EXPERIENCES FROM A VIRTUAL SIMULATOR ENVIRONMENT

Stavanger, October 20th 2011

IRIS
International Research Institute of Stavanger

Overview

Objectives:

Provide a drilling simulation environment which:

- Give a trustworthy responsive from the well to actions from drilling machineries, drill-string and drilling fluid
- Simulate, in a realistic fashion, drilling incidents

Purposes:

- Training of drilling personnel to new technology
- Commissioning of new drilling technology before implementation at the rig site
- Build new work procedures to adapt to new drilling technology
- Study the potential hazards in a complex drilling operation

Principles:

- adapted to NOV's Cyberbase (IRIS)
- adapted to Aker Solutions' DrillView (iPORT at Aker Solutions)
- adapted to team work (driller, mud logger, mud engineer, directional driller)

Status:

- 8 tests between 2009 and 2011

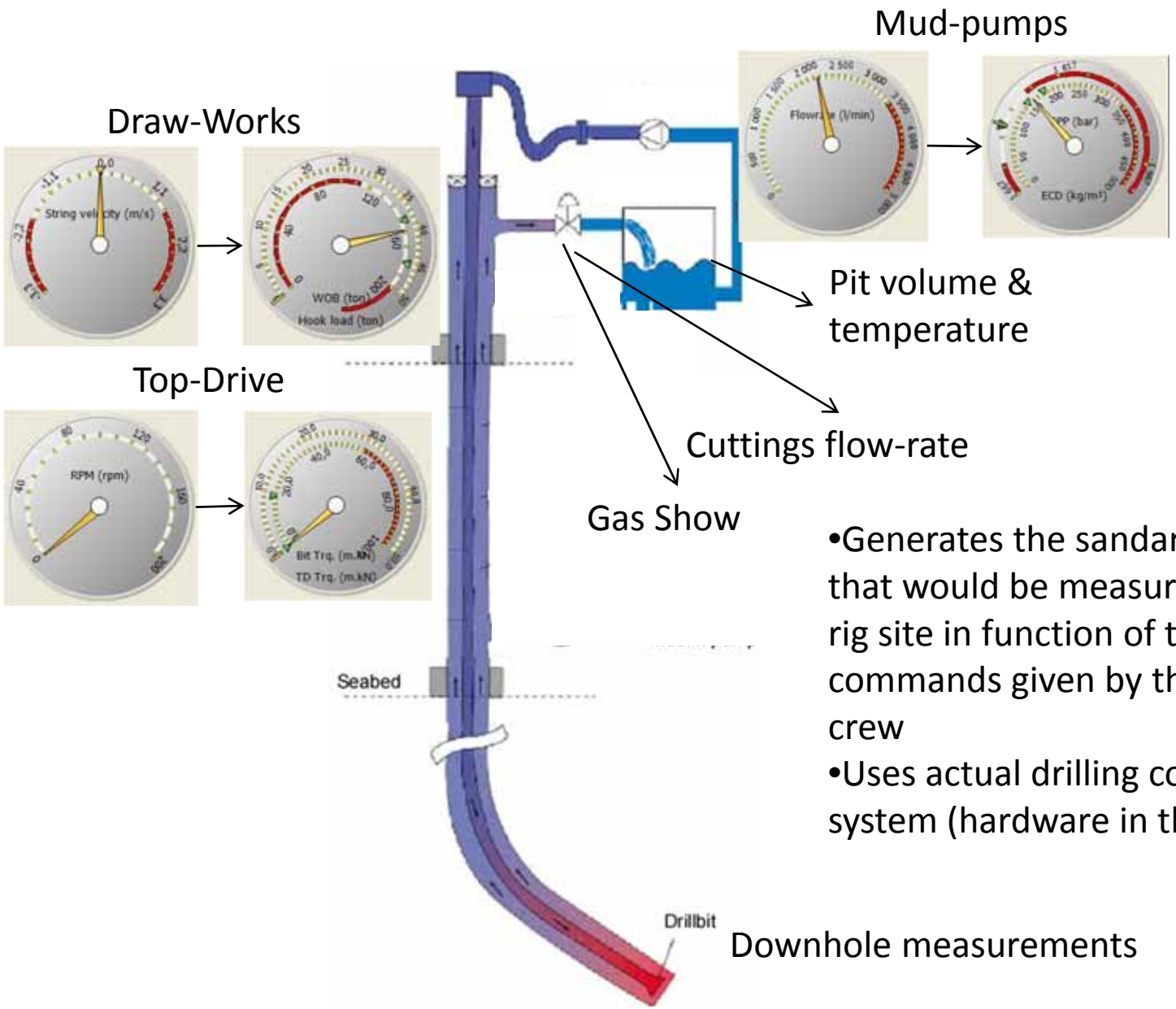
Driller's cabin

