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## Why aren't decisions for oil and gas projects always made the way they "should" be?

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### ABSTRACT

The outcomes of many business decisions do not live up to expectations or possibilities. A literature review of neuroscience and psychological factors that impact decision making has been undertaken, highlighting many reasons why it is hard for people to be good decision makers, particularly in complex and uncertain situations such as oil & gas projects.

One way to diminish the impact of these human factors, is to use Decision Analysis' structured methodology and tools for making good decisions, which have been developed over 50 years. Interviews with senior personnel from oil and gas operating companies, followed up by a larger-scale survey, were carried out to determine whether or how Decision Analysis and Decision Quality are used and why they are used in particular ways.

The results showed that Decision Analysis and Decision Quality are not used as often as the participants think they should be: some 90% of respondents believe they should be used for key project decisions, but only around 50% say that they are used.

Six propositions were tested for why Decision Analysis and Decision Quality are not used more, and three were deemed to be supported:

- Decision Analysis and Decision Quality are not well understood
- There is reliance on experience and judgment for decision-making.
- Projects are schedule-driven.

Further research is proposed to determine the underlying causes, and tackle those with the aim being to improve business outcomes by determining how to influence decision makers to use Decision Analysis and Decision Quality more effectively.

### 1. INTRODUCTION

This paper aims to obtain an understanding of how Decision Analysis (DA) and Decision Quality (DQ) are used for key decisions on oil and gas projects, and to determine why they are not used more effectively. This is further to a previous study (Newman, Begg et al. 2016) examining how Front End Loading is used when making key decisions on oil and gas projects.

Oil and gas projects have often failed to live up to expectations, with higher costs, longer schedules and, most importantly, lower production than forecast (Nandurdikar and Wallace 2011, Preis, Burcham et al. 2014, Whitfield 2014). There are also projects where value has been lost, due to the concept selected (i.e. the development plan chosen) not being the best match for the subsurface structure (Crager 2011). So, why do key decisions for oil and gas projects often miss out on value, or produce outcomes that are systemically worse than predicted?

Before addressing this question, it is important to distinguish between decisions and outcomes. This is explained in the following extract from Making Good Decisions (Bratvold and Begg 2010):

*A good outcome is "a future state of the world that we prize relative to other possibilities." A good decision is "an action we take that is logically consistent with our objectives, the alternatives we perceive, the information we have and the preferences we feel." In an uncertain world, good decisions can lead to bad outcomes and vice versa.*

Unfortunately, the distinction between decisions and outcomes is rarely recognised in everyday language, or in decision reviews and look-backs by oil and gas companies. If a decision results in a bad outcome, the decision is regarded as bad; if a decision leads to a good outcome, the decision is

considered to have been good. Hence it is important to make a distinction between the action (i.e. making the decision) and the role of chance in the resulting outcome, because it allows us to focus on what we can control – the decision.

In this paper we carry out a review of decision making, to provide a background view on the latest thinking on why decisions are not made the way they “should” be. This looks at how people naturally tend to make decisions, and at some practical tools to improve the way decisions are made. Arising from this review we postulate reasons why more effective use is not made of DA and DQ. These are examined in the light of the outcomes of two studies carried out with senior personnel from oil and gas companies: the first a series of interviews, and the second an online survey. Discussion of these results, and determination of which of the propositions are supported by the outcomes of the studies, is then followed by proposals for future research and general conclusions.

## 2. REVIEW OF DECISION MAKING

This section examines the human side of decision making and the reasons, from both a psychological and neuroscience perspective, why decisions may not always be made in an optimum way. It then outlines Decision Analysis and Decision Quality as methods for making better decisions and describes the decision gated framework, and the theory of how it should be applied.

### 2.1. The Human Side of Decision Making

What is decision making? A definition of decision making that applies to oil and gas projects is: The conscious, irrevocable allocation of resources to achieve desired objectives (Bratvold and Begg 2010). More generally and informally: Making decisions is what you do when you don’t know what to do (Howard 1980).

This is succinctly put – if you know what to do, then there is no decision to be made. Interestingly, this was stated when Klein interviewed firefighters (Klein, Calderwood et al. 1986) as part of his research on decision making. Klein asked a fireground commander to tell him about some difficult decisions he had made.

"I don't make decisions, I don't remember when I've ever made a decision."

The fireground commander insisted that fireground commanders *never* make decisions, as it is usually obvious what to do in any given situation.

However, this is a special case. A fireground commander is someone who has frequently experienced similar situations, and who has received quick and reliable feedback on the outcomes of decisions made in those situations. Hence the “decision” has moved from one that requires conscious thought and effort, to one that has become intuitive and automatic.

However, this approach is not suitable for all decisions. Kahneman and Klein spent a long time discussing and debating when it is appropriate to use your intuition and trust your gut feelings (Kahneman and Klein 2009, Kahneman and Klein 2010). Kahneman and Klein agreed that, to increase the likelihood of a good outcome, the following tests should be passed if intuition is to be used (Campbell and Whitehead 2010):

- The familiarity test: Have we frequently experienced identical or similar situations?
- The feedback test: Did we get quick and reliable feedback on the outcomes of past decisions/judgments?
- The measured-emotions test: Is our thinking clouded by emotions we have experienced in similar or related situations? (No = pass.)
- The independence test: Are we likely to be influenced by any inappropriate personal motivations or biased thinking? (No = pass.)

If a situation fails even one of these tests, then we need to regard intuition as potentially unreliable and to strengthen the remainder of the decision process to reduce the risk of a poor outcome.

Oil and gas project decisions - and investment decisions in particular - are very unlikely to pass the above tests. Generally, there are unique features to each project; it is often several years between FID and Ready for Start-Up (RFSU) and even longer before steady production is achieved and feedback is received on outcomes; and when a team has invested significant time and effort on a project it is hard to be dispassionate, and pass the independence test. Hence an intuitive approach is highly unlikely to be appropriate for major decisions on oil and gas projects

### 2.1.1. Two Ways We Make Decisions

Kahneman (2011), describes two different processes that our brains use to make decisions:

- System 1: intuitive and automatic: effortless - Thinking fast
- System 2: reflective and logical: effortful - Thinking slow

Stanovich (2011) originally proposed the terms System 1 and System 2, but now prefers Type 1 process and Type 2 process. He explains the differences and why each are useful:

System 1/ Type 1 Process

- Low on computational power but quick
- Does not allow high accuracy (except in certain, constrained conditions)
- Does not interfere with other ongoing cognition

System 2 / Type 2 Process

- Great computational power
- Enables high accuracy, but
- Slow and interferes with other thoughts and actions

However, humans are cognitive misers and therefore default to Type 1. Evolution has developed our brains to be effective and efficient organs for certain tasks. It enables as many processes as possible to be set to automatic, and keeps its computational power available for 'important' actions. In a decision-making context like oil and gas, however, our brain may need a nudge to remind it which actions are 'important', and hence to deliberately engage Type 2.

### 2.1.2. Heuristics and Biases

We are subject to many heuristics and biases that affect our decision making. Heuristics are simple procedures, "rules of thumb", that provide quick answers to questions. For example, it may be difficult to judge how good a wine is by looking at the bottle, so we may use the heuristic of price, i.e. cheap = poor quality, expensive = good. Heuristic methods are used to speed up the process of finding a solution via mental shortcuts to ease the cognitive load of deciding. Sometimes heuristics provide a satisfactory answer, and sometimes not (e.g. not all expensive wine might be "good" for the decision maker, and vice versa). Problems occur when heuristics cause biases, which are systematic deviations from a standard of rationality or good judgment.

Heuristics and biases result from our tendency to rely on Type 1 processes: our use of heuristics lead to predictable, systematic biases as demonstrated by Tversky and Kahneman's research ; see, e.g. Tversky and Kahneman (1973); Tversky and Kahneman (1974); Tversky and Kahneman (1981); Tversky, Kahneman et al. (1990).

Examples of biases that may affect decision making on oil and gas projects include:

- Availability - prompts us to overestimate the probability of occurrence of recent or most vivid events, i.e. those which are most easily recalled.
- Taking the inside view – An inside view is based upon the specific circumstances of the task using information that is close at hand, and makes predictions based on that narrow and unique set of inputs. The inside view tends to be optimistic. By contrast, the outside view consults the

statistics of similar cases to obtain a comparative forecast, which tends to provide a more realistic prediction.

- Hindsight bias - the effect whereby people think that past events were predictable, or at least more predictable than they really were and, specifically, that they themselves made better predictions than they really had.

Suggestions for helping to overcome these biases include:

- i. Education: Forewarned is forearmed. Although we cannot stop being affected by biases, the more we understand the way our minds work and are aware of the possibility of biases, then the better placed we are to avoid these psychological traps.
- ii. Checklists: Using checklists designed to highlight biases, and help avoid them, can improve decision making, particularly for important decisions such as key project decisions. Examples of checklists to use are the 12 question checklist from 'Before you make that big decision...' (Kahneman, Lovallo et al. 2011), and the identifying red flags checklist from 'Why Good Leaders Make Bad Decisions' (Campbell, Whitehead et al. 2009)

### **2.1.3. Neuroscience**

This section discusses decision making from a neuroscience perspective. Firstly, it will explain the two neural pathways for decision making. Secondly, it shows us how the two processes of pattern recognition and emotional tagging work together to enable us to make intuitive decisions based on our past experiences. Thirdly, it cautions us about trusting our memories and what we believe that we "know" when making decisions.

#### 2.1.3.1. Two neural pathways for making decisions

The two ways we make decisions (i.e. Type 1 and Type 2) can be looked at from a neuroscience perspective. LeDoux (2003) shows that there are two neural pathways in mammals.

- One goes direct from the thalamus (the part of the brain responsible for relaying sensory and motor signals) to the amygdala (the part of the brain that has primary role in the processing of memory, and emotional reactions). It is very quick and has minimal processing. It is an early warning system. For example, if you see a coiled snake-like object ahead of you on the path, it causes you to jump back and stop. This happens before you recognise the object.
- The other pathway goes from the thalamus to the cortex (responsible for processing and thinking) then to the amygdala. It is slower, but with more detailed analysis of information. It causes you to realise that the snake-like object is a coiled rope.

Hence these two pathways are both very useful, and have their place. This parallels the Type 1 / Type 2 thinking, described in 2.1.1 above. Intuition and heuristics (aligned with Type 1) have their place, but not for key decisions on oil and gas projects, where there is uncertainty and complexity, and Type 1 processing is known to produce errors.

#### 2.1.3.2. Pattern Recognition and Emotional Tagging

We depend primarily on two hardwired processes for decision making. Our brains assess what is going on using pattern recognition. We react to that information, or ignore it, because of emotional tags that are attached to our memories. Both processes help us make excellent decisions most of the time. They have survived evolutionary selection because they give us advantages over other animals in the food chain (Mattson 2014, Brusman 2017). But under certain circumstances, both can mislead us, resulting in poor judgments and bad decisions.

Pattern recognition is a complex process that integrates information from as many as 30 different parts of the brain (Campbell, Whitehead et al. 2009). When faced with a new situation, we make assumptions based on prior experiences and judgments. For example, a chess master can assess a chess game and choose a high-quality move in as little as six seconds by drawing on patterns he or she has seen before (Bilalić, Langner et al. 2010). But pattern recognition can also mislead us. When we are dealing with

seemingly familiar situations, our brains can cause us to think we understand them when we do not. For example, if you catch a glimpse of someone walking by, you may instantly ‘recognise’ them as a friend. But when you look again more closely, you realise that it is someone else.

Emotional tagging occurs when the brain stores a memory of an event or action, and it also stores an associated emotion with it. Actions we have previously taken – whether driven by rational decision-making or not – are filed in our brains with emotional tags that serve as markers that can impact subsequent thinking. When we make a decision, our brain will recall past situations that seem similar to the current one and access the emotions that are tagged to them. (Finkelstein, Whitehead et al. 2009)

At the psychological level, there is a long-accepted view that emotionally charged events are likely to be remembered better (Bergado, Lucas et al. 2011). Emotions, such as fear, anger, pleasure and love, are elevated states of arousal that enhance memory and recall of the events occurring during those emotional states. The translation of this into neuroscience has led to the proposal of the ‘emotional tag’ concept, whereby the amygdala is activated by emotionality, resulting in changes to the brain regions involved in forming the memory of the emotional event (Richter-Levin and Akirav 2003). This is an explanation for the availability bias, described in section 2.1.2; emotional tagging causes greater ‘availability’ for such events, which leads to overestimating the likelihood of them occurring.

Under the right circumstances pattern recognition and emotional tagging are very helpful. For example, this is the case with the fireground commanders interviewed by Klein (Klein, Calderwood et al. 1986), as mentioned earlier. They had attended many fires, and going into a fire situation gives you an elevated state of arousal. The experience and feedback they received led to pattern recognition and associated emotional tags. Hence, as far as they were concerned they just “knew” what to do.

Compounding the problem of high levels of unconscious thinking is the lack of checks and balances in our decision making (Campbell, Whitehead et al. 2009). Our brains do not naturally follow the optimal model: define the objectives, determine the alternatives, and assess each alternative against each objective. Instead, we use pattern recognition, which takes cues from the environment to recognise the situation, and arrive at a decision to act or not, guided by emotional tags. The two processes happen almost instantaneously. Indeed, as Klein (1998) shows, our brains leap to conclusions and are reluctant to consider alternatives, and we are particularly bad at revisiting our initial assessment of a situation—our initial frame.

#### 2.1.3.3. Other lessons from neuroscience

Burton (2008) describes a number of reasons why we should be cautious about trusting our memories and our “knowledge” when making decisions. These include:

- We have defective memories (Loftus and Loftus 1980). The study carried out by Neisser on the Space Shuttle Challenger disaster (Neisser and Harsch 1992) demonstrates this. Neisser asked 106 students to write down their memories of what happened, where they were and how they felt about the event and details of the event. They did this one day after the disaster and 2 ½ years later. 25% were strikingly different, 50% had lesser errors, less than 10% had all details correct. Prior to being handed their original scripts, most students presumed their memory was correct. This is a related effect to the hindsight bias described above, which results because our ‘memory’ of an event is updated over time as we gain new information, which we did not have at the time.
- We are fooled by the “feeling of knowing”, i.e. we feel we know things that are objectively false. (Koriat 2000). The feelings of knowing, correctness, conviction and certainty are not deliberate conclusions and conscious choices. This feeling of knowing can be spontaneously activated by direct stimulation of an area of the brain or by electrical manipulation, but it cannot be triggered by conscious thought. (Maril, Simons et al. 2005)

Wilson shows that each human mind operates largely out of view of its owner (Wilson 2002, Wilson and Bar-Anan 2008). This may be because that was the way it evolved initially, and because that is the way it works best, under many circumstances. Without such a quick and effective way of understanding and

acting on the world, it would be difficult to survive. We would be stuck mulling over every little decision, such as whether to put our left or right foot forward, as the world sped by. However, as a result we are strangers to ourselves, unable to observe the workings of our own minds.

