Drillbotics

Building Norwegian Expertise in Drilling Automation

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NTNU BRU21

Digital transformation

- "A fundamental change process enabled by digital technologies that aims to bring radical improvement and innovation to an entity [e.g., an organization, a business network, an industry, or society] to create value for its stakeholders by strategically leveraging its key resources and capabilities."

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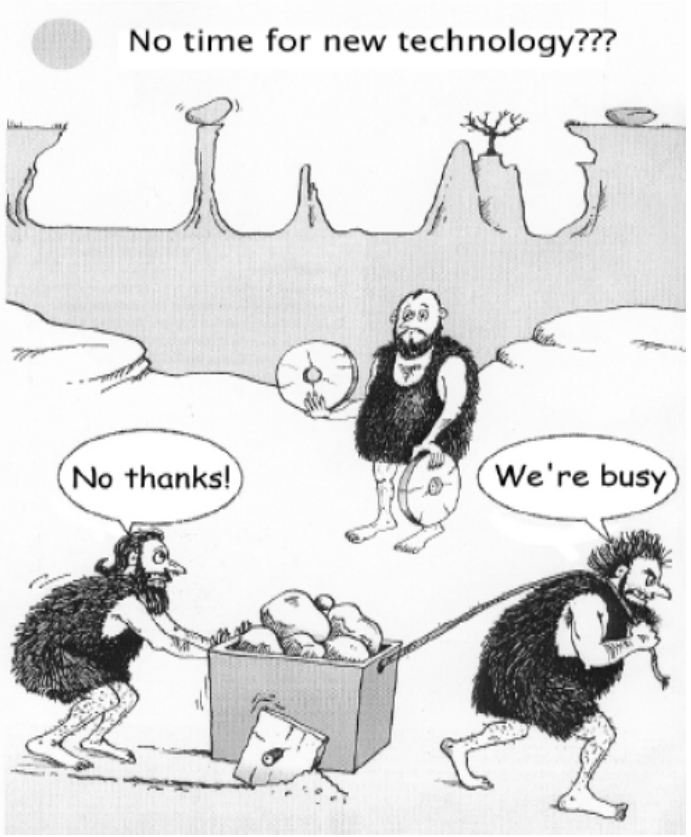

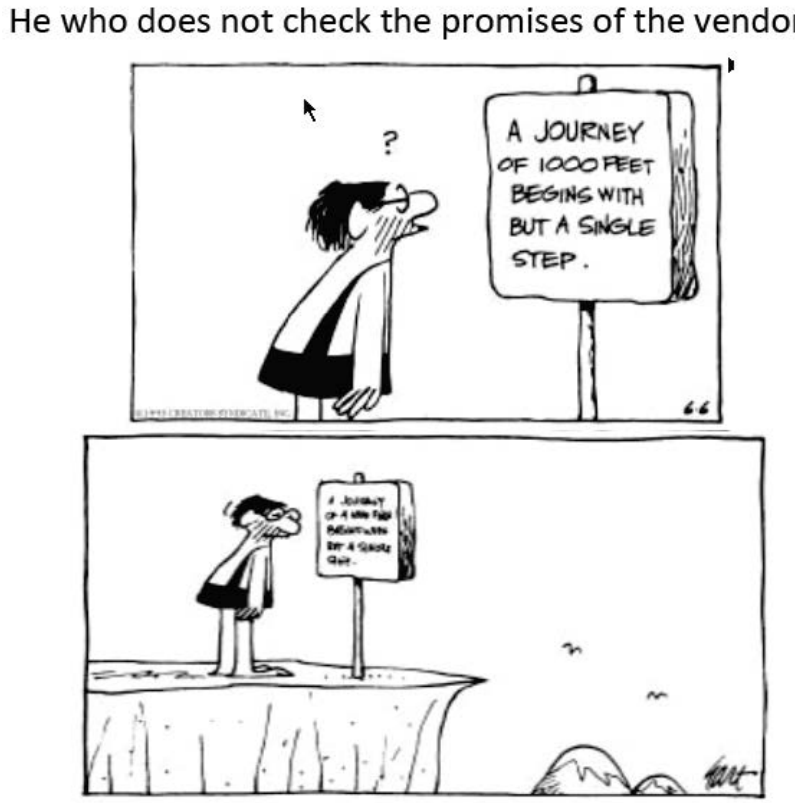

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McKinsey & Company

Transformations are hard, and digital ones are harder

Years of research on transformations has shown that the success rate for these efforts is consistently low: less than 30 percent succeed.[2] This year's results suggest that digital transformations are even more difficult. Only 16 percent of respondents say their organizations' digital transformations have successfully improved performance and also equipped them to sustain changes in the long term. An additional 7 percent say that performance improved but that those improvements were not sustained.

