Look at Situations from all Angles and you will Become More Open: Advanced Analytics Approach to Exploration Portfolio Allocation Decisions*

Dmitry Surovtsev[1], Tom Levy[2], and Muhammad Usman Sethi[3]

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[1]Schlumberger, Moscow, Russia (DSurovtsev@slb.com)
[2]Schlumberger, Dubai, UAE
[3]Schlumberger, Ahmadi, Kuwait

Abstract

The term "exploration portfolio management" means different things to different experts in the E&P value chain (e.g., a new ventures manager, a hydrocarbon accountant, a petroleum economist, a corporate business planner, and a management consultant). A common feature among the various definitions is that all portfolio candidates are compared visually, allocated to certain classes, and considered from multiple angles. In this paper, we review current global practices of portfolio allocation decisions as exploration plays mature; compare and explain differences for bluefield and greenfield assets; study issues with applicability of Markowitz/capital asset pricing model portfolio theory in petroleum exploration; review a balanced scorecard approach for prospect ranking; and propose a management-level prospect-ranking dashboard with a live link to the corporate prospects database of an industry-leading exploration risk, resource, and value (RRV) assessment solution. We focus on practical aspects of handling risk/reward tradeoffs given decision-makers' attitudes towards risk. We discuss applicability of artificial intelligence for making informed exploration drilling decisions and the management choice between exploration decision systems and exploration decision support systems. We apply this integrated approach to a practical case study. We start from mapping leads and generating prospects using a shared earth approach, proceed to a multidiscipline prospect assessment with the RRV suite, and culminate with a portfolio ranking reflecting a customizable set of criteria and a measure of attitude towards risk using a business intelligence/business analytics (BI/BA) tool. The novelty of our study consists of the adopted practical multidisciplinary approach to prospect ranking. Until an E&P company drills out a statistically meaningful sample of prospects and performs a post-drill analysis, there is no way to differentiate between right and wrong ways of prospect assessment and ranking. Even then, the company will face a choice between vaguely right and vaguely wrong ways. The most important aspect in the never-ending route to perfection in exploration, however, is to try to reach a consensus between key exploration disciplines, both geology & geophysics and engineering & economics. This is the most important condition of mitigating individual and group biases, heuristics, and fallacies, which are, in turn, the "mortal enemies to exploration portfolio management".

Introduction

"Exploration is best managed by managing an exploration portfolio" (McMaster 1997). Explorers of various geographies, sizes and ownership groups use prospect ranking at various stage-gates of their decision-making process. It may be used to prioritize farm-in opportunities, to allocate exploration budgets in the existing exploration portfolio, to select preferred areas for seismic acquisition, and to rank proposed well locations.

In this paper, we review current global practices of portfolio allocation decisions as exploration plays mature; review a Multiple Criteria Decision Analysis (MCDM) approach for prospect ranking; study issues with applicability of Markowitz portfolio theory in petroleum exploration; and propose a management-level prospect-ranking dashboard with a live link to the corporate prospects database of an industry-leading exploration risk, resource, and value (RRV) assessment solution. We focus on practical aspects of handling risk/reward tradeoffs given decision-makers' attitude towards risk.

We apply our integrated approach to mimicking the best practice workflows of international explorers. Regional asset teams use the RRV software suite to perform multidisciplinary quantitative and qualitative assessments of proposed portfolio candidates. A central Peer Review/Quality Assurance (QA) team considers the prospect assessments and labels those compliant with the company standards and guidelines as approved. The communication between asset teams and the QA team is streamlined by the corporate database architecture of the RRV solution (on-premises or cloud-based). A web-based dashboard implemented with a business intelligence / business analytics platform queries the RRV prospects database for key features of all assessments approved for a specific decision stage-gate. Ultimately, the decision maker reviews dynamic portfolio ranking suggestions by adjusting the measure of their risk appetite as appropriate.

Exploration Portfolio Management: Multi-Criteria Decisions under Uncertainty

As defined by McLay et al (2003) exploration portfolio management is the "process by which the (exploration) portfolio is managed to achieve multiple and conflicting objectives. It involves continually testing scenarios for future production growth whilst trying to balance long-term and short-term requirements, the need to deliver both value and volume, meet cost targets, deliver robust projects with a suitable balance of risk and reward whilst keeping within spending limits".

We reviewed a dozen of examples of prospect ranking criteria used by explorers across the globe, of which five from client engagements, and seven from published papers (Al-Adwani et al 2017, Chandrasekaran et al 2008, Garcia and Holtz 2003, Leonard and Ozkaynak 2000, Lopes and de Almeida 2013, Moore and Tucker 1995, Murris 1998). We concluded that companies use multiple, different and sometimes conflicting ranking criteria and weights, and that criteria vary by exploration decision stage-gates. Economic factors are rarely taken in consideration for ranking early exploration maturity leads. They become as important as geologic ones for ranking drill-ready prospects.

