DEA Workshop featured latest technologies

ATTENDEES OF THE 2004 DEA Workshop were treated to more than 20 presentations outlining the latest technologies, techniques and methods to make the drilling engineer's life a little easier. Following are brief synopses of the presentations.

Systems Engineering in Research and Development, **Julio Quintana**, Vice President Exploitation, **Schlumberger Oilfield Services**.

As operators consolidated in the 1980s and 1990s, much of the R&D fell into the laps of the service sector, resulting in an ever increasing percentage of E&P R&D centering on incremental improvement rather than system solutions to technical challenges. The evolution of mud-pulse telemetry, subsea systems and casing drilling are examples of how service companies are addressing industry needs by sustaining technology as a response to competitive pressures. However, he said the service sector alone cannot address industry needs that require industry-wide systems engineering solutions.

Three pressing issues today that need a systems engineering approach are subsalt imaging and development, multizone fracture stimulation and casing while drilling. However, he said, no one company can invest the amount of money needed to develop technologies even with significant returns on investment. Mr Quintana's recipe for a 21st century R&D prototype includes industry systems versus sustaining technology; financial drivers of the service sector will focus on sustaining technologies; quantify value of solution and value of accelerating the solution; E&P companies must commit to R&D; and all must collaborate.

Tender Assist Drilling, **Mark A Childers**, **Atwood Oceanics**.

Atwood Oceanics owns and operates two tender assisted semisubmersibles. Several advantages exist for these units. Loads and space requirements on the platform are significantly reduced as only the drilling package is installed on the platform, allowing a drilling package with a higher hookload and set back ratings to be supported by a smaller platform. The tender vessel houses the auxiliary systems such as quarters, helideck, power, active and reserve mud tanks, mud pumps, bulk tanks, etc.

The semisubmersible tender concept is self-erecting and serves as a construction barge for installation of the drilling equipment set (DES) on the platform. The vessel also provides additional storage areas for supplies, allowing inventory management for the drilling phase. In bad weather areas, on site storage reduces work boat related delays.

The tender offers additional accommodations; a construction site with its large rig-up crane and large deck area; well test and storage of clean up fluids; extended well test with the ability to flare produced fluids away from the deepwater platform; and a temporary platform for water flood, gas lift, andmetering off load platform for production fluids.

Additional options for future work include workovers, redrills and new drilling and then mobilizing the same or different semisubmersible tender and DES unit; share the tender and DES contract with other projects in an area; For major redrills, the DES can remain on the platform and if a tender is unavailable, another semisubmersible MODU could act as a tender; and in case workovers, a self-erecting modular rig with a 500,000 lb hook load rating could be used.

The tenders can be independent of the platform, thus providing a safe haven in the event of evacuation or emergency. Furthermore, tender operating efficiency has been estimated by two major operators to be between 10-25% better than platform rigs, according to Mr Childers.

Slider - Surface Automation for Directional Drilling, **Eric Maidla**, **Slider LLC**.

Automated technology for optimizing directional drilling with a downhole motor and measurement while drilling (MWD) system was developed by assimilating surface torque with downhole bit and drillpipe behavior. The technology was developed without introducing new or additional equipment downhole, allowing drillers to maximize drilling efficiency and improve wellbore quality due to less trajectory tortuosity during the sliding operation of the drilling process.

The technology integrates surface and MWD data to provide improved ROP and horizontal reach capability; improved tool-face correction while drilling without coming off bottom; improved well trajectory; improved motor life due to less stalling; quick and accurate tool-face orientation; no lost-in-hole exposure; time savings when switching from rotating to sliding without coming off bottom; overall performance optimization; and less stress on the directional driller due to automation of rocking and sliding techniques that were previously performed manually.

The Development of the First "TRUE" Oilfield Air Hammer, **John Adam Meyers**, **Diamond Air Drilling Services**.

Percussion drilling tools, or air hammers, have proven to significantly increase rate of penetration (ROP) in many oil and gas wells. However, the air hammers were typically designed for mining, water wells or industrial applications so their performance has not been optimized for the specific conditions of deep-hole oil and gas well drilling. Deep-hole drilling (below 8,000 ft) typically requires a higher amount of air volume to clean the annulus, higher air pressures (above 350 psi) to overcome formation water influx, as well as the capability of drilling under hot-hole conditions (above 250°F).