https://www.mckinsey.com/business-functions/organization/our-insights/unlocking-success-in-digital-transformations

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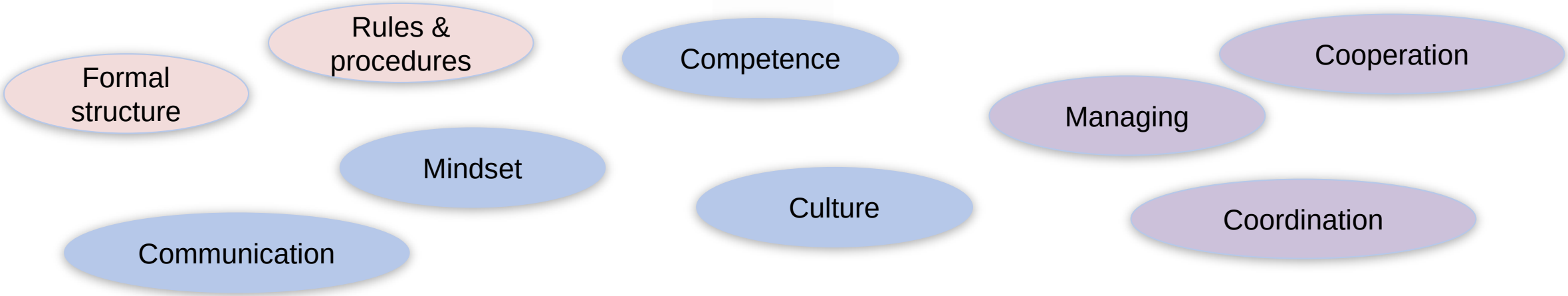

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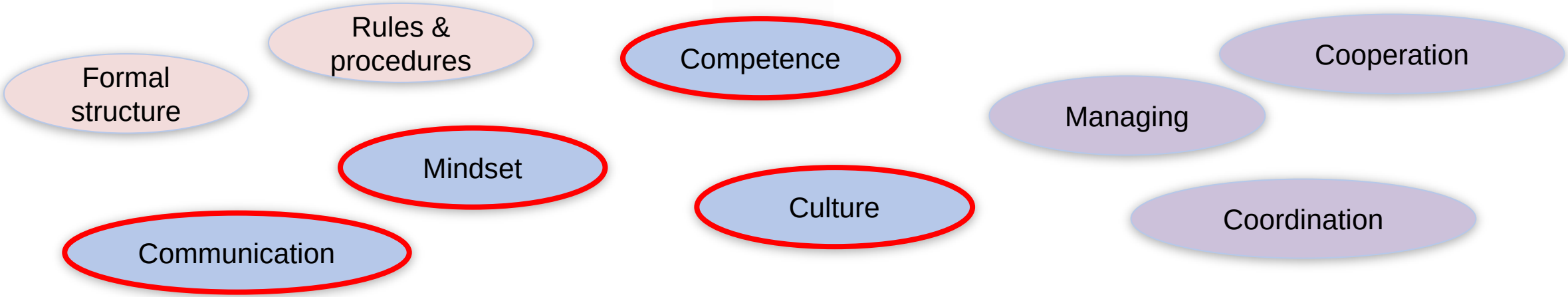

