



OTC 23430

Jubilee Project Overview

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Abstract

The Jubilee Project was a very ambitious challenge for the first significant development ever offshore Ghana. The Joint Venture used a split operatorship to execute a world-class deepwater project in an area with no existing infrastructure, in less than 3 years from the start of concept selection. This paper will highlight the approach used to manage the Jubilee risks and project execution, emphasizing the keys to success and lessons for this fast-tracked project.

Kosmos Energy was appointed Technical Operator for the project with responsibility to assemble and lead the Integrated Project Team (IPT) in planning and executing the project. Tullow Oil was appointed the Unit Operator (UO) with the responsibility to drill and complete wells, build the in-country infrastructure and organization for production operations, and to subsequently operate and manage the field in the future. Anadarko, a non-operating partner, seconded a significant number of experienced key project personnel to the IPT, enabling the IPT to fully leverage the capabilities of the major partners.

Jubilee first oil occurred on 28 November, 2010 and the field continued to ramp up production and injection as wells were completed into 4Q 2011. Despite several significant technical and commercial hurdles, the project achieved excellent HSE, schedule, and cost performance. The IPT continued to support the UO's production operations post-first oil, and the final commissioning of gas compression/injection systems was achieved late 2Q, 2011. While there have been the normal challenges with shaking down a large and complex production system, overall uptime performance has been very good at >95% in the first year of production. Jubilee's unique circumstances justified a very aggressive appraisal development strategy and dictated an unconventional approach to organizing and managing the project, which ultimately was highly successful.

Introduction

The Jubilee Field was discovered in June 2007 in the Gulf of Guinea, approximately 60 km offshore Western Ghana. It is a very large, light, sweet oil accumulation in 1200-1500m of water. The Jubilee Partners, along with Ghana National Petroleum Corporation (GNPC) decided in January 2008 to develop the field using a phased approach, after just one appraisal well. Kosmos Energy was appointed Technical Operator to lead an Integrated Project Team (IPT) in executing the development project and Tullow Oil (Ghana) was appointed Unit Operator to execute in-country activities, deliver wells, and operate and manage the field in the future. A third major partner, Anadarko, provided numerous key project personnel to the IPT. The IPT developed a plan to target just under 300 million barrels in Phase 1 with a 17-well subsea well system and 120,000 bopd FPSO. Phase 1 was approved by Partners in August 2008, and First Oil was achieved in November 2010, within the aggressive goal set by GNPC and the Jubilee Partners.

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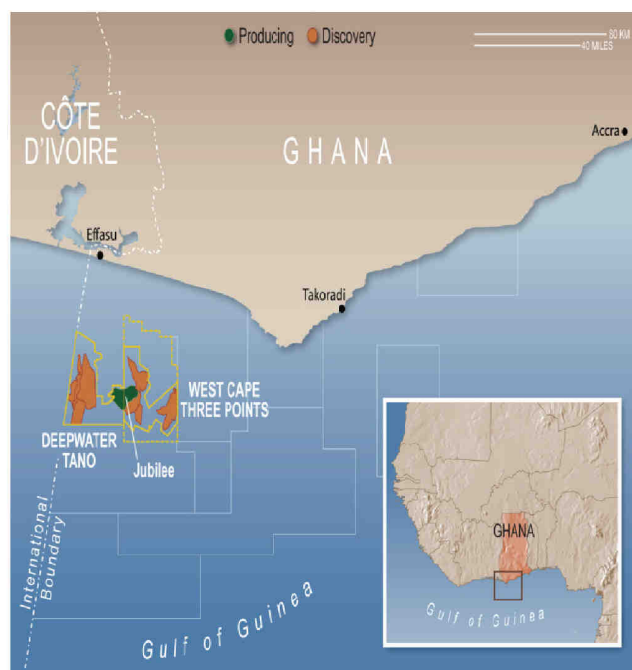
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The Discovery

The Jubilee Field was discovered offshore Ghana by Kosmos in June 2007 with the Mahogany-1 wildcat well on the West Cape Three Points block near its western boundary shown in **Figure 1**. A large oil field was confirmed by Tullow's Hyedua-1 well drilled in August 2007, some 5 km southwest of Mahogany-1, across the lease line on Deep Water Tano block. The field was Ghana's first significant oil find after some 40 years of offshore exploration, and it also was one of the largest fields discovered in the last decade offshore Africa. Understandably, the discovery was a source of immense pride and hope in Ghana, and consequently the Mahogany discovery was renamed Jubilee Field to commemorate Ghana's Golden "Jubilee," i.e. 50 years of independence which was celebrated in 2007.

