DSATS – Drillbotics® Student Competition

Clausthal University of Technology

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Institute of Petroleum Engineering
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Team Members

- Wolfgang Holstein **TL**
  - Mechanical Engineering - Automation Technologies
- Dominik Orgel
  - Mechanical Engineering - Mechatronics
- Ismail Boularas
  - Petroleum Engineering - Drilling & Production

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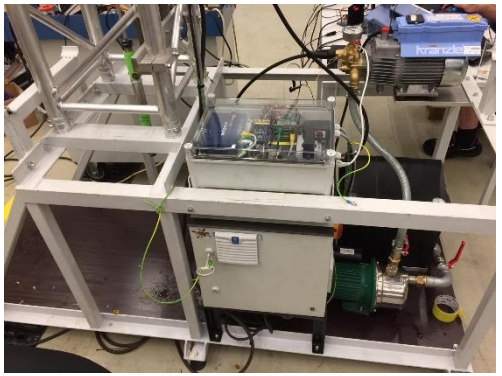
Safety Features

- Electrical
  - Circuit breakers and fuses
  - Kill switch
  - Low voltage circuits
  - Grounded frame

- Mechanical
  - In housed moving parts
  - Low transition speed
  - Inductive end stops

Drill Rig Overview

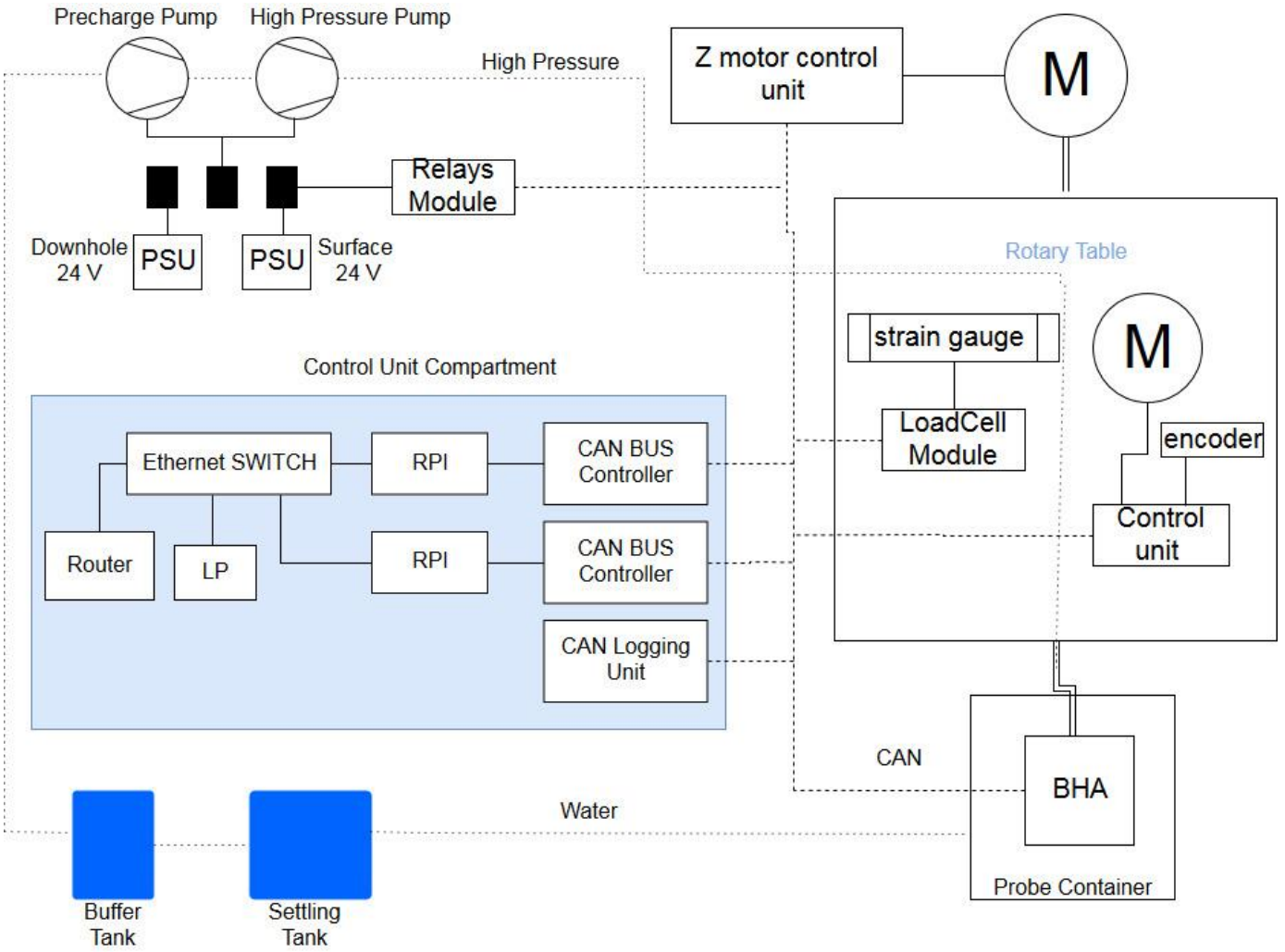
- Traverse as mast
  - Quick release mounting points
- Hoisting system
- Rotary table
- Rock sample receiver
- Electrical cabinet
- Logics electronic compartment
- Water circulation system



