

# Erha and Erha North Development

In March 2006, ExxonMobil affiliate Esso E&P Nigeria started production from the Erha deepwater development approximately 97 km offshore Nigeria in 1200 m of water. The Erha development includes Erha North, a satellite development that came on stream in September 2006. The Erha and Erha North Project consists of 32 subsea wells tied back to a floating production, storage, and offloading (FPSO) vessel. A catenary-anchor-leg-mooring (CALM) buoy is used for crude-carrier docking and product transfer.

### Introduction

The first exploration well, Bosi-1, was drilled on the block in 1996. The Erha oil discovery was made with the Erha-1 well in February 1999. Appraisal well Erha-2 was completed in November 1999, and the Erha-3 appraisal well and sidetrack were completed in September 2001. Well Bosi-2 discovered oil in March 2002. After the start of Erha development drilling, an oil discovery was made in March 2004 with Well Erha-7 and Erha-7 sidetrack, leading to the addition of a third drill center, Drill Center North (DCN). Recoverable reserves are estimated to exceed  $7.9 \times 10^7$  m<sup>3</sup> of oil.

The Erha and Erha North plan included sequential startup of three drill centers, managed simultaneously with a two-rig development-drill-

Components Activity ↓	FPSO			SURF					DRILLING		
	Topside with Quarters	Hull	Hull Moorings	Calm and Moorings	Flowlines, Risers	Umbilicals	Manifolds and Jumpers	SS Trees and Controls	MODU Moorings	MODU Rig	Drilling and Completions Materials and Services
Project Management	Esso E&P Nigeria and ExxonMobil Development Company										
Preliminary Engineering	Design development										
Detailed Design	EPC1		EPC2		EPC3			Piles Chain Wire			
Procure	LS		LS		LS			LS		Lease	
Fabricate	LS		N/A		LS			LS		Many contracts and POs	
Intergration	LS		N/A		LS			LS		N/A	
Transportation to Field Site	LS		N/A		LS			DR		T1 (multiple contracts)	
Offshore Installation	LS		N/A		LS			DR		N/A	
Offshore Commission	LS		N/A		LS			DR		N/A	
Drill and Complete Wells	N/A		N/A		N/A			DR		N/A	
Operate	Esso E&P Nigeria										

**Fig. 1—Work-breakdown structure. LS=Lump Sum; DR=Day Rate; SURF=Subsea, umbilicals, risers, and flowlines; and POs=purchase orders.**

ing program and ongoing production operations. The subsea wells are connected to a new-build, spread-moored FPSO through flowlines and steel catenary risers (SCRs). Processing facilities installed on the FPSO handle  $3.3 \times 10^4$  m<sup>3</sup>/d of oil, as well as provide injection capability for  $2.4 \times 10^4$  m<sup>3</sup>/d of water and  $9.6 \times 10^6$  std m<sup>3</sup>/d of gas. Processed crude oil is stored in the FPSO and periodically offloaded to trading tankers through a CALM offloading buoy.

### Development Planning

Initial development plans focused on selecting a development concept for the Erha field N4 resource with flexibility to accommodate future tiebacks to commercialize additional discoveries on the block. The development concept captured and incorporated learnings from ExxonMobil's worldwide project execution, with particular emphasis on other west Africa projects, technology, and operability.

The original Erha full-field development plan included 24 subsea

wells, clustered in two drill centers: Drill Center East (DCE) and Drill Center West (DCW). All subsea wells would be drilled and completed from a mobile offshore drilling unit (MODU) and tied back to the FPSO. Producing wells would be brought together through manifolds with insulated flowlines and risers connecting the manifolds to the FPSO. All gas-injection wells would be over the gas cap from DCE, and water-injection wells would be from DCW. Injection wells at each drill center would be routed through a manifold connected to the FPSO with a single uninsulated flowline and riser.

The Erha field development plan was updated to incorporate DCN. Initial development of Erha North would include eight subsea wells with production wells tied back to the FPSO through a subsea tie-in at DCE and water injection wells tied back through DCW. Spare DCN manifold slots would provide potential for development expansion without further facility infrastructure investment.

*This article, written by Technology Editor Dennis Denney, contains highlights of paper OTC 18655, "Erha and Erha North Development: Overview," by T.C. Parker and A. Sofidiya, SPE, ExxonMobil, prepared for the 2007 Offshore Technology Conference, Houston, 30 April–3 May.*

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The full-length paper is available for purchase from the OTC Library: [www.otcnet.org](http://www.otcnet.org). The paper has not been peer reviewed.