A discipline of management science that evaluates multiple conflicting criteria in decision making is called Multiple Criteria Decision Making (MCDM). It has nearly 250 years of history. The first known MCDM application is described by Benjamin Franklin who used a simple paper-based Pro vs Con method for making important decisions (Franklin 1772). There are over seventy MCDM methods described in the literature by now. Our quick-look systematization of those is presented in Figure 1. The earliest, simplest and most widely used MCDM method by practitioners is known as WSM, SAW or SMART, as the case may be (Figure 2).

We risk walking into a firestorm of economists' criticism if we do not mention Markowitz theory in the context of constructing exploration portfolios. Harry Markowitz laid out the foundation of modern portfolio allocation theory in a 1952 essay, for which he was later awarded a Nobel Prize in economics. He argued that a financial assets portfolio is "efficient" if its components have the best possible expected level of return for their level of risk. The measure of risk was represented by the standard deviation of return.

However, among the twelve examples reviewed only one used a modified Markowitz concept for prospect ranking (Garcia and Holtz 2003). Others relied on a substantially wider set of criteria than two. Modern portfolio research helps to explain that practical stance. Ceria and Stabbs (2006) argued that "optimal" portfolios obtained through the mean-variance approach are often "counterintuitive", "inexplicable", and "overly sensitive to the input parameters" that affects their broad acceptance by practitioners. Ehrgott et al (2004) considered a portfolio allocation challenge for a stocks investor who uses five risk and return objectives: twelve-month performance, three-year performance, annual revenue, volatility and S&P star ranking. Greco et al (2013) addressed the uncertainty of returns in portfolio components through consideration of a certain number of return distribution quantiles. In all cases the authors applied various MCDM techniques as logical steps beyond the bi-objective Markowitz portfolio optimization. Table 1 presents our set of arguments cautioning against the blind application of pure Markowitz portfolio theory for exploration prospect ranking.

Conflicting Exploration Objectives and Decision Maker's Risk Appetite

The last argument in Table 1, a common lack of risk-neutrality in exploration decision making, has a tangible effect on portfolio composition. Optimum exploration decisions for a reward-seeker and a risk-avoider are materially different. Common performance metrics (e.g., risked resources or EMV) provide no clue to making a choice between a larger prospect with a lower chance of success vs. a smaller prospect with higher chance of success, or a prospect with larger upside and larger downside vs. a prospect with smaller upside and smaller downside. The answer depends on decision-maker's risk appetite.

Economic researchers typically address this phenomenon by transforming a verifiable prospect assessment result (such as NPV) into an abstract utility function (von Neumann and Morgenstern 1947; Savage 1954; Bratvold et al 2007). This theoretical concept has however a very limited adoption by practitioners.

We developed a visual method of handling risk/reward tradeoffs that addresses practical needs of exploration decision makers. The discussion below is focused on comparing prospect size with the geological chance of success. The same concept would apply to comparing mean success-case NPV with economic chance of success, economic upside (NPVP01) vs. economic downside (NPVP99), or any other bi-dimensional choices related to risk / reward tradeoffs. We start by drawing an Opportunity Rectangle around the portfolio candidates plotted on a resource-GCOS scatter chart (Figure 3). The rectangle borders are defined by the outermost points of the sample.

Next, the Opportunity Rectangle is split geometrically into grade areas according to decision-maker's risk appetite. Lowest Risk lover looks for targets with highest GCOS regardless of volume, therefore splits the rectangle horizontally and assigns the highest grade to the topmost area (Figure 4). Highest Reward admirer aims for maximum resources regardless of risk, suggesting a vertical breakdown (Figure 5).

Logically, the grade area divides for a risk-neutral decision maker would feature a slope in between those of the Lowest Risk and Highest Reward ranking views (Figure 6). Following the same logic, the slope of grade area separators could adjust continuously depending on the position of risk appetite control (Figure 7).

It is feasible to assume that a decision-maker may apply a duplicitous attitude to risk. They can be more risk-averse for prospects inferior to their target than for prospects superior to the benchmark. In other words, their portfolio strategy would aim to satisfy both the recommendation of Sir Richard Branson (1998) to "protect the downside", and a lifehack by Paulo Coelho (1993) to "Be brave. Take risks. Nothing can substitute experience". This duplicity can be modelled using bended grade area divides (Figure 8).

