Guidance for Decision Quality for Multicompany Upstream Projects

TECHNICAL REPORT

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Guidance for Decision Quality for Multicompany Upstream Projects

Final Report

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Recent large projects in the upstream oil and gas industry underperformed 80% of the time compared with the outcome expected at project sanction. Approximately 30% of the projects had either significant cost overruns or schedule slippage, and 64% of the projects experienced enduring production-attainment problems following initial production. Smaller projects performed somewhat better, but significant improvement could be realized in projects of all sizes, most of which involve multiple companies working as co-owners.

Focusing on decision quality (DQ) is a natural outcome of the realization that "ultimately, [an organization's] value is just the sum of the decisions it makes and executes." [1] Organizations that make high-quality decisions, make them quickly, with optimal effort, and then translate those decisions into action effectively and create more value for their stakeholders. [2]

Given the predominance of multicompany participation in these projects, alignment on decisions is key to the quality, speed, effort, and effectiveness of those decisions, and is critical to project success. Failure to gain timely alignment between participants on pivotal decisions can affect project delivery significantly.[3]

The guidelines proposed in this report have been drafted by a steering committee of subject matter experts (SMEs)[4]. Following these guidelines should lead to better decision quality and better participant alignment in project decision making. The guidelines apply during all phases of a project's life cycle, including exploration, development, and production. The report is intended to be a high-level overview of key activities that the steering committee agreed should be included in any DQ process. Innumerable additional resources exist for more-specific, "how-to" instruction on a variety of approaches to accomplishing the various steps outlined in this technical report.

The Decision Maker's Bill of Rights

Decision makers should make certain demands of their project teams that will set expectations that are clear and apparent to all involved. These demands, formulated as six decision-makers "rights", underpin DQ, and lead to a consistent approach for evaluating specific project opportunities and to improved multicompany decision making in the oil and gas industry.

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[1] Blenko, M.W., Mankins, M.C., and Rogers, P. *The Decision-Driven Organization.* Harvard business Review, June 2010, section 4.

[2] Edward W. Merrow, founder and CEO of Independent Project Analysis, Inc. (IPA), and a recognized expert on the development and execution of large and complex megaprojects.

[3] Walkup, G.W. and Ligon, B.J. 2006. The Good, Bad, and Ugly of Stage-Gate Project Management Process as Applied in the Oil and Gas Industry. Presented at the SPE Annual Technical Conference and Exhibition, 24–27 September, San Antonio, Texas. SPE-102926-MS. http://dx.doi.org/10.2118/102926-MS and van Driel, J.P. and Pederson, T. 2005. Creating Value by Improving the Operator/Nonoperator Partner Relationship. Presented at the SPE Annual Technical Conference and Exhibition, 9–12 October, Dallas, Texas. SPE-96983-MS. http://dx.doi.org/10.2118/96983-MS

[4] Industry input was obtained from a discussion session at the SPE Annual Technology Conference and Exhibition, 29 September 2015, Houston, Texas. Additional input was received through comments when the report was posted for review on the SPE website in January 2016.

The Society of Decision Professionals (SDP)[5] has developed a "Decision Maker's Bill of Rights" (**Fig. 1.1** below) which, if adopted by decision makers, should result in the fulfillment of all six elements of DQ as described in **Fig. 1.2.**

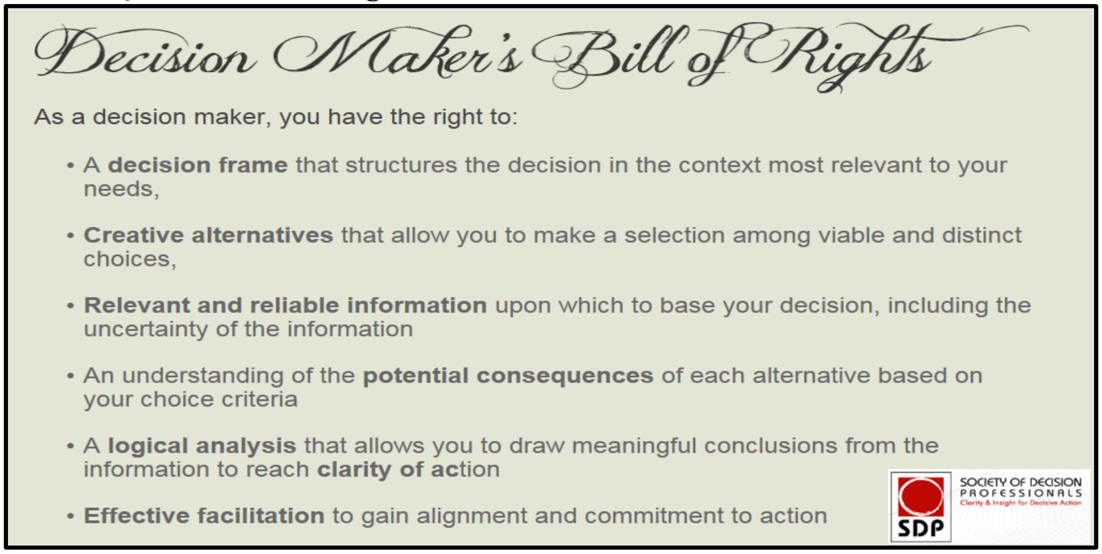


Fig. 1.1—Decision-Maker's Bill of Rights.

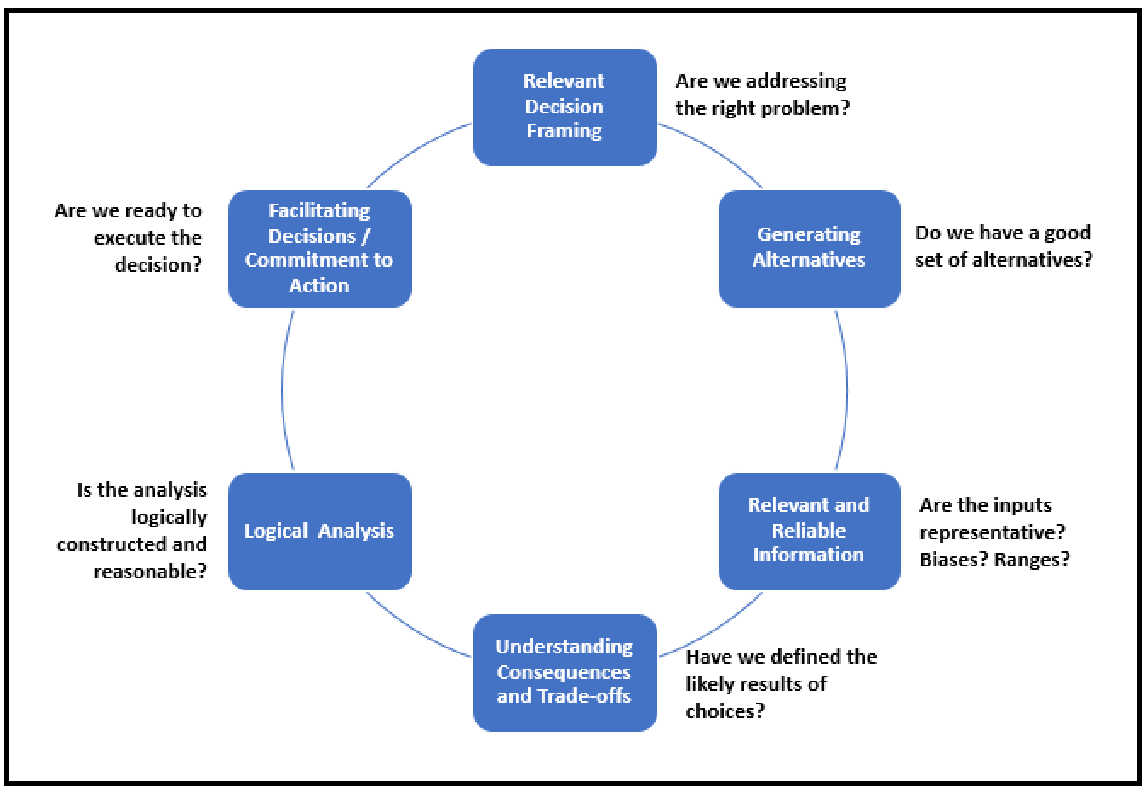


Fig. 1.2—Six elements of decision quality.

[5] Used with permission of SDP, a global, multi-industry organization dedicated to promoting quality decision standards and connecting decision makers, practitioners and academics of decision sciences. http://decisionprofessionals.com/

The six key elements of DQ are shown as a process cycle in Fig. 1.2 and constitute the structure of this technical report.

Adherence to these six elements, combined with a well-defined communication plan with the Participants, can add substantial value by pooling technical know-how and reducing project churn, recycle and missteps among project Participants. This collaborative approach will allow teams to achieve alignment on key risks, decisions and actions, to highlight differences early to allow focus on mitigation plans, to have an understanding of the participants' decision metrics, and to develop appropriate actions plans to achieve the project's and participants' objectives.

1. Introduction

Each element of DQ is described briefly below and is addressed in detail in these subsequent report sections.

