Sekal

Rig systems - Pure physics

DrillScene

Presentation for Finding Petroleum

Drilling and the Digital Oilfield

Aberdeen 08 May 2012

HISTORY

- Technology is based on more than 20 years of research at IRIS.
- DrillTronics Rig Systems and DrillScene established by IRIS in 2004
- The Sekal company was established in 2011
- More than $10 M USD spent to date on software development.
  - Both DrillScene and DrillTronics are now launched for commercial sale.
- Main owners
  - IRIS 35,0 %
  - PV Invest 3 18,3%
  - Statoil Technology Invest 18,1%
  - SaakorninVest 18,1%
- Main Office in Stavanger, Norway
- Opened office in Westhill, Aberdeen in Q1 2012 and in Houston later in 2012.
- Current clients include;
  - ConocoPhillips, Statoil, BP, DONG and others in 2012 ….

DrillScene

- **Objective:**
  - Continuous assessment of drilling performance and risks
  - Early warning in real-time to support drilling operations
  - Continuous re-engineering using current drilling conditions
- **Principle:**
  - Uses WITSML server as the source of real-time data
  - Continuous modeling of the mechanical and hydraulic situation in the complete wellbore and drill-string
  - Continuous calibration of mechanical and hydraulic models
  - Alarm generation when hole conditions deterioration detected
- **Usage:**
  - Used by Mud Loggers, Performance Engineers, Drilling Engineers, Drilling Supervisors
- **Status:**
  - Tested on: Field A /Rig 1, Field B/Rig 1 & 2, Field C/Rig 1, Field D/Rig 1 & 2, Field E/Rig 1

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The linear weight of drill-pipes is calibrated when friction has little influences on surface measurements:

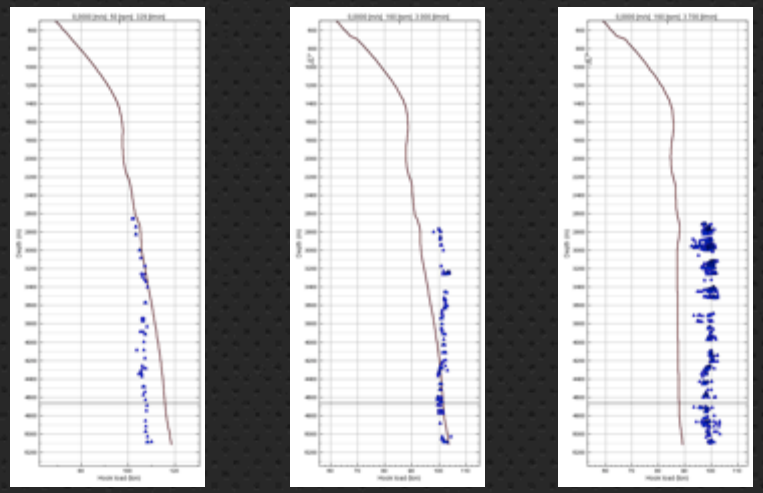
- vertical section
- rotation off bottom without circulation

Circulation has an effect on hook load and surface torque due to:

- viscous friction
- pressure forces

Calibration of hydraulic forces:

- after linear weight calibration
- when circulating and friction has little effect on surface measurements



Uncalibrated

Linear weight and hydraulic effect calibrated

300l/min 3000l/min 3700l/min

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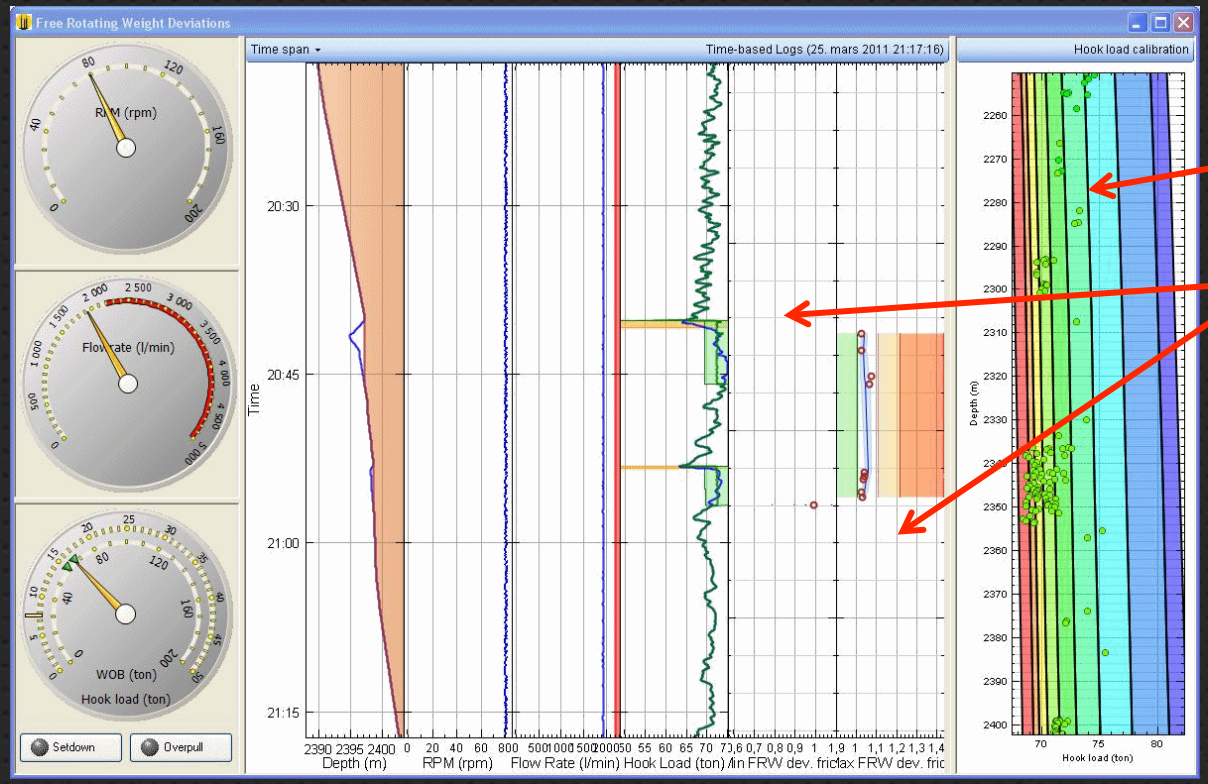
A well calibrated torque and drag model coupled with hydraulic- and temperature models can detect small variations in the down hole conditions

