Subsea Front End Engineering & Design (FEED) for

Deepwater Tano Development, Ghana

PROJECT EXECUTION PLAN (DRAFT)

A	11 MARCH 2011	ISSUED FOR INFORMATION	LH / CK	NBZ	NLF
REV.	**DATE**	**STATUS**	**WRITTEN BY**	**CHECKED BY**	**APPROV./AUTHOR. BY**
DOCUMENT REVISIONS					

TECHNIP ASIA PACIFIC

Table of Contents

1.0 INTRODUCTION

Technip Geoproduction Malaysia Sdn. Bhd. “Tenderer” has been invited by Tullow Ghana Limited (hereinafter COMPANY) to submit a proposal for the Provision of Subsea Front End Engineering Design (FEED) Scope of Work for the Deep Water Tano Development Project.

The purpose of this Project Execution Plan is to define the execution plan for the Subsea FEED Services.

The plan is intended to clearly identify the key areas of the Project and to describe Tenderer execution philosophy and methodology employed to ensure that the overall requirements and objectives as set for in the contracts are met. The execution philosophy to be adopted for this project will be based on a common system long in practice to ensure its successful completion in order to meet the requirements to Safety, Quality, Cost and Schedule.

In executing the project, Tenderer will adopt the following principles set below which are critical features for the execution of the CONTRACT to ensure proper control and co-ordination:

- Execution of the work in meeting the requirements of the Project Scope of Work and the Contract Documentations in Kuala Lumpur.
- Adherence to an establish Project Quality Plan incorporating the requirements of latest ISO standards.
- Development of procedures to establish effective communications.
- Strategic planning and control of the Project utilizing integrated and proven project control and reporting systems.
- Maximizing work efficiency through the appropriate use of IT facilities.
- Assignment of qualified, proactive and experienced personnel familiar with Project requirements.
- Maximize effective design methods to accommodate for Tullow Oil or TECHNIP available assets such as fabrication yards, SIT locations and installation vessels.
- Internal reviews. All designs shall be reviewed by peers from the TECHNIP group (Paris, Houston, Genesis). Assistance from our African office is also envisaged.
- Involving Local Ghana content is envisaged.

2.0 BRIEF PROJECT DESCRIPTION

The COMPANY and partners are exploring and appraising the fields situated in the Deep Water Tano (DWT) block, approximately 60 km offshore Ghana, West Africa. The Tweneboa and Enyenra reservoirs lie approximately 30 km to the West of the Jubilee reservoir, and approximately 50km off the coast of Ghana. The reservoirs are found in water depths ranging between 1,000m and 1,800m. Figure 1 below shows the location of the Tweneboa and Enyenra discoveries in the Deep Water Tano block.

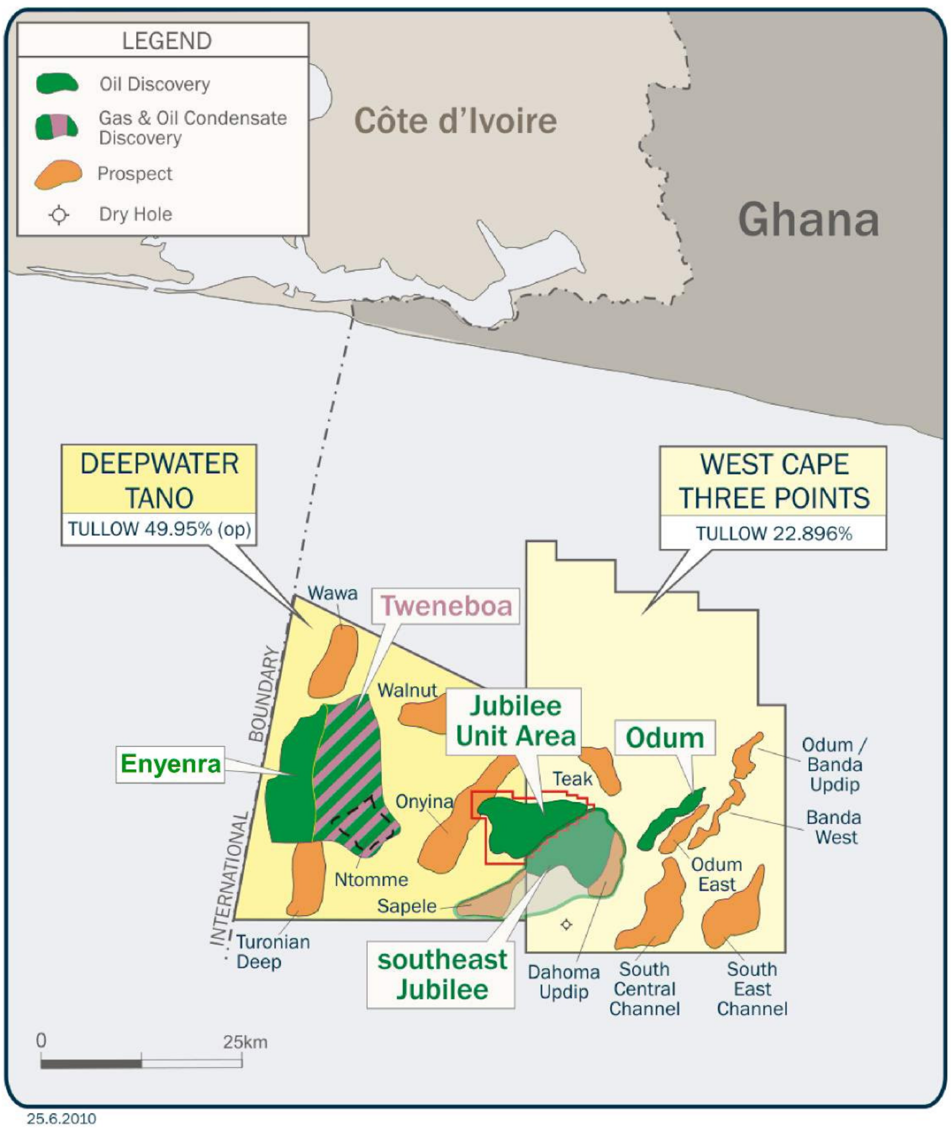


Figure 1 – Deep Water Tano Location

The DWT development fields consist of oil reservoirs and gas condensate reservoirs. The fields will be developed by the use of an FPSO spread-moored to the seabed. Wells for oil production, gas/condensate production, gas injection and water injection will be drilled and tied back to subsea manifolds where local reservoir produced fluids will be commingled, and gas and water for injection will be distributed to wells as necessary. Manifolds will be tied back to the base of the FPSO using infield flowlines. It is envisaged that the flowlines will be tied back to the FPSO using Steel Catenary Risers (SCRs).

Subsea control modules will be used to control all functions on the subsea trees and manifolds. Hydraulic fluids for control of subsea tree and manifold valves and injection chemicals will be delivered by steel tubes in umbilicals routed to each manifold from the FPSO. The umbilicals will supply electrical power/communication to the subsea control module and instrumentation system, and allow for fibre optic cores (if required) between the FPSO and the subsea facilities.
Tenderer's understanding of the Scope of Work is outlined below:

a. Determine and finalise the overall development scheme based on Pre FEED.
b. Provide various subsea engineering inputs as part of the overall FEED programme.
c. Pre define of subsea equipment and facilities required for the full filed development.
d. Prepare a Class 3 cost estimate with budgetary data received from Frame Agreement suppliers.
e. Assist COMPANY in finalizing an optimum contracting strategy for subsequent phases of the project.
f. Support COMPANY in the activities leading to the placement of orders for the long lead items and the award of the EPC contracts.
g. Prepare technical documents for inclusion in the EPC ITT packages.