- **Developing a Relevant Frame.** Are we solving the right problem? Do all the participants agree? DQ begins with a clear decision frame, including agreement on the decision problem to be solved, the given decisions and the solution space, and key criteria the decision makers need to assess. This process creates the correct decision focus from the beginning.
- **Generating Creative and Doable Alternatives.** Do we have a good set of alternatives? Are the participants' concerns and ideas reflected in the alternatives? A high-quality decision will have a few distinctly different, viable alternatives that test the boundaries of the solution space.
- **Using Relevant and Reliable Information.** Are the analysis inputs representative? How do inputs affect decisions? Can participants contribute to the available pool of knowledge? The project participants should pool their knowledge about the performance of the options being considered and be assured that the decision analysis incorporates quality inputs after appropriate quality-assurance reviews. The ranges and/or probabilities for key uncertainties should be assessed appropriately, well-founded, and stated clearly.
- **Assessing the Consequences of Choosing Different Alternatives.** What are the implications from the trade-offs being weighed? How do they affect the participants? Clear alignment of metrics to be used to compare options is critical in making an informed decision. The metrics must be viewed in light of each company's values and objectives, as well as those of the group. This alignment facilitates trade-off discussion, which will ultimately drive the recommendation.
- **Applying Logical Analysis.** Is the analysis approach reasonable? Do participants appreciate why the analysis is being done this way? Analysis of alternatives should have the appropriate rigor. For multicompany projects, this analysis may involve the use of a shared project-economics model to promote alignment and to complement individual-company analysis.
- **Committing to Action.** Are all participants ready to execute the decision taken? DQ culminates in a commitment to a specific course of action. The action plan should incorporate mitigation actions and "off ramps"[6] to address risks and contingencies

[6] "Off ramps" are actions that can be taken contingent on the outcome of recognized risks.

identified in the DQ process. Identification and involvement of the decision makers (decision board) early in the DQ process is critical to building the necessary commitment.

2. Relevant Decision Framing

2.1. Overview

The creation of a decision frame, sometimes known as problem definition, is the initial step to ensure a high-level DQ in any multicompany upstream project. It is based on the premise that "a problem well put is half solved."[7] The aim of all decision framing processes is to create a collective viewpoint of the decision problem.

Decision framing can lead to early alignment between participants and quicker, better solutions. It ensures that the correct problem gets solved. This is especially true of a major decision in a complex multicompany upstream project where participants may have differing experiences, objectives, and value drivers.

Decision framing provides an open, transparent, and consistent process that encourages participation from all stakeholders and decision makers. The creation of the decision frame provides a means for everyone to have the time and freedom to approach challenges creatively and to express ideas and concerns in a nonjudgmental manner.

The decision frame also serves as a communication tool between the project team, participants, and decision makers (who provide validation of task and input). The decision frame thus contributes to an aligned commitment to action.

The greater the complexity of the issues or the consequences of the decision, the more effort that should be applied to decision framing. Decision framing is a scalable process, and any project may benefit from working through the proposed framing steps. Simpler, well-defined projects may need only a single, short framing session.

The decision frame should be constructed as early as possible. Periodically, it should be revisited and updated to respond to new information or a change in circumstances. Depending on the project, this may apply to internal framing with individual participants, multicompany framing, or both.

2.2. Decision-Framing Sessions

The decision frame is meant to represent the participants' collective viewpoint of the decision problem. Given its inclusive nature, an efficient and effective way to develop the decision frame is through framing meetings.

- It is the operator's responsibility to hold a framing meeting that includes all participants.
- All relevant SMEs and at least one representative from each participant should attend framing meetings.
- All participant representatives should be familiar with the project and have authority to represent their company's position on the project.

[7] Dewey, John. 2013. *Logic-The Theory of Inquiry*. Read Books Ltd.

- The framing meeting requires a facilitator to ensure that the decision framing process is followed effectively and efficiently.
- The output of the framing session should be sent to all project participants, whether or not they were represented at the framing session.

2.3. Framing-Session Input

It is recommended that a charter be approved by the relevant Decision Board and include the following.

- An opportunity statement that defines the problem or opportunity that the framing meeting is chartered to address.
- Boundary conditions.
- Guidance on decision criteria.
- Any key questions posed by the Decision Board that are considered central to the decision.

To assure an efficient framing session, some presession work may be needed by the operator, participants, and their SMEs. There is a trade-off, however, between accelerating the framing process with presession work, and getting the broad-based, creative input that can add value in framing. This trade-off must be balanced carefully to avoid anchoring on presession-work issues. Presession work may include use of a structured questionnaire to solicit input from decision makers and experts from both the operator and the participants. It may also include work by a small team to draft a high-level decision frame as a starting point in the discussions. Guidance on a framing presession-work questionnaire is included for reference in Appendix B.

2.4. Decision-Framing Output and Decision-Frame Content

The output from a framing session often is referred to as a decision frame. It should include the following.

- A revised or updated opportunity statement.
- Any proposed changes to boundary conditions that were originally provided by the Decision Board.
- Decision criteria that will be used to make decisions. These criteria will identify metrics of measurement, but may not indicate any required thresholds because that information may be confidential to each participant. If there is uncertainty or disagreement about which metrics should be used, an objectives hierarchy may be developed to clarify the most fundamental objectives (see Section 5.4).
- Project issues identified during the framing session which include:
  - Identification of risks and uncertainties, along with resources needed for addressing those issues (for example, qualified SMEs).
  - Relevant decisions, classified as follows:
    - Past decisions or policies (given decisions)
    - Key decisions to be made in the current project phase and scope (focus decisions)
    - Decisions outside the scope or to be made in future project phases (nonfocus or tactical decisions)

A set of alternatives for evaluation. While generation of alternatives is a separate element of the DQ process, and is covered in the next section, the activity commonly is performed in the framing session and included in the framing output. Alternatives for evaluation may be derived from focus decisions and may be organized into what is referred to as a strategy table or case matrix (see Section 3.2).

An action plan with specific activities (including technical quality assurance), responsibilities, resources, and a schedule.

2.5. Decision Sequencing

To make more-timely and appropriate decisions, consider the order of the focus decisions. This consideration can reveal several potential insights, as follows.

- Some decisions are *affected* by prior decisions and are better made only after the precursor decision has been finalized.
- Some decisions are *dictated* by prior decisions and are essentially outcomes of prior decisions.
- Some decisions are *mutually dependent* and need to be made together.
- Some decisions are *independent* of other decisions and can be worked in parallel with others, allowing acceleration of the schedule.
- Some decisions can be better made *after* the resolution or narrowing of uncertainties. This concept is central to understand the value of information.

A decision map or decision trees may be used to show the sequence and interrelationships of decisions and key uncertainties.

2.6. General Guidance on Decision Framing and Facilitation

Participants should avoid attempting to solve the problem within the framing session. Independent framing sessions, held internally by each participant before the joint framing session, contribute to effective participation in multicompany decision-framing sessions. Framing can be effective for uncovering and mitigating biases through an explicit discussion of bias within the framing session. The facilitator should have some knowledge of the type of problem being evaluated in addition to having facilitation skills, such as:

- Engaging all meeting attendees, including testing group conclusions to achieve alignment .
- Encouraging different points of view to establish a range of solutions or outcomes.
- Managing the meeting in a way that limits negativity and is inclusive of all participants.
- Helping to clarify real constraints vs. assumed constraints.

A mutual understanding among participants of the broader business context of a project may be helpful in identifying its key framing issues. There are many tools available to elicit and understand that context.[8]

2.7. General Guidance on Effective Use of Participants' SMEs

The framing session or subsequent technical meetings should be used to identify the need for involvement of participants' SMEs. Reasons for involving SMEs from participants other than the operator include:

- Pooling experience and knowledge on a particularly complex issue.
- Mitigating bias.
- Assisting in establishing a common view on judgment-based issues, such as uncertainty ranges.
- Identifying participants' internal quality-assurance needs.

[8] Examples of such tools include SWOT, Stakeholder Analysis, and Force Field diagrams.

SMEs from the participants should

- Be experienced and credible practitioners.
- Be familiar with the project and the specific technical challenges.
- Maintain continuity with the project if multiple issues or reviews are anticipated.
- Have adequate time to contribute within the project team's technical assessment schedule.

3. Generating Alternatives and Strategies

3.1. Overview

For decision makers to make a high-quality decision, they need a set of creative, viable, and distinct alternative choices that are consistent with the agreed decision frame.

Major upstream projects typically involve making multiple interdependent "focus decisions" that, together, form a strategy. Creating alternatives for each focus decision and thematically blending them into strategies is an important step. For major projects, these strategies eventually become the choices presented to the decision maker.

Generating focus-decision alternatives and multidecision strategies is a creative process based on brainstorming principles. The objective is a wide range of possible alternatives that represents (but does not exhaustively include) the full spectrum of possible approaches. A wide range of alternatives increases the likelihood of finding a better overall solution (a decision is no better than the best alternative that was considered). Alternative generation is especially important in multicompany projects because this process:

- Highlights biases.
- Encourages consideration of less-familiar alternatives, including alternative technologies.
- Makes use of the ideas and experience of participants.
- Reduces analysis recycling caused by new alternatives identified late in the evaluation process.

Generating a large array of alternatives does not mean that a large number of options will be analyzed in detail. Organizing and prioritizing alternatives for analysis occurs after the full set of alternatives has been identified.

The original set of strategies developed in framing may not be the same as the strategy ultimately brought to decision makers. The primary purpose of the original set of strategies is to understand the pros, cons, and trade-offs of different approaches. These original strategies may be replaced, optimized, hybridized and otherwise refined before final presentation.

3.2. Organization of Alternatives

The recommended way of organizing alternatives is illustrated in **Table 1,** which is an example of a simplified decision analysis on the benefits of an early-production system (EPS) to reduce uncertainty around a new oil discovery[9]. The alternatives listed under each focus decision should explore the full spectrum of options for that decision.

Type of Test/EPS	Number/Type of Test Wells	Production Test Duration	Well Completion
Drill stem test (DST)	Appraisal well	30 Days	Single Zone
Lease 30 kbd FPSO	1 New Well	6 Months	Commingle Multiple Zones
Purchase 60 kbd FPSO	2 New Wells	1 Year	Selective Multiple Zones
Tie-back to nearby field	3 New Wells	2 Years	
	4 New Wells		

Table 1—Example of focus decisions with alternatives.