The free rotating weight is independent of friction but varies with:

- buoyancy (mud weight, temperature, cuttings concentration)
- accumulation of cuttings around BHA elements
- jack-up forces when pumping in an obstructed annulus



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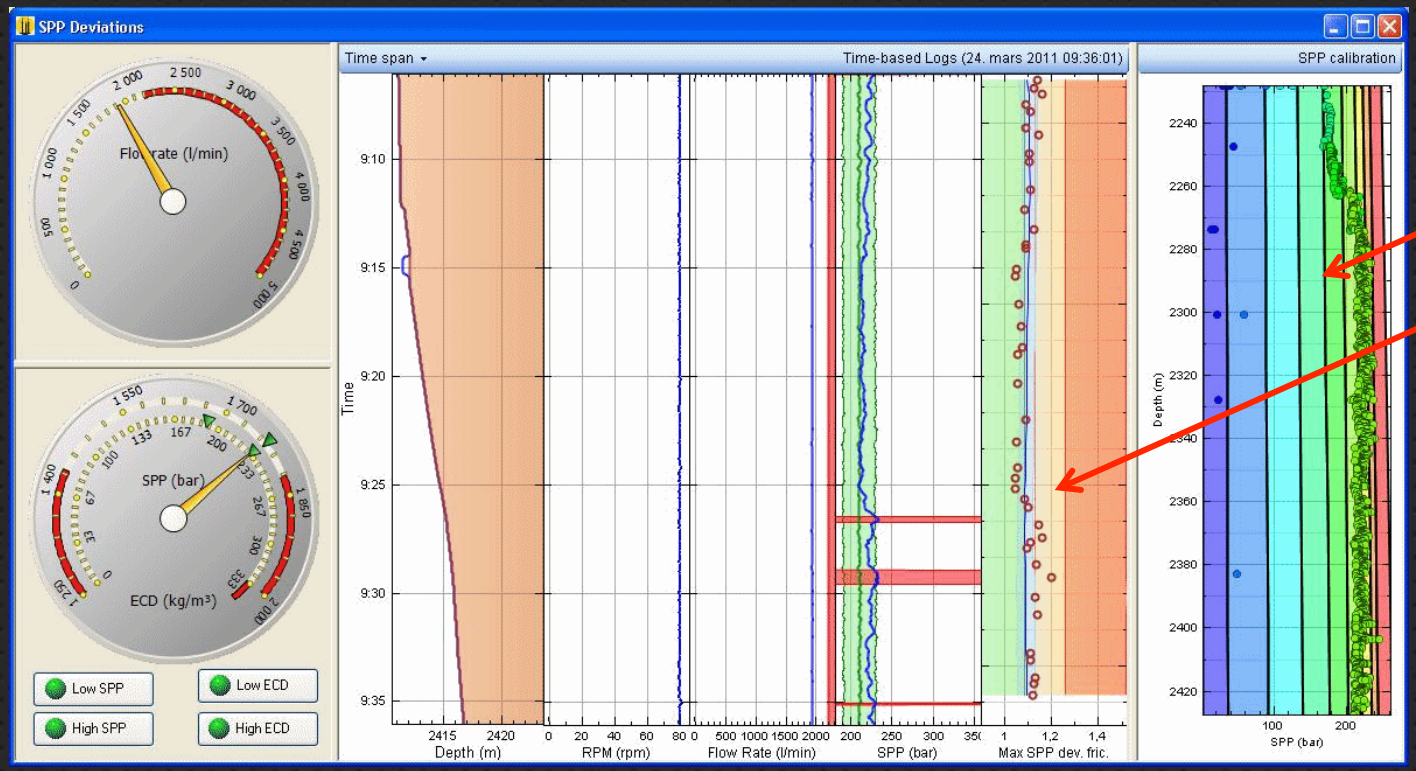
A well calibrated hydraulic model coupled with a temperature model can detect small variations in down hole conditions