This means that: we believe that we know ourselves; we believe falsehoods to be facts; we believe that we are making good judgments; and we “know” when we have made a good decision - when none of this is, necessarily, the case (Kida 2009). This reinforces the importance of taking an ‘outside view’, to avoid bias in our decision making.

#### **2.1.4. Why it is hard to be a good decision maker**

The above sections provide some of the reasons why it is hard to be a good decision maker. It is not because we are not smart, it is because we are human. Our brains have evolved to be efficient, to take shortcuts and trust our intuition. Under the right circumstances this is very useful. But for complex decisions under uncertainty, it is not appropriate.

There may also be motives and drivers that conflict with what would otherwise be a good decision. Decisions to proceed with projects may be driven by commercial, political or social imperatives, which may be given inappropriate weighting, inconsistent with the principal decision maker’s goals. (Preis, Burcham et al. 2014). In addition, there may be misalignments between company objectives and personal incentives (Begg, Bratvold et al. 2003).

It is even harder to be a good decision maker for oil and gas projects, as there are additional factors that apply. As discussed in section 2.1, the requirements for relying on our experience and judgment include that we have frequently experienced identical or similar situations, and we have received quick and reliable feedback on the outcomes of past decisions/judgments. However, this is not the case for oil and gas projects which take a long time, and the projects are generally dissimilar. So, the learning is different on each one. We do not get quick feedback, as there is a significant time between the final investment decision and the outcomes in terms of cost, time and production attained. The feedback is also not reliable, as our memories are revised by subsequent experience (Budson and Price 2005). The longer that time passes, the more likely it is that memories will change. Hence the feedback we receive may be inaccurate, and may also be affected by the hindsight bias.

In addition, a significant number of projects are schedule driven, which means that priority is placed on achieving schedule over other objectives (Walkup and Ligon 2006). Hence the desire to pass through decision gates ‘on time’ overrides the desire to ensure readiness to make a decision, which may lead to decisions being taken based on inaccurate, irrelevant or incomplete information.

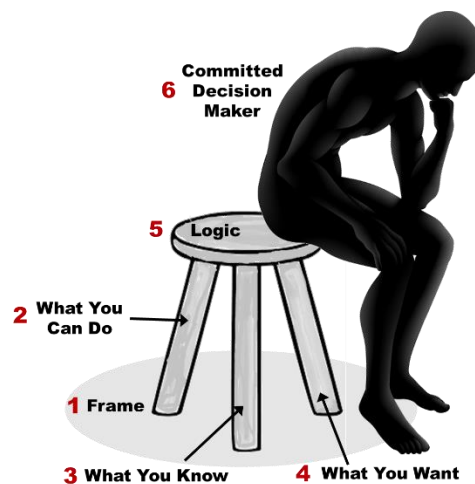
One way of diminishing the impact of these factors is to take a structured approach, as discussed in the next section.

## **2.2. Decision Analysis**

The term Decision Analysis (DA) was coined in 1966 by Howard (1966) and, since then, a plethora of books (such as: Goodwin 2004, McNamee and Celona 2005) and research papers (such as: Brown 1970, Keeney 1982, Thomas 1984, Howard 1988, Davidson 2001, Lev and Murphy 2007) have been written on it.

DA is the discipline of making good decisions, and describes how people should logically make decisions. It is a structured approach for creating and evaluating choices, using a pragmatic application of tools and processes tailored to the needs of the decision. It is a methodology that provides the means for a dialogue between the decision maker and the project team so that uncertainties, concerns, expectations, assumptions and meaning can be brought into the open and clarified, leading to a compelling course of action.

The fundamental aspects of DA can be represented using the image of the man on the three-legged stool (Fig. 1) as adapted from Howard (2007).



**Fig. 1 The six elements of Decision Analysis**

Where the stool is placed represents the frame: what is the correct background, setting, and context for the decision? Indeed, what is the decision to be made? The frame is an important choice. If your car breaks down and is beyond repair, then framing the decision as buying a replacement car is different from framing it as looking at alternative modes of transport. This affects all three legs: what you want, what you know and what you can do. If the frame is buying a replacement car, you will be considering, for example, what features you want from a car, whether you want to buy new or second hand, what types of car you wish to consider and how much you are willing to pay. If the frame is looking at alternative modes of transport, you will be considering: where you might want to travel to, how quickly you want to get there, what types of transport you wish to consider (e.g. bus, train, bike, car, walking, taxi), how much flexibility you want, what would the cost be – in terms of time and money.

The legs of the stool represent the three elements of any decision:

- Objectives: What you want, i.e. what is valuable to you, and how you would trade-off between conflicting values.
- Information: What you know, how well you “know” it (and clarity on what you don’t know).
- Alternatives: What you can do – are there creative, doable alternatives? If there are no alternatives, then there is no decision to be made

These are held together by the seat, which is the sound reasoning to determine which alternative best meets the objectives of the decision maker.

Then commitment is required to move the decision to action; the best decision being useless if it is not implemented.

Although it has been around for 50 years, the uptake of DA has not been good. Keeney (2004), one of the pioneers of DA with over 40 years of experience, estimates that of 10,000 decisions:

9,000 are no brainers or of small consequence (e.g. what shall I have for lunch, what shoes shall I wear?)  
1,000 are worthy of careful thinking, but

- Only 40 get systematic thought. Of these
  - 30 are resolved using qualitative concepts of decisions analysis to guide clear thinking about the problem, objectives and alternatives
  - 10 are resolved using quantitative analysis

By contrast, Keeney indicated how he thought the 1,000 decisions requiring careful thought *should* be made

- 1,000 are worthy of careful thinking
  - 750 should be resolved by clear thinking consistent with DA

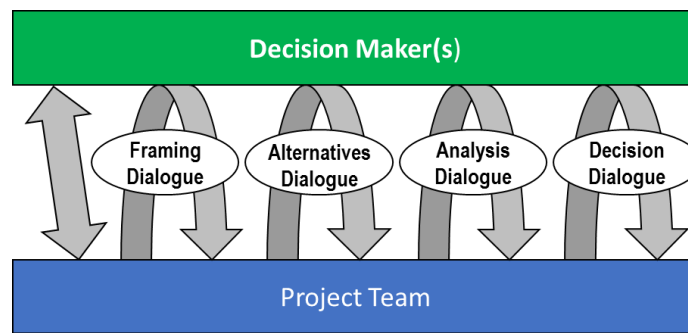


- 200 should be resolved using partial DA (i.e. explicitly addressing specific complexities of the decision. This may involve writing out a clear list of objectives, determining relevant probabilities, or specifying a value trade-off)
- 50 should be resolved using complete DA (i.e. all 6 elements of DA should be rigorously addressed, to ensure that the best decision is made and will be acted upon)

Keeney is not saying that partial or complete DA should be used for all decisions. He estimates that 90% of decisions are either no-brainers or have small consequences. The principles of DA should be used for the rest, but only 20% of these should use partial DA and 5% complete DA. However, this is still a much larger percentage than currently use DA, according to Keeney's estimates.

All major oil and gas project decisions have high levels of uncertainty; the decisions are generally complex with multiple, often competing, objectives; and they have high consequence outcomes. Therefore, according to Keeney's advice, they should use complete DA. Other oil and gas project decisions, with lower levels of uncertainty and complexity, would be best handled using partial DA, or the principles of DA.

### 2.2.1. Dialogue Decision Process



**Fig. 2 The Dialogue Decision Process**

The Dialogue Decision Process (Fig. 2) was developed to bring the power of Decision Analysis to situations where the decision maker is not the same person who is doing the analysis. It has been named the Dialogue Decision Process because of its emphasis on systematic dialogue between the two groups: the decision maker(s), and the team that develops the basis for the decision (McNamee and Celona 2005).

Although the decision makers and the project personnel all work together as one team, there are distinct roles for each of these

- Decision makers: "Declare" decisions, approve frame, provide objectives and trade-offs, and make decisions
- Project team: Develop frame and alternatives, assess information, evaluate alternatives, plan implementation

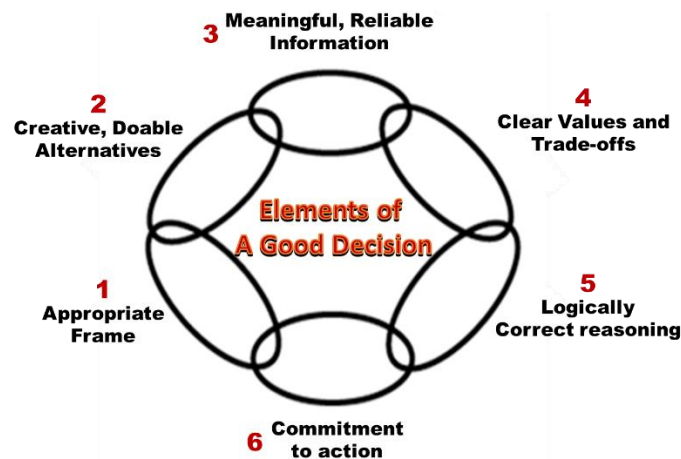
Unfortunately, the Decision Dialogue Process does not always occur. Instead, project teams sometimes adopt an advocacy position, and promote their selected alternative to the decision maker, as shown in Fig. 3.



**Fig. 3 The Advocacy Process**

Walkup and Ligon (2006) cite the advocacy process as one of the key failure modes for oil and gas projects, with advocacy occurring both internally within the operator and externally with partners and other stakeholders.

### 2.2.2. Assessing Decision Quality



**Fig. 4 The Decision Quality chain**

If we want to know how to make good decisions, a first step is to define what “good” means. This is where we use Decision Quality (DQ). The DQ chain (Fig.4) has the same six elements as those of DA (Fig. 1). The DQ chain was developed in the 1980’s (Spetzler 1991), and expanded upon in the book by Spetzler, Winter et al. (2016). It was originally presented in the form of a chain, as this signifies that all six elements are important, and that the quality of a decision is only as good as its weakest link. However, many companies now present DQ in the form of a DQ wheel.

The six elements of DQ are:

1. Appropriate Frame: What is the issue being addressed, including: what is the purpose in making the decision, what is the scope, and how will the decision be approached?
2. Creative, Doable Alternatives: Is there a range of creative and compelling alternatives?
3. Meaningful, Reliable Information: Is all relevant information available for the decision? Is it trustworthy and unbiased?
4. Clear Values and Trade-offs: Is there clarity on the values that the decision will be assessed against? Is there clarity on the trade-offs between values?
5. Logically Correct Reasoning: Is sound reasoning being applied, i.e. which alternative gives you the most of what you want, based on the information that you have?

### 6. Commitment to Action: Is there commitment to action the decision?

The quality of a decision is assessed by reviewing the six elements in turn, to see if they each achieve the 100% rating required for a quality decision. Note that 100% is not perfection. As explained in Spetzler, Winter et al. (2016):

*100% is the point at which the cost of further improvement – in terms of effort and delay – isn't worth it. At 100%, the value from improving the requirement is outweighed by the cost. So, 100% is not perfection; it is a judgment that the incremental cost of improvement is greater than the additional value that would result.*

Hence DQ should be assessed at the start of a phase to determine what work needs to be completed to achieve 100% for each element. The work should then be completed, and another assessment of DQ should be made prior to the decision, to confirm that 100% has been achieved.

In summary, DQ is a simplified way of applying the principles of DA, and a way of assessing the readiness for making a decision. DQ is a pragmatic tool; it directs you to do only the work that has the potential to change the decision.

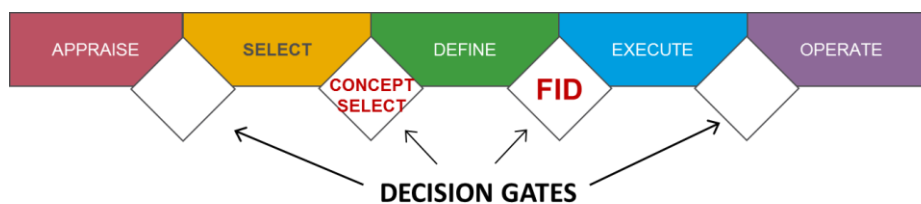
### 2.2.3. Barriers for Wider Adoption of Decision Analysis

Karakaya (2012) reviewed the literature on DA tools, and states that it suggests three broad categories of barriers to wider adoption of DA:

- Theoretical Foundation: complex theoretical foundation, varying solution techniques, lack of understanding of underlying assumptions and applicability
- Practical Applicability: computational challenges, absence of available tools to produce required inputs, organizational difficulties
- Perceived Lack of Value: unfavourable cost/benefit posture, unproven in practical domain, absence of industry acceptance.

These have been considered in developing the propositions for why DA and DQ are not used more, in section 3.

### 2.3. Decision Gated Framework



**Fig. 5 A typical decision gated framework**

While uptake of DA in oil and gas has been limited, most oil and gas companies use a structured process for creating value from opportunities and projects, known as a decision gated framework. These processes typically have five phases (Fig. 5), focused as follows:

- Appraise: Determine if this an opportunity worth pursuing, and whether there is a real understanding of what is being initiated and the commitment required.
- Select: Ensure that an adequate range of alternative concepts has been identified, and that the best alternative has been selected.

- Define: Define the scope in sufficient detail to enable an accurate estimate of cost and schedule to be made, and uncertainties and risks to be understood to enable a Final Investment Decision (FID) to be made. Note: FID is also known as Authorisation for Expenditure (AFE) or sanction.
- Execute: Implement the project execution plan to develop an operating asset consistent with scope, cost and schedule.
- Operate: Operate the asset and realise and optimise the project value.

Each phase is separated by a decision gate. In addition to the questions specific to each phase, there are two generic questions to be answered by the company (or the investors) at each decision gate.