It is anticipated that subsea FEED Services may be awarded no earlier than May 1st, 2011 and no later than end of second quarter and conclude approximately end of 2011.

3.0 PROJECT MANAGEMENT

3.1 Project Team

Tenderer plans to execute this Project utilizing our resources and expertise in the following countries:

Entity	Responsibility	Summary of scope
Technip Kuala Lumpur, Malaysia	Main office	• Overall Management • Flow Assurance • Subsea Manifold Design • Subsea Control System Design • Flowlines & Umbilical Design
Technip Houston, USA	Support	• Riser Selection & Design • Flowline Advisor • Control / Umbilical

Technip Asia Pacific Regional Office in Kuala Lumpur has the relevant experiences, track records and expertise in performing such subsea FEED work, is proposed as the Main Office to execute this project. For best delivery of quality deliverables, we propose to utilize a number of our specialists from the Houston office in this project to take advantage of their expertise and specialty in deepwater development work.

The scope of work as described in the ITT will be executed by a Project Team which is detailed in section T4, "Project *Organization & Key Personnel*". The main project management team is located in Technip's office in Kuala Lumpur. The proposed personnel from Technip Houston also report directly to the Engineering Manager in Kuala Lumpur.

Tenderer plans to execute the Project with dedicated leads in each discipline area, and has adequate technical personnel that can be utilized on an as needed basis for specific technical studies and analysis. The COMPANY representatives will be located in the same offices together with Tenderer's Project Management team. Tenderer believe that , by integrating the COMPANY's representative into the subsea FEED processes at team level , discipline teams are able to provide timely interface and coordination with COMPANY sub-surface team and provide technical input into subsea FEED.

The key Technip team members include: Engineering Manager, Project Engineer, System Engineer, Interface Engineer, Respective Lead Engineers, Senior Cost Estimator and Senior Procurement Engineer.

The team will be headed by an Engineering Manager who will assume the overall responsibility for the project execution, including schedule cost, safety and quality. The

Engineering Manager will be assisted by Project Engineer, Interface Engineer and System Engineer together with other Project Management Team personnel as shown in the organization chart.

A Project Sponsor is identified for general coordination with the Client and Technip. His responsibilities include:

- Facilitate the working relationship between the Tenderer and the COMPANY teams.
- Provide direct access to Tenderer upper management.
- Assist the Tenderer Engineering Manager with regard to personnel resource and other related issues.

The Engineering Manager is responsible for overall project execution in accordance with the scope of work, budget and schedule. The Engineering Manager's responsibilities include:

- Overall delivery of the scope of work.
- Overall HSE performance for the Scope of Work.
- Sourcing and assignment of resources (personnel) in coordination with Technical Managers and Discipline Managers.
- Reporting and accountability to COMPANY and to Tenderer Management for performance (cost, schedule and quality).
- Review and approval of all invoices.
- Development, approval, and tracking of CTRs and costs.
- Resolution of all contract issues.
- Implementation and oversight of project control systems.
- Implementation of Tenderer procedures and, when necessary, definition and implementation of program specific procedures.
- Management of relationship with Client(s), including customer satisfaction survey.
- Coordination of team building activities.
- Participation in technical reviews as required by Client.
- Set up and maintain management of change system.

Project Engineer will be responsible for liaising with the Engineering Manager, System Engineer and Lead Discipline Engineers in the following capacity:

- Assist in the overall delivery of the Scope of Work.
- Assist in the overall HSE performance for the Scope of Work.

- Reporting and accountability to Engineering Manager for performance (cost, schedule and quality).
- Responsible for tracking of CTRs.
- Assist in coordination of team building activities.
- Participation in technical reviews as required by Engineering Manager.
- Facilitate in providing Engineering Manager with status of the scope of work and completed tasks.
- Assist Engineering Manager in compilation of weekly reports and highlight outstanding or hold issues; including review of action items list.
- Support Engineering Manager in HAZOP and HAZID workshops and discussions.
- Project Summary – Close Out Report.

System Engineer and respective Lead Discipline Engineers will have responsibility over specific discipline area workscope, as outlined in the organization chart. The Lead Engineer also is to coordinate with other Tenderer and COMPANY representatives. The responsibilities include:

- Coordination and maintenance of the overall system design.
- Support the Engineering Manager and Project Engineer in progress measurement and reporting.
- Reliability and operability evaluations and planning.
- Development and approval of project specific execution plans as required.
- Coordination between engineering and design/drafting.
- Coordination of project cost estimate(s).

A proposed organization chart for the project is provided in Section T4.

3.2 Project Office

For the subsea FEED of the Deep Water Tano Development Project, the Services will be executed from Tenderer's regional headquarter in Wisma Technip, Kuala Lumpur, Malaysia.

A dedicated project area will be allocated for COMPANY representatives and Tenderer's Project Management Team to execute the subsea FEED services. The facilities available will sufficiently and comfortably accommodate the requirement for the project team to execute the works including COMPANY's personnel. Access will be restricted to approved badge holders via magnetic access cards.

Office space and IT facilities are available for 2 COMPANY representatives for the duration of 8 months from award of project. They are limited to the following:

- One (1) lockable offices for 2 COMPANY representatives with standard office furniture,
- Two (2) desktop computers,
- Internet connections for COMPANY representatives laptop computers,
- Two (2) high specification telephone,
- Network connectivity with Internet access x 2nos.
- Telephone extension x 2nos.
- Dedicated printer and copier
- Stationeries, telephone and fax with local dialing,
- Parking spaces for 2 vehicles

Other details of office facilities can refer to Section T7 of this proposal.

3.3 Planning, Monitoring and Reporting

The Project Team will manage the overall Project planning, progress monitoring and reporting. Progress will be monitored according to cost, manhours and physical progress. Each personnel will be required to submit weekly timesheet and this will be checked by the Discipline Lead and approved by the Engineering Manager. Progress will be measured by agreed milestones and weighted to get the overall progress. The Engineering Manager will be responsible for monitoring and controlling the expenditure and progress. He will be assisted by the Planning Engineer on this matter. The progress will be monitored against the current plan of meeting milestone objectives.

Project Control will be organized around the Schedule Level 3 and Master Document Register for Engineering. A weight and progress measurement will be set up for each activity or sub-activity of Level 3. The physical progress will be calculated and reported against planned.

Schedule will be updated by the Planning Engineer according to the actual date of completion of the event in the Master Deliverable Register.

For project planning, we propose to use the PRIMAVERA Project Planner software and JANUS.

A Deliverable Register will be issued within two (2) weeks of the commencement of this project and will be updated for submission to COMPANY every month thereon.

The Engineering Manager assisted by his team will prepare Weekly Progress Reports. Weekly reports will provide a brief status of the project statistics, an update of the one-week look ahead schedule, an update of the current week activities, and description of areas of concerns. Main attachments include S-curve and histogram charts.

3.4 Meetings

The kick-off meeting will be attended by the Engineering Manager, System Engineer, Interface Engineer and all the Lead Engineers. Design verification on documents / drawings / information shall be performed. COMPANY shall be notified if any errors, discrepancies, inaccuracies and omissions are identified.

The Engineering Manager will also organize weekly project meetings to ensure coordination and conformance of the engineering services as called for in the project. Periodical interface and coordination meetings with COMPANY representatives will be organized in TECHNIP's office in Kuala Lumpur or via conference call to discuss the project progress and plan of action required.

These meetings will be a major source of communication and information transfer for all parties involved. The frequency of the meetings, the choice of attendees and the quality of reporting will be given careful attention to maximize their value.