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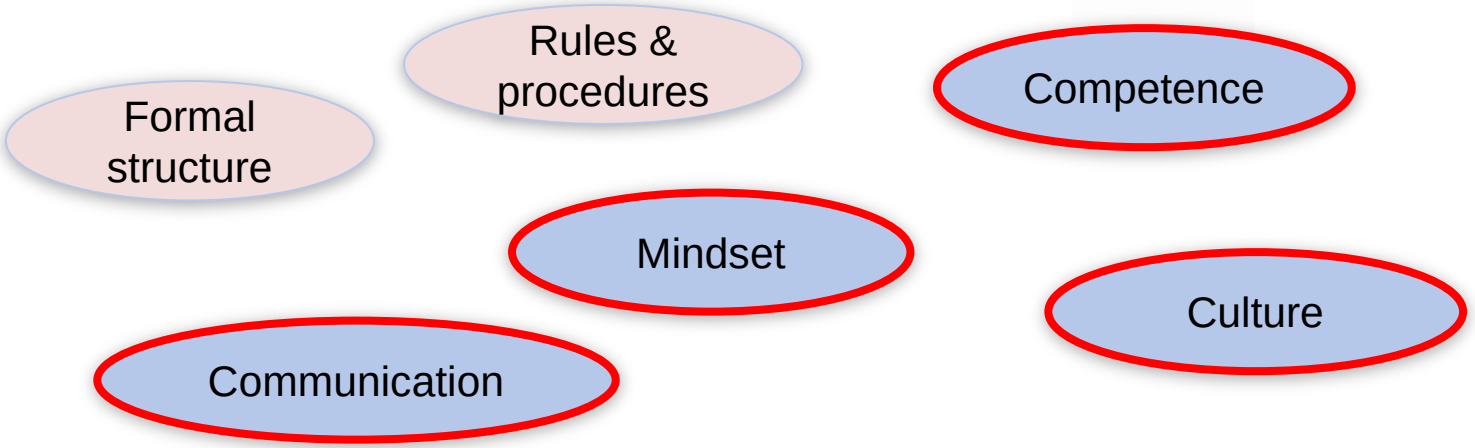

- **Experience**
- **Continued education**
- **University education**

Digital transformation

BRU21 40+ projects

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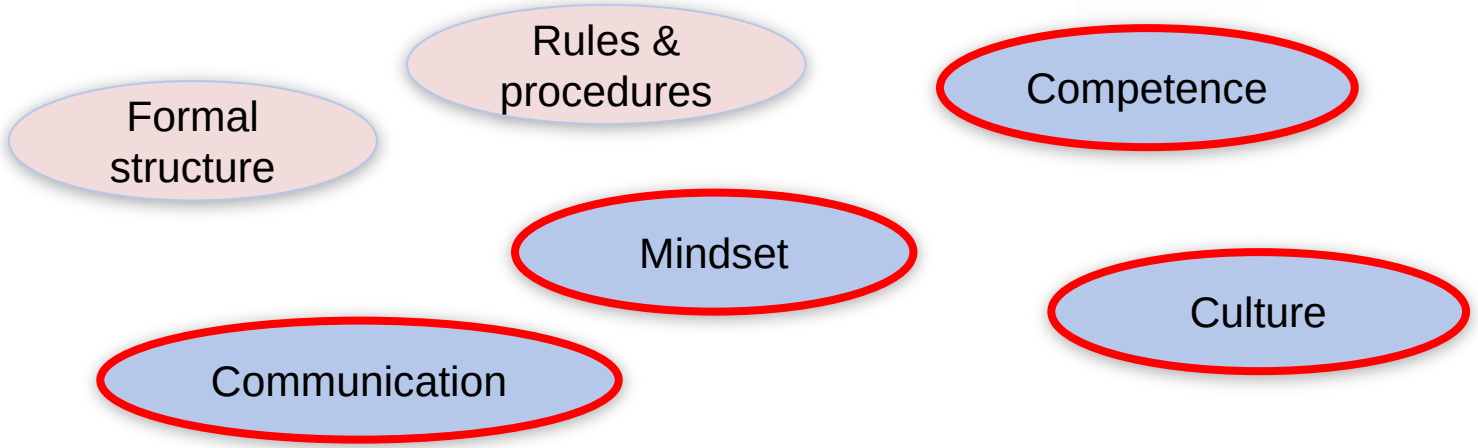


- **Experience**
- **Continued education**

BRU21 Academy

- **University education**

BRU21 Education

OSDU innovation lab

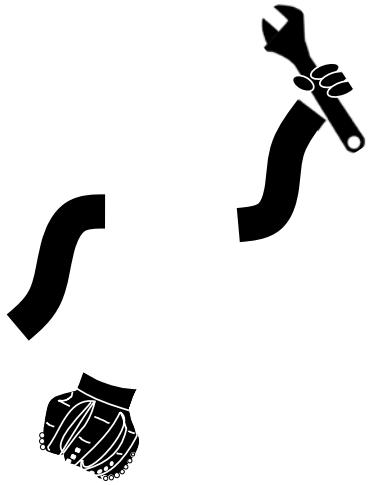
Drillbotics

SPE Drillbotics competition

- **Drillbotics**: international student competition in autonomous drilling
- **Objective (until 2018):**