## Facilities Description

**FPSO.** The new-build Erha FPSO is 285 m long by 63 m wide and is spread-moored at a water depth of 1200 m. All processing equipment is above the main deck. The topside facilities consist of two trains of three-stage oil separation. Associated gas is compressed and dehydrated to provide fuel gas, with the remainder reinjected back into the producing reservoir for pressure maintenance to enhance oil production. The FPSO has capacity for gas injection and seawater injection into the reservoir for pressure maintenance to supplement gas injection as part of the reservoir-management plan. Seawater treatment includes filtration and deaeration.

**Export System.** The export system transfers oil from the FPSO to conventional open-market tankers through a loading buoy. The export system includes two 22-in. oil offloading lines (OLs) connecting the FPSO to a spread-moored CALM offloading buoy system, anchored approximately 1.8 km from the FPSO.

**Subsea System.** The subsea component consists of three drill centers (DCE, DCW, and DCN), each comprising several individual wells clustered around manifolds. Flowlines terminate at DCN. Rigid jumpers make up the well, manifold, and flowline connections. All subsea production and injection trees are a horizontal configuration designed for standard interfaces and interchangeability. This design minimizes engineering, qualification, and testing requirements.

A common electrohydraulic multiplexed control system is on the FPSO to control and/or monitor the subsea tree functions, safety valves, and downhole pressure and temperature gauges in the various wells. Control umbilicals connect the FPSO to each drill center and provide the electric power and signals, hydraulic-control fluid, annulus access, methanol-injection capability, and other services required for the wells and manifolds.

## Project Execution

**Safety.** Executing major offshore oil and gas projects safely is a significant

challenge given the scope, complexity, and schedule inherent with these projects. The Erha and Erha North Project's adoption of a partnership approach to safety with its engineering, procurement, and construction (EPC) contractors and their subcontractors was essential. Through goals and objectives alignment, frequent communication at all levels, workshops, and visible metrics, the project developed an open and improvement-focused relationship among the management teams of the EPC contractors with the aim of ensuring safe work execution. Sharing a common vision and commitment to safety, the contractor management teams in turn fostered similar relationships with their subcontractors and associated site teams.

**Contracting Strategy.** During the front-end engineering and design (FEED) phase, the project definition was developed, and three EPC lump-sum bid packages were prepared. The work packages covered engineering, procurement, construction, integration, transportation, installation, hook-up, and commissioning as shown in the work breakdown structure in **Fig. 1**. In accordance with the Nigeria Petroleum Investment Management Services guidelines, a two-step sequential competitive-bidding process was used, consisting of technical followed by commercial steps.

**Organization.** The project organization plan included all levels of the organization, from the project-leadership team to specific site teams for various project phases by EPC contract. The project had a dedicated project manager reporting to the vice president. Subproject managers, responsible for the EPC1, EPC2, and EPC3 contracts, reported to the project manager. The organization also included operations staff that supported the project-management team (PMT) directly.

**Management Systems.** With three major EPC contracts, a key challenge was to manage project interfaces effectively. The prime contractors were responsible for managing

internal and external interfaces. To support their efforts, the PMT developed a detailed interface-management plan, which included assigning ExxonMobil representatives from each subproject team to monitor the progress of interface management between the EPC contracts and to participate in interface-coordination meetings. The subproject-team representatives provided input on any interface issues that required alignment or facilitation. An interface coordinator on the home-office team provided support for effective interface management.

**Nigerian Content.** Key objectives were to foster development of competitive Nigerian industry capability to support future oil and gas projects and to generate long-term benefits for Nigeria. The strategies implemented to achieve these objectives included use of local contractors and suppliers, enhancement of in-country capability and capacity, transfer of deepwater technology, and establishment of long-term in-country relationships. Key components of the in-country execution plan included proactively maximizing Nigerian content in the Erha and Erha North Project work scopes, enhancing the capabilities of Nigerian contractors, implementing the work such that both near-term and long-term benefits to Nigeria were realized, and providing training, development, and employment to Nigerians.

**Schedule and Cost.** Before contract award, an integrated master project schedule (IMPS) was developed. The IMPS included all EPC contracts, major interfaces, permits, and drilling activities. After award, the EPC contractors' schedules were incorporated into the IMPS. The initial executive summary plan was created with information from the IMPS. Updating of the IMPS continued through engineering and procurement and into the fabrication phase. During the hull and topside integration, updating was discontinued when it was determined that progress could not be forecast accurately and that determination of the critical path from the IMPS was no longer reliable. In

Activities	Dates
<b>Campaign 1</b>	
• Installation of four MODU anchor piles	2–6 January 2004
<b>Campaign 2</b>	
• Preinstallation of FPSO mooring lines • Preinstallation of the DCE subsea equipment	15 April–17 May 2005
<b>Campaign 2.5</b>	
• Preinstallation of CALM buoy mooring lines • Prelay of four DCE tieback SCRs and flowlines, including the touchdown clad section	11 September– 5 November 2005
<b>Campaign 3</b>	
• Mooring of the FPSO	21 December 2005– 14 January 2006
• J-lay of 10 DCE and DCW SCRs and flowlines • Mooring of the CALM buoy • Installation of DCW subsea equipment • Installation of the SCMs • Installation of three main umbilicals to the FPSO • Installation of tandem offloading system for first oil from DCE • Installation of three DCN flowlines • Installation of DCN subsea equipment • S-lay of two OLLs with tieback to the FPSO • Installation of 36 rigid jumpers	6 January– 24 September 2006

