Wood Group

Design Methodology for Modifying a MODU into a FPU
Anders M Moe
1st March 2017
Agenda

- Wood Group Introduction
- Background
- Design Differences MODU vs FPU
- Main Design Changes Required for Converting MODU
- Design Case – A5000E to FPU
- Feasibility Evaluation
Our vision

To be recognised as the best technical services company to work with, work for and invest in, with a relentless focus on excellence.
Our purpose

We provide smart technical solutions which create and sustain value for our customers.
We are experienced

$5bn revenue
About 30,000 people
40 countries
We are where you need us

With around 30,000 people working in more than 40 countries we have a strong network of capability and expertise built over 30 years of successful operations to help you wherever you need it.
We have a proven track record

**WORLD LEADER IN**
- Lightweight topside design
- Offshore decommissioning
- Hook-up & commissioning
- In-house software development

**PIioneer In**
- Standard designs
- Full offshore asset management

**Designed The**
- Deepest TLP, SPAR and platform
- Longest and deepest pipelines
- Largest semi-submersible

**World’s Leading**
- O&G brownfield contractor

**Projects In**
- Over 90 countries

**11.4GW**
- Offshore wind projects assessed

**Wrote The**
- Industry specifications for flexible pipelines
Semi-submersible units

More than 35 years experience with semi-submersibles

1977 Nordraug
1978 Polymariner
1979 Nortrym
1980 Treasure Finder" "Nordraug
1981 T. Swan
1982 Nortrym" "T. Hunter" "T. Finder
1983 Nortrym" "Ross Rig
1984 Sedco Phillips SS" "T. Finder" "Byford Dolphin
1985 Dyvi Stena" "Safe Holmia
1986 Nortrym" "Borgny Dolphin
1987 C. Kirk Rhein Jr.
1988 Byford Dolphin
1989 "Borgsten Dolphin
1990 "Bideford Dolphin
1991 "Borgland Dolphin
1992 "Blackford Dolphin
1993 "Leiv Erikson
1994 "Blackford Dolphin
1995 "Borgland Dolphin
1996 "Bideford Dolphin
1997 "C. Kirk Rhein Jr.
2001 GVA 4000M Bingo9000-3 "Transocean Searcher
2002 "Borgholm Dolphin
2003 "Eirik Raude
2004 "Leiv Erikson
2005 "Blackford Dolphin
2006 "COSLInnovator
2007 "COSLPromoter
2008 "COSLPioneer
2009 "Island Innovator
2010 "COSLProspector
2011 "Safe Caledonia
2012 "Safe Scandinavia
2013 "HYSY982
2014 "Byford Dolphin

1977197919801981198219831984198519861987198819891990199119921993199419951996199719981999200020012002200320042005200620072008200920102011201220132014
Background

- For FPSOs conversion of tankers typically account for close to 2/3rds
- Conversion economically attractive for FPSOs
- Conversion of MODU (drillships, semis or jack-ups) are rare in the last 15 years
- Industry downturn resulting in a dramatic reduction in fleet utilization for MODUs
- Approx. 70% floater utilization per Q4 2016
- Projects are delayed, postponed or cancelled:
  - Focus on increased confidence in reservoir and production profiles
  - Large investments postponed if possible
  - Early production facilities more interesting to some
- Continued strong focus on reducing CAPEX
  - Standardization
  - Simplification
### Market Analysis

#### DEMAND

**Worldwide Offshore Rig Count & Utilization (Quarterly Average)**

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Number of Rigs</th>
<th>Fleet Utilization Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3 2014</td>
<td>800</td>
<td>90</td>
</tr>
<tr>
<td>Q4 2014</td>
<td>780</td>
<td>88</td>
</tr>
<tr>
<td>Q1 2015</td>
<td>760</td>
<td>86</td>
</tr>
<tr>
<td>Q2 2015</td>
<td>740</td>
<td>84</td>
</tr>
<tr>
<td>Q3 2015</td>
<td>720</td>
<td>82</td>
</tr>
<tr>
<td>Q4 2015</td>
<td>700</td>
<td>80</td>
</tr>
<tr>
<td>Q1 2016</td>
<td>680</td>
<td>78</td>
</tr>
<tr>
<td>Q2 2016</td>
<td>660</td>
<td>76</td>
</tr>
</tbody>
</table>

