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REAL-WORLD DECISION MAKING IN THE UPSTREAM OIL AND GAS INDUSTRY—PRESCRIPTIONS FOR IMPROVEMENT

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ABSTRACT

Business under-performance in the upstream oil and gas industry, and the failure of many decisions to return anticipated results, has led to a growing interest in the past few years in understanding the impacts of decision-making processes and their relationship with decision outcomes. Improving oil and gas decision making is, thus, increasingly seen as reliant on an understanding of the processes of decision making in the real world.

There has been significant work carried out within the discipline of cognitive psychology, observing how people actually make decisions; however, little is known as to whether these general observations apply to decision making in the upstream oil and gas industry.

This paper is a step towards filling this gap by developing the theme of decision-making process. It documents a theoretical decision-making model and a real-world decision-making model that has been distilled from interviews with many Australian upstream oil and gas professionals. The context of discussion is to review the theoretical model (how people should make decisions) and the real-world model (how people do make decisions). By comparing and contrasting the two models we develop a prescriptive list of how to improve the quality of decisions in practice, specifically as it applies in the upstream oil and gas industry.

KEYWORDS

Decision making, risk and uncertainty, management, decision type, decision processes.

INTRODUCTION

The upstream oil and gas industry is characterised by projects involving a series of increasingly expensive investments that subsequently generate revenue streams that are highly uncertain, and, in some cases, never recover the cost of the investments. The magnitude of these investments frequently amounts to hundreds or thousands of millions of dollars. These projects, within the industry, are often characterised as being very high risk and have 'frequently been given the dubious distinction of being the classic example of decision making under uncertainty' (Newendorp and Schuyler, 2000).

Business under-performance in the upstream oil and gas industry, and the failure of many decisions to return expected results (Brashear et al, 1999; Brashear et al, 2000; Goode, 2002; Cottrill, 2003; Rose et al, 2003; Durham, 2004), has led to a growing interest in the past few years in decision making. In the past two decades the majority of oil and gas companies have consistently under-performed in returning the economic metrics that were the justification for their investment decisions, suggesting that their evaluation and decision-making procedures result in either a systematic over-estimation of returns or an under-estimation of the risks.

In a previous paper, the need to understand decision type to improve decision making was discussed (Mackie et al, 2007). This paper takes up a second theme, that of decision process, also critical to improving decision making in the upstream oil and gas industry. We document a theoretical decision-making model, extracted from the literature, together with a real-world decision-making model, distilled from interviews with many Australian upstream oil and gas professionals. The two models are compared and contrasted to develop a series of prescriptions of how to improve the quality of decisions in the oil and gas industry.

HOW SHOULD COMPANIES MAKE DECISIONS?

Mackie et al (2007) document some criteria for good decision making in the upstream oil and gas industry and agree with others that the 'best hope for a good outcome is a good decision process followed by good implementation' (Russo and Schoemaker, 2002, p. 5). This is based on the assumption that process and outcome are very strongly correlated (but not absolutely) and pursuing a good process will lead to achieving a good outcome in the long term.

Essentially there are four elements that make up a decision (Fig. 1).

Deciding

In the real world of the oil and gas industry, a decision is rarely made using only one measuring criterion and indeed should not be. Generally it is made using multiple objectives. A process, then, that takes this multi-objective nature of the decision into account needs to be used. Several authors have described, in various ways, what may be termed a multi-objective decision-making process (Begg, 2004; Chankong and Haimes, 1983; Goiciechea et al, 1982; Rudduck et al, 2006; Suslick et al, 2001; Szidarovszky et al, 1986). In the proposed process, three stages are synthesised and subdivided into eight steps for ease of execution (Fig. 2).

The processes involved at each of these steps are discussed below.

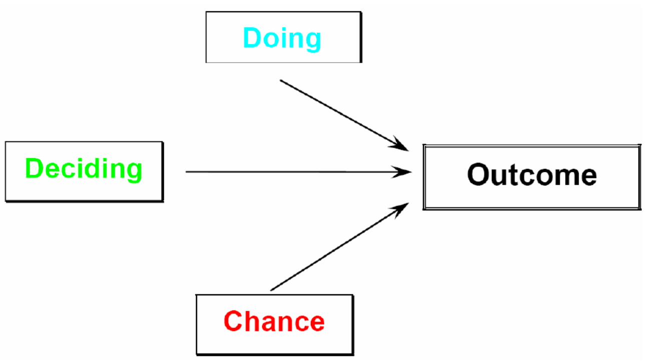

Figure 1. Three factors determine decision outcome.

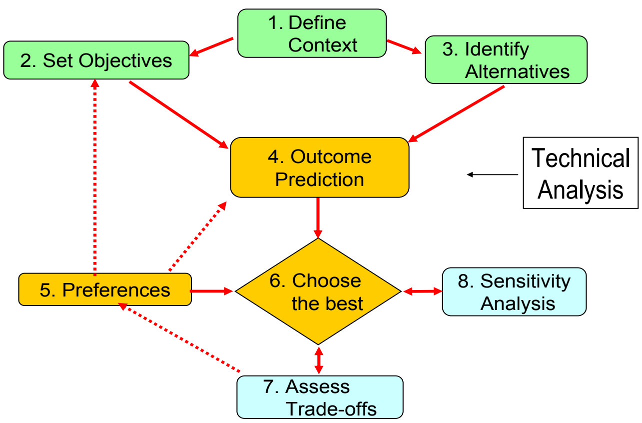

Figure 2. Eight-step multi-objective decision-making process.

STAGE 1—FRAMING

Step 1—define the context. Each of the processes discussed previously starts with this step. As most of the reviewed authors indicate (Campbell et al, 2001; Clemen and Reilly, 2001; Nutt, 2002; Russo and Schoemaker, 2002; Skinner, 1999), this is the time to identify and frame the decision as well as determine who will actually make it. Several of the authors also talk about the need to make sure that the right problem or decision is being addressed. Too often decisions are made only to find out that they were addressing the incorrect problem.

Step 2—set objectives. Once the context is clear, the objectives can be determined—these being the goals or dimensions against which choices or alternatives can be measured. The process is termed a multi-objective decision-making process because it is assumed there is more than one objective, as is usually the case in oil and gas decision making. As well as specifying the objectives, it is important to enunciate the way they are to be measured. What is critical here, as Nutt (2002) points out, is to actually list objectives and their measuring scales and to establish the direction to be taken ahead of determining the alternatives.

Step 3—identify alternatives. In this step, the various choices or options that could satisfy the context and objectives are generated by means such as creative thinking and benchmarking. Although this stage may be perceived as taking a disproportionately long time, the investment in time is seen as worthwhile once the modelling stage commences (see Nutt, 2002; Russo and Schoemaker, 2002).

STAGE 2—MODELLING

Step 4—outcome prediction. Once both the objectives and alternatives have been generated, the alternatives can be rated or measured against the stated objectives. Each alternative should be rated for its ability to satisfy a single objective prior to moving to the next objective and rating each alternative for that objective. This guards against deciding on an alternative without fully evaluating all alternatives—jumping to a conclusion.

Step 5—preferences. To determine which alternative best meets all the objectives, it is necessary to weight the objectives to reflect the relative importance of each.

Step 6—choose the best. The final step in the modelling stage is simply to sum the weighted values for each alternative. The provisional decision rule, at this stage, is to choose the alternative with the highest weighted value.

STAGE 3—ASSESSING

A third stage is included to allow for several methods of checking that the alternative with the maximum weighted value is, in fact, the best choice.

Step 7—assess trade-offs. The objectives can be split into different classes, for example, costs and benefits, or risks and returns. The weighted scores of the alternatives for each of the classes of objective can then be crossplotted to determine whether particular alternatives are dominant across all classes.

