Deepwater Introduction
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OPTIMIZING TODAY’S PRODUCTION AND ASSURING TOMORROW’S DEEP WATER SUCCESS
Agenda

- Definition
- Background
- Challenges and Case Study
- Well Integrity
Definition
# Offshore Environment

<table>
<thead>
<tr>
<th>Water Depth Limitation</th>
<th>Drilling Operation</th>
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<tbody>
<tr>
<td><strong>Shallow Water</strong></td>
<td>Shallow water drilling ops. is dominated by Jack-Up rigs</td>
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<td>0 – 999 ft / 0 – 304 m</td>
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<tr>
<td><strong>Mid-Water</strong></td>
<td>Drilling ops. primarily carried out by early generation semi-submersible</td>
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<td>1,000 – 3,999 ft / 305 – 1,200 m</td>
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<tr>
<td><strong>Deep Water</strong></td>
<td>Drilling ops. primarily carried out by mid-generation semis and drillship</td>
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<td>4,000 – 6,999 ft / 1,200 – 2,133 m</td>
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<td><strong>U-Deep Water</strong></td>
<td>UDW rigs are the most technically capable MODUs</td>
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<td>7,000+ ft / 2,133+ m</td>
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Background
Background – Why Deepwater Matters?

**Global Growth**
- Elasticity to demography
- GNP per capita effect

**Reservoirs**
- Insignificant spare capacity
- Accelerating decline rates

**Implications for E&P**
- Push mature reservoirs
- Chase unconventional

**Manage Extreme Environments**
Challenges and Case Study
Deepwater Challenges

- Water Depth/Environment
  - 1990 - 1000'
  - 2015 - 10,000'
  - Benign to Harsh

- Geological Complexity Increasing
  - Subsalt
  - Rubble Zone
  - Narrow drilling windows

- Reservoir Characteristics
  - Ultra HPHT
  - PF/FG Complexities
  - Fractured Carbonates
Deepwater – Case Study

Macondo/Deepwater Horizon Lesson Learnt

Well integrity was not established or failed
1. Annulus cement barrier did not isolate hydrocarbons
2. Shoe track barriers did not isolate hydrocarbons

Hydrocarbons entered the well undetected and well control was lost
3. Negative pressure test was accepted although well integrity had not been established
4. Influx was not recognized until hydrocarbons were in riser
5. Well control response actions failed to regain control of well

Hydrocarbons ignited on the Deepwater Horizon
6. Diversion to mud gas separator resulted in gas venting onto rig
7. Fire and gas system did not prevent hydrocarbon ignition

Blowout preventer did not seal the well
8. Blowout preventer (BOP) emergency mode did not seal well
Deepwater – Case Study

Macondo Impact to Environment

Spill characteristics:

- Volume
  4.9 million barrels ±10%

- Area
  2,500 to 68,000 sq. mile
  (6,500 to 176,100 km²)

Source: National Ocean Industries Association Annual Conference – April 15, 2011
Technology Adoption Post-Macondo

April 20, 2010: Macondo

How can I drill this well?

How can I improve the economics of this well?

How can I improve operational safety?

Safety

Efficiency

Drillability
Technology Adoption Objectives

<table>
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<tr>
<th>Reduce Risk</th>
<th>Minimize Cost</th>
<th>Optimize Production</th>
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</thead>
<tbody>
<tr>
<td>- How to avoid hurting people</td>
<td>- How to design and engineer wells that achieve reservoir objectives within cost constraints</td>
<td>- How to inform decisions and take control actions to optimize production and maximize recovery</td>
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<td>- How to apply technology to overcome the limitations of conventional drilling wisdom</td>
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Well Integrity
Well Integrity

“The instantaneous state of a well, irrespective of purpose, value or age, which ensures the veracity and reliability of the barriers necessary to safely contain and control the flow of all fluids within or connected to the well.”

