Floater Selection Criteria for Deepwater Development

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1. Who we are
With Engineering, Technologies and Project Management, on land & at sea, we safely and successfully deliver the best solutions for our clients in the energy business.
A Unique Worldwide Footprint

118 nationalities across 45 countries

- 45 Countries
- 24 Vessels*
- 8 Flexible Pipe/Umbilicals Plants
- 4 Spoolbases
- 5 Construction/Services Bases

(1) Former Duco
*4 under construction
2 Business Segments – One Technip

THE BEST SOLUTIONS ACROSS THE VALUE CHAIN

- Subsea design/ Architecture
- Flexible Pipes/ Umbilicals
- Installation Fleet
  - S-Lay/ J-Lay/ Reeled

- Deepwater Floaters
- Major Topside Platforms
- Fixed Facilities

- Refining
- Ethylene/ Petrochemical
- LNG/ Gas/ GTL
Offshore: Expertise in High Added-value Technology
2. Main Deepwater Floater Technology Overview and Selection Criteria
Main Menu

- Overview
- Spars
- TLPs
- Semisubmersibles
- FPSOs
- Comparison
Introduction To Floating Systems

Why use floating production systems?

- Water depth of field exceeds practical limits of fixed structures
  - 400 m WD for conventional jackets and 500 m WD for compliant towers
  - Environmental conditions could reduce jacket limits

- Economic need to lease production system for short life fields
  - Potential for re-deployment allows floaters to be leased – positive residual value
  - Typically used in conjunction with subsea (wet) well completions

- Need for local storage and offloading
  - Remote regions where production is destined for export
  - Lack of pipeline infrastructure – distance to shore/tie-in, arctic areas, very deepwater
Hulls create offshore real estate. They can be deep draft single column spars, or multi-column Tension Leg Platforms and Semisubmersibles, or shallow draft rectilinear ship shapes. All floaters have a hull, topside facility, moorings and risers.
Hull Design Drivers

Floating hull supports surface facilities and risers

- Surface facility provides safe habitat for people and process
  - Design issues same as for fixed platforms covered in separate module
  - Process equipment designed for hull motion

- Mooring system maintains hull on location
  - Spread moorings (spars, semisubmersibles and ship shapes) are combination of chain with either wire or synthetic rope
  - Vertical moorings (TLPs) are thick wall steel tube tethers
  - Moorings secured to seafloor by anchors and/or piles

- Risers transport fluids between seafloor and moving hull
  - Vertical risers are Top Tensioned Risers (TTRs) and provide direct access to downhole well completions
  - Catenary risers, which include Steel Catenary Risers (SCRs) and flexible pipe, provide fluid transport between surface and seafloor
  - Riser design direct function of hull motion

#1 Function of a hull is to support risers
Global Performance Design Approach

- Hulls initially designed as rigid bodies subject to environment
  - This is called “Global Design”

- Strong interface between risers, moorings, hull
  - Mooring design loads & offsets dependent on riser unbalanced forces
  - Riser strength driven by extreme offsets and pitch angles
  - Riser fatigue driven by operational motions of hull

- Philosophy is to design from the inside out
  - Design around riser configuration
Hull And Mooring And Riser Interactions

- Risers
  - Stiffness
  - Tensioning
  - Stationkeeping

- Hull
  - Motions, Offset
  - Set Down
  - Hull VIM

- Mooring

- Waves, Wind & Current

Technip Presentation
Main Menu

- Overview
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Three Generations of Spars

Spar Types

Classic Spar  Truss Spar  Cell Spar
Out of the 20 production Spars currently operating worldwide, 17 have been designed by Technip
Spar Design Drivers

Design Drivers
Topside weight and deck area
Rigid riser number and seafloor layout
Steel and flexible catenary risers number and location
Float-off drafts
Design and survival wind, wave and current criteria
Spar Motion Principles

- Spars are inherently stable
- Spars tend to pitch about the keel
- Spars have minimal heave due to small waterplane area, deep draft and damping
- Vertical risers are laterally constrained at the keel (keel joints), effectively reacting the risers’ vertical and lateral loads as if they were attached at the keel
- Steel Catenary Risers (SCRs) or Flexible are hung also at the keel
- The keel of a spar experiences the lowest vertical and horizontal motion on the hull
Spar Benefit Summary

- **Advantages**
  - Spars have minimal heave due to small waterplane area, deep draft and damping
  - Keel of spar the most stable platform for supporting risers
  - Topsides can be installed in one complete module with catamaran floatover method in Malaysian water

