RLWI, Myths and Misperceptions

Presented by: Ole Edvind Karlsen, VP Global Subsea Operation- Welltec
Date: 14th April 2014
Introduction

Global decline

- Global decline in production (peak oil)
- Increasing consumption

Average Global Recovery Factor without Interventions = 22%

=> 78% left in the ground

The best place to find oil is in the oilfield
World Liquids Supply By Type

We are not running out of oil, We are running out of “easy oil”

We have to further explore the need for cost-effective solutions as RLWI in conjunction with robotic tools.

Source: Exxonmobil

Norwegian Oil production is increasing again. After being on decline for 13 years!!!!!

Source: Dagens Næringsliv 15. Januar 2014
**Intervention Strategy**

- Do you have one?
- Break/fix or scheduled?
- Consider when and whether to intervene
Drivers for Subsea Intervention

- Productivity of subsea wells considerably lower
- General global decline in production
- Increased portfolio exposure to subsea production
- Deeper waters - Greater need for alternatives to costly rig based intervention
- Tightening market for offshore drilling rigs

Gap in recovery from subsea fields

<table>
<thead>
<tr>
<th>CAT A</th>
<th>CAT B</th>
<th>CAT C</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSV</td>
<td>Riserless LWI</td>
<td>Rigid Riser LWI</td>
</tr>
<tr>
<td>Vessel (KUSD/d)</td>
<td>100</td>
<td>200 – 250</td>
</tr>
<tr>
<td>Spread Cost w/Vessel (KUSD/d)</td>
<td>250</td>
<td>300 - 400</td>
</tr>
</tbody>
</table>

Source: Various industry sources
Subsea Challenge

- Lack of Intervention on subsea wells (cost)
- Reduced productivity of subsea wells (~25% less)
- Shortage of drilling rigs
- Intervention too costly/risky (production)
- >>>>> Intervention not performed

Norwegian Recovery Rates

- Field 1
- Field 2
- Field 3

Production vs. time graph showing the trend of recovery rates from 1986 to 2001.
Key Components for RLWI

- **DP2/3 Intervention vessel**
  - 100-150M$, 2 yrs lead time

- **Subsea Lubricator**
  - 30-80M$, 1.5-2 yrs lead time

- **Mechanical Intervention services**
  - Continually developing; ENABLER for the utilization of subsea non-rig based intervention
Well Intervention Options

CAT (A)
Light intervention

CAT (B)
Medium intervention

CAT (C)
Heavy Intervention

Source FMC
Global Subsea Intervention Market

Limited availability

Note: All numbers are 2012 estimates
Source: Quest Offshore; Infield Systems database

Gulf of Mexico
- Existing subsea wells: ~830
- Number of available subsea lubricator systems: 5
- Number of suitable intervention vessels: 10

Brazil
- Existing subsea wells: ~1000
- Number of available subsea lubricator systems: 0
- Number of suitable intervention vessels: 1

West Africa
- Existing subsea wells: ~800
- Number of available subsea lubricator systems: 0
- Number of suitable intervention vessels: 2

North Sea
- Existing subsea wells: ~1800
- Number of available subsea lubricator systems: 5
- Number of suitable intervention vessels: 11

South East Asia/Australia
- Existing subsea wells: ~400
- Number of available subsea lubricator systems: 1
- Number of suitable intervention vessels: 6

World total
- Existing subsea wells: ~5500 by YE 2012
- Number of available subsea lubricator systems: 11
- Number of suitable intervention vessels: ~30

11 Subsea Lubricators Worldwide. 4 on LT contract. 3 are 3” ID. 4 available on call out for standard subsea XMTs. ~30 Intervention Vessels Worldwide.
<table>
<thead>
<tr>
<th>Myth</th>
<th>True or false?</th>
<th>RLWI Community Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>“RLWI is for logging and perforating only”</td>
<td>✗</td>
<td>False - Any intervention performed on a platform can be performed using RLWI; incl. complex mechanical or clean-out operations, subject to rig up height.</td>
</tr>
<tr>
<td>“You can only perform it on shallow waters”</td>
<td>(?)</td>
<td>What is Deepwater? – Depth limitations are not due to the RLWI technique, but due to ratings on subsea lubricator components &amp; umbilical length. This boundary is being extended every year (2012 = 1216m).</td>
</tr>
<tr>
<td>“You cannot perform fishing operations on RLWI if something goes wrong”</td>
<td>✗</td>
<td>False – Toolstrings can be configured to release at various points for fishing with SSL. Proper planning allows additional lubricator sections to be stacked to hold fishing-string + fish.</td>
</tr>
</tbody>
</table>
### Common Myths and Misperceptions of RLWI