  Autonomous vertical drilling

  – *«Design a miniature drilling rig and related equipment to autonomously drill a vertical well as quickly as possible while maintaining borehole quality and integrity of the drilling rig and drillstring»*



Society of Petroleum Engineers

- **Design limitations**: engineering constraints to emulate challenges of full scale drilling, time, budget

SPE Drillbotics competition

- **Drillbotics**: international student competition in autonomous drilling

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  – *«Design a miniature drilling rig and related equipment to autonomously drill a vertical well as quickly as possible while maintaining borehole quality and integrity of the drilling rig and drillstring»*

- **Objective (since 2019):**

  Autonomous directional drilling

  – *«Design a miniature drilling rig and related equipment to autonomously drill a deviated well through specified targets while maintaining borehole quality and integrity of the drilling rig and drillstring»*

- **Design limitations**: engineering constraints to emulate challenges of full scale drilling, time, budget

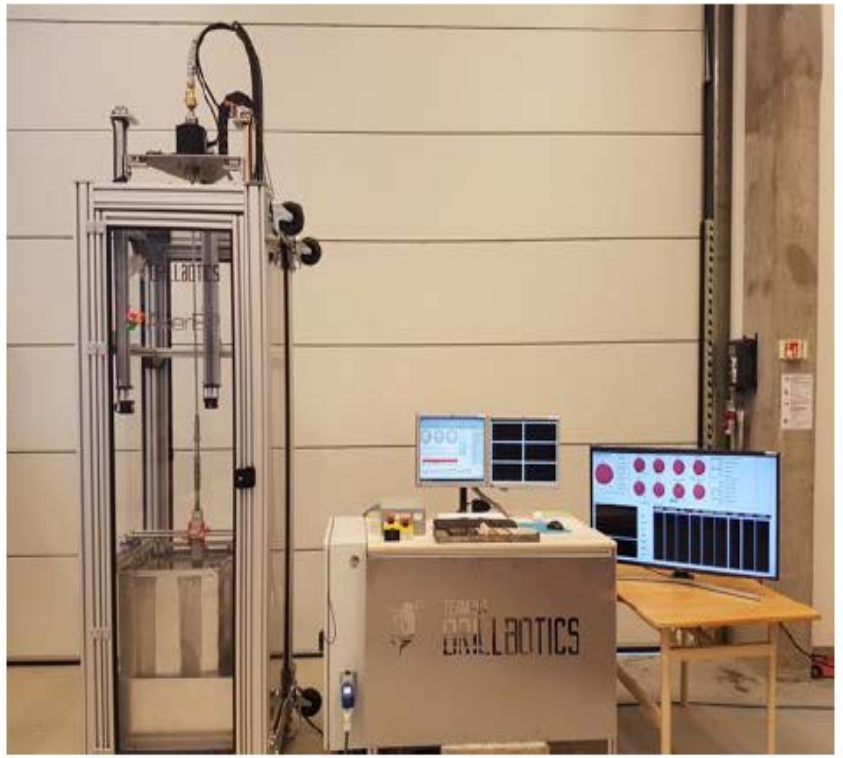
Drillbotics: design specifications

- Fully autonomous miniature scale drilling rig
- 1.5” hole size
- Directional drilling
- Intersect target points
- 30° inclination, 15° azimuth
- 10.000 USD budget

