Overview of Subsea Operations

Guyana Oil and Gas Association

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Guyana Oil and Gas Association Inc.
Invites You To
The Second Public Lecture

“Overview of Subsea Operations”

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Queenstown, Georgetown
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Overview

- Introduction and overview of deepwater subsea projects
- World tour of offshore developments
- Subsea Developments and Key Components
- Delivery Challenges
Introduction and Overview of Deepwater Subsea Projects
Brief History – Offshore Oil and Gas

The Offshore Industry is much older than you might think

- 1891 – First offshore well
  - On Grand Lake in Ohio in 10-ft of water
- 1896 – First well in salt water
  - Santa Barbara Channel in California
  - Drilled on piers built out to the rig
- 1920s – Drilling from concrete platforms
  - Lake Maracaibo in Venezuela
- 1930s – First mobile steel drilling barges
  - Developed by Texas Co. (now Chevron) on Gulf of Mexico coast
- 1942 - Reeled pipelines were installed during World War II
  - This project was known as the PLUTO project (Pipe-Line Under The Ocean).
- 1947 – First commercial oil discovery drilled out of sight of land
  - Ship Shoal Block 32, 10-mi from Louisiana coast
  - Drilled by Kerr McGee (now Anadarko) in ~18-ft of water
Industry Benchmarks
Subsea Tieback Distance

INTECSEA Deep-Offset Projects

Water Depth (ft)

Tieback Distance (miles)
Industry Benchmarks
Subsea Tie-back Distance

World Record Subsea Tiebacks • Sanctioned, Installed, Operating or Future Tiebacks (Water Depth vs. Tieback Distance) • As of March 2012

Source: Offshore Magazine Poster No. 98, 2012 Deepwater Solutions & Records for Concept Selection, Issued May 2012
World Tour of Offshore Developments
Canyon Express  
Gulf of Mexico

Description
- 2 x 50 mile x 12-inch Multi-Phase Flowlines
- In-Line Subsea Well Tie-In Sleds
- Subsea Multi-Phase Flow Meters

Project Highlights
- First Multi-Field/Multi-Operator Subsea Development
- Challenging Flow Assurance and Operability Issues
- Record 7,280 ft Water Depth and Complex Seafloor Topography
- Use of Fiber Optic in Control System Umbilical
Shenzi
Gulf of Mexico

Description
- MC Blocks 609, 610, 653, 654
- 4,400 ft water depth
- 100,000 bopd & 50 MMSCFD
- Purpose-built TLP

Project Highlights
- Shenzi subsea wells tied back to purpose-built TLP
- Development has implemented several additional subsea reservoirs and expansions leveraging standardize equipment
Stampede
Gulf of Mexico

Description:

• 40,000 bopd, 15 MMSCFD
• 30,000 bpd water injection
• 6 subsea producers, 4 injectors
• 3,400 ft water depth in GOM

Project Highlights:

• High Pressure /High Temperature subsea system
• Collaborative development approach
Description:
- FPSO Turret moored
- Gas Export Pipeline to shore
- Onshore Receiving Facilities

Project Highlights
- First Arctic class hull
- Challenging Environment
- Remote location
- Largest gas processing facility
Scarab/Saffron Mediterranean Sea

Description
- 2 Subsea Manifolds with 8 Subsea Wells
- 2 x 13 mile x 20-inch Infield Flowlines
- Multi-Flowline Subsea Tie-In Manifold
- 43 mile x 24-inch and 36-inch Flowlines

Project Highlights
- First Deepwater Mediterranean Subsea Development (2,800 ft)
- Challenging Flow Assurance and Operability Issues
- First Production (400 MMSCFD) January 2003 (600 MMSCFD Peak)
- At time of construction was the World’s Longest Producing Tieback and Delivering 2,000 MMSCFD
Project Highlights

- Longest Subsea Tieback in the world – 147 km
- High Capacity subsea development

Description

- Long Distance Subsea Tieback gas development
- Capacity approximately 1 Bcfd
- Water Depth 1680 m
- Dual 16-inch Gas Pipeline
Project Description:

- Currently in preFEED
- 2500 Meters Water Depth
- 10 KSI Seafloor Equipment
- Multi-Phase Pumping
Description

- Major oil discovery offshore Ghana
- 80 (ultimate) subsea wells to floating production system
- Water depth 4500 feet

Project Highlights

- Project Delivery in 30 months
- Challenging subsea terrain
Description

- 5,400 ft water depth
- 38 wells
- 6 manifolds
- 80 km flowlines
- Insulated flexible production flowlines
- 2.3 MMBBL New Build FPSO producing 250,000 BOPD and 450 MMSCFD, TALM

Project Highlights

- Stand alone FPSO facility and complicated subsea development
- Gas export pipeline and connection to WAGS
- Advanced qualification of flexible pipe for size, depth and pressure
Liwan 3-1
South China Sea

Description
- Subsea gas field in 1,500 m water depth tied back 75 km to a new build shallow water processing platform in 200 m water depth in South China Sea
- Multiphase (gas & condensate) 30 inch marine pipeline from platform to shore (275 km)
- Marine sales gas pipelines (4) totaling 250 km with metering & regulating (M&R) stations

Project Highlights
- First deepwater development offshore China
- 80-km long tieback
- First use of gas recirculation (gas recycle) as part of primary operating condition
- Design condition includes designing for solitons
- Wet gas flowmeters integrated with subsea trees
Description:
- Water Depth: 1,400m
- Tie Back Distance: 15km
- 4 production drill centers & 4 water injection drill centers
- PIP Production Flowlines
- Production flowrate: 40,000 bpd
- Water Injection flowrate: 70,000 bpd
Project Description:
• Water depth of up to 1,350km, 160km north of Exmouth, WA
• Facility design flow rate – 325 MMscfd and includes gas/liquid separation, glycol regeneration, gas dehydration and gas/condensate export with supporting utilities/accommodation

Project Highlights:
• Cyclonic environment
• Deep Draft Semi Submersible
• Lazy Wave Risers
How do you get from here...
...to here?
Why subsea?

Geography
- Well locations are spread out and not supported by dry trees
- Lack of nearby processing/receiving facilities
- Small field in close proximity to existing platform

Safety
- Personnel risk to man a platform or perform maintenance is eliminated with a subsea option

Cost
- Capex – subsea developments are generally less expensive than topside alternatives
- Opex – subsea developments do not require regular maintenance like topside structures
Subsea field architectures are designed around these three main questions:

- How many wells are there?
- Where should the wells be?
- How do I bring them back to the facility?
Generic Subsea Options

Single well tieback
Well template/manifold
Manifold with cluster wells
Manifold with remote wells
Daisy chain

- 10" FLOWLINES
- 10" PLETS
- TREE
- INFIELD UMBILICAL
- (2) MANIFOLD WITH 10"
- UTA WITH FLYING LEADS
Key Subsea Components
Subsea Production System

Key Components

- Manifold
- Jumper
- PLEM Tree
- Umbilical
- UTA
- Flying Leads
- Jumper
- Control Pod
- Flowlines
Wellheads

- Support the BOP (Blowout Preventer) and seal the well during drilling
- Support and seal the subsea tree during production
- Support the tubing hanger for conventional subsea trees
- Act as a hanger for the casing strings in the well annulus
- Common Standard: 18 ¾ in x 15,000 psi
Subsea Trees

- Sits on top of the wellhead
- An assembly of valves to control the well flow

Different types of trees
- Vertical
- Horizontal
Manifolds

- Flowline Jumper Connection
- Structure
- Piping
- Foundation
- Well Jumper Connection
- Valve and Actuator
Jumpers

- Connects two subsea structures
- Can be made of rigid or flexible pipe
- Can include meters and sensors
- Vary in shape
Connectors

- Torus Hydraulic Connector (Vertical)
- MAX Mechanical Collet Connector (Vertical)
- Single or Twin Screw Clamp Connector
- KC4 Collet Connector

