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Digitally Transforming Front End Decommissioning Planning

Farzan Marfatia, Ajero Pty Ltd

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Abstract

National legislation requires removal of offshore oil and gas assets post cessation of production. However, this legislation is currently being challenged due to; Safety concerns, advances in environmental research, technical challenges, societal and economic impacts.

The Comparative Assessment is one method of addressing these factors. An online platform has been developed for this purpose that uses adapted, industry standards and norms to generate a comprehensive assessment assisting in the development of an auto-generated high-level decommissioning plan with high level cost estimates.

The Comparative Assessment's seven-stage process is incorporated in the online platform and when utilised in a facilitated 'HAZID' style workshop, the platform enables all relevant subject matter experts to complete the assessment in days, in lieu of months of consultancy.

The algorithms development for the online platform includes the implementation of a quantitative Comparative Assessment process with complementing high-level cost estimates in-line with AACE class 4 and ASPE Level 1 estimates.

The cost estimates explore various removal techniques currently used in the industry. These techniques are then analysed by performing sensitivity studies for different removal methodologies, vessel charters and cost variance from actual decommissioning case studies.

In order to improve efficiency in the decommissioning industry, the development of an online platform capable of an industry recognised decision making process and cost of decommissioning will improve planning and assist in assessing the global decommissioning liability.

Introduction

Decommissioning is the new frontier in the Oil and Gas industry with major risks for companies, governments and the environment. For example, in South-East Asian region, over 380 fields will require decommissioning at an estimated cost of around US 100 billion (Berchoteau, 2017). This global issue has mobilised industry strategists, policy institutes and subject matter experts to consider the potential of reducing decommissioning costs and liabilities.

Some recent research studies performed by various academic institutes in South-East Asia, the United Kingdom and Australia have challenged current state, national and international legislation and conventions.

Moreover, in 2015, Oil and Gas United Kingdom (OGUK) introduced guidelines detailing a suitable option select process, known as the Comparative Assessments (Oil & Gas UK, 2015), with auditable option selects for decommissioning processes. The guidelines provide a clear outline of the decommissioning processes to be followed as well as itemising other major legislative requirements. However, with the possibility of multiple methodologies, flexibility and reference to other industry norms, the need for a digital solution is self-evident. Therefore, this paper discusses the development of an online platform that can streamline and facilitate the Comparative Assessment process ensuring consistency and adherence to world's best practice and standards.

During the Comparative Assessment process option selects are assessed by criteria which, can be divided into sub-criteria for ease of assessment.

The Methodology

A number of criteria inform the Comparative Assessment underpinning the platform's methodology:

- Safety - where reducing risks to offshore personnel and reducing 'bottom time' during dive operations directly reduce operational risks.
- Environmental - recent studies suggest the optimum solution may be to leave structures in-situ, minimising seabed disturbance to existing marine ecosystems and improving fish stocks in the vicinity by creating artificial reefs.
- Technical - most installed infrastructure was designed to facilitate the installation, operational and maintenance phases with little consideration given to decommissioning. The absence of pre-planning may increase operational risks during decommissioning activities.
- Societal - the impact on local communities and amenities with factors such as employment, local house prices and other societal costs requiring consideration.
- Economical - reasons which include high costs and the potential for cost overruns.

For ease of assessment, the online platform process, has been divided into three key sections:

1. Regional asset database
2. Comparative Assessment
3. High level costing Estimations

Regional Asset Database

The Asset database contains all the critical details of all fields in the region. It is the main input for all scheduling and costing aspects of the platform.

Although the database contains accumulated data from trusted sources such as operator databases, websites and published documents and plans, the operator can override this data in the front-end interface, revising results in real-time.

Comparative Assessment

The Comparative Assessment is a comprehensive process that compares the associated risks of potential decommissioning options, against the base case. The OGUK model is a seven (7) stage process as detailed below:

1. Scope – Develop an appropriate Comparative Assessment methodology, confirm criteria and sub-criteria for analysis; identify use, purpose and all stakeholders for Comparative Assessment
2. Screen - Consider alternative uses and filter out unfeasible options
3. Prepare - Undertake technical, safety, environmental studies and stakeholder engagement
4. Evaluate - Evaluate the options using the chosen Comparative Assessment methodology

5. Recommend - Create recommendations in the form of a narrative report substantiated by charts explaining any key trade-offs
6. Review - Review the recommendations with all stakeholders
7. Submit - Submit to regulators

(Oil & Gas UK, 2015)

The online platform performs steps 1 through to 5 in a workshop style environment, ideally with input from all subject matter experts.