Norwegian Drillbotics rigs: NTNU and UiS

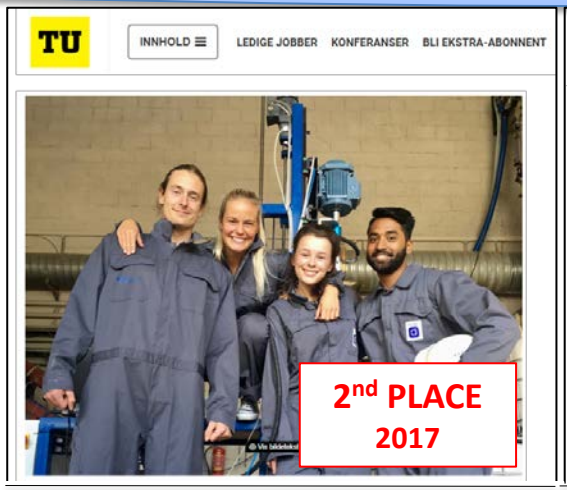
NTNU

University of Stavanger



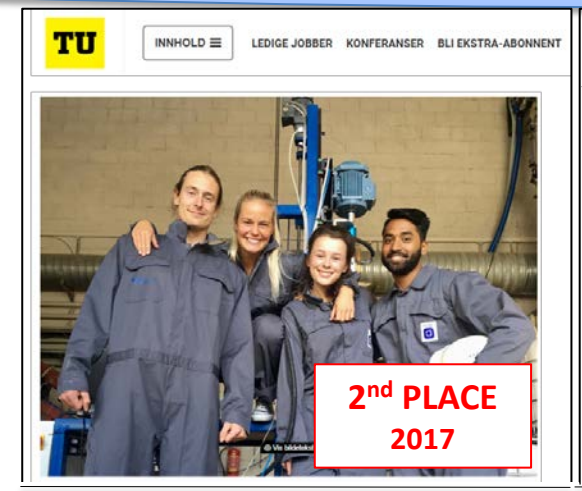
+ Drilling simulator

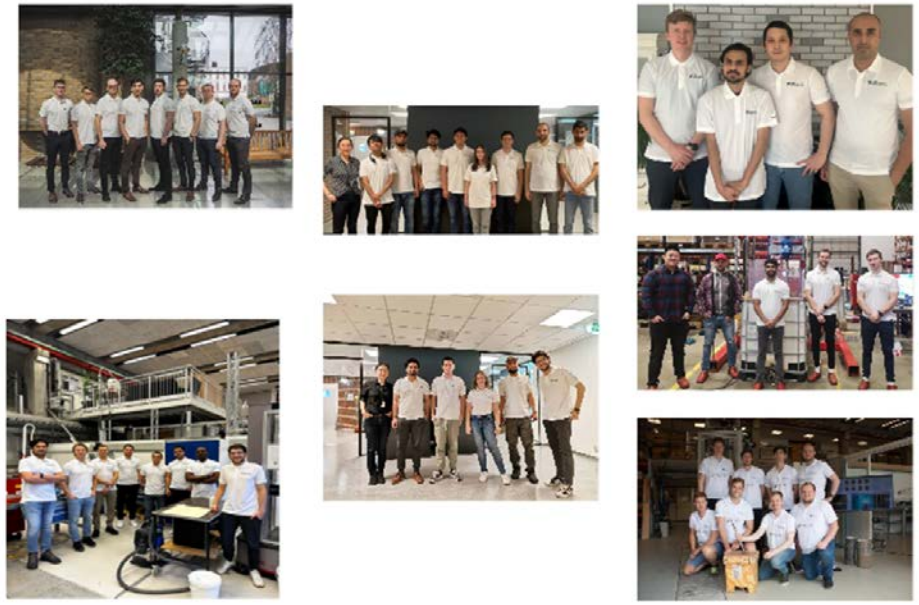
Norwegian Drillbotics Teams: NTNU and UiS



NTNU

Norwegian Drillbotics Teams: NTNU and UiS





2018 – 2nd place

2021-2023 – 1st place in Virtual Rig category

University of Stavanger

What do they learn in Drillbotics?

Digital Engineering

- Instrumentation
- Communication technology
- Signal processing
- Automatic control:
  - PID and Model Predictive Control
- Data analytics (ML)
- Human-Machine Interaction

Mechanical/Electrical/Drilling Engineering

- Hardware design and optimization
  - Mechanical & Materials Technology
  - Electrical
- Rapid prototyping: 3D printing
- Drillbit design: 3D printing
- Automatic well planning
- Drilling optimization and safety

Management

Project management Risk management HSE Vendor management
Technology development & qualification Marketing