3.5 Cost Reporting and Control

The overall project cost management will be the responsibility of the Engineering Manager who will be assisted by a Cost Controller who will perform all cost control tasks throughout the duration of the project. The Cost Controller will be monitoring and control cost by regular analysis of computerized manhour expenditures and associated costs (both actual and forecast) in comparison to the approved budget and physical work progress/schedule issue of project deliverables. He will regularly inform the Engineering Manager of the overall project cost status and provide forecast trends and cost data. The information is necessary to control/minimize cost and to detect any adverse cost/manhours performance trends early enough to allow corrective action to be taken.

For cost control, we will use our in-house developed applications based on the MS EXCEL electronic spreadsheets.

3.6 Document and Record Management

A dedicated Document Control Center (DCC) will be set up, equipped and maintained for centralized Documents and Records Management service using the Electronic Document Management System (EDMS). The DCC will be equipped with a Document Controller to perform the document and record management to ensure all documentation produced are gathered, categorized, collated, disseminated and captured in accordance with the requirements of the Project. This system allows having readily available "on-line" information including documents, drawings, technical queries etc thus minimizing clarification of deliverables, saving time and cost.

At the beginning of the Mobilization Period, the Engineering Manager will set up and organize the engineering document flow control and filing.

The Project Secretary will log electronically, file and archive all incoming and outgoing correspondences and ensure the internal and external dispatch of each document according to procedures and to the instructions set up by the Engineering Manager.

3.7 Schedule

The main Schedule Milestones of Subsea FEED Deep Water Tano Development Project are as follows:

- Subsea FEED Award ~ Q2 2011
- Subsea Frame Agreements Award ~ Q2 2011
- Subsea FEED Completion ~ December 2011
- POD Approval ~ Beginning 2012
- ITT(s) for Subsea Fabrication / Installation ~ Q1 2012
- First Oil ~ Q2 2014

Tenderer understands that schedule development and its continuous tight monitoring are of paramount importance to ensure the Project is handed over to COMPANY according to Contract requirements. Proposed work programme for the FEED services is provided in Section T6 of this proposal.

3.8 Quality Assurance

The Quality System employed on the subsea FEED Services will be based upon Tenderer's overall Quality Management System (QMS) which is structured and accredited to meet the requirements of ISO 9001. Tenderer's QMS applies to ALL projects and processes that support those projects. The system is implemented within project execution by Engineering Managers, assisted by Project Quality Managers.

At the start of the project, a specific Quality Assurance (QA) Plan will be developed. Tenderer's corporate QA Manual will be the reference for the development of the specific QA Plan to this Project which will describe the relevant applicable QA Procedures and any specific project QA requirements. Among them, few will be of prime importance:

- Checking and Inter-discipline Checking.
- Document Flow Control.
- Document Filing and Archiving.
- Change Control.
- Safety Design and HSE.

The specific QA Plan and its referenced procedures constitute the documented Project Quality Management System, which shall be applied to satisfy requirements of the Project and the relevant provisions of ISO 9001. A Project QA engineer, reporting to the Engineering Manager, will be appointed to monitor compliance of all applicable procedures. Furthermore, QA audits will be carried out during the Project to verify the effectiveness of the Project Quality System.

3.9 Health, Safety, and Environment (HSE)

Throughout the execution of the Subsea FEED project, HSE will be the key theme for all of the work performed. HSE is embedded throughout the Technip Group as a core value that is underpinned through a philosophy of continuous improvement and demonstrated safety leadership across every level of our organisation. Tenderer considers health, safety, and environmental protection as essential for all our activities from conceptual design and engineering through to project execution and commissioning. Tenderer believes that HSE excellence enhances productivity and quality. Each individual has a personal responsibility for his or her own safety and the safety of others, and no business objective takes priority over minimising risks to personnel and our impact on the environment.

Within the first month after the project is kicked-off, a project specific HSE Plan will be developed to address all HSE requirements during execution of the Subsea FEED Services. The HSE Plan will cover HSE Policies, programs, systems, procedures, standards, controls, etc for management of HSE activities. The HSE Plan shall be approved by both COMPANY and Tenderer's Project Sponsor, and will be effectively implemented. The HSE Manager in the Project Management Team will ensure that the dedication of the key personnel is at a level consistent with the objectives and will propose HSE indoctrination sessions or HSE training program, whenever necessary.

4.0 PROJECT EXECUTION PROCESS

Tenderer's project management system provides timely and accurate data to enable the project management teams (PMT) to dynamically manage all aspects of a project, including accounts, cost, scheduling, documents, materials, logistics, contracts, risk, and administration. The exchange of critical data among the suite of system components provides project teams with both efficiency and accuracy in the project management process.

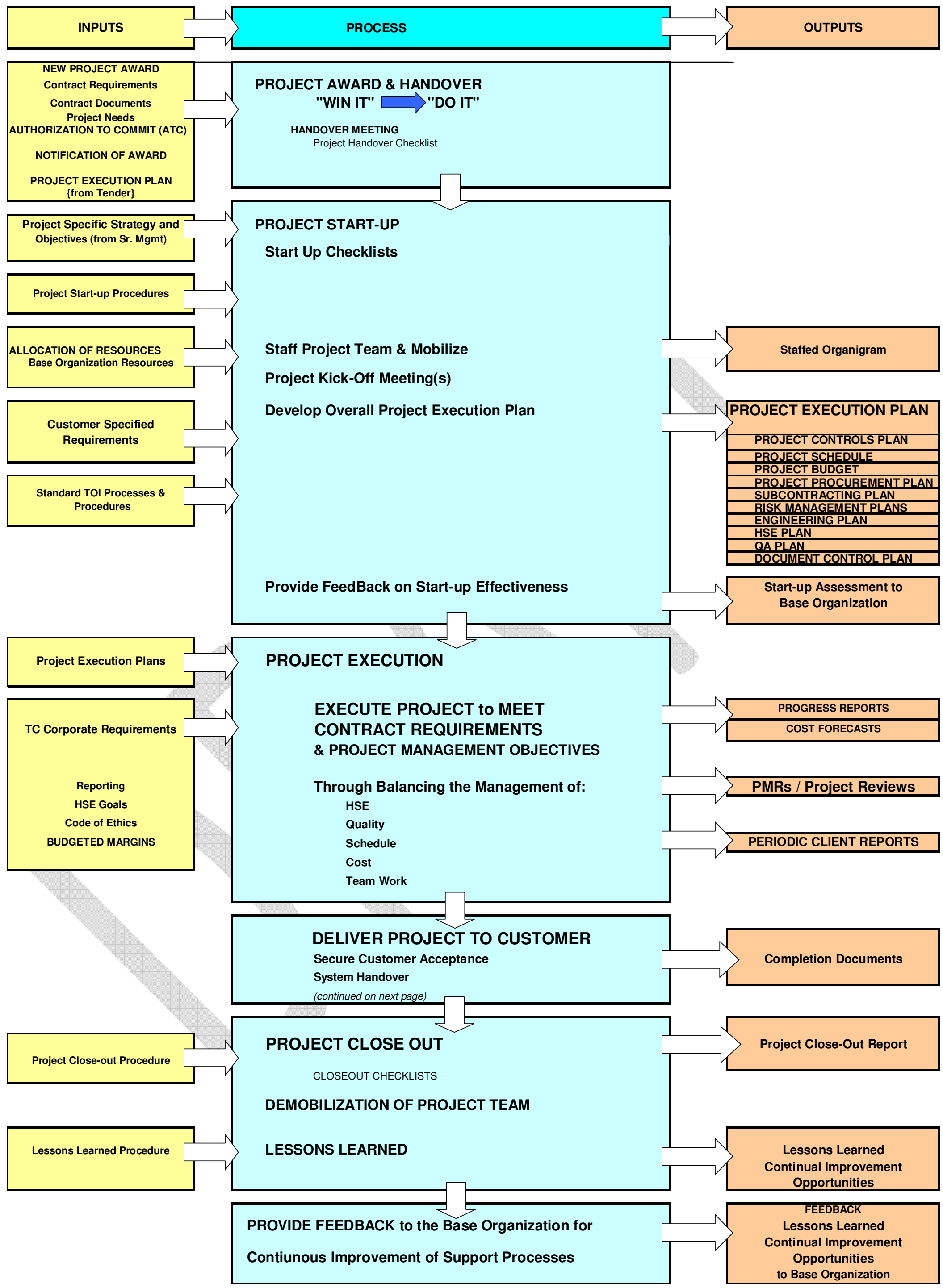
The foundation of the project management information and control interface is the Work Breakdown Structure (WBS). Using the WBS as a project information baseline provides a powerful data retrieval and exchange capability for all disciplines, and an orderly rollup structure to meet specific requirements and expectations in the management of our projects.

