Jubilee Field - Discovery

- Mahogany-1 wildcat well drilled by Kosmos June 2007 in the West Cape Three Points block.
- Ghana’s first significant oil find after 40 years of offshore exploration.
- Confirmed by Tullow’s Hyedua-1 well drilled August 2007, 5 km SW in Deepwater Tano block.
- Discovery renamed the Jubilee Field.
Jubilee Field – Phase 1 Development Considerations

- Accelerated production
- Learning for full field optimization
- Development flexibility for uncertainties/expansion
- Accommodate seabed features and absence of data
- Environmental and social responsibility
- New oil province; remote to major oil and gas industry infrastructure
- Build Supporting Infrastructure
Agenda

- Supporting Infrastructure
- Subsea System Design and Delivery
- FPSO
- Installation, Hookup and Commissioning
- Performance
- Lessons Learned and Conclusions
- Mozambique, The Next Step
Run from Ghana By Operator Tullow with highest standards

Immediate drilling rig support by Q4‘08, expanded rapidly

A long term view. Early localization with development plans.

Existing Takoradi-Sekondi port facilities were largely pre-WWII.
  - Established an early civil engineering project team
Infrastructure Build

- $42 million invested in infrastructure & offices; built by Ghanaians
- A major shorebase/aviation capability established in Ghana
  - ~30,000 personnel movements per year
  - 75,000 tonnes deck cargo and >100,000 tonnes bulks per year
  - in 2010 supported 25 vessel at peak of IHUC; still 12 today
- Takoradi airport traffic indulged sharp rise. Takoradi port doubled.
Subsea System Design and Delivery
Design Challenges

- Secure engineering support – Intecsea
- Conceptualize and specify system with limited and changing design information
- Compressed design time frame to allow purchase and delivery of long lead items and fabrication of equipment

Initial design criteria:

- Light sweet crude (37 degree API, GOR 1000-1300)
- Large field with reserves estimates ranging from 400 million to 1.8 billion barrels
- Shut-in pressures just under 5,000 psig
- Water depths between 900 to 1700 meters
- Anticipated gas re-injection
- Water injection for pressure support
- Production to an FPSO of up to 160,000 BLPD
- Notional number of wells and locations
- Well rates up to 20,000 BLPD
Subsea System Design Basis

Utilized Team’s experience with Subsea oil production systems

Employed common functionality and risk mitigations

- Dual insulated, piggable flowlines
- Methanol injection at the tree and other vital locations
- Corrosion inhibitor injected at the tree
- Chemical injection above the SCSSV (LDHI or methanol)
- Scale inhibitor injection down hole
- Employ riser base with provisions for gas lift, methanol injection and riser circulation
- Insulated flexible pipe risers
Potential Reservoir Souring

Threat to strategy of utilizing suppliers’ standard designs

Critical path status warranted elimination of specialized materials or processes

IPT quickly made the decision to add sulfate and oxygen removal processes to the FPSO
Site Specific Design Data

Offshore Ghana - undeveloped region
  ➢ No Metocean data
  ➢ No geotechnical data

Progress design without site specific data
  ➢ Wind, wave and current data extrapolated from design data for an FPSO offshore neighboring Cote d’Ivoire
  ➢ 20% risk factor applied based on drill rig observations and desk top studies
  ➢ Based on experience, production manifolds, riser bases supported by suction piles and injection manifolds on mudmats

Result was to maintain project schedule

Designs confirmed once the data was obtained
Bathymetry and Field Layout

- Located just off the continental shelf
- Field bisected by channel system
- Reservations about any development on the channel floors
- Production systems required on both sides of the central channel
- Turret moored FPSO chosen, moored over the main channel with risers suspended over the channel
Field Layout Evolution

- Chose drill centers of four wells
- Provided adequate reservoir coverage and allowed standardized manifold design
- Delivered great flexibility without changing base design
- Facilitated an “assembly line” type of manifold fabrication facilitating delivery
Field Layout Evolution
Subsea Infrastructure

- Riser Base, weigh 260 tons each (2 total)
- Typical Flexible Riser, 25cm ID, 3600m length (9 total)
- Typical Riser Bouyancy Element
- Typical Subsea Tree (17 total)
- Typical Flowline Jumper (10m to 13m tall, ~40 to 60 meter long)
- Typical Production Manifold, weight 100 tons (6 total)
Schedule Facilitating Execution Methodology

- Leveraged Anadarko’s existing frame agreement with FMC for the supply of subsea equipment
- Utilized suppliers’ standard equipment and procedures
- Chose suppliers with proven track records
- Performed constructability review for manifolds/riser base fabrication
- Fostered collaborative working relationships with suppliers
- Leveraged suppliers’ experience
- Constantly worked interfaces
- Applied experienced inspection resources abundantly
Leveraging Frame Agreements

