Oil & Gas UK
the voice of the offshore industry

DECOM
North Sea

ADOPTION OF NOVEL SOLUTIONS REPORT 2015

Oil & Gas UK

Executive Summary

The Wood Review identified technology as playing a critical role in controlling and reducing the costs of decommissioning. This was echoed by the newly established Oil and Gas Authority who have committed to working with industry to drive innovation and efficiency in decommissioning. The nature of an emerging decommissioning market is such that innovation will play an important function in reducing costs.

This report, commissioned by Oil & Gas UK and Decom North Sea, and produced by Arup, seeks to identify the barriers and challenges to adoption of novel solutions in the oil and gas offshore decommissioning industry. It sets out a process for the commercialisation of novel solutions to accelerate cost reduction in decommissioning and identifies issues specific to each phase. Finally, it seeks to address how to overcome these barriers and challenges to encourage more rapid innovation in the market by making a number of recommendations to industry and government. These recommendations, as presented by Arup, lay out possible areas of focus for various stakeholders, to support a culture of innovation in the decommissioning market. Oil & Gas UK and DNS will consider the recommendations and engage with the relevant bodies to act upon them, as appropriate.

In carrying out the review, Arup have drawn the expert views of a range of industry leaders in the field representing all facets of the decommissioning work breakdown structure. Consulting with these leaders has allowed Arup to identify the current approaches to encouraging and implementing innovation as well as associated barriers and solutions.

The findings of the report confirm that the industry supporting North Sea operations is a breeding ground for novel technology and new methodologies. Furthermore, the technical and commercial processes that support innovation are generally well-applied in the industry. The industry is conservative in its risk perception which has fostered a rigorous approach to the evaluation of innovative products, with development stage gates commonly used, with thorough risk assessments and regular review of technology readiness as Research & Development progresses.

However, legacy risk aversion and conservatism, coupled with a historically highly competitive market for exploration and production services and tools, has contributed to a marketplace with significant challenges and high barriers to entry for innovators with an interest in decommissioning.

There are signs of more progressive stakeholders, who are already making steps to address these barriers. Best practice can be established using their approaches. Experience should also be drawn from other UK industries which have demonstrated successful implementation of innovation initiatives. Arup have provided a number of case studies of analogous industries.

The report concludes that *innovation is underway* but a more open mind-set should continue to be developed and be adopted by all operators, and supported by regulators, to drive an innovative culture in the decommissioning marketplace. This support will encourage the large service companies and wider supply chain to prioritise work on decommissioning and accelerate the delivery of novel solutions in the form of technical advances, relevant organisational change, targeted knowledge management and more appropriate commercial strategy.

Mick Borwell
Environment and Health & Safety Director,
Oil & Gas UK

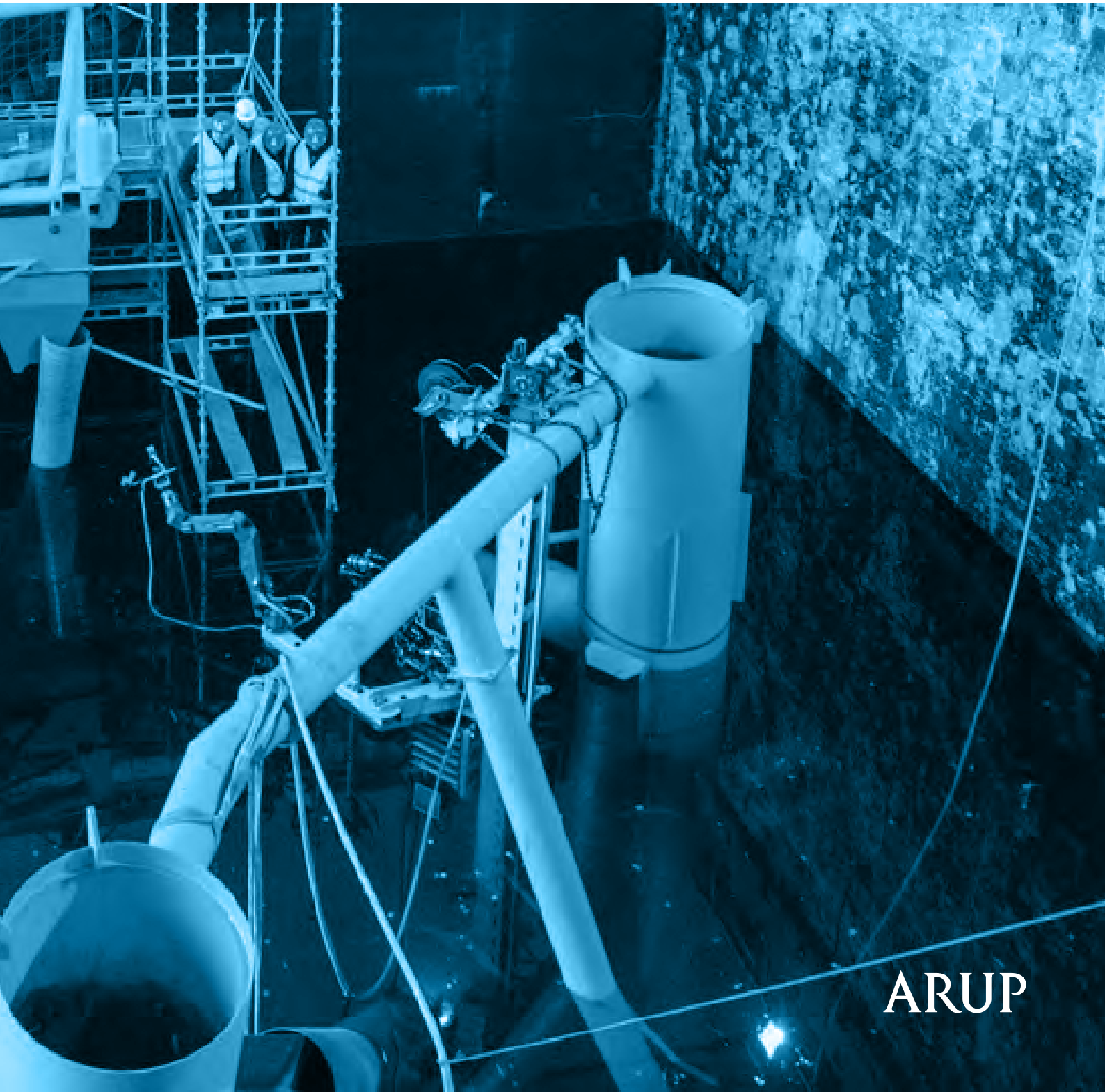
Karen Seath
Interim Chief Executive Officer,
Decom North Sea

Oil & Gas UK
the voice of the offshore industry

DECOM North Sea

Adoption of Novel Solutions

Decommissioning in the North Sea



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List of abbreviations

DECC	Department of Energy and Climate Change
DNS	Decom North Sea
DNV	Det Norske Veritas
EPRD	Engineering, Preparation, Removal, Demolition
FEED	Front-End Engineering Design
FPAL	First Point Assessment Limited
HLV	Heavy Lift Vessel
HSE	Health & Safety Executive
IP	Intellectual Property
ITF	Industry Technology Facilitator
ITT	Invitation To Tender
JV	Joint Venture
MRL	Manufacturing Readiness Level
NDA	Nuclear Decommissioning Authority
NR	Network Rail
O&G	Oil & Gas
OGA	Oil & Gas Authority
OGIC	Oil & Gas Innovation Centre
P&A	Plugging & Abandonment
R&D	Research & Development
RFQ	Request For Quote
ROV	Remotely Operated Vehicle
RSSB	Rail Safety and Standards Board
RTS	Rail Technical Strategy
TLB	Technology Leadership Board
TOC	Train Operating Company
TRL	Technology Readiness Level
TSLG	Technology Strategy Leadership Group
UKCS	United Kingdom Continental Shelf
WBS	Work Breakdown Structure

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1.0 Introduction

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1.0 Introduction

The Scale

The North Sea oil and gas (O&G) decommissioning market is significant, spanning five national waters with over 1,500 offshore installations[1], 45,000 km[2] of pipelines and over 8,000 wells[3], all of which will require decommissioning in due course.

Estimates of the total cost of decommissioning the North Sea varies across studies and organisations. However, even conservative estimates of the UK Continental Shelf (UKCS) alone suggest a required expenditure of around £46bn[4] by 2040. This liability represents a concern to industry in terms of the potential impact on competitiveness of the aging basin. It also presents a threat to the national economy; partly as a virtue of the importance of the associated socio-economic benefits of the industry; but also because the UK Government has significant tax liabilities associated with decommissioning.

The Phase

The market is embryonic and only a small number of very large decommissioning projects have been delivered to date. However, with many of the installations having fulfilled their purpose for around forty years or more, it is expected that the next decade will see a significant growth in activity.

The Drivers

The Wood Review[5] identified technology as playing a crucial role in controlling and reducing the costs of decommissioning. This was echoed by the newly established Oil and Gas Authority (OGA) who have committed to working with industry to drive innovation and efficiency in innovation[6]. The nature of an emerging market means that innovation will play a critical function in reducing costs.

The External Environment

The exposed and remote waters of the North Sea present a technically challenging environment. Whilst innovation is necessary to reduce the costs of facing the engineering challenges, the critical aspects of environmental safeguards and health and safety cannot be compromised. In addition to the numerous commercial and regulatory influences, the global supply chain will affect how the market evolves.

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Innovation in the Sector

Innovation has always been essential to the O&G industry, to push the economic feasibility and technical capability of the industry in pursuit of extracting ever harder-to-reach hydrocarbons. This innovative capability must now be directed at the decommissioning sector.

Despite the accepted need for innovation, there are a number of barriers to its successful implementation. There are a number of tools and best practices in place to bring new technology to market. However, a robust process is not always followed. Even when following best practice, innovators are being presented with a number of challenges when seeking acceptance of their novel solutions. As a result, innovation is currently not perceived to be delivering significant cost savings.

This scenario is not unique to the oil & gas industry and we can learn from the experience of other industries, where similar shifts in focus have been implemented.

