BONGA SOUTHWEST / APARO FIELD
DEVELOPMENT PROJECT
LESSONS LEARNED FROM FPSO FEED

MCE Deepwater
Development 2015

24 – 26 March

LONDON

Charles Essien
BSWA FPSO Delivery Manager
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**Reserves:** Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves.

**Resources:** Our use of the term “resources” in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

**Organic:** Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

**Resources plays:** Our use of the term ‘resources plays’ refers to tight, shale and coal bed methane oil and gas acreage.

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OML 118 BLOCK OVERVIEW

BONGA SOUTHWEST / APARO (BSWA):

- BSWA field is located in the Gulf of Guinea offshore Nigeria
- Field location is about 130km offshore in water depths of 1160m – 1340m
- The field straddles OML 118, 132, 140 block boundaries
- Host facilities will be located in OML118
- Existing infrastructure at Bonga Main is some 19km Northeast of BSWA, but offers limited synergy.
PROJECT OVERVIEW AND CONTEXT

- Major deep-water oil development, 130km offshore Nigeria, in 1,160 – 1,340m of water

- Project objective
  - Produce about 800 million bbls, developed in two phases (Phase 1 + 2) over 25 yrs

- Project scope as per the FDP & BFD
  - Subsurface & Wells
    - Phase 1: 24 wells (12 producers/12 water injectors) pre-FOD
    - Phase 2: Additional 20 wells (10 producers/10 injectors) post-FOD

  - Subsea & Host Facilities
    - Shell Operated Regional FPSO
    - 5 Prod & 8 Water Injection Drill Centres

- Challenging Nigerian content aspirations
  - FEED and detailed engineering to be performed in-country
  - 50% Topsides modules (by weight) to be fabricated in-country
  - FPSO integration to be performed in-country

PROJECT MATURATION PHASE

KEY PROJECT DRIVERS

- Strong host government and partners support for project
- Maximise operational asset value throughout its life cycle (Optimise CAPEX & OPEX)
- Maximise Ultimate Recovery

TOP PROJECT CHALLENGES

- Achieving an aggressive tendering cycle
- Resolution of non-technical risks
- Quality and timeliness of FEED delivery
- Project team resourcing and continuity
- Nigerian Content requirements
TRANSITION FROM SELECT TO DEFINE PHASE

IDENTIFY

ASSESS

SELECT

DEFINE

EXECUTE

OPERATE

DIVERGENT THINKING

CONVERGENT THINKING

PROJECT PREMISES

TECHNICAL SCOPE

Pre-FEED
2012

FEED
2013

Pre-FEED
2012

FEED
2013

Pre-FEED
2012

FEED
2013

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March 2015
TRANSITION TO FEED

- Basis of Design Freeze
  - Fluid data and flow assurance strategy
  - Wells, Operations, Subsea, Pipelines and Risers, and FPSO requirements
  - Metocean, geophysical and geotechnical data

- Management of Change Process
  - Documented process for managing design changes from the Basis of Design

- Feed Deliverables and Technical Assurance
  - Level of definition of FEED deliverables across all technical disciplines
  - List of technical deliverables and required assurance process – aligned with Shell Discipline Controls and Assurance Framework (DCAF) process
  - Definition of Codes and Standards – Shell Design Engineering Practice (DEPs), international codes and standards

- Feed Organization
  - Discipline Delivery Plan and estimate of engineering manhours
  - Team alignment and FEED progress reporting system
Supports Topsides processing facilities, subsea facilities control, oil storage and export

Regional FPSO – simultaneously produce BSWA crude (225 kbpd) and additionally import/handle up to 100 kbpd of processed crude from third party producer

Associated gas export to the OGGS via a 16 inch gas export pipeline to EA shallow water Riser Platform
FEED completed during 2012 – 2013, and underpinned by Shell internal processes, lessons learned, operations & maintenance requirements, and process safety
HULL MAIN CHARACTERISTICS

- The world’s largest FPSO Hull yet at 334m x 65m x 37m (L x B x D)
- Hull Displacement at Maximum Design Draught – 560,284 mT
- Spread moored in 4 x 3 mooring pattern in c. 1,300m water
- 2.5 mln bbl carrying capacity in 18 cargo tanks (6 rows of 3 tanks each)
- 25 years design life based on continuous operations without dry-docking; Fatigue Design Life 40 years
- Cofferdams and production chemical tanks integrated in Hull
- Offloading rate of 1.0 mln bbl/day via SPM Buoy
- POB in normal operation is 160. Maximum POB is 240 during peak requirement (80 single bed cabins + 80 double bed cabins)
- Supports Topsides NTE weight of 45,000 mT
# TOPSIDE SYSTEM DESIGN