Often, there may be too many combinations of alternatives to evaluate efficiently. Therefore, a smaller set of strategies is chosen for initial evaluation. Each strategy includes only one of the alternatives under each decision. The example in **Table 2** is a strategy table (or case matrix), which, for each strategy, shows the alternative selected under each decision.

Strategy tables include only the focus decisions. Good strategies typically are distinctive, viable, and compelling. Useful strategies often are driven by testing parameters that minimize or maximize a particular objective. Revisit the strategy table to add variants or hybrid strategies that may improve overall outcomes.

[9] Coopersmith, E.M., Burkholder, K., and Mendoza L. 2014. Early Production Systems—When Do They Make Good Sense for Your Project? Presented at the Offshore Technology Conference, Houston, Texas, 5–8 May. OTC-25440-MS. http://dx.doi.org/10.4043/25440-MS.

	Type of Test/EPS	Number/Type of Test Wells	Production Test Duration	Well Completion
Strategy A				
Objective Cheapest Information **Rationale** Uncertainty Reduction at Lost Cost	Drill Stem Test (DST)	Appraisal Well	30 Days	Commingle Multiple Zones
Strategy B				
Objective Lowest Cost for Longer Term Data **Rationale** Better Reservoir Investigation	Lease 30 kbd FPSO	Appraisal Well	6 Months	Selective Multiple Zones
Strategy C				
Objective Phased Development **Rationale** Higher Cost Might be Offset by Better Revenue	Lease 30 kbd FPSO	2 New Wells	2 Years	Commingle Multiple Zones
Strategy D				
Objective Phased Development **Rationale** Potentially Higher Production Without Constraint	Purchase 60 kbd FPSO	3 New Wells	2 Years	Commingle Multiple Zones
Strategy E				
Objective Minimum Commitment to New Infrastructure **Rationale** Can Continue Production if Reservoir Performance is Good	Tie-back to nearby field	1 New Wells	2 Years	Commingle Multiple Zones

Table 2—Example of organizing alternatives into strategies.

4. Obtaining and Communicating Relevant and Reliable Information

4.1. Overview

Quality decisions require timely, unbiased, relevant, reliable, and assured input. If one of these elements is missing, then the analysis is suspect and so are the decisions based on this analysis. To be relevant, an input should inform the identified focus decision or strategy. The project team should be decision-driven, focusing on obtaining and refining the most relevant information.

Most of the information provided by SMEs for the analysis is not known with certainty. Such uncertain inputs should be provided as ranges that reflect the likely variation in value. Some form of probability estimate for the values should accompany the range to determine the potential effect on the decisions being debated. The project team should actively seek to access SME knowledge from all participants to understand the reliability of the information better, to test the uncertainty range of the data, to create better alignment among the participants, and to improve the efficiency of the joint decision process.

4.2. Uncertainties

Analytical inputs supporting decisions in upstream projects are often uncertain. When this is the case, and when project decisions are sensitive to reasonable variations in these inputs, it is suggested that the inputs be represented by a range of values with associated probabilities. This offers a good representation of the uncertainty and allows for consistency in comparing the sensitivity of decision criteria to each key uncertain input. The input uncertainty range may be defined as a probability distribution with given parameters (e.g., log-normal distribution with a mean of 100 and a standard deviation of 30), or by low, median, and high estimates. In defining these estimates, whether by historical data analysis or by expert judgment, the following definitions are suggested.

- There should be a 90% probability (P90) that the actual value will equal or exceed the low estimate.
- There should be a 50% probability (P50) that the actual value will equal or exceed the median estimate[10] [11].
- There should be a 10% probability (P10) that the actual value will equal or exceed the high estimate.

This approach defines an 80% probability interval, in which all but highest and lowest 10% of values should be captured, and is the approach used by the SPE Petroleum Reserves Management System (PRMS). Some companies call the low estimate P10 and vice versa for the P90. Therefore, participant companies should clarify their different understandings of these ranges early in discussions.

- Some uncertain inputs may be independent, and are not affected by the values of other inputs. But in many cases the value of inputs are correlated to other inputs. The degree and direction of this correlation is important to understand. Dependencies between input variables can have significant effect on the ultimate range of project outcomes.
- The degree of rigor in estimating uncertain input values should be in proportion to their importance to critical outputs and the amount and reliability of information available.[12]

[10] For probabilistic reserve assessments, PRMS uses the term “best estimate” and defines it as the median, but does not use the term “median” directly as is done here.
[11] Note that the median estimate often is not the “most likely”, or mode estimate.
[12] For example, reservoir modeling may not add value in an early phase of exploration.

- It is useful to talk in terms of chance or likelihood of occurrence in discrete events, both positive and negative, instead of focusing on risk, which has a negative connotation.[13]
- Careful review of the uncertainty inputs with the SMEs should focus on both upsides and downsides to capture the full range of outcomes.
- The relevance of input information can be determined with a tornado diagram, as shown in **Fig. 4.1** below. These diagrams are sometimes done with arbitrary sensitivities (i.e., ±20% of recoverable volumes), but arbitrary ranges may anchor participants and lead to biases when asking for real ranges. In addition, ±20% may not correspond to the appropriate level of uncertainty for different inputs. For example, a 20% variation in projected capital costs may not fully capture a reasonable range of uncertainty, whereas ±20% on a tax rate is too wide. The use of the 80% probability interval is recommended here, where the test is made at the high estimate (10% probability that the actual value is higher than this), and the low estimate (90% chance that the actual value is higher than this). This way, the sensitivity outcomes are meaningful and comparable.

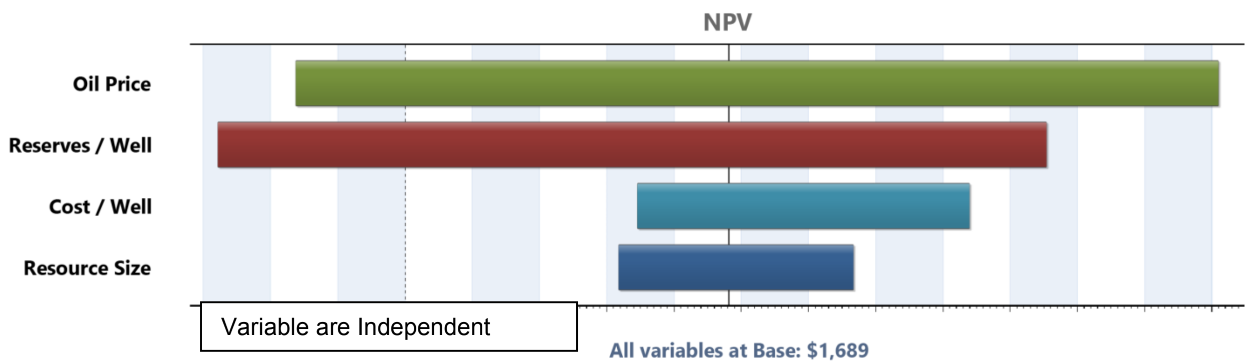


Fig. 4.1—Tornado diagram.

4.3. Reliable Information

Expert judgement of one or more SMEs is vital to determine appropriate values (including ranges, as appropriate) for all project inputs. The SME knowledge and experience is valuable in the following.

- Selecting the most-appropriate data or analogs
- Assessing the representativeness of the information
- Appreciating the ways the information could be misleading
- Translating all insights into an accurate probabilistic range
- Identifying and quantifying any correlations between various inputs

When possible, use of multiple SMEs enables combined experience and a diversity of perspectives and can help in deciding on a range with appropriate breadth. Involving SMEs from non-operator participants brings more diverse experience and it may improve trust and help promote alignment.

[13] Sawiris R., Howes C.S., Rodriguez J.A., and Foley W.L., 2015. Uncertainty and Risk Management Plans are Critical for Team Alignment and Better Decision Quality. Presented at the SPE Annual Technical Conference and Exhibition, 28–30 September, Houston, Texas. SPE-174932-MS. http://dx.doi.org/10.2118/174932-MS

Analog data are important for both the subsurface and facilities inputs to the project. In a subsurface context, no two reservoirs are exactly the same, but comparable analogs can be useful in defining the likely character of a target reservoir. Expert interpretation is still needed to determine how similar the analogs are and the extent to which the analogs represent the target reservoir. Ideally, analog information should be drawn from as many analog fields as are comparable, thus enabling a more reliable statistical interpretation of the data. Differences between the analog and the project should be recorded.

Input-data representativeness is important. Typically, there is a trade-off to be made between obtaining a larger sample of data and obtaining more closely comparable data.

- In a subsurface context, data derived from the target reservoir itself are especially valuable. This includes direct measurements, such as appraisal well information, and more indirect information, such as seismic. While valuable, this information must be interpreted carefully, with careful consideration given to how accurately information from a single location or seismic line represents the overall reservoir. Some parameters, such as oil-quality information may have good overall representativeness, while other parameters, such as sand thickness, may not. This kind of highly localized information simply represents one data point in a very large population.
- In a facilities context, data derived from within the country or geographic area may be more representative than world-wide data. Similarly, data from projects of a similar design type (e.g., complexity, water depth, and facility type) may be more representative than more general data.

Technical assurance processes are an important method to gain confidence in the reliability of key data. These processes are covered in more detail in Section 4.7.

4.4. General Guidance on Subsurface Information and Interpretation

It is operator's responsibility to provide a reference subsurface interpretation to participants, along with the technical basis of the estimate, including ties to field measurements. The project team should consider soliciting participants' input on subsurface characterization and interpretation to access information that may not be available to the operator and to bring in a diversity of perspectives from additional SMEs.