- **Disadvantages**
  - Small plan view layout creates space problems within the topsides

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Disadvantages

- Small plan view layout creates space problems within the topsides
Spar Fabrication

Plate cutting – stringer welding

Plate curved in jig – section erection

Sections combined into half ring

Half rings moved to rails and mated

Ring sections mated on rails

Completed hull skidded onto transport
Spar Installation

Hull off-loaded from transport

Wet tow to site

Soft tank flooded - hull uprights

Iron ore ballast is pumped into soft tank as slurry

Topsides installed with crane

Topsides installed by floatover
Perdido Spar, Gulf of Mexico

Client: Shell Offshore Inc  
Water depth: 2,385 m  
Hull: 170 m x 36 m  
Production capacity: up to 130,000 barrels/day  
Delivered: 2008

Subsea Scope

- 13.2 km flowlines and risers
- 52km umbilicals
- Deepest installed reeled inline structure (PLET) 2,850m
- Deepest installed reeled pipe 2,975m
- Installed by Deep Blue 2009

This record breaking Spar, the 14th ever installed by Technip, is the deepest Spar production facility in the world and the first with Direct Vertical Access.
Kikeh Dry Tree Unit (DTU)

- **Client:** Murphy Sabah Oil Co. Ltd.
- **Water depth:** 1,330 m
- **Project Scope:**
  - Offshore portion - PME, Procurement, Fabrication/Outfitting of Topside, Hull, Top tension risers, Mooring system, including transportation, Installation, Hook-up and Commissioning
  - Subsea portion - EPCI of flexible risers, hold back anchor system for flexible risers and umbilicals, T&I of Company supplied subsea systems and pre-commissioning
- **Contract period:** 2005 - 2009

First SPAR outside of Gulf of Mexico
Deepest installed subsea production system in Asia at the time
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Introduction to TLPs

Extended Tendon Base

Conventional Box

Three Leg

Probably no more
TLP Design Drivers

Design Drivers
Tendon design limitations
Topside weight and deck area
Top tension riser number
Steel and flexible riser numbers and locations
Quayside draft and stability
Tendon hook-up stability
Design and survival wind, wave and current criteria
TLP Motion Principles

- TLPs are vertically anchored to the seafloor resulting in the platform deck remaining parallel to the seafloor as it moves laterally.
- Vertical risers remain parallel to the tendons.
- Lateral movement causes the hull to “set down” into the water.
- Beyond ~1500 m the tendons weigh more than the hull and the overall system weight increases more in an exponential fashion.
TLP Benefit Summary

- **Advantages**
  - Quayside topside installation and integration
  - TTRs experience minimal tensioner stroke
  - Decks remain flat creating an excellent platform for drilling and supporting dry wellheads

- **Disadvantages**
  - “Set Down” creates large surface motion envelope for the SCRs – Solution to mitigate issue with Flexible risers
  - High deck height for set down creates alignment problems with Tender Assisted Drilling (TAD) units
  - Water depth limited around 1500 m
TLP Fabrication

Pontoon sections fabricated

Column sections joined to pontoon

Completed hull prepared for super lift

Deck lifted/hull skidded underneath

Alternative is hull dry transported …

… and topside lifted quayside
TLP Installation

Tendon installation by heavy lift

Hull connection with heavy lift

Alternative - hull Installation by column ballasting
Technip Recent Experience for TLP SHELL Malikai TLP

- **Client:** Sabah Shell Petroleum Co. Ltd.
- **Location:** Offshore Sabah, Malaysia,
- **Scope:** EPC (TP Leader, in JV with MMHE)
- **Facilities:**
  - TLP weight 26,000t, topsides, hull
  - Oil processing 60,000 BPD
  - Gas processing 1.4 cu.m/d
  - Water depth 500m
- **Subsea Scope**
  - T&I Scope
  - 44.3km x 8” Gas and 45.0km x 10” Liquid
  - 8” and 10” SCRs and Tie In Spool at TLP
  - Free span correction
  - Pre-commissioning

Malaysia’s 1st Tension Leg Platform and 3rd offshore floating platform for deepwater field development in the country
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- Modelling Tools
Types of Semisubmersibles

Mobile Offshore Drilling Unit (MODU)

Floating Production System (FPS)
Semisubmersible Design Drivers

Design Drivers
- Riser number, size and locations
- Topside weight and deck area
- Draft quayside and operating
- Global performance
- Strength and fatigue criteria
- On-site draft transition
- Intact and damaged stability
Semisubmersible Motion Principles

- Semisubmersibles are not inherently stable and will capsize when incline angle submerges downflood point, typically top of column.

