Floating Production System Deepwater Development Options

by

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Presentation Topics

1. Deepwater Platform Options
2. Market Trends
3. Primary Drivers
4. Technology Issues
5. Future Trends
Local Host Development Option
Satellite Wellhead Platforms to Central Hub

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Production Floater Hull Types

- Monohull

FPSO - Production, Storage, and Shuttle Offtake
FSO - Storage and Shuttle Offtake
FPU - Production and Pipeline Offtake
Production Floater Hull Types

- Monohull
- Semi-Submersibles

Conversions

New Generation New Build
Deepwater Floater Hull Types

- Monohull
- Semi-Submersibles
- Spars

Classic Spar  Truss Spar
Deepwater Floater Hull Types

- **Monohull**
- **Semi-Submersibles**
- **Spars**
- **Tension Leg Platforms (TLP)**

Classical TLP

Monocolumn TLP

Moses TLP
Floating Production Systems Growth

- Mature Technology.
- Historically has been primarily conversions.
- Historically, FPS were used in medium water depth, early production, short field life, flexible risers.

Reference: International Maritime Consultants 2004
GOM Floating Systems

(Source: MMS Deepwater GOM Report 2004)
Recent Exploration Trends
(Source: MMS Deepwater GOM Report 2004)

Ultra-deep water Trend

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## GOM Discoveries > 7000’ WD

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Block</th>
<th>WD, ft</th>
<th>Year</th>
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<tr>
<td>Aconcagua</td>
<td>MC 305</td>
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<td>Camden Hills</td>
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<tr>
<td>Chinook</td>
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<td>Jubilee</td>
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<td>Spiderman/Amazon</td>
<td>DC 621</td>
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(Source: MMS Deepwater GOM Report 2004)
Primary Drivers for Deepwater FPUs

- Waterdepth.
- Payload
- Production Characteristics – Well Access Requirements.
- Availability of Infrastructure & Market location.
- Platform drilling, predrilling vs postdrilling
- Gas Disposal Requirements.
- Local Content Requirements.
- Field Life.
- Metocean Conditions.
Wellbore Access: Direct vs Subsea?

Direct (Dry Tree)
- Single Drill Center
- Lower OPEX and Life Cycle Costs
- Simpler well Hardware
- Minimize well intervention Cost and downtime
- Less Flow Assurance Risk
- Higher recovery
- Strict motion requirements

Indirect (Wet Tree)
- Multi Drill Centers
- Higher OPEX
- Minimize Drilling Costs and Risks for Large Areal Extent Reservoirs
- Maximize Development Plan Flexibility
- Capability for wide range of hull types
- More complex flow assurance issues
- Seafloor intervention, vessel availability
Proven Deepwater Technology

Dry Tree Solutions
- Classic Spar
- Truss Spar
- Compliant Tower

Wet Tree Solutions
- Shipshape FPSO
- Semi FPS

Source: Offshore Magazine
Deepwater Production Solutions poster; Sept., 2000
Riser Options

Direct Vertical Access Options:
- Direct Tensioned Riser
- Air Can Tensioned Riser \( \{ \text{TTR} \) TTR
- Tubing Tie-back Riser
- Compliant Vertical Access Riser (CVAR)*
- Near or At-Surface Completion*
- Drilling/Completion/WO riser

Wet Tree Options:
- Steel Catenary Risers (SCR)
- Hybrid Risers
- Flexible Catenary Risers

Strict Hull Motion Requirements

Note: * Option is unproven

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Motion Response Characteristics

Sea Energy

5 Seconds

Wave Period (Seconds)

20 Seconds

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**Moorings Options**

**Mooring Leg Options:**
- Catenary leg moorings
- Semi-taut leg moorings
- Taut leg polyester mooring

**Foundation Options:**
- Steel Driven Piles
- Suction Piles
- SEPLA
- VLA
- Drag Embedment

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Houston September 28-30, 2004
Installed & Sanctioned FPSOs

Water Depths > 300 m

Source: Aker Maritime’s & Mustang Engineering 2001 Worldwide Survey of FPSOs; Aug, 2001 Issue of Offshore Magazine
Monohull Mooring Types

- Internal Turret
- External Turret
- Yoke System
- Spread moored
Monohull Mooring Types

- Internal Turret
- External Turret
- Yoke System
- Spread moored
Monohull Mooring Types

- Internal Turret
- External Turret
- Yoke System
- Spread moored

- Old style
- Not Applicable to deep water
Monohull Mooring Types

- Internal Turret
- External Turret
- Yoke System
- Spread moored

- Directional environment
- Offtake issues
Offtake
**FPSO**

- no oil export pipeline required
- Converted tankers, if used, can lower initial cost & schedule
- Available payload & deck area

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- Oil field use only (no advantage for gas field)
- Wet Tree – no direct well access
- Potentially high cost for well workover
- High turret/fluid swivel cost potential
Worldwide Installed & Sanctioned Semi-FPSs
Water Depths > 300 m

- Brazil (13)
- Norway (7)
- US GoM (5)
- China (1)
Semisubmersible FPU

- Hull steel weight equivalent to a TLP
- Deck can be pre-integrated inshore
- Installed with anchor handling vessels
- Hull motions generally acceptable for SCR risers.