1. Are we ready to proceed to the next phase? Technical focus: Has all the work been completed to provide the information necessary to make a quality decision?
2. Do we want to proceed? Business focus: Is there value in proceeding, taking account of uncertainties, risks and opportunities?

These are sequential steps; step 2, 'Do we want to proceed?' should not be addressed until readiness to proceed has been confirmed at step 1.

For step 2, 'Do we want to proceed?', there are four options: proceed to the next phase, stop the project, put it on hold, or recycle and carry out further work before coming back to the decision.

The concept behind the decision gated framework is that each gate is firmly closed until the decision has been made. No work is to be started on the next phase unless a decision to proceed has been made at the decision gate. Approval to proceed at a decision gate is only approval to go to the end of the next phase, not to continue the project through to the end. During the next phase, further information is gathered, which will inform the decision at the end of the phase as to whether there is still value in proceeding further.

For this paper, the key decisions referred to are those at the end of the first three phases in the decision-gated framework, i.e. the decision at the end of the Appraise phase, the Concept Select decision and the Final Investment Decision. Collectively, the work undertaken during these first three phases is known as Front End Loading (FEL).

There is a different focus for each of these decisions. At the end of the Appraise phase, the key question being asked is: Is there a business justification to progress the opportunity? Typically, this will be about the expected value that the opportunity would provide, although there may be other, strategic factors. One of the purposes of the decision gated framework is the early cancellation of opportunities and projects which do not add value. It is obviously better to stop an opportunity at the Appraise stage, rather than using further time and resources during later phases before stopping it. However, circumstances change; opportunities which look promising at the Appraise stage, may turn out not to add value when they have been developed further in the Select or Define phases.

The focus for the Concept Select decision is: Have all feasible concepts been identified and has the best concept been selected? This is the phase that has most impact on value creation or destruction. Value can be destroyed in two ways. Firstly, value can be destroyed by not looking at a wide enough range of alternatives. If range of alternatives is too narrow, and a better concept is missed out, then value will be lost. Secondly, value can be destroyed by making the selection early, before sufficiently accurate information is available to inform the decision. This is the phase where complete DA is particularly beneficial for developing value-creating opportunities.

The focus for the Final Investment Decision is: Is there value in proceeding with this project? Ideally, this would be a two-stage decision. Firstly, are we ready to proceed to the Execute phase? I.e. has sufficient FEL been carried out to inform the decision, and have the appropriate uncertainties, risks and opportunities been taken into consideration, to provide confidence that the predicted project outcomes

are likely to be achieved? Secondly, is there value in proceeding to the Execute phase based on the predicted project outcomes.

### 2.3.1. How DQ and DA fit within the Decision Gated Framework

One of the principles of the decision gated framework is that all the work and activities in a phase should be decision-driven, not activity driven. This means that the only work carried out during the phase should be that required to provide the information necessary for making a good decision, which should be determined by making an assessment of DQ at the beginning of the phase. There should not be a 'standard' list of activities that are completed during the phase. A 'standard' list of activities may help as a checklist for consideration; but whether an activity is necessary, and what level of detail required, is dependent upon whether it has the potential to influence the decision

DQ is used for assessing the work required to be carried out during each phase of the decision gated framework, and then for checking whether it has been completed satisfactorily prior to making the decision. At the beginning of a phase, there needs to be clarity on the context of the decision to be made. On what basis will the decision maker make the decision? What is the frame, the context for the decision? What measures will be used by the decision maker to determine whether to proceed or not? What level of risk and uncertainty are acceptable to the decision maker? Once there is clarity on these, then the activities to be completed during the phase, and the level of detail required for these, can be determined.

At the end of the phase, the readiness to proceed is determined by assessing the 6 elements of decision quality to see if they have been completed to the level of detail required. Only then should the step 2, "Do we want to proceed?" be addressed.

### 2.3.2. Reasons for Decision Gated Framework failures

Unfortunately, there are often gaps between the theory of the decision gated framework and how it is applied in practice. The 2006 paper on the Good, the Bad and the Ugly of the Stage-Gate Project Management Process (Walkup and Ligon 2006) provides a number of reasons why the decision gate framework fails in practice. These include:

- The Decision Review Board (DRB) not owning DQ, i.e. the DRB do not ensure that all stakeholders align with DQ, and do not motivate and inspire project teams to stay focused on DQ through each phase of the decision gated framework. *(Note: There may not be a DRB and DQ may not even be a consideration for the decision maker).*
- Focus more on schedule than value creation - "It is not uncommon for over 50% of projects to be fast-tracked."
- Project teams overplaying their role and develop an advocacy position, believing they should make a recommendation to be approved by the DRB, rather than providing information for the DRB to assess and draw their own conclusions.
- Most stage gate process implementations have become activity driven rather than decision driven.
- Value is lost as there is a strong motivational bias for teams to focus on project approval, as opposed to value maximisation. Teams are rewarded for completion, usually the faster the better.

## 3. PROPOSITIONS

Arising from the review of decision making in Section 2, we have developed propositions for the reasons why DA and DQ are not used more, or are not used more effectively:

- 1) DA and DQ are not well understood.
- 2) DA and DQ are perceived to be complicated.
- 3) People rely mainly on experience and judgment for decision making.
- 4) Projects are schedule driven.
- 5) There is a lack of clarity on the requirements of the decision maker.
- 6) DQ is not assessed at the start of the phase to inform the work to be done.

To determine which, if any, of the above propositions are valid we have carried out two studies with senior personnel from oil and gas companies: the first was a series of interviews, and the second was an on-line survey. These studies are discussed in the following sections.

## **4. INTERVIEWS**

### **4.1. Method**

The first phase of this research was by interview, using mainly open-ended questions to elicit from the participants their understanding of DA and DQ, their experience of using them, and to find out how they are being applied in their company.

This was, primarily, an exploratory phase, to help determine questions to be asked for the survey in the second phase.

#### **4.1.1. Participants**

The participants targeted were oil and gas personnel who were involved in developments and projects in a variety of roles (e.g. decision makers, development managers, analysts, subject matter experts). They were initially targeted for their areas of expertise, using connections known to the researchers. After being interviewed, they were asked to suggest others who might be suitable, with a focus on obtaining participants from a diversity of companies, organisation levels and role types.

Interviews were carried out with 34 senior personnel from the oil and gas industry. These were all highly experienced personnel, having an average of 29 years of industry experience ( $\sigma = 8.8$  years) and 24 years of experience in opportunities and project ( $\sigma = 7.5$  years).

The participants were mostly Australian based, with just two based in the UK. The interviewees were from six companies; two of which are global majors; three are mid-sized, and one smaller oil and gas company. Around two-thirds (23 of 34) of participants came from two of these companies. The participants were from a range of organisational levels, and have been categorised into three groups: professionals, managers and executives ( $n = 4, 19$  and  $11$ , respectively). The professionals were generally experts in a technical discipline. The executives were personnel at the vice president—or equivalent—level.

#### **4.1.2. Materials**

The interview questions were in a semi-structured format to allow for follow-up questions to be used to clarify answers, and for further exploration of areas of interest. There were five questions on the interviewee's experience in the oil and gas industry, five questions on how projects and decision making are dealt with in their company, ten questions to probe their understanding and use of DA, and six questions to probe their understanding of DQ.

The full structure of the interview and list of questions are given in Appendix 1.

### 4.1.3. Procedure

The length of the interviews ranged from 30 minutes to just over an hour, with a typical length of around 45 minutes. The interviews were audio-recorded and then transcribed, or interview notes taken when companies requested that these were not to be audio-recorded, which was the case for ten interviews. The interview questions were about the processes and tools used to make decisions on projects, and not about the details of the projects themselves. The following measures were taken to further protect companies and ensure anonymity:

- The interview notes were reviewed by the researchers, who removed any information that they considered could lead to an individual or company being identified, or could be commercially confidential or sensitive.
- The draft interview notes were then sent to the participant to edit as they considered necessary.

In practice, the participants generally agreed with the interview notes, and there was very little editing by them.

All the interviews conducted have been included in the analysis; none were rejected.

At the end, interviewees were asked to do an assessment of their level of knowledge and understanding of DA and DQ using the template shown in Fig. 6.

#### Assessment of knowledge of decision making processes

	<b>Low</b>	<b>Basic</b>	<b>Fair</b>	<b>Good</b>	<b>Expert</b>
	<i>Little or no knowledge and understanding in this area.</i>	<i>Basic knowledge and an understanding of simple techniques and concepts</i>	<i>Sound knowledge and understanding of the main areas of content. Have used for simple applications.</i>	<i>Thorough knowledge and understanding of most areas of content. Have used this for a range of applications.</i>	<i>Extensive knowledge and understanding. Use this all the time, and promotes its use</i>
<b>Decision Quality</b> <b>YOU</b>					
<b>DECISION MAKER*</b>					
<b>Decision Analysis</b> <b>YOU</b>					
<b>DECISION MAKER*</b>					

**\*DECISION MAKER = Your assessment of the level of knowledge and understanding of a typical decision maker in your organisation**

**Fig. 6 Template for interviewees to assess their understanding of DA and DQ**

The interviewees selected from five options: low, basic, fair, good and excellent. The descriptors to define the options are shown in Fig. 6. In addition, they were asked to assess the level of knowledge and understanding of a typical decision maker in their organisation. A significant number (9 out of 11) of executives interviewed said they were decision makers themselves. Each of these were asked to assess a more senior decision maker, such as the CEO.

The researchers carried out their own assessment of the level of knowledge and understanding of the interviewees. Scoring rubrics were developed to make this as objective as possible. The rubrics used by for assessment of knowledge and understanding of DA and DQ are shown in Appendix 2.

## 4.2. Results

The interviews were aimed primarily at obtaining an understanding of the knowledge and use of DA within participants’ companies and to help determine questions to be asked to a larger audience in the second phase survey for quantitative evaluation.

However, the interview answers also provided information which permitted some limited quantification and simple statistical analysis, to help assess two of the propositions for why DA and DQ are not used more. This is shown below.

**4.2.1. Proposition 1): DA and DQ are not well understood.**

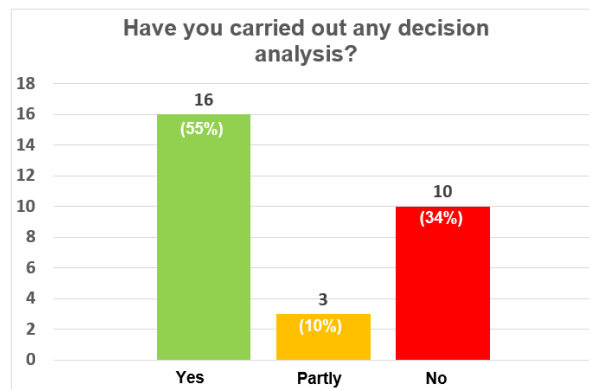
There are several ways in which this proposition has been addressed:

- The answers by the interviewees to the question on whether they have carried out any Decision Analysis.
- The descriptions given to the question on Decision Analysis means to them.
- The answers given to the questions on familiarity with the DQ chain or wheel.
- The comparisons between the self-assessments and the researchers’ assessments on their understanding of DA and DQ.

The results are presented below.

**4.2.1.1. Have you carried out any Decision Analysis?**

The interviewees answers to the question on whether they have carried out any Decision Analysis have been reviewed and assigned into three categories: ‘Yes’, ‘No’ and ‘Partly’. This is presented in bar chart form in Fig. 7.



**Fig. 7 Interviewees answers on carrying out Decision Analysis**

It was generally evident which category the individual responses should be assigned to. Some examples of responses in the three categories are given below

Yes

- Yes, lots of them.
- Yes, and I have helped people frame decisions. I’ve used the SDG (Strategic Decisions Group) framework for decision analysis.

Partly

- In the past, I’ve done things like event trees which look at all possible scenarios. I think that’s an example of decision analysis.



- I have (for) very small components. I haven't, in a major decision. I've looked at them and I've sometimes challenged the decision analysis that have been done. But, I haven't gone into the detail, I haven't had the responsibility where I've had to drive the decision analysis.

#### No

- I haven't done it myself, directly. I've provided input into the process but I have not done it myself.
- Not formally – I have not used any formal structures.

Fig. 7 shows that just over a half of the interviewees have carried out DA, 10% have contributed towards a DA, and a third have not carried out DA.

Note: Five of the 34 interviewees were not asked this question, mainly due to time constraints, hence the above analysis is based on 29 responses.

#### 4.2.1.2. What does Decision Analysis mean to you?

There was a wide range of answers to the question: 'What does Decision Analysis mean to you?'. Some focused on the purpose of DA, e.g.:

- *It means a rigorous disciplined process of working out what options are going to meet your objectives.*

Others gave more of a high-level description, e.g.:

- *The science and process of how you make a decision, both the psychology and the process.*

Some described the components of DA (i.e. the 6 elements of the man on the stool or the DQ chain), e.g.:

- *There are five or six different dimensions to making a good decision and, to me, the Decision Analysis is around assessing those dimensions and determining whether you've considered all the aspects. So, whether you have framed it correctly, whether you've got the relevant information, whether you are committed to action, whether the work is complete to enable you to make a decision.*

Others focused on the tools and techniques, e.g.:

- *It means the techniques and methodology for making decisions, generally under uncertainty, and understanding the quality of these. It's about the tools and the statistical methods you have.*

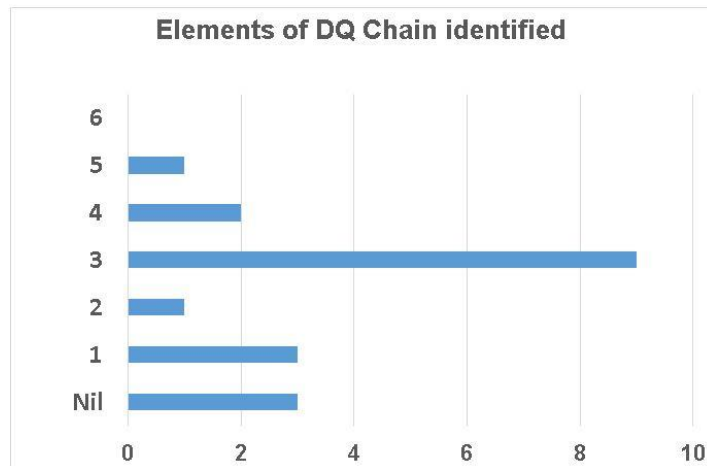
Some were not familiar with DA, e.g.:

- *I'm not sure what Decision Analysis is. I know what decision-making is – when you actually make a decision. But I do not know what Decision Analysis is.*

The full range of answers is given in Appendix 3.