What do they learn in Drillbotics?: Working Principles

The solution must

1. Work
2. Be safe
3. Be efficient

It is allowed to try different options and fail

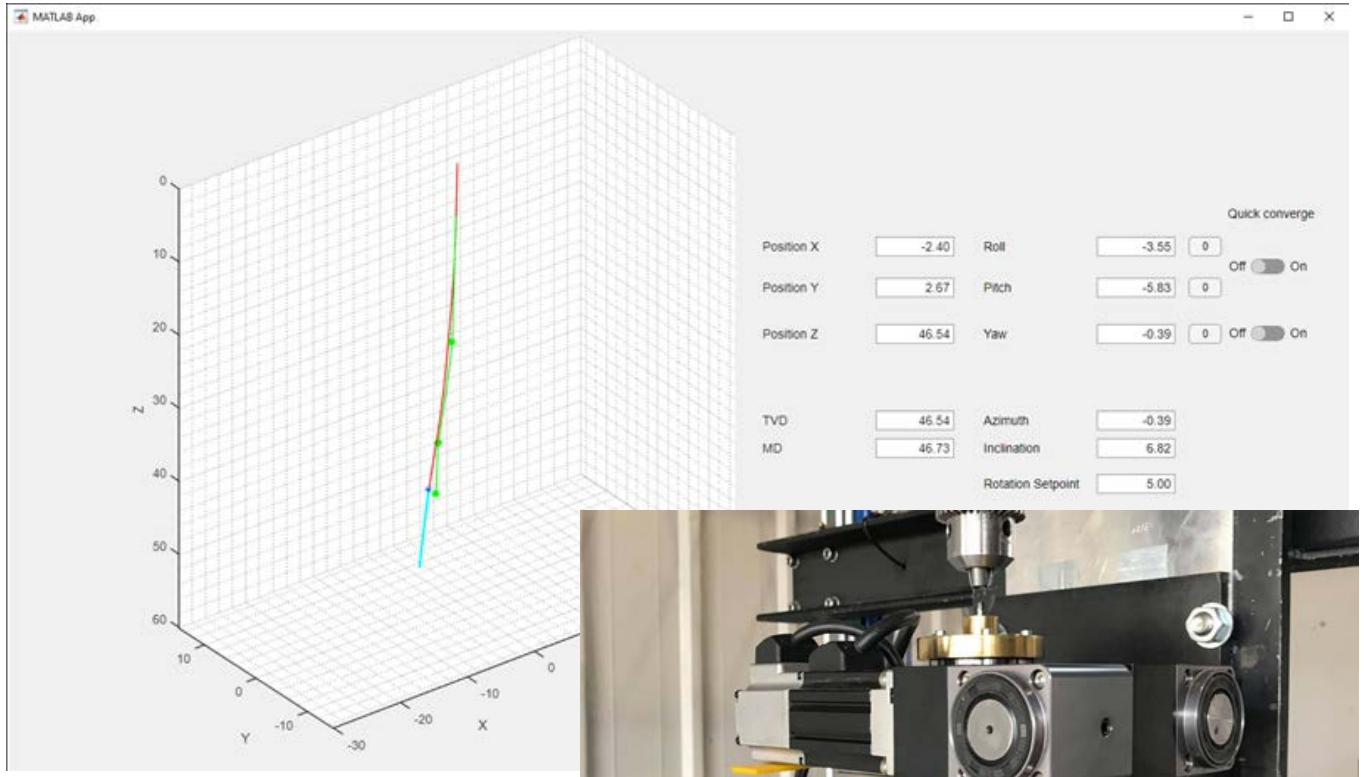
But eventually, you need to find a working solution

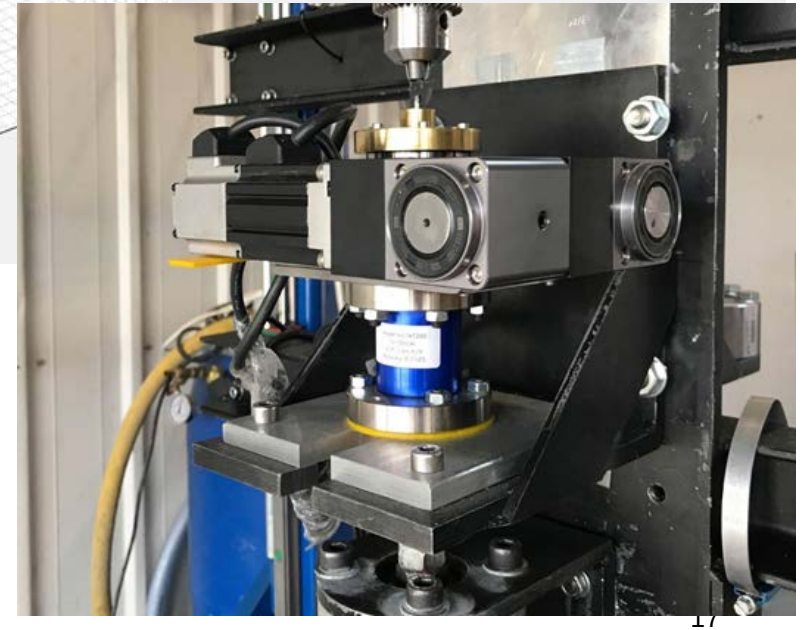
The solution must be as complex as needed for the task but not more complex than that