Surface Mechatronic System Architecture

- Rotary table control unit
  - Servomotor
  - Rotary encoder
- Hoisting system control unit
  - Threaded spindle
- Relay switching unit
  - High pressure pump
  - Pre-charge pump
  - 24V Power supply unit downhole
  - 24V Power supply unit surface

Schematics


Precharge Pump
High Pressure Pump
High Pressure
Z motor control unit
M
Relays Module
Downhole 24 V
PSU
PSU
Surface 24 V
Rotary Table
strain gauge
M
Control Unit Compartment
LoadCell Module
encoder
Ethernet SWITCH
RPI
CAN BUS Controller
Router
LP
RPI
CAN BUS Controller
Control unit
CAN Logging Unit
CAN
BHA
Water
Probe Container
Buffer Tank
Settling Tank

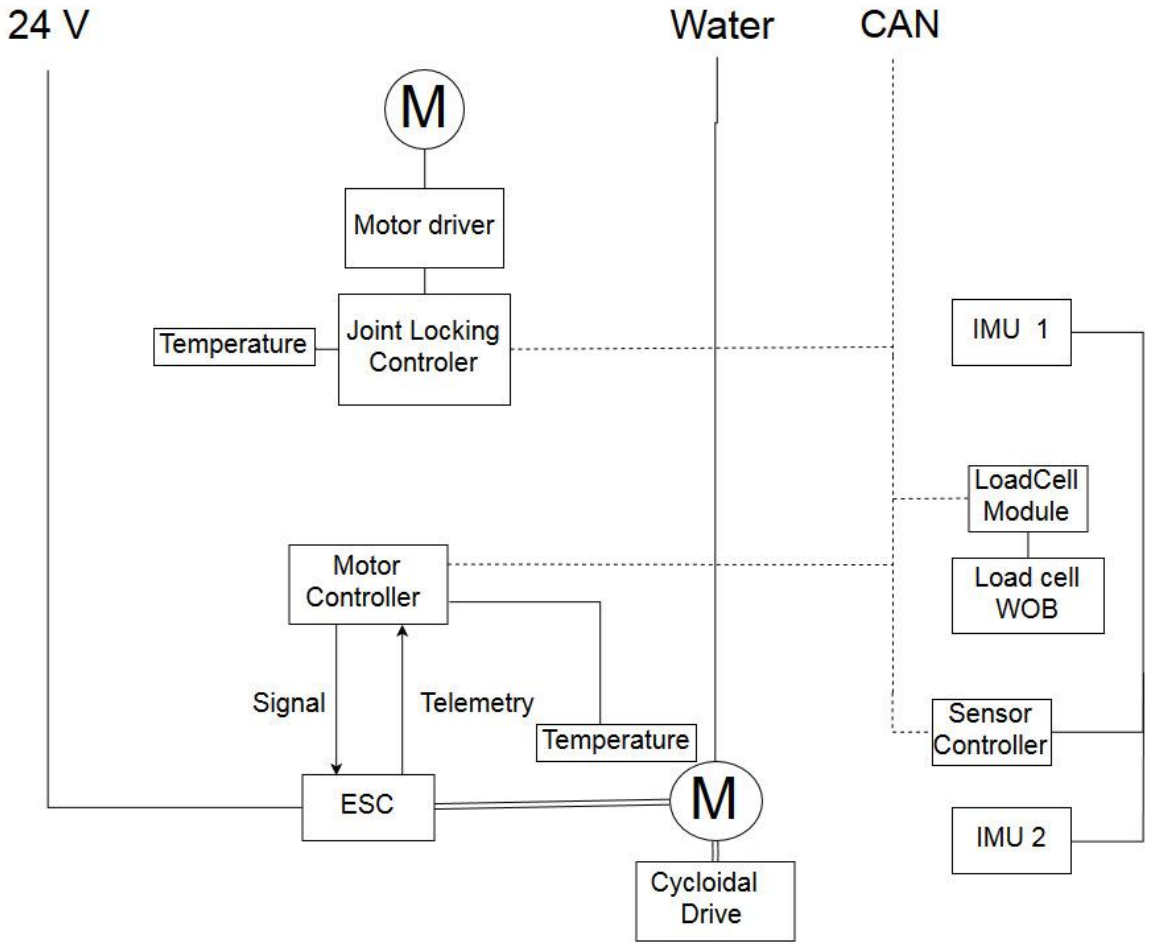
Mechatronics System Architecture BHA

- CAN Bus
- Motor control unit
  - Electronic speed controller
    - Three phase synchronous motor
  - Digital thermometer
- Adjustable kickoff sub
  - DC motor-driver for locking
    - Current feedback
  - Magnetic position feedback

Sensors

- Sensor Unit
  - Two positions of measuring (Upper / Lower BHA)
    - magnetometer (LIS3MDL)
    - accelerometer (LSM6DS33)
- Strain Gauge Unit
  - HX711 (Torque / WOB)
- Telemetry ESC

Schematics Downhole



Sensors

- Magnetic orientation
  - Two coils for a nearly linear magnetic field
  - Allows detection of angle of deviation

