Floating Production Systems

The Industry's Best Solution for the Future

Presented by Bruce Crager

Image Source: McDermott Engineering

Source: FMC Technologies
Rice Global Engineering & Construction Forum
November 8, 2013
1. Deepwater drilling began long before we had production capability

2. Time and depth gap between drilling and production is closing

3. 10,000' has been the water depth threshold for almost 10 years

Source: Mustang Engineering
Issues Driving Use of Mobile Offshore Production Systems (MOPS):

- Geographical Location
- Water Depth and Environmental Regime
- Wellhead Location (Surface, Subsea or both)
- Drilling/Workover Requirements
- Oil Export Options (Need Storage? )
- Gas Usage / Export Options
- Size and Weight of Process System (Primary Function)
- Fabrication (Local Content)
Mobile Offshore Production Systems (MOPS): Principal Types

- **SUBSEA WELLHEADS**
  - SEMI-SUBMERSIBLE FPS
  - MONOHULL FPSO

- **SURFACE WELLHEADS**
  - JACKUP JPU
  - TLP
  - SPAR
PRODUCTION SYSTEM TYPES
Solutions for Recovery of Offshore Oil & Gas

Three System Groups:

1. **Dry Tree Systems** – Fixed Platform, Production Jackup, Compliant Tower, TLP, Spar
2. **Wet Tree Systems** – New Gen. TLPs, Conventional TLPs, FPSOs, Cell Spar, Control Buoy, SS Tiebacks, Semi-FPS
3. **Mixed Dry / Wet Tree Systems** – Fixed Platforms, New Gen. TLP, Conventional TLP, Spar

COURTESY OF: MUSTANG ENGINEERING
Jackup Production Unit (JPU) or MOPU

Operating: 40

First: 1971, Gulftide, Ekofisk

Deepest: Harding, UK, 400 ft

Depth Range: 43 ft – 400 ft

Construction: 2

Locations: Worldwide
FPS – Floating Production System (Semi)

Operating: 43

First: 1975, Argyll, Hamilton

Deepest: 7,920 ft, MC920

Independence Hub

Construction: 7

Locations: Worldwide
FPSC- Floating Production Storage & Offloading

Operating: 165

First: 1977, Castellon, Shell

Deepest: 8,200 ft, Cascade Chinook

Construction: 44

Locations: Worldwide
**TLP- Tension Leg Platform**

<table>
<thead>
<tr>
<th>Operating:</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>First:</td>
<td>1984, Hutton, Conoco</td>
</tr>
<tr>
<td>Deepest:</td>
<td>4,674 ft., Magnolia GB783/84</td>
</tr>
<tr>
<td>Construction:</td>
<td>5</td>
</tr>
<tr>
<td>Locations:</td>
<td>North Sea, Angola, Brazil, Gulf of Mexico, Indonesia and Equatorial Guinea</td>
</tr>
</tbody>
</table>
SPAR

Operating: 19

First: 1996, Neptune, VK 826

Deepest: Perdido 8,008 ft
Alaminos Canyon 857

Construction: 5

Locations: Gulf of Mexico, Malaysia,
Norway (future)
Optimum Application Ranges

Source: FloaTEC
FPS By Type

Source: Douglas-Westwood

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Worldwide FPS Forecast Awards 2004 – 2017 (e)

By Award Status (Mean Case)

Source: Quest Offshore Resources, Inc.
Worldwide FPS Awards 2004 – 2017 (e)
(Mean Case)

By FPS Type

Source: Quest Offshore Resources, Inc.
Worldwide Forecast FPS Spending by Year

Type Contribution Thousands of US Dollars by FPS Award Year

Source: Quest Offshore Resources, Inc.
Forecasted Off Contract FPS Leased Fleet Availability

By Year Current - 2020 (Likely to be retired and EWT excluded)

Source: Quest Offshore Resources, Inc.
Floater Projects Planned or Under Study = 248

72 Floater Projects are in Bidding and Final Design Stage (as of March 2013)

176 Floater Projects are in the Planning or Study Stage (as of March 2013)

Source: www.imastudies.com
Growth of Floating Production, Storage and Offloading Systems (FPSO)

FPSOs were originally considered an economical solution for the production of marginal fields that otherwise might not be produced.