*Source: IHS Markit RigsDB © 2016 IHS Markit*

#### DAYRATES

**Worldwide Semisubmersibles >7,500 ft**

- Average day rates vs Total contracted utilization

#### STACKED RIGS

- **Post-Macondo peak**
- More than 200 rigs stacked since start of downturn

*Source: Clarksons Research and IHS*
Drivers for Conversion

• Drivers for MODU to FPU semi-submersible conversion:
  – Early production facility
  – Minimum processing facility
  – Full production facility
    • May not be feasible for harsh environment areas
## Differences between MODU and FPU

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MODU</th>
<th>FPU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class/Flag</strong></td>
<td>Yes</td>
<td>Typically designed to Class requirements. Leased units often have class and flag</td>
</tr>
<tr>
<td><strong>Inspection regime</strong></td>
<td>Typical 5 years SPS at quayside or dry-dock</td>
<td>Typically inspection in lieu of dry docking regimes</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Worldwide mobile operations and design for typ. 20 yrs</td>
<td>Remains at location for the production/lease time (up to 20 yrs)</td>
</tr>
<tr>
<td><strong>Mooring &amp; station keeping</strong></td>
<td>Pre-laid or self mooring Thrusters and DP</td>
<td>High spec long term pre-laid mooring and no DP</td>
</tr>
<tr>
<td><strong>Fit to purpose equipment</strong></td>
<td>Drilling eq. and utilities often integrated in hull structure. (ship-style)</td>
<td>Topsides process and utilities normally not integrated in the hull. (offshore-style)</td>
</tr>
<tr>
<td><strong>Transit and speed</strong></td>
<td>Transit speed generally a design requirement</td>
<td>Transit is not relevant</td>
</tr>
<tr>
<td><strong>Operational loads</strong></td>
<td>VDL (part of deadweight) is the main design parameter</td>
<td>Topsides weight, footprint and riser loads are main design drivers</td>
</tr>
</tbody>
</table>
## Major evaluation and changes - hull

**Hull**

- Check and verification of global structure
- Check fatigue life
- Verify payload limitations and stability
- Assess hydrodynamic characteristics
- Assess mooring system arrangement
- Assess riser interface on hull
- Check major tank capacity
- For major buoyancy upgrades, evaluate installation of transverse pontoons and removal of bracings
- Establish inspection regime in lieu of typical SPS class renewal
## Major evaluation and changes – topsides & utilities

<table>
<thead>
<tr>
<th>Topsides</th>
<th>Utilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Introduce new process topsides</td>
<td>• Review and upgrade utilities</td>
</tr>
<tr>
<td>• FPU with drilling capabilities</td>
<td>• Cooling water</td>
</tr>
<tr>
<td>• Complete layout redesign</td>
<td>• Fire system</td>
</tr>
<tr>
<td>• Typical minimum processing facility</td>
<td>• Fuel and lub systems</td>
</tr>
<tr>
<td>• FPU without drilling capabilities</td>
<td>• Power generation</td>
</tr>
<tr>
<td>• Removal of drilling equipment</td>
<td>• HVAC</td>
</tr>
<tr>
<td>• Design and installation of new processing modules</td>
<td>• Safety systems – F&amp;G and ESD</td>
</tr>
<tr>
<td></td>
<td>• LQ and working spaces</td>
</tr>
</tbody>
</table>
Weight distribution

Semi submersible MODU

- Displacement
  - Lightship
    - Marine Eq.
    - Structural steel
    - Fixed drilling eq.
  - Payloads
  - Ballast
  - Var. Mooring
  - VDL
  - Pontoon liquids
  - Deck loads
  - Column loads

- Variable drill eq.
- Misc drilling loads
- Consumables, stores & crew fuel, lub oil, fresh wtr.

