Gyroscopic Navigation and the HDD Industry

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Introduction

- Trenchless Technology is continuously expanding
- HDDs getting longer & more complex
- Congested easements
- More and more requirements for HDDs
- Increased need for added curves

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Designing a HDD trajectory

- Calculation programs for pulling forces
- Based on NEN 3650 & ASTM 1962
- Safety factor of 40% added
- Allow for unforeseen circumstances
- Calculations have not changed
- But many challenges can be overcome!

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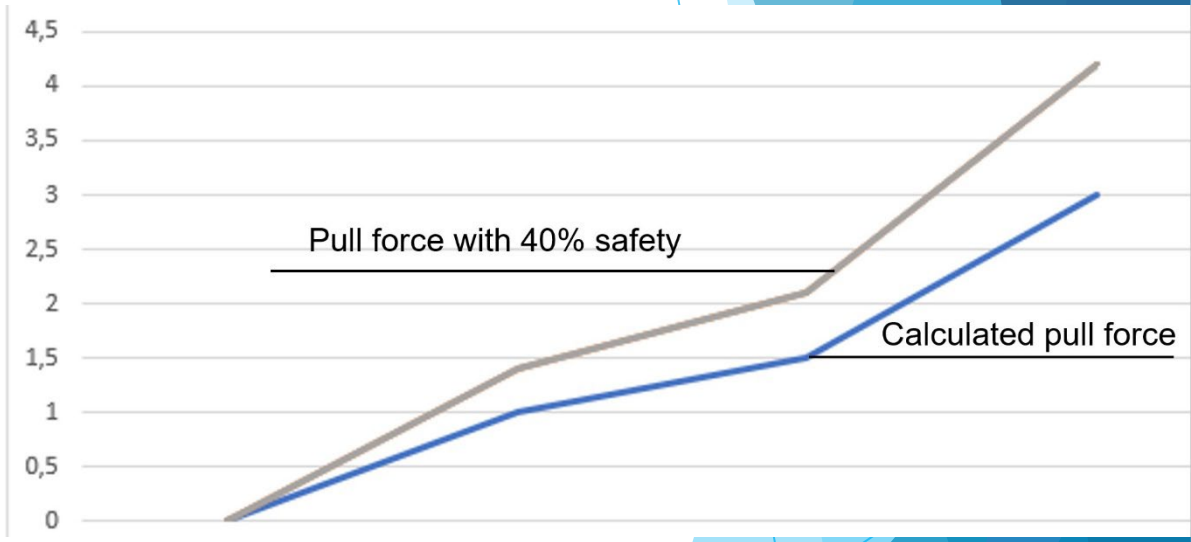
Safety factor?

- Unforeseen circumstances
- Soil deviations
- Compensating deviations due to interference
- Steering tool tolerances
- Mud weight deviations



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Smooth alignment of steel pipelines

- More certainty about pipe stress
- Important for pressurized pipelines
- Reduced risk of coating damage
- Stuck pipe due to doglegs
- Stuck pipe due to insufficient pull force
- Reduce the risk for embrittlement (H2)

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State of the art, or…?

- Improved knowledge about steering, mud, etc.
- Better equipment, safer operations
- But the same calculations & safety factors!
- Using gyro tools
  - Smoother drill line
  - Lower pulling forces
- Mud characteristics
  - SW 1.05 – 1.35?

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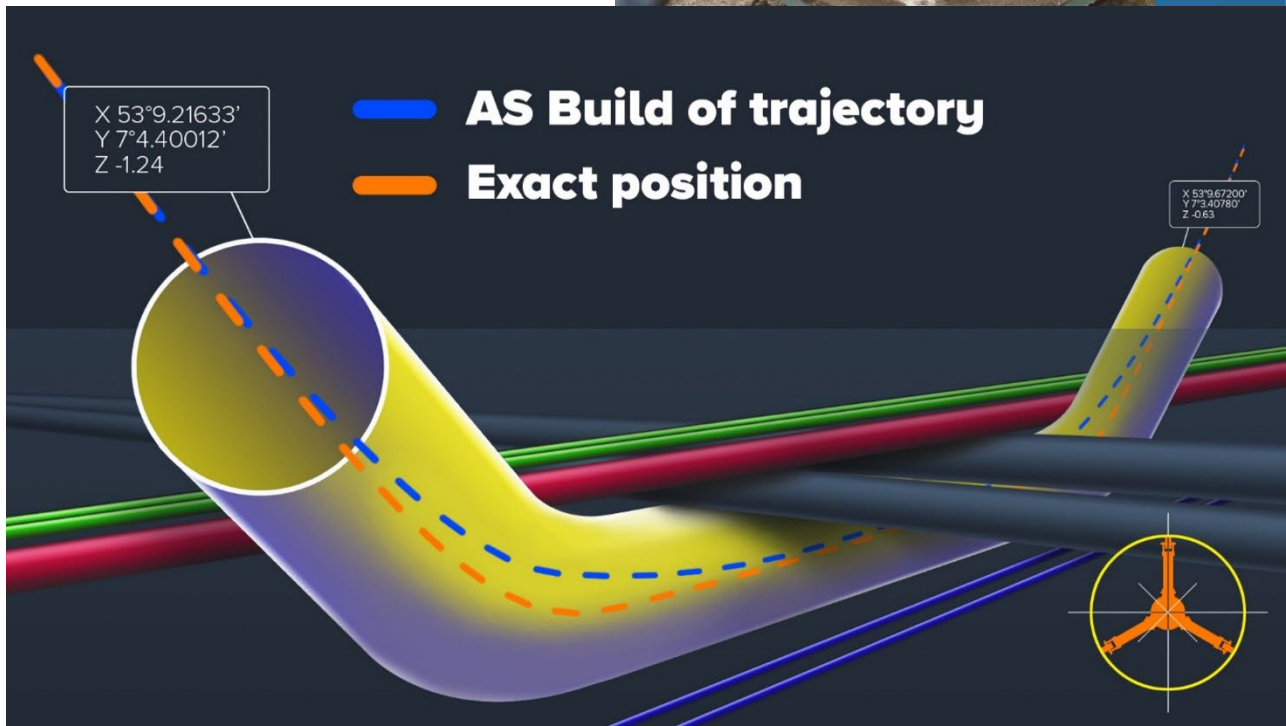
Verification post-installation