Pressure loss in string is normally not context dependent except:

- variations of annulus pressure
- special BHA elements (under-reamer, downhole motors, etc)
- plugging of nozzles
- pipe wash-out



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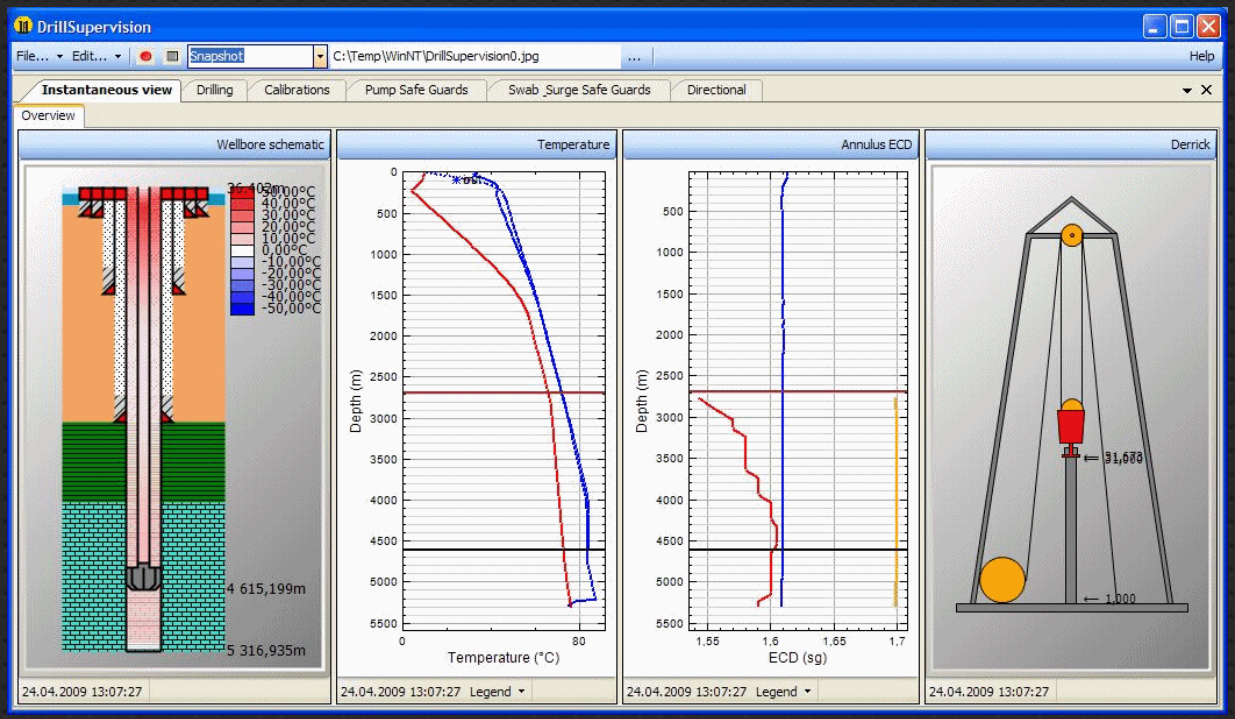
Realism in quick transient behaviours:

- swab and surge
- pump accelerations / decelerations
- mud compressibility and thermal expansion
- pick-up weight/ slack-off weight/ free rotating weight
- top-drive torque