Later, FPSOs became an essential component in developing remote offshore fields as Early Production Systems (EPS) with increasing production capacity, numbers of risers, and ever increasing water depths which now allow their utilization as full field production facilities.

Source: Quest Offshore Resources, Inc.
FPSO Survey Results

• **Gulf Research Panel—Joint venture of Gulf Publishing and Gelb Consulting:**
  – Opt-in database of 45,000+ World Oil and Hydrocarbon Processing readers used exclusively for industry surveys
  – Since 2001, annual multi-client surveys on marketing effectiveness, brand equity, technology needs and HR issues in the oil and gas industry (upstream and downstream)

• **Respondents to this survey have current and/or recent experience in FPSO projects**
  – 125 qualified respondents out of 27,000 surveys
  – Margin of error +/- 8.74%
How many FPSOs have you been involved with in your career?

- More than 5: 23%
- 4-5: 14%
- 2-3: 40%
- 1: 23%
- 0: 0%

n = 125
What is the nature of the biggest challenge we are facing today in our FPSO Industry?

- Technical challenges: 26%
- Project execution: 24%
- Cost overruns: 22%
- Schedule issues: 19%
- Financing capacity: 9%

- Percentage of total respondents

n = 125
What do you see as the main driver for use of an FPSO?

- Flexibility: 30%
- Time to first oil: 19%
- Reservoir / production uncertainty: 19%
- Storage: 17%
- Cost: 10%
- Re-deployment: 6%

Percentage of total respondents: n = 125
Given the gap between demand for FPSO from the Oil companies and supply capacity from the FPSO Contractors, which party shall mostly provide for the missing FPSOs?

- Oil companies themselves: 37%
- New comers FPSO Contractors: 28%
- Large Engineering/Project Contractors: 19%
- Shipyards: 14%
- Re-deployment: 6%
- Other: 2%

n = 125
Where do you feel the FPSO market is heading in terms of hull forms?

- New purpose-built hulls: 46%
- Conversion of existing hulls: 39%
- Re-deployment of existing FPSOs: 14%

n = 125
Converted hull versus new-build FPSO: What will be the ratio 10 years from now?

- In the range of 30% converted hull / 70% new build: 41%
- In the range of 70% converted hull / 30% new build: 28%
- 50% converted hull / 50% new build: 24%
- No Opinion: 7%

n = 125
FPSO Ownership

48% Owned
52% Leased

Leased
Owned
# FPSO Owners (Three or More Units)

<table>
<thead>
<tr>
<th>Company</th>
<th>In Service</th>
<th>On Order</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrobras</td>
<td></td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>SBM</td>
<td>15</td>
<td></td>
<td></td>
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<tr>
<td>CNOOC</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BWO</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teekay/Sevan</td>
<td></td>
<td>12</td>
<td></td>
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<tr>
<td>Modec</td>
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<td>11</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>ExxonMobil</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>BP</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Bumi Armada</td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Chevron</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>OSX/OGX</td>
<td></td>
<td>5</td>
<td></td>
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<tr>
<td>Bluewater</td>
<td></td>
<td>5</td>
<td></td>
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<tr>
<td>Shell</td>
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<td></td>
</tr>
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<td>Woodside</td>
<td></td>
<td>4</td>
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<tr>
<td>Petronas/MISC</td>
<td>4</td>
<td></td>
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<tr>
<td>Rubicon/Sea Prod</td>
<td>4</td>
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<td>Saipem</td>
<td>3</td>
<td></td>
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<td>Statoil</td>
<td>3</td>
<td></td>
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</tr>
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<td>Petrofac</td>
<td>3</td>
<td></td>
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</tr>
</tbody>
</table>

Source: www.imastudies.com
Leased FPSO Market Share by Owner

Owners with > 1 Unit

Source: Quest Offshore Resources, Inc.
Do you expect new build FPSOs to be:

- Ordered for a leased project and owned by an FPSO leasing company: 51%
- Ordered for a project and owned by the Operator after being built: 44%
- Built initially on speculation: 5%

Percentage of total respondents: n = 125
Worldwide FPS Top Operators

2008 to 2017 Top 14 Operators

Number of FPS Units

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Petrobras</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Royal Dutch/Shell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chevron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<tr>
<td>BP</td>
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<td>Eni</td>
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<td></td>
</tr>
<tr>
<td>Statoil</td>
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<tr>
<td>Anadarko Petroleum</td>
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<td></td>
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<tr>
<td>Petronas Carigali</td>
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<td>Premier Oil</td>
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<td>CNOOC</td>
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<tr>
<td>Hess</td>
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<tr>
<td>ONGC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Quest Offshore Resources, Inc.
Do you expect New Build Projects to be:

- The topsides were built at another location(s) from the hull: 46%
- The topsides and hull were built in the same yard: 30%
- The integration was done at a third location from the hull and topsides: 24%

Percentage of total respondents

n = 125
The ratio of global Spread moored versus Turret moored FPSO is increasing, why?

- Larger number of FPSO installed in benign waters: 22%
- Larger number of risers: 20%
- Swivels challenges in terms of pressure, flow rate: 18%
- Changes in Oil Companies philosophy: 14%
- All of the above: 38%

Percentage of total respondents: n = 125
What do you think is the most important factor in designing and operating an offloading system?

- Marine safety policy of the operating oil company on the development: 40%
- Economics: 33%
- Use of dynamic positioned tankers, as is common with "shuttle tankers": 27%

Percentage of total respondents: n = 125
Where do you feel the market is in terms of players?

- New entrants welcome: 49%
- More consolidation needed: 38%
- Too many players: 14%

n = 125
Worldwide FPSO Awards 2004 – 2017 (e)

(Mean Case)

Source: Quest Offshore Resources, Inc.
Are you currently working on a new FPSO project and, if so, for what geographic area?

- I am not working on a new FPSO: 36%
- Asia Pacific (including Australia): 17%
- South America: 16%
- West Africa: 14%
- North Sea: 7%
- Other area: 5%
- Gulf of Mexico: 5%

n = 125
Are all FPSO’s Shipshaped?
# Sevan Piranema Technical Data

<table>
<thead>
<tr>
<th>Operator, Field, Location</th>
<th>Petrobras, Piranema, Brazil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Built / Converted</td>
<td>2007</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Owner</th>
<th>Sevan Marine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Water Depth</td>
<td>1,090 meters (1,600 - Phase 2)</td>
</tr>
<tr>
<td>Number of Locations</td>
<td>1</td>
</tr>
<tr>
<td>Max Liquid Handling</td>
<td>30 MBOPD</td>
</tr>
<tr>
<td>Oil Storage Capacity</td>
<td>250 MBBLs</td>
</tr>
<tr>
<td>Mooring System Type</td>
<td>9 Point Spread</td>
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</table>
Azurite Graphic - FDPSO
## San Jacinto Technical Data

<table>
<thead>
<tr>
<th>Operator, Field, Location</th>
<th>Conoco - Kepiting, Ikan Pari, Sembilang - Indonesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Built / Converted</td>
<td>1986 Built / 1994 Upgraded</td>
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<tr>
<td>Owner</td>
<td>? Coldstacked</td>
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<tr>
<td>Operating Water Depth</td>
<td>91 meters, Sembilang</td>
</tr>
<tr>
<td>Number of Locations</td>
<td>3</td>
</tr>
<tr>
<td>Max Liquid Handling</td>
<td>11,000 bpd</td>
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<tr>
<td>Oil Storage Capacity</td>
<td>53,000 bbls</td>
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<tr>
<td>Mooring System Type</td>
<td>8 Point Spread</td>
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</tbody>
</table>
# Zafiro Producer Technical Data