The conventional air hammer is designed with a foot valve assembly that utilizes a plastic tube on top of the bit as a valve to "seal" the bottom chamber of the hammer. Upon sealing the bottom chamber, high pressure air pushes the piston upward, thus starting the piston's cycle. The bottom chamber must be "sealed" in order for the piston's cycle to begin. If the foot valve is missing or broken, the hammer will not operate.

The major design concept of the oilfield hammer is to eliminate the foot valve mechanism while still maintaining a seal for the bottom chamber. The plastic foot valve can be a major nuisance when causing hammer trips. The conventional hammer is infamous for breaking the foot valve occasionally and causing an expensive trip out of the hole to replace a $30 piece of plastic. The design should minimize the accumulation of water in the bottom chamber so that the impact energy of the piston would not be compromised when mist or foam drilling.

Innovative Downhole Tool to Compensate for Annular Pressure Losses, **Roger Fincher**, **Baker Hughes INTEQ**.

A new drilling tool can actively reduce the pressure in the annulus while drilling. The goal of a JIP with ENI is to demonstrate the feasibility and value of the TurboLift FastTrack concept while exploring the concept of Static Balance Drilling (SBD).

The TurboLift FastTrack is an experimental prototype to demonstrate the technical feasibility of a downhole equivalent circulating density (ECD) reduction device. Two such devices have been built and successfully tested on a flow loop test bench and the first field test is currently under way. A market and feasibility study is also under way to identify applications and operational needs in close cooperation with operators who are helpful to accelerate the program. Commercialization in 2007 is possible.

To date, the JIP has modeled wellbore and tools system behavior, mapped client needs, investigated system concept and component design, manufacturing and full scale bench testing as well as a field test. The benefits of a dynamic ECD management tool in the wellbore include a portable downhole device that can be reconfigured. No modification to rig equipment is required and no change to mud weight or drilling underbalanced. Also, there are less HSE risks compared with other approaches.

Other potential applications include extended reach drilling. The tool will extend drilling sections and improve hole cleaning resulting in higher flow rates. In deepwater, the tool system could result in a positive effect on the casing program of the top hole sections and could also offer many of the benefits of dual gradient models as well as extend hole sections above the reservoir, allowing one casing section to be eliminated.

Telemetry Drill Pipe: A Very High Speed Drill String Communications Network, **Mike Reeves**, **Grant Prideco**.

Telemetry drill pipe is capable of transmitting high bandwidth data. It incorporates a high-speed data cable that runs the length of each joint of pipe and terminates at inductive coils that are installed in connections at each end of the pipe. The system is virtually transparent to standard rig procedures and offers reliable operation, according to Mr Reeves. Data is transmitted at 1 million bits per second, 125,000 times faster than mud pulse telemetry.

The high speed data cable is protected in the pipe and tool joint but does not interfere with mud flow or tool deployment. Inductive coils are installed in the pin nose and corresponding box shoulder. Alternating current in the coil produces a changing electromagnetic field that induces current flow in the other coil. The low power system requires no special handling or make up procedures.

Initial testing of full length prototypes in an Oklahoma field have been completed and extensive testing of 2nd, 3rd and 4th generation full length prototypes are under way in Utah. Additionally Grant Prideco tested 3,000 ft of the pipe with a major MWD/LWD company who developed an interface with the MWD/PWD tool. Additionally, cement jobs were performed with the pipe without problems. Grant Prideco also is working with a major jar manufacturer on a design that incorporates a coiled spring to accommodate jar movement.

Alternative Approaches to Dual Gradient Drilling Systems – A Research Update, **John Rogers Smith**, **Louisiana State University**.

Alternative dual gradient systems include seafloor pumps, for example, Subsea Mudlift and Deepvision concepts, glass beads in the riser (Maurer), nitrogen in the riser (Petrobras) and low density liquid in the riser.

Advantages of gas lift dual density systems include the use of underbalanced drilling equipment such as compressors and/or liquid nitrogen, mud/gas separator and rotating head. The system can achieve wellhead pressure equal to seafloor pressure and the cost versus benefit is favorable. Disadvantages include potentially large space requirements, kick protection and control are not well defined, requiring new methods, and control methodology for multiphase flow in the riser is incomplete.

Key research issues for dual density systems is how to maintain well control and detect kicks during all routine operations; how to control and remove kicks; feasibility of dilution of mud in the riser; how to separate high and low density fluids for reuse; and likely overall cost impact of each alternative on representative deepwater exploration and development wells.

Future issues include understanding and optimizing the cost/benefit relationship versus well prospects and available rigs; evaluate and develop required surface technologies; evaluate and develop required subsea and downhole equipment; develop control systems; develop operating procedures; and demonstrate system applications in full scale tests and field trials.