- Pipe position can be checked
- Allows calculation of the bending radius
- Results show: gyro gives smoother HDDs
- Lower pulling forces for large diameters

- Proposal: Deviate the safety factor



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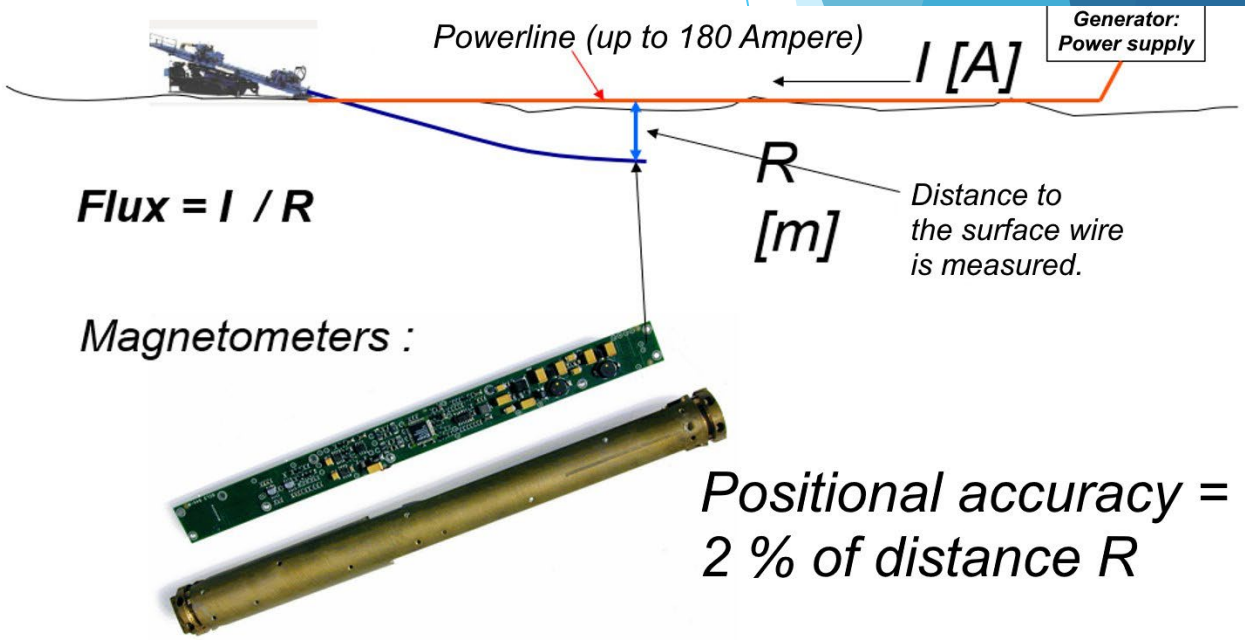
Accuracy: magnetic tools

- Accuracy = ±2% of current depth
- At 40 m: 80 cm tolerance
- Common practice to check every joint
- Next joint could counter-deviate 80 cm
- 160 cm between two joints (9 m)
- 80 cm deviation on 9 m = +2.5° bend



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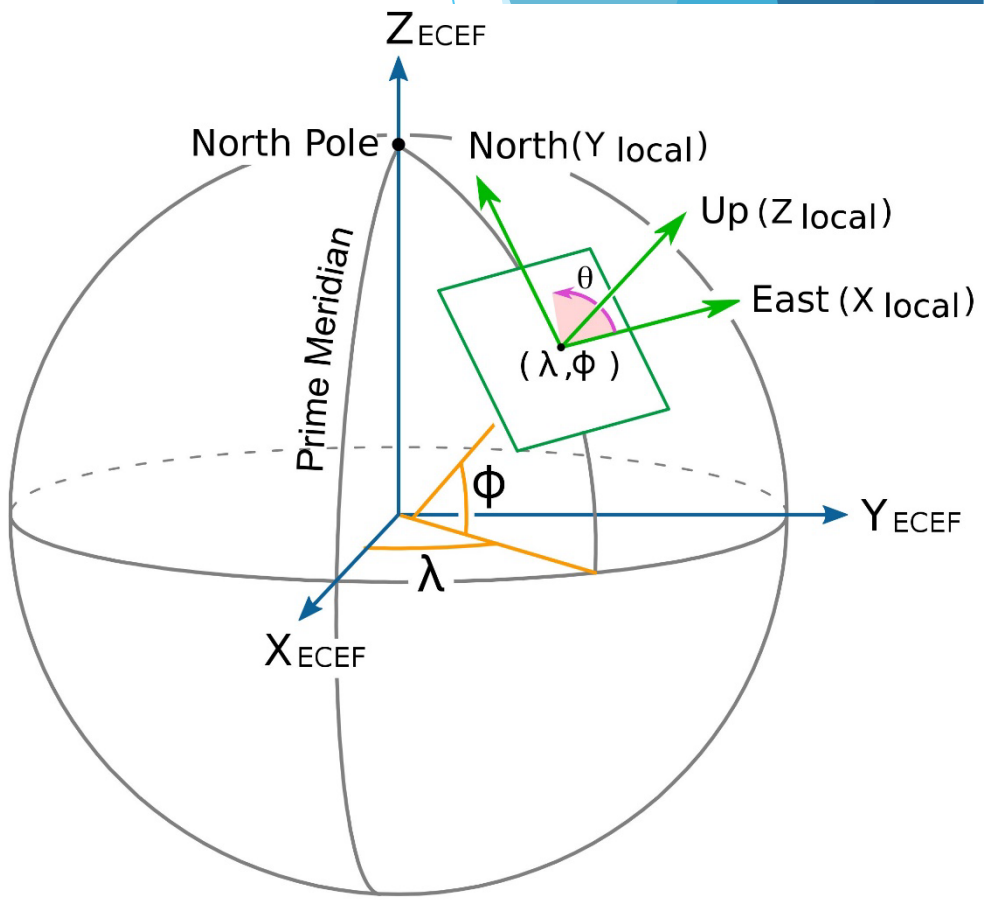
Accuracy: gyro tools

