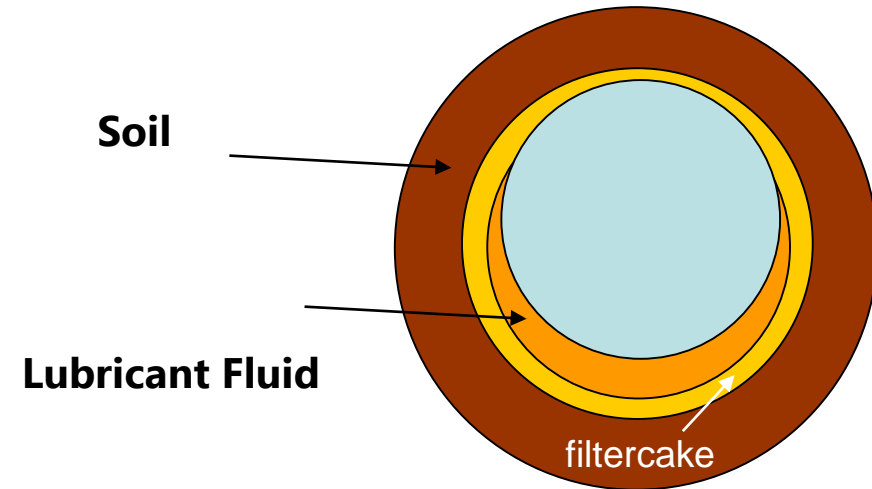
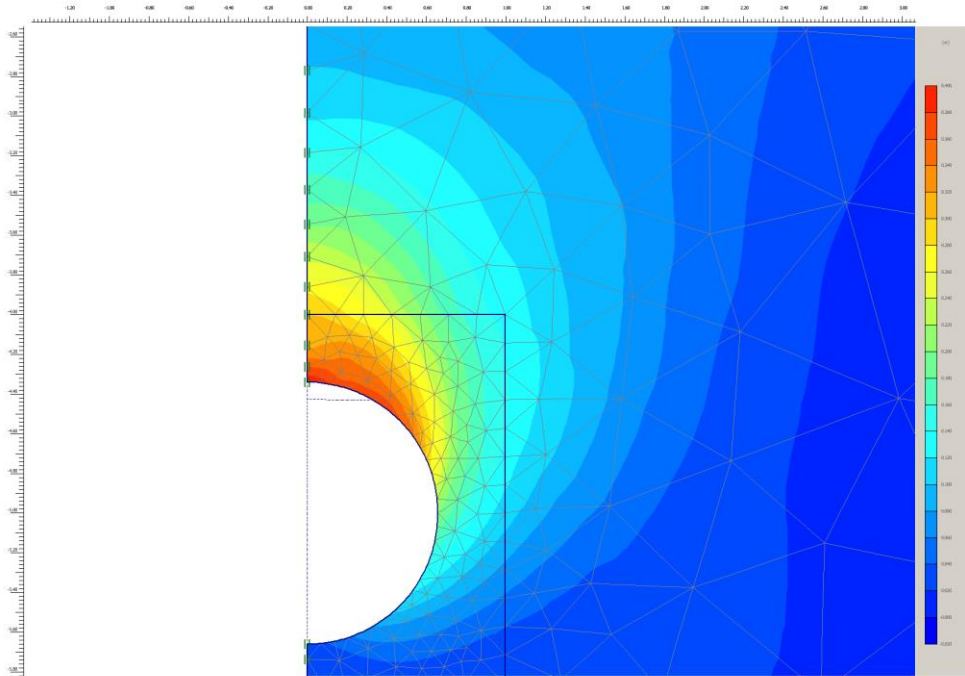
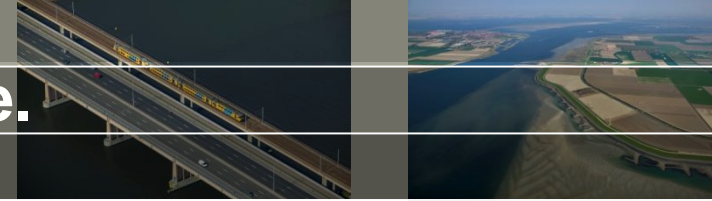
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Calculation of required thrust force.