Subsurface assessments should be broken down into component inputs (e.g., gross rock volume and porosity), including ranges for those inputs in line with Section 4.2 to provide transparency and understanding. These assessments also will expedite probabilistic evaluation by participants who choose to do so. Calculated or modeled subsurface assessments of higher-level results, such as recoverable volume and production rate, should be tested against analogs.[14] This is true even when assessments are based on underlying component inputs that are themselves derived from analogs.

4.5. General Guidance on Cost and Schedule Data

Operators should provide cost estimates with clarity on project scope, execution basis, and costing assumptions. The case description should be tied back to a specific execution basis and specific physical quantities whenever possible to improve understanding and future reconciliations. Benchmark data can be helpful for alignment.

Contingencies and allowances often are part of a deterministic (single-point) cost estimate, such as a budget, and are meant to provide a higher level of confidence that the actual value will fall at

[14] It may be necessary that analogs use only publicly available data to avoid breaching country-specific data restrictions.

or below the point estimate. However, if this uncertainty has already been reflected in a probabilistic range, separate adjustments for contingencies and allowances are essentially double counting the effect of uncertain events.

Participants will often have differing views on the application of contingencies and allowances. The project team should note these cost elements separately and provide clear definitions of how these terms are being applied.

The operator should provide cost data in real dollars,[15] which represent the costs if incurred at a single designated date and does not include the effects of inflation or escalation. The use of inflated or escalated costs is potentially sensitive because they imply an escalation assumption, which may be considered a proprietary forecast. In intercompany communications, any sharing of escalated costs, therefore, should use the real-cost forecast in combination with an agreed arbitrary or publicly available escalation forecast.

The operator should state explicitly whether execution schedules are target schedules or a best estimate schedule. A best estimate schedule should be developed as a median schedule that is equally likely to be beaten or exceeded. Schedule contingencies and allowances included in a best estimate schedule should be stated explicitly.

4.6. Avoiding Bias

Some degree of bias is likely inevitable in any expert assessment of input values and ranges, but bias may be reduced by asking the SMEs to explain the basis of their assessments. When the SMEs with outlying estimates explain why they were much higher or lower than the other assessments, a conversation begins that can help reveal bias within the SME group.

Using multiple SMEs can also be helpful in avoiding bias by bringing in a diversity of viewpoints. It is helpful to remind SMEs of the challenges inherent in providing estimates so they may become conscious of their own potential biases and correct for them in their assessments. Some of the common cognitive traps that produce bias include the following.

- Anchoring—The tendency to rely too heavily, or anchor, on one trait or piece of information when making assessments. The facilitator should be careful not to introduce anchors in the SME interviewing process.
- Motivational bias—The tendency to see only information that supports the position that meets the preferred position of one of the participants.
- Overconfidence—Excessive confidence in one's own answers to questions.
- Availability heuristic—The tendency to overestimate the likelihood of events that have been experienced recently or had unusual or emotionally charged consequences.
- Confirmation bias—The tendency to search for, interpret, focus on, and remember information in a way that confirms one's preconceptions.
- Affect bias—The tendency to perceive less risk in a process that one regards highly and vice versa.
- "Not invented here"—Reluctance to consider ideas or knowledge developed outside of a group.
- Group think—The tendency in a group setting for a person to avoid consideration of alternative viewpoints out of a desire for harmony or conformity to the group.

[15] Or relevant, agreed currency for the specific project.

When multiple SME's provide assessments on the same input, the values and the ranges generated may vary widely. A joint meeting of the SMEs can be used to develop a consensus or at least clarify the basis for the differences.

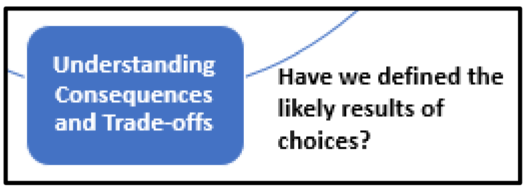
4.7. Technical-Assurance Reviews

To develop confidence that key project-input assumptions are reliable, some participants may require a formal technical-assurance review. Early in the decision process, participants should align on the following.

- The level of technical assurance needed.
- When the technical assurance will be needed.
- Participation in the technical-assurance process.
- How will feedback from the technical review be applied.

The project team, participants, and all appropriate SMEs should have the opportunity to attend the technical-assurance review report presentation.

5. Understanding Consequences and Trade-Offs



5.1. Overview

An important aspect of DQ is fully understanding the consequences of each option being debated and the trade-offs made in deciding between them. Decision criteria are the metrics to be used to describe consequences of each strategy, to weigh them against each other, and to select between them. The decision criteria also are commonly known as value measures or decision metrics and may be qualitative or quantitative in nature. Wherever possible, it is best to establish upfront, as part of the decision framing process, a common understanding of the decision criteria that the joint group will use as primary measures for comparing different strategies.

It is expected that participants may have their own unique decision criteria and may weight the relative importance of some shared decision criteria differently than other participants. In many cases, there may be several important metrics, and different strategies may deliver more on one metric at the expense of others. The goal is to understand and clearly communicate the trade-offs that can be expected when comparing the different strategies.

5.2. Trade-Offs

Trade-offs are defined as the "…balancing of factors all of which are not attainable at the same time."[16] It is typical for a participant to have more than one fundamental decision metric, none of which is subordinate to the others, that must therefore be balanced (e.g., production rate vs. reserve additions vs. NPV). This precipitates the need for making trade-offs in decisions.

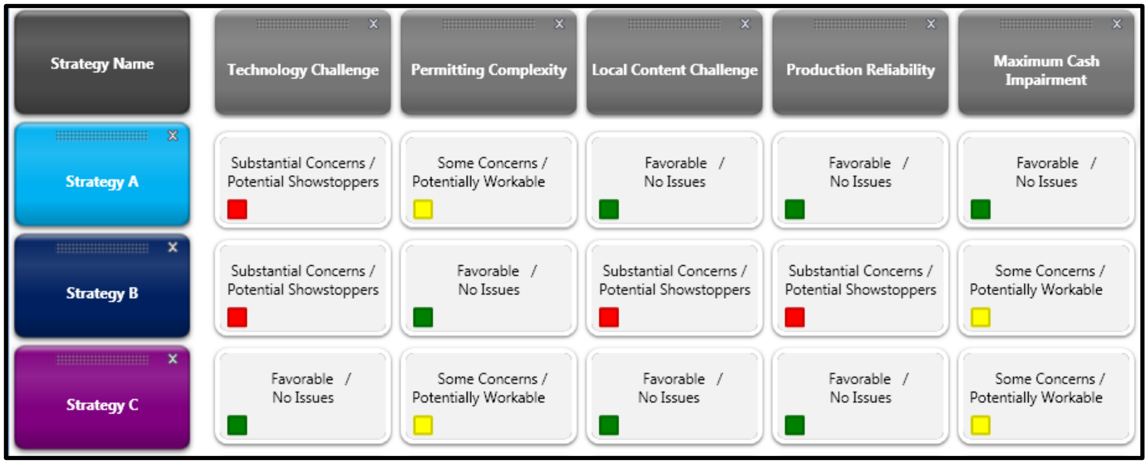
[16] As defined by Merriam Webster, An Encyclopedia Britannica Company

5.3. Guidance on Evaluating Qualitative Decision Criteria

Often, before numerical analysis is run, insights and understanding can be gained by comparing the different strategies by use of qualitative, usually noneconomic decision criteria.[17]

Qualitative analysis generally involves experience and judgement and can be used effectively to reduce the number of strategies that may ultimately be taken to numeric analysis. It may also serve as a tie-breaker when quantitative decision criteria on two strategies are roughly equivalent.

One qualitative comparison method of understanding trade-offs is a stoplight table, as shown in **Fig. 5.1,** that characterizes factors as red/yellow/green and is used primarily to gather insights early in the analysis process.



Strategy Name	Technology Challenge	Permitting Complexity	Local Content Challenge	Production Reliability	Maximum Cash Impairment
Strategy A	Substantial Concerns / Potential Showstoppers	Some Concerns / Potentially Workable	Favorable / No Issues	Favorable / No Issues	Favorable / No Issues
Strategy B	Substantial Concerns / Potential Showstoppers	Favorable / No Issues	Substantial Concerns / Potential Showstoppers	Substantial Concerns / Potential Showstoppers	Some Concerns / Potentially Workable
Strategy C	Favorable / No Issues	Some Concerns / Potentially Workable	Favorable / No Issues	Favorable / No Issues	Some Concerns / Potentially Workable

Fig. 5.1—Stoplight table.

5.4. Objectives Hierarchy

Often, a particular strategy under consideration may have more than one fundamental objective (i.e., we want to develop this project as quickly as possible, but to do so without limiting any upside potential). When it is not clear if one objective is subordinate to others, the joint development of an objectives hierarchy can clarify the issue.

An objectives hierarchy distinguishes between objectives that are subordinate because they simply help achieve a higher goal and those that are fundamental and need to be balanced (refer to Section 2. Decision Framing).

5.5. Guidance on Evaluating Quantitative Decision Criteria

Many times, project teams must run numeric analysis to fully understand the trade-offs between the strategies under consideration. Quantitative analysis can be a very time-intensive process because of the need to collect the appropriate data and build the correct model. It is best, therefore, to look initially at a fairly small but diverse set of strategies to determine insights that can be gleaned from the analysis. Strategies should be measured by use of all quantitative decision criteria to understand the relative pros, cons, and trade-offs of each.

The aim of evaluating the quantitative decision criteria is to understand clearly what makes some strategies more compelling than others and to encourage the participants to think about how the upside can be protected or improved and the downside be mitigated or reduced. In this way,

[17] Common examples of qualitative factors are technology risk, environmental impact, safety exposure, country risk, and market risk.

