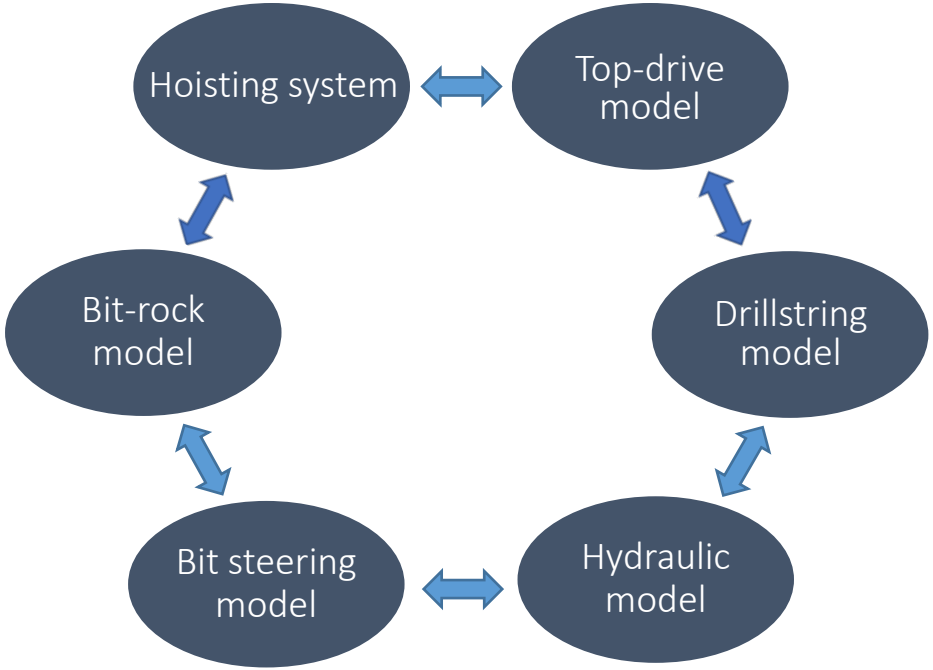
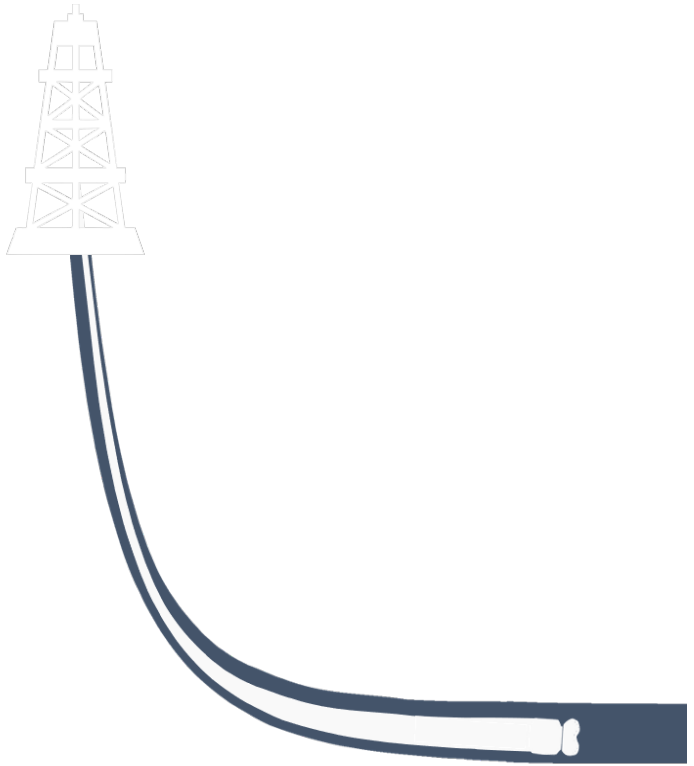
Prediction of Instantaneous Wellpath while Drilling

