INTECSEA
WorleyParsons Group

Decommissioning in Design Joint Industry Project

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Advisian is a global advisory firm that provides project and business solutions to clients who develop, operate and maintain physical assets in the infrastructure and resources sectors.

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DECOMMISSIONING IN DESIGN JOINT INDUSTRY PROJECT:

Rev	Description	Author	Review	Advisian Approval	Date
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1 Introduction

1.1 Study Objectives

The objective of this Joint Industry Project (JIP) is to provide information to change the design of all new subsea installations in order to minimise decommissioning costs. Design changes will result from collating industry experience. The key issues are:

- End of life integrity
- Cleaning and making safe
- Removal from the seabed
- Onshore Disposal

1.2 Project Benefit

Currently, operators and governments are spending significant amounts of money to decommission an offshore oil and gas development. Significant savings can be gained during decommissioning, when there is no more production revenue offsetting the cost, by spending slightly more during the design and operational phases of a project. This project proposes to establish a standard approach for incorporating decommissioning in the design and execution phase by sharing decommissioning experience.

1.3 Scope of Work

The scope of work includes defining the decommissioning challenges for key components of all subsea developments. The JIP participants are expected to be interactive; this interaction will commence with a brainstorming session to determine the major decommissioning challenges that have been faced thus far. By assessing the primary decommissioning challenges, the JIP participants will determine aspects that may be designed out of the system and how early stage preparations during the design phase may benefit the decommissioning activities in the future. Cost benefit analyses of significant design changes will be calculated to support the project design teams.

1.4 Abbreviations

Abbreviation	Definition
HAZID	Hazard Identification
JIP	Joint Industry Project
NORMS	Naturally Occurring Radioactive Materials
ROV	Remotely Operated Vehicle
SSIV	Subsea Isolation Valve
UKCS	United Kingdom Continental Shelf

2 Decommissioning in Design

Decommissioning an oil and gas development is a multi-million dollar expense for both operators and governments. Often, decommissioning procedures are more complex than necessary due to decisions during the system design project phases. INTECSEA's experience of decommissioning projects highlights considerations that if implemented during the project design phases would simplify the decommissioning procedures, saving valuable time and money.

To illustrate, field economics of a development with 65,000 barrels of oil per day production and a 15 year design life has an initial negative cash flow, moving positive a few years after first oil and then negative again during decommissioning, as shown in Figure 2-1. A final decommissioning cost prior to tax refund is estimated £800MM. During decommissioning, no new revenue will be generated to offset these costs. By reducing decommissioning costs by 50% to approximately £400MM, the project Net Present Value (NPV) for the life of field can increase by as much as 13% [REF 1].

