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An approach for assessing the innovation and technology management capabilities in an organisation

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Companies continually seek to derive the best value possible from their investments in technology and innovation. However, managers need to address a wide range of aspects in managing innovation effectively. This paper presents a robust approach for assessing the innovation and technology management (ITM) capabilities within an organisation so that focused improvements can be made. As a practical application, the ITM assessment is used to examine the ITM processes within a selected group of oil and gas exploration and service companies, and presents a picture of the performance trends and issues commonly faced across the energy sector. In alignment with emerging ISO standards for innovation management, the assessment approach applied in this study includes a survey measurement of Likert scale responses to set of 87 questions based on an ITM process framework and related technology management assessment procedure. The survey covers three themes and ten areas of significance to technology-intensive organisations.

1. Introduction and background

Both technology and innovation are considered major contributors to the competitiveness of companies and in exploiting opportunities in the market (Phaal *et al.,* 2001; Yang *et al.,* 2015). As such, companies continually seek to derive the best value possible from their investments in technology and innovation. To do this, managers need to address a wide range of aspects in managing technology and innovation effectively (Goffin & Mitchell, 2017; Centindamar *et al.* 2009). This includes the assessment or measurement of performance.

At first glance, approaches to innovation and technology management assessment appear to split into two separate assessments, for technology management and innovation management. For example, Phaal *et al.* (2001) concentrate on technology management assessment, while Adams *et al.* (2006) look at innovation measurement. Other academic approaches to innovation management assessment include studies measuring product development success and failure (e.g. Griffin & Page 1993) and developing maturity levels approaches for innovation capability (e.g. Narcizo *et al*. 2017). Also, from industry there are standards specifically for innovation management, such as the European CEN TS 16555-1 (2015) Innovation Management Assessment, and the ISO/CD 50501 Innovation management System (under development) on innovation management assessments, both of which are understood to take a view of innovation management as distinct from technology management.

The distinction between technology management and innovation management could, however, be seen as artificial in the context of technology- or manufacturing-based organisations. For such firms, it is perhaps more appropriate to speak in terms of 'technological innovation' (e.g., OECD 1991), and this includes technology and technological development, opportunity identification, new product/process development, market introduction, etc. (Ravari *et al.*

2016). White and Bruton (2007) explain that the alignment of management of technology and innovation is crucial to such firms. It is this train of thought that appears to be followed by Chiesa *et al.* (2008), in their discussion of R&D performance measurement and technical innovation audits (e.g. Chiesa and Masella 1996; Chiesa *et al.*, 1996) and by Schuh *et al*. (2013) in their assessment approach for technology management performance.

There are a number of innovation assessment approaches that are based on self-assessment, some of which are briefly described below as an illustration of the range available.

IMP3rove was established by the European Commission with the aim to improve innovation management performance of SMEs in Europe with sustainable impact. It covers innovation strategy, organisation, culture and innovation processes, including enabling factors. The online self-assessment tool supports and drives the process by generating reports on SME performance, developing insights into strengths and weaknesses, and monitoring progress and performance.

Innovate! New developed by CAU in Germany and other academic partners, is a benchmarking methodology based on an innovation excellence model, which has three central areas leadership & governance, innovation performance, process and projects in the context of six areas: strategy, organisation, launch, development, front end and culture.

The Innovation Management Maturity Assessment offered by CIMS, North Carolina State University, is a tool to assess a company's level of innovation management proficiency. The assessment looks at self-assessed strengths and weaknesses across the organisation. By department, or throughout the entire enterprise, individuals rate their organisation's performance across five core competences (strategy, organisation & culture, processes, tools & techniques, metrics) and five management dimensions of innovation (ideas, market, portfolio, platform and project management).

2. ITM tools and toolkits

Performance assessment tools/approaches belong to the wider set of business improvement tools. There are several issues related to such tools, including their definition (Brady *et al.*, 1997), development, successful adoption and use. Hidalgo and Albors (2008) state that:

> *"There is no one-to-one correlation between one firm's specific business problem and the methodology that solves it. As a result, it cannot be claimed that there is a closed set of developed and proven Innovation Management Tools (IMTs) for solving, one by one, the challenges faced by business as a whole. Furthermore, IMTs do not usually act in a deterministic, unique manner and the diversity of firms and business circumstances means that there is not a single ideal model for innovation management, although there are some principles of good practice."*

Due to the deeply context-specific situation presented by engagement in real industrial circumstances, Mortara *et al.* (2014) hold that, if seeking to classify tools in any way, it is necessary to consider instances of 'tools-in-action'. Thus, they discuss the iterative dynamic between specific tool application in one situation and generic tool abstraction to support diffusion of learning to a new situation, and propose a multi-faceted approach to describe an application in order to understand it fully. This approach details the tool and its context in terms of business task (application domain), tool aim (functions), implementation technique and metrics (application method and variability), time frame and internal/external context (business aspects).