The online platform includes the most suitable removal methodologies currently available, sourced from previous case studies. Nevertheless, its modular framework can be adapted to include new innovative removal techniques for all types of infrastructure that may have been evaluated in steps 1 or 2.

The evaluation methodology, step 4., can use either a qualitative approach, with the use of red, amber, or green 'traffic light' risk assessment practices; or a detailed quantitative approach utilising recognised industry data collection or risk assessment procedures.

The online platform uses evaluation methodology C. This method determines a quantitative assessment by weighting criteria based on importance via a multi criteria decision analysis (MCDA). While MCDA is ideally suited to quantitative Comparative Assessments, it is important to use the correct MCDA for this style of option select. Various sensitivity studies and analysis will determine the ideal MCDA for the Comparative Assessment Process.

Prior to establishing the ideal assessment process, the developers analysed and evaluated various MCDA's including:

- Pairwise functions, (Barzilai, 1998)
- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), (Çalik, Çizmecioĝlu and Akpinar, 2019)
- Analytical Hierarchy Process (AHP), (Saaty, 2004; Fowler et al.,2014)

The Comparative Assessment analysis in this manuscript examines three different MCDA using the following input data in table 1 below.

Table 1—Criteria weighting used in analysis

Weighting			
Hierarchal		Non-Hierarchal	
C1	4		
SC1a	9	C1	9
SC1b	5	C2	5
SC1c	3	C3	3
C2	7		
SC2a	9	C4	9
SC2b	4	C5	4
SC2c	3	C6	3
C3	3		
SC3a	9	C7	9
SC3b	6	C8	6
SC3c	1	C9	1
C4	1		
SC4a	9	C10	9
SC4b	7	C11	7
SC4c	4	C12	4

Cost Estimations

The current costing methodology for the online platform has been formulated from cost estimating standards in-line with the following construction standards:

- American Society of Professional Estimators – Level 1 (Hamilton, 2019)
- Association for the Advanced Cost Engineering - Class 4, (AACE International, 2019)
- Monte Carlo Method – P50 (Estimating the Impact of Lean Construction Practices on Project Duration and Cost using Monte Carlo Simulation, 2017)

High-level costing algorithms are based on current industry rates for vessels, rigs and resources, which are updated quarterly to reflect industry trends.

Durations are based on industry best practice in the global oil and gas industry. These vary depending on infrastructure type methodologies and algorithms for complete removal.

Durations are determined with reference to historical data and previous case studies:

- For well plug and abandonment in UK and Australian waters. Durations may vary between regions (ICF International, 2018) and these can be further varied or overridden according to the regional norm.
- Analysis has been performed between durations for topside removal techniques (Nixon, 2013) in order to understand the most cost-effective technique between small piece, reverse installation and single lift. These are detailed in results and observations.
- Pipeline removal analysis is based on 12 metre section removals. Nevertheless, it can be configured to suit other methodologies including reverse pipe lay or other innovative removal techniques.
- Subsea infrastructure, other than Christmas trees, are modelled on complete removal for a single lift including, vessel cranage sizing, airlifting, excavation requirements and mud-mat removal.

- Allowance has been made for umbilicals and flexibles that are not piggybacked to pipelines.

Case Studies and Results

Four fields have been used in this analysis to determine software accuracy and relevance. Field details are displayed in Table 2 below.

Table 2—Facility details under analysis

	Wells		Topside/ JacketSubsea		Subsea Infrastructure		Pipelines		Umbllicals/ Flexlbles		
Facility	Qty	Type	Type	Weight (t)	Qty	Water Depth (msw)	Qty	Length (km)	Qty	Length (km)	Piggy backed
Facility X (Anonymous)	6	Surface	Fixed	900	5	16	1	11	–	11	Yes
Rose	1	Subsea	Subsea	NA	1	24	1	9	–	9	Yes
Shelley	2	Subsea	Subsea	NA	3	96	1	12	2	12	No
North-West Hutton	24	Surface	Fixed	39000	0	146	2	13	4	13	Yes

Comparative Assessment

The following analysis compares three (3) different MCDA by using four (4) off criteria and three (3) sub-criteria per criteria. Taking account of the variables able to compute different results, the analysis focuses on a base case with typical profiles for safety [C1, SC1a, SC1b, SC1c], environment [C2, SC2a, SC2b, SC2c], technical [C3, SC3a, SC3b, SC3c] and societal [C4, SC4a, SC4b, SC4c] risks. The following table illustrates the results for the inputs detailed in table 1. It also displays the optimum solution based around the calculated risk profiles.