<table>
<thead>
<tr>
<th>Myth</th>
<th>True or false?</th>
<th>RLWI Community Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Sea currents make the cable-through-water concept very unsafe for deeper wells&quot;</td>
<td>✗</td>
<td>False – Open water e-line operations have been successfully performed to 1881m. Correct planning and downline management along with cable simulation software can mitigate this risk.</td>
</tr>
<tr>
<td>&quot;RLWI cannot be done year around&quot;</td>
<td>?</td>
<td>Depends – RLWI operations are performed year round in some areas of North Sea. Reconnection to well after disconnect is much faster than a rig. Job by Job basis.</td>
</tr>
<tr>
<td>&quot;Normally you’d have to have a rig going in there anyways, as RLWI usually cannot finish the job&quot;</td>
<td>✗</td>
<td>False – Of 400+ RLWI operations only 1 occurrence where a rig had to be mobilized to recover the situation; proper planning can avoid these issues.</td>
</tr>
</tbody>
</table>
Subsea Wells vs. Water Depth

Wells with water depth that need further technology development before intervention can take place:
- 1% Wells from 0 - 69 m (0 ft – 300 ft); No RLWI DP2 vessel recommended
- 4% Wells from 70 - 600 m (300 ft – 1,970 ft)
  This is were we do RLWI operations today on
- 7% Wells from 601-1,500 m (1,970 ft - 42,921 ft)
  This is waterdepth were RLWI operations have been proven successful in GoM.

Wells from 0 - 69 m (0 ft – 300 ft); No RLWI DP2 vessel recommended

Wells from 70 - 600 m (300 ft – 1,970 ft)
  This is were we do RLWI operations today on

Wells from 601-1,500 m (1,970 ft - 42,921 ft)
  This is waterdepth were RLWI operations have been proven successful in GoM.

With next generation RLWI stack`s, RLWI operations at 2000m water depth is possible!

RLWI intervention possible in 89% of the subsea wells with todays technology!
**E-line intervention = step change in HSE performance**

- Development in Statoil intervention methods and Norwegian personnel injuries

- Subsea CT requires a riser to surface.

- Same results now on E-line (cleaning, milling, shifting, injecting, cutting, etc.) ➔ ➔ RLWI is technology enabled.

- 2000+ RLWI operations performed with excellent HSE and Quality performance
E-line intervention = step change in HSE performance

- Development in Statoil intervention methods and Norwegian personnel injuries

Introduction of Mechanical e-line services

Personnel injuries - Drilling and Workover

Number of interventions

Injury frequency*

(1992 - 2012)
Expanding the Work Scope on Electric Line

Shifting Subsea wells from heavy solutions to the world of lightweight electric line operations is a revolution of the subsea industry

**Electric Line Advantages:**
- No need for a rig
- Deployed from small vessels
- Most cost-effective solution
- Increased operational efficiency
- Smaller carbon footprint
- Available for Deep Water

Electric line services cover 90% of the work scope for RLWI
West of Shetland Operations

• 2009-2012
  Challenging due to high current.
  Rapidly gained experiences.

• Current 1.5 to 3.5 knots from 50 - 160 meter
• Current 0.7 – 1.2 knots from 360 – 460 meter

Source: Island Offshore
Data input for calculating current effect in open water

- Metocean data from Petrobras

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>1</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.11</td>
<td>NE</td>
<td>1.26</td>
<td>NE</td>
<td>1.31</td>
<td>NE</td>
</tr>
<tr>
<td>30</td>
<td>1.11</td>
<td>NE</td>
<td>1.26</td>
<td>NE</td>
<td>1.31</td>
<td>NE</td>
</tr>
<tr>
<td>100</td>
<td>1.06</td>
<td>NE</td>
<td>1.18</td>
<td>NE</td>
<td>1.22</td>
<td>NE</td>
</tr>
<tr>
<td>350</td>
<td>0.82</td>
<td>NE</td>
<td>1.02</td>
<td>NE</td>
<td>1.07</td>
<td>NE</td>
</tr>
<tr>
<td>500</td>
<td>0.52</td>
<td>N</td>
<td>0.59</td>
<td>N</td>
<td>0.61</td>
<td>N</td>
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<tr>
<td>1000</td>
<td>0.57</td>
<td>N</td>
<td>0.64</td>
<td>N</td>
<td>0.66</td>
<td>N</td>
</tr>
<tr>
<td>1250</td>
<td>0.42</td>
<td>N</td>
<td>0.48</td>
<td>N</td>
<td>0.49</td>
<td>N</td>
</tr>
<tr>
<td>1500</td>
<td>0.22</td>
<td>N-NE</td>
<td>0.27</td>
<td>N-NE</td>
<td>0.28</td>
<td>N-NE</td>
</tr>
<tr>
<td>1650</td>
<td>0.3</td>
<td>N</td>
<td>0.36</td>
<td>N</td>
<td>0.37</td>
<td>N</td>
</tr>
<tr>
<td>1694</td>
<td>0.26</td>
<td>N</td>
<td>0.34</td>
<td>N</td>
<td>0.37</td>
<td>N</td>
</tr>
</tbody>
</table>