Experimentalist room

Onshore Drilling Centre

Rig site support room

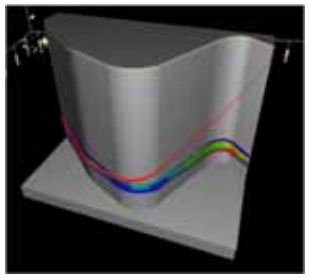
Functionalities



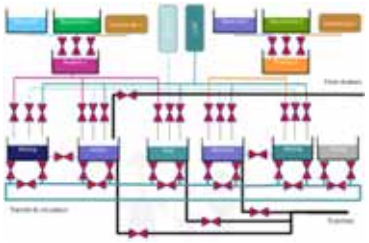
- Generates the sandard signals that would be measured at the rig site in function of the commands given by the drilling crew
- Uses actual drilling control system (hardware in the loop)

Commands and inputs

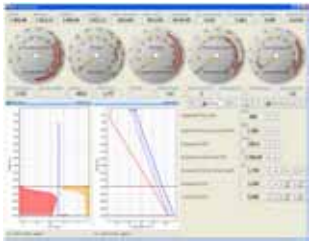
Driller
(Control the drilling machineries)



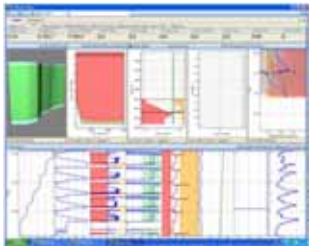
Directional Driller
(Control the RSS or PDM)



Mud Engineer
(Control the Mud Properties)



MPD operator
(Control the BPP and MPD choke)



Data logger
(Warnings & alarms)

Wellbore Simulator

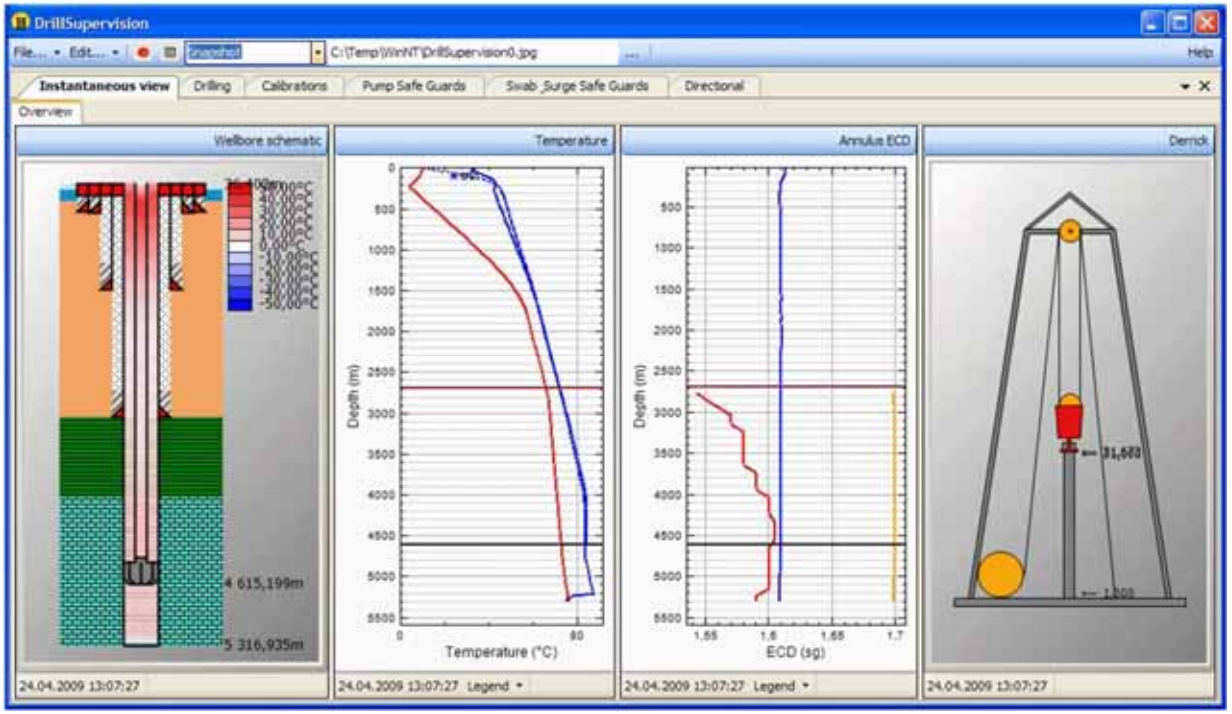
Experimentalist
(Control biases and component failures)

Industrial Psychologist
(human reaction, situation awareness)

Accurate simulation: quick transient behaviors

Realism in quick transient behaviors:

- 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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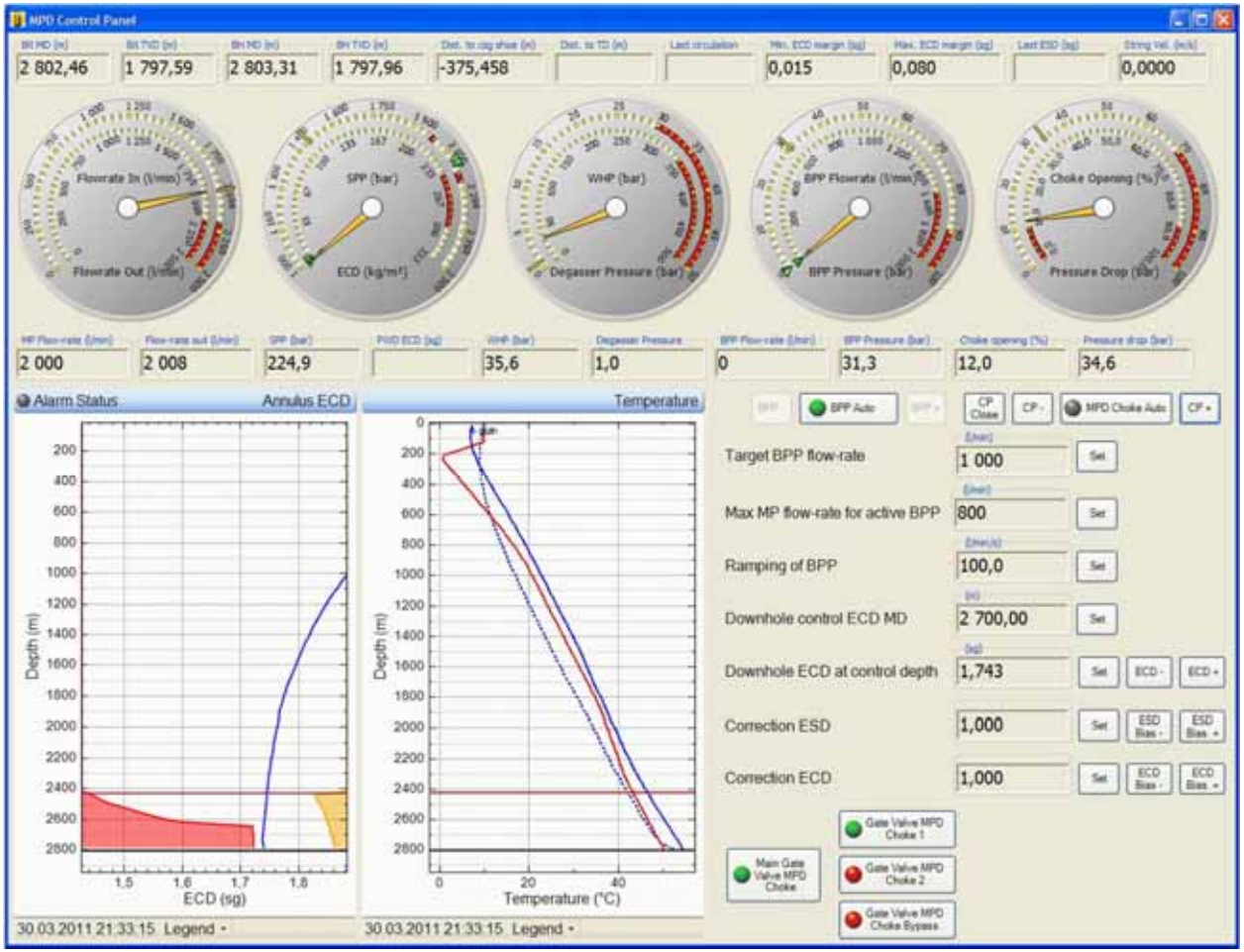
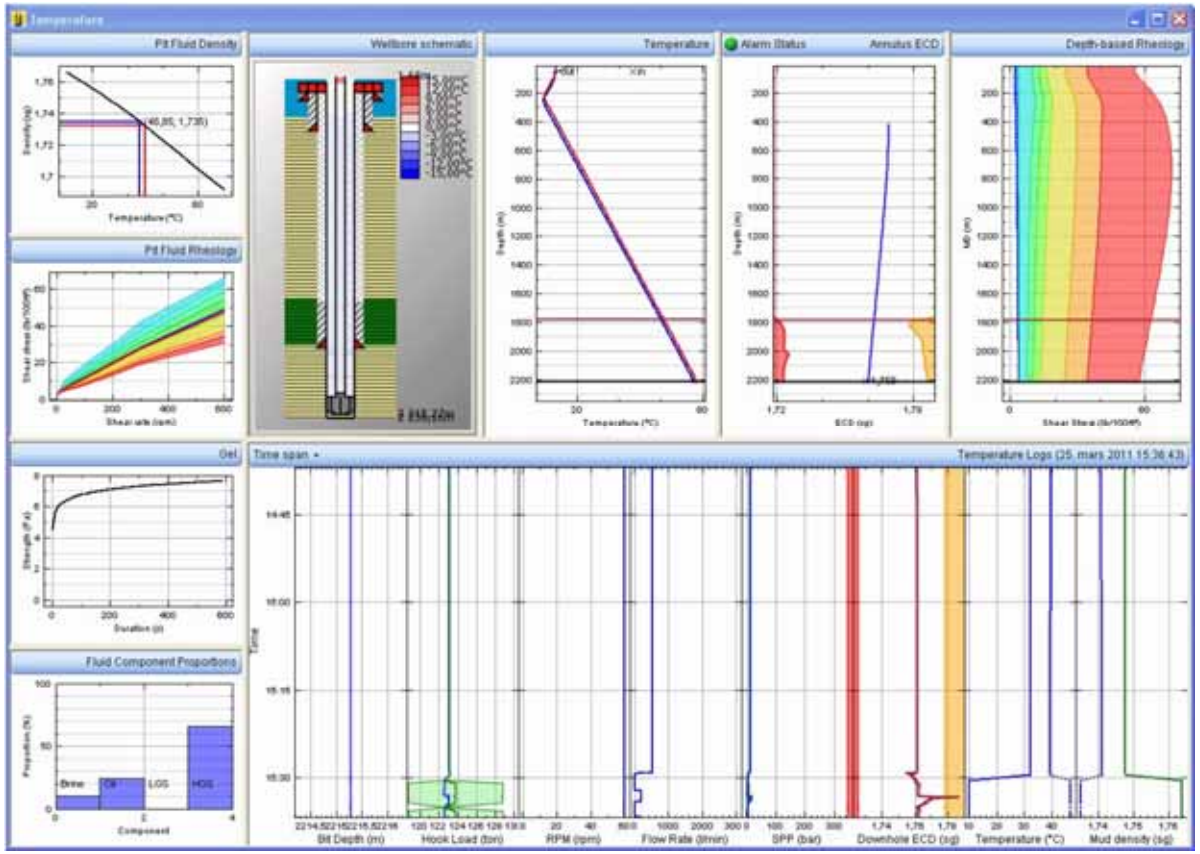