Vertical or Horizontal
Subsea Controls & Umbilicals

Controls
- Operate all subsea equipment – actuate valves, manage chemical distribution, monitor all data
- Managed from the host facility

Umbilicals
- Supply hydraulic fluid to the subsea controls
- Transmit power and signal to the subsea controls
- Supply downhole chemicals to the well via a host facility
System Components

- Subsea Control Modules
- Tree Mounted Controls
- E/H SCM
- SEM
- FL Deployment Frame
- Hydraulic Distribution
- Test Equipment
- Electric Distribution
- Electronics
- Sand detector
- Meters
- Umbilical
- Daisy Chain UTH
- Sensor
- Common Subsea Control System Components
Delivery Challenges

- Weather
- Depth
- Tie-back distance
- Increasing water-cut
- Pressure decline
Projects face delivery challenges in all phases of the program. These include:

- Development arena – environment, location, reservoir fluids
- Engineering - Selection of Key system solutions – flowlines, risers, subsea layout, floating system
- Procurement
- Fabrication
- Installation
Weather Prediction

Weather fronts and storms in global model (source: US NCAR Annual Report)

Regional climate prediction program (source: US NCAR Annual Report)

Better regional weather prediction technologies enhance project feasibility and solutions

Eyes in sky monitor, weather prediction (source: NASA/Goddard Space Flight Center)

Remote sensing (source: NASA/Goddard Space Flight Center Scientific Visualization Studio)
Industry is developing floating facilities for deepwater and larger facilities. Deployment of FPU facilities in deepwater enable accessing difficult reservoirs.

<table>
<thead>
<tr>
<th></th>
<th>Shell Olympus TLP</th>
<th>Anadarko Lucius Spar</th>
<th>Chevron Big Foot TLP</th>
<th>Chevron Jack St. Malo SEMI</th>
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<tbody>
<tr>
<td>Depth (m)</td>
<td>944</td>
<td>2,164</td>
<td>1,585</td>
<td>2,134</td>
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<td>One of the largest</td>
<td>TLPs</td>
<td>Second in terms of</td>
<td>The Largest TLP &amp;</td>
<td>One of the largest Semis</td>
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<td>water-depth</td>
<td>Record Water-depth</td>
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- Shell Olympus TLP
- Anadarko Lucius Spar
- Chevron Big Foot TLP
- Chevron Jack St. Malo SEMI
Flow Assurance:
- Steady State Analysis
- Transient Analysis
- Reservoir fluid characterization
- Operability philosophy and strategy
- Production optimization and stability
- Corrosion/erosion analysis

Challenges:
- Flowline sizing for throughput and all operating scenario
- Slugging
- Hydrates
- Corrosion
- Liquid holdup
- Wax, Emulsions, Scale, Asphaltenes, Sand
Riser Systems

Riser Systems:
- Steel Catenary Risers
- Lazy Wave Steel Catenary Risers
- Flexible Risers
- Hybrid Risers
Procurement

Bid / Strategy Phase
- Scope, Spec and Drawings
- Contracting Strategy
- Supply/Delivery; Risk Assessment
- RFQ’s for Equipment, Vendor Selection and Order Placement; Technical Qualification

Manufacturing Phase
- Kick-off Meeting
- Documentation Review
- HSSE and QA/QC
- Inspection and Test Plan
- Maintain Schedule and Budget
- Daily Reports from Inspector
- FAT, DQT and SIT
- Production Performance
- Non-conformance Issues and Resolution
- Material Certifications

Delivery Phase
- Release for Shipment
- Shipping
- Data Book Review
- Verify Invoicing
- Close-Out
- Equipment Delivery
- Handover of Ownership
Installation

- **Design Support**
  - Constructability
  - Cost Estimating
  - Risk Assessment

- **Construction Planning**
  - Bid Strategy
  - ITB and Evaluation
  - Procedure Reviews

- **Construction Execution**
  - Material Testing
  - Equipment Audits
  - Site Safety Plans
  - Field Execution and Oversight
  - Management of Change
  - Lessons Learned