Prospect Ranking Workflow as a part of Exploration Decision Support System

Figure 9 describes a high-level workflow and system that integrate prospect assessment and prospect ranking into a coherent corporate exploration portfolio decision process. A focal feature of the solution is the RRV suite corporate prospects database, implemented on premises or in the cloud. In line with the fundamental principle of data management, prospect data is entered only once. Users access and manipulate the data securely on an "as needed" basis relevant to the context regardless of their physical location. Regional asset teams prepare probabilistic risk and resource assessments, supplement those with exploration economics assessments (if relevant for the decision stage-gate) and assign values to qualitative ranking parameters required under the corporate ranking methodology.

The central QA team possesses a specific database privilege to approve analyses, that is not granted to asset teams. A prospect will be approved if it is ready for a relevant decision stage-gate and successfully passes the peer review process. All qualitative prospect description properties required under the corporate standard must be defined before a prospect assessment can be approved. Once approved, the assessment becomes read-only. If a newer assessment is approved at a later stage, e.g. because of improved exploration knowledge, the previously approved one receives a Historic status (still read-only). As a result, at any given time a prospect would feature one approved assessment, several historic ones, and a few test assessments. This robust versioning approach alleviates a burden of locating the most up-to-date analysis that is common in communications between geographically dispersed teams. It also allows to archive, explain and demonstrate the logic behind every exploration decision made.

The key feature of the RRV suite database architecture is that one does not need the RRV application to retrieve prospect assessment results. Any third-party tool that can submit database queries can access the same data, provided that a legitimate user is positively authenticated and has the necessary access rights. Such tools may include spreadsheet applications. At the same time, the best practice is to link the prospects database with modern business analytics / business intelligence tools (e.g., Microsoft PowerBI, TIBCO Spotfire, Tableau, SAP Business Objects, etc.). It ensures that relevant prospect scores are presented to decision makers consistently, visually appealing, interactively, in real time and as web dashboard.

A possible realization of the ranking dashboard for a drill-ready class of prospects is presented in Figure 10. The ranking methodology is based on quantitative geologic and economic assessment results (Mean resources vs. GCOS, EMV, Value Upside vs. Downside) as well as qualitative prospect properties (key petroleum systems element risk, oil vs. gas and level of competition). As the risk appetite slider is moved, the slope of area dividers on the risk/reward tradeoff charts changes and the ranking bar chart is recreated. Interactive tooltips and drill-down-on-demand functionality help to interpret the results. The geospatial context (prospect location map) is available as well.

As stated by Benjamin Franklin (1772) describing his multi-criteria decision framework: “though the Weight of Reasons cannot be taken with the Precision of Algebraic Quantities, yet when each is thus considered separately and comparatively, and the whole lies before me, I think I can judge better, and am less likely to make a rash Step.” Bratvold (2012) echoes: “The main value of decision analysis is not in the specific numbers that are generated in the process but in the structured thinking and insight that the process engenders and the resulting transparency and record.”

The described prospect ranking system and workflow enables structured thinking for decision makers and empowers them to make balanced exploration portfolio decisions at every prospect maturation stage gate. “Businesses can’t afford to have their systems make alien decisions. They face regulatory requirements and reputational concerns and must be able to understand, explain and demonstrate the logic behind every decision they make” (Vadhwa 2018).

Conclusions

- Prospect ranking is a multi-dimensional choice under uncertainty with unique criteria and criteria weights for each explorer. A universal one-size-fits-all ranking criteria mix is unlikely to be adopted by the industry. Criteria need to be customized by company, area, decision stage gates, etc.
- Decision-maker’s risk appetite is an important consideration for exploration portfolio allocation decisions that is often either ignored or dealt with non-transparently. An innovative visual approach to handling risk-reward tradeoffs is proposed.
- Until an E&P company drills out a statistically meaningful sample of prospects and performs a post-drill analysis, there is no way to distinguish between right and wrong ways of prospect assessment and ranking. However, a systematic peer review process between prospect assessment and prospect ranking aims to mitigate individual and group biases, heuristics, and fallacies, which are, in turn, the “mortal enemies to exploration portfolio management”.
- The multiple criteria decision analysis workflow for exploration portfolio management is successfully implemented with a custom MCDM ranking methodology using a link between the commercial risk, resource and value assessment software suite and a business intelligence platform relying on the secure relational prospect database architecture.