Maximizing Reservoir Potential Using Enhanced Analytical Techniques with Underbalanced Drilling, **Joe Ansah**, **Halliburton Energy Services**.

Underbalanced drilling objectives related to reservoir performance are to minimize skin damage, increase production rates and increase reservoirs. UBD eliminates damage caused by swelling of clay minerals within the formation; damage due to particle invasion into the formation; damage due to dissolution of matrix cementation, promoting migration of fines within the formation; and damage caused by interaction between drilling fluids and formation fluids, resulting in emulsion blocks, water block or changes in wettability of the reservoir rock.

UBD provides a unique opportunity to perform reservoir characterization early in the life of the well. With UBD, testing while drilling is equivalent to performing a continuous drill stem test. UBD can also derive a productivity index for each productive zone and derive undamaged rock properties utilizing in situ fluids while flowing at actual downhole conditions. The benefits include informed decisions while drilling, early completion design information and enhanced reservoir understanding.

Challenges with reservoir evaluation methods include analytical solutions that are restricted to simpler reservoir geometries and single phase flow in the reservoir where relative permeability is not considered. There are slower calculation times especially as more accuracy is desired. Gridding becomes an issue with the need to assume the zones of interest and reservoir geometry prior to drilling.

Deep Drilling for Natural Gas on the Shelf: With the Introduction to HP/HT Environments, Drilling Contractors Must Take Steps in the Right Direction, **Eddie Robertson**, **Rowan Companies**.

With royalty relief programs initiated by the Minerals Management Service (MMS) and recent lease sales with a majority of blocks leased on the Shelf, offshore drilling contractors should examine newbuilds versus modification to existing rigs to meet operator objectives. Criteria includes utilizing a rig for its design criteria, whether performance results support the need to upgrade or build a new rig, the cost of upgrades versus building a new rig, and the longevity of equipment. Rowan crunched the numbers and decided to build a new class of jackup aimed at the shallow water, deep gas market on the Shelf and produced the Tarzan Class jackup, four of which were ordered by the company.

The rig utilizes higher yield steel for a 10% reduction in total weight that can be incorporated into a higher variable load. A 440 kip opposed jacking system provides the capability to jackup with 50% preload and gain more effective leg length due to a shorter jack housing as well as fewer motors and gear boxes. The rig also has three 3,000 hp mud pumps and enhanced solids control equipment. The derrick has a 2 million lb hook load capacity.

HPHT Deep Gas Well Design Learnings, **U B Sathvalli**, **Blade Energy Partners**.

Today's challenges are extreme pressures, including high MASPs and high H2S partial pressures; extreme temperatures that affect downhole electronics, drilling fluids, elastomers and large delta-t effects; and extreme depth, which produces geologic uncertainty. The goals of good design are to reduce tubular costs by identifying optimium fit-for-purpose design and maximize tubular reliability through quality assurance and field running procedures.

There are several tubular design issues. Burst loading using MMS guidelines exceeds API and von Mises limits. Compressive loading during production are

high and may exceed connection capacity. Collapse load exceeds the API limit, and tensile loads, while not a problem for the casing, present a challenge for the rig.

Conventional design methodologies need scrutiny when extreme HPHT scenarios are considered. A working draft of the ISO 10400 allows the use of less conservative properties and the evaluation of property variations on tubular performance. Optimal tubular design of extreme HPHT/deepwater wells requires careful evaluation of tubular performance based on actual and expected properties rather than nominal API SCT type values, often on a case by case basis. Optimal tubular design also requires examination of loads from a holistic point of view that regards wellbore integrity as a whole rather than string by string analysis. Also tubular design requires ensuring that optimal performance of tubulars is obtained by specifying appropriate manufacturing tolerances.

Finite Element Analysis Simplifies Complex Engineering of Cement Sheaths for HPHT Production Operations, **James E Griffiths**, **Halliburton**.

Several problems exist in the industry regarding cement quality in HPHT wells, including sustained casing pressure, casing vent flows, casing corrosion and collapsed casing. These events occur typically from cement properties that are brittle, have low tensile strength and low Poison's ratio. Use of finite element analysis (FEA) can provide an effective method for arriving at a cement design for life-of-the-well conditions. The cement may not need to be enhanced if extreme pressure from testing and stimulation is minimized. The industry has several cement types available with varying engineering properties. FEA helps the user choose the optimal well solution based upon cement integrity needed versus cement costs. FEA is available to perform pre-job designs for primary jobs or post-mortems for remedial actions.