Table 3—Optimum Solution per MCDA

Resuts				
	Risk Profile			
MCDA	Option A	Option B	Option C	Optimum Option
Pairwise	5.144	3.615	4.38	Option B
TOPSIS	0.689	0.306	0.219	Option C
AHP	51.056	38.916	36.46	Option C

The results are analysed by performing sensitivity studies, option variances and inter-dependency analysis between criteria in order to determine the ideal MCDA.

Cost Estimations

Actual decommissioning costs were extracted from decommissioning close out reports as detailed in numerous references (BP, 2013; Spirit Energy, 2016; Premier Oil, 2019).

Cost estimates were derived from the online platform output, as detailed below in the North West-Hutton example.

Figure 1, below, details the selected removal methodology nodes in the software mirroring North-West Hutton's actual decommissioning activity (BP, 2013). This high-level removal methodology included:

- Well Decommissioning – Plugging the surface trees and cutting the tubing and conductor just above the mudline.
- Topside Structure Decommissioning – Removal of topside, conductors and jacket just above the jacket pileguides.
- Pipeline Decommissioning – Complete removal.
- Subsea infrastructure – Not applicable in this example.
- Umbilical Decommissioning – Complete removal (piggy backed to pipeline).

Figure 2 provides the decommissioning cost breakdown provided by the platform for the base case (Option A) and the removal methodology detailed in (BP, 2013) and figure 1 (Option B).