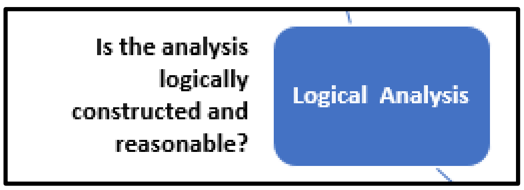
on the basis of trade-offs between the strategies, potential hybrid strategies can be identified and adapted from the original set of strategies considered.

5.6. Sharing and Communicating Insights

It is common for participants to have differing views and decision criteria and, therefore, rank the strategies differently when they conduct their independent analysis. These differences create the potential for misunderstanding and conflict. Clarifying these differences and the reasons for them will assist in the decision process. By communicating these differences, discussing the trade-offs, and sharing insights with the project team, alternative strategies can be sought that might offer improvements from those initially considered.

Decision makers are entitled to understand the trade-offs between the strategies, and these should be communicated to them clearly when the strategies are presented for their review. The objectives hierarchy (Section 5.4 above) is a tool that can help communicate which objectives are subordinate (because they simply help achieve a higher goal) and which are fundamental.

6. Logical Analysis



6.1. Overview

A key step in achieving DQ is that the analysis be constructed logically. We think most clearly when we are confronted by consistent and thoughtful analysis that fundamentally makes sense. When such analysis is incorporated, it will assist participants' ability to reach aligned and meaningful conclusions leading to clarity of decision-making. This clarity is a core justification for the overall DQ process.

Confidence in the logic of an analysis is essential to gain commitment to action among participants, and an assurance review of the analysis tools and methodology may facilitate this commitment. DQ should integrate the decision alternatives with the information known at the time of the decision to determine the values for the decision criteria the participants are trying to optimize. Participants should focus only on providing insights and analyses that are important for the decision. The level of analysis should be tailored to the magnitude, complexity, and effects of the project decisions. It is important to have a fit-for-purpose analysis and economic model.

6.2. Decision-Analysis Tools

The primary analytical decision-analysis tool used in upstream projects is an economic model. Each participant will have a specific model reflecting the participant's proprietary economic data. In addition, it may be decided to develop an open-book economic model (OBEM) for use by all participants. It is the operator's responsibility to ensure that nonproprietary input data (e.g., production forecasts, capital, and operating cost forecasts) are provided to the participants with sufficient time to carry out independent analysis and to debate the results with the other participants. Other established decision-analysis tools include the following.

- Decision trees commonly are used to visually communicate decisions, uncertainties, and outcomes.

- Influence diagrams may be used to understand the relationship between project inputs and ultimate results. They can be a good basis for formulating and communicating the logic for the economic models.
- Probabilistic overlays on other tools (e.g., Monte Carlo analysis and decisions trees) can be used to analyze the effect of uncertainty.
- Result displays, such as tornado plots, cumulative-probability curves, investment-efficiency plots, or spider diagrams are not analysis tools themselves, but are critical for interpreting and communicating the implications of the analysis.

6.3. Analysis With Uncertainty

It is the project team's responsibility to facilitate the identification and quantification of the uncertainties with the participants and to communicate the results of the analysis. This will help identify potential trade-offs between the different strategies being debated.

Some uncertainties can be reduced significantly by expending time and money to obtain additional data. Value-of-information (VOI) analysis is a tool that can evaluate whether collecting additional data adds enough value to warrant the added cost.

There are two fundamental approaches to analyzing uncertainties. Most participants use both approaches from time to time.

- Deterministic analysis uses sensitivities and scenarios.
- Probabilistic analysis uses discrete values with probabilities (decision trees) and continuous probability distributions (Monte Carlo or stochastic analysis).

The deterministic analysis with sensitivities listed above is a preliminary analysis often used to determine how sensitive the decision criteria are to changes in the underlying inputs. Higher effect inputs might be subjected to a VOI to determine whether additional investigation is warranted. Inputs with a minor effect can usually be represented in subsequent analysis by a single value (ideally the mean value) without materially changing the conclusions drawn from the analysis.

For decision models that use decision trees, uncertain input parameters that are continuous usually are assessed in representative discrete form.[18] Results should be presented in graphic form to aid communication, such as the following, which illustrate the effect of uncertainties on various decision criteria.

- Sensitivity charts showing sensitivity to inputs on the basis of arbitrary ranges (±XX%)
- Tornado diagrams showing the effect of the 80% probability range (P10 to P90)
- Probability distributions (i.e. exceedance curves, S-curves, risk curves, cumulative distributions, and probability densities)
- Assessment of sensitivity of decision criteria to changes in input probabilities
- Investment-efficiency charts (if multiple strategies are being evaluated)

6.4. Economic Analysis With OBEM

In general, projects will require economic analysis, and each participant will perform an independent economic analysis. However, on occasions, it may be advantageous for the operator to develop an OBEM that can be shared by all participants. An OBEM can be used if the

[18] Bickel, J.E., Lake, L.W., and Lehman, J. 2011. Discretization, Simulation, and Swanson's (Inaccurate) Mean. *SPE Economics & Management* **3**(3) 128–140. SPE 148542-PA. http://dx.doi.org/10.2118/148542-PA.

participants agree that it provides a substantial benefit to decision alignment. There are two typical situations in which this may be the case:

- Participants have a substantially different view of the relative profitability of different strategies.
- Participants need to share an economic model with a government or a commercial entity (e.g., a bank).

Participants should agree on key assumptions and the economic quantitative decision criteria to be calculated before model construction. The OBEM should conform to the strictest letter and spirit of any applicable competition laws, confidentiality agreements, or fiduciary responsibilities. Appendix D includes guidelines for the construction of an OBEM.

6.5. General Guidance on VOI Analysis

A VOI analysis provides insight into the expected value of obtaining additional information (e.g., obtaining seismic data or drilling delineation wells). VOI is equal to the value of the opportunity with information less the value of the opportunity without information. The additional value is derived from the potential for new information to change a decision that would be made without the information. Importantly, if no decision will be affected, the information can add no value, no matter how much it may reduce uncertainty. Appendix E outlines general guidelines for conducting a VOI analysis.

7. Facilitating Decisions and Commitment to Action

7.1. Overview

Commitment to action arises from acceptance of the inputs as reasonable, a review and agreement of the logical analysis of those inputs, and a clear understanding of the strategies, including values and trade-offs. Quality decision making requires continual dialogue between working teams and decision makers. This dialogue, iterated throughout the DQ process, achieves clarity of thought and clarity of action, as shown in **Fig. 7.1.**

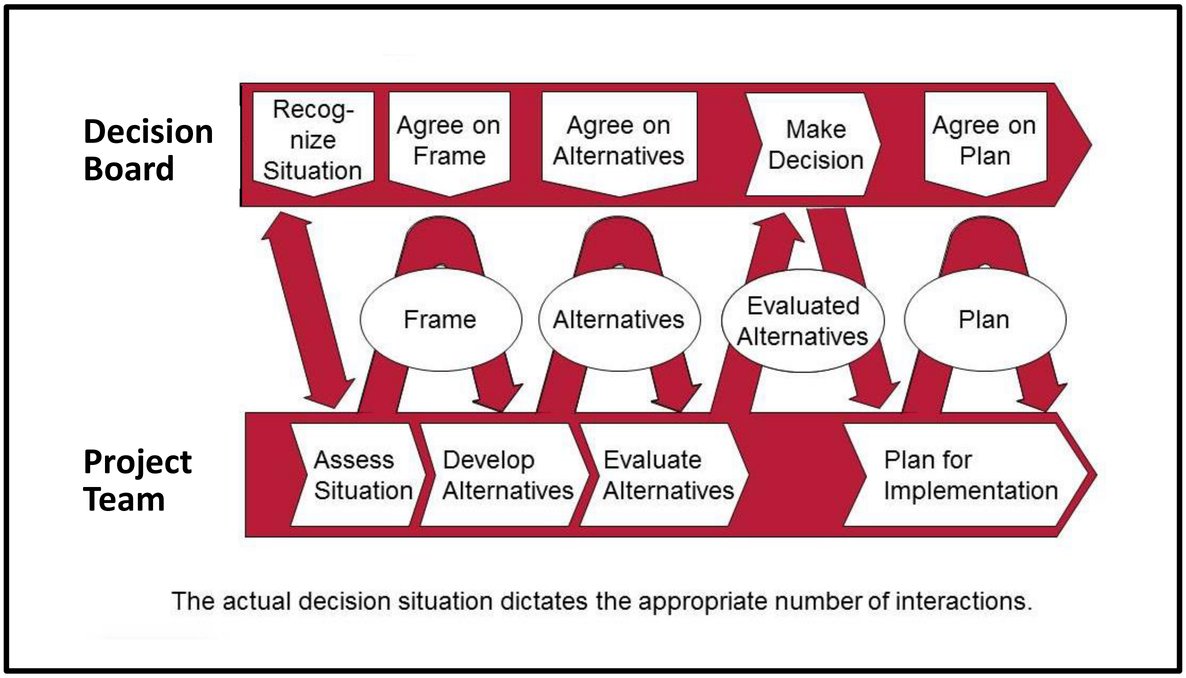


Fig. 7.1—DQ-process dialogue.

7.2. Understanding Commitment to Action

Commitment to action involves more than simply making the decision. It involves committing to an allocation of resources necessary to execute the next phase of the project. As per the Decision Maker's Bill of Rights[19], a decision maker has the right to the following.

- A decision frame that structures the decision in the context most relevant to one's needs
- Creative alternatives that enable making a selection among viable and distinct choices
- Relevant and reliable information upon which to base one's decision, including the uncertainty of the information
- An understanding of the potential consequences of each alternative based on one's decision criteria
- A logical analysis that allows one to draw meaningful conclusions from the information to reach clarity of action
- Effective facilitation to gain alignment and commitment to action

The decision makers need to ask: Are we really ready to execute the project? Has each element of decision quality been addressed to the extent necessary at this stage to proceed with the project? If so, then decision makers, the project team, and all participants should be committed to action.