Sigve Hovda

Professor NTNU / CEO ComputerWell

Digital Twin of the Drillstring





Technology

INPUT

Knowns:
- Drillstring
- Block position
- RPM

Unknowns:
- Rock strength
- Exact trajectory
- Friction factors

MULTIPLE SIMULATORS

COMPARE SIMULATIONS VS MEASURED

- Hook load
- Torque
- Pressure

SMART SELECTION

Simulation
- Unknown parameters

Technology

INPUT

Knowns:
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- Block position
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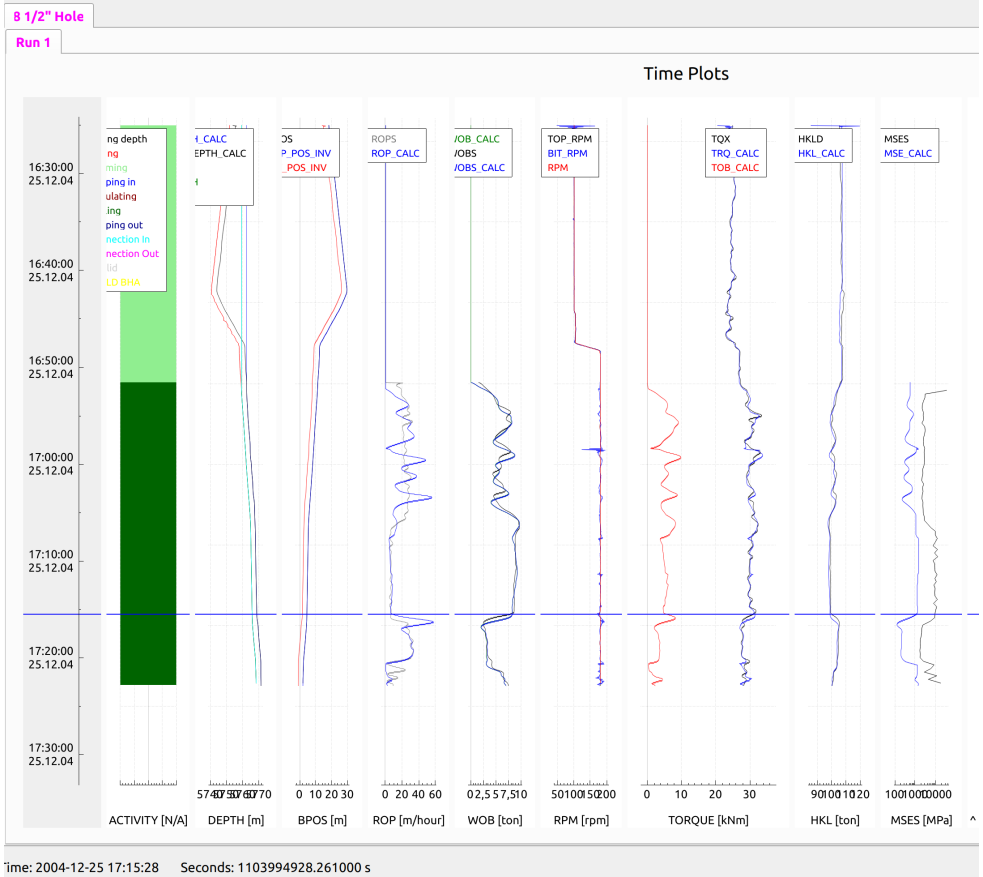
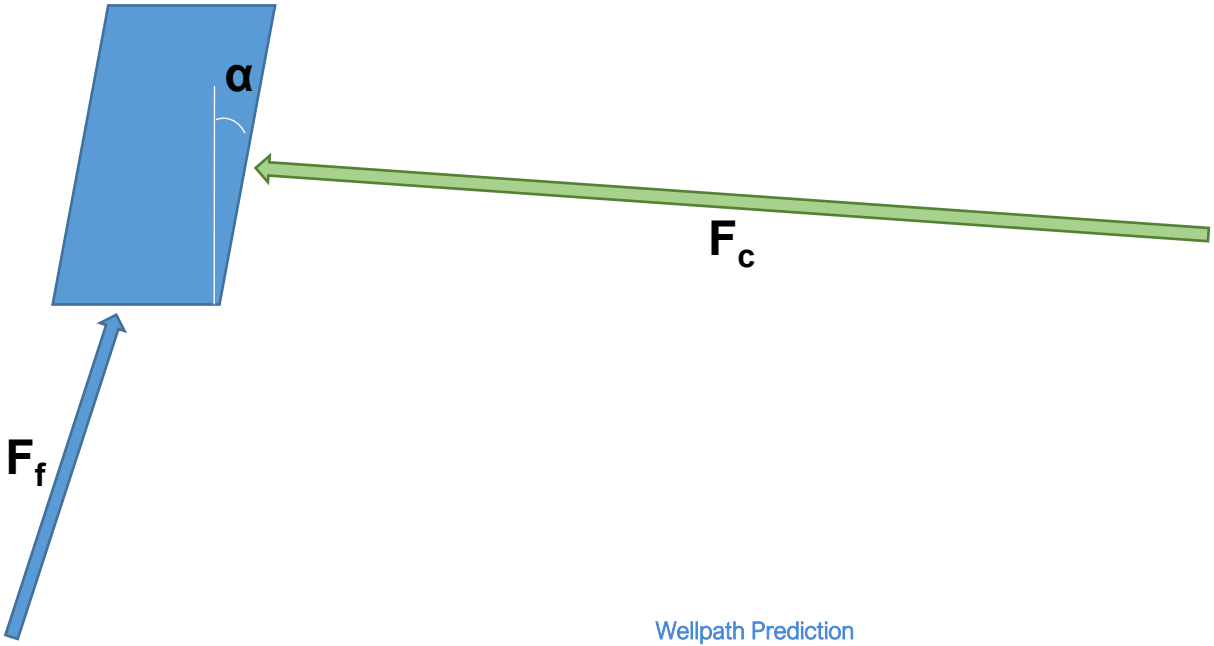
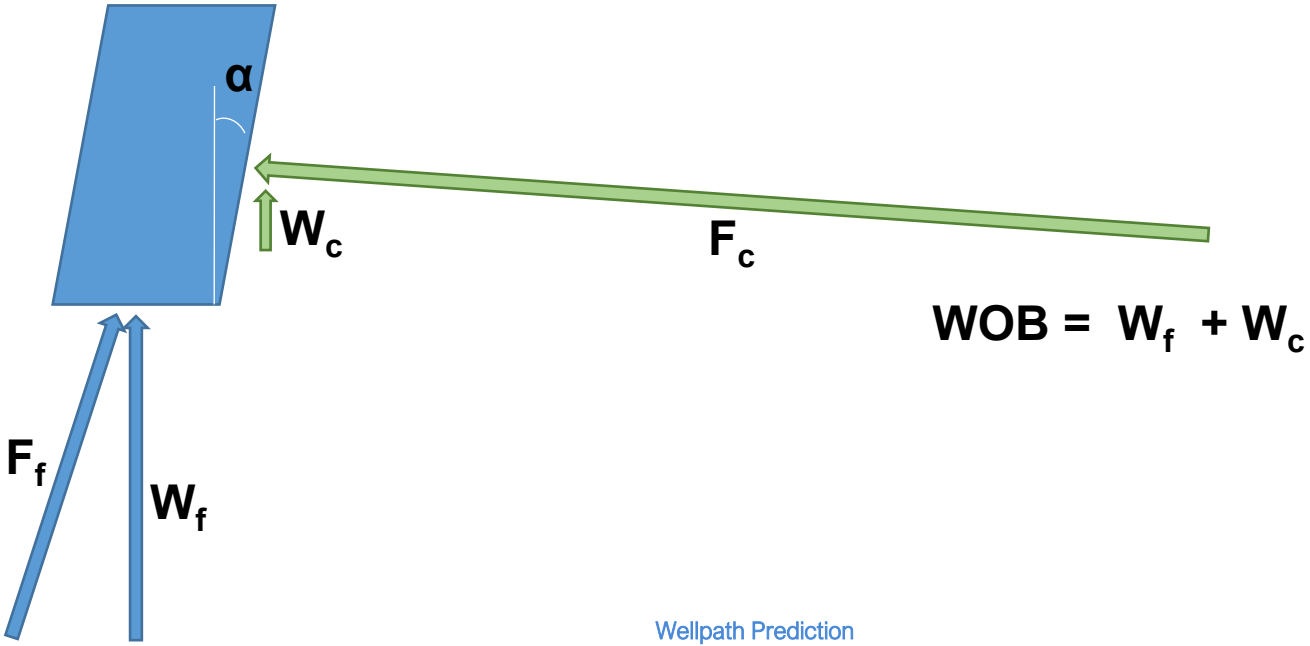