A multidisciplinary drilling-digital team with proper communication skills can solve the challenge

NTNU Drillbotics Automatic Control System

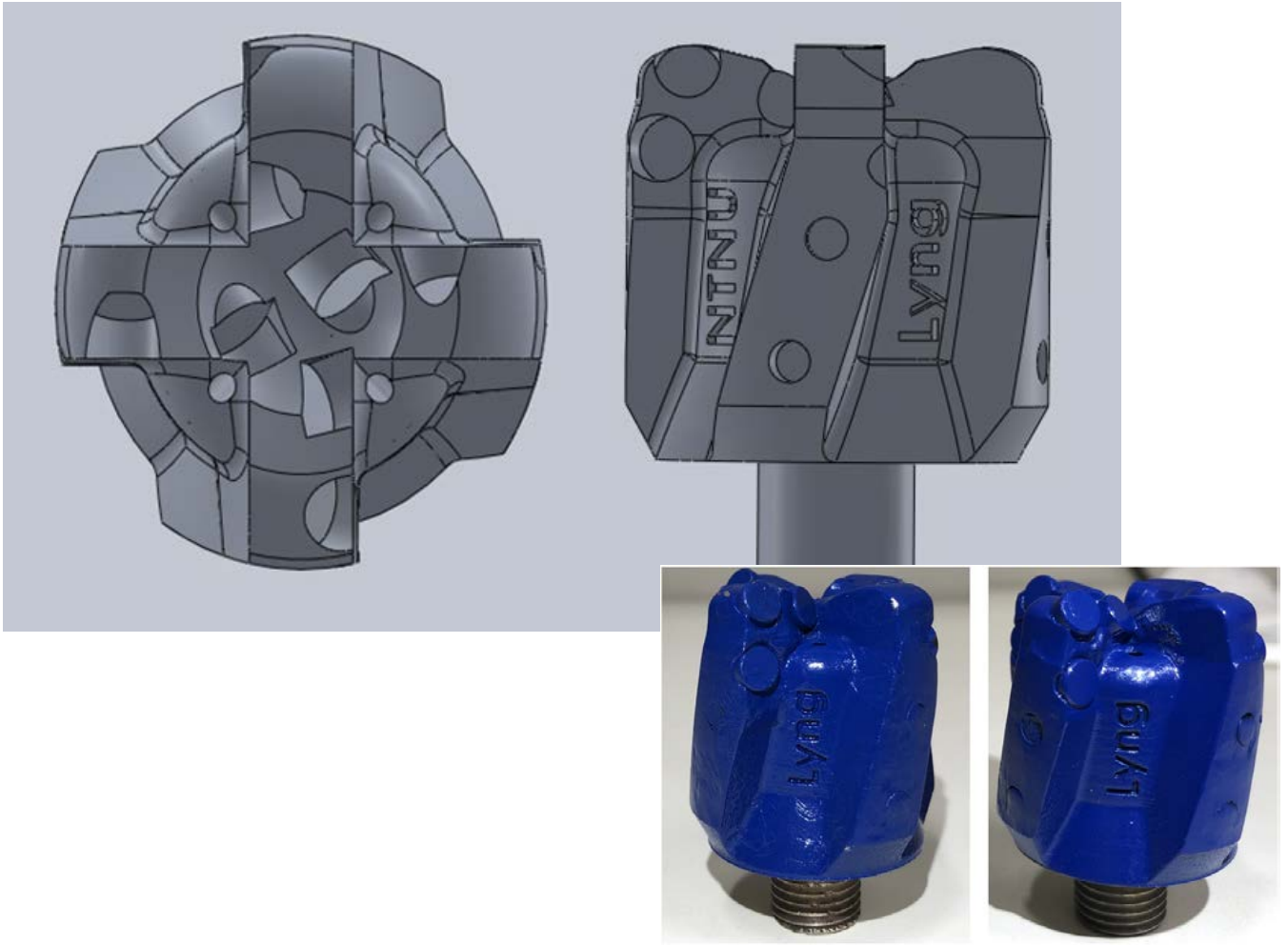
- Low- and high-level control
- Nonlinear Model Predictive Control (nMPC)
- Physics-based model
- Adjust azimuth rotation velocity
- Tune controller in simulations
- Optimized Bezier-curve well path
- Kalman filtering