- Tubulars and piping
  - Drill pipe, collars, marine risers, drilling tools
- Subsea and 3rd party equip.
  - ROV, x-trees, wellhead
- Mud pits and sace material
  - Casing, cement
- Hook load and tension
  - Riser, guide and pod line
  - Tension, hook load, rotary load

Semi submersible FPU

- Displacement
  - Hull (up to and including deck box)
  - Mooring forces
  - Riser hangoff forces
  - Structural steel
  - Equipment (pumps, chainlacks, electrical switchgear etc.)
  - Mechanical outfitting (e.g., piping, outfitting steel etc.)
  - Consumables (diesel, fresh water, mg, general stores etc.)
  - Ballast water
  - Topsides (from top of deck box)
  - Equipment
  - Bulk (piping, cables, hvac, architectural etc.)
  - Liquid content & consumables
Example MODU $\rightarrow$ FPU
MODU main particulars

Square Column Width 15.50 m
Number of Columns 4
Pontoon Width 16.50 m
Pontoon Height 10.05 m
Operational Draught 17.50 m
Elevation Underside Deck Box 29.55 m
Overall Width 70.50 m
Overall Length 104.50 m
Deck Box Height 8 m
Deck Area 5 812 m²
Displacement (approx.) 40 800 t
Lightship weight 25 500 t
Variable Deck Load 5 000 t
FPU main particulars

- Base case is to use the same hull and upgrade/modify where necessary to increase the topside weight
- Particulars are the same but weight budget is changed:

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
<th>VCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull Weight (Including Riser and Mooring Forces)</td>
<td>20 100 t</td>
<td>11 m</td>
</tr>
<tr>
<td>Topsides Dry Weight</td>
<td>10 000 t</td>
<td>44 m</td>
</tr>
<tr>
<td>Riser &amp; Mooring Loads</td>
<td>3 000 t</td>
<td>2 m</td>
</tr>
<tr>
<td>Fluids &amp; Consumables (ex. Ballast)</td>
<td>4 000 t</td>
<td>17 m</td>
</tr>
<tr>
<td>Margin</td>
<td>2 000 t</td>
<td>29 m</td>
</tr>
<tr>
<td>Ballast</td>
<td>5 700 t</td>
<td>6 m</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44 800 t</strong></td>
<td><strong>19.8 m</strong></td>
</tr>
</tbody>
</table>
Potential modifications

Potential hull modifications:

1. Blisters and sponsons
   - Offers improved stability and additional topsides payload
   - Will influence motion characteristics
   - Relatively minor modification

2. Replace bracings with transverse pontoon
   - Requires modifications to areas subject to high stresses
   - Offers significantly increased topsides payload (order of magnitude 5000 tonnes)
   - May be positive with regards to service life compared to bracings

3. Transverse pontoon + blisters and sponsons
   - Relatively large modification
   - Offers significantly improved stability and additional topsides payload
Potential modifications
Technical Feasibility Evaluation

✓ Opportunities
• Upgrade and life extension well known to the industry (i.e. Aker H3 rigs from the 1970s still operating, some as deepwater units)
• Steel replacement/renewal also well known in the industry

✗ Challenges/threats
• Lifetime extension and fatigue sensitive areas
  – Pontoon/bracing configuration
• Payload capacity for integrated production and drilling, and for full production facilities
• Riser interface and hang-off
• Mooring arrangement
• Air gap can limit the operational areas
Commercial Feasibility

✔ **Opportunities**
  - Lease and operate models
  - Reduced CAPEX
    - Low hull cost
    - High number of laid-up rigs
    - Reduced topsides cost?

✗ **Challenges/threats**
  - Cost of upgrade and limitation to the renewal scope
  - Topside facility integration
  - Suitable fields
    - Infrastructure
    - Environmental conditions (e.g. wind and wave loading)
    - Reservoir characteristics
Conclusion

• Drilling market situation is pushing many drilling rigs to be laid-up or scrapped
• This gives availability of reusing relatively modern units for other purposes
• Owners and Investors need to be creative in order to reduce the risk of big financial losses
• Modifying a semi-submersible from drilling to production is technically feasible and could be commercially attractive