- Use of a closed deck box can extend the restoring moment curve and essentially prevent capsizing.

- Wind load on topside principle source of overturning moment.

- Capsizing mishaps usually not due to wind but to ballasting issues in columns and pontoons.
Semisubmersible Benefits Summary

### Advantages

- Topsides can be quite large in weight and layout i.e., 50+ ktons
- Topsides can be installed & integrated either with superlift in the yard or at quayside. Topsides can also be installed by floatover.
- Semi ballasting can handle many different variable load scenarios.

### Disadvantages

- SCR fatigue issues at hang-off and touchdown which can be mitigated with flexibles
- Semis do not yet support top tension risers as production risers with dry trees – but possible.
Semisubmersible Fabrication & Installation

Fabrication plan

Pontoon sections moved onto rails

Column erection

Hull skidded onto transport

Topsides installed/integrated at quayside

Hull and topsides dry transported

Wet tow to site
P-51 Platform, Brazil

- Client: Petrobras
- Semi-submersible platform
- Capacity: 180,000 barrels of oil and 6 million m³ of gas per day
- Value: $639 million
- First oil: January 2009

P-51 is the first semi-submersible platform to be constructed entirely in Brazil. It is anchored at a water depth of 1,255 m.
Technip Recent Experience for Semi Gumusut-Kakap Semi-Submersible FPS

- **Client:** MMHE (Ultimate: Sabah Shell Petroleum Company Limited)
- **Location:** Offshore Northwest of Sabah, Malaysia
- **Water Depth:** 1200 m
- **Year:** Oct 2006 – Apr 2010
- **Scope:** Detailed Engineering, Procurement support

Floating production unit topsides 21,315t, Crude production 150,000 BPD, Gas production 300 MMSCFD, Subsea wells 24+ nos., Living quarter module, Power generation module
Step Column Semi
Same Fabrication Cost – Superior Motions

Conventional Deep Draft Semi (Jack/St Malo)

Technip Deep Draft Semi

Heave

Pitch
Enhancing Heave Performance For Dry Trees

- Introduce 7 top tensioned risers (TTRs)
- Need increased added mass
- Heave period 2 seconds higher w/o TTRs
- Improve hull design for extreme sea state
- Can tailor performance to need
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FPSO (Floating Production, Storage & Offloading) Systems

- More FPSOs than all other floating platforms combined
  - Lowest cost “Real Estate” for offshore production
  - Combines on-site storage and offloading to shuttle tankers
    - Preferred choice when production is going to be exported
  - Riser design major drawback due to high vessel motion
    - Options discussed in riser section

- FPSO options
  - Leased versus purchased – function of exploitation strategy
    - Majority of FPSOs are leased
  - New build hull versus converted of oil tanker
    - Majority of FPSOs are conversions – ten year old tankers preferred
    - Two thirds of all new build FPSOs are purchased
  - Spread moored versus weathervane turret
    - Two thirds of all FPSOs weathervane with turrets and fluid swivels
    - Function of environment – primarily constrained by offloading to shuttles
Design Drivers

- Storage requirement(s)
- Environmental directionality (need for swivel and turret)
- Offloading shuttle fleet
- Motions, particularly roll, and need for disconnection
- Riser numbers
- Topside weight and deck area
Examples of New Build FPSOs

Dalia FPSO - Angola
- 240 MB/D oil
- 280 MMCF/D gas
- 400 MB/D water injection

Akpo FPSO - Nigeria
- 185 MB/D oil
- 530 MMCF/D gas
- 400 MB/D water injection
Examples of Conversion FPSOs

Kikeh FPSO
- Malaysia
- Client Murphy
- Turret mooring

Cascade Chinook FPSO
- US GoM
- Client Petrobras Americas
- ABS and IMO Class
- 600,000 bbls storage
- Disconnectable turret moored
Spread Versus Turret Moorings

Meteocean conditions

Wave direction

wind direction

wave & Current direction

Amplitude

Spread mooring

Turret mooring
**FPSO Fabrication & Transportation**

1. Fabricated in Dry Dock
2. Brought to Quayside
3. Topside Module Installed
4. Topside Integrated to Hull
5. FPSO Towed to Site
Caisson FPSOs

Goliat class
1 MB storage
100 KB/D
Northern NS
DP shuttles required
Direct riser tie-back
No disconnection in storm