In terms of aim or purpose, Ilevbare *et al.* (2016) classified tools according to established business improvement and change process frameworks. They identified that tools can be for assessment (or diagnosis), for planning, for implementation (of plans), or for review (of planning, implementation, etc.). Tools can be combined across these various types into toolkits, in order to provide holistic solutions. The combination of such tools into toolkits (with the goal of aiding decision-making to allow generation, exploration, shaping and implementation of possible solutions), benefits from following design principles established by Kerr *et al.* (2013).

The process of developing these tools and toolkits requires active collaboration with industry and working with organisations on real management problems. This collaborative approach has been illustrated in recent work, which developed an innovation toolkit using roadmapping as a platform (Farrukh *et al.* 2014), and combined tools for assessing sustainable value for technology opportunities (Farrukh & Holgado 2018). However, which tools to use, in

what combination, requires an understanding of the particular organisational context, and the effectiveness of management practices in order to focus improvement efforts.

In this paper, we propose an assessment methodology to support the identification of where improvement efforts should be focused. This assessment tool can serve as a first step to identifying, exploring, shaping and implementing solutions (often in the form of customised toolkits), to tackle technology and innovation management challenges or weaknesses faced by the organisation.

3. Building on an existing technology management assessment procedure (TMAP)

The TMAP approach was developed to assess technology management processes in manufacturing firms, based on Gregory's (1995) process model for technology management, which consists of five generic process areas (see Figure 1):

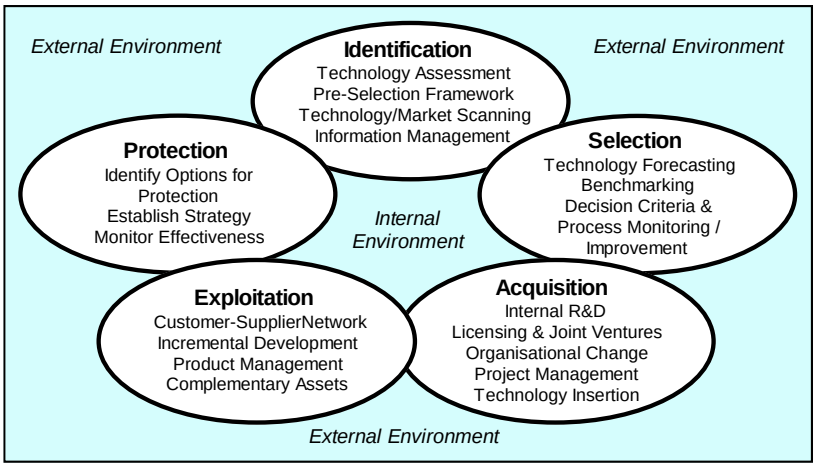

Figure 1. Five-process technology management framework, showing example activities

- *Identification* of technologies which are (or may be) of importance to the business. Example processes include scanning, monitoring, benchmarking and data collection.
- *Selection* of technologies that should be supported by the organisation. For instance, forecasting, portfolio analysis and scenario analysis are associated with selection of technology.
- *Acquisition* and assimilation of selected technologies. Example processes include technology transfer, research and development, corporate mergers and acquisitions.
- *Exploitation* of technologies to generate profit, or other benefits. Example processes include licensing, new product development, incremental developments, process improvements, and supply chain management.
- *Protection* of knowledge and expertise embedded in products and manufacturing systems. These processes include patenting, risk assessment, security management and staff retention.

The aims of the TMAP assessment were to 1) provide a framework for linking technology with business needs, identify critical technology management issues in the firm; 2) map and evaluate important technology management processes in the area of interest; 3) identify strengths and weaknesses, and hence areas of best practice for transfer, and areas for improvement; and 4) lead to recommendations for action plans which have cross-functional support and can be clearly justified (Farrukh *et al.* 2000, Phaal *et al.* 1998, Phaal *et al*. 2001).

4. Innovation and technology management assessment (ITM)

4.1 Background to the ITM assessment framework

This paper presents a robust approach for assessing the innovation and technology management (ITM) capabilities within technology-based organisations so that focused improvements can be made, and appropriate interventions or solutions can be developed.

It is built on a technology and innovation management framework, which integrates key aspects of technology and innovation management. Phaal *et al.*'s (2004) technology management framework (Figure 2), which is an advancement on Gregory's (1995), explicitly showing the inter-linkage between the technology base and core business processes, i.e. strategy, innovation and operations. This framework is an improvement on Gregory's because makes it clear that technology management decisions are often made in areas such as new business strategy formulation, product development and in operational process, rather than discrete technology management processes.