7.3. Decision-Support Package

The primary instrument used by multicompany decision boards is a decision support package (DSP). It makes a recommendation for a preferred alternative and explains why it is preferred. It

[19] Society of Decision Professionals Decision Maker's Landing Page, www.decisionprofessionals.com

summarizes the work leading up to the decision and should fulfill all six elements of DQ: appropriate frame, creative doable alternatives, meaningful and reliable information, clear values and trade-offs, logical reasoning, and commitment to action.

The DSP should also state the recommended strategy and the resulting action steps. The DSP should tie directly to previous DSPs, meetings (including decision-framing meetings), and agreements. The DSP should have a consistent format for all project decisions and meet the minimum needs of all participants.

7.4. Keeping Track of Decisions

Making a decision on a concept or a strategy typically involves making multiple focus decisions along the way. A decision register is a helpful tool for keeping track of decisions that have been or still need to be made. It typically includes the following.

- The preferred alternative selected in the decision, if already made.
- The date the decision was made, or the schedule milestone at which the decision should be made.
- A reference to the decision log (below) or other supporting documentation for the decision.
- A description of any signposts indicating a need to review the decision. A signpost is a threshold in one of the project assumptions that, if crossed, could result in a change in the subject decision. For example, if expected ultimate oil recovery falls below 300 million BO, you may want to review a decision to construct a stand-alone floating production unit rather than construct a subsea tieback to an existing host.

When multiple focus decisions are being made, a decision log is a useful tool for documenting each of these decisions. The recommended content of such logs is similar to that for the overall DSP discussed in Section 7.3, but is focused on a single focus decision. Often, these logs then can be used directly in the overall DSP and simplify that process.

7.5. Economic Analysis in the DSP

Any economics presentation should follow the preparation guidelines outlined for an OBEM. The values used to compare the economic performance of alternatives should tie to the decision criteria. In the presentation of these values, appropriate emphasis should be given to the range of outcomes rather than a single representative value, such as a mean or median case, to capture the risk profile of the result. Commonly, these decision criteria may include the following.

- Net present value (NPV)
- Internal rate of return (IRR) Profitability index (PI)
- Discounted payback (DP)

There are strengths and weaknesses of each of these economic measures that are outside the scope of this report. Similarly, some measures, such as NPV, lend themselves to probabilistic analysis more easily than others. The presentation may include incremental economic analysis to illustrate the comparison between or among alternatives. If other operational metrics are used, their definition and interpretation should be explained.

8. Implementation of DQ

8.1. Overview

Effective implementation of DQ in multicompany upstream projects should provide a pathway for mutual understanding, alignment, and effective shared decision-making. Transparency, collaboration, and facilitation are keys to successful DQ implementation. There are many points in the lifecycle of a project where DQ can add value. **Fig. 8.1** shows several key decision points that may occur in an upstream project. The DQ process is scalable and should be used to fit the intended purpose. While it is important to address each of the six elements of DQ, the depth to which each is addressed should be only to the extent that it continues to add value.

Key strategies to overcome the challenges to implementation include training, sharing success stories, successful pilot implementation, and introduction of management to the Decision Maker's Bill of Rights. While this process will not guarantee correct decisions, DQ can help achieve alignment and clarity on the options available and develop the best solutions on the basis of the knowledge and values of all participants involved.

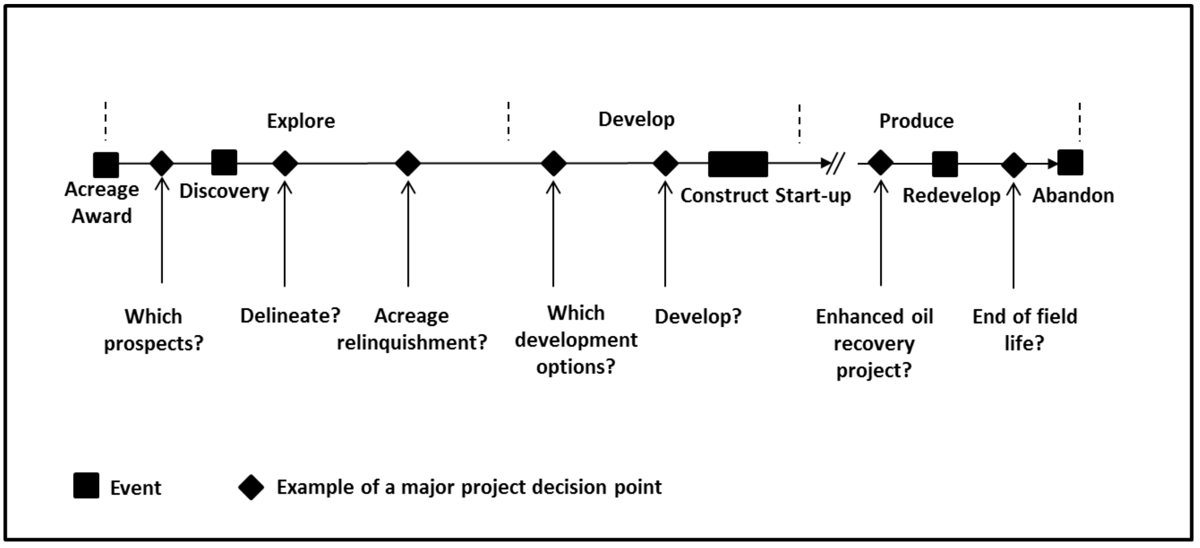


Fig. 8.1—Project timeline with major decision points.

8.2. Strategies for Implementing DQ

Several strategies are helpful, if not essential, to successful DQ implementation.

- Prepare the case for change and value proposition for DQ implementation.
- Ensure that decision makers know and seek DQ by use of the Decision Maker's Bill of Rights.
- Identify DQ-process leaders and champions.
- Initiate DQ training.
- Implement DQ internally and then externally with others.
- Scale DQ appropriately for fit-for-purpose application.
- Use strong internal and/or external facilitators.
- Share success stories.
- Implement pilots.

8.3. Multicompany DQ Challenges

There are challenges to implementing a DQ process and achieving DQ that are characteristically presented in multicompany projects. Some of these challenges and potential solutions addressing them may include the following.

- Some participants in a specific multicompany project, including the operator, may be less familiar with or not developed expertise with the DQ process. The introduction of a new process for decision making may seem overwhelming for such participants. There are several possible approaches those participants and the participant group can take toward bridging gaps in project implementation.
    - The facilitating participant should describe the process at the beginning of the project and answer any questions related to how DQ will be used and how participants are expected to participate.
    - Adopt some of the implementation strategies in Section 8.2, at least to the extent of project-specific decision-making.
    - Select a project team and decision board knowledgeable in DQ
    - Present the DQ work products to participant's project decision makers, including the project frame, alternatives, and decision criteria. This information can be effective in gaining commitment to action and in demonstrating the value of the process itself.
- In decision making among participants, the terms of the joint operating agreement generally dictate the decision-making structures, including an executive committee; but a decision board generally is not prescribed. The relationship between this executive committee and the decision board should be clarified at the beginning of the decision process for the project.
- The decision makers on a project must be consulted on key decisions, but the decision makers may not be readily available to the project team. Within individual participants, many multicompany projects require high senior-level executives to make decisions, and these people likely will not be part of the decision board. If the decision board, as pictured in the decision process dialog diagram (Fig. 7.1), does not have decision authority, they need to seek authority on decisions from the senior decision makers within their own organization.
- Each participant in a project may have different goals, objectives, and decision criteria. Framing the opportunity with all participants should help provide an understanding of how these differ for each of them. Identifying alternatives in the decision frame that recognize the needs of all participants further highlights the value of the process.
- The project team and the decision board that governs it are often staffed entirely by the operator. However, there are potential advantages to including participant representation in each of these groups if it is allowed in or can be incorporated into the project operating agreement. Improved participant alignment on decisions may be one benefit of such inclusion, and may be a head start in satisfying participant assurance processes.

- DQ may be misperceived by some participants in several ways.
  - It may be viewed as an additional process that will slow the pace of a project. In practice, the DQ process can minimize recycle time, improve project execution and pace, and lead to more-informed higher-quality decisions.
  - It may be viewed as requiring large investments of time and resources required to perform complex quantitative analysis. In practice, all six elements of DQ often can be implemented with only simple fit-for-purpose analysis.
  - It may be viewed primarily as a technical process, perhaps because of the use of S-curves, tornado diagrams, decision trees, and other resources that may be applied to only a limited set of technical problems. In practice, the core of DQ can be performed without need for numbers or technical features and can be applied to a broad range of problems.

To overcome misperceptions, participants that have used the process previously should share success stories with other participants. Training can reinforce this message, particularly in regard to the Decision Maker's Bill of Rights, which may help convince decision makers that are unfamiliar with the process that it is worth the required effort.

Ultimately, the proper application of DQ will require champions to drive the implementation of the DQ process. Champions are most successful when there is pull from upper management and push from the project team that will do the work.

Appendix A Definitions and Acronyms

The terms defined in this appendix may have different interpretations in different industries. The purpose of the following definitions is to establish useful definitions for the context of this document (i.e., as an aide to communication and alignment in multicompany upstream oil and gas projects.)