<table>
<thead>
<tr>
<th>Operator, Field, Location</th>
<th>ExxonMobil, Zafiro Block B, Equatorial Guinea</th>
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</thead>
<tbody>
<tr>
<td>Date Built / Converted</td>
<td>1973 / 1996</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Owner</th>
<th>ExxonMobil</th>
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</thead>
<tbody>
<tr>
<td>Operating Water Depth</td>
<td>180 meters</td>
</tr>
<tr>
<td>Number of Locations</td>
<td>1</td>
</tr>
<tr>
<td>Max Liquid Handling</td>
<td>80,000 BOPD</td>
</tr>
<tr>
<td>Oil Storage Capacity</td>
<td>1.9 Million Barrels</td>
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<tr>
<td>Mooring System Type</td>
<td>12 Point Spread</td>
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</tbody>
</table>

© Endeavor Management 2013
ORIBI Development
**ORCA Technical Data**

<table>
<thead>
<tr>
<th>Operator, Field, Location</th>
<th>PetroSA, Oribi, South Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Built / Converted</td>
<td>1970 Halifax Canada / 1997 Conversion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Owner</th>
<th>PetroSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Water Depth</td>
<td>120 meters</td>
</tr>
<tr>
<td>Number of Locations</td>
<td>1</td>
</tr>
<tr>
<td>Max Liquid Handling</td>
<td>30,000 BOPD</td>
</tr>
<tr>
<td>Oil Storage Capacity</td>
<td>34,000 Barrels</td>
</tr>
<tr>
<td>Mooring System Type</td>
<td>9 Point Spread</td>
</tr>
</tbody>
</table>
Conclusions

- Floating Production Systems have become THE solution for water depths over 1000 feet and for many marginal fields.
- FPSO’s make up the majority of the FPS’s now and forecasted for the future.
- Our industry continues to develop innovative solutions.
- Subsea production is the common method for developing wells for FPS solutions.
- The size and cost of FPS units continue to grow significantly.
- Our industry is near full capacity and more projects are coming!
About Bruce Crager
Managing Director – Offshore, Subsea and Marine

Bruce has over 38 years experience in offshore drilling and production activities, primarily in management positions. This has included a significant amount of experience in evaluating and providing field development solutions based on floating production systems and subsea production equipment.

Bruce joined Endeavor in 2010 and is responsible for the development of an experienced team to support clients in the areas of strategy development, organizational change/development, decision analysis and in technical areas such as field development planning and operational improvement. Since joining Endeavor, Bruce has consulted to multiple clients, including Addax Petroleum, Audubon Engineering, Barra Energia, Cal Dive, Cameron, ENI, Lupatech, Maersk Oil, Pemex, Petrobras, Ridgewood Energy, T-Rex Engineering & Construction and VAALCO Energy.

Education:

Bachelor of Science – Ocean Engineering, Texas A&M University– College Station, Texas, 1975
Master of Business Administration, University of Houston– Houston, Texas, 1979
For more information about Endeavor Management’s Oil and Gas practice and specifics about our expertise in Offshore, Subsea and Marine visit: http://endeavormgmt.com/industries/oil-and-gas
Endeavor Management is a management consulting firm that leads clients to achieve real value from their strategic transformational initiatives. Endeavor serves as a catalyst by providing the energy to maintain the dual perspective of running the business while changing the business through the application of key leadership principles and business strategy.

The firm’s 40 year heritage has produced a substantial portfolio of proven methodologies, enabling Endeavor consultants to deliver top-tier transformational strategies, operational excellence, organizational change management, leadership development and decision support. Endeavor’s deep operational insight and broad industry experience enables our team to quickly understand the dynamics of client companies and markets.

Combined with our Gelb Consulting experience (founded in 1965) we also offer clients unique capabilities that focus their marketing initiatives by fully understanding and shaping the customer experience through proven strategic frameworks to guide marketing strategies, build trusted brands, deliver exceptional customer experiences and launch new products. Our experienced consultants and analysts use advanced marketing research techniques to identify customer needs and spot high potential market opportunities.