Accurate simulation: slow transient behaviors

Realism in slow transient behaviors:

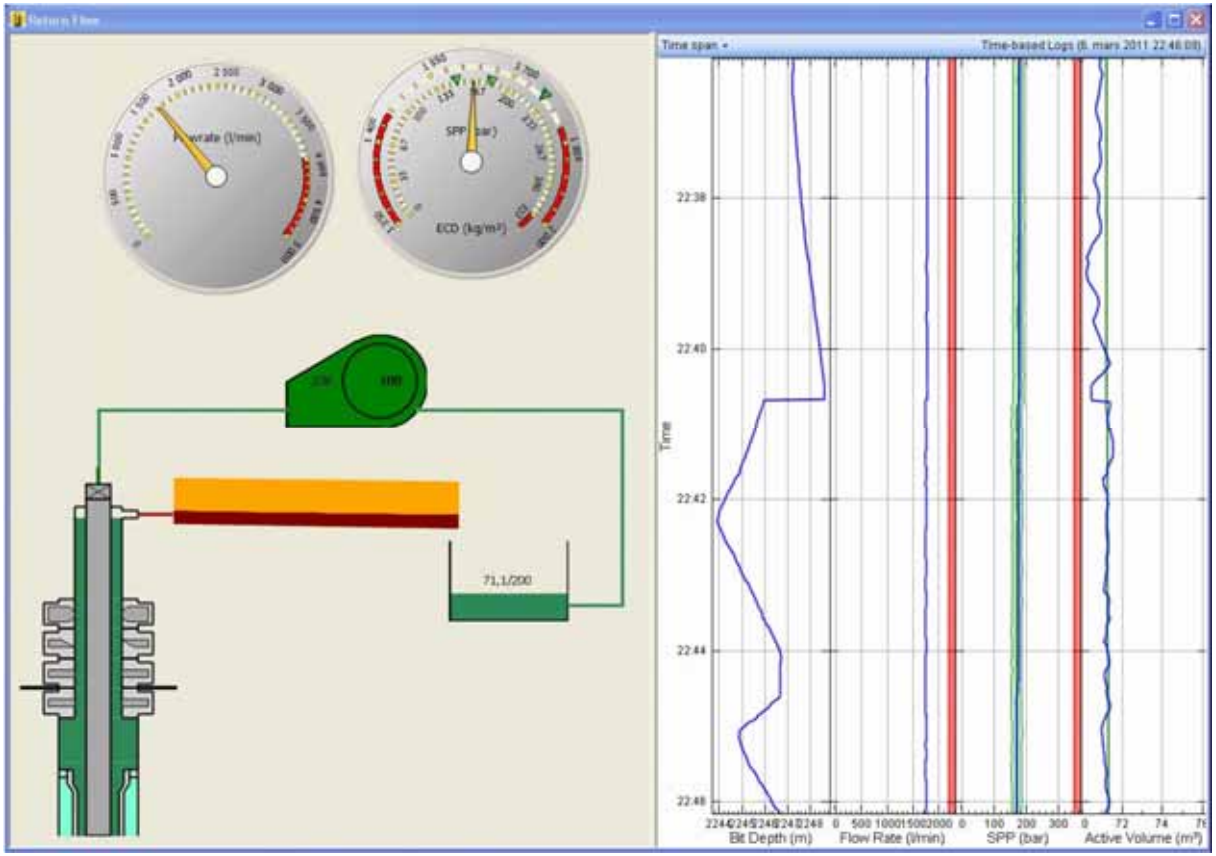
- Temperature evolution in function of drilling operations
- Effects of temperature and pressure on mud properties
- Side effects of mud property variations on buoyancy, downhole pressure and viscosity
- ROP in function of compressive strength of the formation rock layers
- Cuttings transport and cuttings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