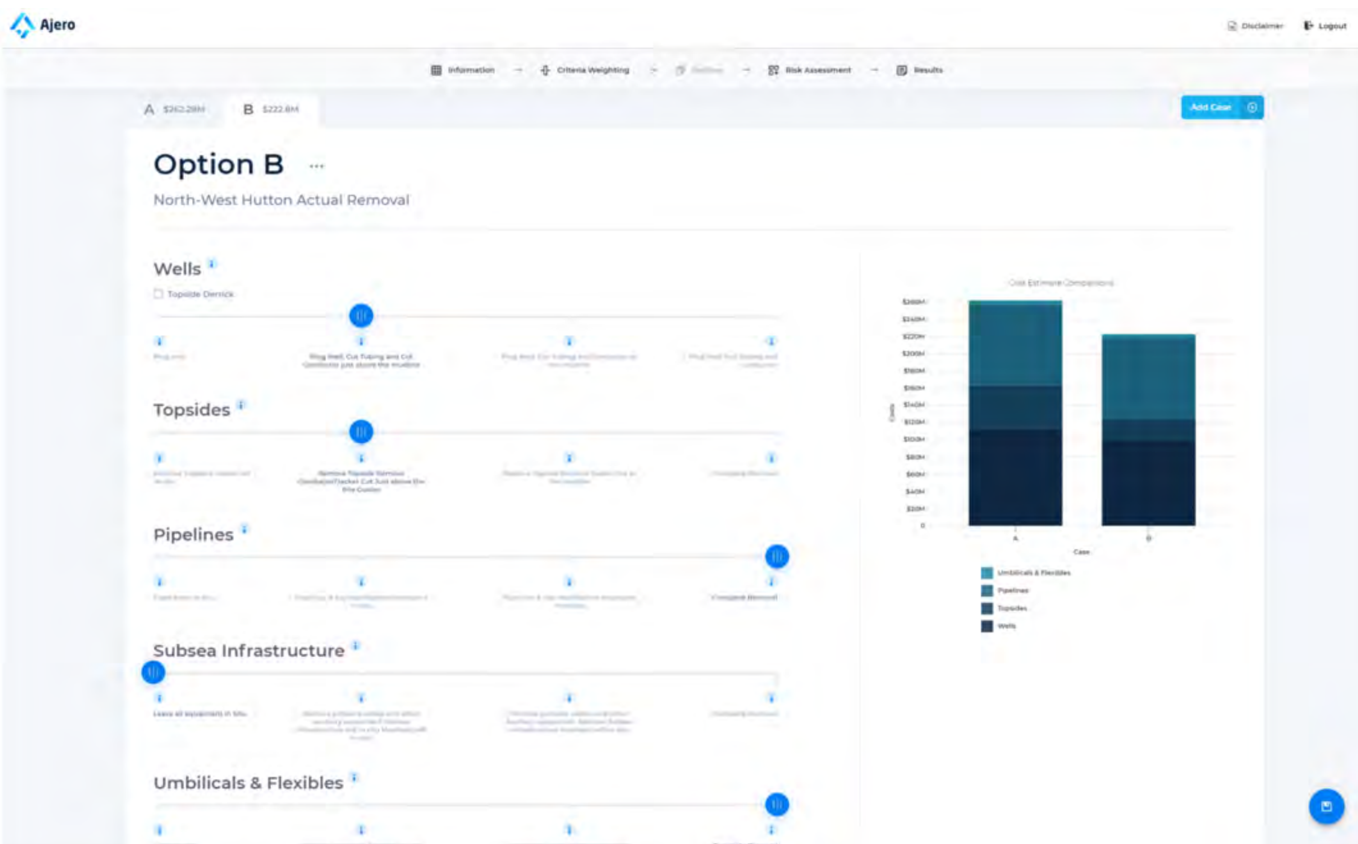

Figure 1—North West-Hutton Option Development in the Online Platform

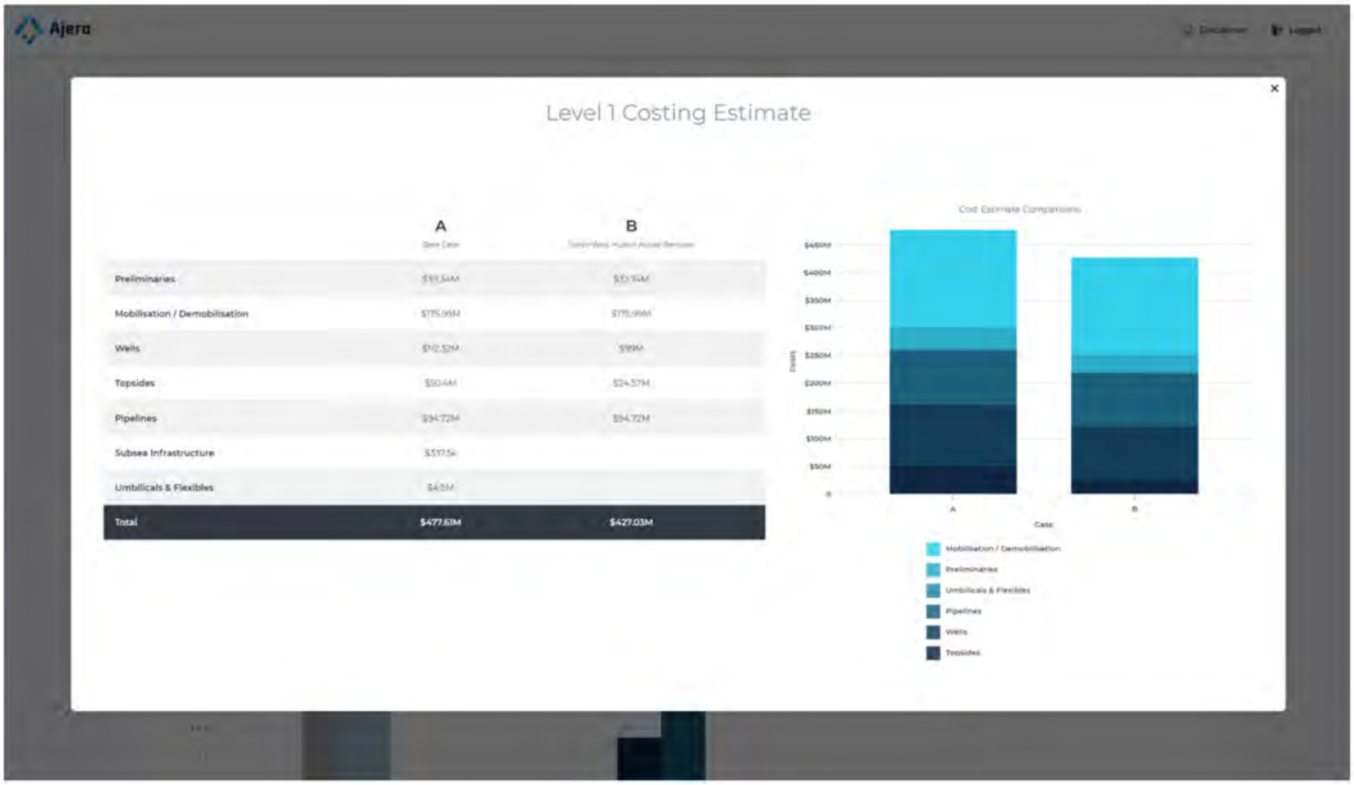

Figure 2—North West-Hutton Cost Estimate in Platform

Table 4 below illustrates the cost difference between the actual decommissioning cost and the platform estimate.