8 1/2" Hole
Run 1
Time Plots
16:30:00
25.12.04
16:40:00
25.12.04
16:50:00
25.12.04
17:00:00
25.12.04
17:10:00
25.12.04
17:20:00
25.12.04
17:30:00
25.12.04
ACTIVITY [N/A]
DEPTH [m]
BPOS [m]
ROP [m/hour]
WOB [ton]
RPM [rpm]
TORQUE [kNm]
HKL [ton]
MSES [MPa]
ROP_CALC
TOP_RPM
BIT_RPM
RPM
TQX
TRQ_CALC
TOB_CALC
HKLD
HKL_CALC
MSES
MSE_CALC
Time: 2004-12-25 17:15:28
Seconds: 1103994928.261000 s

Bit Rock Interaction

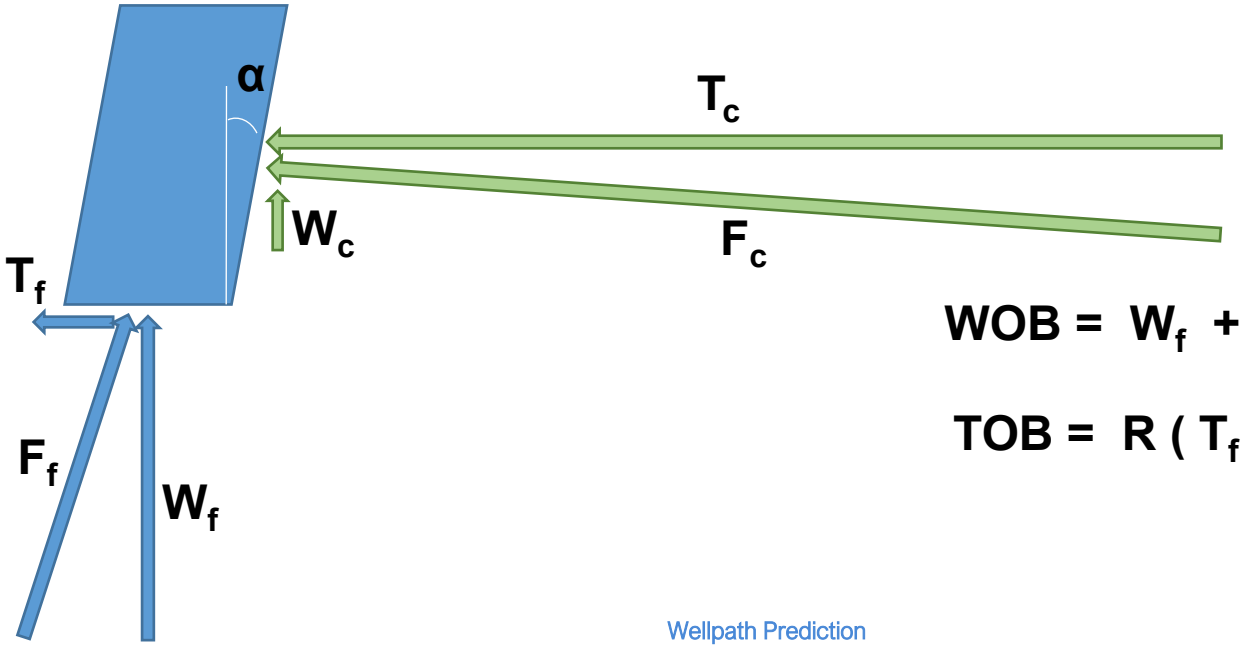