Surface BOP Technology: Latest Advances & Guideline Development, **Tim Newman**, **Shell International E&P**.

Shell's challenge was to drill a well in 9,474 ft of water with a DP rig rated for 7,500 ft of water. Utilizing a surface BOP enables use of a smaller diameter high pressure casing riser with a seabed disconnect system, and enables the use of a smaller earlier generation rig at generally lower cost than a 5th generation unit. Available technology included the surface BOP, a concept of a subsea disconnect system and advanced acoustic communications. Subsea disconnect system (SDS) issues to be resolved were to use one shear ram or two, and could acoustic communications be relied upon or should an umbilical be used? Weight and handling was another key issue. The design target weight of the system was 90,000 lbs but the final weight was 165,000 lbs. Shell split the system into five modules with the heaviest load at 75,000 lbs.

Shell used the Stena Tay, a 4th generation DP semisubmersible with a 7,500 ft water depth rating and hydraulic derrick and tensioners. This was to be the deepest water depth well in Brazil and the deepest water depth well drilled by Shell. This would also be the first use of an SBOP in a non-benign environment and the first with a DP rig as well as the first use of a subsea disconnect system.

Full Length Inspection of Marine Risers Utilizing a High Speed Multi-channel Full Circumference Profiling System, **Hilton Prejean**, **Tuboscope**.

Marine risers are inspected for wall loss, wear, cracking in welds, defective connections, worn seals and locking dogs, corrosion and erosion, dents and ovality. During optical inspection, a crawler goes the full length of the riser joint internally with a video camera for inspection, which can take hours and is the reason for the new profiling system tool. The eddy current inspection is just above the surface and looks for imperfections or changes in wall thickness that may occur during use. This inspection tool reduces the time by 2-3 hours due to its 360° capability inside the riser. The information is then put into a color coded chart with each color corresponding to a degree of thinner wall than nominal and that portion can be located from the chart. Another tool can inspect long seams as well as a circumference scan using a shear wave.

A Solution to VIV of Drilling Risers in Loop Currents, **Steve Armstrong**, **Shell Global Solutions**.

Drilling riser vortex induced vibration (VIV) can result in excessive drag and riser angles, large riser vibration, severe wear and fatigue of the riser and wellhead/soil interface damage, all of which could result in suspension of drilling operations. Current induced VIV can adversely affect a deepwater drilling program. Consequently, VIV caused downtime or VIV suppression installation time should be factored into a deepwater drilling program risk analysis.

Shell developed fairings that can be installed and removed from risers and pipelines to reduce or eliminate VIV in deepwater. Over the past 15 years extensive VIV research and development have been performed and a solution has been developed consisting of two parts. The first is a proper analysis of the riser VIV suppression requirement and the second is fitting the riser with a VIV suppression device. The objective of the VIV suppression analysis to determine what type of suppression to use, how much suppression to use, and where to use it.

Turbodrill and High Speed Bit Analysis in Extreme Drilling Applications, **Rocky Seale**, **Smith Bits Geodiamond**.

Turbodrills provide unparalleled performance in the most hostile environments and, despite their success, there is still room for improvement. Smith Bits Geodiamond has addressed some of the issues on gear units.

A standard old style bit has a lot of diamonds and blades. The company has opened up the cutting structure to allow better hydraulics and better flow, resulting in more efficiency in a formation. The company has done research with the matrix ensuring that the diamond is consistent throughout the blade.

In deep and ultra deep drilling, the cost rises exponentially, so the faster you can drill an interval and the fewer times you can trip out of the hole, the better the well economics. That also provides for a safer operation, which gets back to time and money saved. In terms of reliability, that is also improving. There have been runs of up to 7,000 hours without a failure.

Seismic While Drilling with a Swept Impulse Source, **Jack Kolle**, **Tempress**.

There are several problems when drilling deepwater wells including low margin between fracture gradient and mud density and risk of shallow water flows, gas kicks or circulation loss. Existing services do not provide accurate real-time pore pressure data at the bit or ahead of the bit. Conservative approaches to casing and liner placement can lead to higher well costs.

The solution is high resolution seismic while drilling (SWD) with seismic depth correction and profiling and providing real-time pore pressure at the bit and look-ahead pore pressure prediction. Tempress has developed its HydroSeis Swept Impulse Tool that is mud powered without electronics. The tool features a high amplitude broadband source with continuous pulsing comparable to an airgun array amplitude. Real-time processing is hardware or software based. It can be used in conventional drilling operations and is capable of meeting Deepstar criteria.