The Objectives

This report, prepared by Arup and commissioned by Oil & Gas UK and supported by Decom North Sea (DNS) seeks to provide potential innovators with a clear process to commercialising novel solutions which have the potential to accelerate cost reduction in decommissioning. It also seeks to identify the barriers and challenges to adoption of novel solutions and to offer suggestions as to how these barriers can be overcome by the industry and government stakeholders.

The Contributors

This report uses a number of existing sources of information on the implementation of innovation in the O&G and other industries. It then draws on Arup's knowledge of the Sector, along with the expert views of a range of industry leaders in the field. Consulting with these leaders has allowed us to identify the current approaches to encouraging and implementing innovation as well as associated barriers and solutions. Particular thanks go to the following for their invaluable insight and contributions:

- AMEC Foster Wheeler
- Aker Solutions
- Claxton Engineering
- ConocoPhillips
- GA Drilling
- Industry Technology Facilitator
- Marathon Oil
- Oil & Gas Innovation Centre
- Prezioso LBO
- Reverse Engineering
- Shell
- Sky Futures
- The Decommissioning Company
- Worley Parsons

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2.0 Innovation Philosophy

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2.0 Innovation Philosophy

What is Innovation?

Innovation can be defined in many ways but can generally be described as delivery of a new idea, product or method. It is a response to a problem or obstacle; to rethink how we might solve a given issue, through introducing a new solution.

The traditional perception of innovation is often the light bulb moment, creating a disruptive technology. This revolutionary innovation is where a single advancement can shift markets and change status quo, such as Liquid Crystal Display television replacing the Cathode Ray Tube platform. This type of innovation does occur, but is inherently more risky as it requires step change.

More commonly innovation, like all change, comes from a number of smaller incremental and dynamic progressions that collectively will lead to more significant innovation. This is also referred to as evolutionary or sustaining innovation. By its nature it is lower risk, and allows the supply chain to continue to compete on an open market.

Why Innovate?

Innovation can have various purposes, but in most cases it is either to improve how efficient we are, or to enable us to do new things. It allows us to review and improve existing processes, devices or ideas, to ensure we are investing in improving the future, rather than standing still in a “business as usual” static environment. The shift in the UK and most of the developed world to becoming a knowledge-based economy also requires continuous innovation. This is evidenced through increased investment in knowledge-based institutions (universities), public programmes (InnovateUK) and knowledge-sharing activities (public and private partnerships).

Where is Innovation Seeded and Developed?

There is an expectation in the O&G industry that the supply chain is the driving force in identifying and developing innovation. There is also a perception that small, new-start businesses, academic spin-offs and entrepreneurs are more adept at innovating than larger, more mature organisations.

In reality, sustaining innovation in the decommissioning market will be derived from across the industry, from operators, tier one contractors, consultants as well as the supply chain. The concept of intrapreneurship is the promotion of innovation within larger organisations to foster invention. A number of large organisations are recognising the value of innovation and investing in, and promoting, policy that creates the right environment for innovation.

The public sector has a role to play in nurturing innovation and providing overarching support and co-ordination framework to the industry. The Government will provide a key influence, either through promoting or regulating for innovation. However, regulation can also stymie innovation through the setting of standards that present market barriers to novel approaches.

The majority of innovation does not involve true novelty but involves technology transfer, taking applications from other industries and applications and implementing them in a new context. Again, this represents a relatively low risk alternative, as mature technology only needs to be proven in the new application rather than proving a new technology in a new application. To allow technology transfer to happen, the O&G industry must allow a channel to accept approaches from other industries. Arguably, the O&G industry has been somewhat self-contained and has not fully benefited from technology transfer potential.

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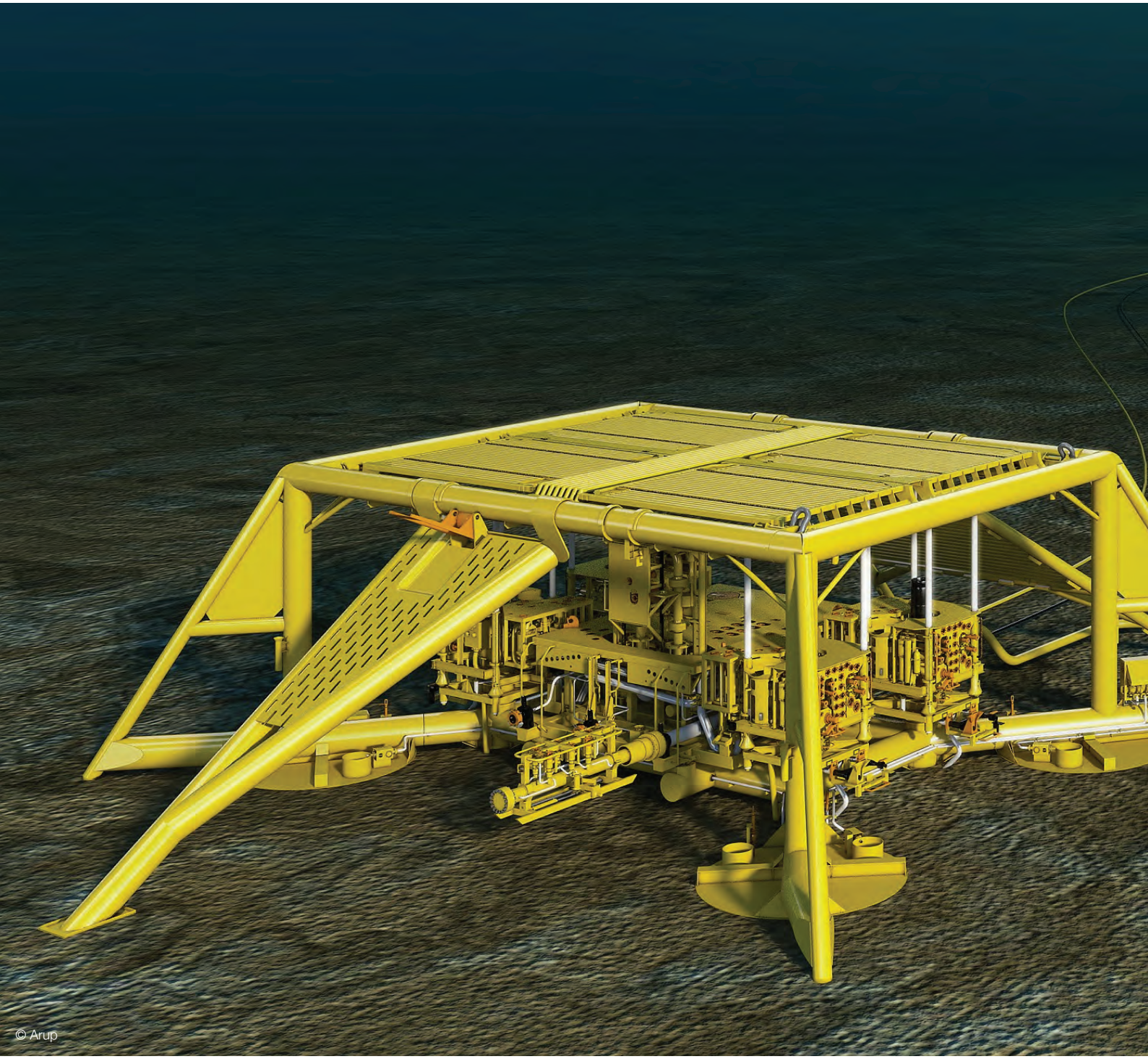

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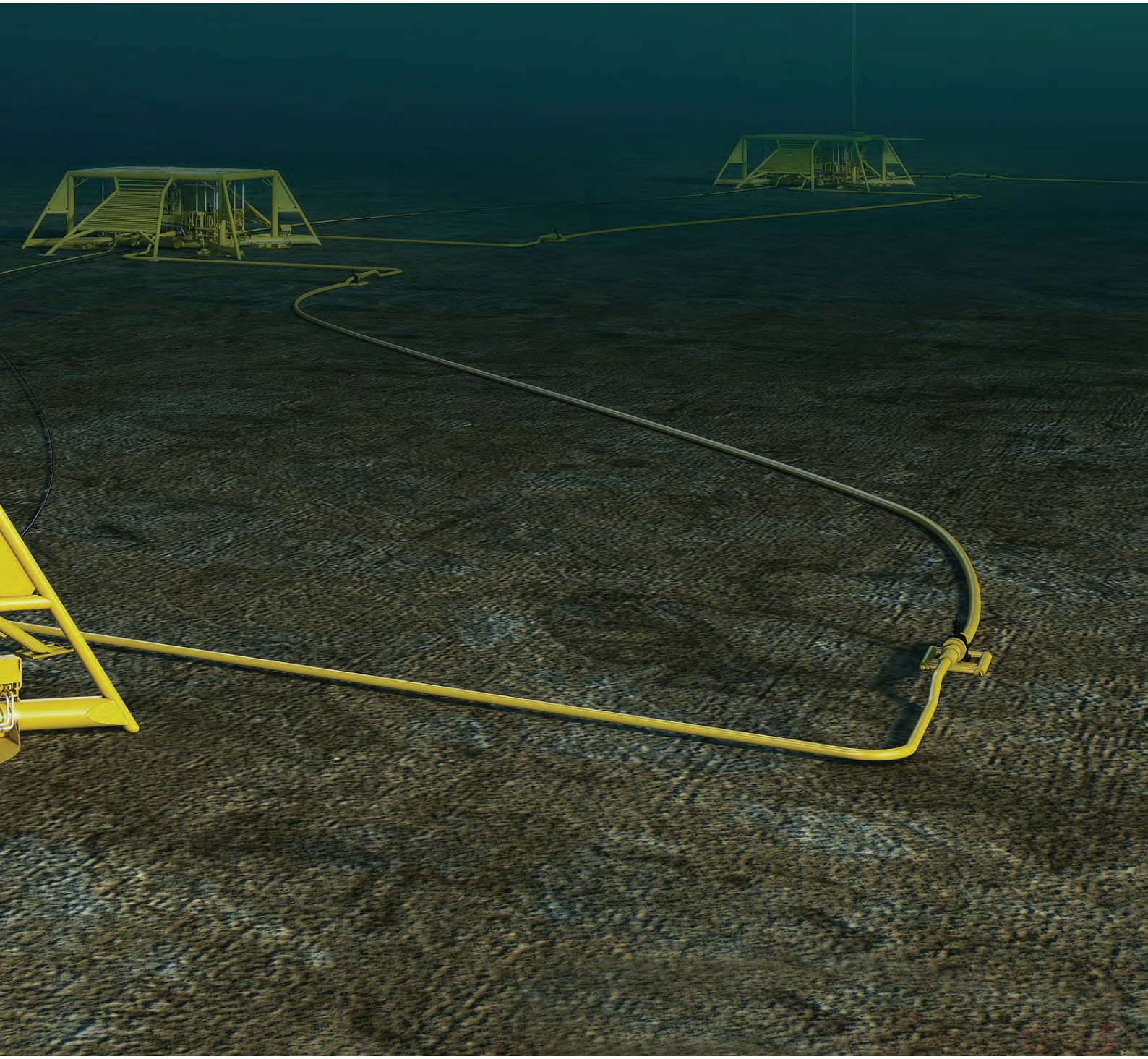
3.0 Approach