Hummingbird class
300 KB storage
10 KB/D
Lower NS
DP shuttles required
Direct riser tie-back
No disconnection in storm
FPSO Summary Benefits

**Advantages**
- Flexible in accommodating range of payload
- Topside can be installed quayside
- Large deck area
- Large hull volume for storage
- Design of hull & mooring is de-coupled
- Modification of existing ships possible

**Disadvantages**
- Motion response limits riser choices
  - TTRs not compatible (no dry trees)
  - SCRs limited to ultra deep water mitigated by use of flexibles
- Turrets & swivels required for weathervaning
- Hull length introduces significant deck deflections
Technip Recent Experience for FPSO Gehem/Gendalo FPU

- Client: Chevron Indonesia
- Location: Offshore East Kalimantan, Indonesia
- Water Depth: 1070 m to 1830 m
- Scope: FEED

Hull, Topsides, Mooring Systems and Steel Catenary Risers for two FPUs
Technip Recent Experience for FPSO Ichthys FPSO Topsides Detailed Engineering

- Client: Daewoo Shipbuilding & Marine Engineering (DSME)
- Ultimate Client: INPEX
- Location: Browse Basin, Western Australia
- Water Depth: 250m
- Year: Apr 2012 – 2014
- Scope: Detailed Engineering & Procurement Services

40,000 MT Topsides, comprises 10 modules and flare tower
PETRONAS FLNG 1

- Client: PETRONAS
- Location: Sabah-Sarawak waters, Malaysia
- Scope: FEED and EPCIC
- Partner: Consortium with DSME
- Subsea Riser supply from Asiaflex

Floating Liquefied Natural Gas (FLNG) facility of 1.2 million ton per year maximum capacity. The 300 meter-long and 60 meter-wide FLNG facility will be located offshore Malaysia.
Comparative Motion Performance
Comparison of Motion RAO

Wave energy intensity

Heave RAO (m/m)

Period (sec)

TLP

FPSO

Semisubmersible

SPAR
Comparative Hull Performance For SCRs

SCR Hang-off Response
100 yr hurricane GoM

- Lateral
- Vertical

Std Dev Motion - ft

Spar
TLP
Semi

Deep Draft Step Column Semi
## Function of Offshore Real Estate

<table>
<thead>
<tr>
<th>Platform Type</th>
<th>Depth Limit (meters)</th>
<th>Christmas Trees</th>
<th>D&amp;C and Workover</th>
<th>Storage</th>
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<tbody>
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<td>150 - 1500</td>
<td>Wet or Dry</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Flat deck</td>
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<td></td>
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<td>• lay down area</td>
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<tr>
<td>Spar</td>
<td>300 – 3000</td>
<td>Wet or Dry</td>
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<td>Limited</td>
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<td></td>
<td></td>
<td>• Inclined deck</td>
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<td></td>
<td></td>
<td>• limited lay down</td>
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<td>Semi</td>
<td>50 - 3000</td>
<td>Wet but Dry possible</td>
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<td>No</td>
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<td></td>
<td></td>
<td></td>
<td>• Rolling deck</td>
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<td></td>
<td></td>
<td>• Abandon in storm</td>
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<tr>
<td>Ship</td>
<td>50 - 3000</td>
<td>Wet only</td>
<td>No</td>
<td>Yes</td>
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<td></td>
<td>• Not as FPSO</td>
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<td></td>
<td></td>
<td>• Yes as drill ship</td>
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<td></td>
<td>• 2+weeks of production</td>
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<td>Tower</td>
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<td>• Big lay down area</td>
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<td>• variable loads</td>
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<td>Yes</td>
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<td></td>
<td>• same as tower</td>
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</tr>
<tr>
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<td></td>
<td>• Similar to ship</td>
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</table>
Comparative Economics

Dry Tree Surface Facilities

Relative Installed Cost vs. Water Depth (m) – not linear

- Spar
- Compliant Tower
- Semi
- TLP
- Jacket
3. Why Technip for your future Floater?
Technip, an Integrated expertise to deliver Complete Solutions for your Deepwater Projects

- Technip is a proven and reliable Partner in developing offshore Projects in Asia
- Technip has a unique presence in the area both in Indonesia and Malaysia to support design through fabrication and installation of a deepwater floater
- Technip invest in State of Art Technology
- Technip can support its Clients with the best deepwater floater solution for your Project

Technip, your preferred Partner to support the selection of the right solution for your Deepwater Project
Thank you