Bit Rock Interaction



$$WOB = W_f + W_c$$

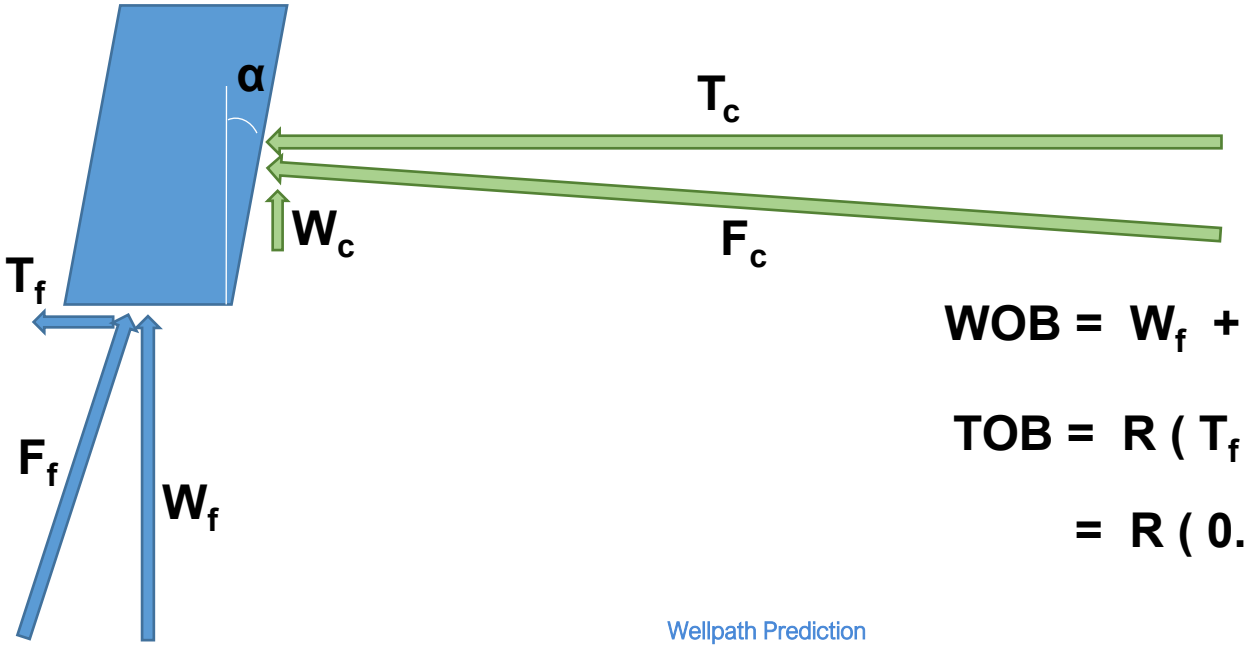
Bit Rock Interaction



$$WOB = W_f + W_c$$

$$TOB = R\,(T_f + T_c)$$

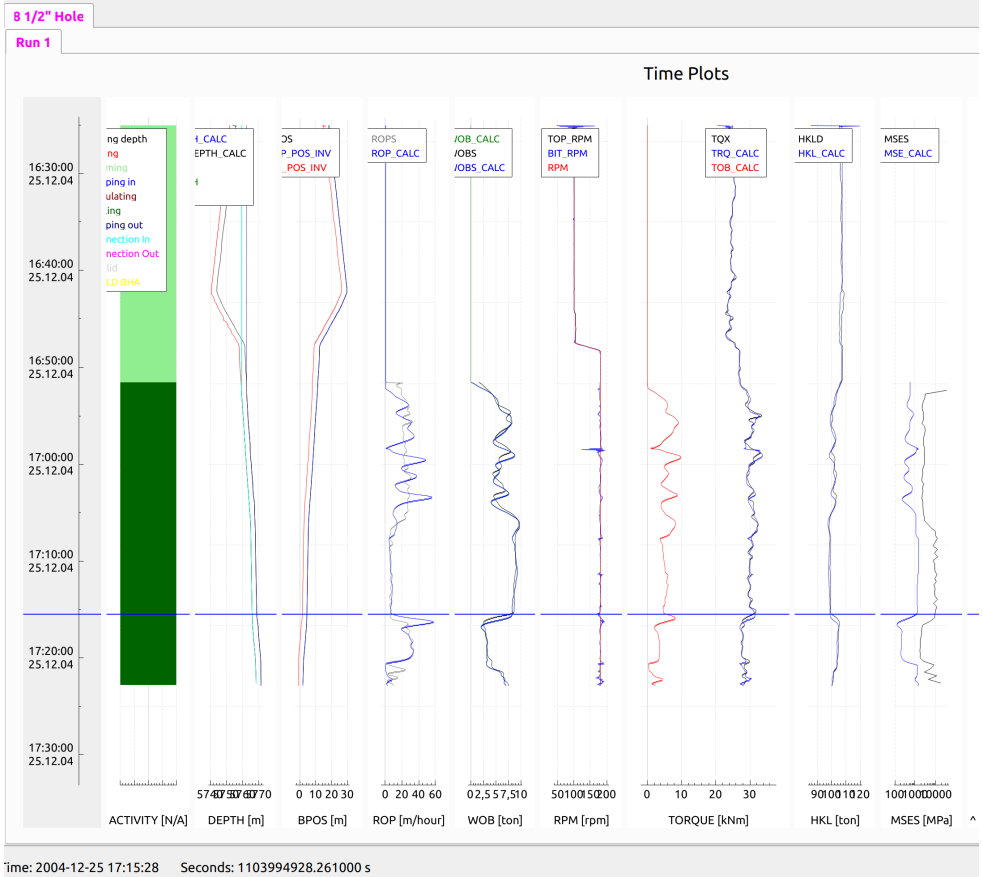
Bit Rock Interaction



$$WOB = W_f + W_c$$

$$TOB = R\,(T_f + T_c)$$

$$= R\,(0.3\,W_f + 3\,W_c)$$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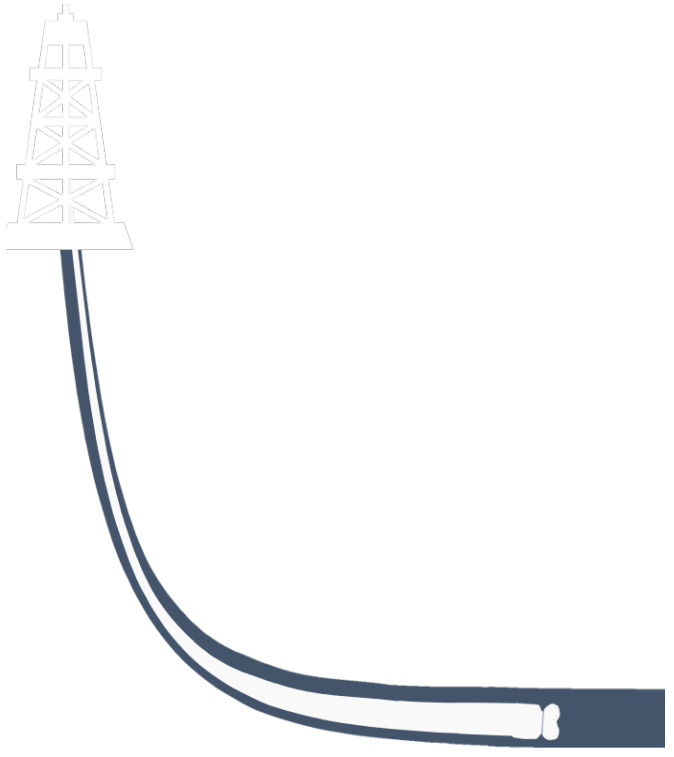
MSES
MSE_CALC
Time: 2004-12-25 17:15:28
Seconds: 1103994928.261000 s