Project teams are supported part time by the Project Controls Department which provides systems and resources to suit the needs of each project. These systems and their integration are addressed in the subsequent sub-sections.

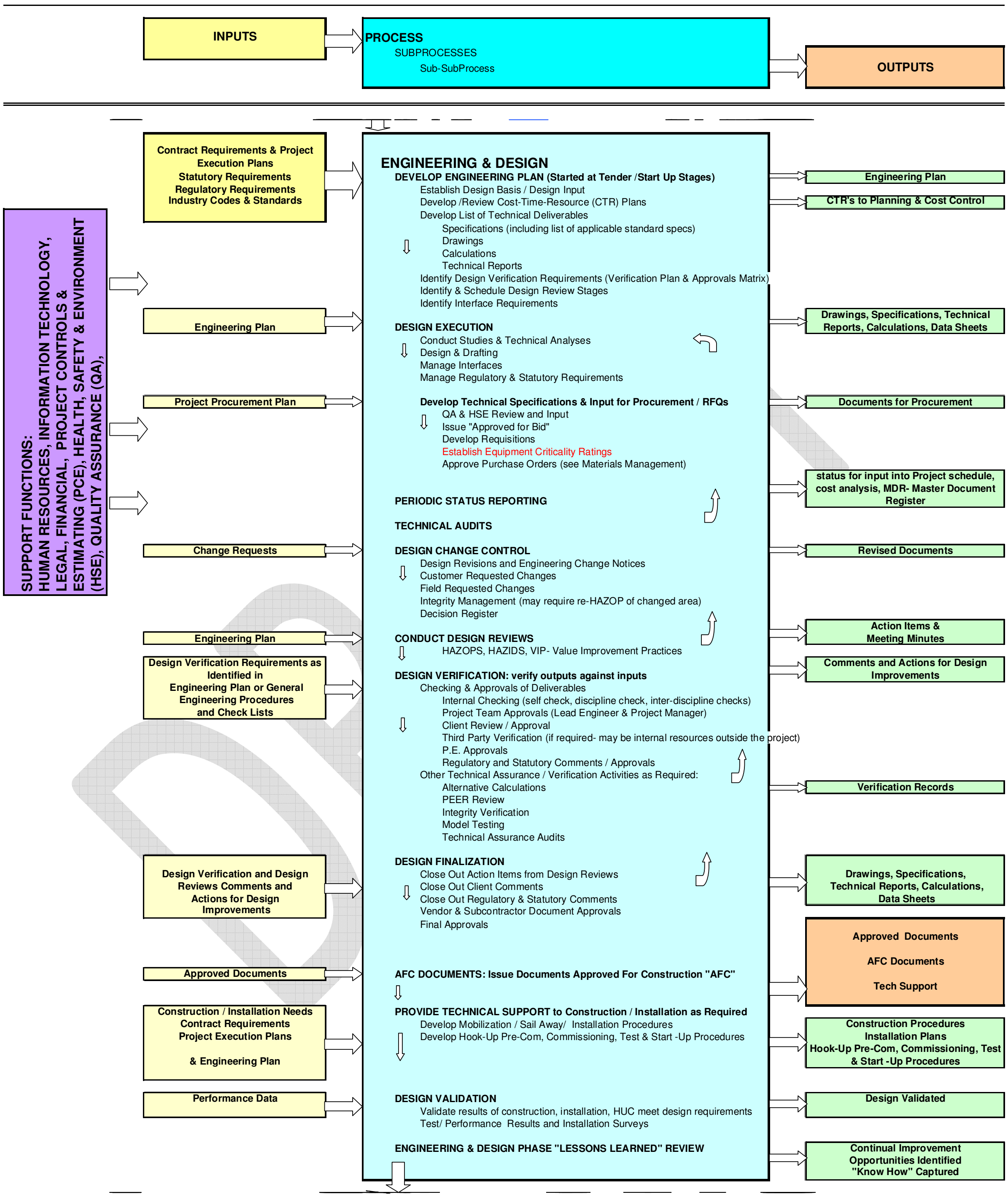
Tenderer's project management processes are illustrated in the following flowcharts for:

- Project Management
- Engineering Design

Project Management Process Map



Engineering Design Process Map



5.0 MOBILIZATION PLAN

Engineering Manager will be mobilized on day 1 after Contract Award and the other key personnel under project management team (PMT) based in the Kuala Lumpur office will be mobilized within two weeks after Contract Award. Mobilization of other key personnel of the Kuala Lumpur will also be within 2 weeks after Contract Award.

It is highlighted however that specialist from other operating centers, e.g. Houston would presently be able to commence the work within one month after the kick off meeting, subject to the approval of visa application.

Facilities for the engineering such as office space, computers, office furniture and other supporting factors will be swiftly organized for the initiation of the project.

6.0 INTERFACE MANAGEMENT

An interface occurs in a development project where there is a change in responsibility in scope or activities being performed by two or more parties, and the activities of one party affect or contribute to those of the other(s). To ensure correct completion of work, it is important to effectively manage the timely flow of accurate information across identified interfaces.

The objective of the Interface Management Plan for the project aims at avoiding any gaps or overlaps between the various parties involved in the DWT Development Project. This requires making sure that all Interface information is properly requested or received and promptly distributed to ensure complete coverage of all Interfaces and that the works of each of the parties involved will be executed in the safest, most efficient and convenient manner.

For TECHNIP, the management of interfaces associated with the execution of the Subsea FEED DWT Development project falls into two basic areas:

- External interfaces
- Internal interfaces

Expected external interfaces are with COMPANY and all other subcontractors & third parties as required by COMPANY, e.g. FPSO engineering and design team, as well as COMPANY's Frame Agreement contractors and the RAM/FMECA consultant. It is necessary to address the day-to-day technical information exchanges between the afore-mentioned parties and Tenderer's design team (project execution interfaces) to ensure an open and close working relationship and interactive decision making.

For the management of the formal interfaces, numerous methods of interfacing and communicating will be utilized during execution of the Work:

- Project Review Meetings with COMPANY.
- Regular engineering meeting with other COMPANY appointed subcontractors either via face to face, or Telephone and / or Video Conference (VC)
- Interface Matrix and Action Item Matrix.
- Project Summary – Close Out Report.

Regular contact will be established between COMPANY and Tenderer teams to ensure technical interfacing and effective communication is maintained throughout the project. A number of critical interfaces are apparent in this project that will require close coordination. To control these interfaces, Tenderer interface procedures will be implemented.