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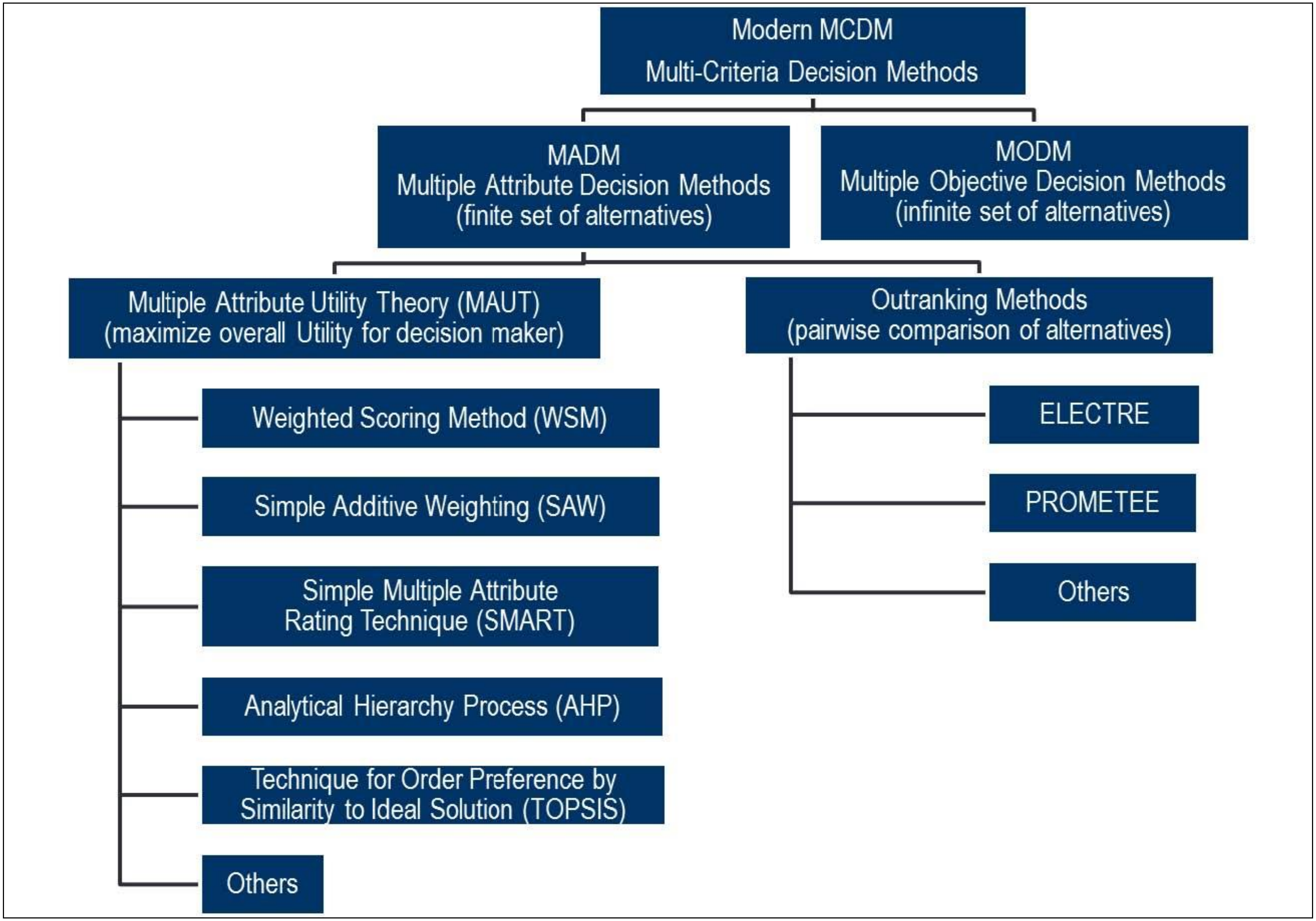

Figure 1. A hierarchy of selected MCDM methods.

Figure 2. A general workflow of weighted scoring MCDM method (WSM, SAW, SMART) as applicable for exploration.

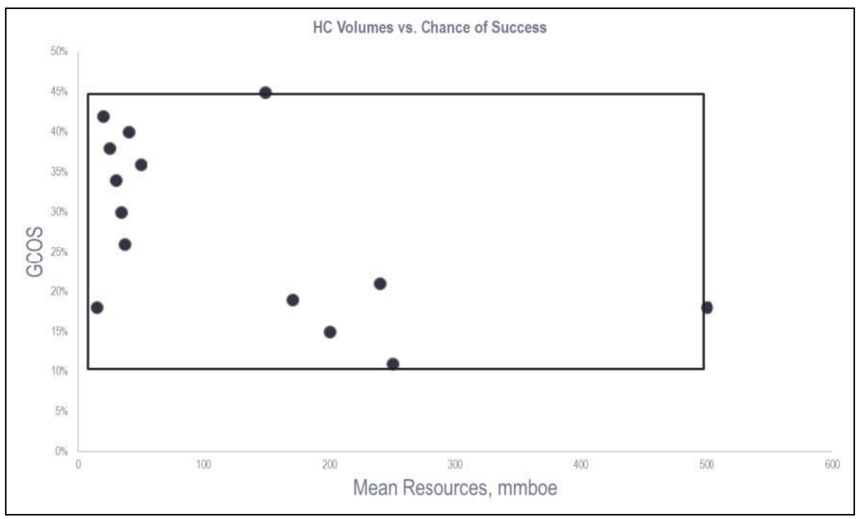

Figure 3. A risk-resource Opportunity Rectangle for a dummy exploration portfolio.

