I - History and trends in deepwater development

Part 1  Definition and clarifications

Part 2  From Brazil to the Golden Triangle to Ormen Lange

Trends

- Deepwater activities developed in GOM and Brazil from the mid 80’s
- West Africa entered the scene in 1993 and we have seen a most impressive development
- While Shell and Petrobras have been the "pioneers" a high number of new actors have entered the scene in the last decade
- A number of new deepwater area have been awarded in the last few years
The Norwegian way

Yesterday
Gravity based platforms for drilling and production

Today
Floating production and subsea systems

Tomorrow
Seabed separation, extended wellstream transfer to onshore plants

Ormen Lange

Source: Norsk Hydro

Snøhvit

Source: Statoil

Part II
Deepwater technology

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13 December 2005
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II - Deepwater technology

Part 1  Field development concepts overview
Part 2  Deepwater platforms
Part 3  Some key issues (positioning, riser systems)

Four major development concepts

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<th>Major field</th>
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Three different concept categories

- With surface units
  - subsea wells (FPSO, FPU)
  - dry wells (TLP, Spar)
- Hybrid development
  - deep subsea wells tied back to shallow platform (hub platform)
- All boy’s dream
  - subsea to shore - S2S

Shell deepwater history
II - Deepwater technology

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Deepwater TLP development

Features
- Medium/deep reservoir
- Centralised wells
- Surface trees
- Integral workover facilities
- Pipeline/FSO for export

TLP’s – Sanctioned, Installed Operating

Features
- Medium/deep reservoir
- Surface trees, direct vertical access
- Integral or tender assisted drilling
- Integral workover facilities
- Integral storage option
- Pipeline/FSO for export

Deepwater Spar development
Deepwater FPSO development

- Shallower reservoir or large aerial extent
- Remote wells
- Subsea trees
- Well workover by specialist vessel
- Integral export system

From reservoir to terminal

- Deepwater technology
- Oil
- Gas
- Water
- Pipeline
- Pipeline
- Storage Tanker
- FPSO
- Terminal

Progression of Spars and TLP’s to Deepwater

- Elevation
- Remote wells
- Subsea trees
- Well workover by specialist vessel
- Integral export system
Norwegian FPSO

FPSO’s - 15 Deepest Units

The compliant tower

Features
- Surface (dry) trees
- Direct vertical access (DVA)
- Integral drilling/workover facilities
- Tensioned riser concept for larger numbers of wells
- No oil storage; pipeline or FSO export
- Insensitive to topsides loads
- Commercially attractive for water depths 400-700 m
The gigantic semi

Semi-FPS’s 15 Deepest Units

The mini TLP

West Seno
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Deepwater rig fleet

West Navigator
West Venture

The DP system

Moorings
Mooring systems

- Conventional mooring systems (wire/chain) becomes expensive in water depth beyond 7-800 metres
- Synthetic fibers mooring systems provide:
  - larger horizontal stiffness
  - reduced seabed footprint
  - decreased floater payload
  - reduced cost

Deepwater riser configurations

- Simple catenary riser
  - Plan Length 0.75-1.5 Depth
  - Mean Top Angle 10-25 degrees
  - Touch Down Point

- Wave catenary riser
  - Lazy Wave Catenary
Flexible risers

Umbilical systems

Typical dynamic umbilical

Umbilical build-up

- Steel tubes
- Electric/Power cables
- Fibre Optic Cables
- Poly Vinyl Chloride - conduit profiles
- Poly Ethylene-static umbilical outer sheathing
Umbilical highlights

Umbilicals for a variety of services:

- Direct hydraulic
- Electro / hydraulic
- Integrated large service lines with center lines up to 4 inches.
- Static and dynamic applications
- Fiber optic and high voltage cables
- Stainless steel tubes for fluid transfer, compatible with all common injection fluids
- High crushing resistance
- Designs to 2500 m water depth

Field proven technology, 603 km installed or on order.

Deepwater technology - Part 3