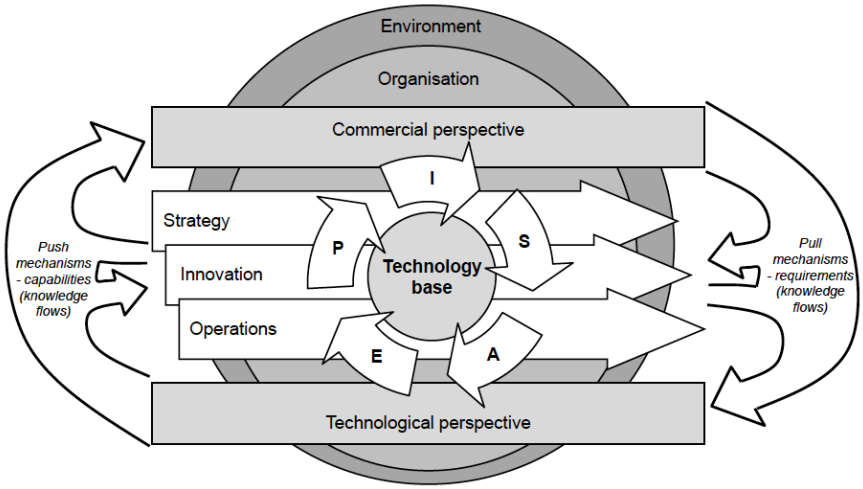

Figure 2. Technology Management framework (Phaal et al., 2004)

However, 'strategy' here goes beyond business strategy. Technology strategy, which can be considered as part of innovation strategy, should be linked to business strategies (Dasgupta *et al.*, 2011; Chaskel 2014; Goffin & Mitchell, 2010). Ultimately, it is technology strategy that should guide the organisation's five technology management processes. (Davenport et al, 2003). Arasti *et al.* (2017) explained that the linkage between technology strategy and business strategy is bidirectional, interactive and dynamic.

According to Lopes *et al.* (2012), there is no single model for innovation management, and some of them are derived from or follow the logic of stage-gates (Cooper, 1990) or the innovation funnel (Wheelwright & Clark, 1992). Adams *et al.* (2006) presented several innovation management frameworks and summed them up in 7-part framework comprising: inputs, knowledge management, strategy, organisation and culture, portfolio management, project management and commercialisation. However, Goffin and Mitchell (2010), based on similar literature, identified the main elements of innovation management more succinctly as follows:

- Innovation strategy: which, in addition to other things, should capture the role of technology and the opportunities it can open up.
- The development funnel: made up of ideation, prioritisation and implementation – a process model reflecting Wheelwright & Clarke's innovation funnel.
- People and organisation: which relates to creation of a culture of innovation. Looking back into literature compiled by Adams *et al.* (2006), one would identify organisational culture, management commitment and leadership as being part of people and organisation.

Thus, the inextricable nature of technology and innovation (as can be seen from the literature) justifies the need for a framework that explicitly links and combines elements of Phaal *et al.*'s (2004) technology management framework and Goffin and Mitchell's (2004) innovation management models.

4.2 The innovation and technology management framework

The core of this integrated framework remains Gregory's (1995) technology management process, which Phaal *et al.* (2001) explained as being very closely related to innovation and new product development process models (e.g. Goffin & Mitchell's development funnel). The advantage of Gregory's five-process model, however, is that it is generic, encompassing both innovation and technology management activities for technology- and manufacturing-based firms (Phaal *et al.*, 2001).

Strategy is now captured by a combination of *business strategy* and an integrated '*innovation and technology strategy*' in accordance with the foregoing on the relationship between business strategy, innovation strategy and technology

strategy. People and organisation, as outlined in the preceding discussion, would include leadership, management commitment and organisational culture.

In summary, the innovation and technology management framework can be described as covering three themes and ten areas of significance to technology-based organisations:

- *Strategy*: investigating the **innovation and technology strategy** and importantly, how it links and supports the organisation's overall **business strategy**
    - **Business strategy***:* is it sufficiently defined to enable ITM strategy (and other functional strategies) to be developed?
    - **Innovation and Technology strategy**: is there a clear statement in terms of competitive positioning and strategic direction in terms of what is required from the innovation and technology system?
- *ITM System*: examining the fundamental technology and innovation management processes of technology **identification**, **selection**, **acquisition**, **exploitation** and **protection**;
    - **Identification:** how do we identify product or process technologies that are or may be of importance to the business?
    - **Selection:** how do we know which of these technologies are most appropriate to deliver business and ITM strategies?
    - **Acquisition**: how do we successfully acquire, develop and assimilate selected technologies?
    - **Exploitation:** how do we generate benefits (e.g. licensing, new products, process improvements etc.) from the technologies?
    - **Protection:** what strategies and processes are in place to ensure that our technology knowledge and capabilities, embedded in our products, processes and systems, are appropriately protected and denied to competitors?
- *People and Organisation*: focusing on the organisation's **leadership** and management style, **organisational culture** and the management of **competences,** and their appropriateness for desired ITM and, ultimately, business performance.
    - **Leadership:** how do we set and communicate clear objectives, manage interfaces and structures within the organisation and empower our personnel?
    - **Organisational culture**: does 'the way we do things' help or hinder the achievement of our business and ITM objectives?
      Competences*:* do we have the skills and capabilities to deliver projects and manage our technology and innovation activities?