Term	Definition
Boundary Conditions	In the context of this document, a boundary condition is a limitation on the alternatives to be considered or not considered. Sometimes referred to as being "in the problem frame" or "outside the problem frame" (i.e., relevant or not relevant to this particular decision). Also sometimes referred to as “given” decisions that are assumed final and will not be worked.
Cumulative-Probability Curves	A graph that displays the probability that a variable will not exceed a particular parametric value. Also known as an "S curve," and related to an exceedance curve.
Decision	An action within the participants' control that usually comes with a commitment of resources to execute an action (but could also be an agreement to do nothing).
Decision Board	A group of executives and managers with project oversight to approve the steps of the decision process, as per Fig. 7.1.
Decision Criteria	Metrics that measure and describe the key consequences of interest of a given decision or strategy.

Term	Definition
Decision Frame	The summary of results from a framing activity.
Decision Hierarchy	A list of decisions in order of priority, which are the most important decisions to be resolved soon, vs. decisions that are dependent on additional data or can be deferred without affecting the project status.
Decision Milestone(s)	Usually defined as major engagements with decision makers and can be tied to stages or phases of project work and/or key deliverables.
Decision-Support Package (DSP)	A summary document used as the basis for achieving and documenting decisions along with an action plan.
Decision Tree	A decision tree is a decision-support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility metrics, such as NPV.
Deterministic Analysis	A calculation based on a single set of inputs yielding a single result rather than a probabilistic or a stochastic analysis, which uses multiple inputs and ranges of results.
Focus Decision	Used by some companies to distinguish the most important and immediate decision from the myriad of decisions that may eventually be required to be considered before project sanction.
Force-Field Diagram	An analysis for understanding the context of a project involving identifying the forces acting on a project either to drive it forward or restrain it.
Framing Meeting	An activity done early in the decision process that develops alignment and a logical basis for subsequent decision analysis.
Given Decisions	See Boundary Conditions.
Indifference Frontier	The value of an assigned probability at which a decision changes.
Influence Diagram	A diagram that identifies the relationships between decisions, uncertainties and results. It can align understanding and ultimately helps with structuring analysis models.
Investment-Efficiency Charts	Graphical methods of displaying the ratio of present-value profit to present-value investment, also known as the discounted profitability index.
Monte Carlo Analysis	A calculation based on multiple trials, each with one or more input variables randomly sampled from given probability distributions. A range of results is produced, with its own probability distribution.
Objectives Hierarchy	A sorting of objectives in the order of importance to a decision board. This method helps align the objectives of participants. It can be thought of as a combination of fundamental objectives and their supporting "how to" objectives. Fundamental objectives tend to defy ranking and typically are dealt with by balancing or trading off one against another.

Term	Definition
Open-Book Economic Model (OBEM)	An economic model constructed such that it can be shared by several participants without breaching competition (or other) laws or individual participants' commercial confidentialities or fiduciary responsibilities.
Operator	Multicompany projects typically have one company nominated as the operator on behalf of the project, usually the company with the largest ownership. Alternatively, the operator may be a joint-venture company that is separate from any one participant.
Opportunity Statement	A definition of the problem or opportunity that a framing meeting is chartered to address.
Participant	Used in this document as a general term for stakeholders in a multicompany project, including the operator, that contribute to the decision-making process.
Probability-Exceedance Curves	A graph that displays the probability that a variable will exceed a particular parametric value. Related to a cumulative-probability curve.
Project Team	The team responsible for most of the technical work on a particular project, including generating or collecting inputs, processing and analyzing those inputs, and sharing the resulting information with all participants. The project team is also responsible for facilitating DQ by working with the participants in the co-operative processes outlined in this report. The project team is often staffed entirely by the operator, but may also include representation from the participants. Each participant may also have an internal project team, which reviews and provides feedback on the work of the main project team, interprets project results for their own management, and engages with other participants to ensure overall DQ on the project.
Risk	Risk can be defined as the probability that a hazard or discrete event will result in a specified level of loss or failure. This is an event that may or may not happen (e.g., a delineation well may or may not penetrate the field oil/water contact).
S Curves	See cumulative-probability or probability-exceedance curves
Scenario	An imagined or projected sequence of events, especially any of several detailed plans or possibilities. In the context of this document, an alternative where multiple parameters are varied relative to a reference case, rather than varying a single parameter (i.e., a sensitivity case).
Stakeholder Analysis	An analysis for understanding the context of a project involving identifying the parties affected by the project, its effect on them, and their influence on it.
Stochastic Analysis	See Monte Carlo Analysis.
Strategy	A portfolio of decisions intended to achieve an overall aim.
SWOT Analysis	An analysis for understanding the context of a project involving identifying strengths, weaknesses, opportunities, and threats (SWOT).

Term	Definition
Uncertainty	The lack of certainty. A state of having limited knowledge so that it is impossible to describe exactly the existing state, a future outcome, or more than one possible outcome. Uncertainty can be represented by a range (e.g., from offset-well data, the field oil/water contact is between 2500 and 2600 m). In principle, the range can have a specific probability distribution assigned to it if there is an adequate technical basis for assessing the range.
Value Drivers	Used by some companies to describe parameters that have the most influence on achieving the participants' overall objectives for a project or opportunity.
Value Measures	Identifiers that help the decision makers balance tangible and intangible values when making investment decisions. Example: Net Present Value (NPV) or Return on Capital Expenditure (ROCE).
Value of Information (VOI)	The equivalent cost of obtaining information. Generally, this is equal to the "value of the opportunity with information" less the "value of the opportunity without information." It also can be expressed as the amount the decision maker should be willing to pay for information before making a decision.

Table 3—Definitions.

Term	Definition
DSP	Decision-Support Package
JOA	Joint Operating Agreement
OBEM	Open-Book Economic Model
P(10), P(90)	Probability of a value or event occurring less than 10% of the time. Note that application varies between companies. For example, some companies will treat the P(10) reserve as the high-side reserve; others use P(90). Therefore, the use of this terminology is discouraged
P(50)	A value that is equally likely to be exceeded or not exceeded
SDP	Society of Decision Professionals
SME	Subject Matter Expert
SPE	Society of Petroleum Engineers
VOI	Value of Information

Table 4—Abbreviations and acronyms.

Appendix B Preparation for Decision Framing Meeting: Pre-Framing Questionnaire

Framing usually benefits from inviting input from the participants ahead of the framing meeting. Benefits include the following.

- Ensures that participants understand the objectives of the meeting.
- Stimulates participants to come the meeting prepared.

- Makes the participants write down their concerns and ideas explicitly.
- Encourages participants to review the subject of the meeting with relevant SMEs and management.
- Allows the project team to have relevant material and SMEs available to facilitate the meeting.
- Provides input to the project team, which may choose to develop a draft frame as a starting point for the framing meeting.

An efficient way to achieve this is through a preframing questionnaire. The project team needs to allow sufficient time for participants to carry out internal consultation, consolidation of participants input, and distribution of combined input to all participants before the framing meeting. The following elements should be considered when preparing a preframing questionnaire.

Charter
Basic administrative information
Problem, issue, opportunity statement
Boundary conditions
Key questions the framing session will be addressing
Other relevant issues
Review materials and SMEs

Appendix C Illustrative Inputs and Outputs For a Framing Sessions

	Inputs from Decision Board (or equivalent) (e.g., Charter)	**Outputs from Framing Team. May require multiple framing sessions for a complex project.**
Objective	Concise statement of board's requirements—Board's view of the opportunity.	Clarification or proposed restatement of the objective, reflecting the discussion in the framing meeting. Collective vision of success.
Boundary Conditions	• Study scope • Previous decisions • Aspects not to be considered	• Validation of boundary conditions. • Additional boundary conditions to be tested with the decision board.
Timeframe for the Study	Anticipated duration to meet business need	• Work plan conforming to timeframe. • Alternative work plans if the project team considers the time frame should be revised.
Anticipated Attendance	• Operator, participant, and SME attendance. • Required or discretionary.	Documented attendance
Decision Criteria	Board's decision hierarchy and metrics	Validation of proposed revisions to the decision hierarchy

	Inputs from Decision Board (or equivalent) (e.g., Charter)	Outputs from Framing Team. May require multiple framing sessions for a complex project.
		• Strategic framework • Situational analysis • Business environment • Competitive environment • Identification of external stakeholders • Project issues essential to decision-making • Assessment of project complexity • Identification of risks and uncertainties • Initial thoughts on risk and uncertainty mitigation Alternatives considered and resulting decision strategies recommended for evaluation. Participants' needs, such as internal review time, data for internal analysis, data-quality review opportunities. Action plan with specific activities, responsibilities, resources, and a schedule (including planned decision board reviews)

Appendix D Guidelines for the Construction of an Open-Book Economic Model

The OBEM should be:

- Constructed with commonly available public-domain software so that the model can be run by all participants.
- Constructed in a way that allows sensitivity analysis and may include provisions for probabilistic analysis.
- Constructed in a way that anticipates the possibility of sharing with governments, which may ultimately result in public release.
- Modular and easy to update with revised project data, without the project team needing to reissue complete models.
- Self-documenting, with user documentation embedded in the model itself, including changes made between versions. The model should include notations stating the specific project and purpose of the economic model. It should also state that the model does not contain individual participants' actual data and there are no warranties made regarding the model, assumptions or outputs. The model should include a version number and date of issue. Assumptions themselves should be documented in a register, which should include date of assumption, type of assumption, rationale and source.
- A cash-flow calculation that uses nominal (money of the day) in local currency and US dollars, incorporating the current fiscal and contract terms[20]. Escalation of real inputs and

[20] For an OBEM, money of the day may be derived from a real cost estimate with an arbitrary escalation assumption to avoid sharing company-confidential economic forecasts. Ultimately, the operator will cash call to a "money of the day" budget.

present-value discount rates must use only nonproprietary values. Where no fiscal regime exists, an agreed range of fiscal parameters should be evaluated. Where project debt is involved, the model should include both leveraged and unleveraged economics, unless the participants agree otherwise.