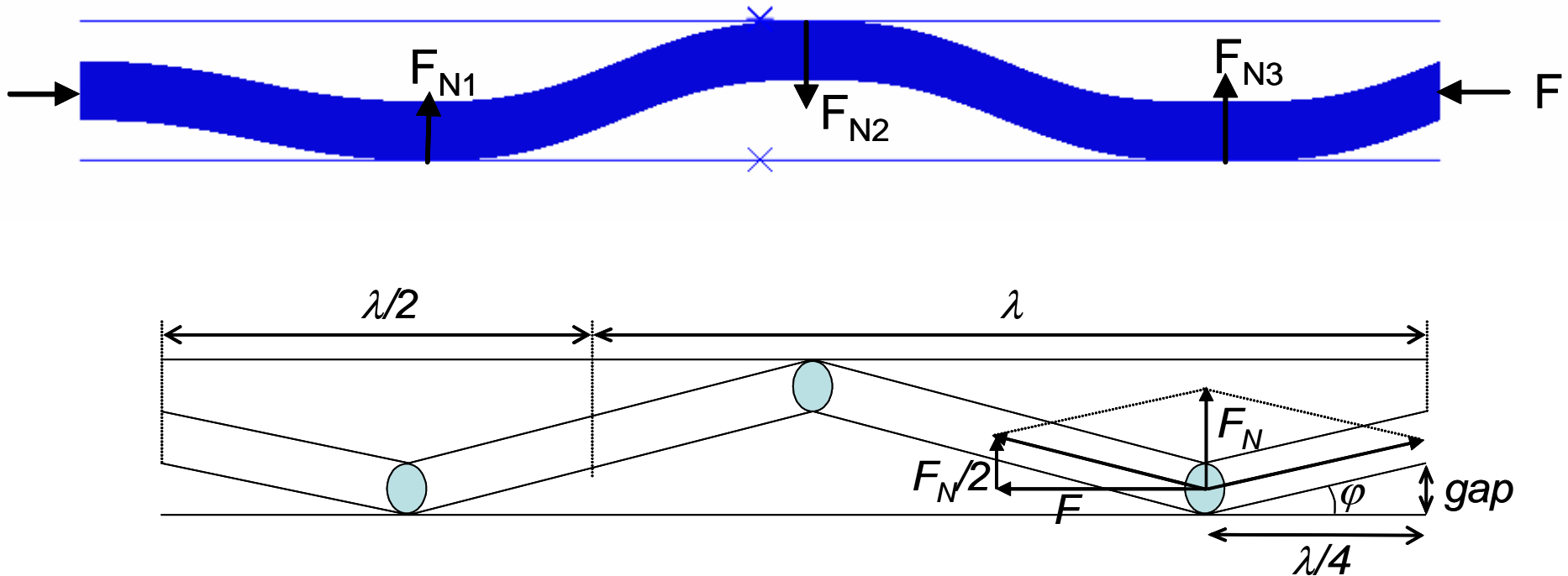
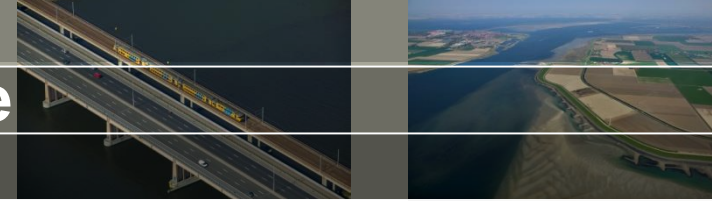