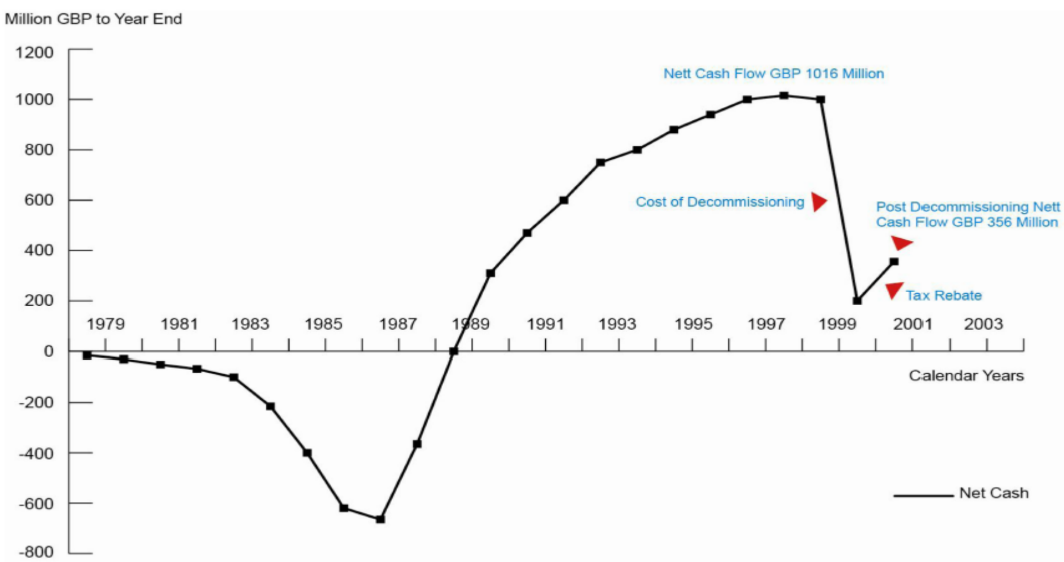

Figure 2-1: Cash Flow for a Typical North Sea Development [REF 1]

Decommissioning is the final phase of an asset and is a financial burden to the operators and governments. Changes in the earlier stages, such as planning, design or operation/maintenance, outlined in Figure 2-2, may decrease the cost of decommissioning significantly. Project procedures may be changed with check lists for decommissioning in design. The approval process for a development plan may include confirmation that the design minimises the decommissioning cost. Periodic testing and planned maintenance during field operation may increase the design life of equipment and ensure the integrity of valves, structures and pipelines will extend beyond the Cessation of Production. Equipment integrity during decommissioning decreases safety risk and increases decommissioning options which could potentially save millions.

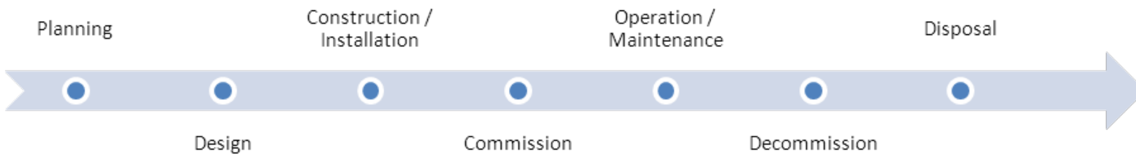

Figure 2-2: Field Development Lifecycle

Decommissioning should be incorporated in the basis of design. The basis for design is developed during the define stage of the project. Hence the define stage of project is the time to incorporate the decommissioning aspects into the design. Decommissioning features or criteria can be incorporated into the design during evaluate and define stages at minimal cost. Incorporating them into the design during the execute stage is costly and time consuming and hence unlikely to succeed.

Cost benefit decommissioning studies may be required to justify the changes to the design. They will vary in their intensity from asset-to-asset and location-to-location. This approach will increase front end costs slightly but overall gains from a reduced lifecycle cost.

3 Potential Cost Saving Areas

This section presents a brief literature review on decommissioning considerations during the design phase. It should be noted that these topics may be investigated further depending on the JIP participants' interests. Several different equipment types were assessed, listed below, and considerations during project design would optimize decommissioning costs in the long term:

- Rigid pipelines
- Flexible flowlines
- Umbilicals
- Bundles
- Valves and tees
- Stability equipment (i.e. grout bags and concrete mattresses)
- Wellheads manifolds and other subsea structures

3.1 General Issues

Prior to any decommissioning activities, a safety case must be submitted by the operator to identify elements of the development that are safety critical and in close proximity to an installation, for example, isolation valves [REF 3]. The Safety Case must demonstrate that the proposed decommissioning arrangements reduce the risk to people to the lowest level that is reasonably practicable. Keeping the Safety Case requirement in mind during the design phase, preparations can be included to ensure the preferred decommissioning option is also the lowest risk to people.

Safety considerations can be considered into two types:

1. Short term operational health and safety challenges: activities during the decommissioning process such as diving, underwater cutting and lifting, hazardous substances, integrity of the pipelines, and the safety of offshore personnel in the removal activities.
2. Long term health and safety challenges: hazards for other users of the sea if the pipeline is abandoned in-situ and the liability of the structures if they are left on the seabed, including snagging risks caused by spanning, exposed pipeline ends, or steep sided rock dump profiles.