4.3 The ITM Assessment

4.3.1 Development

The development of the assessment was carried out in an action research environment as set out by Platts (1993). Within such a methodological environment, organisational systems and interventions can be developed and investigated through collaborative participation, to ensure they are easy to use, comprehensive in coverage and deliver useful results.

The 97 questions that made up the first version (Version 1) of the assessment were compiled from multiple existing innovation and technology management-related assessments. Each of them had been developed through previous research by scholars at the Institute for Manufacturing, University of Cambridge. These existing assessments were: Speeding New Products to Market (Gardiner *et al.* 1998), Technology Management Assessment Procedure (Farrukh *et al.* 2000), Innovation Management (Pentathlon Framework) assessment (Goffin & Mitchell, 2010) and Design Audit tool (Moultrie *et al.* 2007) which highlighted multiple facets of technology and innovation management. The identification of the 97 questions was achieved through rationalisation of a total of over 400 questions/statements compiled from the various assessments, followed by selection of those considered most appropriate for the ITM assessment. To do this, multiple consultations were carried out with innovation and technology management researchers and practitioners.

Following initial tests with organisations, the ITM assessment was revised to improve its usefulness, feasibility and usability. Actions taken in improvement included revising the wording of some of the questions (i.e. making them easier to understand), and further rationalisation of the question set (to remove overlaps or repetitions), thus reducing the question set from 97 to 87 questions in the second edition (Version 2). In addition, to make the assessment more user-friendly, the seven-level maturity model initially used to facilitate response to the questions was revised to a five-level maturity model. Multiple deployment options were also introduced to allow users to access and apply it differently depending on the time and resource they have available, and the levels of detail they require. One of these deployment

options is a roadmapping-based workshop approach, which allows group discussion of the assessment, its results and implications for the organisation.

4.3.2 Presentation format

The 87 questions in Version 2 spread across the ten areas of the ITM framework. The response to each question is facilitated by its adjoining five-scale maturity model (see Table 1), which adheres to a generic maturity model. This generic maturity model is based on Bessant *et al.*'s (2005) levels of organisation absorptive capacity. This gives an indication of the knowledge or capability level of the organisation with respect to the issue being explored by the respective question.

Bessant et al (2005) (adapted)		**Innovation & Technology Management Assessment Maturity Levels**
1	Ignorance	No awareness at all and/or denial of relevance to firm
2	Awareness	Some awareness with no/inadequate evidence to demonstrate sufficient understanding of the issue (and the acknowledgement of need for an effective process)
3	Knowledge	Good awareness and understanding of the issue
4	Implementation	Very good awareness/understanding of the issue; with some implementation (imperfect or in-progress)
5	Effective implementation	Comprehensive awareness/understanding of the issue; have implemented an effective process and can demonstrate benefits to the business

Table 1. ITM Assessment maturity levels

4.3.3 Deployment options

There are two deployment options for the assessment:

- Online survey – in this format, the company applies the assessment to itself. To enable this, the assessment is hosted on a web-portal which the participating organisation can sign-up to, complete the assessment and receive an indicative report afterwards.
- Facilitated assessment – in this format, the company is guided through the assessment by an innovation and technology management specialist. The assessment may also be delivered in workshop format, using roadmapping-structured templates (see Figure 3) to capture the essence of the assessment and allow multiple members of the company contribute to the assessment procedure at the same time in a collaborative setting. The facilitated assessment provides a deeper consideration of issues covered by the assessment. However, it has the potential to take much longer than the self-administered one.
- The advantage of having multiple delivery options is that it makes the assessment accessible to a wider range of potential users, who may have varying needs as it may relate to the level of granularity of analysis required, and the amount of time/resource available to the personnel using the assessment.
- Nevertheless, the recommended delivery option is the facilitated assessment, and an additional workshop-based session helps company personnel discuss results and implications in an open, collaborative environment.

4.3.4 Assessment approach

Regardless of delivery option, the assessment approach is as follows:

- Deployment and data collection – normally to multiple middle to senior innovation/technology managers within the organisation.
- Data evaluation and prioritisation – normally collaborative, face-to-face (sometimes including workshops) assessment and discussion of data or indicative results, identifying and agreeing on key performance weaknesses and strengths against defined organisational and ITM goals.

- Action prioritisation and planning – identification and definition of improvement steps and projects, which includes a modified application of Mitchell *et al*.'s (2014) selection approach.