The discovery is a light (37°API) sweet, high GOR crude covering about 110 km² across the two blocks. Resources are located in 5 stacked zones of thick high-quality rock. The field is located in water depths ranging from 1,200m to 1,500m, about 60 km offshore Ghana and about 130 km west southwest of the port city of Takoradi (the only viable current location for shore base operations).

Figure 1: Jubilee Field Location



Commerciality and Getting Started

The three major Partners, Kosmos, Tullow, and Anadarko (see **Table 1**) began pre-development studies independently for the remainder of 2007, which culminated in a weeklong workshop in January 2008, wherein the various views were shared and debated with the Ghana National Petroleum Corporation (GNPC). There was broad agreement that, despite only two wells, Jubilee was a commercial field and it was best developed using the popular West Africa development concept of a large, cluster-manifolded subsea infrastructure connected to a nearby Floating, Production, Storage, and Offloading facility (FPSO). And most importantly, GNPC insisted it was imperative that first production begin before the end of 2010 due to the significant economic benefit for the nation.

Table 1: Jubilee Partners

Tullow Ghana Limited	34.7%
Kosmos Energy Ghana HC	23.5%
Anadarko WCTP Company	23.5%
EO Group Limited	1.75%
Sabre Oil & Gas Limited	2.8%
GNPC	13.75%

GNPC required that the field be unitized, and whereas there were no rules for unitization at that time, the major Partners agreed a "split" Operatorship amongst the two block Operators, with Kosmos the Technical Operator and Tullow the Unit Operator. Further it was agreed to form an Integrated Project Team (IPT) beginning in February 2008, comprised of experienced personnel seconded from all three major Partners. As Technical Operator, Kosmos was to lead the IPT in preparing the Plan of Development, designing the initial depletion plan, planning and executing the Phase 1 project, and delivering a fully commissioned FPSO-based development system to the Unit Operator. As Unit Operator, Tullow was to formally liaise with the Government, build in-country infrastructure/organization and to prepare for and manage future Production Operations and overall field management. It was further agreed that Tullow would execute the in-country deepwater well activities per the IPT's initial locations and basic well designs. Non-operating partner Anadarko had significant previous deepwater project experience, and was leveraged to provide many key project leadership positions.

The IPT

Due to the criticality of the project, essentially all of the key IPT personnel were made available right away, especially the Jubilee Leadership Team (JLT) and next level, which enabled timely work on establishing a Team culture and identity. The IPT had been challenged to prepare a Plan of Development, coincident with advancing the design and tendering, and to sanction the project by Summer 2008 (within about 6 months). This necessitated a rapid transformation to shed company identities and become simply the Jubilee IPT. This was symbolized by the creation of the Jubilee project logo at the onset; of note, this logo lives on as the only Jubilee logo even though there were efforts outside the IPT in the first two years to consider other options.

Early teambuilding emphasized the team concept and a culture of core values: highly motivated, skilled, integrated team; collaborative; open, transparent, and inclusive communication; committed to excellence; and challenging but mutually respectful. This led to highly integrated, exceptional performance and a “best for project” mentality. Fostering this team culture was very important given the multiple companies represented, multiple project work locations, and misalignment of corporate drivers at times.

In setting out to quickly develop and design the first phase of this giant field, the IPT recognized key development drivers which had to be timely considered and would significantly influence the development design and execution:

- Production as soon as prudently possible, with due consideration to importance of safety, cost, and quality
- Learning for future full field optimization
- Development flexibility for initial uncertainties and expansion
- Accommodate the large seabed canyons and absence of site-specific soil and metocean data
- No gas flaring under normal operations

Adding to this, there were some unique challenges that the IPT needed to manage in planning and executing the work, these being:

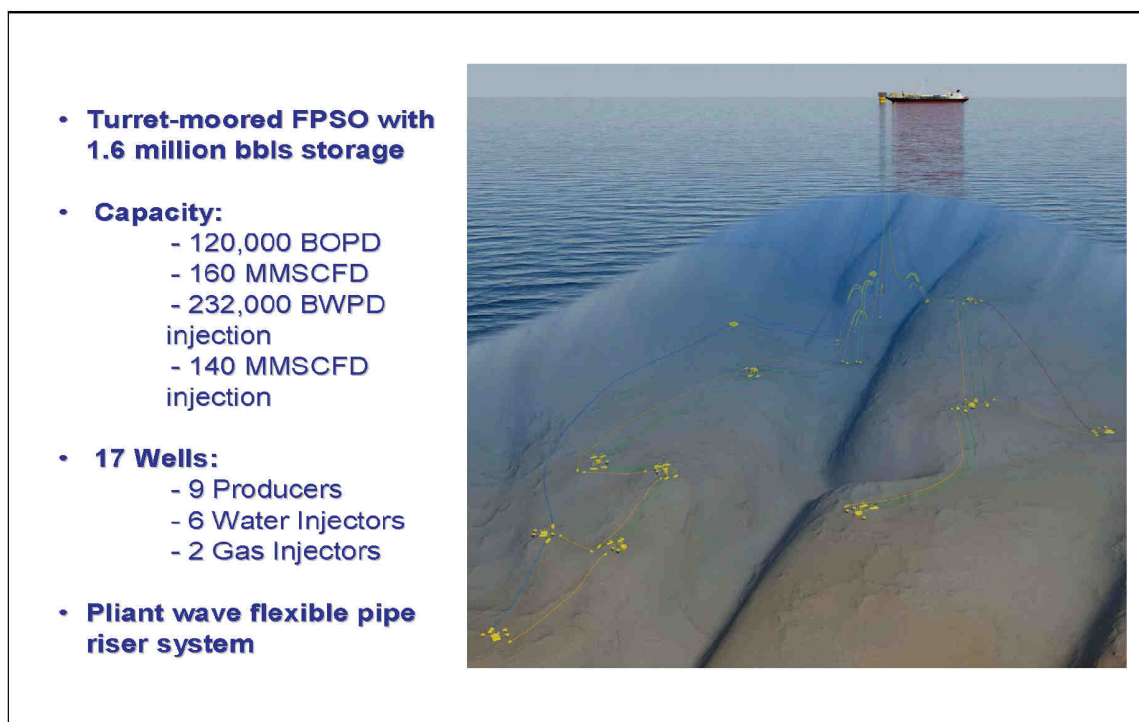
- A new oil province; remote from major oil industry infrastructure
- The aforementioned split Operatorship where governance at the interfaces could be ambiguous
- World-wide financial market credit collapse
- Change of Ghana Government via election in late 2008

Development Plan and Execution

The IPT used technically sound, streamlined subsurface, engineering, and tendering processes to develop the Plan of Development, the preliminary system design, the major equipment/services contracts, and secure internal sanction for the Jubilee Phase1 Project from February to August 2008. This included incorporation of the results of the second appraisal well, Mahogany-2, in May, which had a fairly significant late impact on the development plan by prompting addition of an eastern leg of subsea infrastructure and a change of gas injection location to be used in the field.

The selected concept, plan and design capacities and features are shown in **Figure 2** and **Figure 3**. Phase 1 includes 17 total wells, with 9 producers, 6 water injectors, and 2 gas injectors with large distances between well bottomhole locations. Phase 1 targeted the two most prolific reservoirs of the five, in the lower-risk core area of the field. One of the three broad seabed canyons runs through the middle of the field, between the west and east legs of the subsea architecture. The IPT intentionally designed the system such that no flowlines, umbilicals, risers, seafloor structures, or moorings would cross or have to be located in the canyon, with the FPSO moored over the canyon with risers and mooring chains subsequently laid either side.