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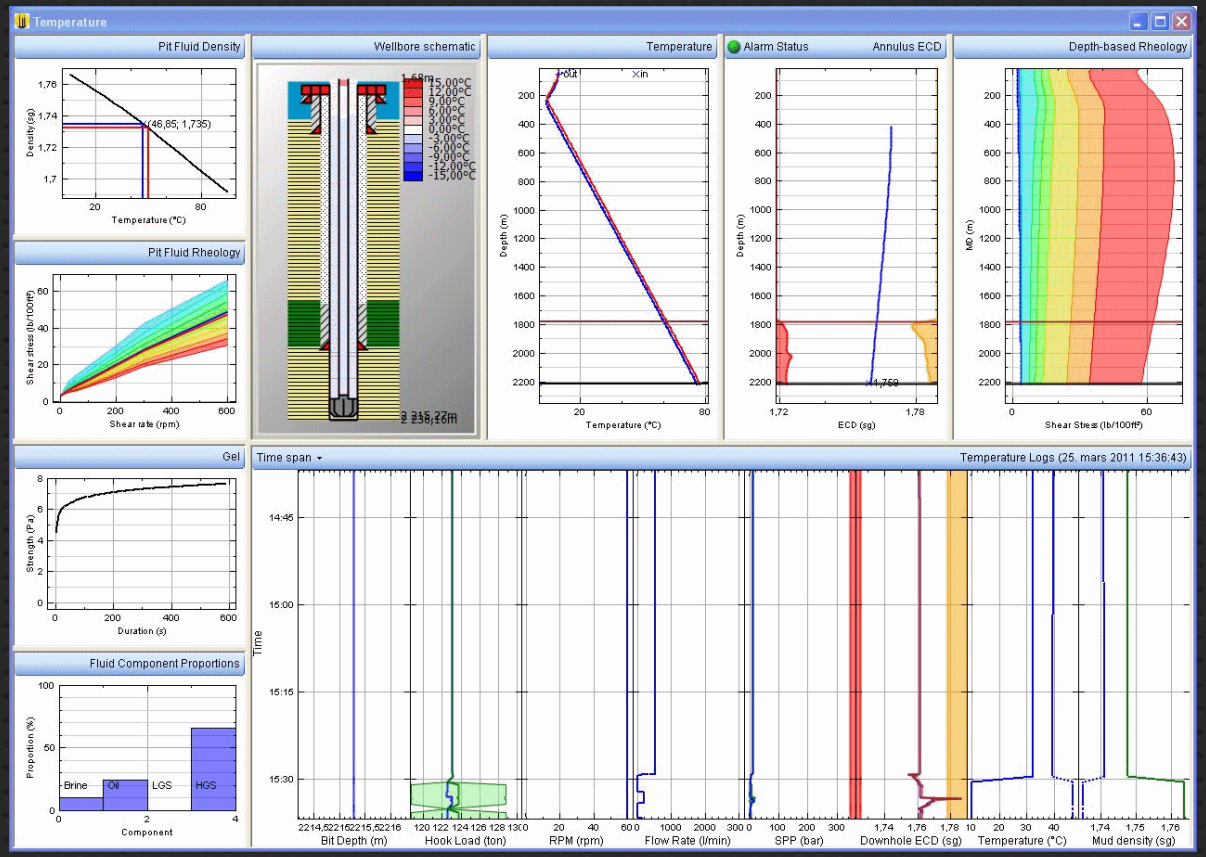
Realism in slow transient behaviors:

- Temperature evolution as a function of drilling operations
- Effects of temperature and pressure on mud properties
- Side effects of mud property variations on buoyancy, down hole pressure and viscosity
- ROP as a function of compressive strength of the formation rock layers
- Cuttings transport and cuttings beds



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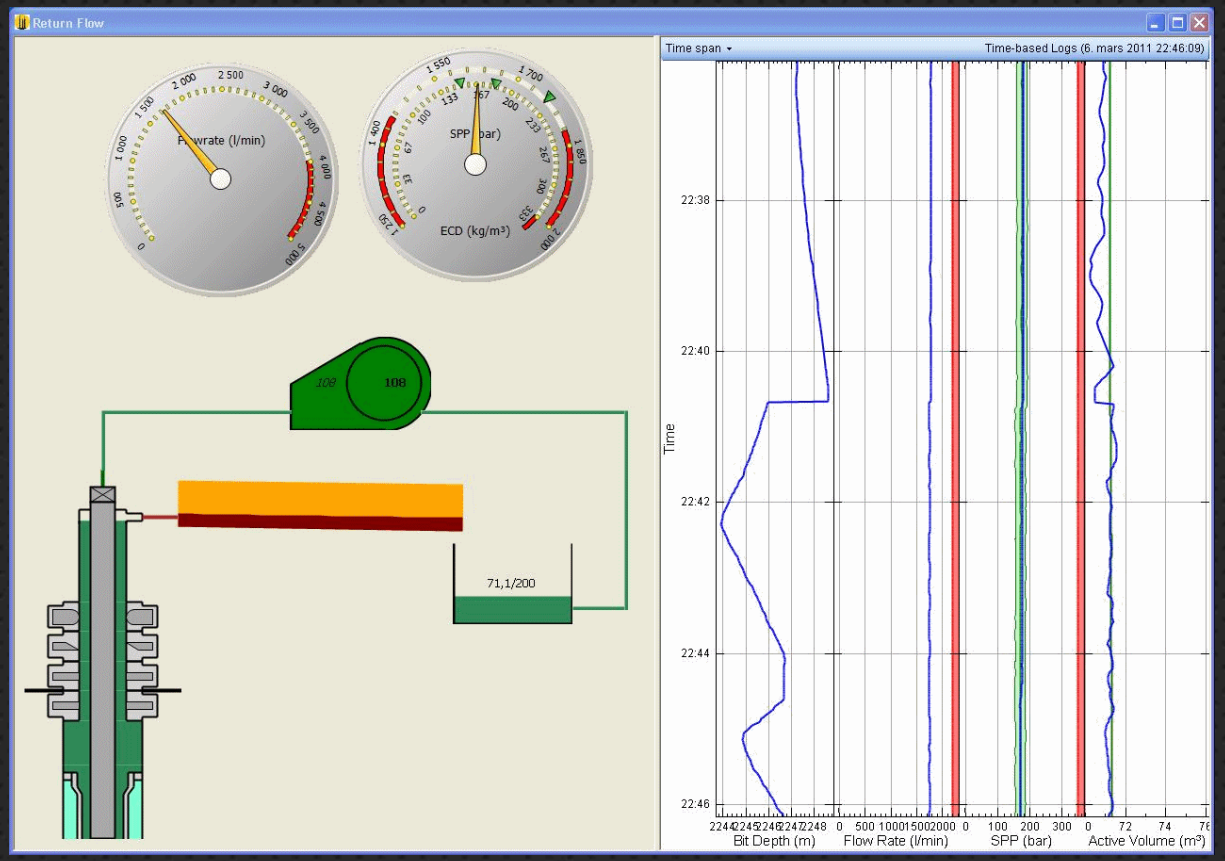
Surface installation modeling:

- mud return channel
- shakers
- degasser
- pit volume and temperature
- pit management
- gate valve opening and closing
- rig and MPD chokes



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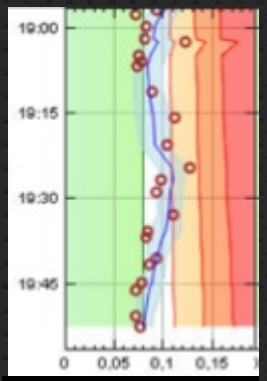
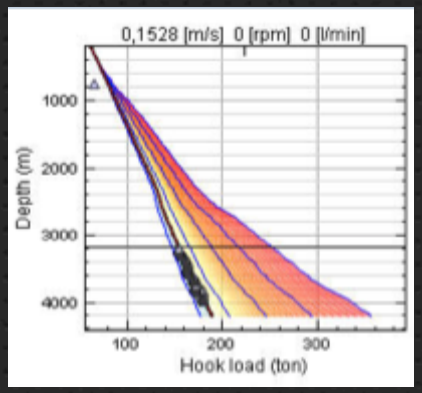
Start POOH:

- Sliding friction: stable and low
- Excellent match between expected hook load and observed hook load

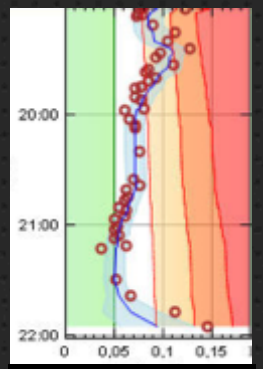


Sliding Friction

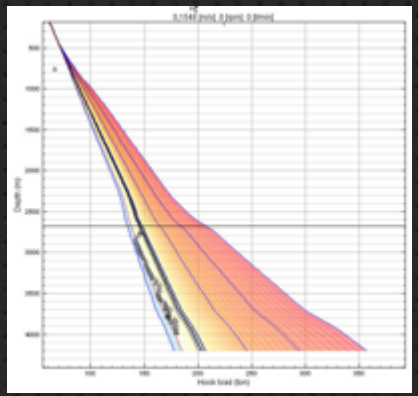


POOH mid-way:

- At 21:30: sliding friction start to increase quickly
- At 22:00: the mud logger is warned (but he can't see anything abnormal)
- At 22:08: follow-up email warning
- At 22:20: another email warning



Sliding Friction



The client was not yet used to the DrillScene system

- ✓ Was warned 1/2 hour prior to 1st overpull **(no actions)**
- ✓ Worked the problem as if it was a ledge (lost 4 hours)
- ✓ Back-reamed and worked out multiple pack-off incidents (10 hours)
- ✓ DrillScene indicated that back-reaming was no longer necessary 4 hours before entering casing shoe (could have saved 3 hours)

Lost 8 hours

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Symptom #1: Sliding friction (example #2, Field B/Rig 1, Apr xx, 2009)

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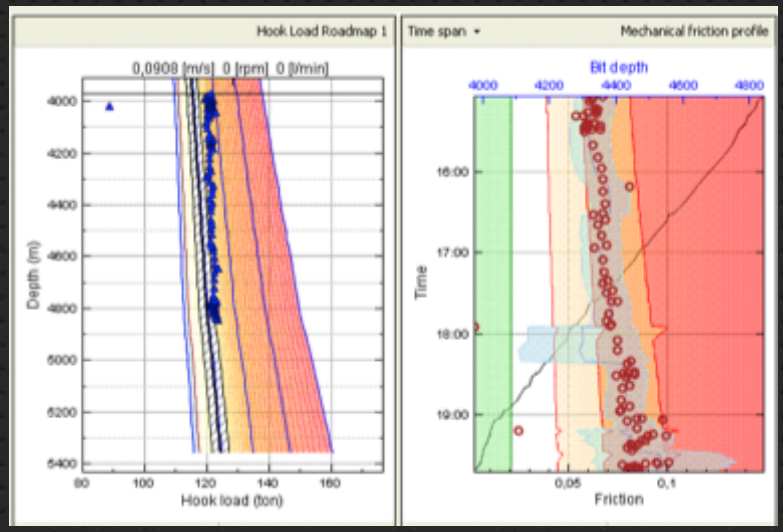
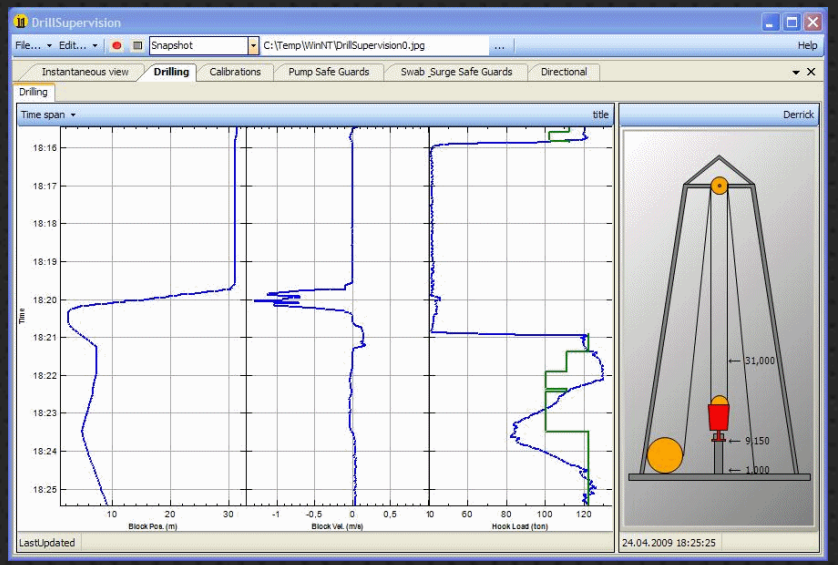