Rigid steel pipelines may be recycled along with some of the outer coatings (insulation, concrete, etc.). Likewise, flexible pipelines, umbilicals and power cables can be processed to separate their metallic and plastic components and then recycled. Material considerations at design do not currently consider re-use / recycle options.

Developing a decommissioning methodology for subsea pipelines would identify any key issues or showstoppers within the decommissioning procedures and allow for design modification. The methodology should include seabed stability, activities of other users of the sea, legislative requirements and expectations, corporate policy, likely decommissioning options, anticipated technical and safety issues, as a minimum. A seabed settling assessment for the life of field should be completed to determine whether the pipelines and subsea assets are expected to be completely buried, partially covered or completely accessible. Generally, throughout the lifecycle of a project, regulations may change however a decommissioning methodology that is put in place during a project's design phase can be taken as guidance while deciding the project's late life decommissioning strategy with the regulator.

During the Hazard Identification (HAZID) workshop for pipeline installation and commissioning, it is recommended to include decommissioning as well. By highlighting decommissioning hazards, risks, threats and opportunities would be identified for the decommissioning method. While it is possible that the decommissioning practices and procedures may change from installation to the Cessation of Production, a decommissioning methodology that makes sense both technically and economically and is included in an approved development plan to the regulators, also transfers knowledge to the decommissioning team when the time comes to decommission the system.

3.2 Flushing and Cleaning Issues

During decommissioning, some, if not all, of the subsea system will be removed and carried to shore for disposal. It is likely that the majority of the pipeline is recycled. There may be some residual pipeline contents that could not be removed through the flushing and cleaning procedures, including wax, scale, oily sludge or NORMS (naturally occurring radioactive materials). For example, a recent decommissioned pipeline unexpectedly had NORMs and onshore NORMs treatment for a removed pipeline is more demanding than offshore treatment under existing permits, increasing the decommissioning costs substantially. During design, if NORMs was expected throughout the operational life, additional options (i.e. pipeline burial during installation) or early preparation for NORMs could be carried out.

Flushing and cleaning pipeline networks that are unable to be pigged or require a vessel to launch a pig are complex and time consuming. During project design, engineers should establish the methodology for both the bulk removal of hydrocarbons and cleaning the pipelines to the proposed cleanliness standards. The bulk removal procedure, possibly completed in parallel with the pre-commissioning procedure, would require calculated pigging and draining routes to transport the bulk hydrocarbons to shore for processing, whether that is through a trunkline or tankers. During the design phase, cleanliness verification procedures must be assessed, for example, sampling pipeline contents at topside until a specified cleanliness is reached (i.e. 30 ppm) or by removal of a section of the subsea pipeline for inner wall inspection.

3.3 Rigid Pipelines

Rigid pipelines, if not buried or trenched, may have to be removed after Cessation of Production. Current best practices for the UKCS state: rigid pipelines, if not buried or trenched, shall be removed after Cessation of Production. Options for flushing and cleaning, making the pipeline safe and abandoning in-situ, removal of structures and mattresses etc. are established on a case-by-case decision and are usually based on engineering justifications and approval by the regulator. There is no guarantee that an analytical negotiation between an operator and the regulators will be an option in the future and the decommissioning solution may simply become a firm law, based on diameters and geographic location.

Generally, rigid pipelines are difficult to remove, especially the larger diameter pipelines. Once a pipeline is buried beyond the mobile sediment layer, a minimum depth of approximately 0.6 metres, it will likely remain buried after decommissioning. A recommendation is to bury the pipeline during installation to avoid costly removal in the future.

For example, in a past project the operator was required to remove a 26 inch pipeline. The structural integrity was unknown and it was high risk to reverse S-lay the large pipeline. The only credible option was cutting the pipeline into small pieces and lifting them individually onto a nearby barge for onshore disposal. The costs totalled several million pounds and the equipment list included:

- a vessel with a large crane;
- ROV spread;
- diver spread (jetting the area around the pipeline to accommodate the cutter required diver intervention);
- cutting spread;
- barge;
- Disposal yard.