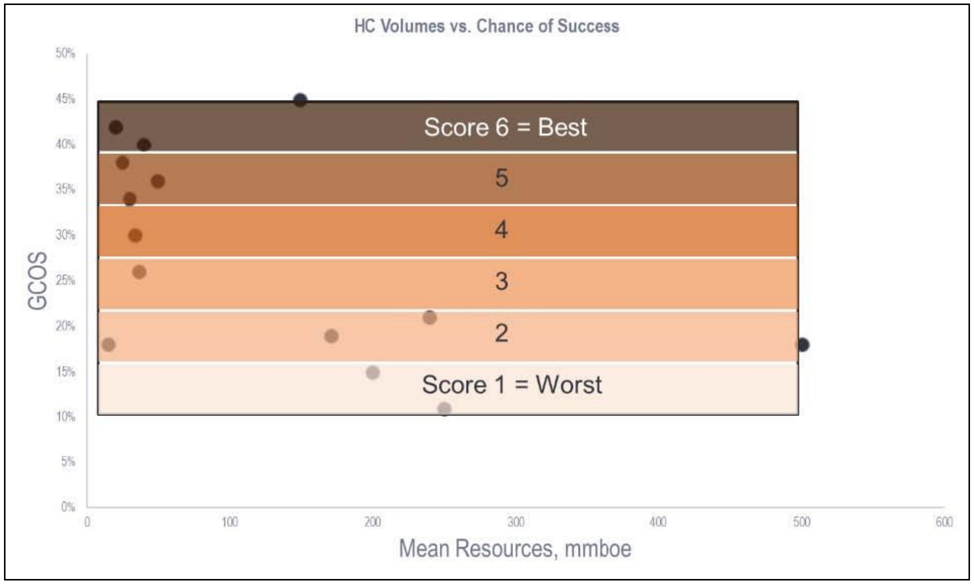

Figure 4. Ideal ranking for Lowest Risk Appetite.

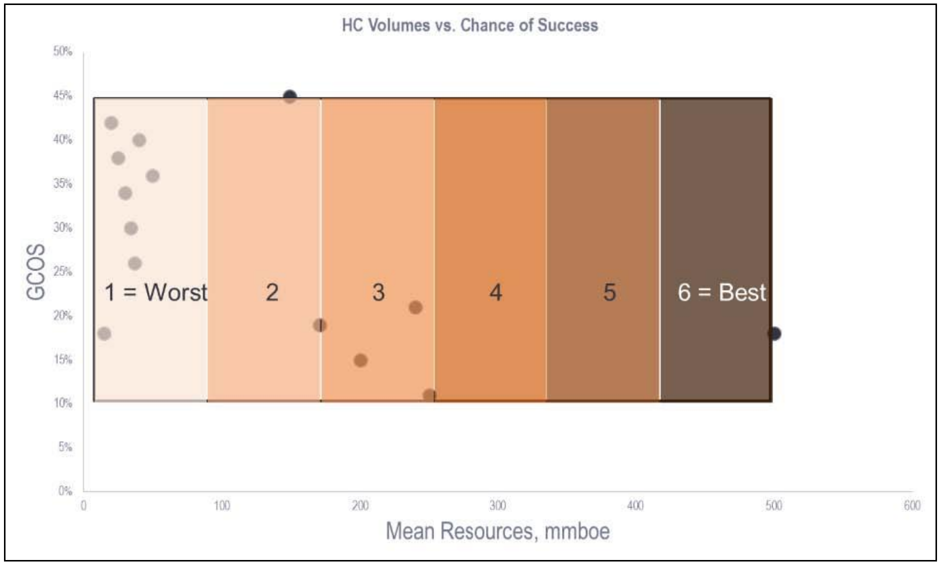

Figure 5. Ideal ranking for Highest Reward Appetite.