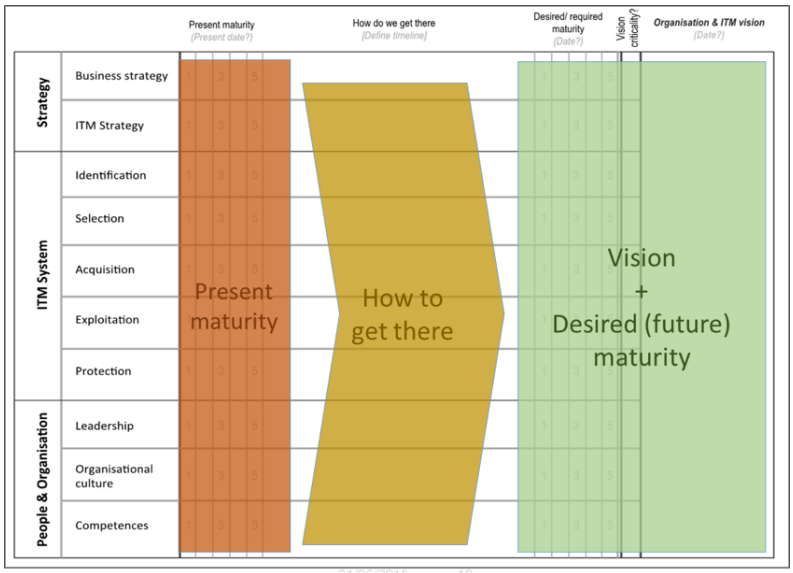

Figure 3. Roadmapping-based workshop format for TIM Assessment deployment

5. Application: ITM Assessment survey of oil and gas sector

An example of the ITM assessment's practical application is its current exploratory use to examine the ITM processes within a selected group of oil and gas exploration and service companies. This mode of implementation provides an industry-wide assessment of a sector, and gives a preliminary indication of performance trends and issues which are commonly faced across the energy sector.

5.1 Survey methodology

In spring 2018, an email was sent out to a selection of oil and gas companies (covering the full range of products and services offered in the industry), inviting them to complete the online survey. In return for up to 3 people from each organisation completing the survey, an individual report was provided giving feedback to the organisation in terms of its strengths and weaknesses. At the end of the survey period, a report summarising the generic results from all the companies will be provided.

Following each company's submission of results, informal feedback on the survey experience was then requested by means of a phone call, to assess the experiences of the participants and to guide further refinement of the approach.

These questions aim to assess whether the tool is easy to use, comprehensive in coverage and delivers useful information to the company:

- What do you think of the survey – first impressions? [pertaining to usefulness/feasibility/usability]
- How do you find the structure and flow of the assessment? [usability/usefulness]
- Were the individual questions clear? [usability]
- Are any areas/topics missing in your view? [comprehensiveness (usefulness)]
- What do you think of the individual output report and format? [usefulness/usability]
  Do you have general comments? [usefulness/feasibility/usability]

5.2 Participating organisations

This is work in progress, as the survey will run until end of July 2018. As of mid-June, twenty-six organisations from across the oil and gas sector had been included in the study, and fifteen of them had completed the ITM Assessment. These organisations are listed as "Company 1", "Company 2", etc. in Table 2.

5.3 Preliminary results

Initial analysis was conducted to study the completed assessments to date. An arithmetic mean of the responses revealed some key trends in the oil and gas industry and these average maturity levels are summarised for each each assessment category and for each organisation in Table 2. In general, higher scoring average maturity levels reveal promising trends while lower average levels reflect issues that may need attention.

The highest variation in the average maturity levels is in the ITM System – Protection category with average scores ranging from 1.2 (Company 2) to 5.0 (Company 7). At the sector-level, the average maturity level is similar for nine of the ten ITM categories. The one notable exception is the People & Organisation – Competences category with the arithmetic mean average of 2.6 for the 15 organisations that completed the assessment. The lower maturity score for the competences area is perhaps unsurprising given the recent decline of the industry with rock bottom oil prices triggering significant staffing cuts worldwide starting in 2015.