Step 8—sensitivity analysis. The primary purpose of this step is to check the robustness of the decision, that is, to see if the chosen alternative changes for a viable change in weights. An objective can be chosen for which the weights are then varied systematically from those used in the original modelling. The weight is varied and the other objectives' weights are prorated. The final scores are then plotted against the changing weights to again look for dominance of an alternative on the changed weighting.

Chance

Having proposed that a decision-making process is critical to success, it is also important to review the other elements affecting the decision outcome. It is important to recognise that identifying good decision making necessitates viewing decision making as a probabilistic process. It is only in the long term that the good decision makers are identified as those who have more successes than failures. No authors argue that implementing their particular decision-making process will yield good outcomes every time, just that there is a better chance of a good outcome. Although, when chance is involved, no individual outcome can be predicted with certainty; a good decision process is argued to yield a higher likelihood that the objective will be achieved (a good outcome) on any individual decision. It also means that the cumulative effect of the long term is the best outcome.

Doing

The final element influencing the decision outcome is the way in which the decision is implemented. Even when a decision is made using the best process and chance is on the decision maker's side, the outcome may still be sub-optimal because of the way the decision is implemented. To assist in overcoming this impediment to good outcome, the implementation can be analysed post-outcome and the results fed back to the decision maker. It has been demonstrated that when this occurs better judgements are made in the future (Murphy and Winkler, 1984; Tomassini et al, 1982). These feedback loops have been a central focus for oil and gas companies in improving decision making (Johns et al, 1998). A comparison between US weather forecasters (Murphy and Winkler, 1977) and US doctors (Christensen-Szalanski and Bushyhead, 1981) shows that the feedback needs to be immediate and continuous to see improvement. When there is some time between the decision and the feedback, there is the chance that the improvements will not materialise. Immediate and continuous feedback is difficult in the oil and gas industry when, for example, the judgement is the amount of recoverable reserves. That number is never really known until the field is depleted.[1] Hence the feedback may be many decades away from the decision.

It is important, then, that the theoretical model contains several feedback loops. One should be undertaken for each of the three decision-making elements:

- process—where the process used is compared to the theoretical model;
- implementation—where the way the decision is implemented is compared with how the decision maker recommended that it be implemented; and,
- outcome—where the actual outcome is compared with the estimated outcome.

Outcome

Having reviewed the elements that contribute to the outcome, it is now important to shift the focus to an examination of the outcome itself. It has been argued, above, that having a clearly defined decision-making process along with the learning mechanism of feedback loops would, in the long term, yield better decisions. It would be incorrect, however, to assert that the success of a decision should not rely at all on the outcome. The real world is an outcome-focussed environment, and too many bad-break stories will not be accepted for long—whereas dumb luck will tend not to be punished. That is, the outcome is important, because the oil and gas industry is a business and must concern itself with the bottom line. This view is summarised by the old colloquial phrase: 'The operation was a success but the patient died.' Brown (2005) uses this phrase to title a discussion where he analyses why some decision outcomes fail when the analysis is successful. He makes some recommendations to abate the problem but still there are instances when good decision analysis will end in bad outcomes.

Clearly some outcomes are not desirable and should be avoided. The game of Russian roulette demonstrates that it is important to consider the possible outcomes.

In the oil and gas industry many decisions involve very high costs, for example, the decision to develop an offshore field, which may cost up to US$1 billion. Regardless of the excellence of a decision-making process, some decisions simply cannot afford to fail or a company will go bankrupt and, thus, be unable to make more decisions. In this way, the oil and gas industry, along with other real-world environments, differs from probability theoretic approaches that assume an infinite number of decisions and therefore the chance to trade out of the negative outcome in time.

Finally, in the oil and gas industry, where the outcome is almost always uncertain, the size of the outcome is extremely important. A well may discover hydrocarbons but it may be of insufficient size to be deemed economic. On the other hand, the discovery may be extremely large, a company maker! Clearly, then, some sized outcomes are more desired than others. So a decision may be technically a success but economically a failure. In this industry, success must be viewed from a commercial viewpoint. Oil and gas exploration and development is a business and not a science.

There is, therefore, a real tension that exists between the decision-making process and the decision outcome. The theoretical model must take this tension into account. It is argued, herein, that priority must be given to the process.

Team decision making

Few decisions in organisational contexts are made solely by individuals. Decisions in the oil and gas industry, like many other industries, are made by individuals working in groups or teams. In fact, early work on the benefits of team decision making was recognised in the oil and gas industry (Sneider, 1999, 2000a, b). Within organisations an individual is usually charged with having responsibility for making the decision. But, due to the highly complex nature of the industry, a single person rarely has sufficient information to make the decision. They therefore need to combine or integrate differing recommendations from diverse, usually subordinate, staff. The decision-making process can therefore be considered as having two steps. The first step is the individual, or core, decision made by an individual staff member. Having been made using the processes previously documented, this decision then becomes a recommendation. The second step consists of having that recommendation endorsed or approved by the organisation. A theoretical model that describes this style of decision making is termed the multi-level theory of team decision making (Hollenbeck et al, 1998; Hollenbeck et al, 1995) (Fig. 3).

Decision level—this is the lowest level in the hierarchy and relates to the many decisions that an individual may make. An example from the oil and gas industry may be as simple as which reflector a geophysicist is to interpret

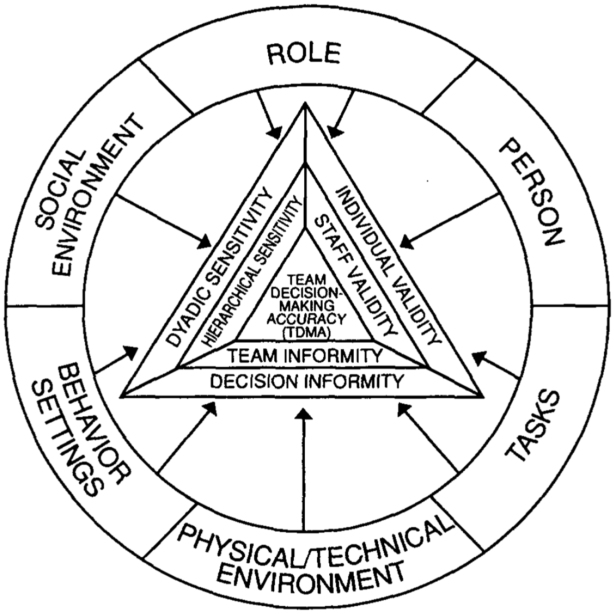

Figure 3. Multi-level theory of hierarchical decision making (Hollenbeck et al, 1995).

in a seismic interpretation project. The core variable that governs success at this level is said to be decision informity, meaning that the staff have access to all relevant information available to assist in making the decision.

Individual level—the next level relates to the individual professional; success at this level is dependent on individual validity, which is the actual judgement made by the professional based on all the preceeding decisions they have had to make. Extending the geophysical interpretation example, this is the final interpretation.

Dyadic level—within the team there are many one-on-one relationships. These exist between the individual team members and between the individual members and the team leader. The dyadic level relates to these individual one-on-one relationships. Decision-making success at this level is predicated on dyadic sensitivity, which is the ability of the team leader to correctly weigh the value of each individual's input. Continuing with the oil and gas example, this is the point where the team leader is reviewing all the individual interpretations, be they geophysical, geological, or otherwise, and deciding on what level of importance is placed on each interpretation.

Team level—finally, at the total team level, full integration of all the weighted individual contributions leads to the best possible decision. For the oil and gas team this is the final team integrated outcome of the entire interpretation project. All team members must feel free to provide and receive input. In such a receptive environment, group wisdom can take place (Stanfield, 2000).