Drillstring Model

- Stiff string model

$$\hat{\mathbf{K}} = \begin{bmatrix}
\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 & -\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 \\
 & \frac{12EI_z}{L^3} & 0 & 0 & 0 & \frac{6EI_z}{L^2} & 0 & -\frac{12EI_z}{L^3} & 0 & 0 & 0 & \frac{6EI_z}{L^2} \\
 & & \frac{12EI_z}{L^3} & 0 & -\frac{6EI_z}{L^2} & 0 & 0 & 0 & -\frac{12EI_z}{L^3} & 0 & -\frac{6EI_z}{L^2} & 0 \\
 & & & \frac{GI_x}{L} & 0 & 0 & 0 & 0 & 0 & -\frac{GI_x}{L} & 0 & 0 \\
 & & & & \frac{4EI_z}{L} & 0 & 0 & 0 & \frac{6EI_z}{L^2} & 0 & \frac{2EI_z}{L} & 0 \\
 & & & & & \frac{4EI_z}{L} & 0 & -\frac{6EI_z}{L^2} & 0 & 0 & 0 & \frac{2EI_z}{L} \\
 & & & & & & \frac{EA}{L} & 0 & 0 & 0 & 0 & 0 \\
 & & & & & & & \frac{12EI_z}{L^3} & 0 & 0 & 0 & -\frac{6EI_z}{L^2} \\
 & & & & & & & & \frac{12EI_z}{L^3} & 0 & \frac{6EI_z}{L^2} & 0 \\
 & & & & & & & & & \frac{GI_x}{L} & 0 & 0 \\
 & & & & & & & & & & \frac{4EI_z}{L} & 0 \\
 & & & & & & & & & & & \frac{4EI_z}{L}
\end{bmatrix}$$