Based on an assessment, the fatigue loading and vortex induced vibration data set was used to assess the worst case scenario.
Environmental Loading On Electric Wireline in open water

• If the wire is kept very tight between the vessel and the seabed, excessive force will be the result.

• Cable data input can be compared with a sail: The tighter the sail is, the more forces will be transmitted to the mast.

If the wire is spooled out from 1,100 m (base case) to 1,250 m (i.e. 150 m wire in excess of water depth) the resulting force on the wire and on the wellhead (Pressure Control Head (PCH)) would drop from 20 KN (2000 kgf) to 3.5 KN (350 kgf).

• Hence, by allowing the wire to “drift” 150 m, the resulting force is acceptable and the operation can be performed without excess force on the wire / PCH.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable Diameter</td>
<td>8.18</td>
<td>mm</td>
</tr>
<tr>
<td>stretchFactor</td>
<td>1.35</td>
<td>m/km/5N</td>
</tr>
<tr>
<td>Cable Weight in H2O</td>
<td>233.00</td>
<td>kg/km</td>
</tr>
<tr>
<td>rho_c</td>
<td>1,030</td>
<td>kg/m^3</td>
</tr>
<tr>
<td>C_D0</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>C_L0</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>7.05E+10</td>
<td>N/m</td>
</tr>
<tr>
<td>x_well</td>
<td>0</td>
<td>0, -1,100</td>
</tr>
<tr>
<td>N</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>5.26E-05</td>
<td>m^2</td>
</tr>
</tbody>
</table>
RLWI - A tool to help you reach your IOR Goal

RLWI operations with subsea lubricator for wireline work and with expanding Surface Read Out (SRO) capability of collected data will increase recovery.

**Typical applications:**
- Data gathering (PLT)
- Perforating
- Well barrier re-establishment prior to rig work over
- Zone isolation (plug/straddle)
- Milling and removal of scale
- Chemical Spotting
- Inspection/repair
- Camera inspection
- Change-out of gas lift valves
- Sleeve operations – DIACS valves
- Caliper logging
- Fishing on e-line
- Temporary P&A operations of subsea wells

RLWI enables the application of Robot Technology in subsea wells at a substantially lower cost compared to conventional rig operations.
Example of expanding Surface Read Out (SRO) capability of collected data

- The toolstring is moving down the well.
- The yellow areas is the sleeve.
- The red and green are latching profiles.
- 218 WK has just passed lower latching profile.
Milling Ashphaltenes in world record water depth

Results:

• First time ashphaltene has been milled on e-line
• Achieved in 1216m water depth
• Successful samples recovered for chemical analysis before future interventions
Operation of DKOT system down hole
Increased Oil Recovery

IOR by 1% on Statoil Subsea wells equal 50 bill USD......

Should also be possible globally!!!

We do have the Apps, but we need some mobil phones

Source: Statoil
... and thank you for your time
West of Shetland
Island Constructor - new in 2008
Riser Less Light Well Intervention Services
Island Constructor

- Delivered 2008
- DP-3 Dynamic Positioning
- Ulstein X Bow
- 8m x 8m Moon Pool with Curser Frame System
- 2 Work Class ROV's
- Tower 100t AHC Main Winch 1 Fall, 200t (2 falls)
- 140T AHC Main Deck Crane (500m) 94t (2500m)
- Cargo Cranes 15t and 2.5t
- 1500m Control and Chemical Umbilical's
- Deck Skidding System
- Mud/Brine Tanks 500m³ (3144 bbl.)
- Chemical Tanks 199m³ (1250 bbl.)
- Well Service Pumps

**Main characteristics**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deadweight</td>
<td>9100 tonnes</td>
</tr>
<tr>
<td>Cargo deck area main</td>
<td>1380 m²</td>
</tr>
<tr>
<td>Cargo deck area mezz</td>
<td>320 m²</td>
</tr>
<tr>
<td>Max speed (at d=6.0 m)</td>
<td>15.3 knots</td>
</tr>
<tr>
<td>Generator power</td>
<td>13800 ekW</td>
</tr>
<tr>
<td>Length over all</td>
<td>120.2 m</td>
</tr>
<tr>
<td>Breadth moulded</td>
<td>25.0 m</td>
</tr>
<tr>
<td>Depth to main deck</td>
<td>10.0 m</td>
</tr>
<tr>
<td>Design draught</td>
<td>7.0 m</td>
</tr>
<tr>
<td>Draught, max</td>
<td>8.0 m</td>
</tr>
</tbody>
</table>
West of Shetland
Yes we can!