Innovation & Technology Management Maturity Assessment (Survey of Multi-National Companies in the Oil & Gas Sector)	**Company 1**	**Company 2**	**Company 3**	**Company 4**	**Company 5**	**Company 6**	**Company 7**	**Company 8**	**Company 9**	**Company 10**	**Company 11**	**Company 12**	**Company 13**	**Company 14**	**Company 15**	**Arithmetic Mean (Category)**
STRATEGY - *Business Strategy*	3.8	2.3	4.0	3.3	3.4	2.8	4.3	3.4	3.3	3.6	2.3	4.0	2.6	3.8	3.1	3.3
STRATEGY - *Innovation & Technology Management Strategy*	3.3	2.6	4.1	3.5	3.1	2.5	3.9	3.5	3.0	3.0	2.9	3.6	3.1	3.8	2.4	3.2
ITM SYSTEM - *Identification*	3.2	2.6	2.9	3.4	3.5	2.1	4.3	3.2	3.6	3.4	2.9	3.7	2.3	3.1	2.7	3.1
ITM SYSTEM - *Selection*	2.5	2.1	3.9	3.1	3.6	2.5	4.3	3.5	3.4	3.6	2.8	3.6	2.0	3.3	2.8	3.2
ITM SYSTEM - *Acquisition*	2.6	2.3	4.0	3.0	3.7	3.0	4.4	2.9	3.4	3.3	3.3	4.0	2.1	3.3	3.0	3.2
ITM SYSTEM - *Exploitation*	3.4	1.8	4.2	3.8	2.9	3.0	3.8	3.1	4.6	3.7	3.2	4.2	2.2	3.5	2.8	3.3
ITM SYSTEM - *Protection (incl. Knowledge Management)*	3.0	1.2	3.6	4.4	3.6	2.0	5.0	3.0	4.4	4.2	4.6	4.8	1.8	3.8	1.4	3.4
PEOPLE & ORGANISATION - *Leadership*	3.2	1.9	2.8	3.9	3.0	1.8	3.2	3.2	4.6	3.6	2.9	3.9	3.1	3.7	3.0	3.2
PEOPLE & ORGANISATION - *Organisational Culture*	2.9	2.4	3.3	3.5	3.1	2.2	4.5	3.0	4.8	2.8	2.3	4.0	2.1	4.0	2.9	3.2
PEOPLE & ORGANISATION - *Competencies*	3.2	2.7	3.5	3.0	2.8	2.3	2.3	2.5	4.0	2.3	1.3	2.8	2.0	2.0	2.3	**2.6**
Arithmentic Mean (Company)	3.1	**2.2**	**3.6**	3.5	3.3	**2.4**	**4.0**	3.1	**3.9**	3.3	2.8	**3.9**	**2.3**	3.4	**2.6**	3.2

Table 2. Summary of selected findings in oil & gas survey

We will discuss some of the maturity levels that scored in the lower and higher ranges and suggest possible reasons for these.

5.3.1 Lower average maturity levels

Table 3 includes a listing of those statements with an arithmetic mean below 2.8. Many of the lowest average maturity levels are in the People & Organisation – Competences category. Two of the lowest levels pertain to innovation-related training (Com – Q4) and whether training and development is incorporated in new projects (Com – Q3). Based on interviews with survey participants, it appears the training area scores are low due to budget cuts incurred during the industry downturn. In addition, the oil and gas industry appears to be generally focused on getting the job done; however, this approach does not help in the long run since the required pause to capture and embed skills and lessons learnt for application in later developments (or to future projects) is often missed. In addition, it appears the oil and gas industry does not invest enough in innovation-related training, and even when trainings are organised, day-to-day tasks and assignments are hectic enough to prevent attendance. This may be a direct product of using overworked resources, where every person is essential and busy every day. Due to the nature of the industry, most training are still in the classroom format. This format does not provide real-time/real-world scenarios during the lectures, hence it makes it difficult to bridge the knowledge gap. Technology should be at the forefront of training, the introduction of simulators, video learning, eLearning and small automated platforms will help employees bridge that knowledge gap.

In addition, the People & Organisation – Competences category included two related areas with lower average maturity scores. One of these areas pertains to skills/capabilities retention for future developments (Com – Q5). The cyclical nature of the industry contributes to skilled/experienced employees leaving the company. That, coupled with competitor's raids on the company's talent anytime the industry is doing better does not help the case either. The other topic covers the question of competency *divestment* needed to advance the business (Com – Q6). Determining which competency areas to divest is often times a complex endeavour as it requires a good understanding of those competences that are needed to advance the business followed by a process for assessing whether non-aligned capability areas in the organisation should be repurposed or divested.

Finally, a comparison between the responses in Table 3 (Bus – Q8 and Ide – Q2) and Table 4 (Bus – Q7 and Ide – Q1) suggests there is a general disparity in how organisations work with suppliers versus their customers. These variations are simply part of the culture of many organisations as they are quite comfortable engaging in collaborative discussions with their clients while planned supplier engagement strategies and tactics are often times implemented in ways specifically designed to commoditise the value of supplier offerings. These approaches could inadvertently remove the potential advantage of any long-term supplier relationships that have (or could have) been established.