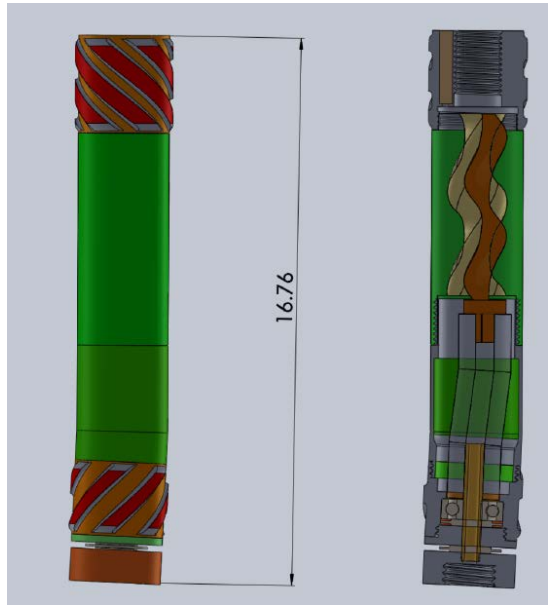
Drilling bit: optimized design and 3D printing

- Designed two **3D printed** bits
- Stability and steerability
- Minimize vibrations and torque
- Force-balance design principle



Other advanced (automatic) solutions

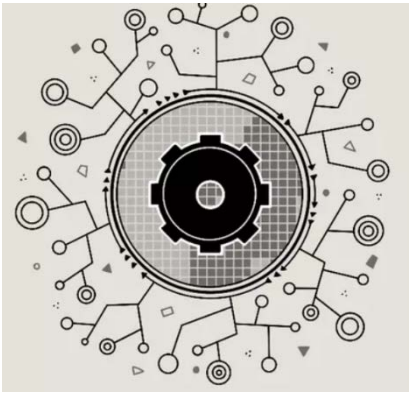
- **Miniature 3D-printed Positive Displacement Motor (PDM)**
- Automatic end-of-well reporting of a drilled well
- Formation classification on real-time drilling data (PhD project)
- Micro-testing while drilling-based optimization (PhD project)
- Advanced Human-Machine Interface: DrillFeel (innovation project)
- ……..



DrillFeel: Feel the drilling process with your bare hands

Driller's chair

Force Feedback
Joysticks

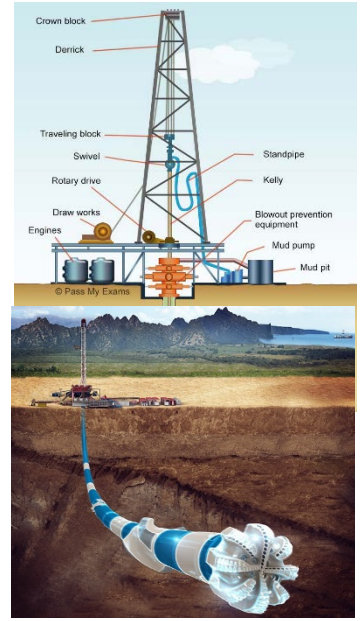


Data processing
+
Joystick Control system

Interface

topside

downhole



DrillFeel

DrillFeel: Feel the drilling process with your bare hands

YouTube Video

Norwegian Drillbotics Teams

Norwegian Drillbotics teams

- Persistently high international level
- Contribution to the digital transformation of the drilling industry in Norway (over 55 graduates)
- Contribution to Research and Innovation (over 45 publications)