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3.0 Approach

Our approach to addressing the issues of innovation in the O&G decommissioning sector is as follows:

- We provide a guide on **current best practice** in fostering and delivering innovation (Section 4)
- We provide the O&G industry and Arup's perspectives on the **barriers to implementing innovation** (Section 4)
- We identify a number of **common themes** (Section 5)
- We provide **cross-industry insight** to other industries where barriers to implementing innovation have been encountered (Sections 6 & 7)
- We provide a **case study** from the O&G industry to illustrate an innovation process (Section 8)
- We provide recommendations to industry to **address the barriers** (Section 9)

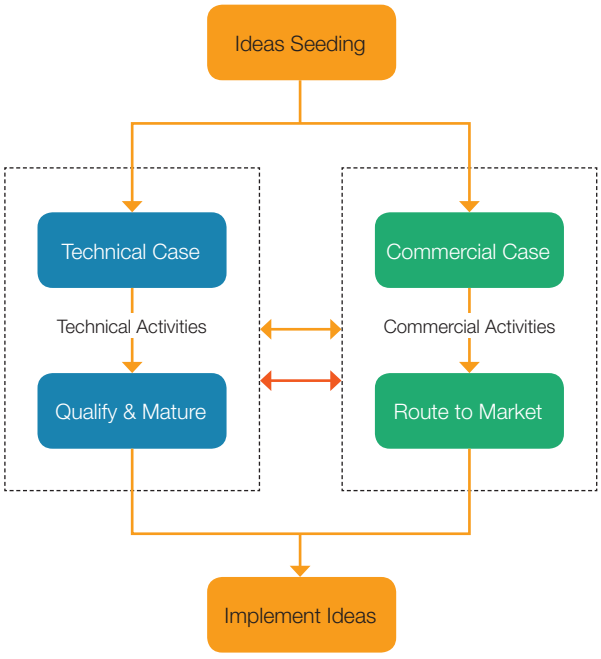

Figure 1. The Innovation Process

Current Best Practice

The O&G industry is already innovating, and there are a wealth of processes and tools that are used in order to deliver innovation. These tools have been put in place to provide a structure and framework for innovating, including when to take an idea from seed to commercialisation.

In Figure 1 we present a simple process of innovation. In Section 4 we provide an overview of current industry best practice and approaches used at each stage. This process includes the following phases on the path to implementation of innovation:

- **Seeding Ideas** – Fostering and promoting innovation, ensuring that ideas are identified and pursued, understanding stakeholders.
- **Commercial Activities** – Quantifying benefits, assessing the value, finding the right route-to-market.
- **Technical Activities** – Classifying novelty, identifying Intellectual Property (IP), proving fitness for purpose, maturing and qualifying a novel solution for deployment in the field.

In practice the process is not linear, and includes iteration as ideas are explored, developed and refined. Depending on the nature of the organisation and their internal processes, considerations do not necessarily have to follow in a particular order. However, it is vital to focus on commercial issues at the earliest possible stage, and engage with the market, rather than concentrate solely on refining technical aspects.

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Barriers to Implementing Innovation

We consulted with a range of stakeholders from across industry to understand the barriers they are faced with in seeding and commercialising innovation in the decommissioning sector. The consultees were asked to describe their innovation governance processes, describe how they bring products to market and, how they perceive the barriers and challenges.

Consultees were selected to cover a range of interests across the Decommissioning Work Breakdown Structure (WBS)[7] including operators, service companies, independent consultants and suppliers of tools, vessels and systems, in addition to public sector interests. The consultation feedback has allowed us to tailor the innovation process to the industry, and make recommendations where practice could be modified to improve the adoption of novel solutions.

Identifying the common themes

We note that many of the issues are common to many stakeholders. Consequently it is useful to categorise the barriers and challenges into a number of themes and provide some background to each, with discussion around the issues and contributing factors.

Industry Insight & Case Studies

Finally, to seek learning from other industries, and to lend support to our recommendations for the O&G industry, we present a number of cross-industry insights. These have been drawn from the UK rail industry and the UK nuclear industry. In both cases, there are similar complex stakeholder interactions, similar needs for innovation, and initiatives and forward thinking have successfully begun to alter practice to promote the adoption of novel solutions.

Addressing the Barriers

We provide a number of recommendations on ways in which the barriers and challenges can be overcome, how to stimulate increased innovation and ultimately how to encourage the adoption of novel solutions.

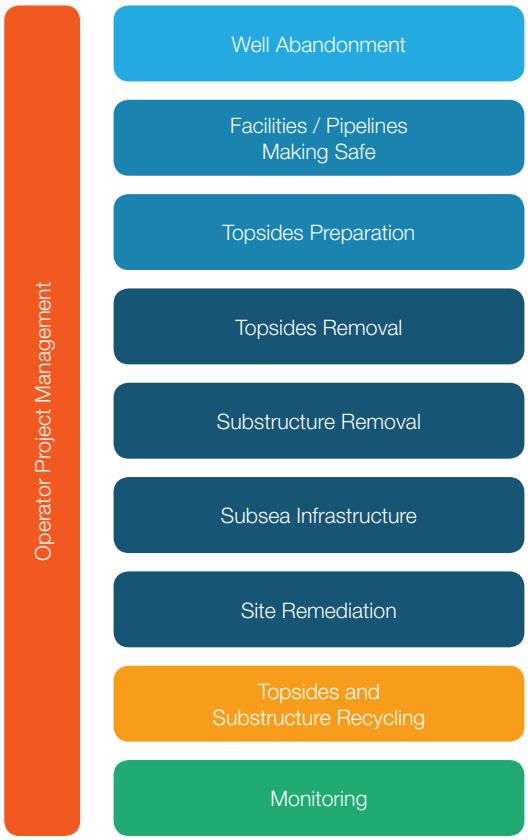

Figure 2. Oil & Gas UK Work Breakdown Structure for decommissioning operations

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Montrose A Tower Structure © Arup

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4.0 Best Practice and Barriers

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4.0 Best Practice and Barriers

In this section we report on the status quo of the industry, how innovations are brought to market and what challenges are present.

4.1 Seeding

Creating an environment which fosters innovation is an obvious, but challenging, pre-requisite to delivering its benefits.

The right environment encourages staff with novel ideas to promote and develop their concepts. Novel concepts are rarely the product of a single individual and are more often a collaborative evolution of ideas to develop a solution. Allowing a free flow of ideas through an organisation, without prejudice, will allow the development of an idea to realise their full potential.

Innovators are typically perceived to reside among the supply chain. However, there is scope for novel solutions to be seeded from a range of stakeholders in the industry. In addition, to take innovation to a higher level, collaboration should occur at an industry level and include a variety of institutions and organisations. Participation in cross-industry and cross-sector partnerships as well as discussion forums can support innovation.

Finally, individual innovators should be rewarded either in tangible ways (career progression) or in intangible ways (recognition and celebration).

Barriers to successful Seeding include:

- Organisations might not recognise that they play a role in innovation, and therefore don't have systems in place to foster innovation.
- Commercial competition between operators and within the wider supply chain discourages collaboration taking place at an industry scale.
- The innovation culture can be perceived to be at odds with the compliance culture which is required to adhere to the rigorous health, safety and environmental constraints of the O&G industry. This creates a challenging environment where both cultures must be integrated.
- The pressure of "business as usual" competes with the resources required for innovation.
- The industry operates very independently which makes transfer of technology and knowledge from other industries challenging.

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4.2 Stakeholder Engagement

An initial step in the innovation process is for the innovators to understand the industry landscape, how the markets function, and most importantly how the various stakeholders interact and make decisions in pulling innovation through the process. We define a stakeholder as any organisation which innovates, benefits from innovation, supports innovation, or regulates the market where innovation is taking place.

In general terms, the overall decommissioning objectives are communicated from the operators, and these are converted to engineering needs by primary contractors for dissemination to the supply chain. Within the supply chain, companies can choose to specialise on certain aspects of the WBS described earlier. A number of industry support groups provide advice to all parties.

A common failure of innovators is a lack of understanding of the makeup of the industry and which stakeholders are critical to accepting their novel solution. Example scenarios of failed innovation launch include:

- An operator's engineering department are interested in a novel solution, but their procurement department will not allow them to 'single source' a solution which is only available from one supplier.
- A prime contractor would like a solution to be used on their projects but their suppliers have not qualified it for use.
- An innovator has robustly developed an innovation but cannot identify how to approach the end users for marketing opportunities.
- An innovator has robustly developed a concept at scale but requires more significant funding to demonstrate the innovation at full scale because they haven't identified appropriate funding partners.

As such it is critical for the innovator to identify the stakeholders that are specific to their solution to understand their drivers and constraints. Innovators must work with industry to remove barriers where they are preventing acceptance of the solution, or work within them where they can't be changed. This engagement should start at the concept phase and continue through the commercialisation process.