Upstream oil and gas literature documents the use of portfolio optimisation or portfolio management as a critical part of the successful team decision-making process (Allan, 2001; DuBois and Howell, 2000; Howell and DuBois, 2003; Howell and Tyler, 2001). The key argument is that if individual projects are assessed independent of each other and then their final metrics are added together, any dependencies that exist between the projects are not accounted for, which results in sub-optimal decision making. Optimal decision making, it is argued, results from reviewing how each individual project affects the outcome of the entire portfolio. Hence the choice of project should be determined by optimisation of the entire portfolio rather than the optimisation of each individual project in the portfolio (Rose et al, 2002).

Theoretical decision-making model

Synthesising the previous sections, the over-arching root definitions of the final theoretical model are schematically shown in Figure 4.

HOW DO COMPANIES MAKE DECISIONS?

Having established a theoretical model of how decisions should be made, the first question that comes to mind is: is that how they are made? To answer this question, 32 semi-structured interviews were conducted with senior decision makers—that is, those of middle-manager level and above (geoscience or engineering managers to chief executive

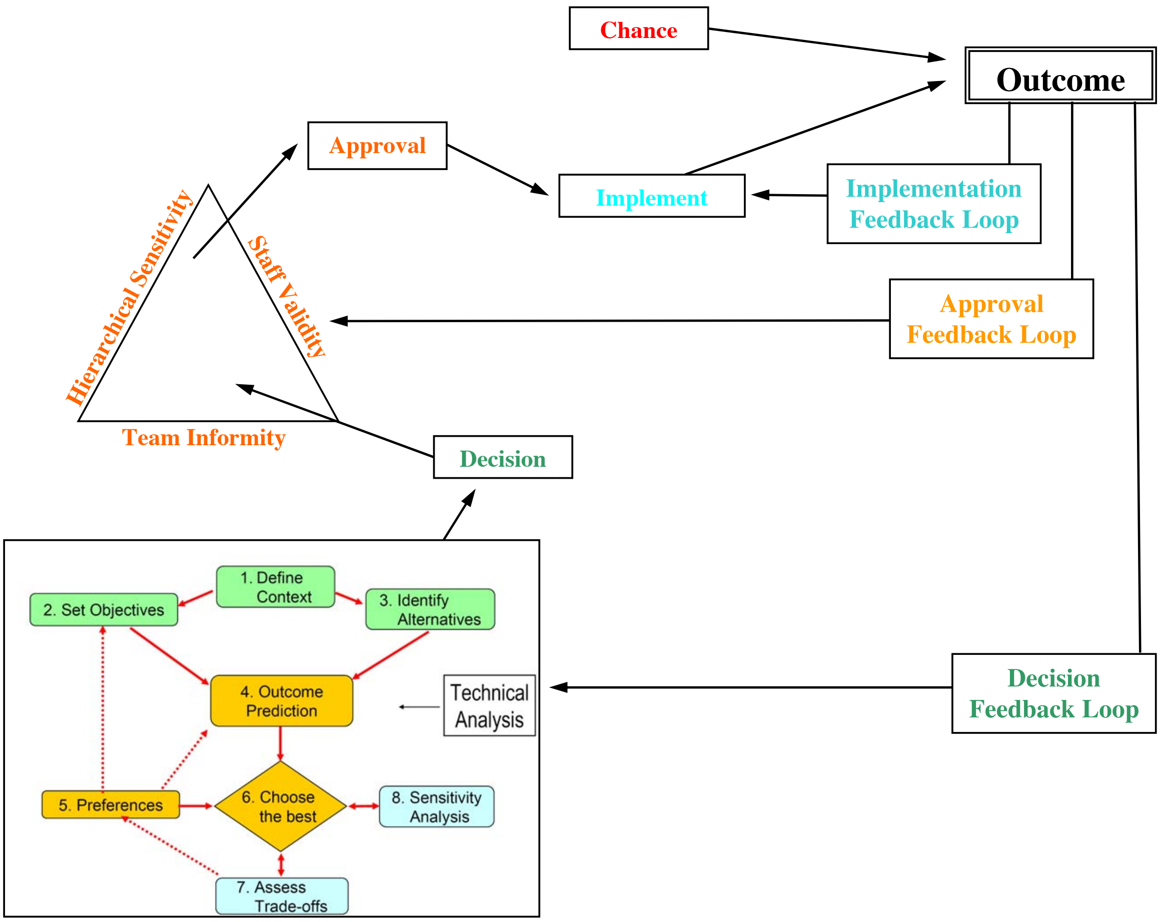

Figure 4. Theoretical model of how companies should make decisions under uncertainty.

officers)—of both large and small publicly listed companies as well as governmental officials from the Australian oil and gas industry. From these interviews a real-world oil and gas decision-making model was distilled.

The analysis of interview transcripts yields several key points about how decisions are made in oil and gas companies. This analysis is now interpreted and evaluated to distil a real-world oil and gas decision-making model: a representation of how decisions are actually being made in oil and gas companies. A key construct needs to be noted. The real-world model itself is built using all the comments combined and does not take the approach that the model should be what elements were in common for all interviews.

Questions like: can a company make a decision?; or statements to the effect: don't individuals make decisions!; raise the issue of group versus individual decision making. Decision making in oil and gas companies is generally seen by the participants as a team or group process. Despite this view, closer analyses have revealed that decision making is, ultimately, an individually based activity that has input from a team.

The style of the group-based process, however, is quite distinct. The groups are making decisions that are being judged in terms of whether they are good or bad. Success or failure is a shared interest the team members have in common. If the decision succeeds, the whole team is seen as succeeding, and vice versa. Although the team consists of interdependent people, usually technical professionals who have specialised knowledge, they influence each other in making the decision. The prime characteristic of the team in the oil and gas industry, however, is its hierarchical nature. The team leader, or manager, makes the final recommendation or decision. The models and theories that may be applicable, therefore, are those that relate to hierarchical decision making. That said, it is still important to see that at the discrete decision level, the human side of decision making is still individually based.

The interviews reveal that various types and numbers of decisions are made at differing levels within an oil and gas company. Based on a thorough reading of the transcripts, there appear to be three general levels. Beginning with the lowest (in ascending order) these are: tactical or operational; then strategic; and, finally, policy.

If the number of decisions observed at each level is taken into account, a triangle of decision recommendations is developed (Fig. 5)—with many more tactical decisions when compared with policy ones.

Alternatively, if the decisions are viewed from the amount of perspective—how much of the picture can be

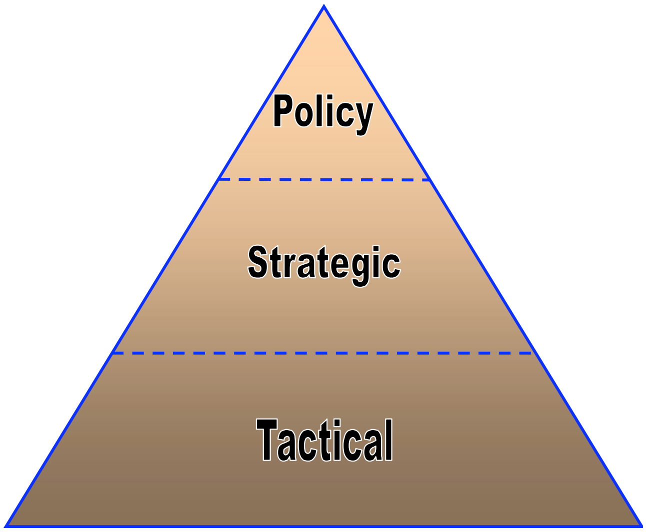

Figure 5. Triangle of decision recommendations.