Innovation & Technology Management Maturity Assessment (Survey of Multi-National Companies in the Oil & Gas Sector)			Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Company 8	Company 9	Company 10	Company 11	Company 12	Company 13	Company 14	Company 15	Arithmetic Mean
STRATEGY - *Business Strategy*																		
8	Bus - Q8:	We are developing strategic plans with input from our suppliers to create a shared future.	3	1	3	3	2	1	4	3	3	3	2	3	1	2	2.5	**2.4**
STRATEGY - *Innovation & Technology Management Strategy*																		
13	I&T - Q5:	We have a budget set aside for 'blue sky' innovation projects.	3	4	2	3	2	2	5	4	2	2	3	4	1	3	1.0	**2.7**
ITM SYSTEM - *Identification*																		
21	Ide - Q2:	We include supplier inputs in our technology developments.	3	2	3	3	3	2	3	3	4	5	4	3	1	2	3.0	**2.9**
26	Ide - Q7:	We have a process which allows us routinely to evaluate the results of our technology identification activities.	2	2	2	3	3	2	5	3	3	2	3	3	3	3	2.0	**2.8**
ITM SYSTEM - *Selection*																		
32	Sel - Q3:	We have taken steps to ensure that our technology selection decisions fit with our Business and Innovation & Technology Management strategies.	2	1	4	3	4	2	5	3	3	4	1	3	1	3	2.5	**2.8**
34	Sel - Q5:	Our technology selection process helps us to learn lessons, so that we can improve and make better selection decisions.	3	2	4	2	3	2	3	2	3	3	2	4	2	3	2.5	**2.7**
ITM SYSTEM - *Acquisition*																		
41	Acq - Q4:	We take the opportunity to learn from and share experiences with other organisations ('open innovation').	2	3	3	2	2	2	5	3	3	4	2	4	1	3	1.5	**2.8**
ITM SYSTEM - *Exploitation*																		
57	Exp - Q13:	We seek opportunities to trade in (e.g. sell off) technologies which are not core to our longer term strategic plans.	2	2	NA	3	2	3	4	3	5	3	3	3	1	2	2.0	**2.8**
PEOPLE & ORGANISATION - *Competencies*																		
84	Com - Q3:	We are deliberate in incorporating training and skills development in our new product/service/process projects.	4	2	4	2	2	2	2	2	5	3	2	2	1	1	2.0	**2.3**
85	Com - Q4:	We allocate resources for innovation-related training.	3	2	4	2	2	2	2	2	3	3	1	3	2	1	2.0	**2.2**
86	Com - Q5:	We retain the skills/capabilities required for tomorrow's products/services.	4	3	3	3	3	2	1	2	5	2	1	3	2	1	2.5	**2.4**
87	Com - Q6:	We understand what competences we need to divest to advance our business.	3	2	4	4	3	2	2	3	3	2	1	4	2	2	3.0	**2.6**

Table 3. Selected findings in oil & gas survey – Lower scoring questions

5.3.2 Higher average maturity levels

Table 4 includes a listing of those statements that reflected positive feedback from the questionnaire (arithmetic mean above 3.6). A common trend that stood out is the focus on *project execution*, particularly with respect to new product (or service) development (I&T – Q9, Sel – Q1, Acq – Q2, Exp – Q3, and Exp – Q10), the emphasis on supply chain performance (Exp – Q8) and awareness of the value of intellectual property (Sel – Q8 and Pro – Q1). Existing products that work for oil and gas companies make the backbone of all their engineering development. Building on top of already existing and successful products allows the industry to keep their existing customer base happy with upgrades and allows new customers are coming in, looking at incremental improvement in products. Moreover, it appears there are well defined processes and procedures in place to protect company's intellectual property. In the oil and gas industry due to the cost of research, development, and innovation the product markets are very competitive. Technological advantage is extremely helpful in retaining market share. Therefore, most companies spend a lot of money on intellectual property frameworks to maintain and dominate a market.

As discussed earlier, the surveyed organisations have very good customer relationships (I&T – Q9 and Ide – Q1). This may be credited to the oil and gas industry having knowledgeable field facing personnel with good market intelligence and a better sense of meeting their customers' needs. These field personnel not only talk to customers about their needs,

but also use their knowledge to predict what the customer will need next, and the time after it. Combining these opinions with good business intelligence and analysis provides these companies with a solid basis for being able to come up with products that are superior regarding the value they deliver.

5.4 Future work

Further work includes bringing into the analysis the companies currently carrying out the survey, compiling a summary report for the companies and canvassing further responses from companies on the final results and their reflection of their own performance with respect to the wider picture for the industry.