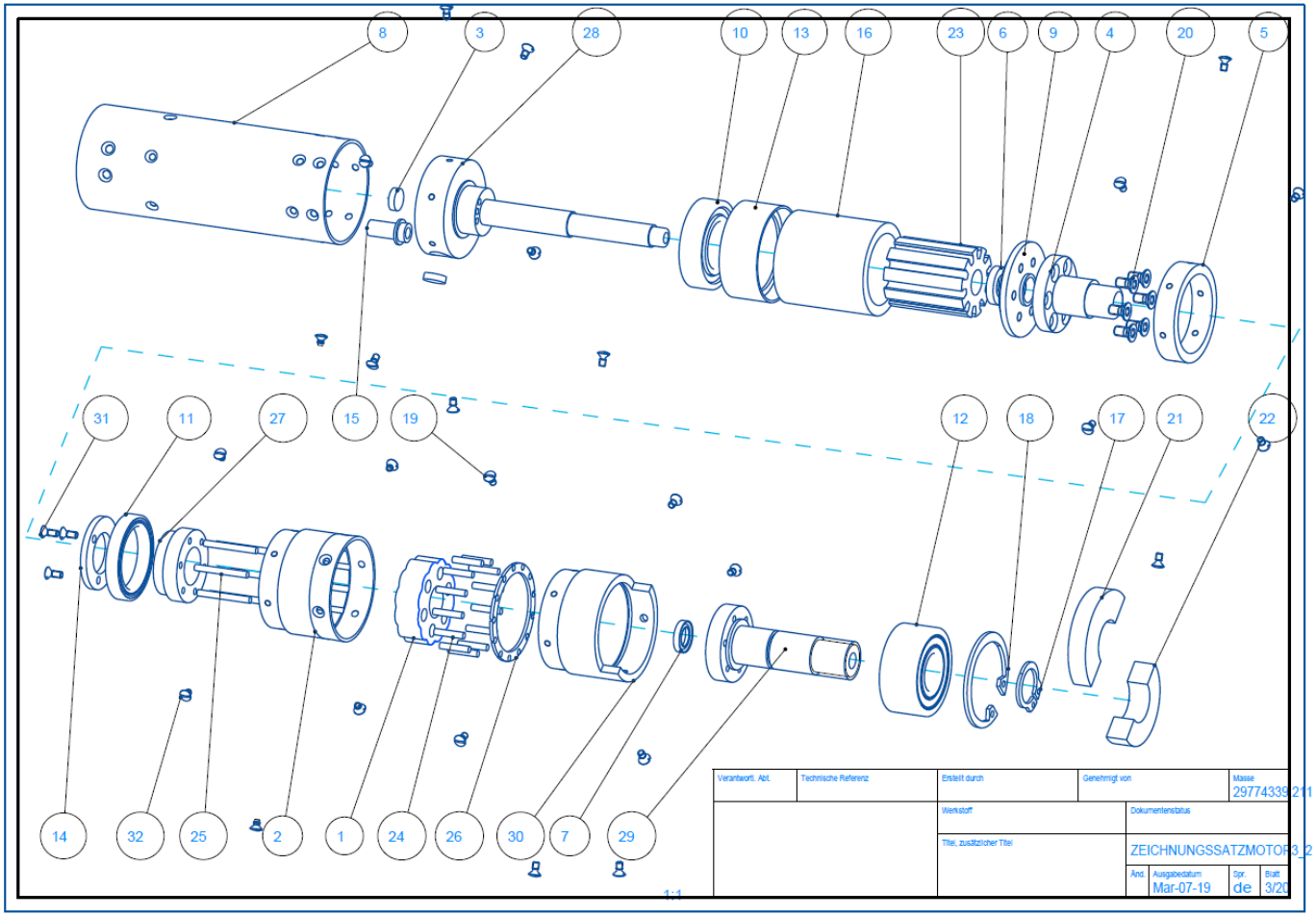
BHA Design

- Drill spindle
  - Shaft sealing ring seals the BHA from dirt and drilling fluid
  - The bearing 3001-B-2RS-TVH allows a stiff bearing in a small space (contact angle of 25°)
- Cycloidal gearbox
  - A central swashplate
  - This type of gear is very short
  - Reduction of 1/12

BHA Design

- Brushless DC motor