POOH:

- Cleaned hole (8 bottoms-up)
- Sliding friction increasing continuously since the start of running out of hole



Block pos. Block Vel. Hook Load

- ✓ Definitive warning signs 4 hours prior to 1st overpull
- ✓ 7 days to pull out of hole
- ✓ run cleaning assembly with no success (10 days)
- ✓ plug back and sidetrack (16 days)

Lost 33 days

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Symptom #2: Geo-pressure margins (example #1 Field D/Rig 2, well ?, date xx)

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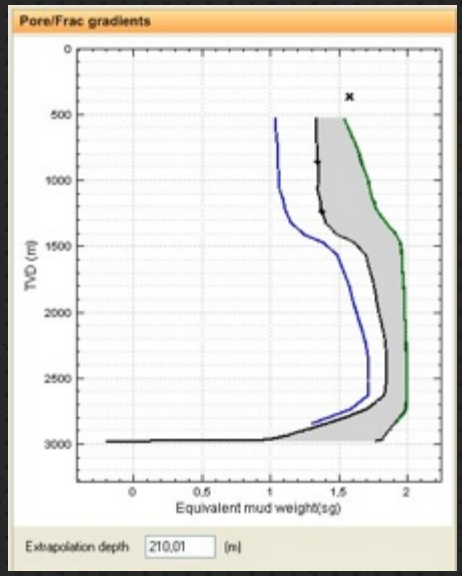
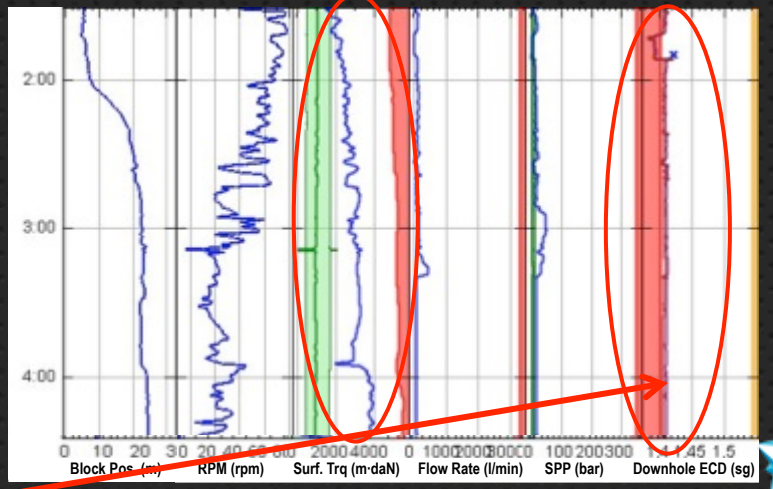
- Mud engineer reports pressure cavings on shaker
- Mud weight increased from 11.2ppg to 11.4ppg
- DrillScene's geo-pressure prognosis updated accordingly
- Day x at 16:00, calculated ESD is below corrected collapse pressure margin, warning is sent to client
- Day x+1 at 2:00, flow check after circulating hole clean result in complete stuck pipe situation



- For Sekal the stuck pipe cause is hole collapse
- Client treats the problem as cuttings avalanche

- BHA with 1 RSS, 1 MWD, 1 LWD, 1 PWD is lost
- well is plugged back and sidetracked

Lost 9 days



Downhole ECD below lower bound of geopressure margin

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Symptom #2: Geo-pressure margins (example #2 Field D/Rig 2, well ?, date xx)

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- Day x+9 at 18:00: the downhole ECD goes below the corrected geo-pressure boundary limit. Gas show increases in the same period of time.
- Cavings are reported in daily drilling report. Mud weight is increased from 11.7ppg to 11.8ppg.
- Day x+10 at 8:30: during flow-check, the top-drive torque starts immediately to increase. Emergency call to operation. Client was still working with hypothesis that it was a new cuttings avalanche!
- Circulation is re-established and mud weight is increased to 12ppg. Well stable afterward.