Alternatively, another client trenched and buried the existing pipeline post-production to avoid the costly cut-and-lift procedures. Post-lay trenching is very difficult and the operation took 3 times longer than anticipated, resulting in significant budget overruns.

In hindsight, both operators could have decreased overall costs by trenching the seabed prior to pipeline installation and natural burial would settle the seabed throughout the life of the field. During design, it is recommended to perform a cost benefit analysis on a lighter, buried pipeline compared to a heavy walled option on the seabed. It should also be assess against the inspectability and maintainability during the pipeline’s operating phase.

3.4 Flexible Flowlines

Flexible flowlines, due to their size and length, are typically recovered by re-reeling after the life of the field. During design, it is recommended to run a recovery analysis case to determine whether the plastic and structural degradation during operations would impact the ability to re-reel the flexible flowline at the end of life. End connections should be analysed for their long term structural integrity needed to support the weight of the pipeline during the re-reeling process. Similar to rigid pipelines, the installation HAZID should include a discussion on the decommissioning methodology.

Flushing and cleaning flexibles is challenging especially if they are not designed with a smooth bore. Smooth bore flexibles are easier for hydrocarbon removal during decommissioning than rough bore as hydrocarbons become trapped in the flowlines’ rough inner wall and are unable to be cleaned. Depending on the cleanliness standards, a smooth bore may be chosen during design to ensure the cleanliness standard is reached prior to removal of the flowlines. If not, a rough bore, upon reeling, may spill trace hydrocarbons into the ocean and cause for a difficult onshore disposal for the trace hydrocarbons that remain trapped in the flexible flowlines' inner walls.

Potential opportunities may exist for the reuse of flexible pipelines and umbilicals if their post recovery integrity can be confirmed.

Flexible flowlines which have been used for gas have long tem integrity doubts as the gas may have migrated into the plastic and steel carcass.

3.5 Umbilicals

Umbilicals are required to be removed unless they are buried and are proven that they will remain buried post-decommissioning. Decommissioning umbilicals create problems that are similar to flexible flowlines, including flushing and cleaning, removal and integrity checks. Hydraulic fluid and chemicals inside umbilicals must be cleaned out, with more stringent cleaning standards than trace hydrocarbons in pipelines.

There may be issues with umbilical recovery and an integrity assessment is recommended to determine the umbilical integrity at the end of life. The removal method and whether potential reuse is possible will depend on the integrity. The long term derogation of umbilicals in sea water should be studied during the design phase and the predicted derogation should be related to the preferred decommissioning methodology.

There are several interconnector cables across the Irish Sea and the English Channel and it may be beneficial to understand their issues and lessons learned during cable retrieval.

3.6 Pipeline Bundles

Experience on removal of pipeline bundles is limited. Similar issues need to be considered as for rigid pipelines – cleaning of each pipeline, removal procedure, can justification be made to leave in place, reuse potential etc.

If a bundle consists of an umbilical and a pipeline, the bundle is generally considered one unit. However, if the pipeline is unburied and is to remain, a further assessment is recommended on the stability of the straps. If the straps are expected to corrode, the straps may have to be cut and the umbilical removed to prevent any snagging hazards. These issues should be reflected in the pipeline design.

3.7 Subsea Valves

Valves and tees are useful pipeline components during decommissioning. Strategically placed valves could be used as an isolation point to remove a subsea structure while leaving the pipeline in place. For example, a subsea manifold with an elevation of 5m on the seabed must be removed while the buried flowlines connecting it to the riser base remained in-situ. A subsea isolation valve was located 2m away from the subsea manifold. Therefore, the logical cut point was directly upstream of the isolation valve and provided an end cap for the pipeline remaining in-situ. During design, it is recommended to ensure an adequate amount of double block and bleed isolations to ensure isolation of a section of pipeline for decommissioning work is possible. If not, isolation plugs may be required as contingencies.