  - The temperature at the stator windings is monitored by a digital thermometer
  - Three phase synchronous motor
  - Water feed through the stator
- Downhole load cell
  - Completely enclosed in ferromagnetic steel

Motor Unit Drawing



BHA Design

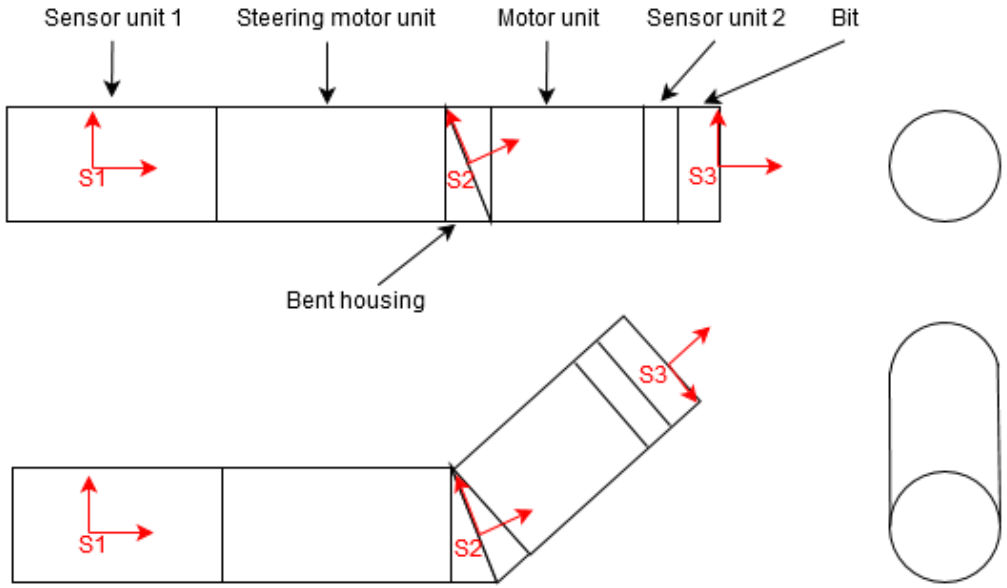
- Drillbit
  - Diameter of 1.5",
  - Built of alloy steal
  - Carbide inserts