#### 4.2.1.3. Familiarity with the DQ chain or wheel

19 of the interviewees said they were familiar with the DQ chain or wheel, 15 were not. Those who said they were familiar were asked to name the 6 elements of the DQ chain. 3 out of these 19 people were unable to identify any elements. Nobody identified all 6 elements. The average number of elements identified (by those familiar with the DQ chain) was 2.4 out of 6, i.e. 40%. Further details are shown in Fig. 8.



**Fig. 8 No. of elements of the DQ chain identified**

**4.2.1.4. Understanding of DA and DQ - comparisons between self-assessments and researchers’ assessments**

Figs. 9 and 10 show the comparisons between the self-assessments and the researchers’ assessments of the interviewees understanding of DA and DQ. The S for Self-Assessment and the R for Researcher Assessment are positioned at the mean values. The ranges from minimum to maximum are indicated by the horizontal lines. The 25<sup>th</sup> and 75<sup>th</sup> percentiles are shown as vertical lines.

The self-assessments are higher than the researchers’ assessments by about half a category for DA, and almost a full category for DQ.

The assessments by the researchers show that only 25% of participants have a good understanding of DA, and less than 25% have a good understanding of DQ. Hence this is evidence to support the proposition that DA and DQ are not well understood.

**Assessment of Understanding of Decision Analysis**

	<b>Low</b> <i>Little or no knowledge and understanding in this area.</i>	<b>Basic</b> <i>Basic knowledge and an understanding of simple techniques and concepts</i>	<b>Fair</b> <i>Sound knowledge and understanding of the main areas of content. Have used for simple applications.</i>	<b>Good</b> <i>Thorough knowledge and understanding of most areas of content. Have used this for a range of applications.</i>	<b>Expert</b> <i>Extensive knowledge and understanding. Use this all the time, and promotes its use</i>
<b>All</b>					
Self-Assessment				S	
Researcher Assessment			R		
<b>Executive</b>					
Self-Assessment				S	
Researcher Assessment			R		
<b>Manager</b>					
Self-Assessment				S	
Researcher Assessment			R		
<b>Professional</b>					
Self-Assessment			S		
Researcher Assessment		R			

**Fig. 9 Comparison of understanding of Decision Analysis**

**Assessment of Understanding of Decision Quality**

	<b>Low</b> <i>Little or no knowledge and understanding in this area.</i>	<b>Basic</b> <i>Basic knowledge and an understanding of simple techniques and concepts</i>	<b>Fair</b> <i>Sound knowledge and understanding of the main areas of content. Have used for simple applications.</i>	<b>Good</b> <i>Thorough knowledge and understanding of most areas of content. Have used this for a range of applications.</i>	<b>Expert</b> <i>Extensive knowledge and understanding. Use this all the time, and promotes its use</i>
<b>All</b>					
Self-Assessment				\$	
Researcher Assessment			R		
<b>Executive</b>					
Self-Assessment				S	
Researcher Assessment			R		
<b>Manager</b>					
Self-Assessment				\$	
Researcher Assessment			R		
<b>Professional</b>					
Self-Assessment			S		
Researcher Assessment		R			

Fig. 10 Comparison of understanding of Decision Quality

**4.2.2. Proposition 5): There is a lack of clarity on the requirements of the decision maker.**

Fig. 11 shows analysis of answers given to the following questions:

- Is time spent upfront in framing the decision, e.g. providing clarity on the boundaries, the objectives and the criteria to be used by the decision makers?
- Is much time spent with the decision maker(s) to clarify their requirements, both upfront and during each phase?

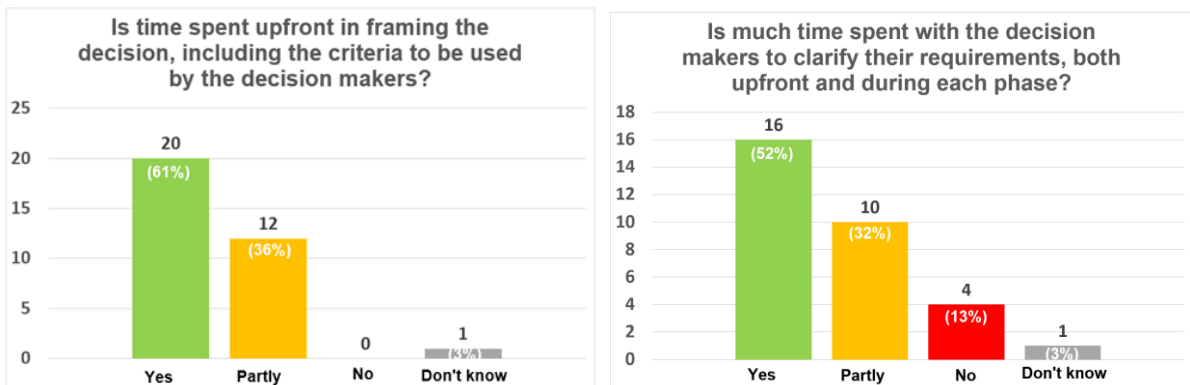


Fig. 11 Interviewees answers on clarity of decision makers' requirements

Looking at Fig. 11, most of the participants consider that time is spent framing the decisions and clarifying requirements with the decision makers. If this is the case, there should be clarity between the project team and the decision maker on the requirements for the decision. Hence the proposition is not supported.

## 5. SURVEY

### 5.1. Method

The second phase of research was an on-line survey, designed to enable quantitative analysis. The survey results, in conjunction with the first stage interview outputs, were used to gain an understanding of why Decision Analysis is not better utilised for major decisions on oil and gas projects.

#### 5.1.1. Participants

The participants were, again, oil and gas personnel from operating companies involved in developments and projects in a variety of roles (e.g. decision makers, development managers, analysts, subject matter experts). These were selected by convenience and snowball sampling (i.e. specific people were targeted for their areas of expertise, connections to the researchers and amenability for participation. They then suggested others in similar areas).

The invitation to take part in the survey was sent out by the researchers to 123 people in ten oil and gas companies, including the 34 people who took part in the interviews. Several people emailed stating that they had forwarded the survey invitation to others.

78 people participated in the survey, 49 of whom gave their email addresses. Of those 49, 11 were positively identified as having been interviewees. Pro-rating (i.e.  $78 \times 11/49$ ) suggests that around 50% of the interviewees are likely to have also completed the survey.

The participants were, again, mainly based in Australia, with only 4 out of the 49 who gave their email addresses being based overseas - three in the UK and one in Canada.

#### 5.1.2. Materials

The questions were in the form of response-scale ratings regarding the participant’s knowledge, opinion about, and use of specific aspects of FEL and DA. The survey was designed to be quick to complete, to encourage participation. It asked 4 demographic questions and 20 questions on decision-making: 6 on FEL; 5 on Decision Analysis; 5 on Decision Quality; and 4 general decision-making questions. A list of the survey questions is given in Appendix 4.

The questions on decision making were written as a statement, and the participants had to state whether they agreed or disagreed with the statement, with a range of options from Strongly Agree to Strongly Disagree.

Fig. 12 is an example of how the questions were set out in the survey:

\* 7. I regularly check decision quality prior to making decisions.

	Strongly agree	Agree	Slightly agree	Neither agree nor disagree	Slightly disagree	Disagree	Strongly disagree
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Fig. 12 Example of how the questions were set out in the survey**

### 5.1.3. Procedure

A link to the survey was sent out to potential participants as part of an email of introduction, along with an information sheet on the research. Phone calls were also made to potential participants, to increase the likelihood of them participating.

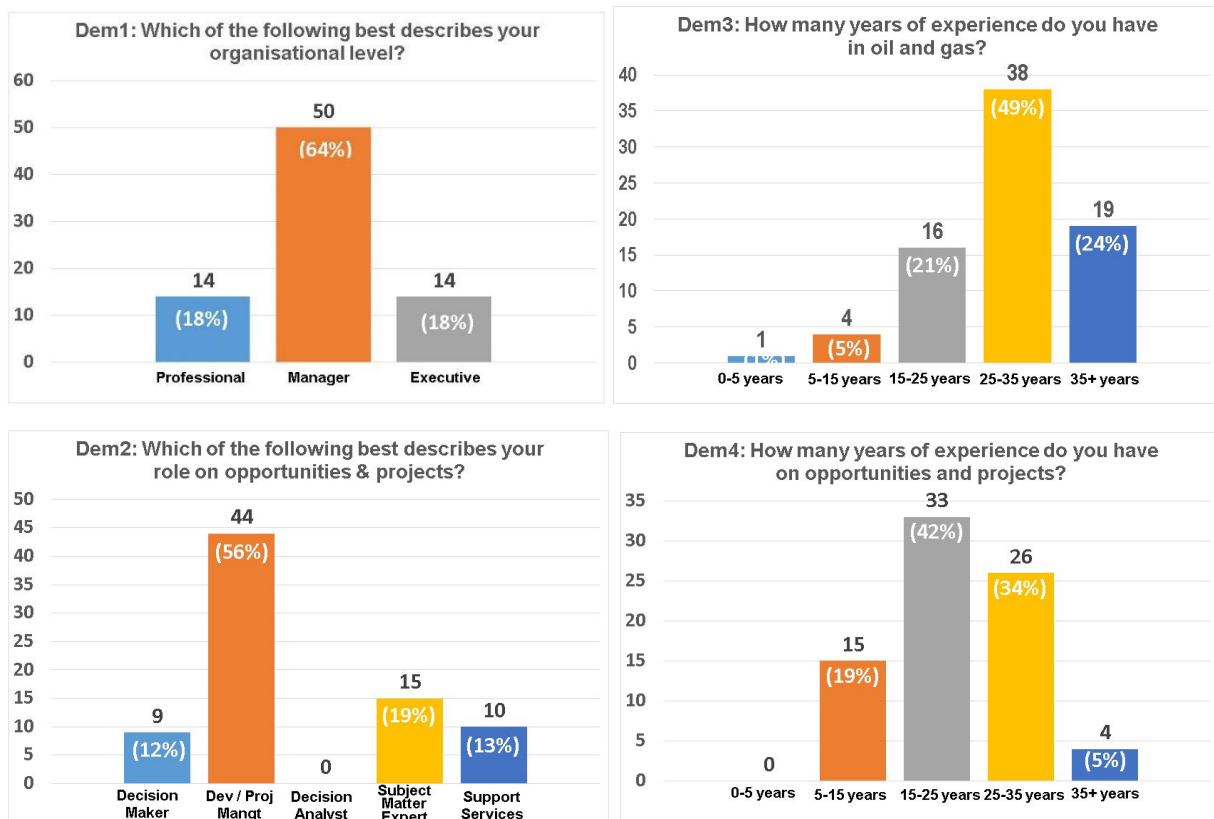
The survey participants were offered a copy of any resulting published papers.

## 5.2. Results

To assist with analysis of the survey results for the decision-making questions (i.e. for everything except the demographic questions) the strongly agree (StA), agree (A) and slightly agree (SIA) figures have, in some cases, been aggregated into one ‘broadly agree’ figure, and the strongly disagree (StD), disagree (D) and slightly disagree (SID) figures have been aggregated into one ‘broadly disagree’ figure.

### 5.2.1. Demographic questions

The survey results for the demographic questions are shown in Fig. 13.



**Fig. 13 Survey results – Demographic questions**

Dem1 shows that almost two-thirds of participants were at managerial level, with the remainder equally split between the executive and professional levels.

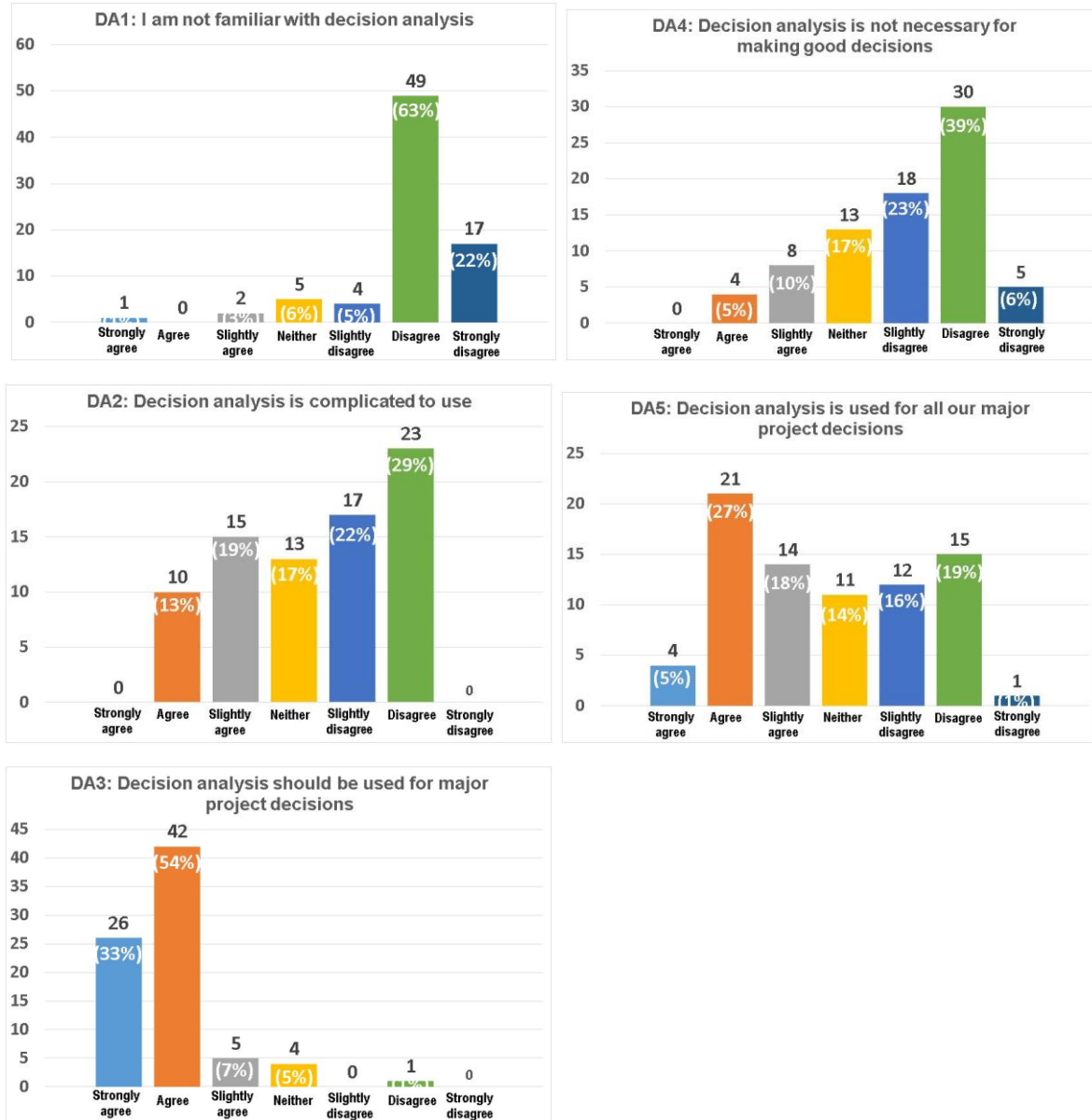
Dem2 shows that over half of the participants are involved in development or project management. Almost one-fifth were subject matter experts, and others whose main roles were in support services or as a decision maker. No decision analysts participated in the survey.