- Accuracy: 0.04°
- Independent of depth
- Independent of interference
- Drilling 18 m: max. 13 mm deviation
- Surface access not necessary



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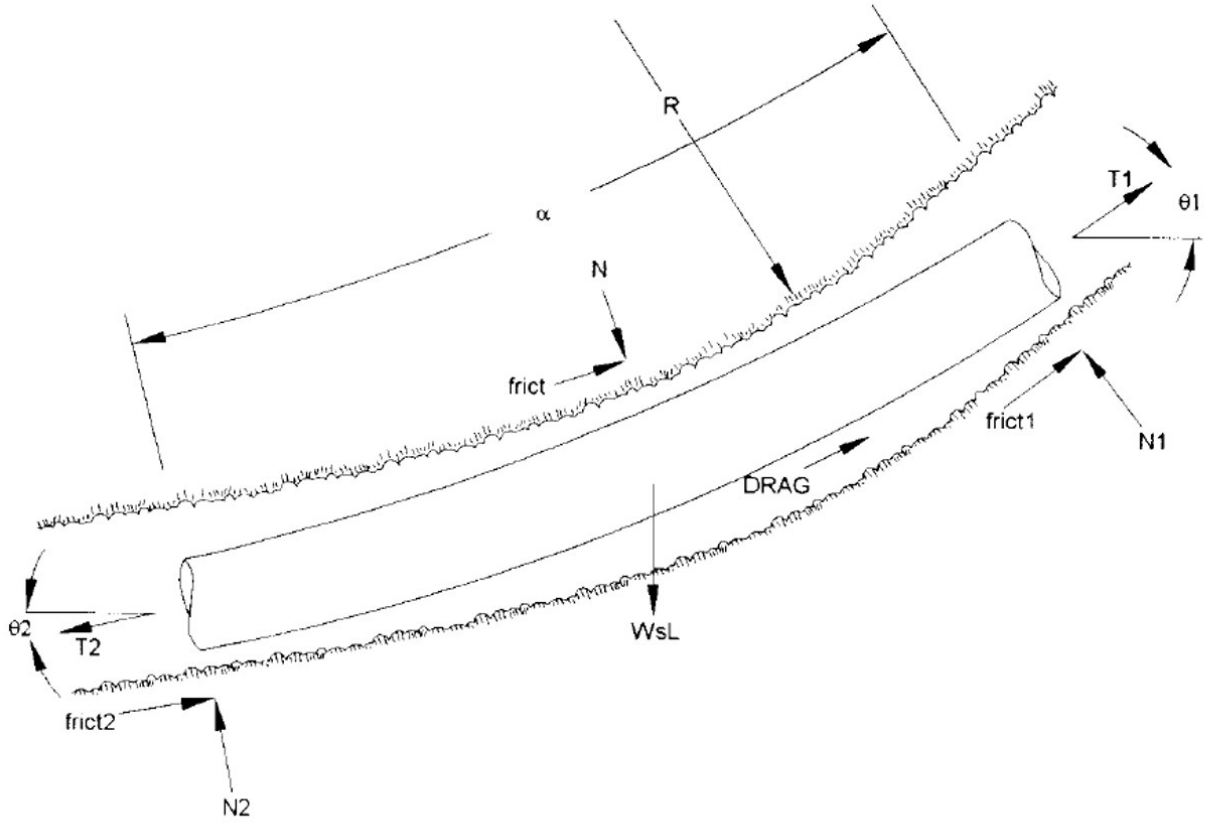
Bending

- Calculation for pipe stress: $M = \frac{EI}{R}$
- Guidelines add a 1.4 safety factor
- Same factor used for pulling forces
- Based on 15-year-old uncertainties
- Reducing safety factor will help industry
- Knowledge can reduce several risks