After many years of use, the seabed valves may not provide a seal for decommissioning. Therefore timely inspections and maintenance is important throughout the life cycle so the valve can maintain a seal at the end of the design life. The valve may require a design life for beyond the life of the field to ensure adequate performance after the Cessation of Production during decommissioning.

Valves should be ROV operated for ease during decommissioning. In many cases, operators choose diverless decommissioning methods to minimize the personnel safety risk. It is recommended that all valves are designed to be ROV operated to allow for a diverless decommissioning option, if applicable. During decommissioning, the determining factor with diver assisted vs. ROV tasks are the access around valves and subsea structures. Debris removal by jetting, dredging or mass flow excavation creates extremely low visibility and hinders the ROV's workability. Seabed settling around valves during the design life is a concern and a seabed settling study is recommended during the design phase for the life of the field. If seabed settling is determined to be very likely, measures to ensure valve access at the end of life, regardless of the seabed settling, should be considered.

3.8 Stability Units / Concrete Mattresses

Mattresses are used for stability and protection on pipelines, valves and subsea structures. They withstand severe storms and the current UKCS procedures are that they are required to be removed during decommissioning if the structural integrity allows. An additional complexity for underwater lifts is exacerbated by the uncertainty in weight and centre of gravity of the unit/mattress. During design, heavier and stronger materials may be included to withstand more severe storms to ensure the mattresses remain intact for removal for decommissioning.

Generally, any stability units that are placed on the seabed are to be removed during decommissioning so it is important to keep that in mind during the design phase. Consider alternate means of stability and protection of subsea structures, for example, pipeline burial, removable trawling covers on equipment, and fewer larger mattresses instead of several smaller ones.

Mattresses have been difficult to remove. The lifting wires corrode and the ropes break. Thought should be given in design to the lift wires and ropes to the removal in 25 years' time.

3.9 Wellheads, Manifolds and other Subsea Structures

Subsea structures, including wellheads and manifolds, will require removal during decommissioning. During removal, actual weight of the structure will be unknown. Corrosion will decrease the unit weight by consumption of the sacrificial anodes while spillage of grout, marine growth and particle settling on the structure will increase it. The original pad eyes will remain on the structure and ideally, they will be suitable to lift the structure with a crane. Break out loads can be double the underwater weight of the manifolds. For ease in lifting, bigger and stronger pad eyes on the template should be used to allow for extra weight uncertainty during removal.

As discussed above, the seabed will settle around the structures during the operational life. A suction pressure of an unknown force will likely be evident during the initial pull from the seabed and steps during design can alleviate this problem. During template installations, a geotextile membrane should always be used below the mudmats to assist removal.

Accurate records during design and installation of subsea equipment is important to ensure there is a comprehensive list of the equipment associated with the pipeline network. It should describe components, materials, quantities, dimensions, weights, contents, burial coverage, protection structures, anodes, and valves, at the very least.

3.10 Standardization

Standardization provides cost savings in Greenfield design as well as decommissioning. Recent work established cost and man-hour reductions of 10% for like on like projects (Ref 2). A standard design results in savings of removal time by providing familiarity of tasks as the tasks will not be new to the offshore personnel.

3.11 References

[REF 1] Stokes, A.W., (2014) Decommissioning Costs Can Be Reduced. OTC 25247. Offshore Technology Conference, Houston TX.

[REF 2] Burke, J., Stokes, A.W., (2015) Preparation for Cost Effective Decommissioning and Abandonment of Pipelines. SPE 175426. Offshore Europe, Aberdeen, UK.

[REF 3] Oil and Gas UK: Decommissioning of Pipelines in the North Sea Region 2013. Retrieved on 16 December, 2015 from: http://oilandgasuk.co.uk/wp-content/uploads/2015/04/pipelines-pdf.pdf

4 Project Execution Plan

4.1 Overview

All participants will share their experience in decommissioning during the programme. Decommissioning in the UKCS has proved to be executed safely, on schedule and to budget because there is a culture of sharing information and knowledge and assisting others. The execution of this JIP work programme has been planned to give all parties the opportunity to contribute and learn from others.