Barriers to successful Stakeholder Engagement include:

- The stakeholder landscape is complex, and is not consistent across operators, the supply chain and contractors. As such it presents a major challenge for innovators to engage in a way that ensures their ideas will be accepted.
- The regulatory landscape is also complex, with a number of parties including Department of Energy and Climate Change, Health & Safety Executive, HM Treasury and OGA, each with its own mandate. This can make it challenging for innovators to understand the market drivers.
- At the practical level, there is a proliferation of support organisations and interest groups which can provide a role in strategic stakeholder engagement. Although their intentions are positive, there is potential for duplication of effort or engagement with the wrong party.
- The communication of needs is generally one-way process from the operators to the supply chain. There is less opportunity for dialogue to be initiated by the supply chain, or communicated to the regulators.

4.3 Commercial Activities

It is common for those who conceive ideas to have unrealistic expectations of their likely success. Innovators may have a disproportionate focus on technical performance, ignore competition, and expect greater revenues and shorter development times, than are likely in practice.

A robust commercial development programme should be undertaken in parallel to the technology development. This will manage the risk of investment against the potential market opportunity in a robust and transparent manner.

Quantify the Market Value

The value assessment of an innovation is fundamental in deciding whether or not to pursue its development. In simple terms, an innovation must be considered of value to the market to support the investment and provide the innovator with commensurate income. And the perceived market value must be proportional to the investment in Research & Development (R&D) plus the cost of its deployment.

The innovator must have an objective understanding of what is considered as value to their target customers to justify their investment. The O&G industry is very clear that the benefit of a novel solution (and hence its value) should be measured in one of three concise terms:

- Reduced decommissioning expenditure
- Reduced safety and/or environmental risk
- Improved execution quality

It is generally noted that the UK offshore industry operates under a well-established safety and environmental framework, with high standards relating to managing environmental and safety risk, based on significant lessons learnt from past experience. As a result, the primary focus of innovation in decommissioning is currently on reducing expenditure and commercial risk over the project lifecycle, without compromising Health and Safety or Environmental quality. Expenditure reductions can be impacted by:

- Reducing the time taken to do individual tasks
- Reducing the costs of equipment required for individual tasks
- Assuring quality of execution

As a result, the innovator must have a detailed knowledge of the working environment where their innovation will be deployed to be able to quantify the commercial benefits. Only then can an investment case be made to any potential customer who may be being asked to share the cost of development.

This value should be quantified on a specific application e.g. utilisation on a single project, to ensure it is meaningful to an individual customer. But it is also useful to consider the macro application in the market at a national and global level to identify the overall value of the market to the innovator.

Determine the Investment Profile

It can take anything from months to decades for the commercialisation of a product, depending on the novelty and the nature of the application. Allseas famously launched the concept of their heavy lift vessel (HLV), Pioneering Spirit, in 1987[8] and it is anticipated to be operational in 2015. Although it is unlikely that development was continuous over the 28 year programme, it gives a feel for the scale of programme associated with capital intensive concepts.

To allow for adequate returns against the investment commitment, innovators must have a good understanding of the maturity of the technology and its programme to commercialisation. Immature technologies will require more investment over a longer period of time. Funding requirements tend to be modest at concept stages and increase dramatically when testing moves to full-scale and into the field.

Investments should be made in a phased process with a number of stage gates where technical success is quantified and measured, and further investment is made only if identified elements have been successfully proven.

Understand how Innovation is Procured

As discussed in Section 4.2 it is critical that innovators understand which parties influence the procurement of novel solutions and how these individuals make their decisions. Currently, decommissioning engineering needs are mostly communicated as follows:

- Through detailed specification in Requests for Quotations (RfQs) from operators to pre-qualified contractors.
- Through observation of issues and subsequent learning while executing a task.
- Through dialogue in industry trade organisations, workgroups, conferences, etc.

The innovator's chosen route to respond to these needs will dictate how to seek funding for development work and how to market the innovation.

Provide Funding for Innovation

Investment in research is inherently risky as a return on the investment is dependent on technology success, the targeted market manifesting itself (if it doesn't already exist) and market acceptance of the innovation. At an industry-wide level, investment in innovation has the potential to provide major benefits in terms of cost reduction. However, at the organisational level investment has to be balanced against the individual programme and risk/reward profile.

There are currently five commonly-used R&D funding models in the O&G industry:

- Funded procurement contracts where the client supports all costs from Front End Engineering Design (FEED) through to execution.
- Industry joint ventures with partners from operators and supply chain, sometimes facilitated by organisations such as the Industry Technology Facilitator (ITF).
- Innovator-funded with internal investment supported by other activities:

  a) Either as a discrete project, or

  b) As part of early engineering in a tender response
- Public sector funding where UK Government bodies such as InnovateUK disburse funds against specific research topics.
- Academic research & development funded by industry and facilitated by organisations such as the Oil & Gas Innovation Centre (OGIC).

These funding models represent varying degrees of cost sharing between supplier, customer, academia and the Government.

There is currently an overwhelming view among suppliers that the operator community should adopt a greater share of costs if the supply chain is to pursue innovation.

Challenges to making a commercial case include:

- The paucity of actual decommissioning projects hampers the ability to invest in innovation.
- Innovators must possess operational knowledge of how their innovation will be used. Without this, its benefit cannot be expressed and the investment case becomes very hard to make.
- Marketing an innovation is a time-consuming and expensive exercise for smaller innovators.
- Engineer, Procurement, Removal and Demolition (EPRD) projects executed by large contractors can require very significant investment at the tender stage, with an expectation that some early engineering is conducted at no cost to the client.
- Project specifications in Invitation To Tenders (ITT) are often very specific which limits who in the supply chain can bid.
- The industry is evolving and needs can change in operation – or even during a tender period.
- Joint ventures are often difficult to arrange, mostly as a result of commercial interests, background IP negotiations and funding constraints among the target stakeholders.
- Public sector funding is currently very limited in the Oil & Gas industry, with very few active programmes addressing decommissioning R&D.

4.4 Technical Activities

A robust programme of technical development is essential to ensure fitness-for-purpose of the product, manage technical risk and provide the end user with a required level of confidence.

Early concept identification in an objective manner, appropriate IP governance and how to mature the technology are core aspects of the development process.

Developing a concept

Developing a concept benefits from a structured process at the initial stages, where the innovator must ensure the objective review of ideas. This structured approach is reasonably well-adopted in the O&G industry, and can be generalised the sequence below.

This process of innovating and bringing a product to market should be broken down into a number review points. At each stage, the innovator must objectively review the status of their innovation. These stage gates ensure that a controlled process is followed. This supports phased investment, ensuring that the risk-reward profile of the project is managed.

1. Thoroughly understand the engineering needs and any specific problems that the innovator wishes to address. The people involved at this stage should represent those with operational knowledge as well as R&D.
2. Spend time reviewing ideas. This may simply require research into existing working practices to assess work-arounds to current challenges, as well as technology transfer options from other industries or “blue-sky thinking”. Again, a balance of skills is essential to ensure that time is not wasted with “solutions looking for a problem”.
3. A shortlist of concepts should be created even if a “killer solution” is emerging. Choosing a lead concept too early in the process can cloud judgement, cause friction in the team and prevent objective review.
4. The shortlisted concepts should be evaluated, with all candidate concepts broken down into features which can be individually rated and compared with others in a robust manner, often with assigned weightings. If features cannot be compared in a quantitative manner then care must be taken to agree the terms of qualitative review.
5. The most advantageous concept can then be identified for further evaluation and detailed design work. Design features which require prototyping must be considered as early as possible so as to correctly assign technical risk and properly inform the qualification process.

Identifying novelty

Novelty, by definition, implies something new, unusual or original. We should also bear in mind that, in the context of decommissioning, we may mean by novel solutions that the solution is new to this market. As such, we are not necessarily considering novel intellectual property and instead are seeking alternative solutions to the status quo. We should also bear in mind that novel solutions may take the form of organisational changes, novel contract frameworks or novel funding strategies, and not just technological innovation.

In engineering terms, defining a solution’s novelty would be common when considering its patentability and whether the solution represents new IP. Along with market knowledge and existing solutions, an IP search is an excellent tool for ascertaining novelty of any given solution. New IP can result in added value for a company where the registered IP becomes an asset to which a value can be assigned and becomes a marketing differentiator.

> *A patent may be granted only for an invention in respect of which the following conditions are satisfied, that is to say - (a) the invention is new; (b) it involves an inventive step; (c) it is capable of industrial application.*[9]

It is often useful to distinguish between enhancing and enabling technologies and to review how this classification affects our assessment of a novel solution. Enhancing innovations are generally those which make incremental improvements on the status quo whereas an enabling innovation would be more of a step change which allows for a new way of working. This distinction is helpful when assigning technical risk to a concept, and whether there is scope for new IP or if the innovator is building on background IP.

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Qualifying and maturing the innovation

The technical maturity of an innovation must be considered. To manage operational risks, then tools, techniques and processes should be mature for use prior to deployment in the field. This is an accepted view across the industry. The process of maturing a novel solution to an acceptable level will vary depending on the application but the principle is the same regardless – reducing the risk profile by making the transition from a concept, through prototypes and onwards to commercialisation. Appreciating this is also essential to avoid innovator's optimism bias.

Final qualification generally involves demonstrating a full-scale prototype operating in conditions representative of the end-user's application. This requires access to onshore test facilities or well-controlled access to offshore assets.

Technology qualification is the process of providing the evidence that a technology will function within specified operational limits with an acceptable level of confidence.[10]

The principle of technology maturation is understood in the industry, and generally in the context of progressing rigorously through Technology Readiness Levels (TRL)s. In larger organisations, this language is commonly used when structuring decision stage gates to review progress and approve subsequent stages of work. However, smaller companies, or academic research groups are not as aware of this language. As a result they can have a difficult time communicating to other stakeholders and can lack a realistic appreciation of the development process. Adoption of this common language of maturity allows for consistent, uniform, discussion between stakeholders.