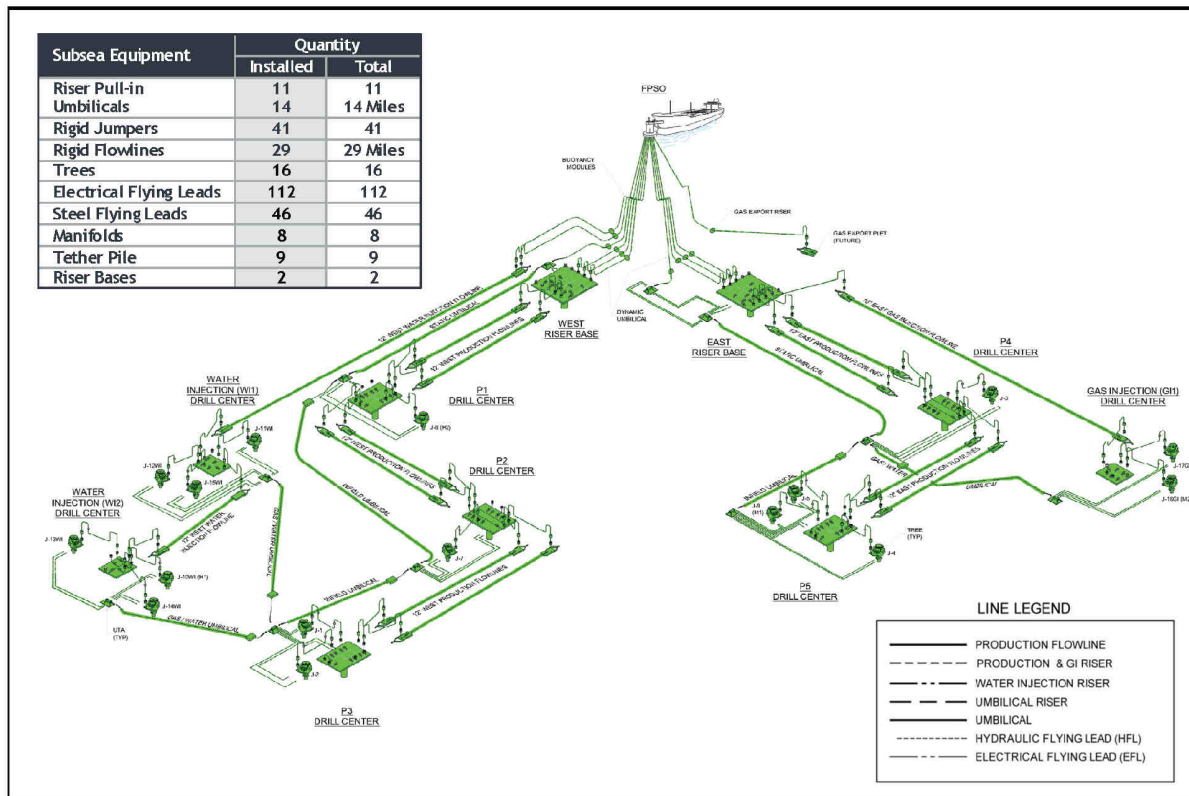
Figure 2: Jubilee Phase 1 Development Concept



In order to provide consistent and integrated direction to execution of the project, the JLT was comprised of the Project Director and a Manager from each major delivery area or function (Subsurface, Drilling, Completions, Facilities, HSE/Regulatory, Business Services, and Commercial). Early on (September 2008), the UO's Operations Manager became a virtual member of the JLT to ensure the closest possible link to and integration with the ultimate customer, Production Operations. The JLT met weekly, as did most of their teams. Communication was a major emphasis, and the philosophy of empowerment to all team members and their associated Contractors was a vital success factor. This became especially important as the project advanced and the IPT had site teams in Dallas, Houston (3 locations), Singapore, London, Paris, and eventually Takoradi, Ghana. Frequent, regular conference calls, and face-to-face workshops, HAZOPs, and kick-off meetings were encouraged to involve all stakeholders across the spectrum.

One of the key organizational and leadership evolutionary changes during project execution was the formation and transition to the Installation, Hook-Up, and Commissioning (IHUC) team for managing all of the in-country activities and operations. Formation of the IHUC team was initiated in September 2009 to begin detailed IHUC planning, and the transition began with the start of offshore installation in January 2010. Two IHUC Managers, rotating in-country, were added to the JLT and reported directly to the Project Director. One of the two IHUC Managers transitioned to this position from their role as the Subsea Equipment Delivery Manager and so was already familiar with the project and could readily continue his responsibilities for subsea technical support. The Subsea Installation Manager transitioned directly to the IHUC team. The Facilities Manager focused on delivery of the FPSO, which overlapped the offshore installation phase for the first five months, but continued to coordinate the major contracts for commercial continuity. The governance of the offshore activities during IHUC phase was carefully considered and agreed to ensure accountability for coordinating safety, logistics, and particularly simultaneous operations. This accountability was transitioned from the IHUC Manager/Project Director to the UO's Operations Manager (and JLT member) at the introduction of hydrocarbons (see OTC Number 23456 for more details). The UO's existing (by then) in-country logistics and infrastructure was leveraged to its full extent to support the IHUC phase and this was facilitated by embedding a UO Coordinator onto the IHUC team.