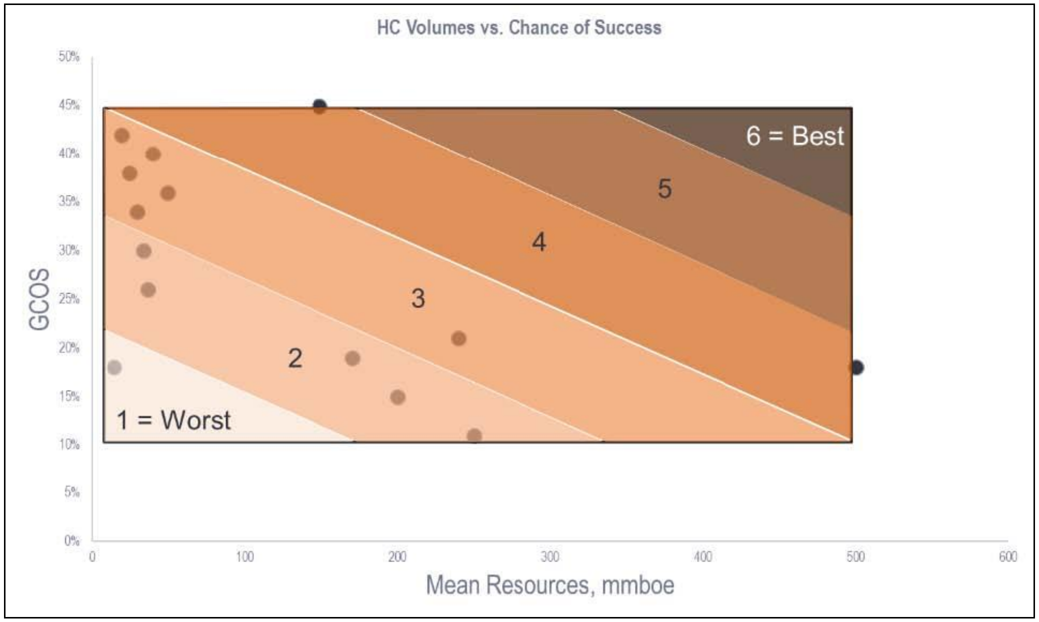

Figure 6. Ideal ranking for Neutral Risk Appetite: average between two absolute extremes.

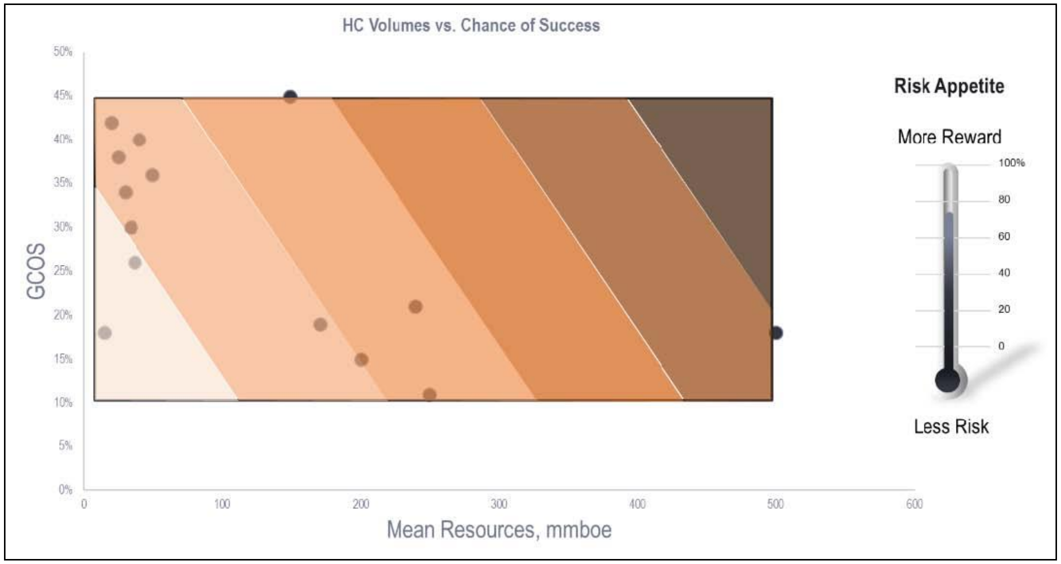

Figure 7. Continuous Risk-Reward Area Segmentation - a case of 75% risk appetite.