The participants were generally highly experienced. Dem3 shows that nearly three-quarters had over 25 years’ experience in the oil and gas industry. Dem4 shows that there was less experience on

opportunities and projects, although nearly two-fifths had over 25 years’ experience, and over four-fifths had more than 15 years’ experience on opportunities and projects.

### 5.2.2. Decision Analysis questions

The survey results for the Decision Analysis questions are shown in bar chart form in Fig. 14.



**Fig. 14 Survey results – Decision Analysis Questions**

The DA1 subplot of Fig. 14 shows that the vast majority consider that they are familiar with DA. Only 4% have broadly agreed that they were unfamiliar with DA, and 90% broadly disagree.

DA2 indicates that, on balance, DA is not considered to be complicated. 32% broadly agree that DA is complicated, versus 51% who broadly disagree.

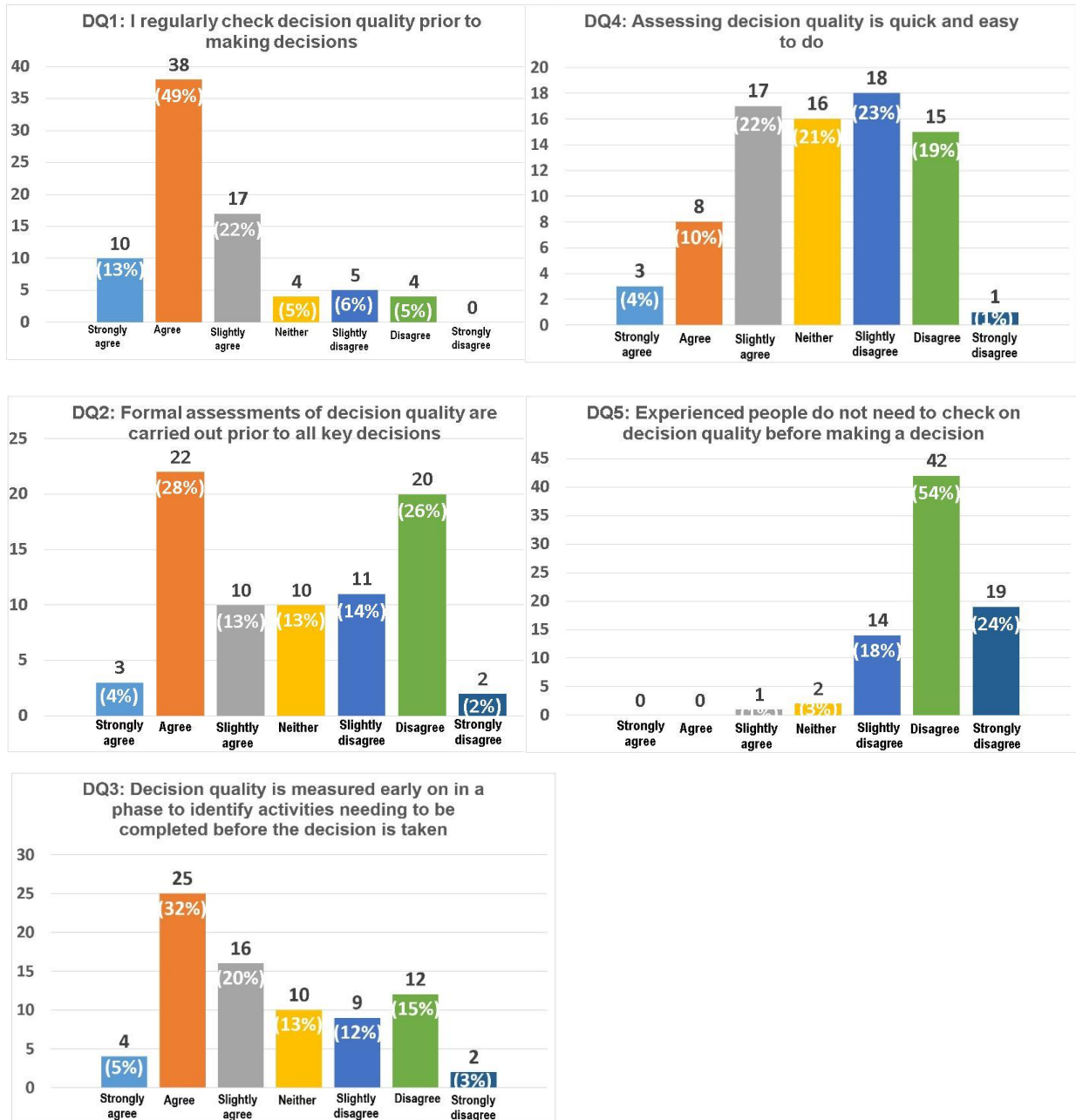
DA3 shows that nearly everyone considers that DA should be used for major project decisions. 94% broadly agreed that DA should be used for major project decisions, and only 1% broadly disagree.

DA4 indicates that most people consider that DA is necessary for making good decisions. 15% broadly agree that DA is not necessary for making good decisions, and 68% broadly disagree.

DA5 shows that over a third of participants consider that DA is not used for major project decisions. 50% broadly agreed that DA is used for major project decisions and 36% broadly disagree.

### 5.2.3. Decision Quality questions

The survey results for the Decision Quality questions are shown in Fig. 15.



**Fig. 15 Survey results – Decision Quality Questions**

The DQ1 subplot of Fig. 15 shows that most people regularly check DQ prior to making decisions. 84% broadly agree that they regularly check DQ prior to making decisions versus 11% who broadly disagree.

DQ2 indicates that there is a split view on whether formal assessments of DQ are carried out prior to all key decisions. 45% broadly agree that formal assessments of DQ are carried out prior to all key decisions, and 42% broadly disagree.

DQ3 shows that about twice as many people consider that DQ is measured early on in a phase to identify activities to be completed before the decision is taken, compared to those who do not. 57% broadly agree that DQ is measured early on in a phase to identify activities to be completed before the decision is taken, and 30% broadly disagree.

DQ4 shows that there is a slight majority who consider that assessing DQ is not quick and easy to do. 36% broadly agree that assessing DQ is quick and easy to do, whereas 43% broadly disagree.

DQ5 shows that experience is not considered to be a substitute for checking Decision Quality. Only 1% broadly agree that experienced people do not need to check on DQ before making a decision, whereas 96% broadly disagree.

### 5.2.4. General Decision-Making questions

The survey results for the general Decision-Making questions are shown in Fig. 16.

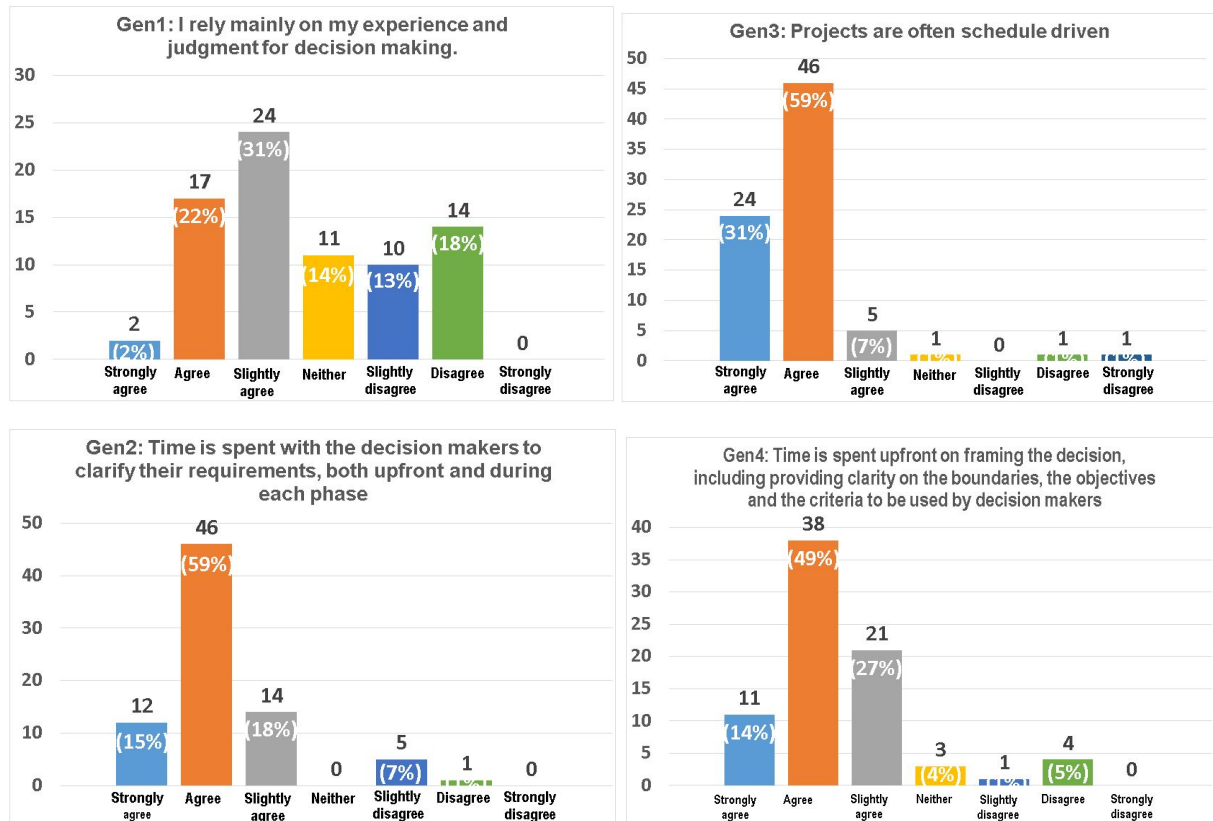


Fig 16 Survey results – General Decision-Making Questions

The Gen1 subplot of Fig. 16 shows that the majority agree that they rely mainly on their experience and judgment for decision making. 55% broadly agree that they rely mainly on their experience and judgment for decision making, whereas 31% broadly disagree.

Gen2 shows that nearly all agree that time is spent with the decision makers to clarify their requirements. 92% broadly agree that time is spent with the decision makers to clarify their requirements, both upfront and during each phase, whereas 8% broadly disagree.

There is a strong view that projects are schedule driven. Gen3 shows that 97% broadly agree that projects are often schedule driven, whilst 2% broadly disagree.

Gen4 shows that the vast majority consider that time is spent upfront on framing the decision. 90% broadly agree that time is spent upfront on framing the decision, including providing clarity on the boundaries, objectives and criteria to be used by decision makers. 6% broadly disagree.



### 5.3. Testing the propositions

#### 5.3.1. Null Hypothesis Significance testing

In the following sections, the propositions have been tested using null hypothesis significance testing. This approach requires that we assess the likelihood of our proposition (known as the alternate hypothesis for null hypothesis significance testing) being wrong – i.e. the null hypothesis being right. Only if that is unlikely can we reject the idea that there is no relationship and conclude that our proposition is likely to be correct. For this null hypothesis significance testing we have set an  $\alpha$  value of 0.05. Hence if  $p$  (the probability if the null hypothesis being correct) is less than or equal to 0.05, then the null hypothesis is rejected in favour of the alternative hypothesis (i.e. our proposition). If  $p$  is greater than 0.05, then the null hypothesis is not rejected.

For testing the null hypothesis, a binomial test has been used with the expected rate set at  $3/7$ , i.e. 0.4286. This is based on there being 7 categories to select from, 3 of which will agree with the alternative hypothesis (Strongly agree, Agree and Slightly agree) and 4 will disagree with the alternate hypothesis (Strongly disagree, Disagree and Slightly disagree and Neither agree nor disagree). Hence, if categories are being selected at random, it would be expected that 3 out of 7 would agree with the alternate hypothesis, and 4 out of 7 would agree with the null hypothesis.

Alternative analyses were conducted in which the neither agree/disagree responses were either excluded entirely or split between the agree and disagree groups. Neither of these changes, nor the use of single sample t-tests, changed the results. As a result, the described 3:4 split was retained.

#### 5.3.2. Proposition 2): DA and DQ are perceived to be complicated.

This proposition was tested separately for DA and DQ, using DA2 and DQ4.

On balance, it seems that DA is not considered to be complicated. DA2 shows that 32% broadly agree that DA is complicated, versus 51% who broadly disagree. This observation was confirmed by a binomial test ( $H_0$ : DA is not perceived to be complicated,  $H_A$ : DA is perceived to be complicated,  $p=0.98$ ), showing that the proposition is not supported.

The question of whether assessing DQ is quick and easy to carry out is more in the balance. DQ4 shows that 36% broadly agree that assessing DQ is quick and easy to do, whereas 43% broadly disagree. A binomial test ( $H_0$ : DQ is not perceived to be complicated,  $H_A$ : DQ is perceived to be complicated,  $p=0.49$ ), however, showed that the proposition is not supported.