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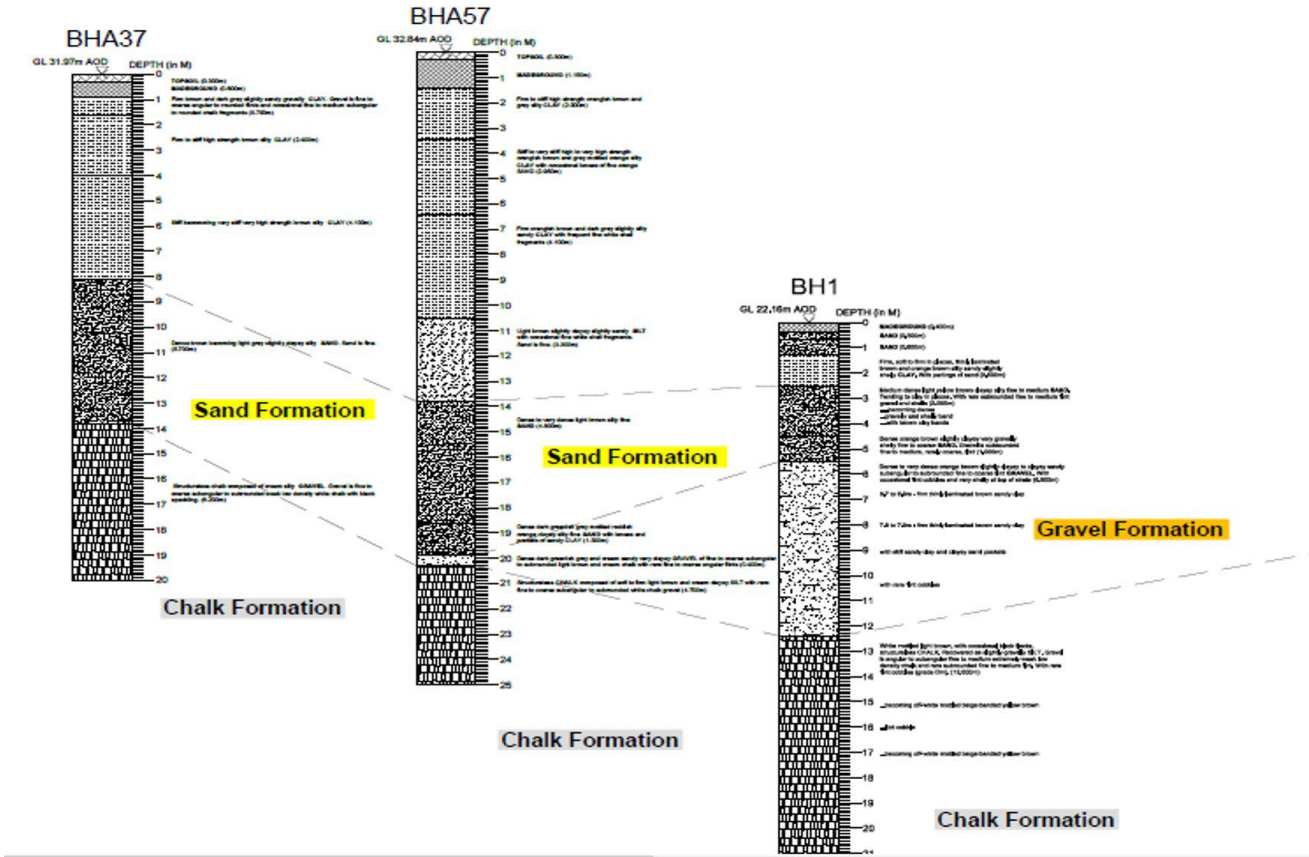
Safety factor based on uncertainties

- Still a factor:
  - Soil risks (although improvements made)
  - Unforeseen circumstances
- To be reconsidered:
  - Deviations in mud weight
  - Type of steering tool used
  - Possible interference
- More knowledge is available now



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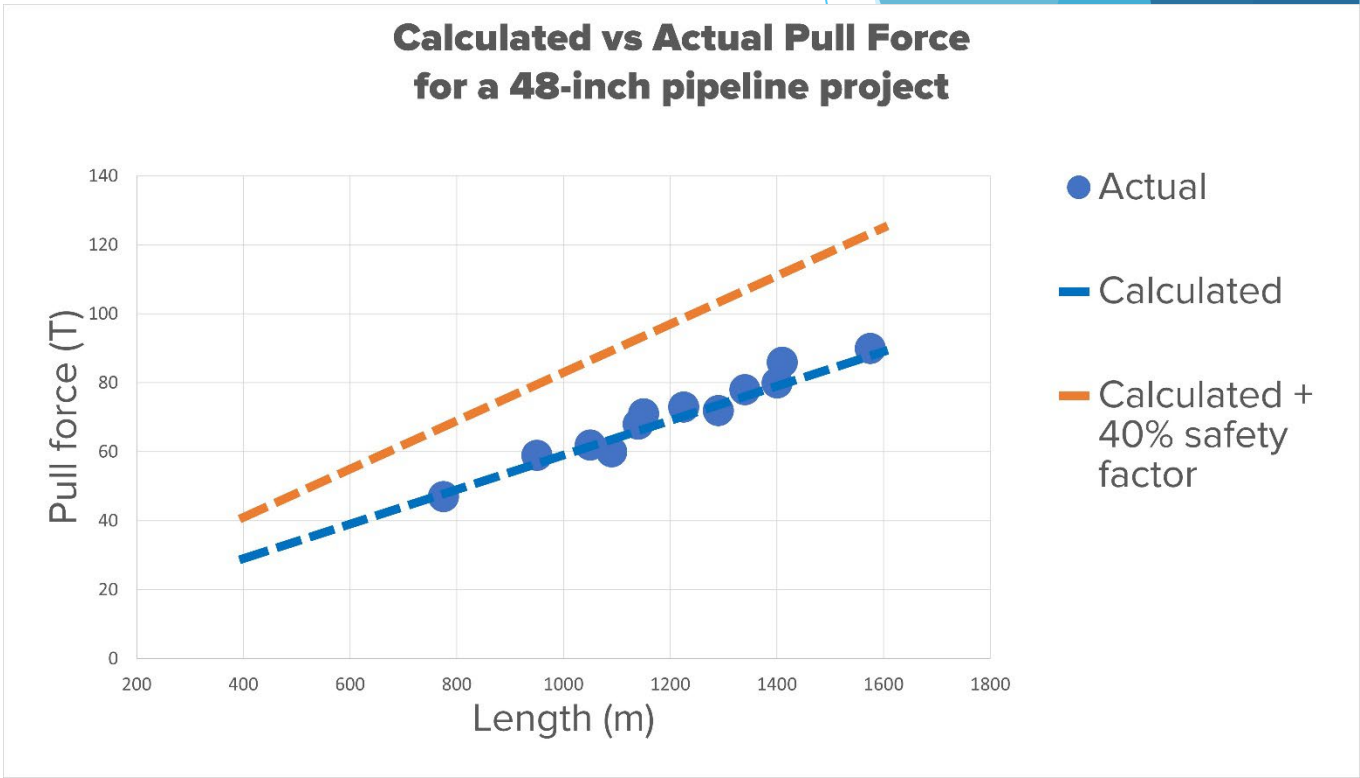
Actual pull forces