Directional Drilling Objectives

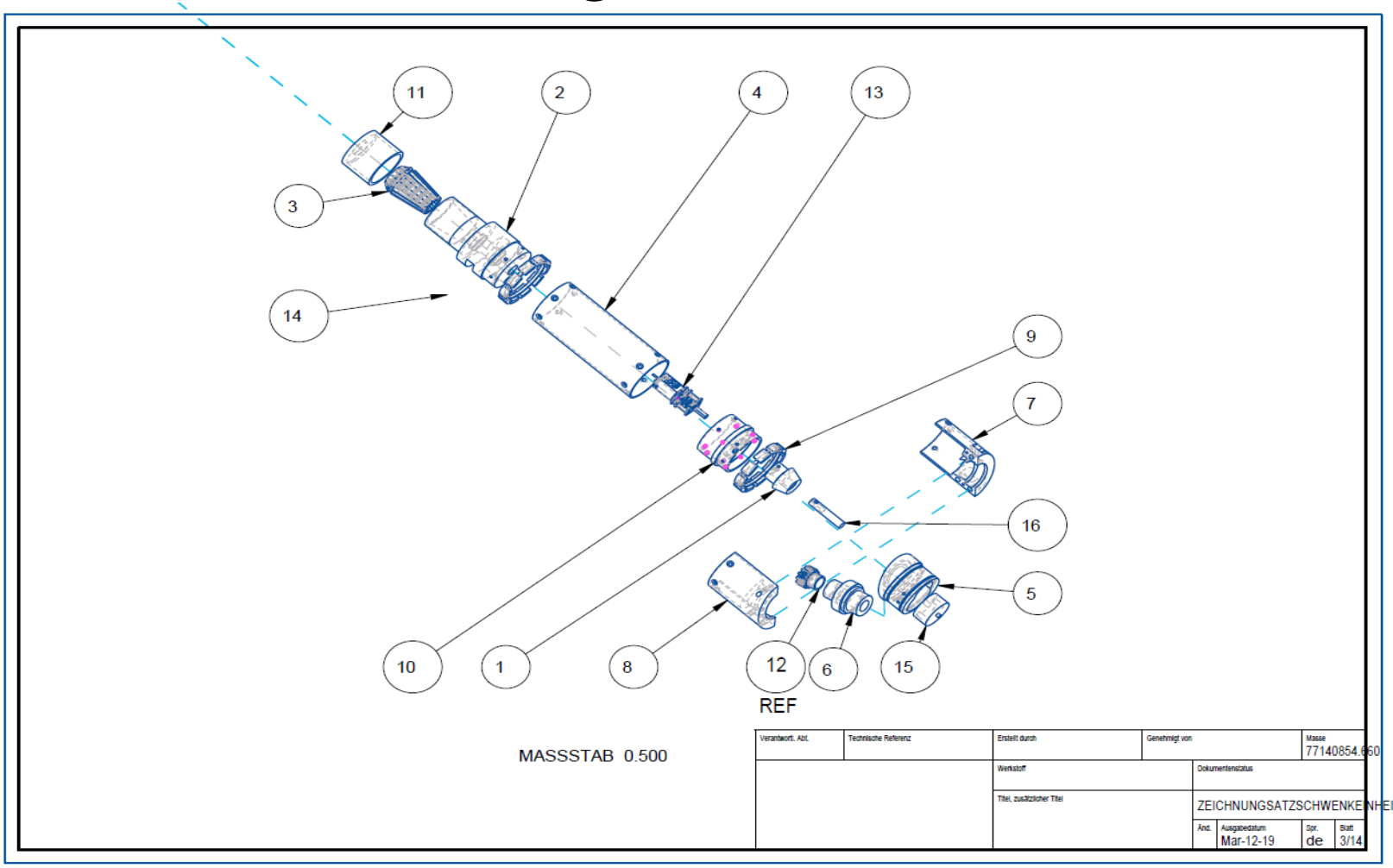
- Calculation of the desired well trajectory
- Calculation of the northing, easting, TVD, vertical section and dogleg severity of a surveying station.
- Monitoring of the actual well path while drilling
- Correction of the drilling path during drilling by an algorithm