table 4—Online Platfornm VS. Actual Decomissioning Cost Analysis

Offshore Production Facility Comparison to Platform

Facility	Removal Methodology	Year	Region	Ajero Platform Total ($M) AUD	Actual Total ($M) AUD	% Δ
Facility X (Anonymous)	Complete (pipelines in-situ)	*2029	Australia	60.2	49.3	22.1%
Rose	Complete (pipelines in-situ)	2016	North Sea	29.1	34.6	16.0%
Shelley	Complete (Base Case)	2012	North Sea	54.7	49.7	10.1%
North-West Hutton	Jacket pileguides in-situ	2013	North Sea	427.0	403.3	5.9%

* Denotes future decommisioning cost estimate in today's cost

Additional analysis on the costing methodology has been performed (see observations below), which includes sensitivity studies for major charter hire and removal methodology comparison.

Observations

Comparative Assessment

In order to understand the best MCDA process to build a quantitative Comparative Assessment, it is important to recognise the key drivers and requirements of criteria characteristics and how they will impact the analysis.

In the global oil and gas industry, safety remains the main driver of success followed by environmental impacts. With this in mind, a key criteria requirement is a clearly defined hierarchal structure that will enable overall criteria preferences in the comparative assessment.

Therefore, it can be inferred that:

- The removal of decommissioning options should not affect criteria ranking (hierarchal sense).
- The removal of other criteria should not affect criteria ranking (hierarchal sense).
- Limited inter-dependencies between criteria weighting is ideal.

The availability of relatable data is critical in a purely quantitative assessment. The most appropriate type of risk related objective data that criteria could be compared against is cost. Long range data can be used to evaluate the direct relationship between cost and:

- Safety – Cost per fatality, Loss-Time Incident (LTI) and medical treatment
- Technical – Typical cost of overruns and schedule delays based around individual tasks
- Societal – impact for associated communities and other stakeholders

Current studies are developing direct costing models for environmental impact effects, including Naturally Occurring Radioactive Matter (NORM) and subsistence and commercial fishing. Once the collection of these data is completed, an objective assessment can be performed for the comparative assessment. In the absence of direct data, the online platform utilises risk-profiling in-line with industry standard ISO 31000 risk assessment, see figure 3.