- Behavior in the bends is different from pulling
- Buckling may play a role

Calculation formula's for the thrust force

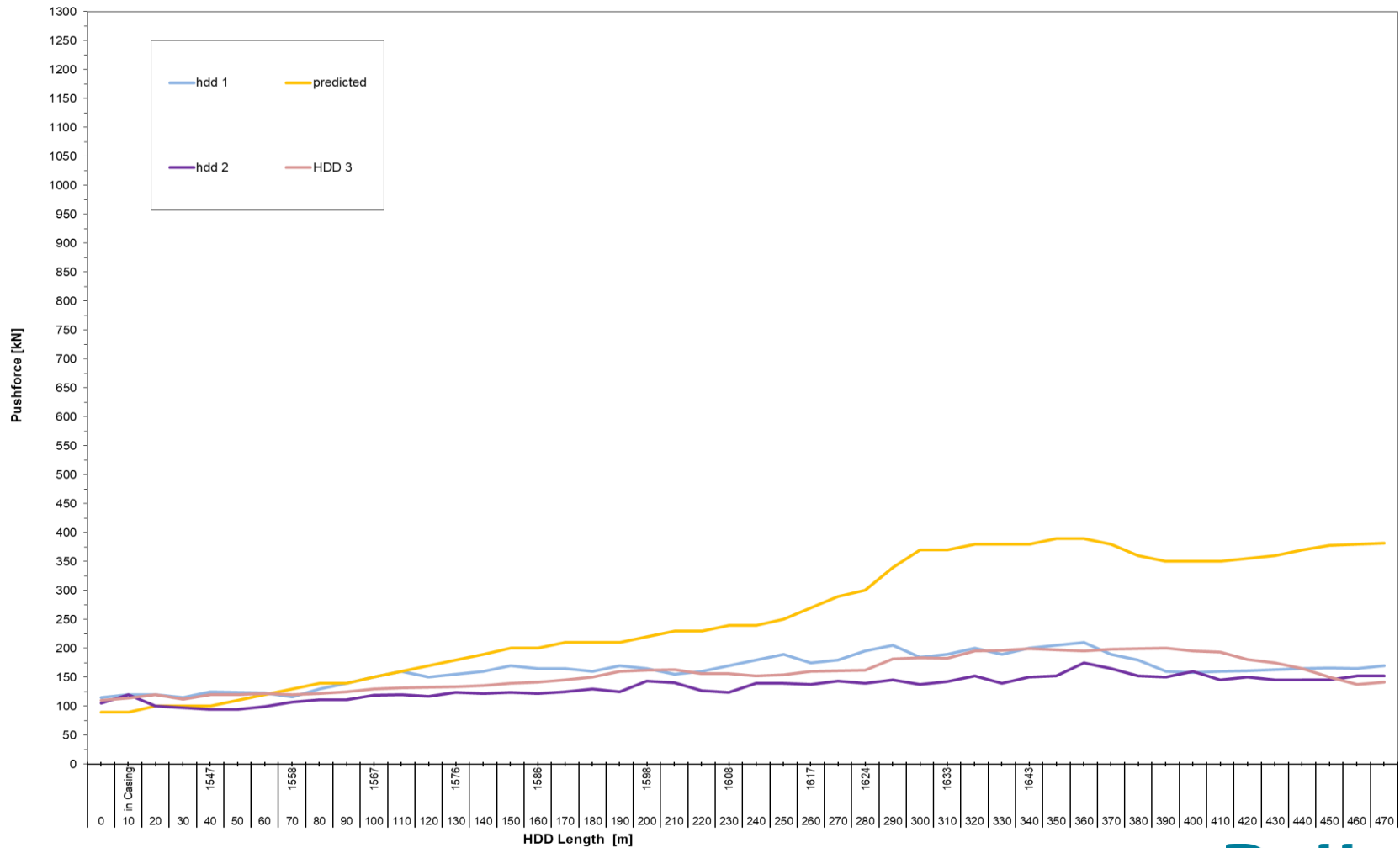
- Normal friction determined by the buoyant weight of the pipe
- Interaction between the buoyant weight and the thrust force
- Effect of the thrust force partly determined by additional friction in the bends.
- Buckling of the pipe is considered in a conservative way
- Assumptions for the safety factor

Friction due to buckling of the pipe

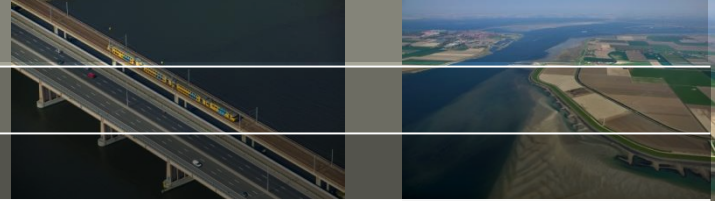


Stiffness of the pipe and gap size/ overcut of the borehole play an important role

Results of Thrust forces for three HDD's



Conclusions



- 1) The prediction of the pulling force can and should be improved
- 2) Shape of the borehole is important for pipeline installation
- 3) Calculation formulas for forward pipe installation are available
- 4) Predicted Thrust forces for forward installation are higher than measured
- 5) Forward pipe installation is carried out more often nowadays
and in the future

End