Directional Drilling Assembly

- Steerable motor assembly



Directional Drilling Unit

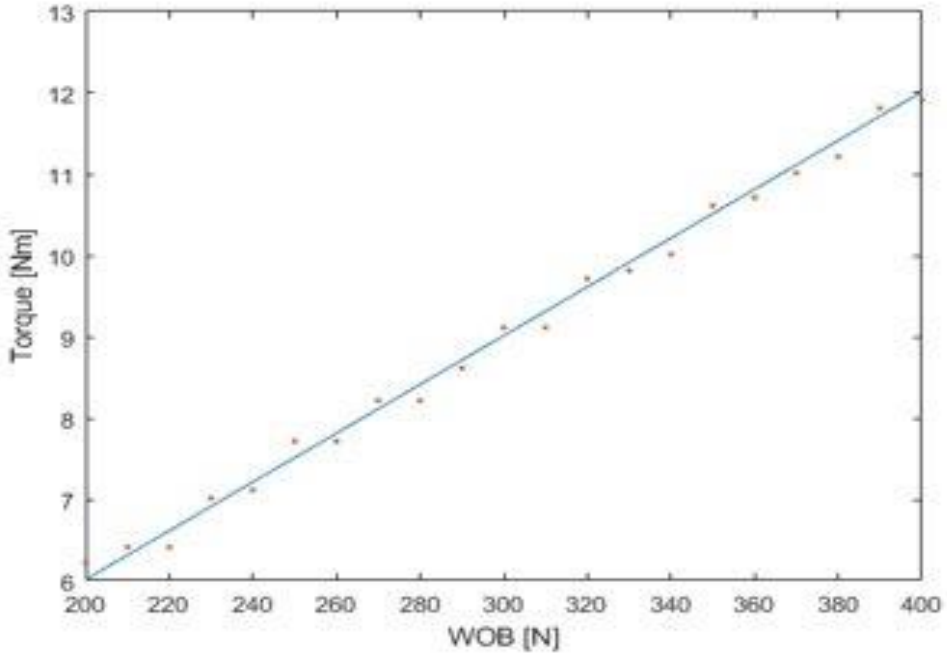


Cost Control

- TU Clausthal student team has stayed below budget limit for this year´s Drillbotics® competition
- Sponsoring of 4000 EUR was granted by Wintershall Holding GmbH and spent for this competition in total

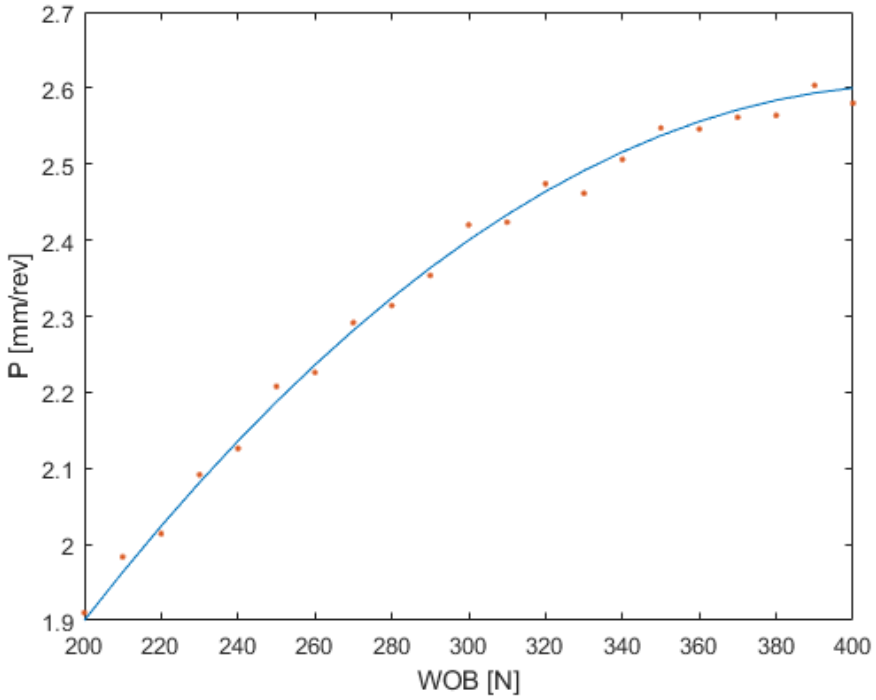
Thank you for your attention

Calculations



$$Torque = f(WOB) = A_0 + A_1 * WOB$$

Calculations



$$P = g(WOB) = B_2 * WOB^2 + B_1 * WOB + B_0$$

Calculations

$$MSE = \frac{WOB}{Area} + \frac{2\,\pi * f(WOB)}{Area * g(WOB)}$$

$$MSE_H = \frac{WOB}{Area} + \frac{2\,\pi * (A_0 + A_1 * WOB)}{Area * (B_2 * WOB^2 + B_1 * WOB + B_0)}$$