Following an established process of qualification will provide comfort to the end user. One commonly used process is Det Norske Veritas' Recommended Practice DNV-RP-A203[11].

In addition, to monitor the progression through TRLs and offer a third party view of the adherence to the process, it is common in the industry to engage with a Third Party to perform this role. Standards bodies are common candidates for this role, who can also offer type certification.

A number of challenges are present:

- Many engineering needs are project-specific and the longevity of the IP beyond a first project may be of limited value.
- Innovators must possess operational knowledge of the challenge they wish to address.
- Operators are conservative and generally reluctant to deploy novel solutions until they have been proven in the field.
- Commercial pressures while preparing tender responses can mean that resources for innovation are limited.
- Incremental innovation without ownership or licenses of background IP can lead to costly disputes.
- There is a lack of common practices and standards for decommissioning tasks.
- Certification of individual components is an expensive undertaking.
- Facilities for prototyping equipment at full-scale are costly to access.

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Ravenspurn North, North Sea © Niki Photography Ltd

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5.0 Common themes in adopting novelty

5.0 Common Themes in Adopting Novelty

Throughout our consultation, a number of common themes emerged, with recurring challenges spanning across the industry. The companies consulted believe these are more significant barriers to the adoption of novel solutions than innovators not following the development process discussed earlier. In this section we present these common themes in the context of overall industry behaviour to illustrate the more strategic issues. The common themes are:

- **Learning by doing:** we provide a high-level view of innovative steps currently being taken.
- **Procurement arrangements:** we assess how the current marketplace impacts on the adoption of novel solutions.
- **Risk assessment:** the assessment of commercial risks is a valuable contributor to decision-making when considering novelty.
- **The regulatory environment:** the industry is highly-regulated hence the regulators have a role to play in fostering an innovative culture.
- **Skills & collaboration:** there is a wealth of skills in the industry and these must be correctly guided to contribute to decommissioning.

5.1 Learning By Doing

Technical and project management innovation has started to bear fruit by driving down costs as a natural part of the learning process.

In well Plugging & Abandonment (P&A), intervention in the wells typically uses largely the same tools that were used when the wells were first drilled. Some tooling is improved but the development of this has been incremental, with no step changes seen yet. As a consequence, the only time and cost savings seen to date have been a result of learning-by-doing. However, for operators conducting sustained campaigns, this learning has been significant (evidenced by time savings).

There is no reason why these individual learning rates cannot, over time, translate to industry-wide learning rates. This confirms the view that learning-by-doing is valuable and that the supply chain is stepping up to the challenge, but only when the needs are clearly defined.

In topside and substructure removal, the market supply of HLVs is the main constraint. This has promoted the investment in more HLVs being brought to market but overall progress has been slower than in P&A. This is consistent with the volume of decommissioning addressed to date – in the North Sea only a small number of platform removals have been executed whereas 50 to 100 wells are estimated to be plugged and abandoned annually from 2014 to 2023[12].

Results of the study show that as well as bringing more HLVs to market, there is a willingness in the supply chain to engineer-out the use of HLVs, and significant strides have been made in other areas of work that support the removal task, including planning, late-life asset management, inspection, subsea cutting and lifting techniques. For example, one novel inspection technique can reduce task durations from months to days[13].

Overall, the position is consistent – technical and project management innovation has started to bear fruit but needs certainty of procurement of services and more investment in the short term for adoption of novelty to accelerate, and for costs to reduce in the medium to long-term.

5.2 Procurement arrangements

The services industry that supports exploration & production operations must be opened up to introduce new players, and innovation costs should be supported by the end user.

This is a complex topic, where commercial interests and stakeholder strategies often conflict. The O&G engineering services market, and the procurement methodologies which support it, is still heavily geared towards contracting for services relating to exploration and production. This market is almost purely transactional, seeking to control quality or service at an acceptable price within very tightly controlled frameworks. This is typically through the issuing and responding to ITTs. Pre-qualification of suppliers is essential, and procurement tools such as Achilles First Point Assessment (FPAL) prevail. It is common for operators to procure all engineering services for any given project through a single tier one service company. Once contracts are let, these tend to be reimbursable, with the contractor not liable for consequential losses.

These market features are acceptable when the purchaser is schedule-driven and confident of a revenue stream from projects (i.e. production of hydrocarbons). Thus the tight, top-down, control of scope and risk in procurement can be justified, despite commonly resulting in over-engineering and hence higher prices for services.

Operators are not the only stakeholders whose procurement is open to critique. Anecdotal evidence suggests that innovative stakeholders can be reluctant to propose novel solutions to tier one service companies. This is because there are concerns regarding the larger contractors' pursuit of IP which could be of competitive advantage to them.

However in the decommissioning market, where there is no revenue stream from the work and the cost is a net loss to the purchaser, there is a need for a new approach to procurement. Operators are now procuring for lowest cost services. In pursuit of this, the operators must now examine the variables which contribute to the cost of executing individual tasks in the WBS, not just the contractors' prices. This means that procurement needs to be more strategic, and seek input from unfamiliar contractors, smaller partners and even from outside the industry in order to execute tasks which are not required as frequently in oil exploration and production.

A very obvious example of a lack of strategic vision is some operators' views that HLVs are the only realistic tools for topside removal and hence a reluctance to engage with contractors who can't deliver a complete removal solution. This risks stifling the market if operators don't engage with smaller, more creative companies. Breaking down the overall removal into a subset of tasks would open up the opportunities for the supply chain, and create markets within the market, encouraging innovation within each task.

This should be seen as a significant opportunity: allowing more suppliers to enter the market will almost certainly drive down costs purely on the basis of competition. Innovation would be an added advantage.

Lump sum contracting for well P&A or platform removal is not the most common procurement framework, given the unknowns in dealing with ageing infrastructure and the consequences these can have on the duration and complexity of operations. However, breaking down large scopes of work would enable lump sum contracts for individual tasks and, as work scopes standardise and mature, then pain/gain sharing can be considered to further share the risk and reward of innovation.

Finally, funding is a barrier to the procurement of R&D. Given the paucity of contracts, investing in novel solutions for decommissioning is a speculative business. Encouraging investment now in the knowledge that the market is valid, is a task for the operator community to undertake. This encouragement may have to come with regulator support. The return on the investment in any successful novel solution will come in the form of a saving many multiples of the investment.

5.3 Commercial Risk Management

Rigorous risk assessment is essential but the commercial consequences of risks in decommissioning are not necessarily the same as those in exploration and production activities. Embracing these differences is essential to the adoption of novel solutions.

Commercial risks in the offshore industry are traditionally sub-surface or process-related, i.e. commercial risks as a result of non-production (usually driven by weather, geology or plant downtime). This leads to the controlling contracting structure by operators discussed earlier. The endemic risk aversion which results must be addressed for the decommissioning market, where there are no revenue consequences, and a controlling attitude to the supply chain does not foster an innovative culture.

Safety was not raised as a barrier to innovation as consultees viewed it as an absolute requirement and perceived it to have less scope for high-impact innovation.

In decommissioning projects, the risks are numerous. In P&A, quality of work is paramount, given the operator liability in perpetuity. In both P&A and topside removal tasks, the potential for encountering hidden unknowns is viewed as a key issue, given the consequence this could have on scheduling of expensive assets such as HLVs. This highlights the need to introduce some novel organisational change, and engage asset-life-extension teams with decommissioning teams. This would be enormously risk-reducing as it makes the decommissioning team intimately aware of the status of the asset and mitigates against the risk of encountering hidden unknowns during dismantling. This can commence as soon as Cessation of Production date is defined. This may be viewed as adding complexity to asset management as involving more partners in a project will increase the number of interfaces. But that may be a relatively low administrative cost to bear if there are overall operational savings. An associated benefit of the organisational change is that it will bring about closer liaison between R&D and asset management departments.

In both cases, there is value in well P&A and asset removal sooner rather than later, as older assets in worse condition will be more difficult to deal with. And without a doubt, the riskiest option of all is to do nothing.

As mentioned earlier, a common vocabulary in the assessment of technology readiness is a discussion enabler. Similarly in the context of risk, it is useful to consider the language of the industry and how we describe decommissioning as a whole and how this affects our perception of risk. Consider the following three ways of describing a topside removal:

Description	Implied nature of work	Risk perception
Decommissioning	Detailed analysis of assets, involving multiple disciplines, careful disconnection of high-value components.	High execution risk
Dismantling	Labour-intensive manual task	High safety risk
Demolition	Highly mechanised breaking-down of assets for removal, low exposure to personnel	Lower execution risk, lower safety risk

This illustrates how the perception of risk is affected by language. In reality, the nature of work will be a combination of all the above and all work should be subjected to rigorous risk assessment, but just reconsidering the vocabulary can foster a mind-set which is more receptive to alternative approaches to tasks. This could help the industry to move from a “race to be second” attitude to a “race to be first” in adopting novel solutions.

5.4 The Regulatory Environment

A forward-thinking, strategic regulator, with decommissioning as a key theme will unlock the industry's ability to innovate.

The Oil & Gas Authority in its new role is welcomed by the industry with an expectation that it can constructively put its powers to supporting innovation in the O&G industry. We can draw parallels between the UK aerospace industry and its strategy policy which has supported, with extremely positive effect, the growth of the industry[14]. The OGA could work closely with the Technology Leadership Board (TLB) (which does not currently have decommissioning as a key theme) to deliver a decommissioning industry strategy similar to that developed for the aerospace industry. This would build on the UK's existing world-class offshore industry and help secure a future for engineering know-how beyond hydrocarbon production.

The regulator(s) also have a role in fostering innovation indirectly. An evidence-based review of the regulator's own requirements (irrespective of whether it leads to any change) would be seen positively by the industry and could encourage other stakeholders to also adopt a more progressive attitude. A regulator with a progressive mind-set, and latest environmental understanding, would almost certainly encourage innovative thinking in the decommissioning WBS.

Finally, several consultees commented that number of decommissioning initiatives is disproportionate to the level of activity.

5.5 The Regulatory Environment

Concerns over knowledge constraints within the industry should be viewed as a significant opportunity to develop the capability.