- Eliminated time consuming bid and evaluation process
- Supplier was able to plan ahead even before award
- Supplier assembled team and kicked-off work almost immediately
- Allowed Subsea System Delivery Team to expeditiously move on to other critical items
Standard Equipment and Procedures

- Utilized Anadarko’s standard 10K horizontal tree

- Utilized Supplier’s standard subsea distribution equipment

- Other equipment supplied per supplier’s standards
  > Eliminated significant engineering, evaluation and qualification time

  > Enhanced supplier’s ability to meet schedule requirements

  > Allowed Subsea System Delivery Team to more productive; able to focus on other schedule critical items
Constructability Review

Manifold and riser base fabrication was the critical path item

Experienced construction superintendent reviewed designs
  - Eliminated piping welds
  - Eliminated difficult and unnecessary structural framing and welds
  - Identified manpower deficiencies

Success of the review due in part to good working relationships focused on problem solving
Interface Management

“Slowed down to go fast”

Established an interface manager and a management software tool

Bi-weekly meetings with major suppliers’ designated representatives and Subsea System Delivery Team Members

Meetings provided:
- Timely transfer of design information
- Promoted understanding of interdependence of designs and deliveries
- Forum for identifying and vetting issues
- Avoided surprises
- Fostered accountability
Inspection Effort

- Core group had good working relationships with suppliers
- Quality of our inspection team aided suppliers in meeting deliveries
- Supplemented suppliers’ QA when schedule pace or volume forced the use of secondary subcontractors
Subsea System Development Results

- All components and equipment delivered within project schedule constraints
- Critical path manifolds and riser bases completed 2 weeks ahead of schedule
- System installed and commissioned without any interface issues
- Safety goals were exceeded
- Subsea design proved to have reasonable conservatism and flexibility
- Subsea System delivered at 6% over original budget
  - Additional cost incurred for inspection, service technicians and air freight
  - Strong currents did require tethering risers and umbilicals to the seafloor
  - Second water injection riser was added
Jubilee FPSO Development in Singapore
Jubilee FPSO Development in Singapore

- FPSO Kwame Nkrumah delivered as planned
  - Installed <24 months after LOI
  - Sailaway at more than 95% of systems through pre-commissioning
  - Delivery well coordinated with installation & commissioning activities
  - Delivered within overall budget
Keys To FPSO Accelerated Development

- Use of a functional design basis;
- Use of proven, off-the-shelf technologies and designs;
- Teaming with a robust FPSO provider with an established, well-proven supply chain;
- Use of industry-accepted engineering and quality standards;
- Project management with a small, experienced, empowered, integrated project team
- Focus on use of the 80/20 rule for making decisions; and
- Alignment with key overall project drivers and priorities.
Installation, Hookup, and Commissioning

- IHUC team in place in-country one year to manage field-wide activities (Takoradi, Sekondi, offshore)
- Comprehensive execution plan, procedures and integrated offshore schedule developed
- Multiple installation vessels, HLVs, supply boats, security boat in Ghana
- Utilized FPSO “Attendant Vessel” for managing POB and equipment space
- Leveraged Unit Operator’s existing in-country processes and infrastructure

Deep Blue

Deep Pioneer
Operational Readiness and Assurance

Production Operations members integrated very early into the IPT:

- Continuity of personnel from engineering to production
- Integration of Operations Readiness and Assurance (OR&A) Plan into schedule
- Influence design, functionality and flexibility of the system
- Witness FATs and SITs of critical components
- Seamless transitions between phases / real time sign-off of systems
Ready for Startup (RFSU)

- Establish a start-up philosophy to identify priorities and sequence the work
- Water injection and production systems critical

**Subsea Mechanical Completion - Subsea Operations**
- Pig and hydrotest all systems up to the riser base.
- Schedule improvement
- Risk mitigation
- **FPSO Operations**
  - Leak test of the riser
  - Flushing / dewatering
  - Top spool, N2He test
  - Umbilical tests
  - Manage pull-in / testing.

**Subsea Systems Static Commissioning**
- Ensure communication to subsea SCMs.
- Valve function testing of the trees and manifolds.
- LCV with WROV monitored.
- Remediate crosstalk and communication issues
- Subsea valve management / tracking of valve positions.

**Subsea Dynamic Commissioning**
- Workshops for alignment on chemical requirements.
- Flushing of MeOH and Corrosion Inhibitor systems.
- Safe Introduction of MeOH onboard the FPSO systems without impeding any remaining topsides activities.