- Tenderer Internal Interfaces

Engineering meeting by Voice or Video Conference (VC) between the KL Engineering team and other Technip group specialist (as an when required), especially the riser specialist will be organized weekly, to further reinforce to internal interfaces. The agenda as a minimum will include:

- Key events/achievements of the past period
- Status of the scope of work and completed tasks
- Progress Measurement
- Planned activities
- Outstanding or hold issues
- Review of action items list

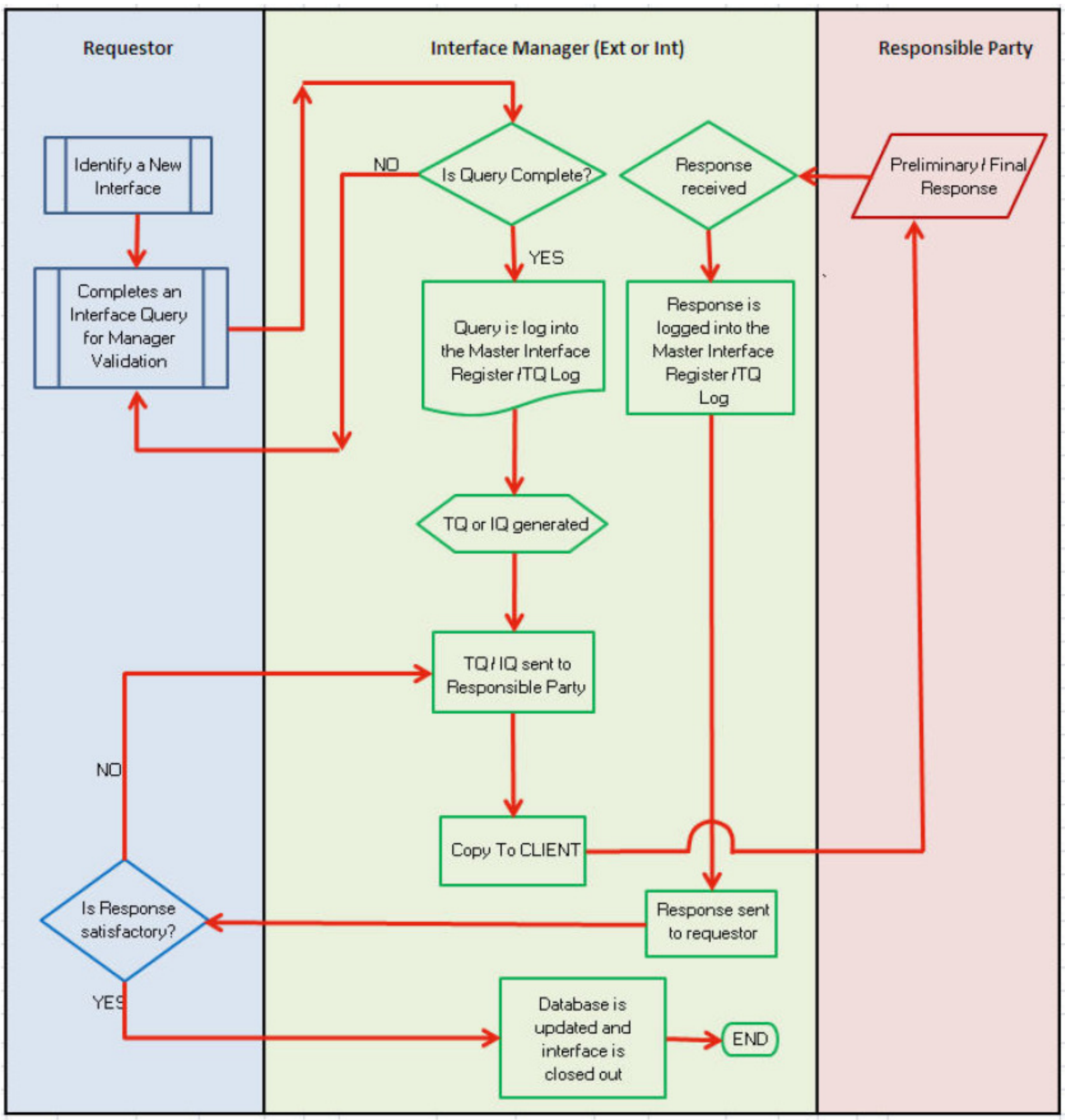
Minutes of Meeting will be recorded for follow up action. Any disputes or major issues which may arise from such meeting will be reported to COMPANY.

Other project team members in both offices will be invited to participate as required.

The riser specialist will visit the Kuala Lumpur office at relevant times during the course of the work performance to ensure that the riser design work performed is understood and carried forward with consistent objectives.

Detailed interface register with agreed schedule will be developed upon Contract Award. The Interface Register will be updated and distributed on regular basis (bi-weekly).

Interface Management Flowchart



7.0 DESIGN CHANGE MANAGEMENT

The Change Management Guideline defines the minimum expectations of a project team in their change management during the execution phases of a project. The Change Management process is a management tool that is to be implemented as an integral part of the overall project management process. Changes can be initiated by any project team member, project subcontractor, or project client. It is the responsibility of each team member to be aware of their scope of work to be able to have an effective Change Management process.

Changes to the Project Baselines established by the Contract, Project Execution Plan, Project Design Basis, Budget/Estimate and Schedule, must be documented and approved at the appropriate level prior to any change being implemented. These include changes in project execution, design, procurement, construction, scope of work, shortfalls in productivity as compared to progress (earned value), estimating omissions, delays or any other changes which may affect the project in the areas of economics, cost, schedule, safety, risk, operability, health hazards, the environment or regulatory requirements.

The objective of the Change Management process is to ensure that changes are identified, controlled, approved and implemented in an orderly and timely fashion along with providing an auditable mechanism for tracking changes. Key objectives in Change Management are to:

- Minimize project changes by eliminating non-essential changes and limiting any adverse impact of essential changes on project objectives.
- Control changes against the Project Baselines for risk, safety, environment, regulatory requirements, cost and schedule through a systematic process of identification, assessment, approval and close-out.
- Implement procedures that require each change to be appropriately identified, reviewed and approved prior to implementation.
- Ensure that approved changes are implemented, appropriately communicated to the Project Team members and any other affected parties, and closed-out on a timely basis. Close-out includes documentation and finalization of a permanent record.
- Manage temporary and urgent changes within the overall change process.
- Assess and control the impact of multiple changes on schedule and cost.

A Project Deviation Notice (PDN) is the tool to document the identification and impact of any potential change whether it is a construed as a Change to the Project Baseline, internal change or interface impact, deviations, or External Budget Transfers. The PDN can be used to document a perceived change initiated by the client, the Tenderer Project Team or a third party (vendor, fabricator, or subcontractor). Project Changes can be categorized as technical, commercial or schedule. Examples of changes that can be documented by the PDN are:

- Revisions to the latest Process or Engineering Design Package.
- Revisions to the latest Project Execution Plan (PEP).
- Deviations and Changes to Specifications (technical, materials and construction).
- Changes to Drawings approved for design (PFDs, P&IDs, etc.).
- Changes to “Issued for Design” (IFD) or “Issued for Construction” (IFC) drawings, plans and designs.
- Changes initiated by or due to regulatory requirements.
- Changes to the national, federal, state, or local laws and regulations
- Changes associated with addition or deletion of facilities or equipment not in the original project scope or equipment list.
- Development changes/refinements to the specifications/design and/or execution plan that alter the original scope of work as design and construction progresses as follows.
- Design development: added work, facilities or deliverables (identified during design evolution) not included in the original scope of work.
- Execution development changes normally resulting from circumstances unforeseen at the time of contract award.
- Estimate adjustment to correct arithmetical errors or omissions/duplications in the Baselines or Control Budget.
- External Transfers of work to increase or decrease Tenderer’s scope of work.
- Changes to Control Schedule that impact the Project’s Key Schedule Milestones and/or Project Critical Path schedule, or execution plan.