- Constructed on a 100% equity basis (all venture parties included) and should not reveal the profitability of any individual party.[21]
- Based on nonproprietary economic assumptions. The following options can be considered, but should be tested with the operator's legal advisor before implementation.
  - Based on one or more external forecasts in the public domain.
  - Based on public-domain historical data.
  - Deliberately left blank to be filled by the participants.
  - Based on whole, round figures (e.g., USD100/bbl or 10%) to demonstrate the functionality of the OBEM
- Constructed with case management to expedite running and comparison of multiple cases.
- Constructed with outputs that:
  - Display a variety of economic metrics as agreed in advance of building the model, including point-forward (ignores sunk costs) and full-cycle (includes all costs) economics, and when the analysis is probabilistic, a probability distribution of the metrics (e.g., an S-curve on NPV)
  - Report appropriate economics for potential discussion with governments.
  - Emphasize ranges over specific values.
  - Use graphical displays for clarity of understanding.
- Constructed without passwords, even if sections of the model are locked to avoid unintended changes.

Appendix E Guidelines for Value of Information Analysis

The VOI is equal to the "value of the opportunity with information" less the "value of the opportunity without information." The additional value is derived from the potential for new information to change a decision that would be made without the information. Because value comes from the potential to change a decision, it is critical to understand the original state of a decision before adding information. It is also important to understand whether affected decisions are still truly variable (i.e., whether there is already some kind of commitment to one path in the decision). If the decision will not be changed with new information, then the information can add no value, no matter how much it may reduce uncertainty.

The need for a VOI analysis is driven by the relative reliability of the existing and potential new information, the magnitude of the uncertainty being investigated, and the potential effect of information on future decisions in terms of likelihood and magnitude. A good first step in a VOI analysis is to start with an assumption of perfect information[22]. This avoids having to assess the reliability of the new information, and may be sufficient to obtain participant alignment, especially if the analysis shows no value.

[21] References to the potential effect of any side agreements between parties, such as an investment "carry" or overriding royalty should be avoided because of their complexity and risk for error.

[22] For example, perfect information might assume that drilling a delineation well will substantially resolve a key reservoir uncertainty, such as average permeability. It is more common to find that the well contributes to the understanding of the uncertainty but does not resolve it completely: imperfect information.

The uncertainty being investigated should be as specific as possible, corresponding to information that will actually be gathered in the investigation. For example, oil/water contact is better than oil in place. The contact depth is information that a delineation well can measure directly. A change in oil in place may be a consequence of revising the oil/water contact, which is not measured directly and is a complex value affected by several reservoir parameters.

It is often difficult to obtain agreement on probabilities associated with the branches on a VOI decision tree, especially assessments of reliability. The following approaches can be considered.

- The analyst can assign indicative probabilities to the decision-tree branches to explain the benefits of obtaining additional information. This may be sufficient to reach a consensus.
- Alternatively, the analyst can poll the views of the participants' SMEs and test the outcome for a range of probabilities.
- The analyst can determine the indifference frontier. This is the value of an assigned probability that changes a decision. It usually is easier for participants to agree that a value is above or below a threshold value than to agree on a specific value.

A data-gathering activity, such as a delineation well, usually will provide more than one piece of information. It may be necessary to evaluate the combined contribution of more than one piece of information to justify gathering additional data. However, the number of factors incorporated in the decision process should be limited to a few major considerations.

Often, a VOI decision is most powerful when a clear go vs. no-go decision depends on additional information. This situation requires a realistic application of the decision threshold, such as a minimum economic rate of return (hurdle rate). Use of a conservative decision threshold can distort the VOI materially, because the analysis may mischaracterize go decisions as no-go and misrepresent the value associated with those decisions.

Appendix F Decision Support Package (DSP)

Element	Comment
Executive Summary	One page with key recommendation(s)
Reiterate decision frame	Include direct tie to previous meetings or decisions (may be in the Executive Summary) Highlight Decision Criteria or Objectives Hierarchy
Geological and reservoir bases	Highlight key uncertainties (ranges) and plausible alternative geological concepts and risks.
Alternatives evaluated	Highlight issues (consequences) with the alternatives
Reservoir analysis and depletion-plan alternatives	Ensure reservoir assumptions, analogs, and range of outcomes are represented
Relevant technology assessment: • Drilling • Facilities (marine or subsea) • Pipelines or onshore plants • Infrastructure • Operational aspects • Execution • Cost and schedule	As applicable, for all alternatives under consideration. Operational aspects include safety, environmental aspects, production reliability, and availability among others.
Nontechnical considerations	Commercial, environmental, and regulatory
Evaluation of alternatives	All relevant cases identified in the decision frame, highlighting tradeoffs between alternatives. Economic indicators*
Issues management	Including signposts and risk-mitigation options
Recommendation and required decisions	Clarity on actions and implications including cost, budget, timeline, and signposts or off-ramps. Demonstrate tie to the decision frame.
Next steps	Ongoing communication, deadlines, actions by the operator, and actions by the other participants
Case specific	More detailed information on key issues covered above. By exception, charts typically covered in the main package (listed above) but relegated to back-up because of limited relevance to the current focus decisions.
Note: * May be profitability parameters, such as rate of return from an OBEM if the group has decided that an OBEM is required to facilitate decisions.	

Fig. F.1—Example structure for a DSP.

Appendix G Additional Reading and Resources

There are many references available for additional background and how-to instructions on all of the DQ activities discussed in this report. The following list represents a few of these references.

Topic	Reference
Analytical tools	Parnell, G.S., Bresnick, T., Tani, S.N. et.al. 2013. *Handbook for Decision Analysis*. Hoboken, New Jersey: Wiley
Analytical tools	Bratvold, R.B. and Begg, S.H., 2010. *Making Good Decisions.* Richardson, Texas: Society of Petroleum Engineers.
Anchoring and bias	Russo, J.E. and Schoemaker, P.J.H. 1989. *Decision Traps—The Ten Barriers to Brilliant Decision Making & How to Overcome Them.* New York: Doubleday
Decision framing	Keeney, Ralph L. 1992. *Value-focused Thinking: A Path to Creative Decision Making.* Cambridge, MA: Harvard UP
Decision framing	Framing and evaluation graphics used in this report courtesy of Decision Frameworks.
Decision theory	Skinner, David C. 2001. *Introduction to Decision Analysis.* Third Ed. Gainesville, FL. Probabilistic Publishing
Decision theory	Porter, M.E. *The Five Competitive Forces that Shape Strategy*, Harvard Business Review, January 2008, p.86-104.
Decision theory	Clemens, R.T. 1997. *Making Hard Decisions*. Brooks/Cole
Decision theory	Leach, P. 2014. *Why Can't You Just Give Me The Number? An Executive's Guide to Using Probabilistic Thinking to Manage Risk and to Make Better Decisions*. Sugar Land, TX. Probabilistic Publishing
Decision theory	Charlesworth, D.L. 2013. *Decision Analysis for Managers.* Business Expert Press
Decision theory	DQ Process Dialogue chart courtesy Society of Decision Professionals
Objective hierarchy	Keeney, Ralph L. 1992. *Value-focused Thinking: A Path to Creative Decision Making.* Cambridge, MA: Harvard UP
Partner relationships	Van Driel, J.P. and Pederson, T. 2005. Creating Value by Improving the Operator/Nonoperator Partner Relationship. Presented at the SPE Annual Technical Conference and Exhibition, 9–12 October, Dallas, Texas. SPE-96983-MS. http://dx.doi.org/10.2118/96983-MS
Partner relationships	Walkup, G.W. and Ligon, B.J. 2006. The Good, Bad, and Ugly of Stage-Gate Project Management Process as Applied in the Oil and Gas Industry. Presented at the SPE Annual Technical Conference and Exhibition, 24–27 September, San Antonio, Texas. SPE-102926-MS. http://dx.doi.org/10.2118/102926-MS
Guidelines for Application of the Petroleum Resources Management System	Sponsored by SPE, AAPG, WPC, SPEE and SEG. http://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf
Strategy tables	Coopersmith, E.M., Burkholder, K., and Mendoza L. 2014. Early Production Systems – When Do They Make Good Sense for Your Project? Presented at the Offshore Technology Conference, Houston, Texas, 5–8 May. OTC-25440-MS. http://dx.doi.org/10.4043/25440-MS
SWOT analysis	http://ctb.ku.edu/en/table-of-contents/assessment/assessing-community-needs-and-resources/swot-analysis/main
Uncertainty analysis	Coopersmith, E.M., Burkholder, K., and Schulze, J. 2012. Improving Exploration, Appraisal & Pilot Planning through Better Forecasting of Uncertainty Reduction via Reliability of Information Interviewing and Confidence Plots. Presented at the SPE Hydrocarbon Economics and Evaluation Symposium, Calgary, 24–25 September. SPE-159587-MS. http://dx.doi.org/10.2118/159587-MS

Topic	Reference
Uncertainty analysis	Sawiris R., Howes C.S., Rodriguez J.A., and Foley W.L., 2015. Uncertainty and Risk Management Plans are Critical for Team Alignment and Better Decision Quality. Presented at the SPE Annual Technical Conference and Exhibition, 28–30 September, Houston, Texas. SPE-174932-MS. http://dx.doi.org/10.2118/174932-MS
Uncertainty analysis	Bickel, J.E., Lake, L.W., and Lehman, J. 2011. Discretization, Simulation, and Swanson's (Inaccurate) Mean. *SPE Economics & Management* **3**(3) 128–140. SPE 148542-PA. http://dx.doi.org/10.2118/148542-PA.
Value-of-information analysis	Winkler, R.L. 2003. *An Introduction to Bayesian Inference and Decision*, Second Edition. Holt, Rinehart & Winston