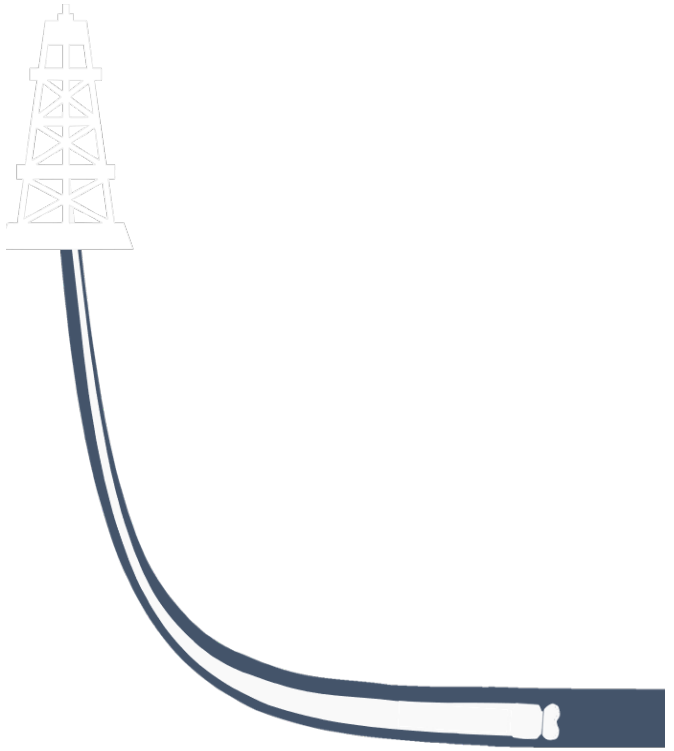


Drillstring Model

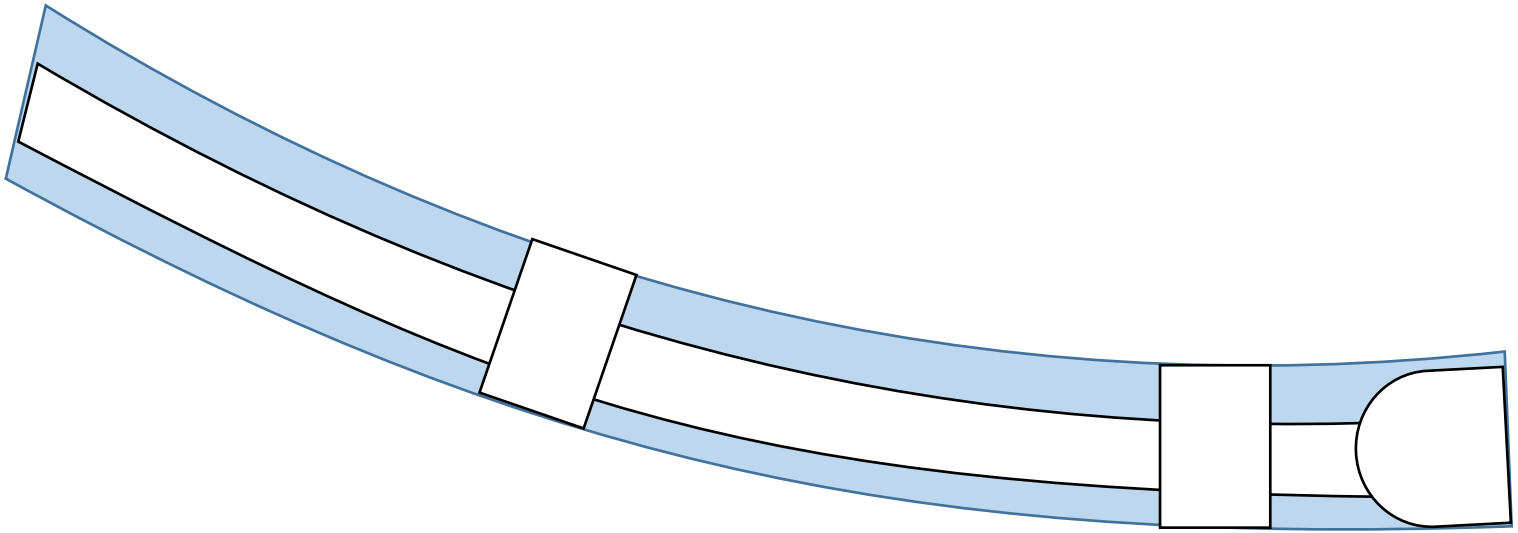
- Stiff string model

$$\hat{\mathbf{K}} = \begin{bmatrix}
\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 & -\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 \\
 & \frac{12EI_z}{L^3} & 0 & 0 & 0 & \frac{6EI_z}{L^2} & 0 & -\frac{12EI_z}{L^3} & 0 & 0 & 0 & \frac{6EI_z}{L^2} \\
 & & \frac{12EI_z}{L^3} & 0 & -\frac{6EI_z}{L^2} & 0 & 0 & 0 & -\frac{12EI_z}{L^3} & 0 & -\frac{6EI_z}{L^2} & 0 \\
 & & & \frac{GI_x}{L} & 0 & 0 & 0 & 0 & 0 & -\frac{GI_x}{L} & 0 & 0 \\
 & & & & \frac{4EI_z}{L} & 0 & 0 & 0 & \frac{6EI_z}{L^2} & 0 & \frac{2EI_z}{L} & 0 \\
 & & & & & \frac{4EI_z}{L} & 0 & -\frac{6EI_z}{L^2} & 0 & 0 & 0 & \frac{2EI_z}{L} \\
 & & & & & & \frac{EA}{L} & 0 & 0 & 0 & 0 & 0 \\
 & & & & & & & \frac{12EI_z}{L^3} & 0 & 0 & 0 & -\frac{6EI_z}{L^2} \\
 & & & & & & & & \frac{12EI_z}{L^3} & 0 & \frac{6EI_z}{L^2} & 0 \\
 & & & & & & & & & \frac{GI_x}{L} & 0 & 0 \\
 & & & & & & & & & & \frac{4EI_z}{L} & 0 \\
 & & & & & & & & & & & \frac{4EI_z}{L}
\end{bmatrix}$$

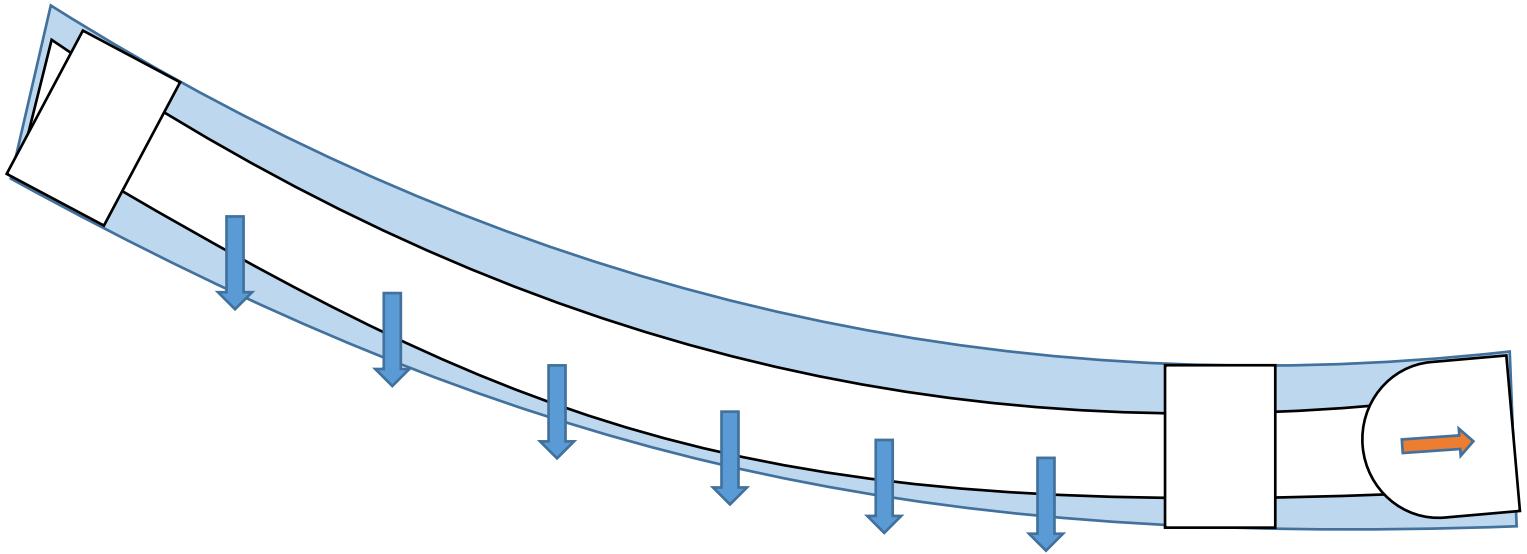
Dependent on tension and compression!