Decommissioning skills and know-how is undoubtedly a short-term challenge in the area. However it also presents the UK with an opportunity to build the capability and form an export industry. The key to tackling the perceived lack of knowledge may simply be to kick off decommissioning projects and free up the human resources to execute the engineering.

This is reasonable, because although there may be a perceived lack of knowledge about how to go about decommissioning, there is no lack of skills in the industry – the industry has a commendable track record of rising to the challenge of complex engineering problems in the past.

Collaboration is a much talked-about route to innovation. Again, we should consider the language we use. Are stakeholders just sharing ideas or are they actually working together on programmes for mutual business benefit? The proliferation of conferences and scarcity of specific joint ventures suggests the former. As we have noted, there are barriers to collaboration, notably a mind-set regarding commercial interests. To address this, it could be acknowledged that commercial interests are more closely aligned in decommissioning than during production, such that the overall goal of sustainable environmental and cost-effective execution is aligned. Hence any concerns about competitive advantage or fears of collusion allegations should be unfounded.

However, anti-competition laws were cited by consultees and a specific example given where decommissioning tools and techniques can be freely talked about with other stakeholders but disclosure of costs, suppliers and detailed metrics is not permitted. To enable full sharing of information, the datasets would need to be sanitised and there is no common framework for doing this. But we can learn from other areas of the industry where there are mechanisms to share well data[15] and this type of data collation could be extended to decommissioning project execution data. Service companies may view their proprietary knowledge as a marketing lever – anonymised sharing of knowledge may address this challenge too.

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6.0 Cross-industry insight

GB Rail Industry - enabling the adoption of novel solutions

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6.0 Cross-industry insight
GB Rail Industry Enabling the Adoption of Novel Solutions

The rail industry in the UK is similar in many ways to the oil & gas industry: a large number of operating companies responsible for significant annual spend, a broad supply chain of large and small contractors, a robust safety culture, issues with ageing infrastructure and a number of government influences in the form of multiple regulatory bodies.

The rail industry has suffered from poor adoption of novel solutions and a number of initiatives have been deployed to address this.

6.1 Industry Background

The GB rail industry generated income of about £13.3bn in 2013/2014[16]. In 2009/2010 it invested about 0.5% of turnover in innovation, below international best practice of 3.5%[17]. Nonetheless, it has seen growth in passenger number of about five percent year on year for the last fifteen years[18].

The industry is made up of a fragmented mix of stakeholders. These include Network Rail (NR) who own most of the infrastructure, twenty-three private franchise train operating companies (TOCs), four main freight operating companies, and a large number of suppliers and contractors. Two regulators, the Office of Rail Regulation and Department for Transport, regulate NR and TOCs respectively. Due to extensive subsidies the government is also a substantial stakeholder.

The industry has suffered from a lack of efficiency. In 2011 the ***Rail Value for Money*** study benchmarked the industry against four other European countries and estimated that GB rail costs would need to be 40% lower to match their counterparts. NR costs were found to be a significant reason for this gap. However, TOCs and rolling stock costs also contributed primarily because of lower level of train users in Britain. The benchmarking indicated that the cost of these inefficiencies is primarily borne by British passengers and tax payers who also suffered from a poor quality rail service.

In recent years the GB rail has sought to improve efficiency by removing barriers to the adoption of new solutions. In the case of rail a large number of interlinked barriers were identified by the industry. Proposed solutions included stronger industry leadership, changes to the policy environment and improving the interface between different industry bodies. In response the industry implemented a number of initiatives to address these problems. While it is too early to say if the initiatives alone have resulted in improved services and reduced cost there are encouraging signs that it is more dynamic and open to innovation than it was before.

6.2 Identification of Barriers & Challenges

The RVfM study identified a number of barriers which were preventing the industry from creating an enabling environment conducive to change where innovative ideas might be able to take root. The barriers included:

- A lack of leadership from the top to set overall vision for the industry.
- Government involvement may have caused the industry to shirk responsibility for strategic planning.
- The interface between the numerous players in a fragmented industry was not working well to secure cooperation on cross industry activities needed to be undertaken for the common good.
- Misaligned and ineffective incentives to both TOCs and NR meant that they did not share common interest to improve efficiency.
- Relatively short term franchising to TOCs discouraged a long term strategy.
- A lack of best practice in areas which need to be managed from a whole system perspective such as asset management, programme and project management, supply chain management and management of standards and innovation.
- All of the above meant that a whole system approach was difficult to apply since players within GB rail were more inclined to follow approaches which maximise their position within a “silo” rather than optimising the outcomes of the industry as a whole, for example in technology and innovation.
- Intertwined with all of these issues was the industry’s culture and relationships which were likely the result of a lack of leadership[19].

As one might expect in an industry facing these barriers the product acceptance process lacked a whole system approach. Individual products were typically assessed on the basis of their immediate impact and their compatibility with the existing products with which they interfaced. The acceptance process could take years and lacked an overarching strategy.

6.3 Initiatives to Address Challenges

Rail Technical Strategy

In 2007 the first edition the Rail Technical Strategy (RTS) was published by the Department for Transport in conjunction with the white paper Delivering a Sustainable Railway. It set out a long term vision for the railway as a system and explored how new technology and technical approaches could respond to key challenges[20]. It was aimed at policy makers, funders, and existing and potential suppliers. The document succinctly links vision, objectives, strategy and enablers for each technology theme.

Technology Strategy Leadership Group

To address the lack of leadership, a cross industry group of senior stakeholders called the Technology Strategy Leadership Group (TSLG) was set up to develop and implement the strategy (the RTS was updated in 2012 to reflect progress).

Policy and Structure

In response to the RVfM study a number of policy and structural changes were made. The British government funded major rolling programmes of electrification and supported the development of high-speed rail networks[21]. Longer franchising periods were introduced which encouraged train operators to adopt a longer term strategy. NR underwent some structural reform to make itself more route orientated, helping to align it with operators. NR and operators even began to share some office buildings. The overall effect was to reduce fragmentation and mend the interface between industry players.

Government collaboration

LB rail was also successful in securing government funding to developed UK capabilities in key technologies. TSLG has collaborated with Innovate UK, a non-departmental public body, in three initiatives: the Knowledge Transfer Network; the £10m Accelerating Innovation in Rail competition to develop projects between companies; and the case for the £30m/year transport System Catapult technology innovation centre21.

Future Railways

Once a unified whole-industry technology strategy was in place co-operation became easier within the industry. It also became more approachable for start-ups, academia and those with ideas from other industries. Future Railways (a NR/Rail Safety and Standards Board partnership) is currently offering £6m to co-fund innovative proposals to address key challenges faced by UK train operating companies with the intention of increasing train operators awareness of and ability to design an innovative strategy and put mechanisms in place for its delivery[22]. Such competitions are welcoming to those outside of the rail industry and encourage consortium building and collaboration through regular supply chain events. Importantly, such initiatives help innovators outside of the industry find the right individual to approach inside it.

Future Railways are also proposing to provide guidance to help innovators understand and negotiate standards and how they fit into the railway system. The breadth and depth of these standards in rail is often cited by innovators are a barrier to innovation.

An important enabler to the technology strategy was the determination of priority areas to drive economic growth and exports through analysis of industry and academia's capability in the rail sector. The results of which are used by Future Railways to make decisions on how best to deploy their resources.

6.4 Conclusions & Learning for O&G Decommissioning

It is too early to say if these initiatives have resulted in improved efficiency in GB rail. However, there are encouraging signs that many of the barriers to innovation have been removed. Many of the barriers and challenges are very similar to those we have observed in the O&G decommissioning market. The following points can be highlighted:

- Giving a leadership mandate to a single top-level agency.
- The value in aligning the strategy of all stakeholders to achieve long term goals.
- Addressing commercial constraints in order to remove 'silo' mentality and enable collaboration.
- Funding from innovation agencies for specific, relevant, topics.
- Use of innovation competitions to widen the supply chain.
- Benchmarking against operations elsewhere globally to assess progress and encourage investment.
- Acknowledgment of an export opportunity to strengthen the investment case.

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7.0 Cross-industry insight:
UK Nuclear Decommissioning - enabling the adoption of novel solutions

7.0 Cross-industry insight

UK Nuclear Decommissioning - enabling the adoption of novel solutions

There are several similarities between the nuclear decommissioning industry and the O&G decommissioning industry such as: the necessity for stringent regulation, the need to mitigate risk to people and the environment at all cost, the sporadic nature of projects, a large financial obligation, and a perceived lack of approachability to potential innovators from outside the industry.

7.1 Industry Background

The UK nuclear legacy clean-up, at about £3billion per annum, is a major market[23]. Some estimates put the country's current liabilities as higher than those in those in both France and the US[24]. This could be an opportunity for the UK to become a world leader in decommissioning. However, the perception is that the industry does little to incentivise innovation or progress on nuclear decommissioning or waste management.

As of May 2012, twenty-eight nuclear power stations had been shut down in the UK. These facilities must be dismantled and decontaminated to the point that they no longer require measures for radiation protection, a process which can take over 100 years. The current estimate is that total clean-up costs across the UK will be between £90 and £220 billion spread over 120 years.

The UK decommissioning industry involves a number of stakeholders. The Nuclear Decommissioning Authority (NDA) was formed in 2004 with the primary function of managing the effective and efficient clean-up of the UK's nuclear legacy[25]. It owns an estate of 19 nuclear sites but does not have a 'hands on' role in the clean-up. Instead the NDA delivers decommissioning through Site License Companies who are directly funded by the NDA.

The NDA receives two-thirds of its funds from the government and the rest from its own commercial assets. It primarily deals with the first generation nuclear power plants. The UK's second generation nuclear power stations are operated by EDF Energy and have funds set aside for their future decommissioning via the Nuclear Liabilities Fund. This fund is underwritten by the government.

The Energy Act of 2004, which formed the NDA, also mandates its commitment to R&D in order to cut costs, improve safety and reduce the environmental impact of decommissioning work. The industry has a wealth of ideas and technologies of varying readiness such as the application of remote robotics. However, many inside the industry have expressed the opinion that there is not much new technology being implemented. Instead the industry focuses on: adapting technology from other applications (particularly military); care and maintenance of nuclear sites as opposed to actual decommissioning; and executing decommissioning largely through force or manual labour.