Accurate simulation: surface installation modeling

Surface installation modeling:

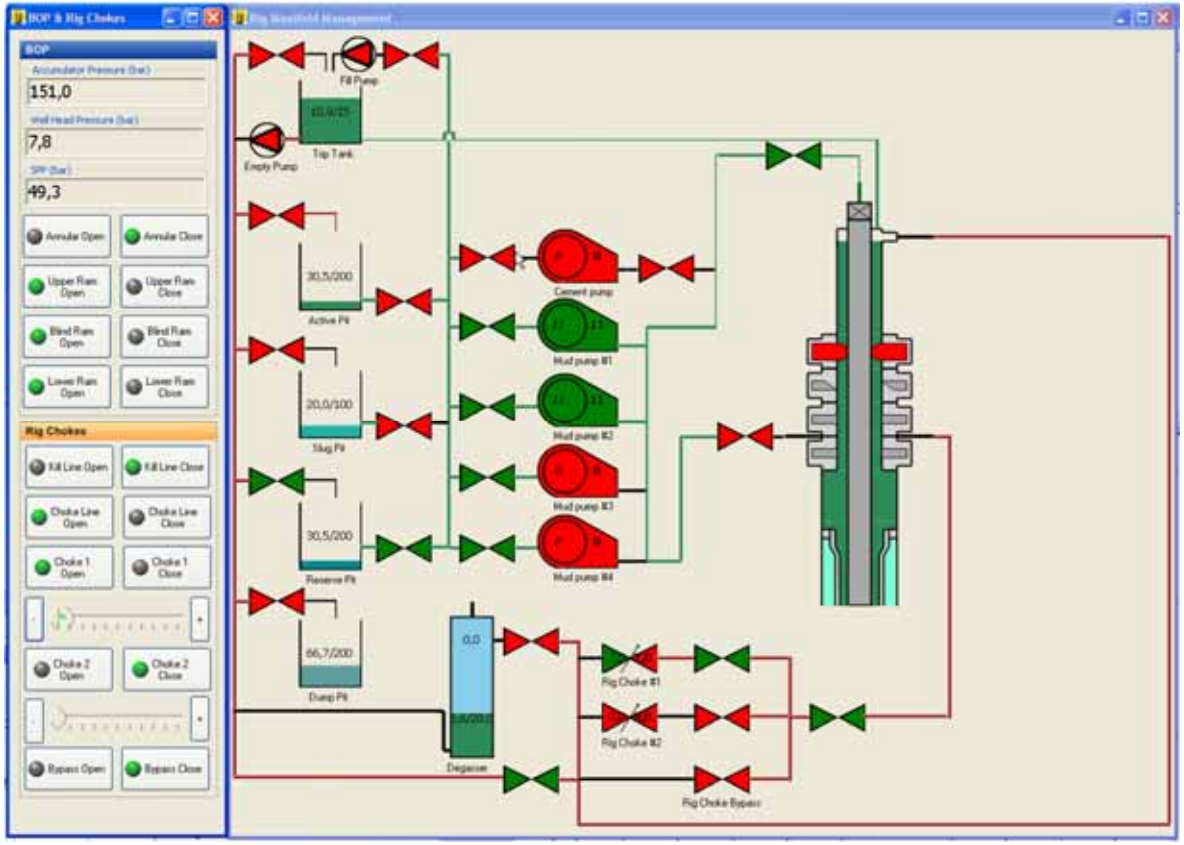
- mud return channel
- shakers
- degasser
- pit volume and temperature
- pit management
- gate valve opening and closing
- rig and MPD chokes