Pre-commissioning equipment onboard Skandi Aker
Jubilee Performance

Schedule

Discovery to first oil < 3 ½ years
Concept start to sanction – 6 months
Sanction to first oil < 2 ½ years

Cost

Sanction Estimate $3.15 billion
Facilities $1.43 billion*
Wells $1.50 billion
Pre-Ops $0.22 billion
Overall within 3.5% of original budget
* FPSO leased

HSE

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<th>Goal</th>
<th>Current</th>
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<tbody>
<tr>
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<td>&lt;= 2.5</td>
<td>1.52 (17 recordables) (11.2 MM Mhr)</td>
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<tr>
<td>Lost Time Incident Rate (LTIR)</td>
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<td>0.45 (5 cases)</td>
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<td>Zero Level II or III</td>
<td>Zero (2-Level 1)</td>
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<tr>
<td>Significant Incidents</td>
<td>Zero Level III</td>
<td>Zero</td>
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Facility Performance

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<tr>
<th>Topsides Systems, Unplanned Downtime</th>
<th>Oil System Downtime</th>
<th>Water Injection System Downtime</th>
<th>Gas Injection System Downtime</th>
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<tbody>
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<td>Jan/Feb 2011</td>
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<tr>
<td>February 2012</td>
<td>0.5%</td>
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<td>3.6%</td>
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<tr>
<td>March 2012</td>
<td>0.0%</td>
<td>1.0%</td>
<td>1.6%</td>
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</table>
Keys to Success

- Willing and supportive Government and national oil company
- Very experienced and empowered team
- Fit-for-purpose process and procedures
- Used proven technologies and “off-the shelf” solutions
- Collaborative approach with Contractors based on relationships
- Incorporate Operations and IHUC personnel early in design
- Comprehensive Readiness for Start-Up Plan
- Diligently work interfaces
- Abundant Inspection resources
Jubilee Lessons Learned
Selected Learnings – Concept to Delivery

- Execution Strategy – establish principles/priorities at start and stick with them (e.g. schedule priority, proven technology)
- Project Staffing – find personnel that can work within framework without need for direct guidance; change personnel quickly if necessary
- Team Integration – subsurface, well design, and well delivery personnel should all be members of the same integrated project team
- Culture – take whatever time is necessary to establish and nurture the project team and leadership culture
- Ways of Working – Co-design fit-for-purpose work systems and processes
- Major Contractors – build relationships and trust, before the inevitable conflicts arise
Jubilee Lessons Learned
Selected Learnings – Installation to RFSU

- Project Team Organization – IHUC team was created well before going offshore and transitioned with the Delivery teams
- Maintain flexibility of the design concept as long as possible
- Offshore First-Oil Focus – keep resolution of commercial issues separate from the offshore execution
- Vessel Audits
- Spares Management – was not given sufficient focus on the project
Conclusion

- Large scale deep water developments can be accelerated without compromising safety, quality or production flexibility
- Requires complementary strategy which eliminates overly prescriptive and time consuming processes
- Fast pace possible for Jubilee but may not be appropriate for all future developments

Many thanks to all the people involved, both Team and Suppliers, who through their dedication and personal commitment, accepted the challenge and delivered
Jubilee Next Phase

- Add 5 production wells to existing infrastructure
- Add third water injection flowline and two 4 slot manifolds
- Add three water injection wells
Anadarko Mozambique Area 1

The Next Step
Prosperidade

Mozambique: A World-Class Reservoir

- 17 - 30+ Tcf Gross Recoverable Resources
- Three Successful Barquentine Flow Tests
  - ~100 MMcf/d Facility Constrained
  - Up to 200 MMcf/d Well Design
- Advancing Initial 2-Train LNG Facility
- Completing Appraisal Program
  - Appraisal Drilling Complete
  - Ongoing Flow Tests
- Reserve Certification Expected in 2013
- FID Targeted in Late 2013
- Anticipate First Sales in 2018
Golfinho-Atum

Mozambique: Growing a Giant Resource

- **Golfinho Discovery**
  - 7 - 20+ Tcf Gross Recoverable Resources
  - 2012 Planned Appraisal Program
  - Cost-Effective Development Option

- **Significant Additional Resource Potential**
  - 20+ Prospects and Leads

- **Planned 2012 Exploration Activity**
  - Drilling Atum
  - Black Pearl
  - Barracuda
Conceptual Development
Mozambique Project

Subsea Challenges

- Installation/Construction logistics
- Heavy wall 22” pipe lay in deep water
- Canyon Crossings
- Probable high currents
- Talus slope negotiation
- Pipe lay down the reef slope/transition from shallow water to deep water
- Shallow bay lay/shore crossing
- Main umbilical installation
Mozambique Project – Area Views