7.2 Identification of Barriers & Challenges

A number of barriers to innovation have been identified which are intrinsic to the nuclear industry. Some of these are outlined below:

- The nature of applicable strategies, practises and guidance vary significantly from one facility to the next. Furthermore, regulation and waste disposal options differs from one country to the next. This makes technology transfer between projects challenging.
- Decommissioning projects are sporadic in time and isolated in geography. This limits the potential 'payback' for the capital expenditures required to incorporate and develop new technologies and practices[26].
- Mitigating risk to people and the environment is paramount, necessitating stringent regulation and testing of new products, practices and innovations.
- The general public are extremely cautious of the nuclear industry. In 2013 for example, Cumbrian stakeholders rejected continued participation in the search for Geological Disposal Facility for radioactive waste.
- There is a long route to market for new products in heavily regulated industries with sporadic projects. Sustaining R&D funding for this length of time can be difficult, especially for Small and Medium Sized Enterprises.

However, other barriers have been identified which originate from the industry's structure and culture. Some of these are outlined below:

- Decommissioning managers are risk averse and reluctant of to deploy new technologies in the field.
- Nuclear site licenses tend to be very prescriptive in their ITTs.
- The industry is not very good at knowledge management. There is poor provision of documentation to identify knowledge gaps, poor awareness of potential technology transfer and insufficient use of retirees' knowledge [27].
- A lack of long term strategy combined with a lack of clarity on who does what makes it difficult to know who to talk to, who funds what and who to consult about new alliances[28].
- The current structure of the NDA and National Nuclear Laboratory are seen as sub optimal[29]. For the NDA, this includes its role in setting strategy and the level of its control and influence on Standby Liquid Controls. In particular the NDA does not accept responsibility for technical strategy and expects its contractors to lead engineering innovation and development.
- Potential sponsors of innovation complain about a lack of appreciation of the problems that need to be tackled and the time scales involved.
- Innovators complain about a lack of access to information about the specific problems the decommissioning industry is facing.
- Complex organisational and commercial arrangements give no clear drivers or paths for innovation and savings.

7.3 Initiatives to Remove Barriers

Since the inception of the NDA in 2004 there have been no major initiatives to remove the barriers discussed above. However, a number of ideas have been suggested from within the industry:

Focus on technologies in areas of commonality between decommissioning projects

Although nuclear decommissioning projects vary in strategies, practices, guidance and regulation, the report R&D and Innovation Needs for Decommissioning Nuclear Facilities (2014)[30] observed that there are key areas of commonality. These were: characterisation & site monitoring; segmentation and dismantling; surface decontamination; and materials and waste management. It is suggested that R&D spending is focused on these areas to promote knowledge transfer and continuity between projects. This focus would also provide potential for an export market.

Improving supply chain path first

The report Nuclear Innovation Analysis: Landscape Review[31] recommends a review of the innovation supply chain. It suggests that initially, instead of investing in innovative ideas, money/effort should be invested in removing barriers and giving a recognised path to equitable rewards for innovation across the supply chain.

Communication between players in the innovation supply chain

Addressing communication between various players in the innovation supply chain could address several of the barriers discussed above. This could be achieved by developing and communicating a clearer strategy on technology and innovation from overarching bodies such as the NDA. One report also stated that participants in workshops had expressed a need for 'innovation portals' such as those used in the Centre of Defence Enterprise[32]. These portals would effectively provide a 'one-stop-shop' for organisations with ideas to approach the nuclear industry.

7.4 Conclusions & Learning for O&G Decommissioning

Although the UK nuclear decommissioning industry has no evidenced initiatives to address barriers to innovation, we can learn from the analysis undertaken and feedback from the industry. Some key points that North Sea decommissioning can learn from nuclear decommissioning are:

- Focus should be applied to developing core technologies which are adaptable to suit site-specific features.
- Ensure that managers who are responsible for carrying out the decommissioning are incentivised to adopt innovative practices.
- Early R&D funding is essential to support innovation which may have a lengthy route to market.
- Recognising that the UK is in a strong position to become a world leader and securing government support for achieving this goal.
- Innovation portals and competitions are known to be an effective means of broadening supply chains.

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8.0 Case Study
Prezioso Linjebygg Tempo Process

8.0 Case Study
Prezioso Linjebygg Tempo Process

8.1 The Company

PREZIOSO Linjebygg AS provides services and turn-key projects to the oil and gas industry both offshore and onshore. As a result of a successful and rapidly growing activity in the offshore oil and gas industry, PREZIOSO Linjebygg has developed a broad line of services within the maintenance, modification and inspection area, and is engaged in projects on a large number of installations on the Norwegian Continental Shelf and in dedicated markets abroad.

PREZIOSO Linjebygg

In the early 1990's PREZIOSO Linjebygg undertook several challenging projects in the splash zone. It was realized that advanced access tools were needed to perform this type of work in a safe and efficient manner. In 2008 PREZIOSO Linjebygg initiated a major development project to develop the equipment and methods to perform various types of operation in the splash zone.

8.2 The Innovation

Remotely operated PREZIOSO Linjebygg Access Tools were proposed for a range of advanced operations in the challenging splash zone. Since deployment, several successful projects have been implemented on offshore installations in Norway and abroad. The Splash Zone Concept deploys custom made access tools on a traditional Remotely Operated Vehicle (ROV) robotic arm, which is remotely operated from a control cabin on deck. The robotic arm is compatible with standard ROV tools. Examples of operations possible (but not limited) to 20 meters below sea level include:

- Inspection (visual, crack detection, thickness measurements)
- Cutting of structures
- Bolting and installation
- Cleaning of surfaces

8.3 The Innovation Process

To support the process of bringing the innovation from the drawing board to the marketplace, PREZIOSO Linjebygg makes use of a proprietary innovation process called Tempo. This process ensures that innovations are right first time, by the appropriate focus of time and resources.

This structured innovation process was developed to meet the following aims:

- Better organization of innovation projects, especially in "the fuzzy front end" of innovation. Generally this involved spending more time and/or extending the focus at the early stages of development.
- Highlighting the innovation strength to clients, future employees and relevant authorities.

Success factors include:

- Visual working method, including simple modelling.
- Getting the right team together (users, clients and suppliers who must all participate to provide the most relevant input).
- Exploring the "problem" thoroughly before looking for opportunities and solutions.
- A structured process (well-planned and facilitated) with clear and ambitious goals.

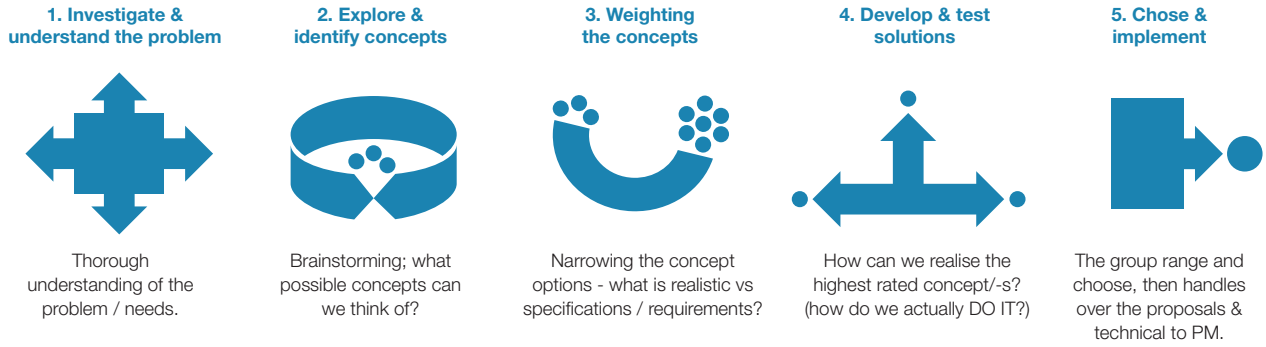
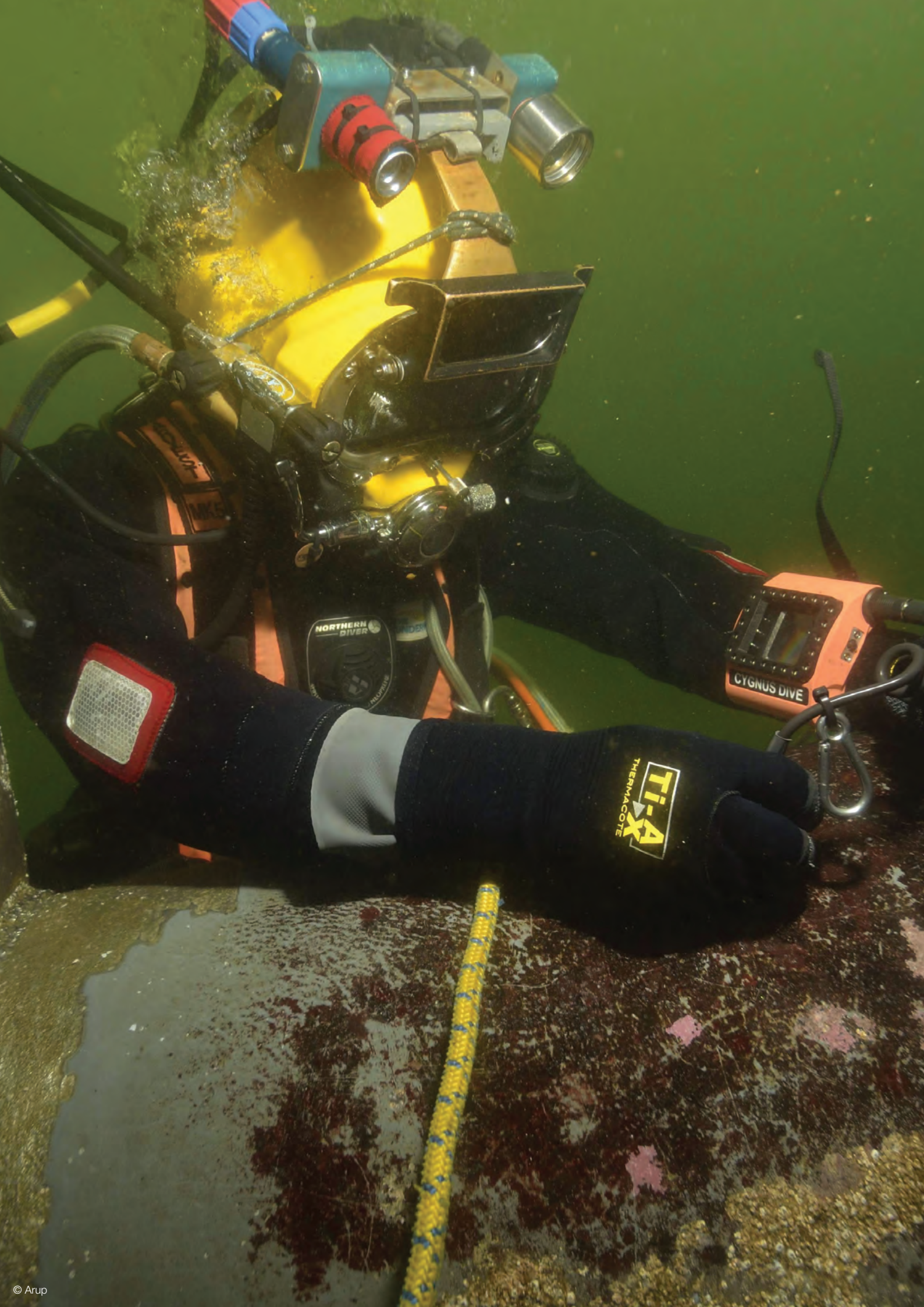