- Gasunie Holland 48-inch pipelines
- Calculated and actual pull forces compared
- Substantially lower than calculated model
- HDDs executed using Gyro Steering Tool



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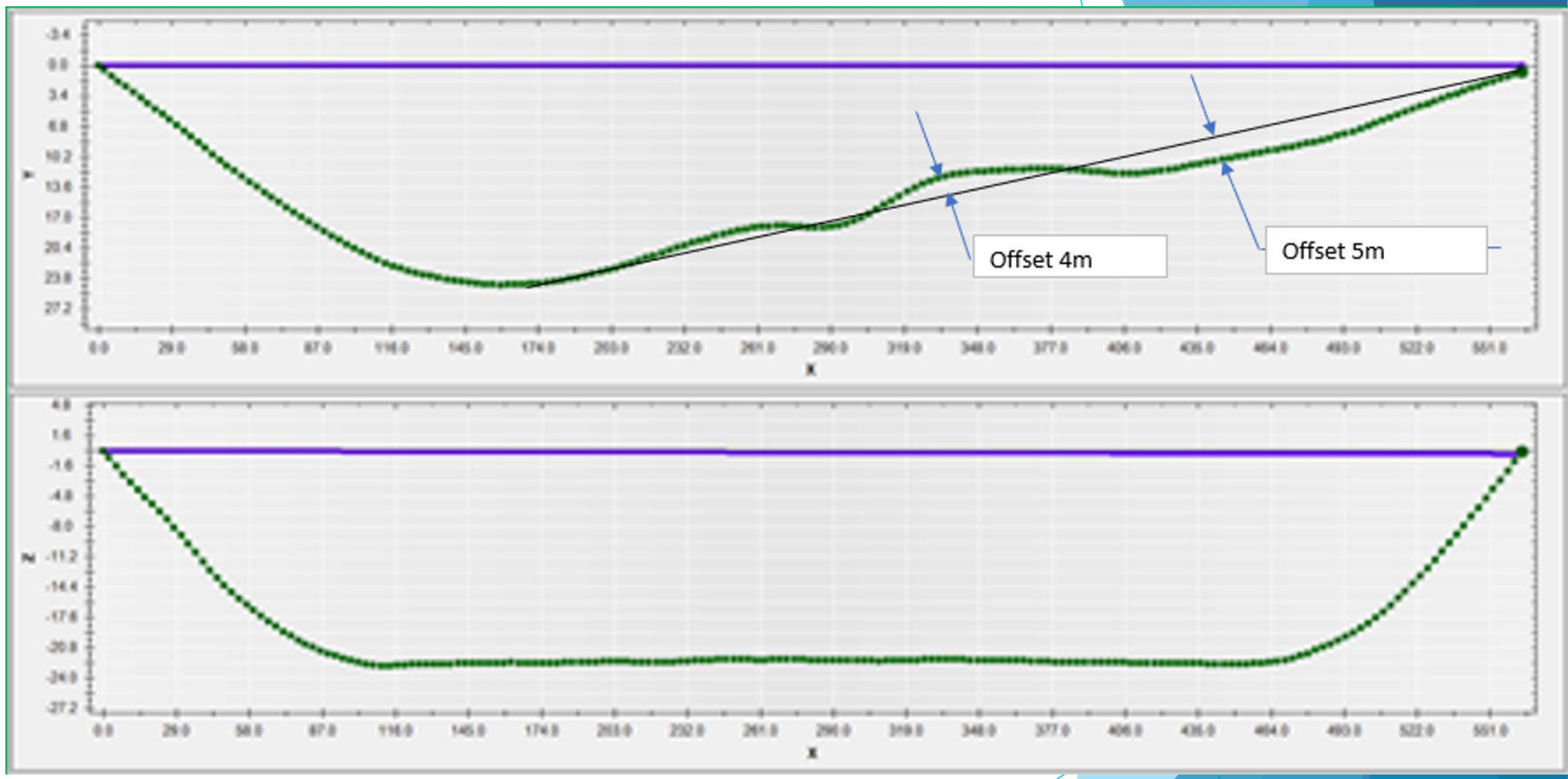
Tolerances

- Comparing as-built data: magnetic vs gyro
- Magnetic example: accurate entry and exit
- But deviations up to 5 m!



