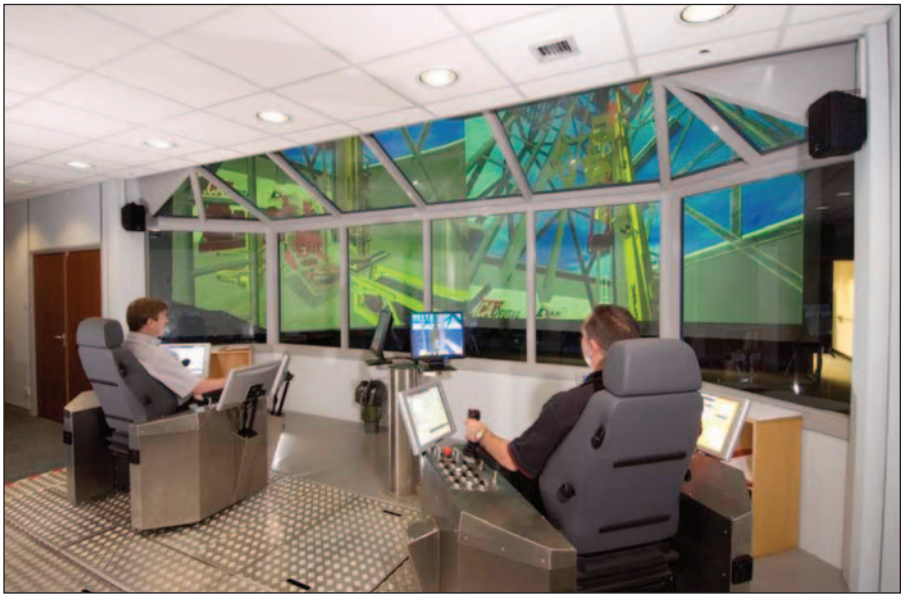
Advanced drilling simulators offer realistic models to reduce crews' learning curve

By Roger Hodgson, P Hassard,
KCA DEUTAG Drilling Ltd

TRADITIONALLY, simulators have been used for well-control training, or the training of crews to operate new-generation automated drilling equipment. Modern drilling simulators now are also being exploited by performance-oriented teams to practice techniques and procedures in a risk-free, low-cost environment.

Techniques such as Through Tubing Rotary Drilling (TTRD) and Extended Reach Drilling (ERD) have become routine techniques for many operators. However, they are still typically new to field drillcrews. Now, state-of-the-art simulators are being used to realistically model proposed operations, placing emphasis on anticipated well challenges.



The Aberdeen DART facility, installed in 1999, was initially used to train crews of the Brent Charlie NDES (New Derrick Equipment Set) and the KCA DEUTAG PT-2000 land rig. Since then, it has been upgraded to replicate the offshore Sakhalin Lunskoye and Piltun platform rig equipment.

INTRODUCTION

The DART (Drilling and Advanced Rig Training) simulator is a full-scale replica of a modern offshore platform rig's driller's control cabin, complete with "cyber" driller and assistant driller chairs and their respective touchscreen consoles.

Surrounding the control cabin is a 50-ft long cinema screen onto which 3D graphics of the rig's drillfloor and derrick equipment are projected. As the driller operates the rig equipment, the surface simulator provides realistic moving graphics replicating the sights and sounds the driller would actually experience on the rig.

The downhole simulator is programmed with details of the well geometry, geology, pressure, fluids and casing scheme, and can be tailored to represent the subsurface conditions of the well. The software model translates the reservoir and wellbore effects into visual indicators that the crews would normally see on reproductions of the gauges along with other visual and audible indicators. The combination of the surface and downhole simulators allows sections of the well to be "drilled" in a safe and low-cost environment.

HISTORY

In the late 1990s, a new generation of drilling equipment was evolving with the installation of fully mechanised drilling and pipe-handling equipment. These were operated by crews that had experience with only manual equipment. Initially, performance was slower than that of manual rigs until crews became familiar with the new "cyber" chairs and controls.

The Aberdeen DART facility was originally installed in 1999. The drilling operators' interface with the simulator was based on 2 rigs: the Brent Charlie NDES (New Derrick Equipment Set), a new-generation mechanised platform drilling package, and the KCA DEUTAG PT-2000 land rig. The initial use of the simulator was to train crews to efficiently use the specific equipment of the NDES and PT-2000.

Since then, similar facilities have been used by other drilling contractors to accelerate learning for the Sedco Express-class semisubmersibles and the Discoverer Enterprise-class drillships, as well as some of the world's most advanced deepwater drilling units.

A facility has more recently been installed near Baku, Azerbaijan, that can replicate 5 cyber rigs being installed in the Caspian Sea. The resulting extensive operator investment in more than 150 manhours hands-on pre-operational training per man on this facility has already resulted in the world-classs start-up of the first operational rigs. Due to the 100% utilisation of this facility for equipment familiarisation and handling training, a mobile simulator has also been mobilised to undertake other training needs. This mobile unit will subsequently be used to undertake training events in remote locations, when more training space becomes available on the main simulator. Based on the success of the Baku simulators and the demand for effective start-ups, the Aberdeen facility has since been upgraded to replicate the offshore Sakhalin Lunskoye and Piltun platform rig equipment.