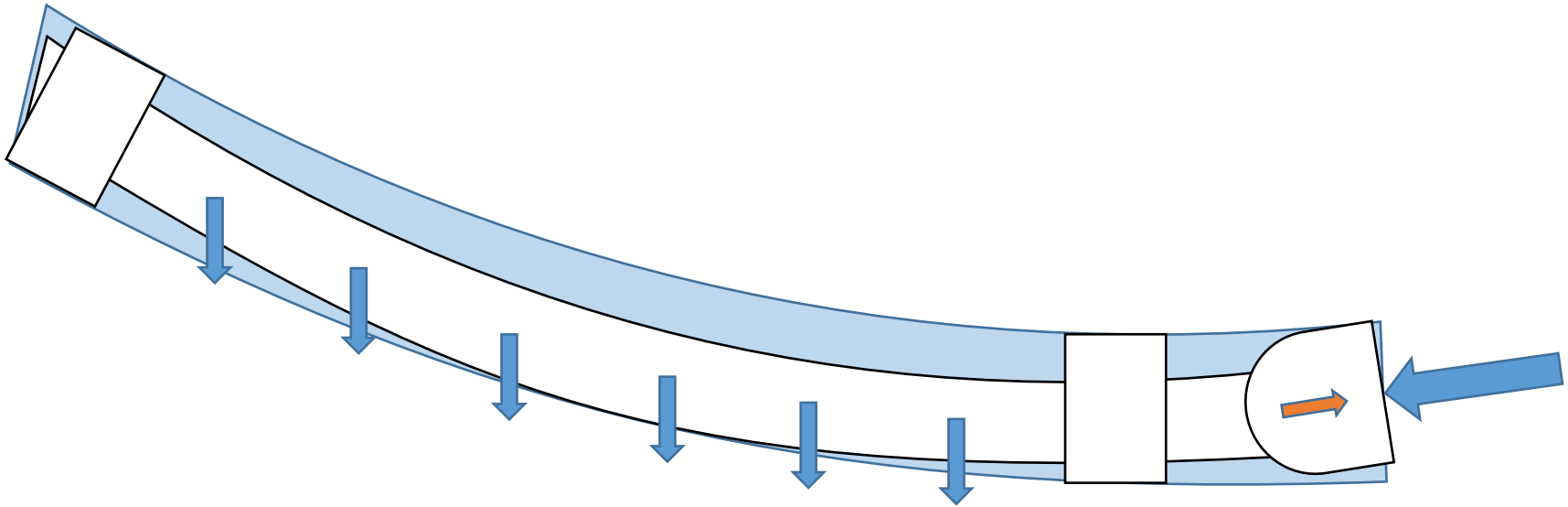
Pendulum assembly



Pendulum assembly



Pendulum assembly



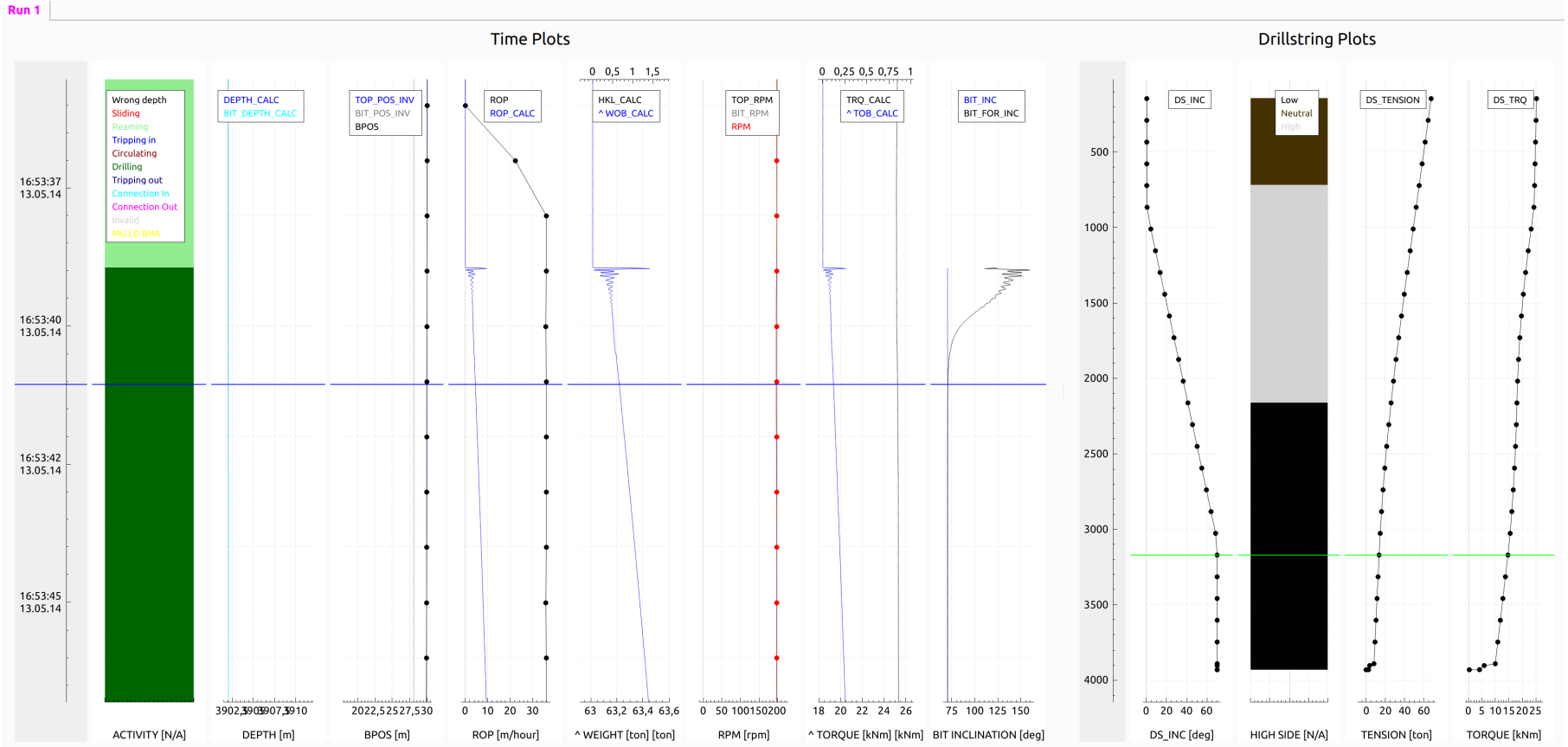
57th General Meeting
Main meeting 10th of March 2023
Stavanger