CP Semi – New Generation Semi
**Semisubmersibles**

- Low structure weight
- Catenary or Taut-Leg Spread moored
- Good motions, SCRs are possible
- Platform drilling or workover rig is possible
- Subsea trees with vertical access

- DVA risers w/dry trees unproven
- Large mooring footprint
- Pipeline offtake
Installed & Sanctioned SPARs
Water Depths > 300 m

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Air Can Risers

SPAR Production Riser System
Spars

- Dry tree capable
- Low heave motions
- Catenary or taut leg moorings
- Low sensitivity to topsides weight
- Large structure weight
- Large seabed footprint
- Large lateral motions at deck and keel
- Hull VIM may cause fatigue of components (aircan, riser, mooring etc.)
Installed & Sanctioned TLPs
Water Depths > 300 m
Classic TLPs

TLWP

Concrete

PDQ
MOSES New Generation TLP

Marco Polo TLP in 4300 ft Waterdepth

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Steel Tendon Practical Depth Limits

Classic TLP

Water Depth (ft)

Payload (st), excludes deck steel, includes risers

SE Asia
W Africa
GoM
Steel Tendon Practical Depth Limits

New Generation TLP

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Payload (st), excludes deck steel, includes risers
Integrated TLP Tow out
Direct Tensioned Risers

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**Tension Leg Platform**

- Stable with minimal heave, roll and pitch motions
- Dry Tree capable
- Small seabed footprint
- Scalable to small fields
- Low structure weight
- Inshore integration

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- No oil storage
- Sensitive to topsides weight
- Has water depth limit with steel tendons
Global Design Efficiency

Payload Excludes Deck steel and product storage

Displacement/Payload

Conventional TLP
Seastar TLP
Moses TLP
Conventional Semi
Spar
Unocal TLP
CP Semi

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Deepwater System Comparisons

**SPAR**
- Hull design less depth sensitive
- Riser air cans are weight sensitive
- Lower Payload Sensitivity of hull
- Simpler mooring system
- Simpler hull construction

**TLP**
- Simpler risers
- Less motions
- Lower Hull Weight
- Small seabed footprint
- Topsides can be integrated inshore

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# Deepwater System Comparisons

<table>
<thead>
<tr>
<th>FPSO</th>
<th>Semi</th>
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<tbody>
<tr>
<td>Used in area lacking pipeline infrastructure</td>
<td>Used in areas with accessible infrastructure</td>
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<tr>
<td>Oil storage and offtake capability</td>
<td>SCR Risers feasible</td>
</tr>
<tr>
<td>Gas handling and offtake is an issue.</td>
<td>Efficient hull weight</td>
</tr>
<tr>
<td>SCR Risers are generally not feasible</td>
<td>Simpler Mooring system</td>
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## Technical and Commercial Maturity

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>TECHNICALLY MATURE</th>
<th>COMMERCIALY MATURE</th>
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<tbody>
<tr>
<td>FPSO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Spar - Classic</td>
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<td>No</td>
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<td>Semi FPS</td>
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<td>Yes</td>
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<tr>
<td>DD Semi</td>
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<tr>
<td>TLP</td>
<td>Yes</td>
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</tbody>
</table>
**Deepwater FPU Design Challenges**

- Efficient Hulls with good performance
- Reducing Installation costs & risks
- Deepwater mooring designs
- DVA riser designs
- Deep currents & VIV of risers and tendons
- Reduce drilling costs
- Non-linear hydrodynamics – VIM, run up, free surface effects, higher order loads
- Model Testing scale effects and mooring truncation effects
Emerging Deepwater Production Solutions

- FDPSOs
- Deep Draft Semisubmersibles
- Floating LNG
FPU Technology Direction

- Ultra-deep water
- New Generation efficient hulls
- Improved lightweight topsides
- Tender Assisted Drilling (TAD)
- Improved moorings and foundations
- Improved risers
- More efficient platform installation methods
New Generation Hulls + Lightweight Topsides

Dry Tree TLPs in GoM

- Brun - Powell
- Jolliet
- Marlin
- Matterhorn
- Typhoon
- NaKika
- Prince
- Marco Polo

Hull + Deck Steel, tons

Design Throughput, KBOEPD

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Summary

- SPARS, proven to 6000’ and TLPs, proven to 5000’ dominate deepwater in GOM.
- SPAR w/dry trees can be extended to 10,000 ft water depth; riser and mooring systems are a challenge.
- Semis and FPSO w/wet trees can be extended to 10,000 ft water depth; mooring system is a challenge.
- Development of emerging tendon technology is required to extend TLP beyond 7500 ft water depth.
- Costs and schedule for deepwater floating systems are market driven.
- “Best System” dependent on water depth, field size, existing infrastructure, market conditions, and reservoir characteristics.