#### 5.3.3. Proposition 3): People rely mainly on experience and judgment for decision making.

Gen1 shows that 55% broadly agree that they rely mainly on their experience and judgment for decision making, whereas 31% broadly disagree. This observation was confirmed by a binomial test ( $H_0$ : People do not rely mainly on experience and judgment,  $H_A$ : People rely mainly on experience and judgment,  $p=0.0195$ ) which showed that the proposition is statistically significant.

#### 5.3.4. Proposition 4): Projects are schedule driven.

There is a strong view that projects are schedule driven. Gen3 shows that 97% broadly agree that projects are often schedule driven, whilst 2% broadly disagree. This observation was confirmed by a binomial test ( $H_0$ : Projects are not schedule driven,  $H_A$ : Projects are schedule driven,  $p<0.001$ ) which showed that the proposition is statistically significant.

### **5.3.5. Proposition 5): There is a lack of clarity on the requirements of the decision maker.**

There seems to be no lack of clarity between the project team and the decision maker on the requirements for the decision. Gen2 shows that 92% broadly agree that time is spent with the decision makers to clarify their requirements, both upfront and during each phase, whereas 8% broadly disagree. This observation was confirmed by a binomial test ( $H_0$ : There is clarity on the requirements of the decision maker,  $H_A$ : There is a lack of clarity on the requirements of the decision maker,  $p > .99$ ), which showed that the proposition was not supported.

In addition, Gen4 shows that 90% broadly agree that time is spent upfront on framing the decision, including providing clarity on the boundaries, objectives and criteria to be used by decision makers, compared to 6% who broadly disagree. This observation was confirmed by a binomial test ( $H_0$ : There is clarity on the requirements of the decision maker,  $H_A$ : There is a lack of clarity on the requirements of the decision maker,  $p > .99$ ), which showed that the proposition was not supported.

### **5.3.6. Proposition 6): DQ is not assessed at the start of the phase to inform the work to be done.**

Based on the answer to DQ3, 57% broadly agree that DQ is measured early on in a phase to identify activities to be completed before the decision is taken, and 30% broadly disagree. This observation was confirmed by a binomial test ( $H_0$ : DQ is assessed at the start of the phase to inform the work to be done,  $H_A$ : DQ is not assessed at the start of the phase to inform the work to be done,  $p = 0.995$ ) which showed that the proposition was not supported.

## **6. DISCUSSION**

### **6.1. General**

This section discusses some general issues which may have influenced the results.

#### **6.1.1. How representative are the samples?**

The sample is predominantly Australian, although many participants have overseas experience. The initial participants for both the interviews and survey were oil and gas personnel known to the researchers, who were targeted for their knowledge and experience in opportunities and projects. As stated in section 4.1.1, the interviewees were from six companies, and around two-thirds of these came from two companies. Hence, there is likely to be some inherent bias with the participants, and the results may not be truly representative of all companies.

This is similar for the survey. As stated in section 5.1.1, the survey request was sent out to people currently working in ten oil and gas companies. Again, around two-thirds of these came from two companies. A balancing factor is that there is a great deal of varied experience, as many participants have previously worked for a number of different companies.

#### **6.1.2. Format of survey questions**

The survey questionnaire was deliberately set up to have a balance of positive and negative questions. This was based on research, e.g. Choi and Pak (2005), which suggested that some respondents may be either 'yes-saying' or 'no-saying' – that is, tend to answer yes (or agree) to all questions or to answer no (or disagree) to all questions. Having a balance of positive or negative questions is suggested as a solution.

However, this may have had unintended consequences. Some questions can be made negative by changing one word, e.g. DA2: 'Decision analysis is complicated to use' is the negative of 'Decision

analysis is simple to use'. However, for three questions, (DA1, DA4, DQ5), we have made the question negative by including the word 'not'. This may have led to errors in answering the survey, as respondents may not have noticed the 'not', or may have become confused when answering with a double negative i.e. disagreeing with the not.

### **6.1.3. Decision Analysis vs decision analysis**

For this paper, we have used Decision Analysis with capital letters to mean, specifically, Decision Analysis as described in section 2.2. Similarly, we have used Decision Quality to refer to the process described in section 2.2.2. However, for the interviews and surveys we were not explicit about this, and we did not use capital letters in the survey for either decision analysis or decision quality. Hence, understanding of decision analysis or decision quality could be limited to English language use of the words or restricted to just one part of it, e.g. decision trees.

### **6.1.4. Being familiar with DA or DQ**

What do people mean when they say they are "familiar" with something? There are different levels of understanding, which can be described in the following way:

- On paper
- On the lips
- In the head
- In the heart

On paper means "Yes, I've seen that. It's written down somewhere. If I can find the piece of paper, I'll be able to show you". On the lips means that I can talk about it, and explain some bits of it. In the head means that I have a good intellectual understanding of it, including the principles and concepts behind it. In the heart means that I live and breathe this, I fully understand this, and I'm committed to doing it.

Hence there are different possible interpretations of what 'being familiar with' means. Some people might only consider that they are familiar with DA or DQ if it is 'in the head' or 'in the heart'; others might consider that they are familiar with DA or DQ if it is 'on paper' or 'on the lips'.

## **6.2. Are DA and DQ used as much as they "should" be?**

This research was predicated on the assumption that DA and DQ are not used as much, or as effectively, as would be required to achieve a high decision quality, and hence increase the likelihood of a good outcome. To check whether this assumption is correct, we have reviewed the relevant survey results.

Comparing the answers for DA3 and DA5, it is evident that DA is not used as much as the industry personnel believe it should be. DA3 shows that 94% broadly agreed that DA should be used for major project decisions, whereas DA5 shows that only 50% broadly agreed that DA is used for major project decisions.

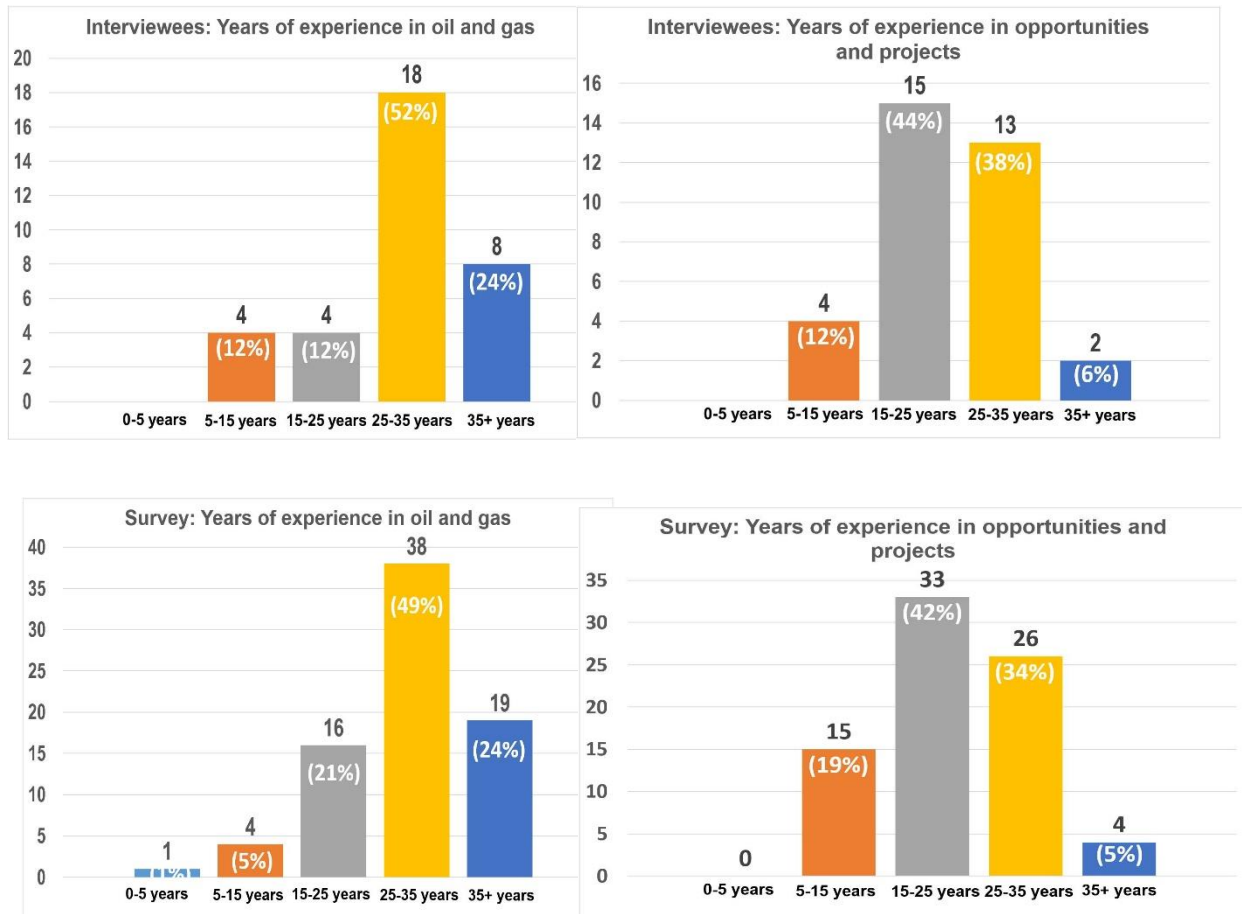
This is similar for DQ, as DQ2 shows that only 45% broadly agree that formal assessments of DQ are carried out prior to all key decisions. Interestingly, DQ1 shows that 84% broadly agree that they regularly check DQ prior to making decisions, indicating a mismatch between the respondents' views of what they and their companies are doing. Experience is not considered to be a valid reason for not checking DQ, as DQ5 shows that only 1% broadly agree that experienced people do not need to check on DQ before making a decision.

Hence, the results suggest that neither DA nor DQ are used as much as respondents think they should be. Nearly all personnel say that they should always be used for major project decisions whereas, in practice, they are only used for around half of these.

## **6.3. Reviewing the propositions**

**6.3.1. Proposition 1): DA and DQ are not well understood.**

The surveys and the interviews contain conflicting information on how well DA and DQ are understood. In general, the survey outcomes imply a reasonable understanding of DA and DQ, whereas the interviews cast doubt on this. One possible explanation for this is the difference in the demographics of interviewees and the survey respondents, and how representative they are of the overall oil & gas project population. However, Fig. 17 shows that the demographics of both groups, in terms of years of experience in oil and gas, and years of experience in opportunities and projects, are very similar.



**Fig 17 Comparison of demographics for interviewees vs survey respondents**

DA1 shows that the vast majority of participants consider that they are familiar with DA. This seems to be an endorsement that DA is well understood. However, for the interviewees only 55% said they had carried out DA, another 10% said they had done part of a DA and 34% had not carried out any DA. Hence there is a contrast here between 90% from the survey that say they are familiar with DA, compared to 55% of interviewees who have carried out DA. This implies that some people consider themselves ‘familiar with’ DA even though they have not carried out DA themselves.

In DQ1 of the survey, 84% broadly agree that they regularly check DQ prior to making decisions. If you ‘regularly check DQ’, then the expectation is that you are familiar with the DQ chain or wheel, and would be able to name all, or most of, the six elements. However, in the interviews only 19 out of 34 (i.e. 56%) said they were familiar with the DQ chain or wheel. And for the 19 people who said that they were familiar with the DQ chain or wheel, the average number of elements identified was only 2.4 out of 6. No-one correctly identified all 6 elements, and 3 people could not identify any elements. So, what does ‘being familiar with’ mean? It seems anomalous that 84% of the people surveyed stated that they regularly check DQ prior to making decisions, when only 12 out of 34 interviewees (35%) could identify 3 or more elements of the DQ chain.

The assessments of understanding of DA and DQ (Figs. 9 and 10) showed that the average level of understanding of DA & DQ was around the ‘Fair’ range. These also show that the researchers considered that DA and DQ were not understood as well as the interviewees think they are; and the difference is greater for DQ.

When asked: ‘What does Decision Analysis mean to you?’, the interviewees gave a variety of answers (see section 4.2.1.2 and Appendix 3). Does this mean that DA is not fully understood, or DA means different things to different people? A potential reason for this is a lack of clarity and understanding on what Decision Analysis is. Part of this may be the difference between Decision Analysis and decision analysis, as discussed in section 6.1.3.

This is not helped by the many different definitions available for DA. Some definitions of DA are accurate, but use specialised language that is not readily accessible to the layman and/or are high level and not sufficient to explain what it is. For example:

- Specialised language: *Decision Analysis is a philosophy, articulated by a set of logical axioms, and a methodology and collection of systematic procedures, based upon those axioms, for responsibly analysing the complexities inherent in decision problems.* (Keeney 1982)
- High level: *Decision Analysis is a systematic procedure for transforming opaque decision problems into transparent decision problems by a sequence of transparent steps.* (Howard 1988)
- Specialised language and high level: *The application of decision science to real-world problems through the use of systems analysis and operations research.* (McNamee and Celona 2005)

On balance, considering all the above, it is judged that DA and DQ are not well understood. It is considered that a car analogy might be helpful for explaining DA and the different ways in which it is understood. This is shown in Fig. 18.