As a minimum a weekly change review meeting will be held to facilitate the alignment and agreement to implement a specific change. This meeting will establish whether the change will proceed or whether it will be recycled or rejected. The meeting will also be utilized to establish specific action plans and follow-up for a resolution of each deviation alert.

Overall description of the Change Management process to be developed prior to project commencement.

8.0 ENGINEERING, PROCUREMENT AND CONSTRUCTION

8.1 General

The Engineering Manager with the assistance from Systems Engineer and Project Engineer shall oversee all engineering activities including the coordination among the disciplines where such person shall liaise closely with the Lead Discipline Engineers to ensure quality and safety are built into the design in compliance with the applicable International and Project Codes and Standards.

The engineering documents will be controlled via Master Deliverables Register (data base) which captures all documents prepared as well as their status. Main activity within the Subsea FEED engineering work is outlined in the CTR catalogue in Attachment T1.1. During execution of project, these CTRs are to be assigned accordingly to individual discipline so that clear ownership and responsibility is identified. In order to further facilitate a correct understanding of the work within each CTR, a CTR kick off meeting will generally be held with COMPANY at the commencement of the Subsea FEED Services.

Tenderer has not included manhours for the Riser Base Case based on COMPANY document (Contract No. TGHA-02154-Subsea FEED – ATTACHMENT B – SCOPE OF WORK) for the following reasons:

SECTION 6.1 states, “An initial study of potential deep water riser configurations has been undertaken as part of concept selection [Ref. 4]. This qualitatively recommends the Steel Catenary Riser (SCR) solution as most suitable configuration for the Deep Water Tano development, due to its simplicity, lack of requirement for a riser base and the ability to apply external installation.

A Lead Engineer per discipline will be appointed and assisted by Senior and/or Discipline Engineer(s), Designer and Draft person as needed. The Lead Engineers and Senior Engineers will be assigned as required by the Scope. However, their assignment may be limited to a period corresponding to the peak of the discipline workload. In any case, all the personnel proposed can be made available at any time as they are all working permanently within Technip Malaysia.

The Lead Engineers are responsible for the timely delivery of the deliverables at the expected level of quality. All personnel are guided by the Project QA Plan, Project Coordination Procedures as well as their respective Department Working Procedures.

Quality assurance management will be put in place to ensure the engineering quality will be up to the expectation of COMPANY. The interdisciplinary Check (IDC) System will be implemented where drawings are circulated to their relevant disciplines for review/check to ensure uniformity, compatibility and consistency of design across the various disciplines.

Using the Design Basis, approved subsea facilities layouts and schematics, Tenderer will develop definition of the subsea flowlines, umbilicals and equipment to support preparation of tender packages for long lead items, installation and the EPIC. This will include generation of the required data sheets, philosophies, specifications based on design and system analysis for:

- Flowlines
- Riser
- Structure and Hardware
- Subsea Control System
- Umbilical

8.2 Flow Assurance Engineering

Fluid characterization will be carried out. In the mean time, Tenderer's Process team will compile the data and information obtained from COMPANY to produce the flow assurance simulation basis. The simulation basis is to be approved by COMPANY before commencing any simulation run.

Tenderer's Process team will construct the steady state pipeline model of the full field development or update the existing model given by COMPANY to include the full field development using PIPESIM with OLGAS correlation. Simulation runs to cover the system performance through field life, and with this confirm the line sizing and insulation thickness. The main output from steady state studies includes pipeline pressure and temperature profile, liquid hold-up, flow regime, etc. The results will be compiled and reported in one steady state report. Required data will be provided for corrosion analysis and also in support of flowline design.

Once the selected line sizes and insulation thicknesses has been approved by COMPANY, Tenderer's Process team will construct the dynamic model of the full field development or update the existing model given by COMPANY to include the full field development using OLGA with Compositional Tracking Module. The completed OLGA model will be sent for client's approval before proceeding with dynamic runs.

Tenderer's Process team will define case matrices which detail the dynamic runs (as per CTR-4020G) to be performed for COMPANY's approval. We will issue preliminary results upon completion of each run for client's review. At the end of the study, the preliminary results sent will be compiled as one draft report. Liquid surge profiles will be provided to FPSO design team and required data will be provided in support of flowline design.

Additional OLGA runs will be performed to consider refined blowdown and liquid displacement strategies, track hydrate inhibition during restart and wax deposition. The finalized set of OLGA runs (as per CTR-4020M) will be performed, simulating finalized chemical inhibition dosing and agreed flowline operating strategies followed by final report.

8.3 Flowline Engineering

The work related to the flowline Subsea FEED design covers the following main activities:

Flowline Route Selection

Identify and develop the most optimized pipeline route based on the process and equipment layout schemes with consideration given to the environmental, design, installation, operation and maintenance aspect of the pipeline. The routing study shall also include review of the route and soil survey requirement for installation purpose. In addition, the selection of the pipeline routings shall take into account the FPSO and manifold locations, seabed slope areas and any existing infrastructure / obstructions. Pipeline route alignment drawings will be prepared.

Flow line Mechanical Design

For the given flow line size and process design parameters, flow line mechanical design will be carried out in accordance with limit state and partial safety factor methodology, also called Load and Resistance Factor Design (LRFD). The primary design code for the flow line design shall be DNV-OS-F101.

The flow line mechanical design consists following analyses:

- Wall thickness analysis - In this, the material grade and wall thickness of flowlines shall be determined. This analysis shall include pressure containment, collapse and buckling check and shall be in accordance with DNV-OS-F101.
- On-bottom stability analysis - Pipeline on-bottom stability (lateral and vertical) will be ensured. DNV-RP-F103 commercial software or AGA software will be used to perform the analysis. The analysis shall be performed in accordance with DNV-RP-F103.
- Upheaval buckling analysis - Level 1 upheaval buckling analysis will be performed and identify any further detailed analysis requirement. The analysis shall be performed in accordance with DNV-RP-F110 and OTC guidelines.
- External Corrosion Protection and Insulation Design – Suitable external corrosion coating selection and insulation requirements shall be identified.
- Follow line cathodic protection shall be performed in accordance with DNV-RP-F103. External coating and field joint coating selection shall be in accordance with DNV-RP-F106 and DNV-RP-F102 respectively.
- Span Analysis – Flow line allowable spans will be determined. The span analysis shall be carried out in accordance with DNV-RP-F105 using FATFREE software.

8.4 Riser Engineering

As a first step, the following riser concepts will be studied from feasibility point of view to choose the best suited riser concept for Subsea FEED DWT Development Project.