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>DESIGN CAPACITIES</th>
<th>MAJOR EQUIPMENT/TECHNOLOGIES</th>
</tr>
</thead>
</table>
| Oil Production              | 225 Kbd           | ■ 2 x 50% train; three Separation stages; pre-heating  
■ 3 Phase Test Separator  
■ Dehydration Equipment: Bulk Oil Treater |
| Gross Liquid Handling       | 300 Kbd           | Gross design capacity set incorporating Lessons from Bonga Main. |
| Produced Water Treatment    | 200 Kbd           | ■ Primary and Secondary Hydrocyclones  
■ Compact Floatation Units |
| Gas Processing              | 270 MMscf/pd      | ■ Three stage LP compression (VRU) – Centrifugal compressors  
■ 2 x 66% Field Gas Compressor Trains – GT Driven  
■ Glycol Contactor/Regeneration system between Stages 2 and 3 of FGC. |
| Water Injection             | 400 Kbd           | ■ Seawater strainers and Ultra filtration package  
■ Deaeration Tower  
■ 3 x 33% High Energy Injection pumps – GT Driven |
| Power Generation            | 29.5 MW – 45 MW for four operating cases | ■ 4 units in N + 1 configuration  
■ Dual Fuel Gas Turbines reference equipment – 23MW ISO  
■ Diesel Driven Emergency and Essential Services Generators |
| Process Heating             | Available         | ■ Waste Heat Recovery installed on gas turbine exhaust system. |
| Process Cooling             | Available         | ■ Fin Fan coolers  
■ Water cooling for lube oil systems and generator motor |
| Chemical Injection          | Available         | ■ 23 production and water flood chemicals required |
| Crude oil export system     | 7500 m3/h         | ■ 3 x 50% export pumps, delivering 1.0 million bbl parcel in 24hrs.  
■ 3 x 18.7 inch mid depth export risers (unbonded flexible) to SPM |
BSWA FPSO PDMS VIEW

- Layout design facilitated by Tech HSE SME
- Mechanical handling philosophy
- Lessons learned (Bonga Main, CoVs)
- Dropped object assessment
- Human factor engineering

- Major equipment, structures and up to 6-inch piping modelled.
- FEED verification by EPC Tenderers introduced as part of technical tender.
TECHNICAL ASSURANCE ACTIVITIES - 2012/2013

- Value improvement
  - Detailed process engineering review
- Process Engineering Peer Review
  - Review of process engineering design
- Energy Efficiency Review
  - Process engineering design/flow schemes
  - Drivers selection and electrical loads
  - Greenhouse gas and energy efficiency
- Topsides Structures
  - Structural Efficiency review
  - Design Peer Review
- Mechanical Engineering
  - Design Peer Review
  - PDMS reviews
- Materials and Corrosion
  - Design Peer Review

- Rotating equipment
  - Design Peer Review
- Process Automation Control & Optimisation
  - Design Peer Review
- Electrical Engineering
  - Design Peer Review
  - SAFOP Review
- Technical HSSE
  - Topsides Layout Review
  - HFE
  - Coarse HAZOP
  - FEED HAZOP
- FPSO Integrated Design Review
  - Topsides & Hull
  - Tech HSSE
  - Interfaces

- Close collaboration and engagement with Shell Affiliate technical teams and external consultants:
  - Shell Global Solution, NL
  - Deep-water Projects, US
  - Shell Shipping Technology
  - Babcock Engineering, UK
  - Lloyd's Register
FEED PERFORMANCE MANAGEMENT - SAMPLE

**Weekly reports**
- Monthly reports
- Partner bi-monthly reviews
- Engineering hours
- Deliverables status

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**Reporting Period - Aug 2013**

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<tr>
<th>Disciplines</th>
<th>Plan (%)</th>
<th>Actual (%)</th>
<th>% Effort</th>
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**Discipline - I - Monthly Progress (Incremental)**

**Discipline - C - Progress To Date (Cumulative)**

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**FEED PERFORMANCE MANAGEMENT - SAMPLE**

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FPSO ITT - SCOPE OF WORK OVERVIEW

- FPSO Main EPC responsible for delivery of the FPSO Unit (Hull + Topsides), including related sub systems

- Following subcontractors selected by FPSO EPC from SNEPCo AVL:
  - Main Automation Contract
  - Main Telecoms Contractor
  - Main Information Contractor

- SNEPCo procures 4 x Turbo generator units + 2 x Turbo compressor units for free issue to FPSO EPC.