	Driving a car	Carrying out Decision Analysis
<b>Purpose</b>	To transport people from A to B	To provide insight to help decision makers make better decisions.
<b>Description</b>	A road vehicle, typically with four wheels, powered by an internal-combustion engine and able to carry a small number of people	Decision Analysis is a structured approach for creating and evaluating choices, using a pragmatic application of tools and processes tailored to the needs of the decision.
<b>Components</b>	<ul style="list-style-type: none"> <li>Engine</li> <li>Gearbox</li> <li>Chassis</li> <li>Body</li> <li>Wheels</li> <li>Steering</li> <li>Brakes</li> </ul>	Ron Howard’s Man on the stool: <ul style="list-style-type: none"> <li>• Frame                             <ul style="list-style-type: none"> <li>• What you know (Information)</li> <li>• What you want (Objectives)</li> <li>• What you can do (Alternatives)                                     <ul style="list-style-type: none"> <li>• Logical reasoning</li> <li>• Committed action</li> </ul> </li> </ul> </li> </ul>
<b>Types “Horses for courses”</b>	<ul style="list-style-type: none"> <li>Small runabout</li> <li>Family saloon</li> <li>4WD</li> <li>Sports car</li> <li>Formula 1 racing car</li> </ul>	<ul style="list-style-type: none"> <li>• Use clear thinking consistent with DA</li> <li>• Partial DA (i.e. clear thinking consistent with DA, plus detailed review of at least 1 of the 6 elements)</li> <li>• Complete DA (i.e. all 6 elements, including probabilistic analysis of the alternatives)</li> </ul>
<b>Tools</b>	<ul style="list-style-type: none"> <li>Tyre pressure gauge</li> <li>Jack</li> <li>Spanners</li> <li>Battery charger</li> <li>Air compressor</li> <li>Torque wrench</li> <li>Tap and die set</li> <li>Diagnostics service tools</li> <li>Engine hoist</li> </ul>	<ul style="list-style-type: none"> <li>Decision hierarchies</li> <li>Key decision logs</li> <li>Decision quality</li> <li>Sensitivity analysis (e.g. Tornado charts)</li> <li>Uncertainty, risk and opportunity assessments</li> <li>Strategy tables</li> <li>Monte Carlo simulation</li> <li>Probabilistic analysis</li> <li>Decision conferencing</li> </ul>
<b>Education</b>	Driving instruction	Training in decision analysis

**Fig.18 Car analogy for Decision Analysis**

This also provides a good analogy of when to use different types of Decision Analysis. For example, if driving in a Formula 1 race everything in the car would need to be perfectly set up, with meticulous care taken over each of the components; if you are going four-wheel driving you need a suitable type of car that is set up for four-wheel driving and to ensure that you have the appropriate tools with you, including an air compressor; if you are only going to the local shops, you can just hop in your car and

drive. What you need to do is dependent upon the levels of complexity and uncertainty, and the potential consequences if things go wrong. This is the same for Decision Analysis. Major oil and gas project decisions have high levels of uncertainty, are generally complex and have high consequence outcomes. Therefore, they should use complete DA. Other oil and gas project decisions, with less uncertainty and complexity, and lower consequence outcomes, may be made using partial DA, or clear thinking consistent with DA principles.

An interesting aspect of the analogy is education. If you want to drive a car it is important to have some driving instruction. It helps to have both the theoretical knowledge of how a car works and how to drive, and to have had a significant amount of practical experience at driving. However, it seems that people may be happy to make decisions without having had the necessary training in Decision Analysis – that is, without either the theoretical knowledge or practical experience.

### **6.3.2. Proposition 2): DA and DQ are perceived to be complicated.**

It was a surprise that null hypothesis testing (see 5.3.2) showed that the proposition, that DA and DQ are perceived to be complicated, was not supported. Prior to the survey results, it had seemed to be a likely reason why DA is not used more.

However, it is interesting to compare the answers to DA2 and DQ4. One could be the corollary of the other, i.e. if something is quick and easy, then it could be deemed to be not complicated – and vice versa.

Hence, if we substitute ‘quick and easy’ for ‘not complicated’, comparing DA2 and DQ4 we get:

DA2: 32% broadly agree that DA is complicated, 51% broadly disagree

DQ4: 43% broadly agree that DQ is complicated, 36% broadly disagree

A t-Test carried out to compare the answers to DA2 and DQ4 gave the following results:  $t[77] = 2.73$ ;  $p=0.008$ , two-tailed; mean DQ4 = 3.88, mean DA2 = 4.36 (based on a scale of 1-7 from Strongly Agree to Strongly Disagree). This shows that there is a statistically significant difference between the outcomes.

This implies that DQ is considered to be more complicated than DA. This is surprising, as DQ is a part of DA and hence, if anything, would be expected to be simpler than DA. Maybe this is simply semantics, and ‘quick and easy’ does not equate to ‘not complicated’. Or, perhaps, DA is better understood than DQ and, because it is better understood, it is considered to be less complicated. There is possibly some evidence of this by comparing Fig. 10 and Fig. 11. Although the interviewees assess their own understanding of DA to be very similar to that of DQ, the researchers assess the interviewees’ understanding of DA to be better than they that of DQ.

### **6.3.3. Proposition 3): People rely mainly on experience and judgment for decision making.**

Although the survey respondents have confirmed (see 5.3.3) that the proposition, that people rely mainly on experience and judgment for decision making, is supported, this is confounded by the outcomes of two other survey questions. DA4 shows that only 15% broadly agree that DA is not necessary for making good decisions, and 68% broadly disagree, i.e. they consider that DA is necessary for making good decisions. Similarly, DQ5 shows that experience is not considered to be a substitute for checking Decision Quality; 96% consider that experienced people do need to check on DQ before making a decision.

Hence, according to the survey outcomes, although DA and DQ are considered necessary for making good decisions, most people still rely mainly on their experience and judgment. Perhaps this means that they still rely on experience and judgment despite considering that DA and DQ are necessary for making good decisions. Or it could mean that they rely on their experience and judgment in conjunction with using DA and DQ.

### **6.3.4. Proposition 4): Projects are schedule driven.**

The survey outcomes (see 5.3.4) show that there is strong support that projects are schedule driven. This implies that the desire to pass through decision gates ‘on time’ overrides the desire to create value and ensure readiness to make a decision – that is, confirmation that the information on which the decision will be based is sufficiently complete and accurate, and that there is a good understanding of the uncertainties and risks, and how these will be managed.

This is in line with the findings of Walkup and Ligon (2006) who stated that “..most DRBs are concerned more with project schedules and rarely encourage the creativity to achieve quality alternatives.”

### **6.3.5. Proposition 5): There is a lack of clarity on the requirements of the decision maker.**

The analysis of the interviews (see 4.2.2) and the analysis of the survey results (see 5.3.5) show that both the interviewees and survey respondents consider that there is clarity on the requirements of the decision maker.

However, how well is this tested in practice? Perhaps assumptions are sometimes made, and there is a belief by the project team that they have clarity on the decision makers requirements, but they have not checked that their understanding is correct. Also, decision makers may not always state their true reasons, or some things are kept back from the project team, for reasons of commercial confidentiality.

### **6.3.6. Proposition 6): DQ is not assessed at the start of the phase to inform the work to be done.**

The analysis of the survey outcomes (see 5.3.6), shows that the proposition, that DQ is not assessed at the start of the phase to inform the work to be done, is not supported. However, considering DQ2 - which shows that only 45% broadly agree that formal assessments of DQ are carried out prior to all key decisions - it was decided to carry out some further analysis to see how many broadly agree that formal assessments are carried out prior to all key decisions AND broadly agree that DQ is measured early in the phase to identify activities to be completed before the decision is taken. The result was:

Broadly Agree to both DQ2 and DQ3:	31 (40%)
Mix of Broadly Agree / Neither / Broadly Disagree:	30 (38%)
Broadly Disagree to both DQ2 and DQ3:	17 (22%)

This suggests that around 40% of respondents are using DQ effectively by using it prior to all key decisions AND measuring it early in the phase to identify activities to be completed before the decision is taken.

## **6.4. What could be done to encourage better use to be made of DA and DQ?**

To encourage better use to be made of DA and DQ, steps need to be taken to mitigate the impact of the three propositions that are deemed to be valid, i.e.

- DA and DQ are not well understood.
- People rely mainly on experience and judgment for decision making.
- Projects are schedule driven.

Suggestions are given below on mitigating the impact of these through education and determining underlying causes.

### **6.4.1. Education.**

Education would help mitigate the impact of all three of the above propositions. However, it is appreciated that decision makers are busy people at a senior level, and so focused, just-in-time training is proposed prior to key decisions. The initial training could be carried out in 1-2 hours, and retraining (for subsequent decisions) could be 30 minutes – 1 hour.

It is proposed that training emphasises the ease of carrying out DA/DQ, and provides practice at applying it. Ideally, this would be followed by further practice, which is frequently repeated so that using DA and DQ becomes a habit. By applying it, for even simple decisions, it helps provide a good understanding of the principles and concepts, which reinforces its use. The aim of training is for DA/DQ to go beyond a good intellectual understanding of DA/DQ (i.e.: ‘in the head’) and it becomes compelling and the natural thing to do for all decisions (i.e.: ‘in the heart’). To assist with this, it is proposed that a habit is made of reviewing each of the 6 elements of the DQ chain or wheel for all, even simple, decisions.

To address the tendency to rely on experience and judgment for decision making, the training should include explanations of why this is from the neuroscience and psychology perspectives, as covered in section 1.3 above. It should also include an explanation of decision situations where relying on experience and judgment might be appropriate (Kahneman and Klein 2009, Kahneman and Klein 2010) - with a strong endorsement that it is not appropriate for key decisions on oil and gas projects involving complexity and uncertainty, where DA should be used.

To address the issue of projects being schedule driven rather than value driven, the training should raise awareness of the impact that this has on decision making and consequent project outcomes. Research has shown that schedule driven projects tend to have a longer schedule, higher costs and lower production attainment (Nandurdikar and Kirkham 2012). If projects are schedule driven, there may not be enough time to complete the work necessary to provide sufficiently complete and accurate information to enable a good decision to be made. Decisions are likely to be taken based on information which does not provide a true picture of the full range of outcomes, and the associated uncertainties and risks

#### **6.4.2. Determining underlying causes**

Although education and regular practice are likely to help encourage the use of DA and DQ, this will be insufficient if there are strong drivers and motivations opposing the use of DA and DQ.

While further research is required to investigate this, one avenue may be to adopt the causal reasoning approach used by Stockholm (2011) for investigating incidents. This has had an impact in improving both safety and operational performance in the petrochemical industry, and it could be used for improving the performance on projects. This would be achieved by determining the underlying causes for reliance on experience and judgment for decision making, and for why projects are schedule driven. This would look for the motivation behind the above reasons to determine what needs to change, and how people might be influenced to change.

#### **6.5. Premortem**

A useful adjunct to DA is to carry out a premortem, which provides a final check on the decision. Research on prospective hindsight (Mitchell, Russo et al. 1989) has found that imagining that an event has already occurred increases the ability to correctly identify reasons for future outcomes by 30%. This concept was used by Klein (2007) to create the premortem, which provides a safe environment for project team members to identifying weaknesses that could result in project failure. The premortem technique has been shown to be effective in a crisis management planning context (Veinott, Klein et al. 2010).

A premortem is like a post-mortem, but with one significant difference: a post-mortem takes place after the event to determine why things went wrong; a premortem occurs during a project to prevent the project going wrong, or to minimise the consequences if it does go wrong. The premortem takes place



after an important decision has been made, but before it has been formally committed. Key project team members are gathered together. The leader starts the exercise by informing everyone that it is now a time in the future, when the project has been implemented as per the decision, and the outcome is a spectacular disaster. During the next few minutes everyone works independently and writes down all the potential reasons they can think of for the failure - especially things that would not normally be mentioned for fear of being impolitic. The leader then asks each team member to read one reason from their list; everyone states a different reason until they are all recorded. After the session has finished the project manager reviews the list, looking for ways to strengthen the planned way forward.

A benefit of the premortem is that it legitimises doubt, which helps overcoming groupthink (Esser 1998) that can affect teams once a decision has been made. Otherwise, when a team comes to a decision, and particularly when the leader has a strong involvement in it, doubts about the plan are gradually (even unconsciously) suppressed. This contributes to overconfidence in the team, as only support for the decision is expressed. The premortem overcomes this by letting doubts be raised, and encourages even supporters of the decision to look for potential threats that they had not considered before.

The six elements of DA and DQ could be used as a prompt to help find reasons for failure, e.g. did it go wrong because of incomplete or inaccurate information, did we look at sufficient alternatives, has sound reasoning been used when selecting the preferred alternative?

## 6.6. Further Research

Further research is proposed as follows:

- I. Investigate the effectiveness of just-in-time (re)training in the principles of DA and DQ before decisions are made.
- II. Carry out work to provide convincing evidence that high quality decisions (i.e. decisions that score highly on the DQ chain or wheel) lead to a higher likelihood of project success.
- III. Investigate the effectiveness of premortems for improving project outcomes.
- IV. Use a causal reasoning approach to determine the underlying drivers and motivations behind why DA and DQ are not used more, why projects are schedule driven and why there is a preference to rely upon experience and judgment for decisions on projects.

## 7. CONCLUSIONS

Decision Analysis and Decision Quality are not used as much as they should be. The survey showed that around 90% think they should be used for major project decisions, but only around 50% say that they are used for major project decisions.

Six propositions were tested for why Decision Analysis and Decision Quality are not used more, or are not used more effectively. Based on the outcomes of the interviews and survey, three of these were not supported:

- Decision Analysis and Decision Quality are perceived to be complicated.
- There is a lack of clarity on the requirements of the decision maker.
- Decision Quality is not assessed at the start of the phase to inform the work to be done.

The three propositions that were deemed to be valid are:

- Decision Analysis and Decision Quality are not well understood
- People rely mainly on experience and judgment for decision making.
- Projects are schedule driven.

Just-in-time training is proposed as a first step to mitigate the effect of these three propositions. This should emphasise the ease of carrying out Decision Analysis, and the use of Decision Quality to guide what work needs to be done to achieve a high-quality decision. It should also raise awareness on the impact that relying on experience and judgment and being schedule driven has on decision making, and the adverse consequences for expected outcomes.

Training alone, however, is unlikely to be sufficient to encourage use of Decision Analysis and Decision Quality if there are other strong motivations opposing this, such as schedule drivers. Further research is proposed, to dig down to a deeper level to determine the underlying causes of the underuse of these tools, and tackle those. Specifically, to determine how to influence decision makers to change their behaviours so that Decision Analysis and Decision Quality are used more effectively.

A premortem is proposed as a final check on decision making. This could use the six elements of Decision Analysis and Decision Quality to help identify potential reasons for the project to fail, leading to corrective actions prior to finalising the decision.

## **8. ACKNOWLEDGMENTS**

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## **APPENDIX 1: FULL STRUCTURE OF INTERVIEW**

### **Individual Information / Demographics**

- What is your current role?
- How many years of experience do you have in oil and gas?
- How many years do you have on opportunities and projects?
- What previous roles have you held on opportunities and projects?

Which of the following best defines your current role for projects

- Decision maker (*i.e. authorised to commit resources for major development decisions*)
- Development or Project Management
- (Decision) Analyst
- Support Services
- Subject matter expert
- Other

### **General Questions on Projects and Decision Making**

- Do you use a gated decision-making framework for your projects?
- Are there any requirements to be met before for moving from one phase to the next?
  - Typically, what are these?
  - Are these requirements generally adhered to?
- What are (typically) the drivers for proceeding through decision gates?
- How are key decisions on oil and gas projects made in your company?
- Are any tools used to assist with decision making?