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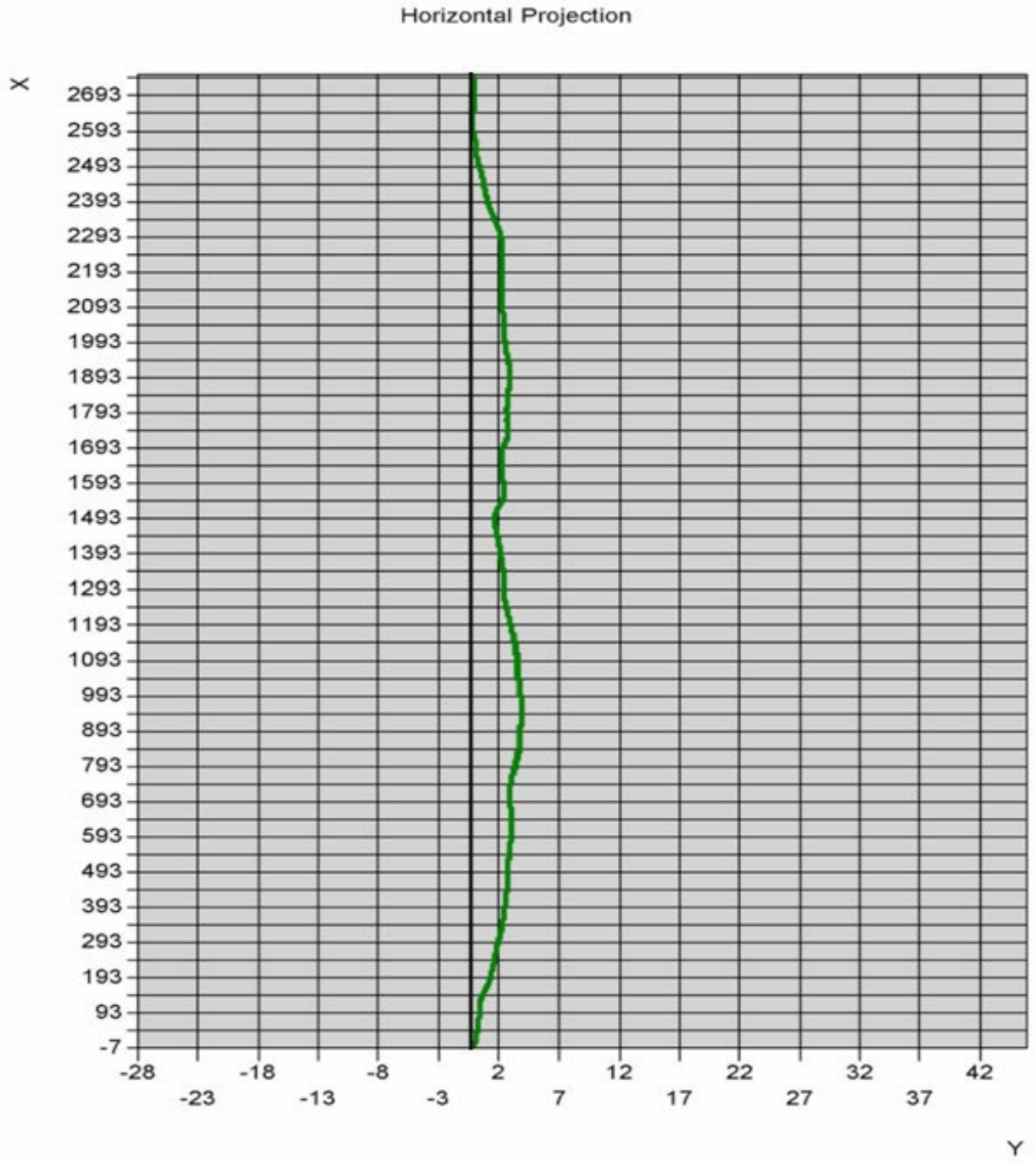
Deviations