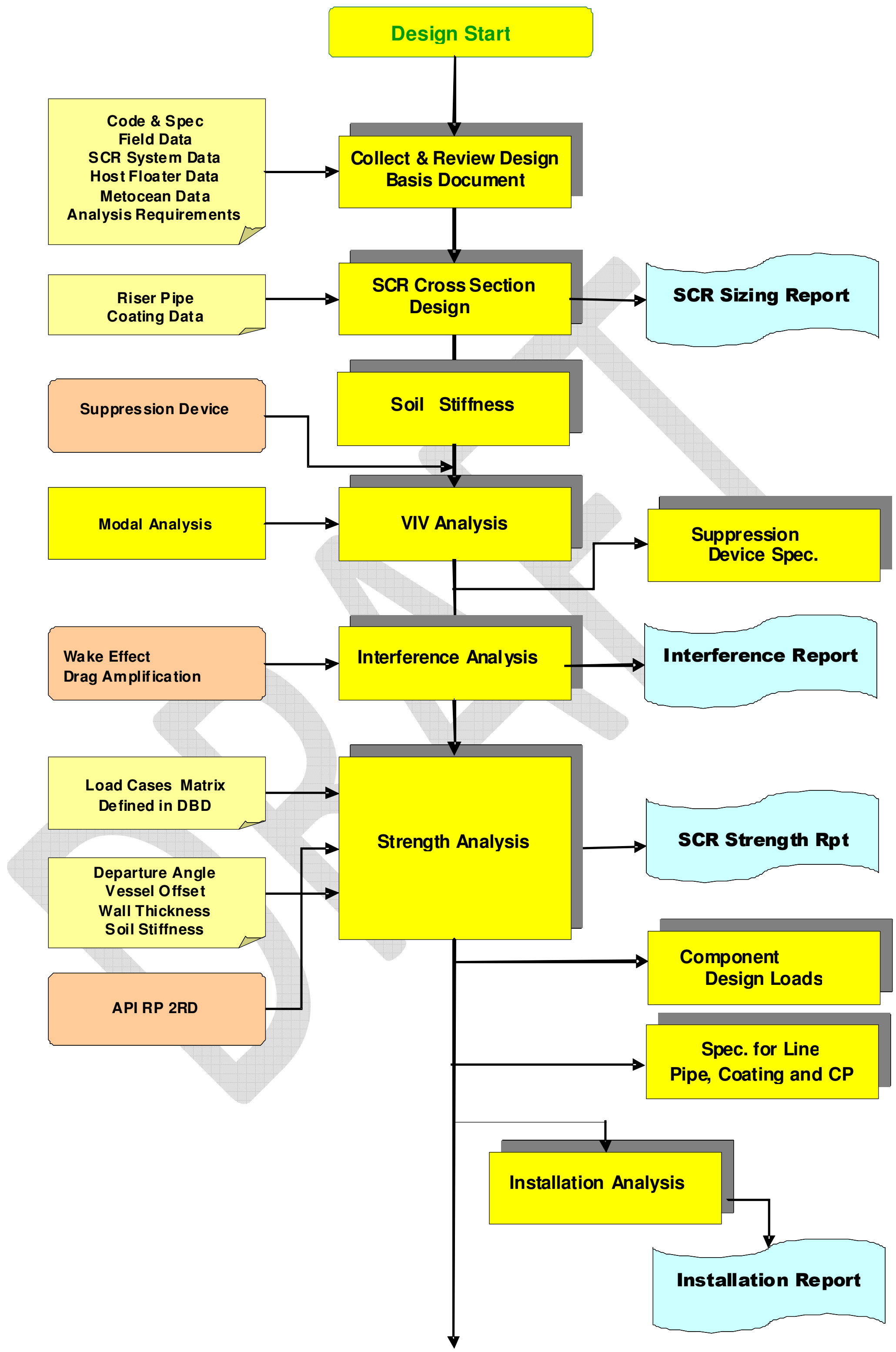
- Flexible Risers
- Steel Catenary Risers
- Multibore Hybrid risers
- Single Offset Hybrid Risers
- Concentric Offset Hybrid Risers

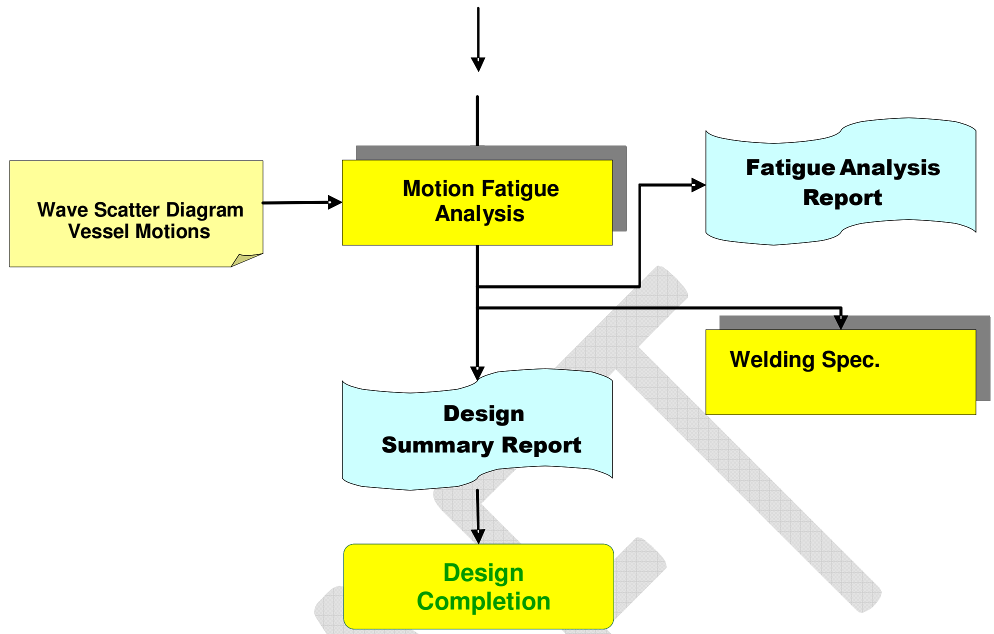
Preliminary sizing will be conducted for these concepts to understand the makeup of the systems. A comparative cost study will be completed for these options. The assumption is that SCR's are feasible for the development, and hence will be focused closely in this phase as well. A plus delta analysis will be conducted ranking all the systems. A Riser system recommendation technical note will be published summarizing the findings of these studies.

Following the concept selection, the following design activities are conducted for each riser. As mentioned earlier, the assumption is that SCR's are feasible for the development; the design activities mentioned below pertains SCR system only. One or more SCR's will analyzed based on COMPANY requirements. The attached CTR accounts for work for three SCRs (e.g. 1 Production, 1 Export, 1 Water Injection).

- Wall thickness sizing and sizing of special components
- Global Configuration
- Strength and Fatigue Design
- Establish hang-off configuration
- Routing
- Preliminary Installation Feasibility

SCR analysis and design is an interactive procedure involving not only the SCR itself, but also the hull and subsea architecture design. The following flowchart shows the proposed procedure and major issues considered during the design. Some critical steps are detailed in the following subsections.


Design Start
Code & Spec
Field Data
SCR System Data
Host Floater Data
Metocean Data
Analysis Requirements
Collect & Review Design Basis Document
Riser Pipe
Coating Data
SCR Cross Section Design
SCR Sizing Report
Suppression Device
Soil Stiffness
Modal Analysis
VIV Analysis
Suppression Device Spec.
Wake Effect
Drag Amplification
Interference Analysis
Interference Report
Load Cases Matrix Defined in DBD
Strength Analysis
SCR Strength Rpt
Departure Angle
Vessel Offset
Wall Thickness
Soil Stiffness
API RP 2RD
Component Design Loads
Spec. for Line Pipe, Coating and CP
Installation Analysis
Installation Report



<u>Review of Input Data</u>

The input data provided by COMPANY will be reviewed. This data includes:

SCR Design Basis and Analysis Methodology

- Metocean Design Basis
- Soil Data
- Guidelines for VIV Analysis of fully straked risers
- SCR Soil Interaction Modeling Guidelines
- Vessel Motions
- Hull Configuration
- Field Layout

<u>Cross-Section Design</u>

The SCR cross-section designs will be code checked for hoop stress and collapse. In addition, preliminary analysis of the combined stress criterion specified in API RP 2RD also will be performed. The SCR wall thicknesses will be confirmed to resist internal pressure and hydrostatic collapse under bending and tension. Manufacturing tolerances and wear and corrosion allowances will be taken into account for wall thickness sizing. The hydrotest design case is the exception to this, where the corrosion allowance is not accounted for in the wall thickness calculations.