TRAINING DEVELOPMENT

Since the initial training of the crews in mechanical handling techniques was completed, other potential uses of the simulators have been investigated. Development was initially focused on operations, looking at competency for rig crews (a transition course for assistant driller to driller) and IWCF training. The focus then moved toward drilling engineering optimisation, team building and

the DWOP (Drill Well on Paper) workshops, stuck pipe courses and TTRD courses. The DART simulator is now being used regularly by several operators as part of their training programmes for graduate drilling engineers.

SIMULATION VS WELL PLANNING

Although real-time drilling simulators are primarily designed to simulate pipe-handling and well-control operations, development of downhole packages in conjunction with software providers has allowed the effective simulation of drilling operations and common drilling problems.

This results in output drilling parameters such as pump pressure, hookload, rotary torque, ROP, etc., being displayed realistically and being able to be acted upon by the driller as he would at the rigsite. The ability to reproduce this realism has drawn comparisons with the output from planning/design tools. It therefore needs to be emphasized that simulators such as DART are not replacements for proprietary well planning/design tools.

A well design tool will calculate parameters (torque/drag/pump pressures/cuttings buildup, etc.) for the complete section. However, simulators reproduce the dynamic changes in these parameters at a particular depth when the pumps are "physically" turned on, the rotary "engaged" and "drilling ahead" is progressing with weight on bit. Because simulators are not programmed as design tools, the input variables may be more basic than those required for well design tools.

SIMULATOR STRENGTHS

The strength of realistic simulators is not necessarily the accurate prediction of specific wellbore conditions. It lies in the production of such effects with the ability to place the well's team in the typical environment of their next well to enhance their preparedness for situations that may arise. These simulations provide the opportunity to confirm that all the lessons from previous wells have been captured and to ensure that the team is starting at the top of the learning curve. This prospect is especially beneficial when a new operation, or new technology, is being applied.

While an exercise progresses, gaps in available information, procedures, understanding and application of procedures become apparent. Roles and responsibilities, communication links and competency can all be checked in this safe environment. Any gaps and deficiencies can then be addressed before the actual operation commences. Team strengths and weaknesses can also be managed, and the operator has the opportunity to introduce new procedures and systems in a controlled environment.

The training facility installed near Baku, Azerbaijan, can replicate 5 cyber rigs being installed in the Caspian Sea.

SOFTWARE CAPABILITIES

Software capabilities vary between simulator providers. However, the DART simulator software can effectively be configured in the 3 main areas of:

- Surface/rig configuration;
- Well design;
- Formation/reservoir characteristics;
- Surface/rig configuration.

As described earlier the simulator software can be developed in conjunction with the equipment providers to create a 3D world where crews can experience the integration of the rig's equipment prior to working in the field. Such ability provides real and comprehensive training. The more closely that the simulator reflects the actual operating environment, the more successful the training will be. This is illustrated by the 96% uptime experienced initially on the Central Azeri platform rig operation and the exceptionally low number of unplanned events relating to the start-up of the new mechanised equipment.

However, traditionally it is not cost-effective to configure the graphics to suit a specific rig for training needs, other than newbuild start-ups. For operational training of crews who are already familiar with their own rigs equipment operation – whether manual or automated – it is sufficient to modify an existing programmed environment in order to reflect the specific rig's configuration.

Without changing the 3D environment, the software is reconfigured to suit the specific application by changing the other variables such as circulation system, BOP and choke configuration, mud pump numbers and specifications, power system parameters and hoisting system limitations.

It has been found that while the 3D environment may not reflect the particular installation, crews can familiarise themselves with the cyber chairs and controls within the first hour of the training programme, thus opening up a whole range of cost-effective training without complete simulator reconfiguration.

WELL DESIGN

Prior to any simulation, the software is programmed to represent the well design as proposed by the drilling engineers. Main well design inputs include basic wellbore geometry, casing scheme, mud/fluid properties, drillstring configuration, jar position and setup details and bit types. The data is then used by the software to calculate the appropriate parameters such as volumes, circulating pressures, torques and drags.

FORMATION, RESERVOIR

Key formation and reservoir characteristics can be programmed to derive the appropriate responses to specific crew actions as drilling proceeds through different geological formations or reservoir zones. The main programmable requirements include:

- Formation depths (TVD & MD)
- Formation pressures and fracture gradients
- Rock strengths and abrasiveness
- Geothermal gradient
- Rock/reservoir fluid properties (water/oil/gas)
- Porosity
- Dip and strike
- Kick/loss zones, faults, etc.

TRAINING SCENARIOS

The combination of the simulator with a fully facilitated workshop can result in a logical progression from "Drilling the Well on Paper" (DWOP) workshops to "Drilling the Well on Simulator" (DWOS) sessions. Here the hands-on involvement of the team can result in much more interaction with those who can contribute best to class performance.