Accurate simulation: surface installation modeling

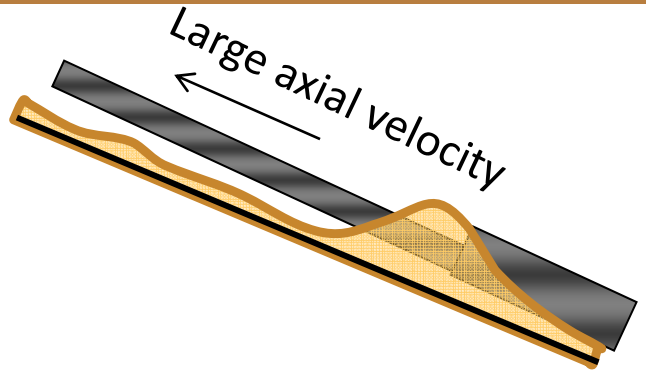
Change of pit for:
- displacement to a new mud
- LCM pill
- Slug
- Well control

Trip tank:
- smaller (more accurate) volume
- need to empty when tripping in
- need to fill when tripping out
- used to maintain level in annulus otherwise



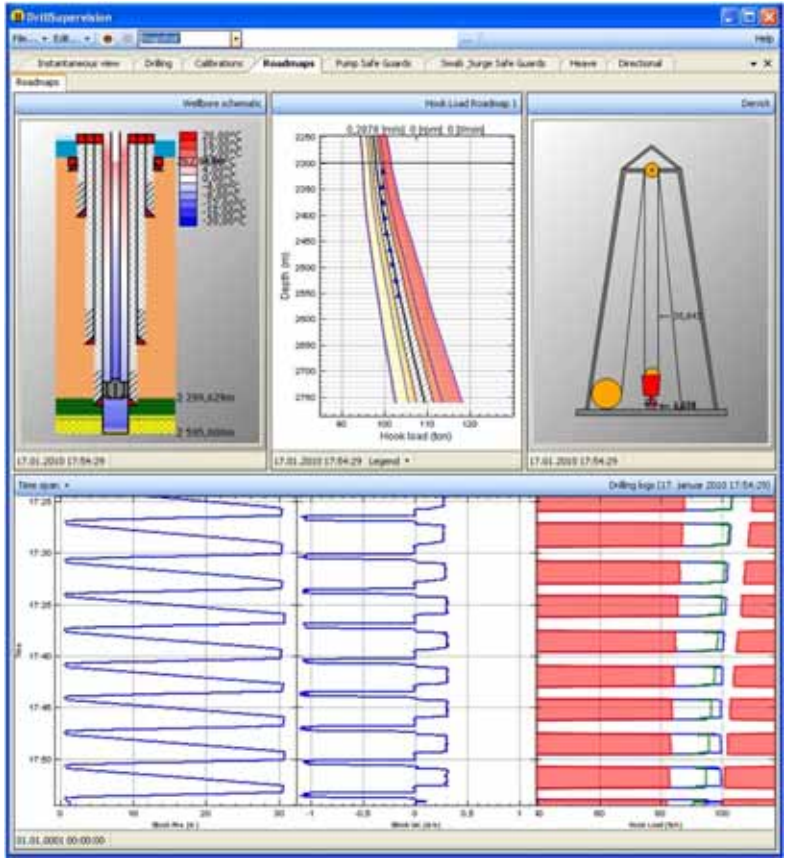
Well control:
- close BOP and kelly cock
- control well head pressure by controlling rig chokes opening

Simulation of incidents: mechanical restrictions



Overpull & set-down weights, torque:

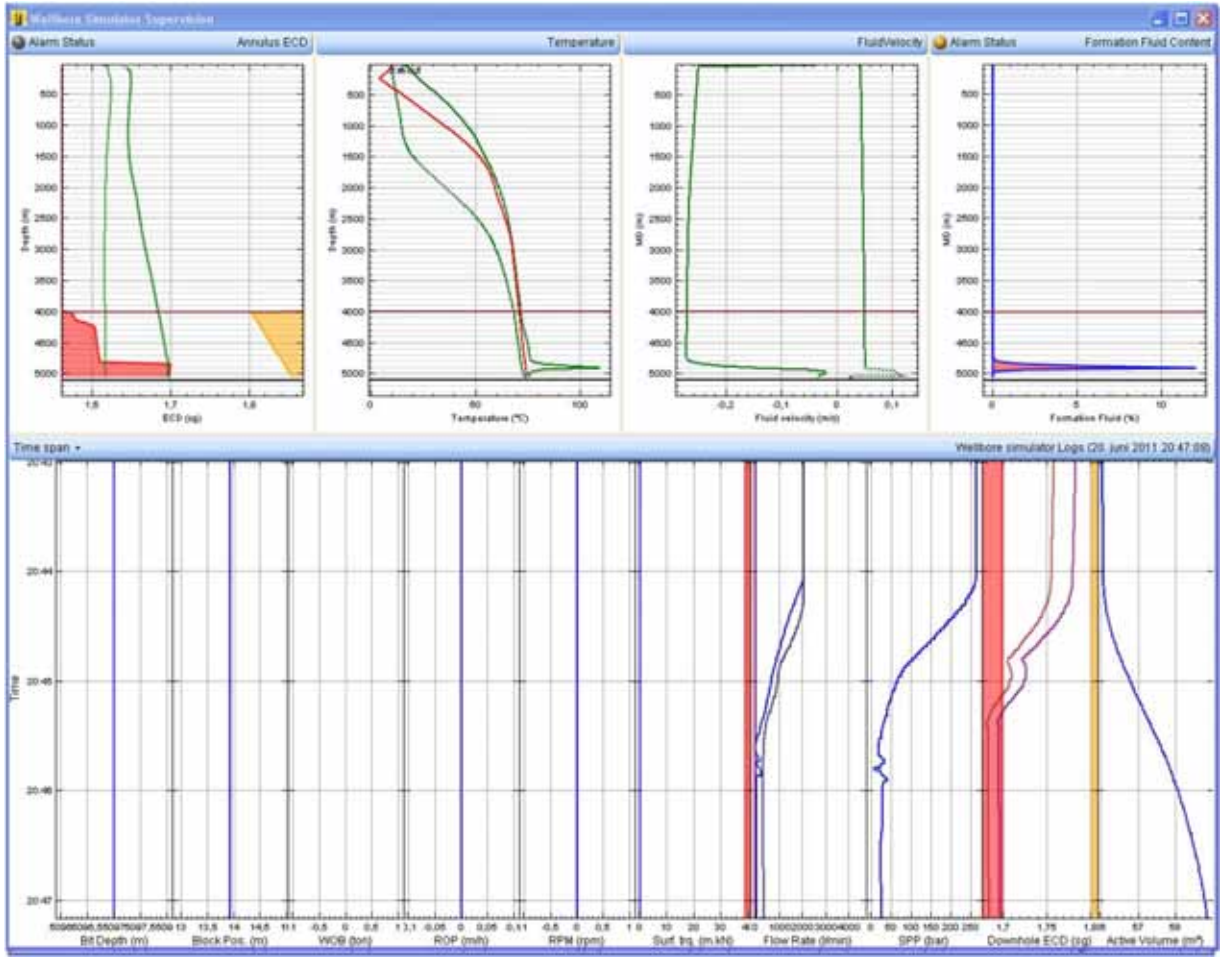
- Cuttings bed accumulation due to poor cuttings transport
- Cavings accumulation due to hole collapse
- movement of large BHA elements in cuttings/cavings beds



Simulation of incidents: formation fluid influx

Triggering:
- too low ESD/ECD
- swabbing

Effect:
- reservoir model (porosity, permeability, skin factor)
- transport in annulus
- change of downhole ECD due to presence of formation fluid



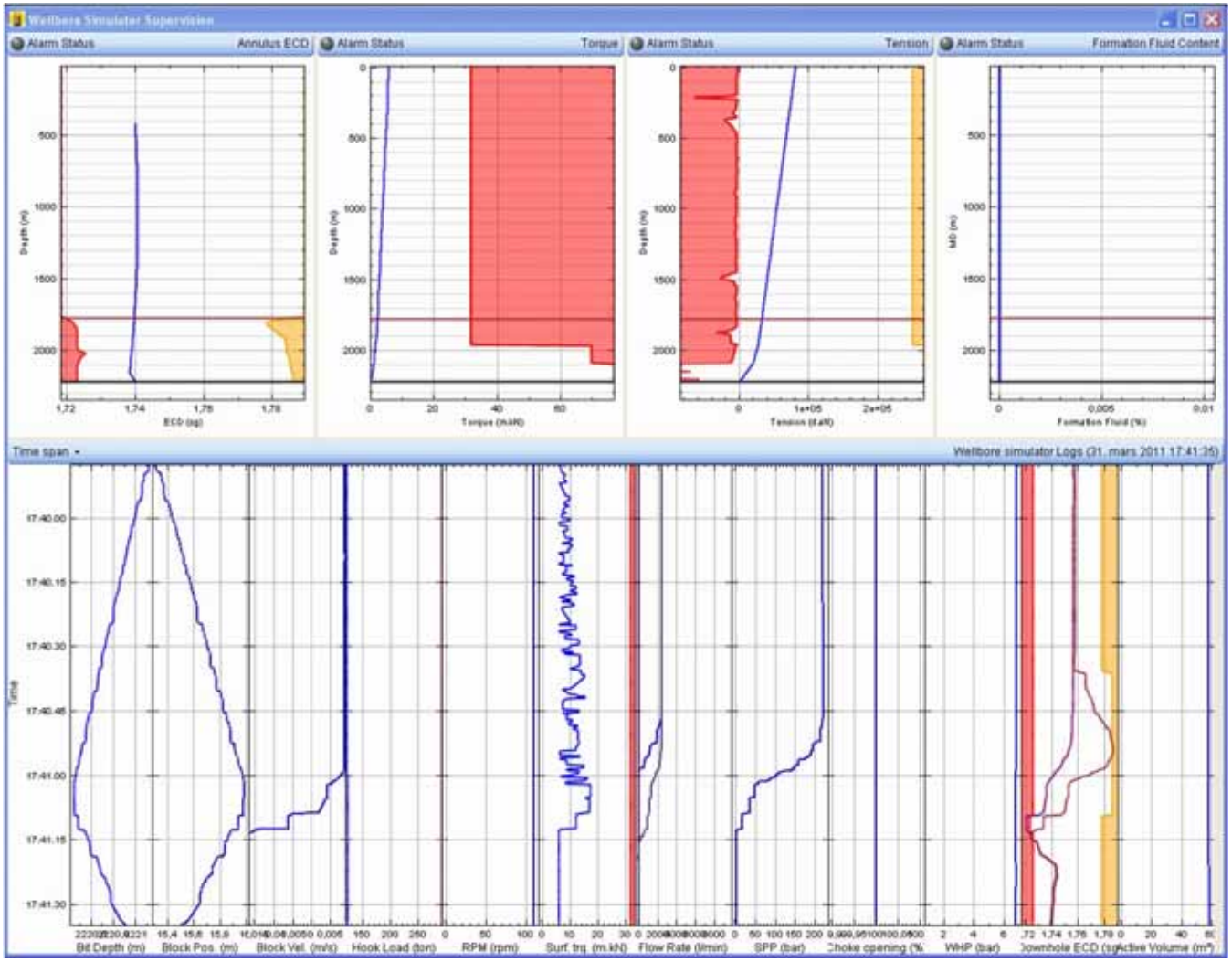
Simulation of incidents: hydraulic restrictions