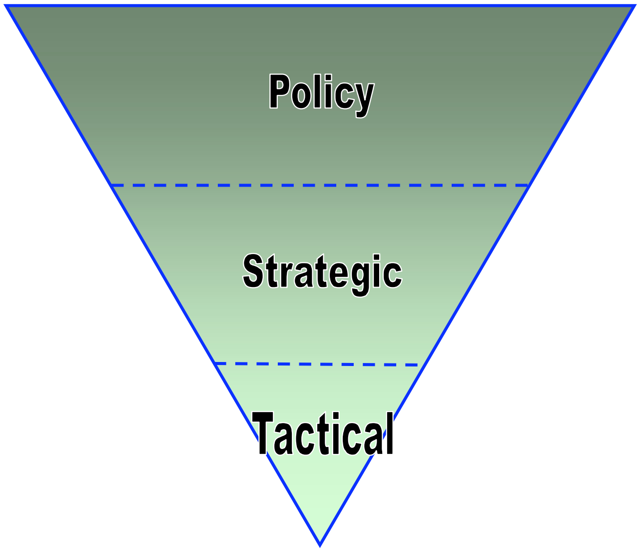

Figure 6. Triangle of decision perspective.

seen by the decision maker—needed to make the decision, rather than the number of decisions, the interviews indicate an inverted triangle of decision perspective (Fig. 6).

From the interviews, it appears to be common practice for companies to require that the majority of decisions be passed up the chain. This is viewed by those higher up the hierarchy as necessary for strategic perspective to be brought to bear in the decision. It is viewed with frustration by those lower down the hierarchy due both to the amount of time the decision takes and their feelings of being under-utilised. This is evidence that the company's objectives are not being clearly specified to all levels of the company. Taking into account the definition of a decision—the irretrievable allocation of resources to achieve a desired objective (Skinner, 1999)—these apparent dichotomies can be resolved. Rather than making decisions at the level where the strategic perspective is greatest, or where input is received, it should be possible to make the most practical decision at the lowest level where the resources are under the individual's control. Where the decision maker is the person who has control of the resources and clearly understands the company's aims and objectives, they are able to make decisions on behalf of the company, not themselves.

To achieve this simplified and balanced model of decision location within the hierarchy, it is necessary to have clear and concise communication. Rather than just bottom-up communication—with lower levels communicating their reasoning for recommending a certain decision—it is also necessary to have reciprocal feedback from the top down. Higher levels should be communicating their policy, strategy and objectives in a clear and concise way to the lower levels. Similarly, communication from the bottom up needs to be clear and concise with regard to the available and required resources. This yields a balanced hierarchy of decision making (Fig. 7).

The interviews highlighted a nested structure of decisions being made within decisions. Actual individual or core decisions were made and then passed on to upper levels of the hierarchy. These people, in turn, made their decision by either approving or disapproving the decision made at the lower level or passing it on to an even higher level. This upward movement of decision making continued until a final approval (or disapproval) was given.

Two models are needed to account for these somewhat independent processes. The first covers the individual, or core, decision-making process, while the second deals with the approval, or hierarchical, decision-making process—the individual decisions being nested within the hierarchical approval process.

Individual or core decision-making process—the individual decision-making process is best described as a linear process consisting of:

- determining the aim;
- taking time to frame the problem;
- determining objectives and their relative weights;
- seeking alternatives that achieve the objectives;
- checking other possible solutions; and, finally,
- making the decision.

The process is, however, heavily modified by constraints, the primary ones not only being time and change of environment but also the availability of appropriate tools, which are used in a fit-for-purpose way for filtering data into usable information.

Furthermore, biasses, both cognitive and motivational, exist in individual decision making, highlighting the need to find ways to debias decisions. A key aspect of any remedy for bias is constant, clear and concise communication—particularly of feedback, which serves to sift out biasses in the long term.

Although learning feedback, or the learning cycle, may be seen as the connection between the two nested

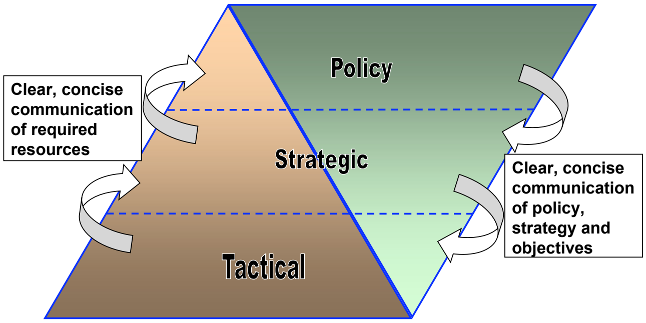

Figure 7. Balanced hierarchy of decision making.

models, most interviewees believed that the success of a learning cycle was dependent on the level of the hierarchy at which it was initiated. If the feedback is initiated from, or carried out at, the lower level of the hierarchy it is termed a peer review. If it is initiated from the higher level of the hierarchy it is termed an approval process. The feedback loops were argued by participants to work best when conducted as volunteer peer reviews rather than as a management-imposed approval process. It is thus best to see them as sitting within the individual decision-making process and not part of the hierarchical process.

Hierarchical approval process—the primary purpose of the hierarchical process is to deal with how the team or group members interact to arrive at the final decision (if it cannot be made at the individual level). The key determinant in this process, as seen by the participants, is the weighting of the recommendations (the individual core decision) that come to the higher levels of the hierarchy. The weighting is a function of the level of trust and confidence the team leader has in the individuals who are making the various recommendations.

Portfolio management process—portfolio management processes have been recently introduced into the upstream oil and gas industry as a methodology to take into account dependencies between projects. It is interesting, given this recent innovation, that most interviewees did not discuss this approach at all. The majority of responses that talked of portfolios simply used the word to mean a group of projects rather than the dependencies between the projects. Given this level of response it is concluded that portfolio management has yet to become mainstream in its practical application. It is therefore left out of the model (in Fig. 8) depicting real-world oil and gas decision making under uncertainty.

Trust heuristic

A vital aspect of hierarchical decision making in the oil and gas industry, strongly highlighted in the interviews, is the trust heuristic. Several interviews reveal that, to make timely decisions in this type of environment, people higher up the hierarchy have developed what is herein termed the trust heuristic. This heuristic is visually portrayed in Figure 9.

If the person making the recommendation is trusted by the decision maker, the recommendation is approved. If the recommender is not trusted by the decision maker, the recommendation is questioned. Where the stakes are high, the decision maker tends to give the data to a trusted subordinate to make the decision for them. This trust appears to be built up incrementally through experiences with the person.

PRESCRIPTIONS FOR GOOD DECISION MAKING

Having distilled a theoretical decision-making model and constructed a real-world decision-making model for the oil and gas industry, it is possible to compare and contrast them to determine areas for improvement. The first series of prescriptions deals with structural change. These range from organisational change to changes in functional responsibility—the static parts of the system. A second series of changes looks at the more dynamic parts of the system. These are the procedural prescriptions. Finally, prescriptions in attitudes are addressed. People act according to their attitudes and perceptions. Even though structural and procedural prescriptions may be implemented, little improvement may occur unless people's attitudes are also changed. Hence the discussion centres on what is feasible as well as what is desirable.

Similarities

The first observation is that both models are very similar at the macro level. Each consists of an individual decision-making process followed by some form of approval process. This then leads to implementation, an outcome and some form of feedback. Even at the next level down, the individual process level, the models are still fairly similar. The ideas of frames, objectives, alternatives, modelling and assessment are all present. What adds more to the similarity is that the order of the phases is also very similar. Several reasons for such similarity may exist. Firstly it could be that the interviewees simply responded the way that the literature said they should, and therefore any real-world model is simply a copy of the theoretical model. This reason does not appear to be likely in this instance because there are sufficient differences as to imply that the participants did not refer to the literature as their guide.