**Fig. 2—Offshore installation sequence.**

response, the individual EPC sub-project teams forecasted variances to the fabrication activities and to the dates of major events. The contractor schedules then were used to update the executive summary plan. During offshore installation and commissioning, an offshore integrated schedule was developed and used as the controlling schedule for the Erha and Erha North offshore installation work and coordinated EPC1, EPC2, EPC3, drilling, and startup activities.

The project duration from contract award to DCE first oil production was 42 months, 3 weeks. The FPSO durations from contract award were 44 months, 3 weeks to first gas injection and 45 months, 2 weeks to first water injection.

**Quality.** A structured-quality program was designed and implemented for the Erha and Erha North projects. The program required each EPC prime contractor to develop specific quality-control and assurance plans and processes tailored to each phase of the project (i.e., design, procurement, fabrication, integration, installation, and commissioning). The sub-project team assigned to each EPC contract verified contractor imple-

mentation of quality plans, processes, and procedures on an ongoing basis.

**Offshore Installation.** The offshore installation was divided into four campaigns, ranging in duration from 2 weeks to 9 months, as detailed in **Fig. 2**. The plan initiated during the bid stage and that became the contract basis called for three campaigns with specific objectives. An intermediate campaign subsequently was added between Campaigns 2 and 3, with the goal of mitigating schedule risk through prelay of the SCRs and flowlines.

**Commissioning and Startup.** A key success factor of the Erha EPC1 integrated commissioning team was the ability to leverage commissioning resources that had recent experience and lessons learned on ExxonMobil-operated west Africa FPSO commissioning teams. For EPC2 and EPC3, a team consisting of the EPC prime contractor's discipline engineers and commissioning specialists, with oversight from the relevant PMTs, planned and executed commissioning activities.

Startup planning commenced early in the construction integration phase. The startup manager planned activi-

ties in conjunction with the project team, the individual EPC contractor-commissioning teams, and the operations team. Operations personnel were assigned to the project for training and familiarization with the facilities and were integrated into the commissioning teams at the various sites. This integration enhanced training, alignment, commissioning, and startup planning and execution. As each system was completed, a formal, documented process was used to turn over each system from the EPC contractor to the project team and then to operations for startup.

Final commissioning, turnover, and startup of the FPSO was completed as planned after the FPSO mooring operation was completed in Erha field. The installation and commissioning of critical subsea equipment, including SCRs, flowlines, manifolds, and a temporary tandem offloading system, were completed, and the Erha development started production from DCE on 27 March 2006, 92 days after the arrival of the FPSO. Initial processing from the FPSO was limited to oil systems and supporting utilities. Following stable oil operations, the gas-injection and water-injection systems were brought on line.

### Lessons Learned

The lessons-learned process commenced in June 2000 with FEED and continued throughout the project, with the dual aim of continuously implementing applicable lessons learned from previous projects and capturing new lessons for future applications.

**Safety.** The success of the project-safety program is attributable to the PMT providing leadership and establishing high visibility for safety issues and participation across all organizational levels.

**Change.** Tight change control, with the aim of having no changes, contributed to project success. However, acceptable technical and execution alternatives that are more economical should be encouraged and expedited.

**Contractor Management.** Open communications should be estab-

lished with contractors to confirm that the contract is understood and to help them execute their work scopes successfully. Commercial concerns should be segregated from technical and execution issues. Providing timely incentives will enhance contractors' performance and minimize execution risks.

**Interface Management.** Interfaces should be minimized wherever possible. Formal interface-management processes with dedicated interface-team members from the EPCs and the PMT are critical to maintain interface alignment. A process for commercial settlement between EPC contractors

should be improved to prevent commercial disputes from delaying project execution.

**Organization.** Experienced resources should be used fully. PMT members colocated at project worksites to enhance internal communication (between PMT disciplines) and external communication (with the prime contractor).

**Logistics.** To meet local-content objectives and to address cost and schedule pressures, the development and use of in-country resources should be planned for early.

**Offshore Coordination.** All participants, including PMT, operations, contractors, subcontractors, and drilling, should be engaged early in the offshore planning effort.

**Erha North.** The project gained significant value by having a fully integrated and aligned team (PMT, drilling, reservoir, and geoscience) working toward a common goal and capturing an opportunity. Existing Erha designs were leveraged to achieve cycle-time and cost synergies for Erha North.

**JPT**