Saved 9 days + 1RSS, 1MWD, 1LWD, PWD?

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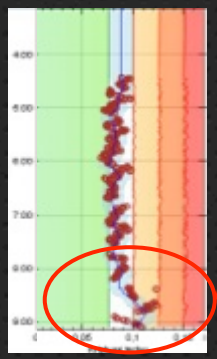
Symptom #3: Rotational Friction (example #1, Field D/Rig 2, well ?, date xx)

DrillScene

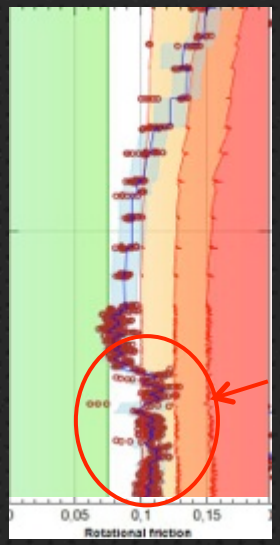
- Day x+10, 8:30: During flow-check, the rotational friction start increasing immediately
- Day x+10, after 18 bottom-ups, the rotational friction has not decreased back to its minimum value, indicating that the cavings have not cleared out.



Rotational friction increases as soon as flow-check started

- many over pulls during pull-out of hole
- problems running in hole with casing

Lost 3 days



After 18 B-U, rotational friction has not reduced to its minimum

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Symptom #4: Active Volume (example #1 Field B/Rig 2, Mar xx, 2010)

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Little changes in active volume because almost no cuttings transport

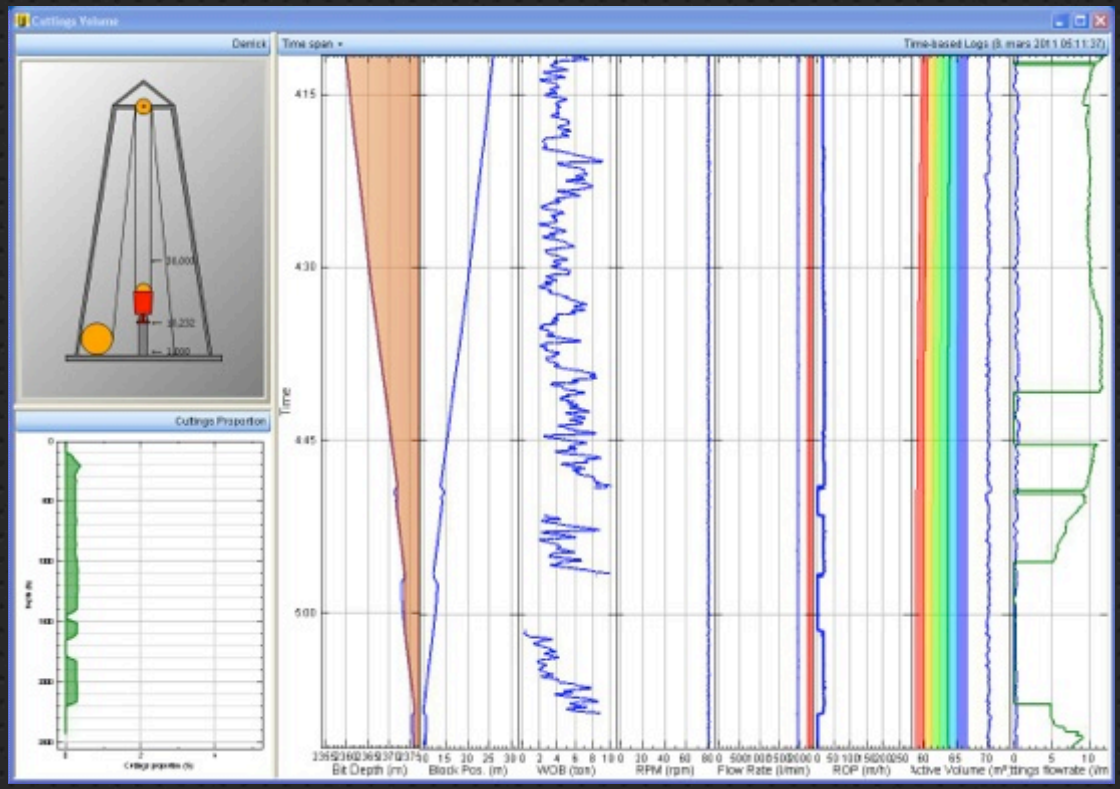
Confirmed by cuttings flow-rate

Early warning of very ineffective cuttings transport

Increasing risk of pack-off

- Warned 4 hours prior to 1st pack-off **(no actions)**
- 20 hours to regain control of the situation
- While working the pack-offs, the cement has been fractured causing mud losses
- Uncertain whether the formation has also been damaged (compromising the LOT)
- Needed to set a new cement plug and re-drill

Lost 4 days



Lacking at least 5m3

No mud film around cuttings

Mud film is same volume as cuttings

Mud film is 2 times the volume of cuttings

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Symptom #4: Active Volume (example #2, Field D/Rig 2, well ?, date ?)