- Class Society selected by SNEPCo

- FPSO EPC responsible for managing interfaces with other EPCs. Interface management process and interfaces defined in ITT.
FEED CHALLENGES - 1/2

- **Nigerian Content Requirement for Feed Execution In-Country**
  - FEED office established in Lagos
  - Experienced Technical leads with Bonga Main/FPSO experience to drive the process
  - Specialist engineering support from Shell Affiliate teams – Hull design, CFD, Smoke & Gas Dispersion, etc.
  - Perform Pre-FEED in-house before involvement of local Engineering companies

- **Managing Shell Internal Stakeholder Interests**
  - Application of Shell Assurance Processes – DEM 1 & 2, Discipline Control Assurance Framework (DCAF), selection of codes and standards
  - Strong Process Safety involvement in key design decisions e.g. topsides layout, FPSO heading, HC gas blanketing, flare sizing and orientation, etc.
  - External Peer Reviews for each Discipline Engineering output

- **Managing Inter-Discipline Interfaces**
  - FEED delivery primarily through the Deepwater functional matrix organization
  - Package leads (Topsides, Hull) and Technical Delivery have line of sight
  - Joint FEED activities – Topsides layout review, Integrated FEED HAZOP, PDMS review, etc.
Managing Topsides & Hull Interfaces
- Single Discipline oversight for Topsides and Hull equipment
- Topsides weight management – Topsides NTE weight, Riser Loads, etc.
- Topsides – Hull interface meetings

Feed Completion within 18 Months, on Time for ITT
- Performance management through weekly reporting against plan
- Development of ITT Scope of Work and Technical Specifications
BEST PRACTICES & CONCLUSIONS - 1/2

- Managing the transition to FEED
  - Basis for Design Document
  - Set-up Management of Change (MOC) Process
  - Maximise the use of existing design templates
  - Alignment of Technical Leads

- FEED Deliverables and Assurance
  - Define technical deliverables and man hours
  - Technical Assurance process
  - Establish and communicate the level of detail of FEED across project
  - Set-up reporting and performance management metrics
  - External Peer Reviews and Integrated Design Review

- Strong Teams Deliver
  - FEED execution strategy and location of core FEED team
  - Strong homogeneous matrix organization
  - Strong Operation Readiness & Assurance involvement
  - Strong Technical HSE team validating key design decisions

![Diagram of topsides and hull with functional areas]

- TOPSIDES
  - PROCESS
  - MECHANICAL
  - STRUCTURAL
  - PROCESS AUTOMATION CONTROL OPTIMIZATION
  - ELECTRICAL
  - TECHNICAL HSE

- HULL

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BEST PRACTICES & CONCLUSIONS - 2/2

- Post FEED Management
  - Standard templates for FPSO design e.g. design philosophies, P&IDs, PDMS model, etc.
  - FEED Lesson Learned database
  - Provision of FEED clarification to Tenderers in face-to-face meetings during Technical Tender phase

- FEED Verification during Tendering
  - FEED documents included in the ITT package for review and verification by Tenderers
  - Any qualifications priced-in by the tenderers
  - Post-Tender, Contractor owns the FEED and uses as the basis for the detailed design
  - Any updates, enhancement/optimization required forms part of detailed design development by EPC Contractor

COMPANY TECHNICAL DOCUMENTS
- Rely Upon Information
- Design Philosophies
- FEED Documents

EPC FEED VERIFICATION
- Independent calculations
- Leverage norms & experience
- Vendor data
- F2F FEED clarification meetings
- 6 – 8 months

EPC VERIFICATION REPORT
- Report on findings
- Qualifications if any
- Topsides weight envelope
- Hull principal dimensions

Technical Dossier in ITT Package
FEED Report & Certificate of Verification
THANK YOU

ROSEMARY IFEAGWU
Engineering Manager Floating Systems

DEBO TAIWO
Technical Delivery Manager

YEMI SUARA
Topsides Lead

ALI ANATURK
Hull Lead (2010 – 2013)

SJORS JANSSEN
Hull Lead (2013 – Present)

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