- Projected horizontally, the deviations really show



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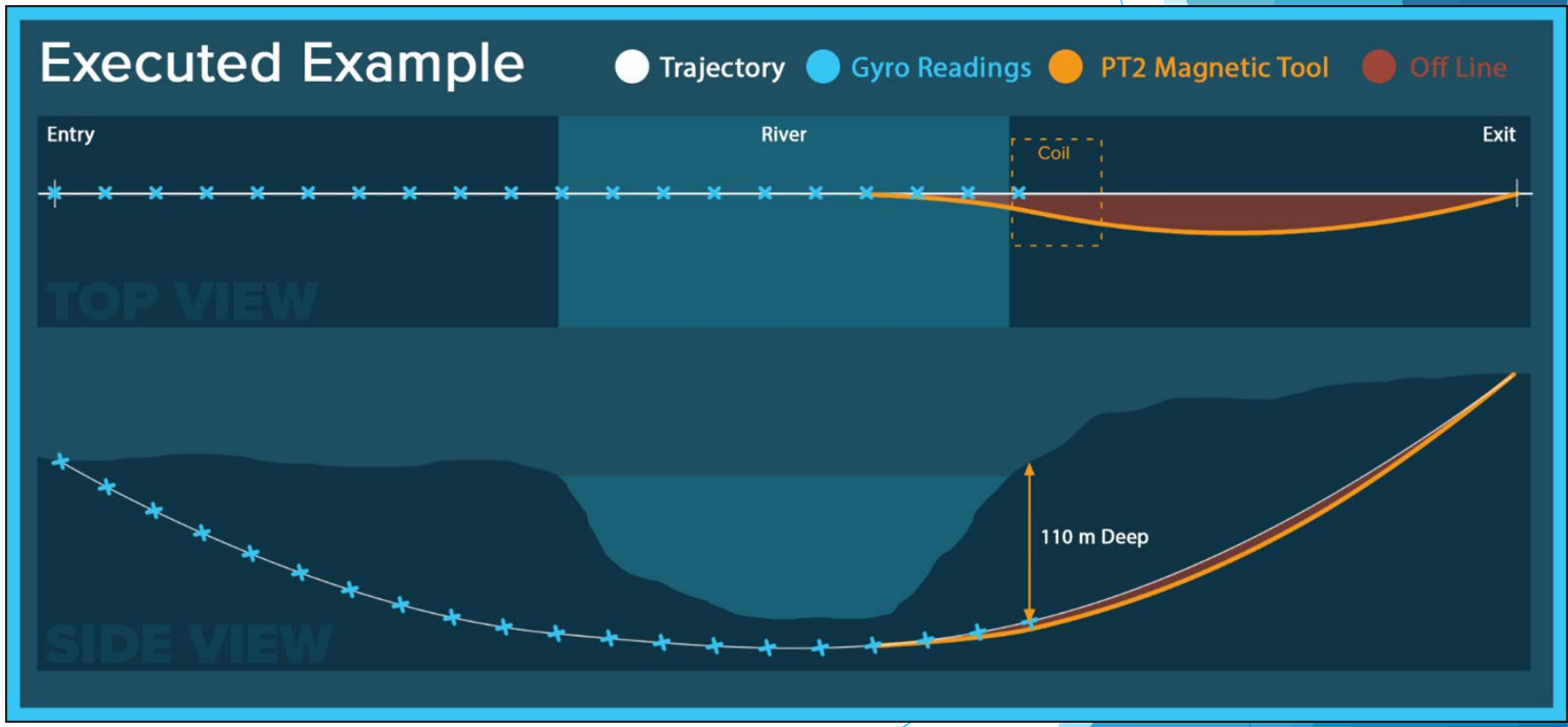
HDD using magnetic + gyro

- Gyro used only for river crossing portion
- Post-installation verification using two tools
- Last section (magnetic steering) showed deviation



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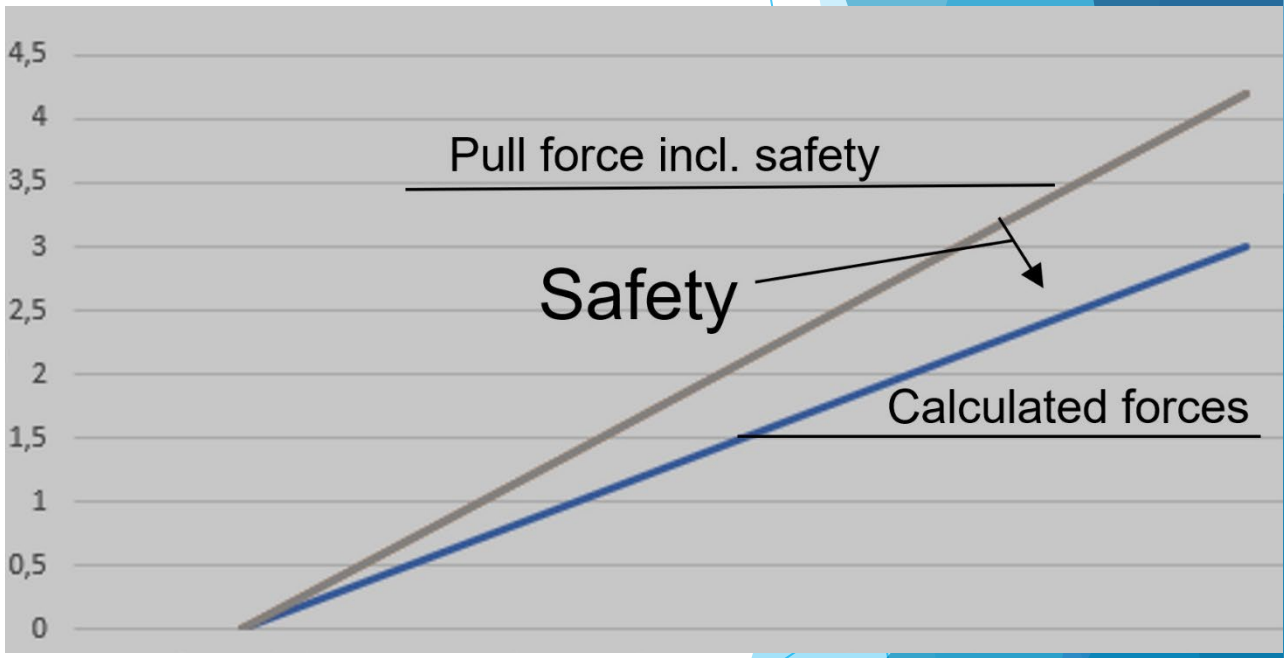
Research