Tempress is proposing a DEA/JIP to demonstrate deep onshore capability with a prototype to test improved pilot signal acquisition, receiver configuration, increased sweep bandwidth, demonstrate reliability while drilling and lost circulation compatibility. For processing and display, a possible JIP would demonstrate real-time vertical corridor stack, seismic section depth migration and integrated pore pressure prediction. For deepwater geophoneand hydrophone deployment a JIP would investigate ocean bottom cables and hydrophone arrays.

Continuous Circulation System: Constant Drilling Fluid Circulation Even During Connections, **Hugh Elkins**, **Varco Drilling Equipment**.

Numerous advantages result from continuous circulation systems (CCS), including near steady state circulating conditions and continuous drill cuttings transport as well as continuous ECD control. CCS allows for a more even drilling fluids treatment cycle and operating within a narrow pore pressure/fracture gradient differential. CCS can also result in lower drilling fluids costs and improved overall bit penetration rates as well as a significant reduction in stuck pipe incidents.

Wellbore Stresses and Thermal Effects, **Ben Bloys**, **ChevronTexaco**.

The paper presented the results of temperature effects on boreholes and suggested possible DEA projects. Higher borehole temperatures from hot drilling fluids will cause rock to try to expand. Since it cannot expand outward it tries to expand radially and toward the inside of the borehole. Also, since it can't expand, the hoop stress level in the rock will increase.

This higher stress will increase the rock's resistance to fracture. Conversely, chilling the rock (deepwater drilling) makes it more tensile and easier to fracture and lose circulation. This effect has been well known in stimulation and production operations. The higher the temperature of fracturing fluids, the harder it is to break a formation.

ChevronTexaco will perform internal company testing in 2005 on rock mechanics on Gulf of Mexico cores to quantify hot mud effect with standard Berea sandstone and shale for heat capacity and thermal expansion.

Additional testing will include downhole friction sub development for deepwater drilling and downhole liner cementing equipment to apply hot mud technology. Improvements in modeling software will be examined.

Possible DEA projects in 2005 include the need to look at insulation effects for the riser and at ways to heat mud at the rig site in the mud pits.

New Technology Can Widen Mud Weight Window to Significantly Lower Well Costs, **Hong (Max) Wang**

The method presented uses the rock mechanics of the borehole to hold pressure that is much higher than normally possible.

The challenge is to widen the mud weight window (MWW) so the operator can reduce drilling costs by eliminating intermediate casing strings and liners; reducing or eliminating mud losses while drilling; and achieving the one-trip well, wherein a single diameter wellbore is drilled from the surface casing shoe to TD without a bit change, then cased with a single production string.

An advanced engineering process to widen the MWW to help achieve these benefits includes data analysis, job design, treatment delivery and post-job verification.

The key process in the system is placement of sealant in wellbore cracks to strengthen the wellbore to enable the use of a greater range of mud weights, i.e., a wider MWW.

Offshore Managed Pressure Drilling Activity, **Don Hannegan**, **Weatherford**.

Managed pressure drilling is an enabler for other emerging technologies. These include all variations of dual gradient drilling, including true dual gradient drilling with a marine riser and subsurface BOP; light fluid injection into the riser; and riserless dual gradient with returns to the rig. Additional technologies are drilling with casing, slim riser, deepwater drilling with a surface BOP and dealing with riser gas while drilling ahead.

Unlike UBD, MPD is uniquely suitable for dealing with wellbore instability by imparting greater overbalance than drilling fluids and cuttings in the wellbore would otherwise impart. Additionally, no more hydrocarbons are produced to the surface than with conventional drilling. Also, a complete UBD kit is not required for MPD systems.

A rotating control device is required for most applications of MPD, onshore and offshore. An RCD and a dedicated choke manifold affect a closed and pressurizeable mud returns system while drilling ahead.

About 75% of the working rigs in the US and Canada use a rotating control head in each well's drilling program for one reason or another. A larger number of RCHs are used onshore for MPD purposes other than underbalance drilling.

Offshore variations of the rotating control head have been developed and proven for UBD and MPD operations offshore.

Additional specialized equipment that was initially developed for UBD operations that enable various MPD applications include wireline retrievable drill string float; downhole deployment valves; membrane nitrogen generation units; real-time pressure and temperature monitoring; closed system surface separation; drilling with casing; and drill-in liners. ■