SPE International

Wellbore Positioning Technical Section

ISCWSA

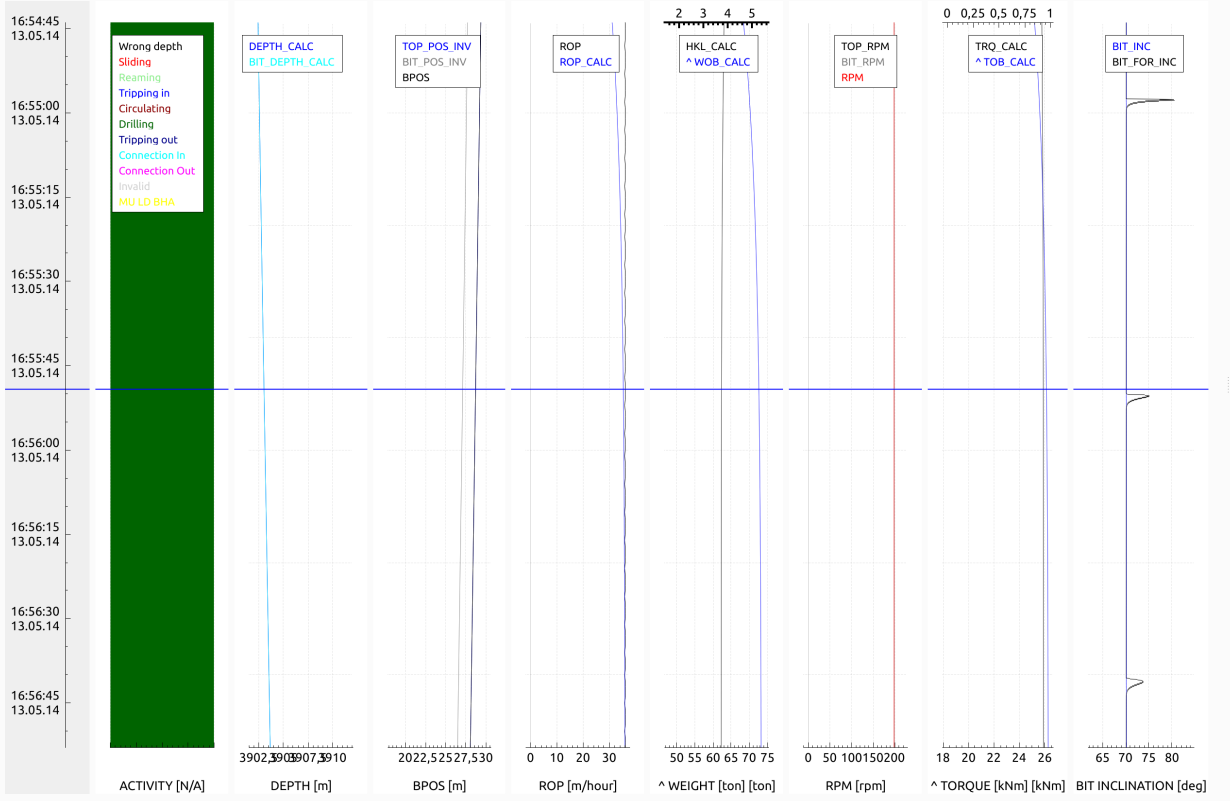
The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)



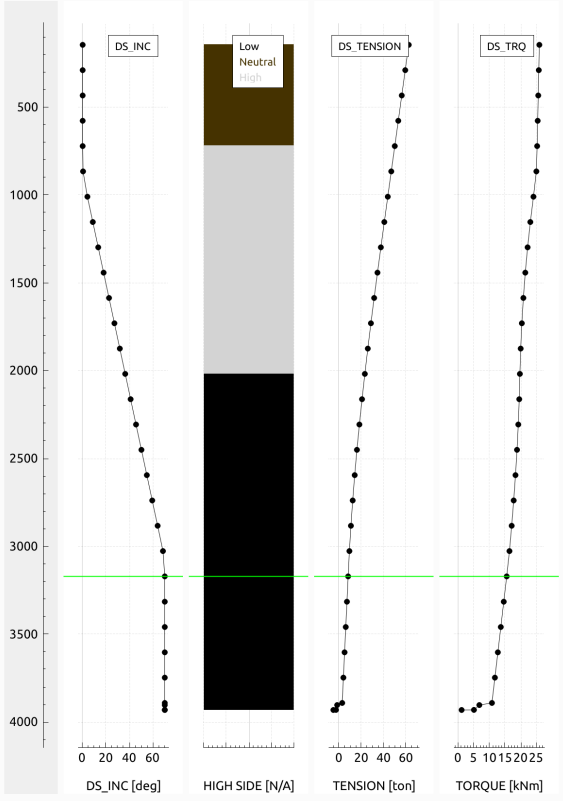
Wellbore Positioning Technical Section

Run 1

Time Plots



Drillstring Plots



Discussion

- Steering equipment
  - Mud motor
  - RSS

Discussion

- Steering equipment
  - Mud motor
  - RSS
- Wellbore wear model
  - Mechanical
  - Hydraulic
  - Chemical

Thanks for listening!

Sigve Hovda

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