Figure 3: Jubilee Facilities Schematic



Project Performance

Jubilee Phase 1 Project’s performance around EHS, cost, and schedule were good in spite of the significant hurdles the team faced. **Table 2** shows the EHS goals and outcomes for the Facilities (see OTC Number 23463 for more details). The goals were based on OGP benchmarks, and for activities in the Singapore vessel conversion yard, the Sekondi, Ghana jumper fabrication yard, all installation support vessels offshore Ghana and the FPSO. As shown, the goals were exceeded by a significant margin, by helping create a safety culture in environments where one didn’t exist, and selecting Contractors with strong commitment to safety performance.

The overall cost performance was good compared to the original sanction budget, within less than 5%, as shown in **Table 3**. The Facilities were completed over 10% under budget. This is attributable mainly to three things (1) an allowance on many cost items initially due to the limited engineering and subsurface data; (2) a 20% contingency applied based on range analyses; and (3) tight monthly cost review and periodic risk range analyses. It should be noted that the FPSO was leased, and it incurred cost/day rate increases as described in OTC Number 23439.

Table 2: Jubilee Phase 1- EHS Goals and Outcomes

Measure	Goal	Current
Total Recordable Incident Rate (TRIR)	≤ 2.5	1.52 (17 recordables) (11.2 MM Mhr)
Lost Time Incident Rate (LTIR)	≤ 0.6	0.45 (5 cases)
Hydrocarbon Spills	Zero Level II or III	Zero (2-Level 1)
Significant Incidents	Zero Level III	Zero

Table 3: Jubilee Phase 1- Overall Cost Performance

Total Phase 1 Sanction Estimate	\$3.15 billion
Facilities (FPSO leased)	\$1.43 billion
Wells	\$1.5 billion
Pre-Ops (Includes UO G&A, production prep, infrastructure, spares)	\$0.22 billion
Facilities completed	\$170 million under budget
Overall cost forecasted	within 3.5% of budget

The schedule performance was a great success for such a fast track project, particularly given several incidents and outcomes which put enormous pressure on the first oil date. Some of these included: extended approval of the Plan of Development; later than expected delivery of the FPSO to Ghana; flowline jumper insulation reapplication; dock crane collapse while loading first riser transport; two defective riser end-fittings; and the late decision to install thermal Flowline Expansion & Walking mitigation devices. The world class schedule achievements were: discovery to first oil, 41 months; concept start to internal sanction, 6 months; sanction to first oil, 28 months (See **Table 4**). The keys to success for this fast track project were:

- A willing and supportive Government and GNPC
- The ability to leverage the capabilities within the major Partners
- Use of fit-for-purpose processes and procedures
- Use of proven technologies and “off-the-shelf” solutions
- A collaborative approach with Contractors based on relationships
- Very experienced and empowered team and Contractors
- A completely integrated effort with Project and Production Operations
- Comprehensive Ready for Startup Plan

Table 4: Schedule Performance

Schedule Performance	
Jul '07	Discovery Well
Aug '07	Appraisal well confirms large discovery
Jan '08	JVs/GNPC agree concept, commit to develop
Feb '08	Initiated IPT and preliminary unit agreement
May-Jun '08	Ordered long-lead items
Jul '08	IPT completes POD
Aug '08	JVs sanction project, commit LOIs
Oct '08	Begin development drilling
Jul '09	POD and UJOA approved
Jan '10	Begin offshore installation
Jun '10	FPSO installation
Nov '10	First Oil
Discovery to first oil (<3 1/2 yrs)	
Concept start to sanction (6 months)	
Sanction to first oil (<2 1/2 years)	

Regarding reliability of the installed equipment, availability and uptime of the subsea and topsides equipment has been good, although there were the usual shake-down difficulties with commissioning the 4-stage gas compression/ injection system.