Secondly, it could be that the models were built in a very similar fashion. The real-world model is distilled from the interviews and is built from a series of good ideas, or real-world practices. The theoretical model is similarly built from three primary models. The model is developed from different sources because no one theoretical process or model fully described the situation.

Based on the type and breadth of data obtained during the interviews both reasons appear to be unlikely. It is therefore concluded that the similarities are present because they are valid or real. These similarities show, therefore, that real-world experience at the macro level aptly follows the theoretical model.

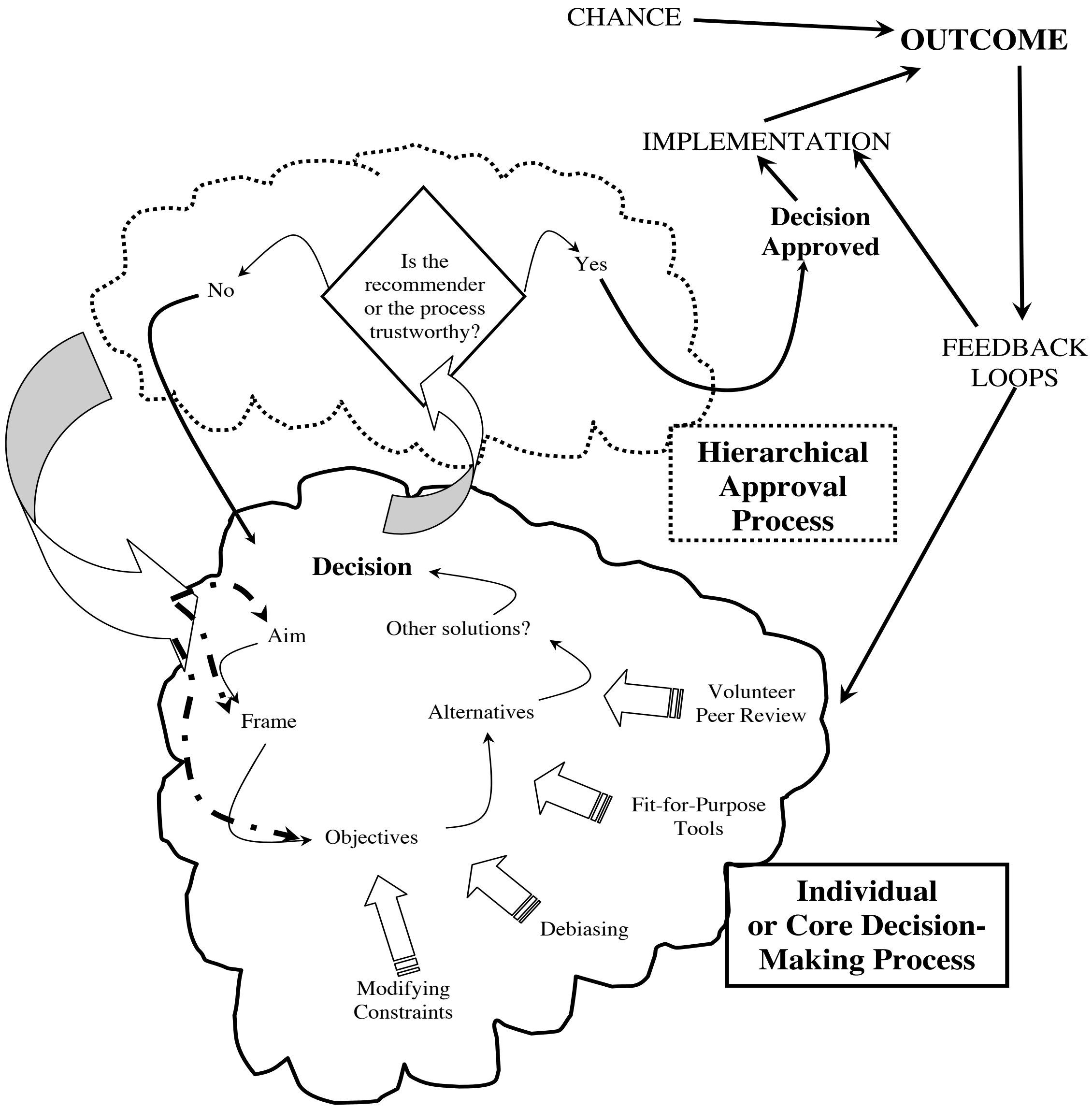

Figure 8. A model of real-world oil and gas decision making under uncertainty.

Differences

The first series of differences deals with elements of the processes that are present in the real-world model but absent in the theoretical one. The differences include the influences on the individual decision-making process, the relationship between peer reviews and approval reviews, and the predefinition of aims, objectives and frames.

In the individual decision-making process, the real-world model has four key influences: modifying constraints, debiassing, fit-for-purpose tools and volunteer peer review. These influences are not explicitly named within the theoretical model. A key observation from the semi-structured interviews is that the participants, by and large, talked about these influences more than they did the actual basic elements of the process, namely, framing, modelling and assessing.

In the real-world model, the arrow that links the individual decision-making process with the hierarchical approval process is, essentially, some form of review. In the model it is seen as a management-imposed approval review. One of the primary ideas developed by many of the participants in the interviews was that such a review should not be confused with a peer review. Voluntary peer reviews are seen as extremely beneficial. The root of the benefit lies in the idea that two heads are better than one. And this is especially true if the other head understands the situation and is a respected peer. Voluntary peer reviews, or brainstorming, can and should occur throughout the entire decision-making process, both during the individual process and the approval process. There should, however, never be the actual linkage between the two processes. A management-imposed review is a formal recommendation and approval process. By this time all ideas are solidified

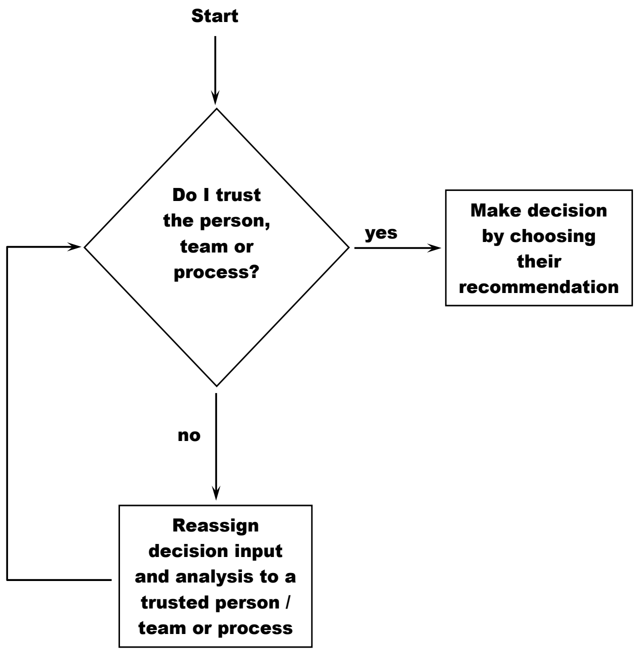

Figure 9. The trust heuristic.

and defence is the main aim, whereas a voluntary peer review occurs before any solidification of ideas and thus assists in expanding possibilities, fostering optimisation.

Within the theoretical model the aim, frame and objectives are understood to be determined by the decision makers who act on behalf of their organisation. In the real-world model, however, the participants argue that, in their minds, better decision making will occur within companies if the companies predefine some or all of these critical elements. In much of the literature on why decisions fail (Hammond et al, 2002; Nutt, 2002; Russo and Schoemaker, 1989, 2002), one of the key themes is that people spend a great amount of time and effort on solving the wrong problem. It is difficult to determine what the correct problem is ahead of any outcome, especially when the outcome is subject to uncertainty. Yet, those who were interviewed clearly resonated with the idea that the aims and objectives should be predefined by the corporation and should be those of the owner. Thus, whenever a situation arises where a decision needs to be made, the decision maker already knows the aims of the corporation and frames the decision within those aims and objectives.