The resulting collective knowledge base will be collated by INTECSEA. INTECSEA will issue two (2) deliverables to all participants in the JIP for use on their new build projects. The deliverables will be in a format that can be used by the Lead discipline engineers on a new build project and will also provide explanations or cost benefits as to why the changes should be made to the design.

4.2 Participant Categories

In order for the deliverable to be a comprehensive document, INTECSEA will pursue the collaboration of three (3) categories of participants to ensure a comprehensive Industry Guidance document:

Type A – Operators

Type B – Installation Contractors

Type C – Industry Regulators

By incorporating the opinions and past experiences of the three participant categories, the deliverables will be all-encompassing and include a wide range of knowledge, experience, and guidance.

4.3 Deliverables

INTECSEA shall deliver two documents defined below:

- Industry guidance document. The document will be structured in accordance with the Work Breakdown Structure of Oil and Gas UK. For example “cleaning”, “making safe”, “removal”, “transport to shore”. “disposal”, etc. will be the subject of separate chapters. For each chapter heading the issues for that element of the Work Breakdown structure will be listed. The key equipment/issues such as valves, umbilicals, legislative requirements, lifting, contamination, and structural degradation/unknown condition will be addressed. The solution or mitigation will be included and the cost or safety benefit noted.
- Template for decommissioning review at Stage Gate Reviews. The template will document the questions to be addressed at the Stage Gate Reviews when the new build project transfers from the Select to Define phase and from the Define to Execute phase. The template will be in the form of

matrix so it can be completed during the time assigned to decommissioning in the Stage Gate review.

4.4 Project Management

INTECSEA shall host the kick-off meeting within 1 week of contract being signed with interested participants. The kick-off meeting shall discuss the scope, methodology, required input data and interface requirements. It will also introduce the extended team to participants and company representatives.

An allowance for travel has not been made, hence in order to perform presentations and conduct discussions during the work, video or teleconference will be utilized, where physical presence is cost inhibitive.

INTECSEA shall submit progress reports by the end of each fortnight, which shall contain the following as a minimum:

- Tasks completed this fortnight and tasks planned for next fortnight
- Issues and mitigations
- Schedule progress

INTECSEA shall allow 10 working days for participants to review the deliverables before issuing of the final report.

4.5 Preliminary Proposed Schedule

The preliminary proposed schedule is approximately 6 months to 1 year, depending on the level of effort provided by the participants.

Three meetings are proposed for the JIP:

1. **Kick Off meeting**
   The participants will gather to set the scene and agree the format of the deliverables. The participants will discuss the areas of their expertise. Any gaps in the knowledge base and experience of the participants will be identified.
2. **Workshop**
   The participants will present their contributions to the design guidance and project reviews. These will be discussed and the collective experience at the work shop will provide improvements.
   Intecsea will record the information and then prepare the draft of the deliverables.
3. **Presentation meeting**
   Intecsea will have submitted the draft of the guidance prior to the meeting to the participants. At the meeting the participants will provide their input to the guidance.

Final Issue

Intecsea will issue the guidance for use by the participants.

5 Project Organization and Key Personnel

5.1 Study Management and Coordination

The study will be coordinated by INTECSEA through the Aberdeen office. The Project Manager will be Julie Burke with Alan Stokes, INTECSEA's Global Decommissioning Manager, supporting the initiative from the Aberdeen office.

Julie will be the primary point of contact during the study and will be performing her role with the advisory support from Alan. INTECSEA's Technology Director, Andrew Low, will be the Project Sponsor to provide support where required and ensure the project remains on course.

As this is proposed as an industry wide collaboration, it is anticipated that the steering committee is formed among participants to provide advice and identify the priorities and concerns as the study develops.

5.2 Proposed Study Location

The project will be conducted out of the INTECSEA office in Aberdeen, UK.

5.3 Study Organization

INTECSEA's proposed organizational structure is shown in Figure 5-1.