Lessons Learned

The IPT conducted a fit-for-purpose Lessons Learned initiative in two phases, beginning in the summer of 2010 and finalized in early 2011 after production startup and the essentially complete transition from “Project” to “Operations.” The first phase covered the period/activities from start of ‘Concept Selection’ (Jan/Feb 2008) through delivery of the major equipment (Dec 2009 for subsea system and May 2010 for FPSO). The second phase covered the period/activities from start of IHUC detailed planning (Oct 2009) through first oil and final installation (Dec 2010).

The process that was used entailed detailed interviews with about 25 key IPT and Contractor participants. The interviews were designed and conducted by a management consultant who had worked with the IPT from early on in the project on activities such as team-building, leadership development, IHUC planning, and several kick-off workshops. This provided a familiarity with the technical aspects of the project as well as with the people and relationships. The results of the interviews were validated and interpreted in workshops with the JLT, including also representation from the Unit Operator. Ultimately, the findings were organized into High Level Learnings (29), Medium Level Learnings (24), other Ideas/ Opinions (32), and Contractor Learnings (41). **Table 5** and **Table 6** present some selected learnings from the two Lessons Learned phases.

Table 5: Lessons Learned- Selected Learnings on 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
Well Design/ Delivery	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 management system and processes; ensure that they add value and supported by team
Major Contractors Senior Management	Establish regular engagements at multiple levels of senior management, to build relationships and trust, before the inevitable conflicts arise

Table 6: Lessons Learned- Selected Learnings on Installation to RFSU

Project Team Organization	Be prepared to make significant changes mid-project; the IHUC team was created well before going offshore and transitioned with the Delivery teams
Offshore First-Oil Focus	Keep resolution of commercial issues separate from the offshore execution
Completions Management System	Define and establish a total system CMS process (FPSO and subsea)
Vessel Audits	Investigate recent crane performance, conduct audits, provide commercial discretion for chronic crane failures
Spares Management	Needed greater focus on project for delivery and ownership

Two of the selected learnings (Major Contractors Senior Management, and Offshore First-Oil Focus) concern a very important aspect of working with the Contractors in a collaborative fashion to get better results, particularly when adversity strikes, as it inevitably will. The trust relationships, especially between senior management, help ensure that the teams keep their focus on critical project goals and solving big issues together when plans need to be adjusted. This collaboration with Contractors was also vital to meeting the base plan of an aggressive and compressed schedule, as highlighted in **Table 7**.

Table 7: Collaborative Relationships with Contractors

FEED ongoing while SUPPLY/URF contracts being executed	Aggressive overall development schedule
Establish collaborative working relationships between Client and Contractors to expedite solutions	Extensive use of existing designs for equipment engineering
Adjust project organization to accommodate changes from FEED during design (using matrix organization to enable high focus on HSE and planning while ensuring technical integrity)	Focusing on field proven solutions and technologies
Take conservative assumptions to progress the design and enforce strict observance of interface system to control changes	Contract with world-class Contractors having relevant expertise
	Support Contractors and share expertise rather than policing

Conclusions

The Jubilee discovery presented a unique set of circumstances which both drove and enabled world-record development pace for a project of this scale, while at the same time inherently challenging fast-track project execution. The drive for economic boost to Ghana and increased value for accelerated development justified the added risks of design and commercial uncertainties. The size and quality of the reservoirs and fluids enabled certainty of a commercial Phase 1 development using proven solutions with flexibility and wider design margins. However, the lack of in-country infrastructure, complicated operatorship, and collapse of oil price and credit markets were not conducive to moving very quickly and efficiently. Still, the very ambitious goal of safely developing the first phase of Jubilee before the end of 2010 was achieved.

The Jubilee Phase 1 project employed industry best practices and standards in the absence of established regulations and experience, thus providing a solid foundation for regulatory evolution and social responsibilities. It was a world-class deepwater project in its own right, and a giant step in the development of a major new industry for Ghana. Remarkable outcomes were achieved through the dedicated and collaborative efforts of the IPT, its Contractors, the Partnership, GNPC, and the Government of Ghana.