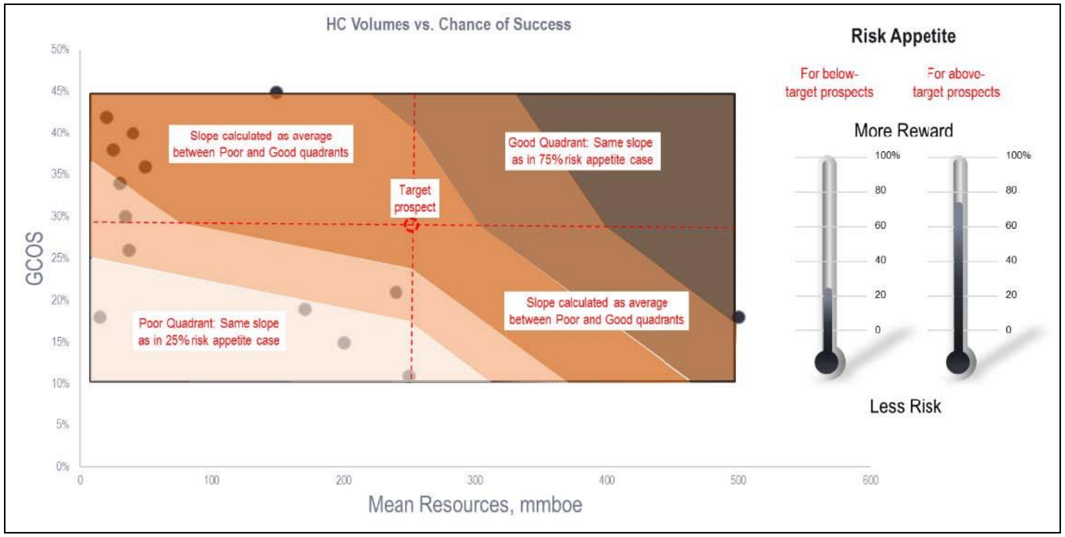

Figure 8. Risk-reward grade area segmentation for duplicitous risk appetite.

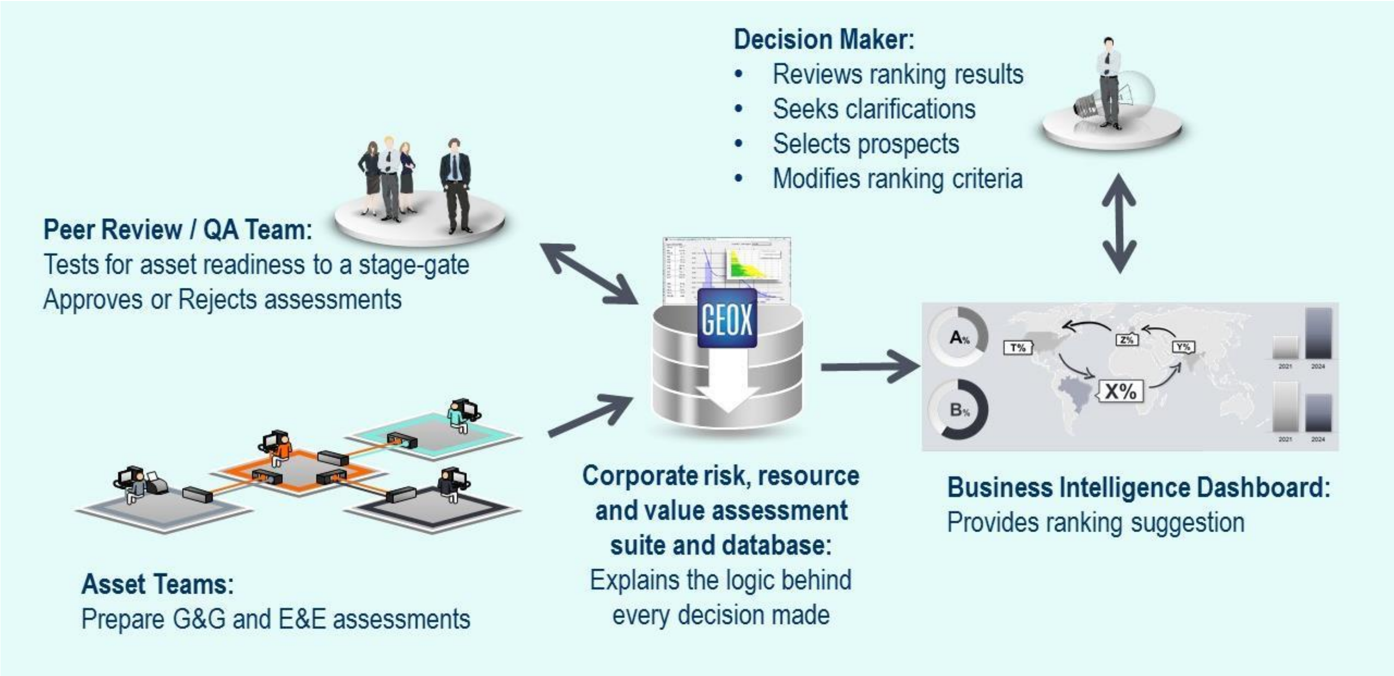

Figure 9. A workflow linking prospect assessment and prospect ranking.