### **Questions on Decision Analysis**

- What does Decision Analysis mean to you?
- What do you consider the key aspects of Decision Analysis are?
- Have you carried out any Decision Analyses?
- What processes and tools are used (in your company) to help you in making decisions?
- Are you familiar with any other processes and tools used for Decision Analysis?
- How can Decision Analysis be tailored for different decisions?
- Is time spent upfront in framing the decision, e.g. providing clarity on the boundaries, the objectives and the criteria to be used by the decision makers?
- Is much time spent with the decision maker(s) to clarify their requirements, both upfront and during each phase?
- Is probabilistic analysis used for any of your decisions?
  - When is it used and why?
- Are completed analyses adjusted to take account of any new information?

### **Questions on Decision Quality**

- How would you judge the quality of a decision?
- How would you know if it was a good decision?
- How are good decisions related to good outcomes?
- Does your company carry out any formal assessments of the quality of decisions made?
- Are you familiar with the DQ chain or DQ wheel?

- Can you name and describe any of the 6 components the DQ?
- Are checks made of Decision Quality prior to key decisions?
  - How are they made (all 6 aspects DQ wheel?)
  - What action is taken if Decision Quality is not good?

**Self-assessment of knowledge and understanding of DA and DQ**

See separate template

- What is your level of understanding on a scale of 1-5?
- What is your assessment of the level of understanding of a typical decision maker in your organisation?

**APPENDIX 2: RUBRICS FOR ASSESSING UNDERSTANDING OF DA & DQ**

The researchers carried out their own assessment of the level of knowledge and understanding of the interviewees. Scoring rubrics were developed to make this as objective as possible. The rubrics used for assessment of knowledge and understanding of DA and DQ are shown below.

**Decision Analysis**

	<b>Low</b>	<b>Basic</b>	<b>Fair</b>	<b>Good</b>	<b>Expert</b>
	<i>Little or no knowledge and understanding in this area.</i>	<i>Basic knowledge and an understanding of simple techniques and concepts</i>	<i>Sound knowledge and understanding of the main areas of content. Have used for simple applications.</i>	<i>Thorough knowledge and understanding of most areas of content. Have used this for a range of applications.</i>	<i>Extensive knowledge and understanding. Use this all the time, and promotes its use</i>
<b>Understanding of DA</b>	Not familiar with DA	Some understanding of DA	Reasonable understanding of DA	Good understanding of DA and how it can be tailored for different situations	Excellent understanding of DA, both psychological and technical aspects
<b>Has carried out DA</b>	No	Provided input for / assisted with decision analyses	Has carried out simple decision analyses	Has carried out a range of decision analyses	Has carried out a wide range of decision analyses
<b>Aware of processes and tools used for DA</b>	Not aware of tools and processes	Aware of some tools or processes used for DA	Aware of tools and processes used for DA	Familiar with a range of tools and processes for DA	Strong knowledge base of tools and processes for DA
<b>Provides judgment &amp; comments on DA</b>	No judgment or comments	Some comment on DA	Some judgment and comment on DA	Sound judgment and comment on DA	Expert judgment and comments
	<b>Low</b>	<b>Basic</b>	<b>Fair</b>	<b>Good</b>	<b>Expert</b>
<b>Scoring</b>	0.5	1.5	2.5	3.5	4.5

Scores were on a scale of 0 to 5, with 0.5 indicating the midpoint of each category. The researchers' score for assessing understanding of DA for each individual was calculated by taking the average score for the four criteria (i.e.: Understanding of DA; Has carried out DA; Aware of processes and tools used for DA; Provides judgment and comment on DA). The same approach was used by the researchers for assessing understanding of DQ.

### Decision Quality

	Low	Basic	Fair	Good	Expert
	<i>Little or no knowledge and understanding in this area.</i>	<i>Basic knowledge and an understanding of simple techniques and concepts</i>	<i>Sound knowledge and understanding of the main areas of content. Have used for simple applications.</i>	<i>Thorough knowledge and understanding of most areas of content. Have used this for a range of applications.</i>	<i>Extensive knowledge and understanding. Use this all the time, and promotes its use</i>
<b>Explanation of how to judge the quality of a decision</b>	Explanation is outcomes based	Explanation is mainly outcomes based	Fair explanation of decisions vs outcomes and judging quality	Good explanation of decisions vs outcomes and judging quality	Excellent explanation of decisions vs outcomes and judging quality
<b>Understanding of DQ chain / wheel</b>	Not familiar with DQ wheel	Slight familiarity / has seen DQ wheel	Reasonable understanding	Good understanding	Fully familiar & received training (e.g. SDG course)
<b>No. elements of DQ wheel identified</b>	0	1	2-3	4-5	6
<b>Provides judgment &amp; comments on DQ</b>	No judgment or comments	Some comments on DQ	Some judgment and comment on DQ	Sound judgment and comments on DQ	Expert judgment and comments
	<b>Low</b>	<b>Basic</b>	<b>Fair</b>	<b>Good</b>	<b>Expert</b>
<b>Scoring</b>	0.5	1.5	2.5	3.5	4.5

### APPENDIX 3: ‘WHAT DOES DECISION ANALYSIS MEAN TO YOU?’

These are the answers given to the question: ‘What does Decision Analysis mean to you?’:

- *It means a rigorous disciplined process of working out what options are going to meet your objectives.*
- *The science and process of how you make a decision, both the psychology and the process.*
- *There are five or six different dimensions to making a good decision and, to me, the Decision Analysis is around assessing those dimensions and determining whether you’ve considered all the aspects. So, whether you have framed it correctly, whether you’ve got the relevant information, whether you are committed to action, whether the work is complete to enable you to make a decision.*
- *It means the techniques and methodology for making decisions, generally under uncertainty, and understanding the quality of these. It’s about the tools and the statistical methods you have.*
- *I’m not sure what Decision Analysis is. I know what decision-making is – when you actually make a decision. But I do not know what Decision Analysis is.*
- *Satisfying yourself that you have made the right decision. Weighing the risks and rewards to see how/whether to proceed.*
- *It’s the breaking down of a decision into component parts that enable you to assess whether you are making a good, well-informed decision against certain criteria.*
- *I’ve been through the Stanford school and use their approach to Decision Analysis. The aim is to understand the problem and determine whether we can make a decision.*
- *I’m not sure what you mean by it.*
- *Not much Decision Analysis is done. Lookbacks are done on projects, both for good and bad outcomes. But they don’t do a formal assessment of decision making after the fact.*
- *We have a rigorous decision-making list of criteria. It measures projects in an economic sense versus various metrics. It analyses risk and uncertainty in decisions, it looks at what drives the value proposition on projects.*
- *Every decision you make carries a risk. And every decision you make will be made with the analysis of the data at that time. In hindsight people may ask why that decision was made, but it was the right decision at that time.*  
*You may make the decision that the project was going to be economic, given the price of the product at that time. But the price may change, and the market is not going to treat you well and say: ‘You didn’t make the right decision’ and ‘You are not making any money with my money’.*
- *In essence, it’s a structured approach to informing and making an investment decision. It is addressing the risks, the uncertainty and the value potential of a particular investment, or series of investments.*
- *Decision Analysis is:*
  - a) *Working out what is the problem you are trying to solve - be it commercial, schedule, regulatory – and what are the criteria and bandwidths around that particular problem.*
  - b) *Putting in processes and procedures to take you through those various gates.*
- *Taking all the information, looking at risk and uncertainty and making the right decision.*
- *Basically, what I think it means is that if you are making a decision, what do you need to analyse to make that decision robust in the present time frame, and robust for the future use of those outcomes.*
- *For me, Decision Analysis would be the assessment of risks and ranges, for a series of different outcomes in a particular area, and then comparing them to reach a good decision. It’s never*

*whether it is black or white, it is shades of grey. And it's a matter of understanding the shades of grey – how sensitive they are to change.*

*To my mind, Decision Analysis is about testing the outcome, e.g. the value outcomes. You are trying to make the best decision for what your business objectives are. So, it's testing risk and range for scenarios to meet your business objectives.*

- *The mathematics of making a decision.*
- *Good Decision Analysis means that you are not biased and not using heuristics. You capture the full range of uncertainty, and find the right balance with what you are trying to achieve, making clear what the alternatives are.*
- *It means the techniques and methodology for making decisions, generally under uncertainty, and understanding the quality of these. It's about the tools and the statistical methods you have.*
- *I suppose the economics of the investment decision come right up to mind. We have DA teams, and they typically look at the economics of an investment, the risks, sensitivities, NPV's – all those sorts of measures fall into the big bucket, in my mind, called DA.*
- *I guess to me it's looking at the quality of the decision that you're trying to make.*
- *Decision Analysis I'm presuming means, for instance, the decision tree. So, it's the process of making a decision and, in making that decision, what factors, elements get taken into account.*
- *Decision Analysis is looking at the quality and should be looking at the capability of the people who are actually making the decision. Then, on a technical component, be it on a direction or a decision to move forward: Has the adequate amount of engineering been done so that you can get the class of the cost estimate? Is the contractor capable of actually producing the class of the cost estimate that you're wanting? So it's really saying, what are the key decisions that are critical in the phase, and has the work been done, have the people that should be involved been involved, and are the decision-makers the right decision-makers?*
- *A structured or repeatable way of approaching decisions.*
- *There are five or six different dimensions to making a good decision and, to me, the Decision Analysis is around assessing those dimensions and determining whether you've considered all the aspects. So, whether you have framed it correctly, whether you've got the relevant information, whether you are committed to action, whether the work is complete to enable you to make a decision.*
- *It means – for me, there's three "going in" components. The going in components are, first of all, the information: Were the studies appropriately framed? Did we really map out what was needed to make this decision? And by map out it can be, were the executives that need to make the decision engaged early enough? So, is it that their concerns were addressed in that mapping framing session? It can be that the subject matter experts involved to identify the necessary studies that are needed and it can be that there are sort of wild card approaches, where we just get people in who have not done it before who ask oddball questions and say yes, but what about? And what if? So, it's good framing.*

*The second part is good process that defines what you need to study to be able to bound the information that underpins the decision. So, let me explain. If the decision doesn't change from A to B independent of the range of outcomes of a particular variable – don't study it.*

*The third part is that there are reviews by subject matter experts during the course of the work. There's no value in information that is reviewed just before a decision to see whether it was good information, because the only thing that that can produce is a yes or no answer, and if it's a no answer, then you can't make the decisions. So, good decisions come from work that was reviewed during the course of the work, not just before a gate review.*



- *It means either a structured or a formal process to review a decision. To review the inputs and aspects of a decision from risk to consequences to outcomes to costs – all sorts of parameters that might surround that decision, depending on what the decision is.*
- *I don't know, I've not used it.*
- *Understanding risk reward. That's what it all comes down to.*
- *It's having sufficient information to be able to commit to the next financial commitment or stage of the work program.*
- *That's a really good question. We quite often find that engineers, in particular, are the worst at this, where they will home in on a particular solution based on a past experience way to soon. And in order to fully undertake a robust Decision Analysis before you come to the point of making a final decision, there perhaps are multiple more solutions that have just been ignored and perhaps could offer a robust and cost-effective solution. So, for me Decision Analysis comes back to front-end loading, in terms of making sure at the outset that you spend the right amount of time framing including brainstorming, researching past lessons learnt, and understanding options that are out there before you start diving in and evaluating too soon. And if you can get that level of front-end framing in place, then through the different stages of the development, you can get a healthy Decision Analysis before you come to make key decisions.*
- *In my view, it is around taking a holistic approach towards taking a decision. It can be around looking at different metrics, different drivers, including uncertainty. So, doing probabilistic analysis, if you have the luxury of being able to do that, and understanding your low probability, high impact outcomes and taking all of that into account in your decision-making process.*
- *Decision Analysis. I would say, how informed were the decision-makers? Did they have any bias? Were they presented with the right frame? Was the right decision made and was it an informed decision? Was there any bias? What were the inputs? What were the outputs? For me, it would be assessing the quality of the decision and did it lead to a good outcome?*
- *To me it really means understanding the frame first, getting the right inputs, having clarity around what the decision criteria are and obviously understanding people and who the decision-maker is. So, getting that clarity on those. That's what it means to me.*

## **APPENDIX 4: LIST OF SURVEY QUESTIONS**

This is a list of the survey questions relating to decision making. For ease of reference, they are presented here in separate sections of Demographic questions, Decisions Analysis questions, Decision Quality questions and General Decision-Making questions.

For the survey, the demographic questions were first, and then the questions on Decisions Analysis, Decision Quality and General Decision-Making were mixed together.

### **Demographic Questions**

Dem1. Which of the following best describes your organisational level?

- Professional
- Manager
- Executive (e.g.: VP, Director, Country Manager)

Dem2. Which of the following best describes your role on opportunities and projects?

- Decision maker
- Development or project management
- Decision analyst
- Subject matter expert
- Support services

Dem3. How many years of experience do you have in oil and gas?

- 0-5 years
- 5-15 years
- 15-25 years
- 25-35 years
- 35+ years

Dem4. How many years of experience do you have on opportunities and projects?

- 0-5 years
- 5-15 years
- 15-25 years
- 25-35 years
- 35+ years

### **Questions on Decision Analysis**

DA1. I am not familiar with decision analysis.

DA2. Decision analysis is complicated to use.

DA3. Decision analysis should be used for major project decisions.

DA4. Decision analysis is not necessary for making good decisions.

DA5. Decision Analysis is used for all our major project decisions.

### **Questions on Decision Quality**

DQ1. I regularly check decision quality prior to making decisions.

DQ2. Formal assessments of decision quality are carried out prior to all key decisions.

DQ3. Decision quality is measured early on in a phase to identify activities needing to be completed before the decision is taken.

DQ4. Assessing decision quality is quick and easy to do.

DQ5. Experienced people do not need to check on decision quality before making a decision.

### **Questions on General Decision-Making**

Gen1. I rely mainly on my experience and judgment for decision making.

Gen2. Time is spent with the decision makers to clarify their requirements, both upfront and during each phase.

Gen3. Projects are often schedule driven.

Gen4. Time is spent upfront on framing the decision, including providing clarity on the boundaries, the objectives and the criteria to be used by decision makers.

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