Figure 3. A visualisation of Tempo

Some insights from the Tempo process include:

- New opportunities (often which the client was not aware of) may arise as a result of systematic observations.
- Inspiration can be found far beyond the core field of interest.
- Rough models and experiments "in a jiffy" reduces calendar time required.
- Development time can be reduced to a fraction if the client is directly involved.
- Rejected ideas are equally as valuable and are put in the "ideas bank" for possible relevance in later projects.
- A structured innovation process raises the company's ambitions.



8.4 Process Implementation

The Tempo process has been important for the successful development of many PREZIOSO Linjebygg products and solutions being introduced in the oil & gas industry in recent years, including the splash zone concept. A good measure of this success is the time elapsed for development.

For example, only 24 months passed from the first ambitious ideas, right through to the first and very technically challenging project being executed (remote installation of anode protection on Statoil's Snorre B platform at 12 m below sea level).

The process was robust, following the stages described above as well as:

- Testing at scale at The Norwegian Marine Technology Research Institute MARINTEK.
- Testing at full-scale at PREZIOSO Linjebygg's own test centre/dry dock in Trondheim/Norway.
- Engagement with standards bodies for design verification.
- Adhering to design standards and following processes such as DNV-RP-A203.
- Preparation of the business case in parallel.
- Use of stage gates to assess progress and approve subsequent phases of development.

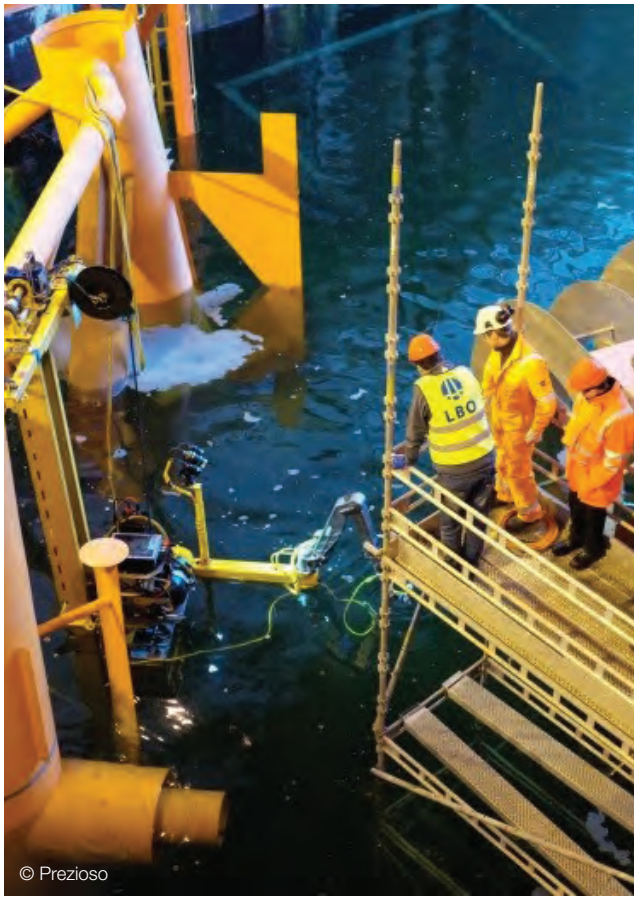


Figure 4. Full-scale testing

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9.0 Conclusions and Recommendations

9.0 Conclusions and Recommendations

9.1 Conclusions

In summary, ***innovation is underway in decommissioning*** but a more open mind-set should continue to be developed and be adopted by all operators, and supported by regulators, to support an innovative culture in the decommissioning marketplace. This support will encourage the large service companies and wider supply chain to prioritise work on decommissioning and accelerate the delivery of novel solutions in the form of technical advances, relevant organisational change, targeted knowledge management and more appropriate commercial strategy.

We must stress that there are signs of more progressive stakeholders already taking steps in the right direction. Guidance can be drawn from these organisations, and from lessons learnt in other industries.

To conclude, we can make a number of recommendations to the industry. Although the themes discussed earlier affect all stakeholders, we can direct our recommendations to individual communities:

Regulators & industry bodies who need a mandate to provide a clear strategy on the topic of decommissioning.

The innovation providers who should consider technical and commercial development in parallel, engaging soonest with the end user.

The innovation purchasers (generally operators and tier 1 contractors) who can make a number of modifications to their "business as usual" to promote innovation in the marketplace.

9.2 Recommendations

Recommendations to regulators & industry bodies

- The OGA and TLB could create a single, coherent national decommissioning strategy, to capture the attention of operator senior managements and promote an innovative culture in the industry.
- The UK regulator could engage with their Norwegian and US counterparts to review where requirements and standards could be harmonised.
- The regulator could encourage funding agencies, innovation centres and technology facilitators to make decommissioning a priority topic for funding. Industry groups and trade associations should pool their resources and concentrate their efforts on jointly-organised events, studies, publications, etc. to avoid the duplication of effort.

Recommendations to innovation purchasers

- Innovation purchasers could adopt an "open-door" policy to innovators in the supply chain. This would be both during and outside tender response periods, so as to capture any potentially disruptive technologies. There are a number of ways to do this, including innovation competitions such as Statoil Innovate[33], dissemination events, innovation exchanges and frameworks such as Procter & Gamble's Connect & Develop programme[34].

- Innovation purchasers should ensure they have a culture which is receptive of innovations. Those involved in reviewing innovations should be well-supported with representation from all relevant departments including R&D, operations, asset management, finance and strategy.

- Innovation purchasers could consider the risk assessment of novel solutions being deployed during decommissioning as being different to the risk assessment of operations in exploration & production. For example, there may be in-service requirements (e.g. expected lifetime, adherence to standards) which can be relaxed to lower costs and reduced development time.

- Innovation purchasers could engage in dialogue with suppliers well in advance of preparing tender packages to allow operators to consider novel solutions and potential technology transfer at an early stage.

- Innovation purchasers could consider a "loser's fee" for unsuccessful ITT responders to compensate them for engineering novel solutions which are not subsequently deployed.

- Innovation purchasers should consider breaking up scopes of work into smaller elements to open up competition from more contractors who may have specific capabilities in certain areas but not possess the overall project execution skills.

- Innovation purchasers should be amenable to joint ventures (JVs) or direct investment in R&D outside their organisation. JVs with an appropriate number of members are an effective method to raise significant capital and reduce risk exposure.

Recommendations to innovation providers

- Innovators should engage with the operational teams within operators and service companies to fully appreciate how their innovation impacts on work flow. This will ensure that the innovator "speaks the same language" and will make it easier to assign value to innovations.

- Innovators should be aware that decommissioning tasks are not 100 per cent generic and there will always be differences between assets. Hence a solution with core novelty but with the option to customise is likely to be more useful.

- Innovators should partner with end users at an early stage to agree what maturation of technology is required and what level of third-party engagement is required before an innovation will be considered. If development steps are robust and monitored by the end-user (for example in a joint venture) then this may provide sufficient comfort without involving a third party reviewer.

- Contractors with a global presence should be encouraged to commit to decommissioning R&D. Investment to support the UKCS market now will surely support longer-term opportunities elsewhere.

- As well as novel engineering, innovators should consider novel contracting approaches, for example to allow larger turnkey packages of work to be fixed-priced in advance[35].

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For further information please contact:

Ken Cruickshank

Oil & Gas UK
3rd Floor
The Exchange
62 Market Street
Aberdeen
EH30 9SE

t +44 (0) 1224 577250
e kcruickshank@oilandgasuk.co.uk

Jacob Ahlqvist

Arup
Scotstoun House
South Queensferry
Edinburgh
EH30 9SE

t +44 (0) 131 331 1999
e jacob.ahlqvist@arup.com

Karen Seath

Decom North Sea
33 Albyn Place
Aberdeen
AB10 1YL

t +44 (0) 1224 452170
e kseath@decomnorthsea.com

www.arup.com

ARUP

Oil & Gas UK (Aberdeen)
3rd Floor
The Exchange 2
62 Market Street
Aberdeen
AB11 5PJ

Tel: 01224 577 250

Oil & Gas UK (London)
6th Floor East
Portland House
Bressenden Place
London
SW1E 5BH

Tel: 020 7802 2400

info@oilandgasuk.co.uk

www.oilandgasuk.co.uk

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