The second set of differences relates to elements of the process that are present only in the theoretical model. These include the approval feedback loop, the criteria relating to approval, the lack of portfolio management, and, in a general sense, the absence of the framing stage. As decision makers are not fully cognisant of all decision theories, their practical implementation of the decision-making process is sub-optimal.

Even though those being interviewed saw feedback as critical to improving the decision-making culture in their companies, not one mentioned feedback on the actual approval process. The feedback that was spoken about related to how the decision was implemented and to the actual outcome of the decision. The theoretical model has three primary feedback loops: the implementation feedback loop, the decision feedback loop, and the approval feedback loop. If there is no way to give feedback on the approval process, most employees will feel trapped by something they have no control over. This is strongly expressed in some of the interviews when timing of approval is seen as frustrating. If there was a method to acknowledge and alleviate this frustration, the overall success of the process would be improved. It is therefore recommended that more communication of the steps in the approval process be undertaken, especially from the approval groups in the organisation.

In the real-world model, approval is centred on the trust value. This is either trust in the individual making the recommendation and/or trust in the process of recommendation. In the theoretical model, however, several criteria are used for approval. Those that are noted as being the most critical are:

- staff validity, that is, how much information the team has to make the decision and have it approved;
- team informity, which relates, in part, to the trust heuristic used in the real world; and, finally,
- hierarchical sensitivity, which is the ability the whole team, not the leader, has to weigh its input to make the final approved decision.

Comparison of the real-world and theoretical models shows that there are two criteria that are not being used in the real world. Theoretical experiments (Hollenbeck et al, 1995) have shown that up to 64% accuracy can be predicted on decision outcome when all three criteria are used. Whereas, if only team informity (or trust) is used, this drops to 24%. These models should be expanded to allow for all criteria to be used as part of the approval process. Some form of team involvement in the actual approval process, rather than it just being left to the leader, should see more optimal decisions being made. As to the question of staff validity, the introduction or expanded use of value of information techniques should also lead to improvement. If the amount of information needed to make the decision is actually discussed and agreed to in the very early stages of the process, then objectives become clearer and outcomes more successful.

One of the most obvious differences between the two models is the distinct lack of portfolio management in the real-world model. The theory of portfolio management argues that risk and uncertainty can be decreased if individual projects are viewed as part of a holistic portfolio. Determining good decisions for individual projects is related more to the change in the portfolio outcomes than to the individual project metrics. The projects are not independent of each other. All projects in the upstream oil and gas industry have dependencies between them. Not recognising these results in sub-optimality (Al-Harthy et al, 2006). It is recommended that the process be more widely adopted and adapted in the industry.

The final difference deals with the way the individual decision-making process is implemented in the real world.

Most interviews demonstrated that the framing stage of the process was left out. The decision makers appear to jump straight to the modelling stage. This may occur for several reasons. One explanation may be that oil and gas decision makers are more adept at modelling—coming from a modelling world, being geologists, geophysicists or engineers—and therefore concentrate on what they do best (modelling) and leave out what they do not do well (framing). Another explanation may be that because the oil and gas industry focusses on outcomes, shortcuts are believed to be important. Many participants discussed the need for companies to predefine the framing stage. This may indicate that they, as decision makers, believe that the frame is defined and therefore jump right into the modelling without determining if the frame has been defined as they assumed. Whatever the reason, the behavioural observation is that most decision makers leave out the framing stage and therefore the risk that they are solving the wrong problem(s) is extremely high.

Possible changes

There are three areas where change in a system that involves humans can be enacted. Changes at this level can either be static (i.e. they deal with the procedural aspects of the system) or dynamic (i.e. they deal with the functional aspects of the process). Simply because these changes are desirable does not make them implementable. This is where the third area of change becomes important. When dealing with systems that interface with humans, people's attitudes are vitally important if change is to be enacted. People act according to their attitudes and perceptions are usually created by rewards and penalties. Even though structural and procedural prescriptions may be desirable, unless people's attitudes are also changed, little improvement in decision making may occur.

WHAT IS SYSTEMATICALLY DESIRABLE? STATIC (PROCEDURAL) AND DYNAMIC (FUNCTIONAL) CHANGES

Based on the interviews, several modifiers were added to the individual decision-making process of the theoretical model. These include debiassing, fit-for-purpose tools, modifying constraints and peer review. The first series of recommended changes, therefore, relates to these modifiers. The actual decision-making process should be a prescribed workflow, which, apart from the basic elements of framing, modelling and assessing, has a place for each of the modifiers.

Cognitive debiassing has been the subject of some research and recommendation (Welsh et al, 2006; Welsh et al, 2005). Essentially it has been shown that if decision makers recognise that they are susceptible to cognitive bias, they can form standardised ways of removing, or at least allowing for, the bias in their judgements. Hence, from a procedural perspective, it is important that decision makers undertake certain training programs and also be alert to their bias. Functionally, the best prescription is for decision makers to regularly participate in feedback learning cycles or loops that help show what level of bias may be present in past decisions so that improvement can occur into the future (Johns et al, 1998). It is therefore recommended that a procedure be put in place in the decision-making process that allows for regular look-backs.

Technical debiassing has also received some review. The most successful methodology is reality checking. This is where the geotechnical and economic parameters are reviewed against statistical expectations looking for exceptions. Research has shown that this is more powerful in improving decision making than cognitive debiassing (Rose, 1985, 1987; Johns et al, 1998; Citron et al, 2002).

Fit-for-purpose tools have not been researched as much. In fact recent research (Jonkman et al, 2000; Macmillan, 2000; Simpson et al, 2000) recommends using the highest level risk analysis tools—such as portfolio analysis, option theory, preference or utility theory—as well as quantitative and qualitative analysis for optimal decision making. There is an underlying assumption that these tools be used no matter what types of decisions are being made. Fit-for-purpose is not so much a technology as an awareness that the decision maker's analytical efforts should be commensurate with the importance of the business question at hand.

The interviews revealed that the ability to decide on what tools are fit-for-purpose is related to the experience of the decision maker. Hence there is a need to understand both the type of decision and the experience of the decision maker. It is therefore recommended that a procedure for typing decisions be put in place first; decision makers can then assess their experience in such decisions prior to identifying what tools will be used for the decision.

Much has been discussed about peer reviews. The critical point raised by this research is that such reviews should be voluntary and initiated by the decision maker. What is prescribed is that such reviews should exist and should take place long before the decision is solidified. A peer is seen as being equal to, in terms of experience and profession, the decision maker. Asking such a person to review and comment on work to date can help identify factors that may not have been considered or some that have been given too much emphasis, prior to forming a decision. The interviewees also expressed the need for experienced eyes to be cast over the decision. Too often this experience is seen as being given during the actual approval process. This, however, is not what is required to facilitate better decisions. The idea would be to have the experience brought to bear prior to the solidification of the decision.

It is recommended that the idea of what may be termed mentoring reviews should also be canvassed. Mentors are seen as having more experience. Therefore they can bring extra experience to bear on the decision-making process. As with peer reviews, however, it is critical that mentors and their input are voluntarily called for by the decision maker and not imposed by management.

This is because such imposition may be interpreted by the decision maker as a lack of trust on the part of management. Procedurally, then, the decision-making process should call for peer and or mentor reviews while the decision is being framed, modelled and assessed. From a functional point of view, how peer and or mentor reviews are conducted should be left to the decision maker so that he or she gets the optimal response in ideas and personal assurance of management confidence. This could range from impromptu requests through to full-day workshops. The key elements of the reviews are their voluntary nature and that they occur far enough in advance of the decision being made as to allow changes to be implemented.