VIV Analysis

Fatigue due to VIV should be analyzed early on to determine the need for VIV suppression devices, which could impact the interference analysis results. The analysis will be conducted by use of SHEAR7 or VIVA. The modal data required by SHEAR7 will be determined using Flexcom or ABAQUS. Analysis will be performed for both long-term and single-event fatigue, using the environmental criteria in the Metocean design basis.

Interference Analysis

Interference analysis is important for the general arrangement of the SCRs at the top termination locations. Interference will be assessed between adjacent risers as well as between risers and mooring lines and hull. Clashing may require changes to the riser top arrangement, so it is important to perform this activity at an early stage to determine if the proposed top connection points, hang off angle and azimuth angle are satisfactory.

The interference criteria and design load cases to consider will be determined from the SCR Design Basis and Metocean Design Basis.

Strength Analysis

Dynamic, time-domain analysis will be performed to verify the strength performance of the SCR pipe and vendor components. Analysis will be performed for a suite of critical load cases, including operating, extreme, and survival loading conditions, as defined in APR RP 2RD. FLEXCOM will be used as the primary analytical tool for this task.

Fatigue Analysis

Analysis will be performed to determine long-term and single-event fatigue damage. Fatigue will be assessed using the S/N approach, with the appropriate S/N curve and SCFs obtained from the SCR design basis or execution team documentation. Analysis methodologies for hull VIM-induced and wave-induced fatigue are described below. The methodology for VIV fatigue is given above.

Wave-Induced Fatigue

Wave-induced fatigue will be determined through time-domain, dynamic FEA analysis. Vessel motions for the fatigue seastates in the metocean design basis will be imposed on the Flexcom FEA model. Damage from each sea state will be computed using rain flow counting and Miner’s rule. Fatigue damage will be summed over all seastates to give total damage.

<u>Specifications</u>

The following specifications for SCR system will be developed for ITT. Again, the assumption is that SCR's are feasible for the development. In the event that an alternative riser configuration is recommended, a similar set of Specifications will be generated to cover that configuration. The hours included in the Riser System Design CTR are dependent on developing specification for SCR system only.

- Specification for Riser Linepipe
- Specification for Insulation
- Specification for Riser Construction
- SCR Anchor Specification(s)
- SCR Flex-Joint Specification
- SCR installation Specification
- Corrosion control philosophy

8.5 Structural and Hardware Engineering

The structural department involvement in the FEED design will be pertaining to the following:

- Immediately after award, Tenderer's Structural team will commence verification of the available documents provided by COMPANY and raise Technical Queries to COMPANY as required. All the required information like sizes, weights and COG of the equipment, Valves, Piping etc. to be housed on manifolds and PLETs will be gathered from other disciplines to decide on the size of each manifold and PLET to be designed keeping ease of construction and installation in mind with the commonly and easily available marine spread. The key design requirement of these subsea structures is optimum weights and COG as close to the geometric centre of the structure and COG as low as practical. To manage this requirement, at the initial stage itself, discussions with client will be held to select the installation vessel contractors to understand the vessel availability and interface constraints. All the above information, Basis of Structural Design, specifications for steel material, anode material, CP design, protective coating, fabrication and installation will be collated into a functional specification for subsea manifolds and PLETs which will be provided to COMPANY.
- The FEED study shall also focus on determining the best subsea hardware structure foundation type based on metocean data.
- Inputs for ITT to EPCI contract.

All documents and drawings shall be in accordance with the Project QA procedure and Project QA plan and shall be reviewed and checked to ensure quality and correctness.

Jumpers

During the FEED stage of a project it is advantageous to base the field architecture on feasible jumper span lengths, heights, and angles to flowline growth directions. This will help prevent rework during later stages of the project and will tend to reduce the cost of the subsea jumper systems.

Flowline jumper hard pipe sizing and design is in accordance with ASME B31.8, and ASME BPVC Sec. VIII D3.

Since the jumpers must be rigid enough to support their self weight, the final shape of the jumpers must be carefully designed. The jumper design is documented in specifications and drawings:

- Functional Specification
- General Assembly Drawings
- Connection / Interface Drawings

8.6 Subsea Control System Engineering

Tenderer Subsea Control System Engineer will be responsible for the integration of the subsea control system, multiphase flow meters and sand detector. This task also includes interface definition and data requirements between the subsea equipment, FPSO Distributed Control System (DCS) and the facility safety systems (Emergency Shutdown System – ESS).

The Subsea Controls engineering staff has been involved with the latest subsea controls technology related to subsea control systems, flow meters, subsea and FPSO communication networks.

To develop the specified design reports, specifications / procedures, and documentation deliverables, the control system engineering activities will require significant and close coordination with subsea, FPSO, and operations project team members. The deliverables will establish the subsea and FPSO systems integration, Cause and Effects / interlock safety matrices, and subsea data parameters for the Subsea FEED DWT project.

Subsea Control System

The primary objective for the subsea controls system goal for the Tweneboa and Enyenra subsea field development is to assure that all components and subsystems of the entire subsea system come together to form a coherent, functional system that meets COMPANY Tweneboa and Enyenra needs. This will be accomplished by working with COMPANY and with the equipment vendors as well as performing engineering studies and analysis.

The subsea control systems engineering will perform required FEED work for the subsea control system including:

- Systems engineering and field layout control support
- Utility distribution
- Interface with FPSO DCS

The documentation for the control systems include:

- System Level Layout / Interconnect Diagrams
- System Level P&ID diagrams
- System Level Block Diagram, Subsea Control System
- System Level Instrumentation and Alarm Database
- Preliminary Cause and Effect Chart
- Subsea Electronic Module Power and Communication
- Subsea Control System – MCS, EPU, HPU
- FPSO Equipment Layout / Interconnect System Level Diagram
- Subsea Control System to FPSO Process Control System Interface Specification
- Subsea Distribution – Electro-Hydraulic Jumpers

8.7 Umbilical Engineering

Tenderer umbilical lead will review the following requirements for the DWT umbilical FEED Study.

- Tree and Manifold Control and Chemical umbilicals

The hydraulic and chemical injection requirements will be determined in relation to their pressure, volume and flow rates expected for effective operation of the subsea equipment. Electrical requirements for power and signal will be stipulated to size the electrical cables, along with manufacturing and testing requirements.

<u>Control Umbilicals</u>

Control umbilical specification and drawings will be supplied including:

- Functional, Design / Interface Specifications
- Installation / Testing / Commissioning Specification
- Pull-in Interface Specification
- Field Layout drawings (lengths and routing alignments)
- TUTA Interface Tubing Drawings

Once the functional components sizes have been established, a full umbilical cross sectional design review will be performed to address manufacturing capabilities for the various designs. This will include not only manufacture of the umbilicals, but also address the implications for storage and load out from a manufacturing facility and handling / deployment onboard an installation vessel. Also, the method for pull-in and hook-up of the FPSO terminations will be carefully addressed. An important interface to establish within the FEED phase is the size and configuration requirement for any pull tubes that may be required in order to support and guide the umbilical termination FPSO.

Ultimate design construction of the umbilicals will require analysis of the dynamic sections to ensure that there are no fatigue issues related to interference with other umbilicals or risers and also stability of the static section on the seabed. Final dynamic analysis to determine the design service life will be performed by the selected umbilical vendor.