Innovation & Technology Management Maturity Assessment (Survey of Multi-National Companies in the Oil & Gas Sector)			Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Company 8	Company 9	Company 10	Company 11	Company 12	Company 13	Company 14	Company 15	Arithmetic Mean
STRATEGY - *Business Strategy*																		
7	Bus - Q7:	We are developing strategic plans with input from our customers to create a shared future.	5	1	5	3	4	3	5	4	5	4	3	4	2	5	3.0	**3.6**
STRATEGY - *Innovation & Technology Management Strategy*																		
11	I&T - Q3:	We subject projects during their early stages to an effective rational decision process that assesses whether or not to proceed.	4	2	4	4	4	3	4	4	3	4	3	4	4	5	3.0	**3.6**
17	I&T - Q9:	Our record of new product/service development is satisfactory when compared with our main competitors.	5	3	4	3	3	2	5	4	5	3	3	3	5	5	2.5	**3.6**
ITM SYSTEM - *Identification*																		
20	Ide - Q1:	Customers are a major source of ideas for our new products.	4	1	3	3	3	3	5	4	4	4	3	5	3	5	4.5	**3.6**
ITM SYSTEM - *Selection*																		
30	Sel - Q1:	We are able to draw upon a strong base of technologies, ready for easy incorporation into projects.	4	3	4	3	5	4	3	4	4	4	2	4	3	5	3.5	**3.7**
37	Sel - Q8:	The ability to protect the product/service developed is assessed routinely as part of the Technology Selection process	3	2	4	5	4	3	5	5	4	5	5	5	3	4	2.5	**4.0**
ITM SYSTEM - *Acquisition*																		
39	Acq - Q2:	We prove our new technologies to be stable and manufacturable before inclusion in projects.	3	2	5	4	5	4	4	2	4	5	5	4	3	4	3.5	**3.9**
ITM SYSTEM - *Exploitation*																		
47	Exp - Q3:	Specifications clearly identify factors considered critical for project success so we are able to prioritise the important features for development.	4	1	4	5	3	3	4	3	4	4	4	5	3	5	3.0	**3.6**
50	Exp - Q6:	The new products we develop offer clearly superior value to the customer in comparison with our competitors' offerings.	4	2	4	5	3	2	4	3	5	4	2	4	4	5	4.0	**3.6**
52	Exp - Q8:	We have a program to measure and improve the performance of our suppliers.	4	3	4	3	4	3	4	4	5	4	5	5	3	4	3.0	**3.9**
54	Exp - Q10:	We have a systematic new product or new service development (NPD) process.	4	2	4	4	4	4	5	4	5	2	5	4	2	5	3.0	**3.8**
ITM SYSTEM - *Protection (incl. Knowledge Management)*																		
58	Pro - Q1:	We are very much aware of the value of intellectual property and we have been careful to establish processes and procedures to protect our intellectual property.	5	1	4	5	4	2	5	4	5	5	5	5	3	5	1.0	**3.9**
PEOPLE & ORGANISATION - *Leadership*																		
63	Lea - Q1:	Members of a development project team tend to share the same vision about what to achieve, how to achieve it, and why.	3	1	4	5	N A	2	3	3	5	4	4	5	4	5	4.0	**3.8**
PEOPLE & ORGANISATION - *Organisational Culture*																		
75	Org - Q4:	Cross-functional product development project teams reinforce cooperation across department lines.	4	4	4	5	3	3	5	4	5	3	1	4	2	5	2.5	**3.6**

Table 4. Selected findings in oil & gas survey – Higher scoring questions

6. Conclusions

6.1 Business benefits

The survey of targeted oil and gas companies will run until the end of July, when the analysis will be completed and a report summarising the generic results will be provided to the participants. It is proposed that the ITM Assessment results could, at a high level, support senior technology managers in reviewing whether they believe their organisation has the right strategies, systems and people in place to manage its innovation and new technologies to generate business value.

6.2 Academic benefits

The process of assessing whether the tool is easy to use, comprehensive in coverage and delivers useful information to the company is underway and is expected to result in further refinement of the survey questions and the overall assessment delivery. It is hoped that the approach presented in this paper will help researchers seeking to link organisational performance with specific innovation and technology management metrics under investigation.

6.3 Summary of survey outputs

The analysis of responses to date has revealed some key trends in the oil and gas industry and these average maturity levels are summarised for each assessment category and for each organisation in the paper. In general, higher scoring average maturity levels reveal promising trends while lower average levels reflect issues that may need attention.

The highest variation in the average maturity levels is in the ITM System and at the sector-level the average maturity level is similar for nine of the ten ITM categories. The one notable exception is the People & Organisation – Competencies category. The lower maturity score for the competencies area is perhaps unsurprising given the recent decline of the industry. The data also suggests there is a general disparity in how organisations work with suppliers versus their customers. These variations are probably part of the culture of many organisations as they are quite comfortable engaging in collaborative discussions with their clients, while planned supplier engagement strategies and tactics are often implemented in ways specifically designed to commoditise the value of supplier offerings.

Positive feedback from the questionnaire shows a focus on project execution, particularly with respect to new product development, the emphasis on supply chain performance and awareness of the value of intellectual property. Existing successful products form the backbone of all their engineering development. Building on these allows the industry to keep their existing customer base happy with upgrades and satisfies new customers coming in, in terms of incremental improvement in products. Moreover, it appears there are well defined processes and procedures in place to protect company's intellectual property as most companies seek to maintain and dominate a market. The data shows that the surveyed organisations have very good customer relationships. Field personnel not only talk to customers about their needs, but also use their knowledge to predict what the customer will need. Combining these insights with good business intelligence and analysis provides these companies with a solid basis for creating products with superior value.

6.4 Key takeaways

There are several key observations from this work:

- In complex areas such as innovation and technology management, time efficient and tangible approaches to support managers in formulating their own action plans are welcomed by industry
- Easy to access survey interfaces can enable companies to select where they wish to go into greater depth although they do not replace workshop discussions and face to face interactions
- Companies are interested in comparing themselves to others in the same industry as a driver for performance improvement
- Feedback from industry is a crucial input for the development and refinement of management tools such as the ITM survey
- Building up a wider view of survey outputs could guide future research into building effective toolkits for industry

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