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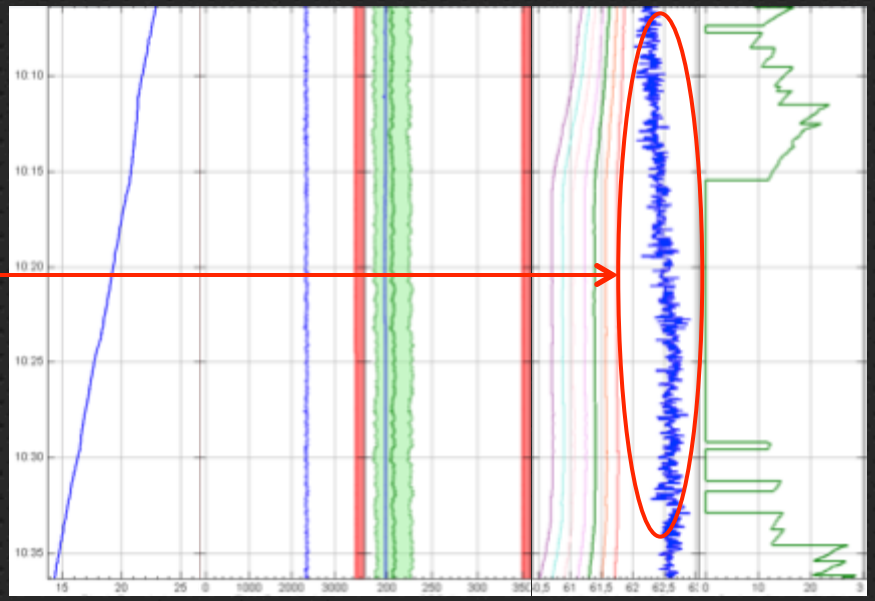
First warning sign while drilling **(1 ½ hour before kick)**

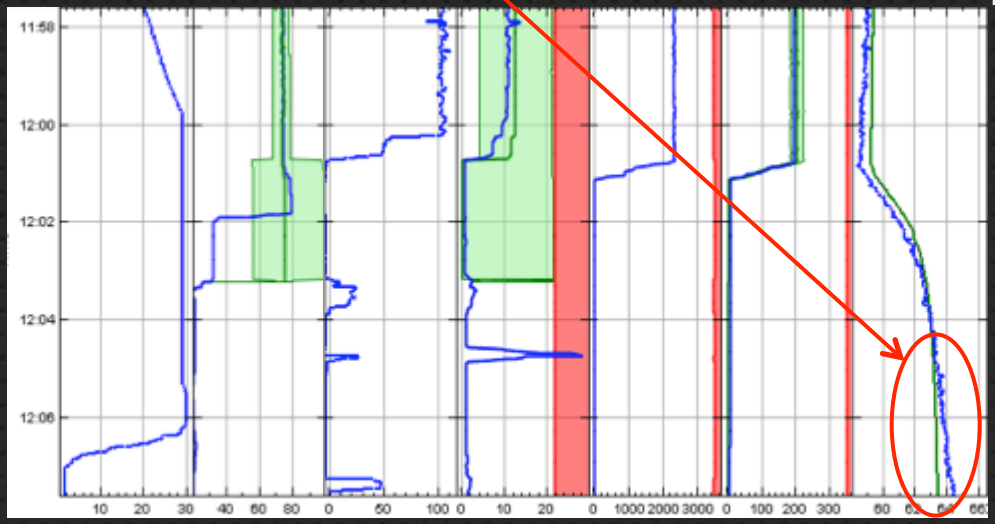
- Active volume is slightly increasing while drilling



Block pos. Flow-rate SPP Volume Cuttings flow-rate

DrillScene kick detection **(2 min. after pump shutdown)**

- Active volume change does not match prediction



Block pos. Hook load RPM Torque Flow-rate SPP Volume

- Drilling team started shut in procedure 40min after pump shutdown
- Kick volume in excess of 20m3

Well control procedure took 2 days

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DrillScene

Automatic symptom detection of abnormal drilling conditions → Enable proactive corrective measures before an incident has occurred

Multiple symptom analysis → Increase the chance of detecting abnormal down-hole conditions

DrillScene use physical models with auto-calibration → No learning curve to adapt to new field or region.

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Tested on 14+ wells (5 fields) over the last 2 years with great result:

Warned about all detectable problems ahead of time:

- Slow changing conditions (e.g. too high ROP) → Warning signs 12 hours to 1 day prior to serious downhole condition deterioration
- Medium pace changing conditions (e.g. very poor hole cleaning) → Detection 3 to 4 hours ahead of time.
- Fast changing conditions (e.g. tripping) → Warning signs visible 30min to 1 hour before the occurrence of first incident

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Further Technical Papers upon the Sekal solutions and digital drilling

SPE 150942

SPE 150422

SPE 128958

SPE 128286

SPE 128285

SPE 128234

SPE 119884

SPE 119650

SPE 119435

SPE 112744

SPE 99027

AADE-07-NTCE-45

E: Nick.Gibson@Sekal.com
M: +44 7714 171 853

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