Well integrity must be maintained throughout the well’s lifetime, from well construction, through completion, steady state production, intervention, decommissioning and abandonment.
Well Integrity – Key Elements

Planning the Well

Managing Risks while Drilling

Managing Integrity

Completing for Lifetime Integrity

Plan

Drill

Construct

Produce
Well Integrity – Key Elements

Planning the Well
- Well design and engineering according to objectives
- Risk Management: Analyse & Mitigate the risks, Technology applications and availability, Establish process safety

Managing Integrity
- Wireline logs – cement quality and casing inspection logs, Casing leak detection Zonal isolation of reservoir fluids
- Reservoir pressure measurements
- Well intervention services – fit-for-purpose technology as necessary and economical

Managing Risks while Drilling
- Wellbore Pressure management
  1. Closed loop drilling techniques – MPD
  2. Solid expandable systems for contingency
  3. Drilling with casing for dealing with problem hole sections

Completing for Lifetime Integrity
- Comprehensive casing handling services, including ensure connection integrity
  1. Tubular management services
  2. Best-in-class completing equipment, including Casing shoes, Swellable elastomer packers, Liner hanger systems, completion systems
Managing Risk in Deepwater Drilling

GEOLOGICAL COMPLEXITY

PMCD – Pressurized Mud Cap Drilling to address severe circulation losses provides multiple efficiency and safety benefits over conventional methods.

CBHP – Constant Bottom Hole Pressure to navigate narrow mud weight windows and HPHT wells in clastic reservoirs.

PMCD and CBHP to addresses uncertainties and risks associated with pre-salt formations.

Carbonate  Clastic  Pre-Salt
Deepwater MPD System

- MPD Riser Joint
- Buffer Manifold
- Hydraulic Power Unit (HPU)
- Rotating Control Device (RCD)
- Annular Isolation Device
- Automated MPD Control Manifold
- Automated MPD Detection Manifold
- Reelers
- MPD Flow Spool

Optimizing today's production and assuring tomorrow's deep water success

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Deepwater MPD System

Weatherford MPD Integrated Riser Joint with Model BTR-S RCD

Indonesia, 2016

Deepwater, integrated

- Ensco 8504
- MPD deepwater system

New integrated MPD riser stack design offers:
- Reduced flat time
- Significantly improved operational safety
**Well Integrity – Key Elements**

### Planning the Well
- Well design and engineering according to objectives
- Risk Management: Analyse & Mitigate the risks, Technology applications and availability, Establish process safety

### Managing Risks while Drilling
- Wellbore Pressure management
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### Completing for Lifetime Integrity
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**Plan**

**Drill**

**Construct**

**Produce**
Connection Integrity

JamPro – TorkPro 3 Software

- **Connection Integrity**
  - Quality connections are critical to well integrity and operational efficiency
  - Torque turn monitoring equipment used to evaluate connectional make up and mitigate risk of failure

- **TorkPro-3 Software**
  - Graph Overlays and Auto evaluation
  - TorkPro 3 is compliant with 2016 general VALLOUREC requirements, with the VAM Field Services and VAM threading Competence Center specifications (TSSU & TSLI)

- **JAMNet**
  - Real Time Monitoring
Handling Equipment – The Stabberless System

Conventional

Advanced

Conventional

Advanced
Tubular Manager Services

- TorkWrench 10-100 MBU
Real Result

TorkWrench™ Iron Roughneck Improves Efficiency, Saves ENI Over $2.2m and 63 hours of Rig Time

Value to Client

- The ability to remotely operate the MBU and its capacity to handle double stands reduced the number of required personnel on the rig floor, enhancing operational safety.

- The TorkWrench MBU successfully performed 422 makeups and 158 breakouts over a 154-day period, saving the operator 63hrs and $2.2m.

Client
ENI Krueng Mane Ltd.

Well Type
Offshore, vertical

Product / Services
TorkWrench 10 – 100 MBU
For post-event discussion, please send questions to

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