This presentation has been prepared as a general overview of challenges encountered during LWI operation for BP West of Shetland from 2009 to 2013.

Some information will be shared with regards to how Island Offshore as an organization and the vessel has dealt with these challenges.
Why is West of Shetland so difficult?

**West of Shetland 2009 (WoS)**
During the initial LWI campaign in 2009 when operating WoS we found conditions challenging which we found were mainly due to high sea currents in the WoS area. Due to these challenging conditions experience and learnings were quickly gained in how to react to and overcome the conditions and it was very much to the credit of the operational personnel onboard that the campaign in that first year ended without any major incidents and no harm to personnel or damage to the environment. Given that this type of Intervention operation from a Monohull vessel in the WoS area was totally new with the vessel, personnel and equipment/systems also being new it was deemed that the campaign was to a fair degree a success with this initial campaign.

Post the operations in 2009, the Island Constructor was taken into dry dock in Stavanger where the extent of the challenges experienced in the initial campaign WoS were to be seen. The damage to the lower part of the moon-pool area of the vessel indicated in the following slides show that the initial campaign may not have been as successful as it was due to the damage that was caused by contact of the Subsea controls umbilical and the vessel Guide Wires causing severe frictions in these areas and thereby inflicting wire-cut grooves in the Hull & Cursor Guide beams.
Aft starboard corner/lower section of cursor guide beam.

Also signes on forward starboard guide beam that GW or umbilical has been trapped behind cursor beam.

Aft port lower section of moonpool/guide beam
Guide Wire acting as a wire saw cutting into LCF structure

Damage to Subsea stack controls umbilical due to sea current and frictional forces against the vessel structures
Why is West of Shetland so difficult?

West of Shetland
The following slides are not a scientifically correct illustration. The slides have been included to illustrate the complexity of the waters between Shetland and the Faeroes Isles to highlight the necessity of constant monitoring of all the associated elements that make WoS a very challenging environment to conduct Subsea Interventions with regards to the various oceanic and sea currents that exist in the area, this makes the attempting to predict the behavior of subsea equipment in these conditions very difficult.
Why is West of Shetland so difficult?

Main current components - NOT including tidal current!

- **MNAW** = Modified North Atlantic Water: flows mainly south west at low speed
- **NAW** = North Atlantic water (slope current): flows mainly north east
- **EI/AIW** = East Icelandic/Arctic Intermediate Water: flows mainly south-southwest
- **NSAIW** = Norwegian Sea Arctic Intermediate Water: flows mainly southwest
- **NSDW** = Norwegian Sea Deep Water: flows mainly southwest
Why is West of Shetland so difficult?

BP: Schiehallion/Foinaven/Loyal

© Department of Mathematics
University of Oslo
1995
Why is West of Shetland so difficult?

NSDW = Cold Norwegian Sea Deep Water
EI/AIW = Cold East Icelandic/Arctic Intermediate Water
MNAW and NAW = Surface water North Atlantic Water (slope current)

Conclusion: Schiehallion / Foinaven / Loyal = unpredictable congestion
Cascading

Winter cooling or evaporation helped by lack of freshwater on shelf

→ dense water

→ down-slope flow under gravity

Typical cascading fluxes locally 0.5 – 1.6 m²s⁻¹

- significant where present
  - eg. Celtic Sea, Malin, Hebrides shelves
Why is West of Shetland so difficult?

On the upper slope (depths 200 m to 500 m)

This region includes Foinaven and Schiehallion. The Slope Current dominates here, so that net flow is usually towards northeast, following the depth contours. Its speed is around 0.3 m/s; tides usually are recognisable as modulations about the mean, and seldom succeed in reversing the flow. With the arrival of an eddy the current increases in strength – say peaking at 1 to 1.5 m/s - but usually maintains its northeastward direction (the eddy centre usually being offshore of the site). However, all directions are possible. Eddy-rich conditions may persist – or remain absent – for several weeks at a time. 100-year extreme speed may be 2 m/s near the surface, decreasing with depth. In depths greater than about 350 m, there is a risk of sudden severe currents close to the bed, associated with internal waves. They may be very infrequent and are difficult to predict.

