EXPERIENCES FROM A VIRTUAL SIMULATOR ENVIRONMENT

Stavanger, October 20th 2011
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
**Functionalities**

- **Draw-Works**
  - String velocity (m/s)
  - WOB (lbf)
  - Hook load (lbf)

- **Top-Drive**
  - RPM (rpm)
  - Bit TFG (lbf)
  - TD TFG (lbf)

- **Mud-pumps**
  - Flowrate (l/min)
  - ECD (kg/m³)

- **Pit volume & temperature**

- **Cuttings flow-rate**

- **Gas Show**

- **Downhole measurements**

**•** Generates the standard 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)

**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
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)
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 2\textsuperscript{nd} 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
Tests

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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?