A comparison between the Brent Charlie NDES simulator cabin and controls (above) and the Brent Charlie Original NDES equipment shows the realistic modeling of the training facility.

In addition to configuring the simulator to imitate the rig, well design and reservoir characteristics, the management team will have established the key scenarios to be used for training. "Snapshots" and "Facilitators Briefs" will be developed to effectively undertake the training and allow the drilling process to "fast forward" to a particular area of interest or concern in the well. These scenarios could comprise specific operations that are to be experienced by the team and which, if not optimally performed, could result in significant nonproductive time and associated cost.

DWOS

Before any simulation can take place, the simulator is programmed with all the relevant rig and well information as taken from the draft drilling programme or as provided by the operator. This is often the first time when all the rig and well information comes together and can in itself already highlight planning shortcomings.

Additionally, the standard operating and drilling procedures, operations risk register, previous lessons learned and specific project procedures are all collated by the facilitators and trainers. This allows the simulator, contractor and operator to discuss specific objectives.

After gathering everyone together – but before actually "drilling" the well on the simulator – the onshore and rig operations teams, along with service company representatives, hold the equivalent of a "pre-spud" meeting. Here, the project team, including the subsurface team, can present well objectives and information such as offset data and discuss learning from similar wells and any special procedures.

"Drilling the Well on Simulator" (DWOS) sessions are optimised when undertaken as a team exercise. While the driller drills ahead with the chosen parameters, the other team members can monitor the output from the simulator. Flow rates, rotary RPM and ROP will load the annulus with cuttings, increasing the hydrostatic bottomhole pressure and equivalent circulating density (ECD). Poor hole-cleaning may be noted with increasing pump pressure, torque and overpulls. Pump rate may be limited by pump liner size, nozzles, ECD or specific downhole equipment. The reservoir section being approached may be under- or overpressured. While "drilling," the planning and supervising team can review the techniques being used and monitor specific actions being taken, such as:

- Does the team circulate clean above the reservoir?
- Do they rotate or reciprocate during a flow check?
- Is there an LCM pill prepared? What does it contain?
- How/where are directional surveys taken?
- How is the well to be closed in?
- Is there a float in the string?
- Are they stuck?
- How are they stuck?
- How are they going to get free?

As the well progresses, an action register is built up. This will detail all the required actions to be completed before the well is actually drilled and may record such things as:

- Gaps in understanding of operations, procedures or the drilling programme;
- Inadequate information being available on the rigsite;
- Requirement to generate new procedures;
- Requirement to procure additional equipment;
- Requirement to fine-tune the well design;
- Conflict between service company, drill-

ing contractor and operator procedures;

- Lines of responsibility/reporting not clear;
- Lack of contingency plans/equipment;
- Opportunities to optimise operations.

At the end of the simulation, the action list is reviewed with the participants to ensure that all relevant issues have been captured and action parties assigned. By working through this action list, inefficiencies and potential problems are removed from the operation and assurance is built in. This is the key to the accelerated learning – through removing any poor practices and replacing them with best practices, thus giving greater confidence in achieving top-quartile performance.

It has been noted that the observation of the team dynamics is as valuable as the technical skills training, with the opportunity for rigsite and planning teams to work together being greatly appreciated by both teams, who rarely have the opportunity to interact, other than by remote communication or irregular site visits.

TTRD

TTRD operations are still new to some operators and crews. The combination of slimhole drilling, reduced design influx volumes and small drillpipe size could be new to the rig teams and result in poor performance. By using an advanced simulator, it is possible to significantly reduce the learning curve and deliver exceptional performance from the first TTRD well.

ERD

Ideally, all ERD wells would be drilled back-to-back with rigs equipped with 3 x 7,500 psi mud pumps, 60,000 ft-lb top drives and 4,000HP drawworks. This is rarely the case, and many ERD projects are already hampered with outdated equipment more suited to near-platform development wells. With discontinuous drilling sequences, or single ERD wells, performance is rarely exceptional and does not allow a learning curve to be developed. By using a suitable simulator, it is possible to build in a learning curve and deliver exceptional performance on each and every ERD well.

Operator-specific concerns can be addressed during an ERD simulation, generally focusing on hole-cleaning, ECD management and contingency planning. Again, it is found that the simulator exercises identify much more than a DWOP (Drilling the Well on Paper) exercise.

CONCLUSIONS

The use of a real-time, drilling simulator can significantly reduce the learning curve for drilling contractors and operators. The simulator training allows for the testing of communications and comprehension in a non-threatening environment, providing an ideal opportunity to test and develop emergency or contingency plans.

Savings are acknowledged to be significant, not only for state-of-the-art mechanised rig training but also by those who are exploiting drilling techniques such as TTRD and ERD.

The monetary value of avoiding "train wrecks" can be huge, and exceptional performance on a well can be invaluable. Confidence of delivery is given to senior management, additional subsurface targets become feasible, drilling sequences are filled and platform life extended. It is this potential that can really illustrate the value of simulated drilling operations.

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