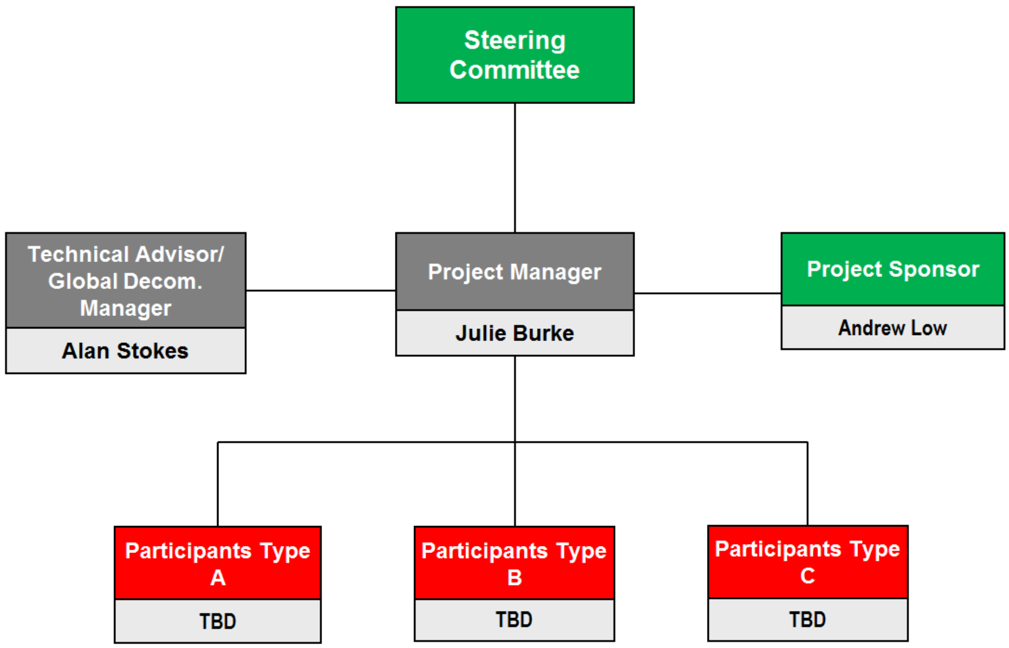

Figure 5-1: Study Organizational Structure

5.4 Key Personnel

As this exercise involves industry wide collaboration with INTECSEA as coordinator as well as participant, the list of Key Personnel shall be populated by all participants. In the position of project Coordinator, INTECSEA is seeking to provide the best personnel to ensure the study's objectives are met in a timely and technically robust manner. To achieve this, we have proposed the most suitably qualified and experienced personnel. An overview of the proposed key personnel is provided in , while full CVs are included as Appendix B.

Name, Position on Project	Qualifications and Experience
Andrew Low Project Sponsor	Mr. Andrew Low is the Global Technology Director in INTECSEA and has more than 15 years of experience in the offshore oil and gas industry. He is responsible for the development and technical delivery of INTECSEA Joint Industry research projects and stewardship of technology partnerships globally.
Alan Stokes Technical Advisor / Global	Leader of decommissioning work for the last 8 years. Extensive experience in all aspects of decommissioning for whole platform removal and subsea equipment recovery. Membership of Oil and Gas

Decommissioning Manager	UK Decommissioning Work Group (Industry/Government joint working group). Chairing the topic group on Efficient Execution.
Julie Burke Project Manager	Julie Burke is an Engineering Specialist and has worked more than 7 years in the offshore oil and gas industry. Having worked in Perth, Houston, Aberdeen and St. John's, her global experience provides her with the background for the Project Manager role in the Decommissioning in Design JIP. She has worked together with Alan on multiple decommissioning projects and co-authored an Offshore Europe paper titled "Preparation for Cost Effective Decommissioning and Abandonment of Pipelines".

6 Commercial

6.1 Terms and Conditions

The JIP will be executed under the INTECSEA Terms and Conditions for Joint Industry Projects, included in Appendix A.

6.2 Estimated Cost and Participant Cost

The cost will depend on the number of participants as costs are shared with all participants. The target participant cost is about £10,000.