The next area of prescription deals with the inclusion of an approval feedback loop in the decision-making process. Such feedback is not now present in most oil and gas decision-making processes. This feedback is centred specifically on the actual approval process and not on the decision and/or the implementation feedbacks that are reported as already generally being part of the present processes. To review an approval process, it is first critical that such a process is documented. Hence the procedural part of the prescription calls for a decisions approval mechanism to be documented. This documentation should include discussion of why the decision was or was not approved and specifically define the process used for the approval. It would be beneficial if the documentation were both quantitative and qualitative. Such quantification facilitates objective feedback. This feedback is seen as being more beneficial for those decisions that have more than one cycle up the hierarchy. Many of the interviewees expressed either concern that they were left out of the loop or frustration at the time it took to receive approval whenever the approval process moved higher up. Both these feelings would be counteracted by clear and concise documentation of the entire approval process. Thus, functionally, if the approvers (decision takers) are not totally removed from the original proposers (decision makers), better decision making may occur.

One of the key mismatches, which leads to sub-optimal decision making in the oil and gas industry, is that people—not organisations—make decisions. Unless the organisation makes extremely clear its frames—aims and objectives—employees can easily substitute their personal aims, objectives and preferences. Hence, one further addition to the decision-making process that should be prescribed is the need for the organisation to predefine the aims and objectives. From a functional perspective, this can be monitored on an ongoing basis to determine if the aims and objectives are clearly understood and implemented.

The final series of prescriptions deals with the criteria used to approve a decision. In the real world, trust is used as the primary determinant. Theoretical research, however, has shown that to achieve more optimal decisions, two other criteria need to be added. The first deals with how much information the team presents to have the recommendation approved, while the second relates to the ability of all team members, not just the leader, to weigh their various inputs to make the final approved decision. Approval of an individual project should also be reviewed in a holistic portfolio context so that dependencies and the resulting changes in risk and uncertainty to the entire portfolio are more clearly understood. From a procedural perspective, then, it is recommended that, as part of the addition of approval documentation, all three criteria be discussed and documented together with the implementation of portfolio optimisation.

Another procedure that can be prescribed is the implementation of regular value of information analysis to determine the value of data required in the approval process. Functionally, there is large scope for implementation of such a prescription. Virtually all approvals in the oil and gas industry are made hierarchically. Yet theory has shown that the more the team has the ability to weigh all aspects of the decision input (rather than just the leader), the better the decision will be. Further research is warranted that reviews research on consensus teams and how they make decisions (see Davis, 1973, 1992; Steiner, 1974, 1983) to determine its applicability to this function.

WHAT IS CULTURALLY FEASIBLE? ATTITUDINAL CHANGES

With several changes recommended for the improvement of the decision-making process, the most vital or critical issue lies in how to have such changes accepted. Just because a process is re-engineered does not mean that it will be accepted and implemented by people. For example, Welsh et al (2006) showed that even education on biasses lost its effect after time. The real question is how the changes can be implemented within a human system. People rarely continue to do something just because it is good. Hence, there is a need to encourage the adoption of the recommended prescriptions so that the changes are enacted and continued.

In the oil and gas industry, most employees are rewarded with bonuses based on decision outcomes and not decision processes. It is essential to understand that most of the major decisions in the industry will not have known outcomes for many years. Hence, industry-based rewards that reward interim outcome run the risk of rewarding dumb luck or penalising bad breaks (Bratvold et al, 2002).

To implement the recommendations discussed thus far, it is recommended, therefore, that a series of final changes be enacted. These changes are: that people be rewarded for applying a defined decision-making process; that penalties associated with bad outcomes be removed; and, that good outcomes be celebrated. It is argued that if these changes are implemented, the attitudes towards decision making will also change for the better. People will be focussed on the process but not to the extent of blindly following a process because they are told to, or given incentive to. It will thus be easier to implement the systematic changes because they form part of the process. It is also recognised that rewarding outcome is actually a motivational activity and that its removal may result in removing motivation and deterring risk taking. To overcome this possibility it is also recommended that successful outcomes be celebrated by the team.

CONCLUSION

Based on the review of the similarities and differences between the theoretical and real-world models, several prescriptions have been enunciated and critiqued, and are now recommended. They are noted as dot points. The prescriptions are listed in three levels of improvement priority—three ticks being the highest priority through to one tick being the lowest. It is strongly recommended that all prescriptions be implemented over time. The priority relates to the order of implementation and is assessed based on analysis of the level of response from the interviewees and other researchers.

✔ ✔ ✔ That rewards for adhering to decision-making processes be implemented, penalties based on outcomes be removed, and, instead of rewarding outcome, successful outcomes be celebrated by the team.

✔ ✔ ✔ That peer and/or mentor reviews form part of the decision-making process and that such reviews be voluntary and initiated by the decision maker early in the decision-making process. They can range, in style, from impromptu requests through to full-day workshops.

✔ ✔ ✔ That reality or plausibility checks be used routinely to debias technical and/or economic estimates in decision making.

✔ ✔ That the actual decision-making process be a prescribed workflow, which includes the basic elements of framing, modelling and assessing, as well as debiassing, fit-for-purpose tools, modifying constraints and peer review.

✔ ✔ That the approval process be documented and a learning cycle be implemented that deals specifically with the hierarchical approval process. The documentation should be both quantitative and qualitative and within the context of portfolio optimisation.

✔ ✔ That decision makers undertake training programs that alert them to possible biasses. As well as face-to-face formal training, this best occurs through feedback loops that help show how to separate the bias from the chance factor in past decisions so that improvement can occur into the future.

✔ That the organisation predefines its aims and objectives so that the employees can act as agents of the organisation and not as individuals.

✔ That mechanisms be found to facilitate using value of information analysis, options thinking or value of flexibility as part of the approval process to determine what data is needed for the approval of decisions.

✔ That further research is made into how consensus teams allow team members to weight the value of their input into the final decision approval.

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NOTES

1. Some may argue that the true reserve number is never truly known! Is reserves growth real or not? Beliveau, D., 2003, Reserves Growth: Enigma, Expectation or Fact?: SPE 84144.

REFERENCES

AL-HARTHY, M.H., KHURANA, A.K., BEGG, S.H. AND BRATVOLD, R.B., 2006—Sequential and systems approaches for evaluating investment decisions—influence of functional dependencies and interactions. The APPEA Journal, 46 (1), 511–23.

ALLAN, P.D., 2001—A portfolio management approach to assessing acquisition and divestiture candidates. SPE 71425.

BEGG, S.H., 2004—Petroeng 4024: Decision making under uncertainty: course notes. Australian School of Petroleum, The University of Adelaide.

BRASHEAR, J.P., BECKER, A.B. AND FAULDER, D.D., 2000—Where have all the profits gone? SPE 63056.

BRASHEAR, J.P., BECKER, A.B. AND GABRIEL, S.A., 1999—Interdependencies among E&P projects and portfolio risk management. SPE 56574.

BRATVOLD, R., BEGG, S.H. AND CAMPBELL, J.C., 2002—Would you know a good decision if you saw one? SPE 77509.

BROWN, R., 2005—The operation was a success but the patient died: aider priorities influence decision aid usefulness. Interfaces, 35, 511–21.

CAMPBELL, J.M., JNR, CAMPBELL, J.M., SNR AND CAMPBELL, R.A., 2001—Analysing and Managing

Risky Investments. John M. Campbell: Norman, Oklahoma, USA.