Lower slope and channel (depths 500 m to more than 1000 m)

The deeper the site, the less influence the Slope Current has, so the direction of flow has more freedom. Towards mid-channel (e.g. Suilven), southwestward flows can persist for many weeks under the influence of the western water mass. The arrival of an eddy can strengthen currents in any direction according to which part of it affects the site. Current velocity may be both strong and uniform with depth, leading to riser instability. For example, on one occasion speeds of 1 m/s prevailed from the surface to a depth of around 500 m. Uniformity is less likely to extend deeper than this, as the underlying cold water has its own behaviour, but the two water masses do move coherently at times.

Extreme speeds are similar to those of the upper slope (up to 2 m/s at the surface). Tides are still perceptible even in deep water, but have decreasing importance.
Why is West of Shetland so difficult?

What does this mean to us?

How much will this affect us?

How often will we see "strong" current?
Forces acting on “In water cables” based on Current data from a clients metocean dep.

- **Current profile**
  - 1.71 m/s surface
  - 1.48 m/s 60m depth
  - 1.23 m/s 180m above seabed
  - 1.11 m/s 100m above seabed
  - 1.11 m/s 4m above seabed
  - 0.91 m/s 1m above seabed
## Statistical exposure time over 24 hours and 14 days periods

<table>
<thead>
<tr>
<th>Interval</th>
<th>T tons</th>
<th>α deg</th>
<th>N tons</th>
<th>%</th>
<th>24h</th>
<th>14 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 20 %</td>
<td>1.5</td>
<td>0.1</td>
<td>0.004</td>
<td>0.47</td>
<td>11 h 17 min</td>
<td>6 d 13 h 55 min</td>
</tr>
<tr>
<td>20 - 40%</td>
<td>1.8</td>
<td>4.3</td>
<td>0.13</td>
<td>0.41</td>
<td>9 h 50 min</td>
<td>5 d 17 h 46 min</td>
</tr>
<tr>
<td>40 - 60%</td>
<td>1.8</td>
<td>11.1</td>
<td>0.36</td>
<td>0.06</td>
<td>1 h 26 min</td>
<td>20 h 10 min</td>
</tr>
<tr>
<td>60 - 80 %</td>
<td>3.5</td>
<td>9.7</td>
<td>0.59</td>
<td>0.03</td>
<td>43 min</td>
<td>10 h 5 min</td>
</tr>
<tr>
<td>80 - 100%</td>
<td>3.7</td>
<td>15.2</td>
<td>0.98</td>
<td>0.02</td>
<td>29 min</td>
<td>6 h 43 min</td>
</tr>
</tbody>
</table>
Umbilical’s – "on a good day"
Umbilical’s – ”on a not so good day”
Way forward

Following the first campaign the following upgrades where made

- Installation of a Acoustic Doppler Current Profiler (ADCP) systems
  
  The objective was to move from a “we believe” to “we know” condition with regards to actual ocean current condition in the whole water column from the vessel to the seabed.

- Better protection of components exposed to wear from lifting and guiding cables
- Improved operational procedures
- Better training of operational personnel
- Prepared animation of umbilical behavior when exposed to ocean current
Before operation WoS: (Phase II)

The WoShetland operational procedure has been upgraded by implementing an Umbilical management guideline.

The guideline includes parameters and decision trees to aid in operational and umbilical management.
Installation of Current Monitoring System

Experience with temporary installed ADCP was that this equipment was not sufficient. It did not give us the information needed.

A full depth range scientific type ADCP was purchased. This is a vessel mounted long-range 38 kHz Acoustic Doppler Current Profiler (ADCP) for reading 40 - 1000m water depth allows long range profiling and has permanently been installed in the vessel hull.
Installation of Current Monitoring System

The installation of the ADCP has given the operational personnel on-board the vessel a real time “picture” of the full depth water column illustrating the current magnitude and direction as a function of water depth.

Understanding the ocean current has proven to be a vital tool and provides information to the ongoing decision making process with regards to the WoS Shetland operation.
WoS Preparation - Summary

1. Improved protection of guiding equipment in moon-pool
2. Improved guiding system
3. Improved umbilical system
2. Introduced protection to reduce consequences by umbilical and cable collisions
3. Introduction of current speed/direction monitoring
4. Performed analysis of umbilical behavior
5. Revise operational procedures and operational decision making methods

All of the above can be summarized into the most important factor - the real life training the operation West of Shetland has given the personnel planning the operation onshore and in particular the operational personnel onboard Island Constructor.
Island Constructor between Christian Radich and Statsraad Lehmkuhl in the Baltic Sea 2013