- Gyro Steering Tool:
  - Smoother drill line
  - Lower pulling forces
  - Less pipe stress
- Proposal: deviate safety factor based on:
  - Steering system used
  - Possible interference
  - Mud engineering capabilities



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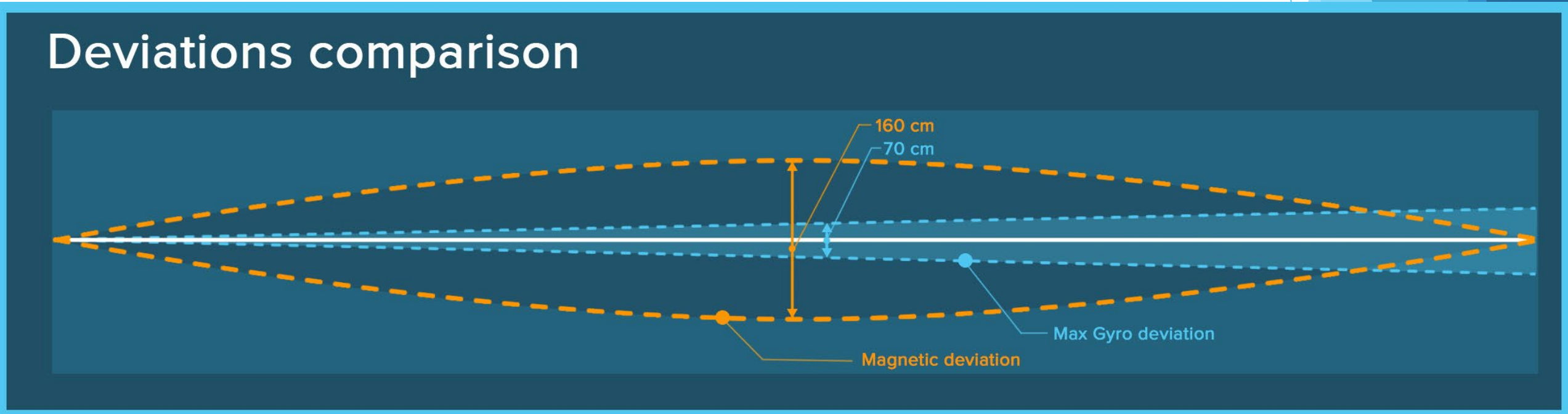
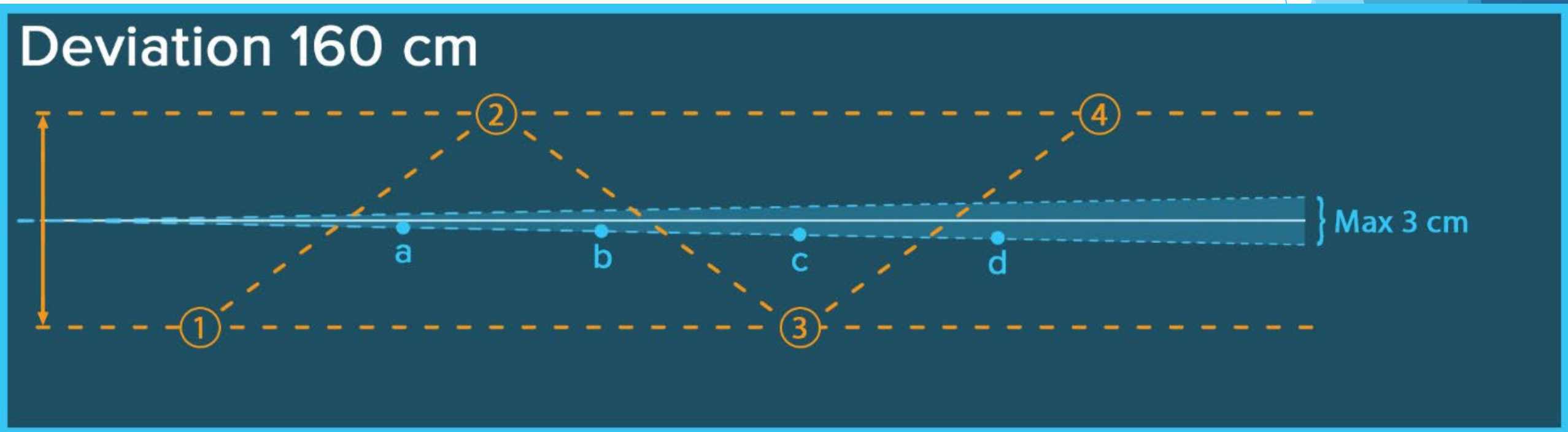
Comparing deviations

- Maximum deviations for gyro & magnetic HDDs
- Example: 1000 m long, 40 m deep
- Magnetic limitations: interference & surface access



Comparing deviations

- Detailed comparison: 50 m section
- Inaccuracy will cause added friction



Calculations

- Drilling radius 70% of design radius:
  - Pro rata higher pipe stress
- $\sigma = M/W$
- $M = E*I/R$
- If R = 70%, pipe stress = 140%
- Additional bending = more friction

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Conclusion

- We can still improve our industry

- Understand the differences in steering tools
  - + effects on your product pipe
- Post-installation checks
  - Better as-built
  - Opportunity to learn

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Conclusion

- Increase our collective knowledge about HDD
- Researching accuracy will benefit our industry
- Needed to further develop H2 projects

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Questions?

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