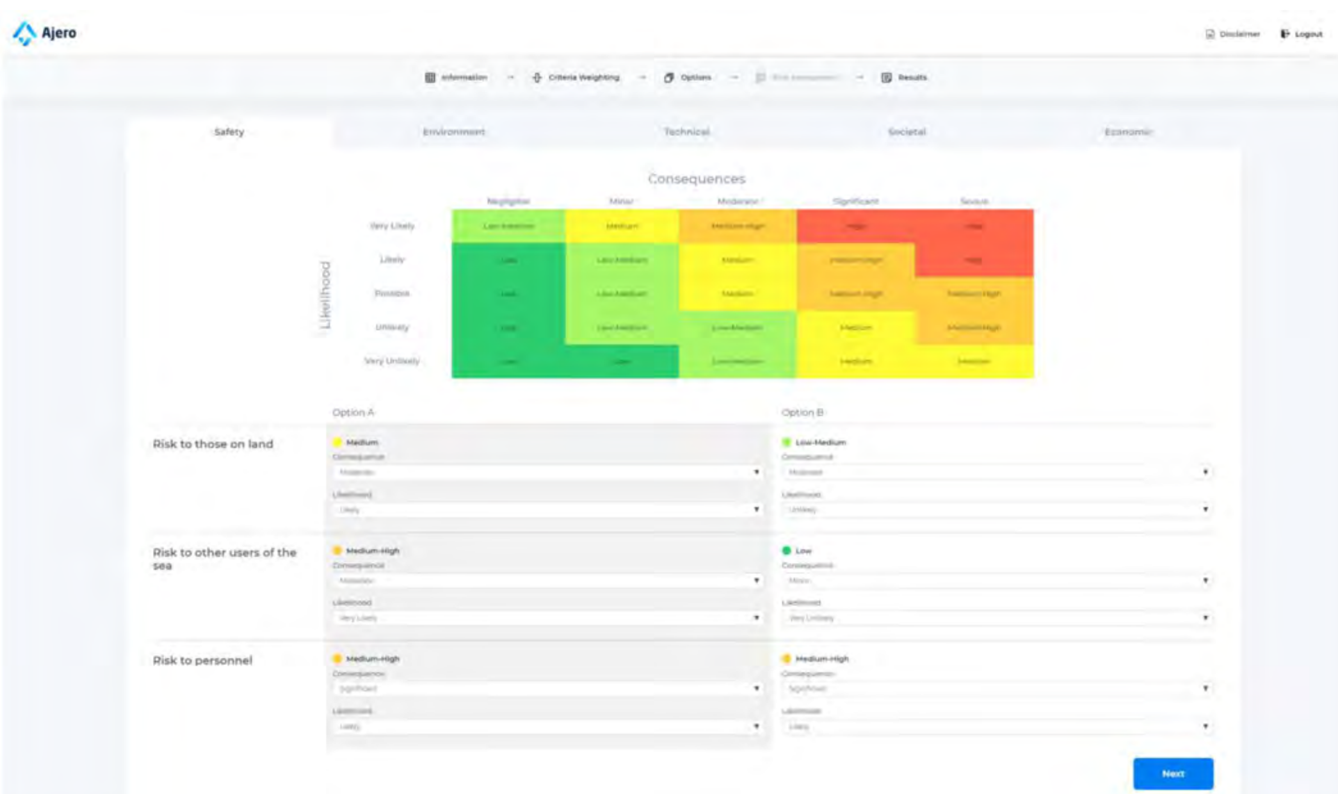

Figure 3—Risk assessment in-line with ISO 31000 risk management

The absence of environmental data makes the use of a Net Environmental Benefit Analysis (NEBA) difficult to enact within the current UK comparative assessment model. However, new environmental research around future costing models is currently underway. New models will enable the future integration of the NEBA model and allow a directly relatable ‘net positive’ analysis to be performed.

Taking into account the requirements for the comparative assessment the pairwise, TOPSIS and AHP were compared against each other to determine the ideal MCDA for the comparative assessment.

Our analysis of the platform detailed the following sensitivities and findings:

Optimum solution sensitivity– TOPSIS and AHP appeared to have the same optimum result for all the inputs. However, this was not always the case for the pairwise MCDA. For typical risk profiles and weightings (see table 1 above), the non-hierarchal pairwise MCDA provides a differing optimum option, as seen in table 5 below. This suggests that sub-criteria in key criteria (i.e. Safety and environment) may not always uphold their required dominant weighting in marginal analysis.

Table 5—Risk Profile Sensitivity Results

	Risk Profile			Optimum Option	% ΔOption A (Base case)	
MCDA	Option A	Option B	Option C		Option B	Option C
Pairwise	5.144	3.615	4.38	Option B	-30%	-15%
TOPSIS	0.689	0.306	0.219	Option C	-56%	-68%
AHP	51.056	38.916	36.46	Option C	-24%	-29%

Although the risk profiles vary with different inputs, typical industry assessments based around a 5 × 5 risk matrix (ref. ISO 31000 Risk Management) suggest the major varying margin of difference, from the base case is the TOPSIS MCDA, as shown in table 5 below.

It is important to understand these percentage differences will vary slightly. However, with industry reflected inputs it is apparent that out of the three (3) MCDA, the TOPSIS is the outlying exception.

Option Removal – Another interesting observation, which supports the optimum solution sensitivity, is the interdependency of options when options are deleted. It is ideal to have an algorithm that is unaffected by the addition or removal of various options. With the inputs detailed above, when option C was removed from the algorithm the AHP and pairwise risk profiles for the base case were unchanged. However, the TOPSIS risk profile deviated by 23%. Although this does not rule out the TOPSIS as a suitable MCDA for the comparative assessment, it is preferential to have the number of options or alternatives and risk profiles independent of each other.

Sub-criteria Weighting – Ideally, changing one criteria weighting should be independent from other criteria. This is evident with hierarchal MCDAs. In the sensitivity study, the effect on Sub criteria 1B (Sc1B) was measured if sub-criteria 2A (Sc2A) was modified. TOPSIS and AHP Sc1B was unaffected by changes in Sc2A. However, the pairwise analysis produced a hyperbolic relationship between the percentage change of Sc1B as Sc2A weighting input was changed. Figure 4, below, illustrates the relationship between the effect on pairwise criteria by changing other criteria weighting inputs:

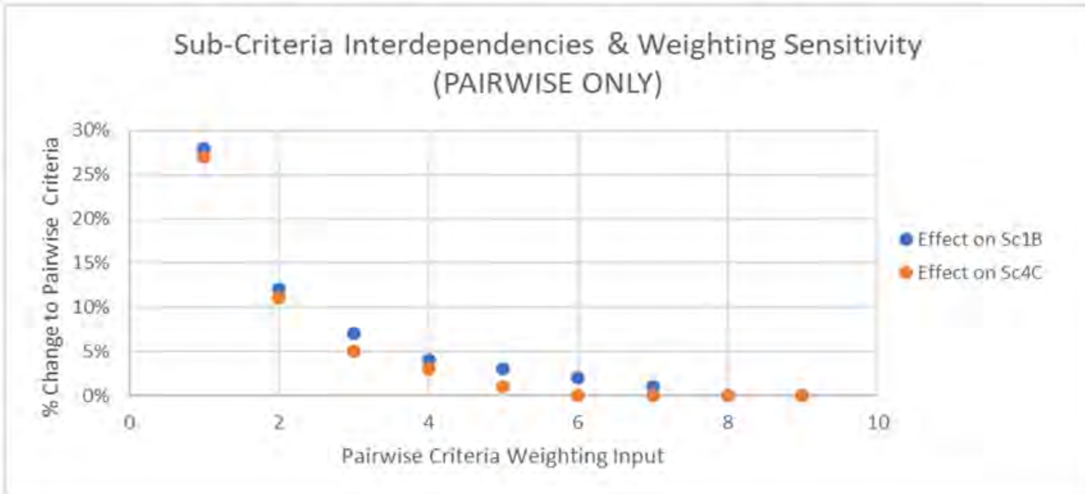

Figure 4—Pairwise inter-dependencies relationship between sub-criteria.

Cost Estimations

As seen in table 4, the platform performs cost assessments well within AACE Class 4 (-30% / +50%) and ASPE Level 1 estimates (-30% / +40%).

Removal Methodology Analysis - To keep the cost estimates as accurate as possible, the online platform topside removal algorithm is the most complicated of the costing algorithms. It has been subject to thorough review and continuous fine-tuning. The initial assessments were derived utilising Nixon's three removal techniques and analysed to determine the most cost-effective removal technique for different infrastructure sizes and types. Analysis on all topside structures, including Facility X and North West Hutton, had the ideal costing algorithm to be a 'reverse installation' type methodology, less than 7-8 lifts) which was 30-40% more efficient than a single lift operation. The main contributing factor for the major difference in price was the mobilisation costs of Heavy Lift Vessels (HLV) (all assumed to be mobilised from the North Sea at 80% of the cruising / towing speed).

Local access to a Single lift HLV can potentially improve the economic benefit of performing the removal in a single lift.

Cost estimation exceptions - The exception in these results is Facility X, a cost estimate performed on an Australian facility in shallow waters. The cause of the major difference / overestimation is the Dive Support Vessel (DSV). In this case, a DSV suitable for local waters was used in the estimate. As there was no requirement for berths on-board, the size of the DSV was considerably smaller and more economical than its larger counterpart. This illustrates that total cost is highly sensitive to major charter hire rates.

Consequently, sensitivity analysis was performed on the costing methodology based on the two major CAPEX costs dive support vessels (DSV) and rig charter.

DSV – The March 2019 Subsea Vessel Broker report (Clarksons Platou, 2019) referred to Sat DSV single Bell vessels ranging from USD 65,000 to USD 95,000 for charter (excluding Dive team). Assuming the dive team cost is a constant, there is a variance of USD 30,000 per day. The report also states the variance between Air DSVs to be around USD 20,000 per day. However, given the charter rates are predominantly for DP2 vessels and do not consider the wide range of possible Air DSVs used in the industry, it is possible that a variance of at least USD 30,000 for Air DSVs is also applicable.

The sensitivity analysis between major charter hire and total costs was performed and the following graph (figure 5) illustrates the results:

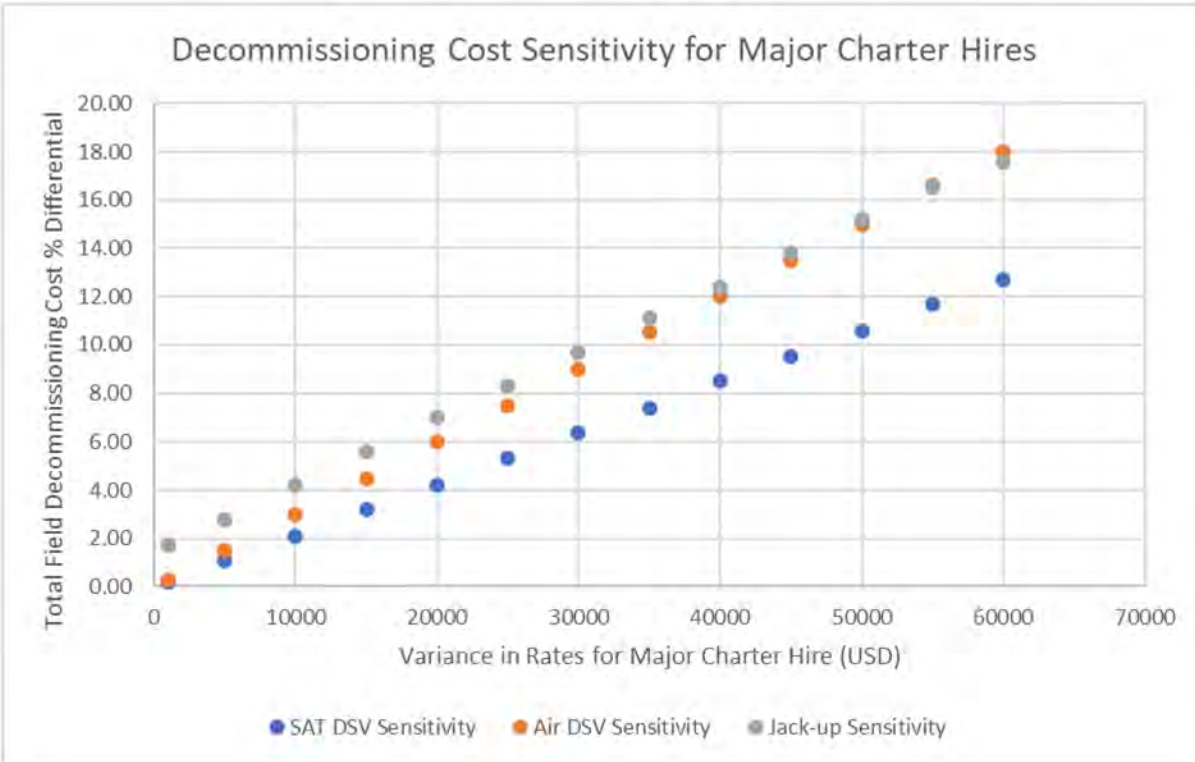

Figure 5—Overall vs. major charter cost variances.

The analysis demonstrates that all major charters have a linear relationship as estimates are generally a duration multiplied by a day rate.

A noteworthy result of the analysis showed that the sensitivity of the Air DSV was greater than the rig and Sat DSV. Further analysis revealed the reason for this is to be that shallower waters attracted smaller structures and therefore avoided major costs such as HLV's and drill ships. This is an interesting observation, which may need to be considered in order to reduce excessive costs and improve estimations for shallower smaller structures.

Conclusion

Industry research and advancements in new technologies, over the past decade, have witnessed new alternatives being considered as part of the decommissioning process.

There are various types of Comparative Assessments, some more commonly utilised than others. Although the use of the Comparative Assessment is slowly increasing globally, it is important to note this process is continually improving and evolving.

With the Comparative Assessment being a critical element, decommissioning plans can avoid unjustified assumptions during planning, while also having the ability to perform iterations with live results.

Utilising a weighted quantitative analysis in the Comparative Assessment can arguably reduce the bias of the analysis. However, using the correct MCDA is critical in this process. The analysis concludes the AHP to be the best suited MCDA for the Comparative Assessment as its hierarchal nature prevented weighting inter-dependencies when options and criteria were deleted or edited.

To improve industry wide efficiency, world's best practice methodologies and standards for the most efficient removal techniques are needed, such as those discussed in relation to B. Nixon's current topside and jacket removal methodologies.

While subject to future research and on-going analysis, updated software revisions must include:

- Automated removal methodology analysis.
- Analysing/optimising complete removal methodologies.
- Auto-scheduling capabilities (project and region specific).
- Integration of NEBA to perform net positive calculations.

If greater emphasis is given to planning, simulating removal and decommissioning methodologies, decommissioning costs will continue to improve, especially for smaller fields which are highly sensitive to major charter hires.

The various guidelines and recommended practices give a holistic understanding of the decommissioning process. Nevertheless, operators can face the issue of multiple sources all offering conflicting information. However, developing an online portal capable of facilitating assessments with access to all relevant costing, case studies and methodologies in a single location front-end means decommissioning planning can be improved and streamlined.

In conclusion, with billions of dollars of liabilities at stake, it is important to seek direction and clarity on future decommissioning projects. To this end, providing an online platform with decision making and costing capabilities will give the industry the capability it needs to tackle the new frontier of decommissioning in the global oil and gas sector.

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