CHANKONG, V., AND HAIMES, Y.Y., 1983—Multiobjective Decision Making: Theory and Methodology. North-Holland: New York, USA.

CHRISTENSEN-SZALANSKI, J.J.J. AND BUSHYHEAD, J.B., 1981—Physicians' use of probabilistic information in a real clinical setting. Journal of Experimental Psychology: Human Perception and Learning, 7, 928–35.

CITRON, G.P., COOK, D.M. AND ROSE, P.R., 2002—Performance tracking as a portfolio management tool. AAPG Bulletin, 86 (13).

CLEMEN, R.T. AND REILLY, T., 2001—Making Hard Decisions With Decision Tools. Duxbury: Pacific Grove, California, USA.

COTTRILL, A., 2003—Taking on a cult of mediocrity. Upstream, 8.

DAVIS, J.H., 1973—Group decision and social interaction: a theory of social decision schemes. Psychology Review, 80, 97–125.

DAVIS, J.H., 1992—Some compelling intuitions about group consensus decisions, theoretical and empirical research, and interpersonal aggregation phenomena: selected examples. Organizational Behavior and Human Decision Processes, 52, 3–38.

DUBOIS, J.R. AND HOWELL, J.I., 2000—The decision maker's dilemma. Oil and Gas Executive, 3.

DURHAM, L.S., 2004—Wall Street has its own rules and oil stocks have their own personality. AAPG Explorer, October 2004.

GOICIECHEA, A., HANSEN, D.R. AND DUCKSTEIN, L., 1982—Multiobjective Decision Analysis with Engineering and Business Applications. John Wiley and Sons: New York, USA.

GOODE, P., 2002—Connecting with the reservoir. The APPEA Journal, 42 (2), 50–55.

HAMMOND, J.S., KEENEY, R.L. AND RAIFFA, H., 2002—Smart Choices: A Practical Guide to Making Better Decisions. Broadway Books: New York, USA.

HOLLENBECK, J.R., ILGEN, D.R., LEPINE, J.A. AND COLQUITT, J.A., 1998—Extending the multilevel theory of team decision making: effects of feedback and experience in hierarchical teams. Academy of Management Journal, 41, 269–82.

HOLLENBECK, J.R., ILGEN, D.R., SEGO, D.J., HEDLUND, J., MAJOR, D.A. AND PHILLIPS, J., 1995—Multilevel theory of team decision making: decision performance in teams incorporating distributed expertise. Journal of Applied Psychology, 80, 292–316.

HOWELL, J.I. AND DUBOIS, J.R., 2003—Monitoring and managing business performance from a portfolio perspective. SPE 84333.

HOWELL, J.I. AND TYLER, P.A., 2001—Using portfolio analysis to develop corporate strategy. SPE 68576.

JOHNS, D.R., SQUIRE, S.G. AND RYAN, M.J., 1998—Measuring exploration performance and improving exploration predictions with examples from Santos' exploration program 1993–1996. The APPEA Journal, 38 (1), 559–69.

JONKMAN, R.M., BOS, C.F.M., BREUNESE, J.N., MORGAN, D.T.K., SPENCER, J.A. AND SONDENA, E., 2000—Best practices and methods in hydrocarbon resource estimation, production and emission forecasting, uncertainty evaluation and decision making. SPE 65144.

MACKIE, S.I., BEGG, S.H., SMITH, C. AND WELSH, M.B., 2007—Decision type—a key to realising the potential of decision making under uncertainty. The APPEA Journal, 47 (1), 309–19.

MACMILLAN, F., 2000—Risk, uncertainty and investment decision making in the upstream oil and gas industry. PhD Thesis, University of Aberdeen.

MURPHY, A.H. AND WINKLER, R.L., 1977—Reliability of subjective probability forecasts of precipitation and temperature. Applied Statistics, 26, 41–7.

MURPHY, A.H. AND WINKLER, R.L., 1984—Probability forecasting in meteorology. Journal of the American Statistical Association, 79, 489–500.

NEWENDORP, P.D. AND SCHUYLER, J., 2000—Decision Analysis for Petroleum Exploration. Planning Press: Aurora, Colorado, USA.

NUTT, P.C., 2002—Why Decisions Fail: Avoiding the Blunders and Traps that Lead to Debacles. Berrett-Koehler Publishers, Inc: San Fransisco, USA.

ROSE, P.R., 1985—Dealing with risk and uncertainty in exploration: how well do we predict? How can we do better? AAPG Bulletin, 69, 2046.

ROSE, P.R., 1987—Dealing with risk and uncertainty in exploration: how can we improve? AAPG Bulletin, 71 (1), 1–16.

ROSE, P.R., CITRON, G.P. AND MCLANE, M.A., 2002—Current status of E&P portfolio management as a corporate 'best practice'—obstacles, solutions and consequences. AAPG Bulletin, 86.

ROSE, P.R., CITRON, G.P. AND MCLANE, M.A., 2003—The link between chronic E&P under-performance and the 'prospector myth'. AAPG Bulletin, 87 (13).

RUDDUCK, N.A., KHURANA, M., CONGREVE, M. AND LOURENS, J., 2006—Multiobjective decision making: a critical analysis of the applicability of renewable energy technologies. SPE 101770.

RUSSO, J.E. AND SCHOEMAKER, P.J.H., 2002—Winning Decisions. Currency: New York, USA.

SIMPSON, G.S., LAMB, F.E., FINCH, J.H. AND DINNIE, N.C., 2000—The application of probabilistic and quantitative methods to asset management decision making. SPE 59455.

SKINNER, D.C., 1999—Introduction to Decision Analysis, 2nd ed. Probabilistic Publishing: Gainsville, Florida, USA.

SNEIDER, R., 1999—Multidisciplinary teams in exploration and production—their value and future—part 1—concepts, definition and team successes. The Leading Edge, 18, 1366–70.

SNEIDER, R., 2000—Multidisciplinary teams in exploration and production—their value and future—part 2—financially successful and unsuccessful teams. The Leading Edge, 19, 28–31.

SNEIDER, R., 2000—Multidisciplinary teams in exploration and production—their value and future—part 3—building successful teams, team recognition and rewards, and MDTs in the future. The Leading Edge, 19, 136–7.

STANFIELD, R.B., 2000—The Art of Focussed Conversation: 100 Ways to Access Group Wisdom in the Workplace. Canadian Institute of Cultural Affairs. New Society Publishers: Gabriola Island.

STEINER, I.D., 1974—Whatever happened to the group in social psychology? Journal of Experimental Social Psychology, 10, 94–108.

STEINER, I.D., 1983—Whatever happened to the touted revival of the group? In Blumberg, H.H., Hare, A.P., Kent, V. and Davies, M.F. (eds) Small Groups and Social Interaction. Wiley and Sons: Chichester, UK.

SUSLICK, S.B., FURTADO, R. AND NEPOMUCENO, F., 2001—Integrating technological and financial uncertainty for offshore oil exploration: an application of multiobjective decision analysis. SPE 68579.

SZIDAROVSKY, F., GERSHON, M.E. AND DUCKSTEIN, L., 1986—Techniques for Multiobjective Decision Making in Systems Management. Elsevier: Amsterdam, Holland.

TOMASSINI, L., SOLOMON, I., ROMNEY, M.B. AND KROGSTAD, J.L., 1982—Calibration of auditors' probabilistic judgements: some empirical evidence. Organizational Behavior and Human Performance, 30, 391–406.

WELSH, M.B., BEGG, S.H. AND BRATVOLD, R., 2006—Correcting common errors in probabilistic evaluations: efficacy of debiasing. SPE 102188.

WELSH, M.B., BRATVOLD, R. AND BEGG, S.H., 2005—Cognitive biases in the petroleum industry: impact and remediation. SPE 96423.

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