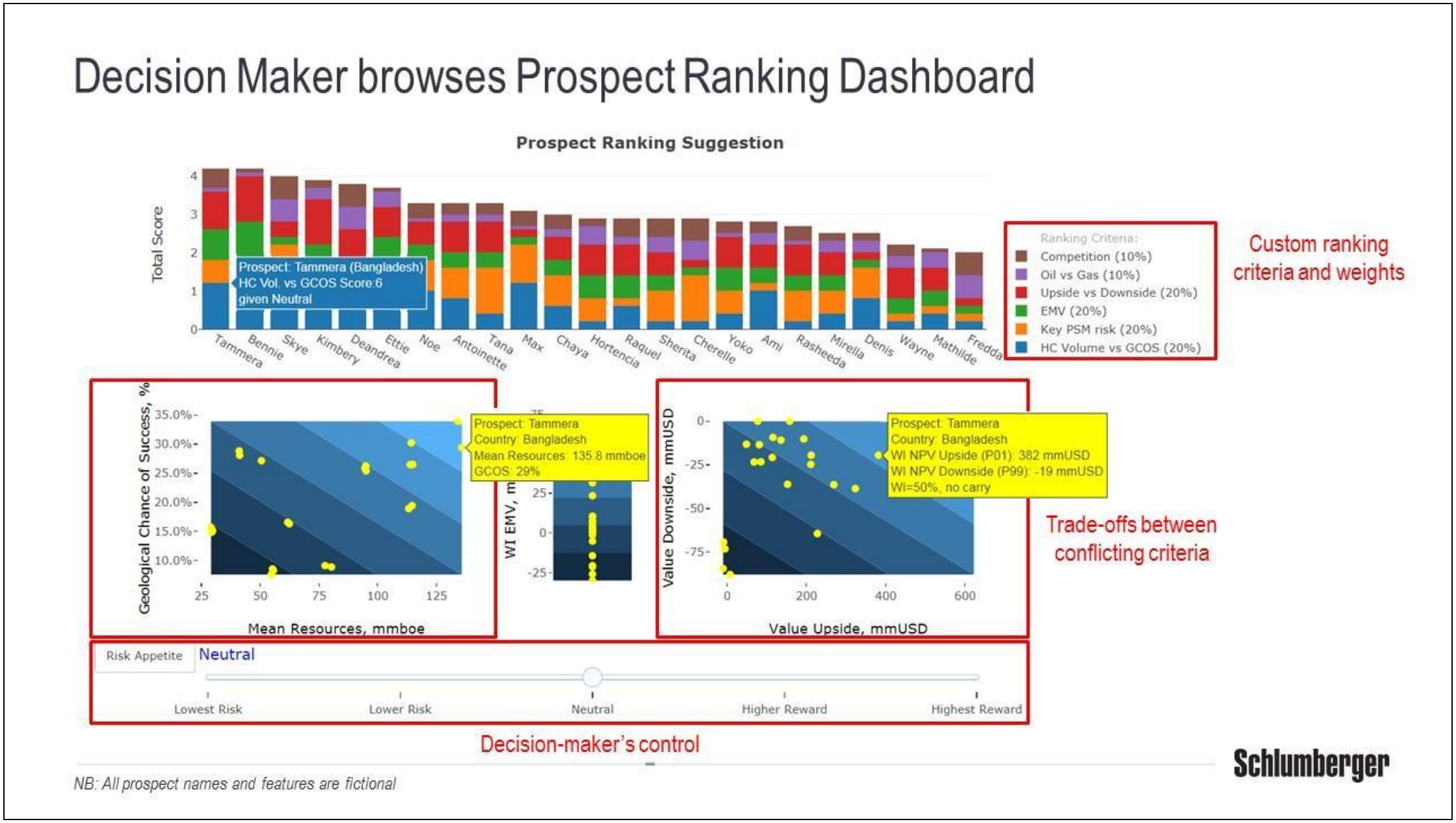

Figure 10. Key design features of a customizable prospect ranking dashboard for drill-ready prospects.

Markowitz Theory	Reality of Exploration Business
Designed for financial assets with normal distribution of returns	Exploration asset returns are highly asymmetric
Proven to be overly sensitive to estimation error	Exploration assessments cannot be precise
Relies on quantifying just two parameters – risk and reward	Multiple definitions of risk and multiple facets of return
Assumes that financial metrics adequately and comprehensively describe studied assets	Cross-discipline link is not perfect in exploration; a lot of decisive information is lost in the dialogue between departments with different mind-sets
Assessment bias can be avoided by reviewing historic returns of asset classes	Systematic post-drill analyses are rare. Bias is mitigated using expert teams of diverse backgrounds
Financial investors only look at financial metrics	Oil & Gas companies use a mix of financial and technical KPIs for measuring corporate performance
Assumes decision maker's risk neutrality	Decisions under uncertainty are never risk-neutral

Table 1. Markowitz portfolio theory vs. realities of petroleum exploration.