Triggering:

- Packing of cuttings
- Hole collapse

Effect:

- Restriction over a length
- Gradual increase of restriction
- Compressibility of fluid = transient reduction of flow
- Possibly formation fracturing and mud losses

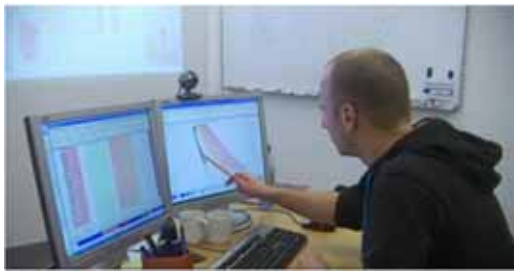


Training conditions

Multi room environment:
- Driller's cabin
- Offshore support room (DD, Mud engineer, Drilling Supervisor, Tool Pusher)
- Onshore drilling centre (Mud logger, Drilling Optimizer)
- Experimentalist room (instructor, industrial psychologist)

Team cooperation:
- "VHF" communication
- Telephone
- Shared data management

Training sessions:
- Real-time mode
- Fast forward with "auto-driller" scenario manager
- Play-back of recorded session (under construction)
- Multiple scenario management (under construction)



Tests

1. Training of Statfjord C's drilling crew for the Automated Drilling Pilot (ADP) test in 2009
   - Drillers, Assistant Drillers, Tool Pushers, Drilling Supervisors
   - Theoretical training with practical exercises in the virtual rig
2. Integration of Drilltronics, DOTS and CMFP for the ADP test in 2009
   - WITSML integration between NOV, IRIS, Trac ID and GeoServices
   - commissioning of the integrated solution in the virtual rig
3. Testing of a commercial system for pack-off detection in 2009
4. Validation of newer functionalities of a Drilltronics (a drilling automation system)(2010):
   - Heave enablement of Drilltronics
   - Safety triggers (overpull/set-down weight, over-torque, pack-off)
5. Testing of the initial functionalities of another drilling automation system (2010)
6. Analysis of side effect of wired pipe telemetry for kick detection in 2010s
   - simulation of distributed pressure sensors with high speed telemetry
7. Testing of the improved functionalities of 2nd drilling automation system (2011)
8. Preparation of an advanced well control training course for Aker Solutions' iPORT (2011):
   - team cooperation during detection and management of a gas kick

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Commissioning

Training

Testing and validation

Study

Conclusion

Trustworthy simulations (accurate transient behaviors):

- the persons working in the virtual rig are focusing on the experiment not on the lack of realism

Drilling workstation of NOV and Aker Solutions MH:

- the drillers are working in a familiar environment

Hardware in the loop from both NOV and Aker Solutions MH:

- exact replication of top-side equipment behavior (draw-works, top-drive, mud pumps, etc.)

Advanced and accurate simulation of drilling incidents:

- incidents are the result of the actions applied to the well (non-determinism)

Multi-disciplinary setup

- team-work cooperation
- work procedures

Operational since 2009 and tested in multiple instances and different contexts

Any questions?