

Portfolio Management in an Upstream Oil and Gas Organization

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Implementing portfolio management in an organization presents organizational and analytical challenges. A successful implementation requires an integrated solution for both the people aspects and the analytical aspects of the problem. Strategic Decisions Group (now Navigant Consulting, Strategy Consulting Practice) developed and implemented a portfolio-management process and system for a client organization in the upstream oil and gas industry. The tailored process provides a forum for decision-focused dialogue between senior management and asset teams. The system provides the analytical support for the process and enables management to compare decisions and assets across the portfolio and determine optimal allocation of resources. The system architecture builds on a rigorous model of the asset life cycle and the key decisions in the life cycle. To further integrate portfolio management into its business processes, the organization set up an internal core team to facilitate the process and work with the asset teams on an ongoing basis. This has helped reduce the time for developing regional and business-unit portfolio strategies. The value added from strategic alternatives developed using the method is in the hundreds of millions of dollars.

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Implementing portfolio management in an organization requires a process that engages the expertise of the various stakeholders in the organization and a system to provide the analytical support for the process. A well-thought-out process tailored for the organization takes care of the people issues and ensures buy-in for the selected portfolio strategy. A transparent and validated system that incorporates the knowledge of the various experts in the organization and models the portfolio decisions and uncertainties solves the analytical part of the problem. A successful implementation requires an integrated solution for both the people aspects and the analytical aspects of the problem.

For a client company in the upstream oil and gas industry, Strategic Decisions Group (now Navigant Consulting, Strategy Consulting Practice) developed and successfully implemented a portfolio management process and system. The overall portfolio management approach and key elements of the system are easily transferable to other industries and organizations.

Overview of the Portfolio Management Approach: Portfolios and Interdependencies

A portfolio is a collection of entities among which there may be several interdependencies. An entity can be a single physical asset (such as a producing field in the oil and gas industry or a manufacturing plant in another industry), a business unit (which may include several assets), or a financial security. An interdependency may exist between any two entities in the portfolio and may affect specific performance measures of the portfolio. Interdependencies among entities in a portfolio

can be informational, or they can be physical or operational.

The concept of informational interdependency between two entities builds on the concept of relevance between two uncertainties. An informational interdependency exists between entities A and B in the form of relevance when at least one uncertainty about entity A is relevant to at least one uncertainty about entity B (Figure 1). This includes the special case in which the expert or decision maker believes that entities A and B share a specific uncertainty. (An uncertainty A_i is relevant to an uncertainty B_j if knowing the value or outcome of uncertainty A_i , we would assign a different probability distribution to uncertainty B_j [Howard 1990]). For example, consider two prospects A and B in an unproven play (a play is a group of prospects and any related fields having common hydrocarbon sources, migration relationships, reservoir formations, seals, and trap types [White 1992]). If the uncertainty about geologic success for prospect A is relevant to the uncertainty about geologic success for prospect B, an informational interdependency exists between prospect A and prospect B. Many forms of risk correlation among entities would thus fall under this category of interdependency. Other instances of informational interdependency are opportunities for learning, process improvement, and the like.

The category of physical or operational interdependencies includes the use or sharing of the same physical resources, competencies, or skills. Examples of physical interdependencies are a producing field tied to a specific processing facility for another field or assets competing for

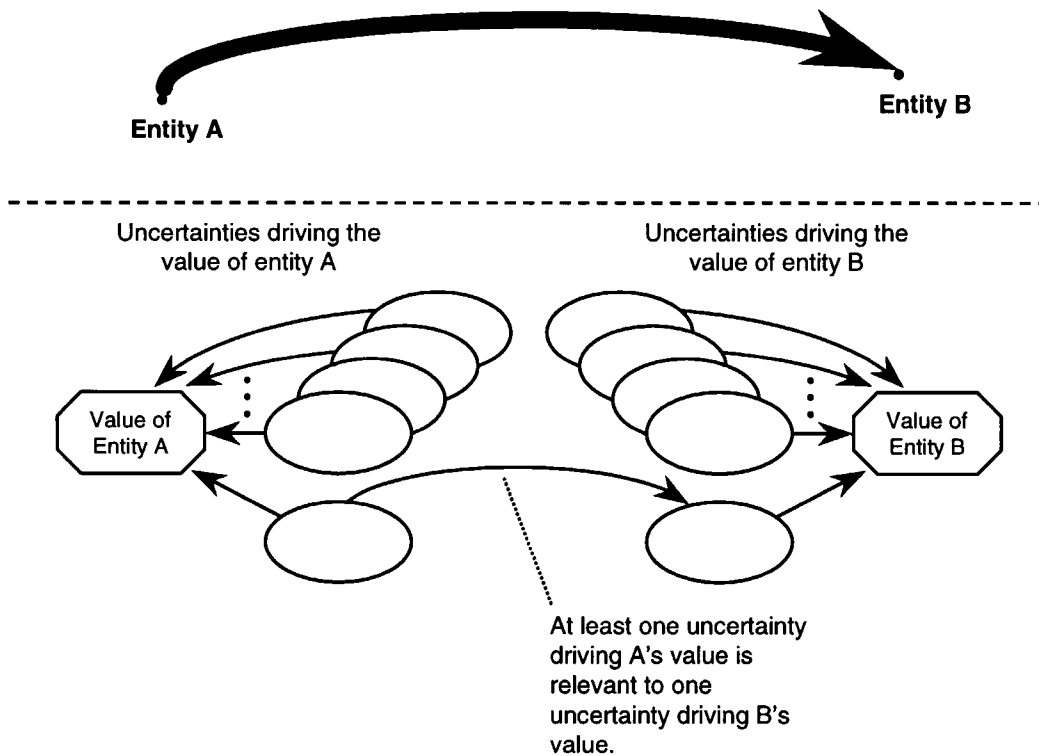


Figure 1: The concept of informational interdependency between two entities builds on the concept of relevance between two uncertainties. An informational interdependency exists between two entities, A and B, in the form of relevance, when at least one uncertainty about entity A is relevant to at least one uncertainty about entity B. (This includes the special case in which the expert or decision maker believes that entities A and B share a specific uncertainty.) The bold arrow in the upper part of the figure represents the informational interdependency between the two entities. In the lower part of the figure, relevance diagrams show the uncertainties driving the value (or any other measure) of each entity and possible relevances among them.

the same capital and human resources.

Portfolio Management

In this approach to portfolio management, we focus on interdependencies among entities in the portfolio to develop strategies that improve the performance of the portfolio as a whole. Interdependencies bring relevance to the concept of portfolio management. Otherwise, in the absence of interdependencies, we could treat each entity separately and not be concerned with portfolio management.

Portfolio Management at Two Main Levels in an Upstream Organization

Portfolio management can be applied at two main levels of portfolio decisions in an upstream organization: the corporate portfolio of business units and the business unit portfolio of assets and projects (Figure 2). The corporate portfolio consists of all the business units in the organization and any assets that do not fall in any specific business unit. Each business unit may have its own portfolio of assets or

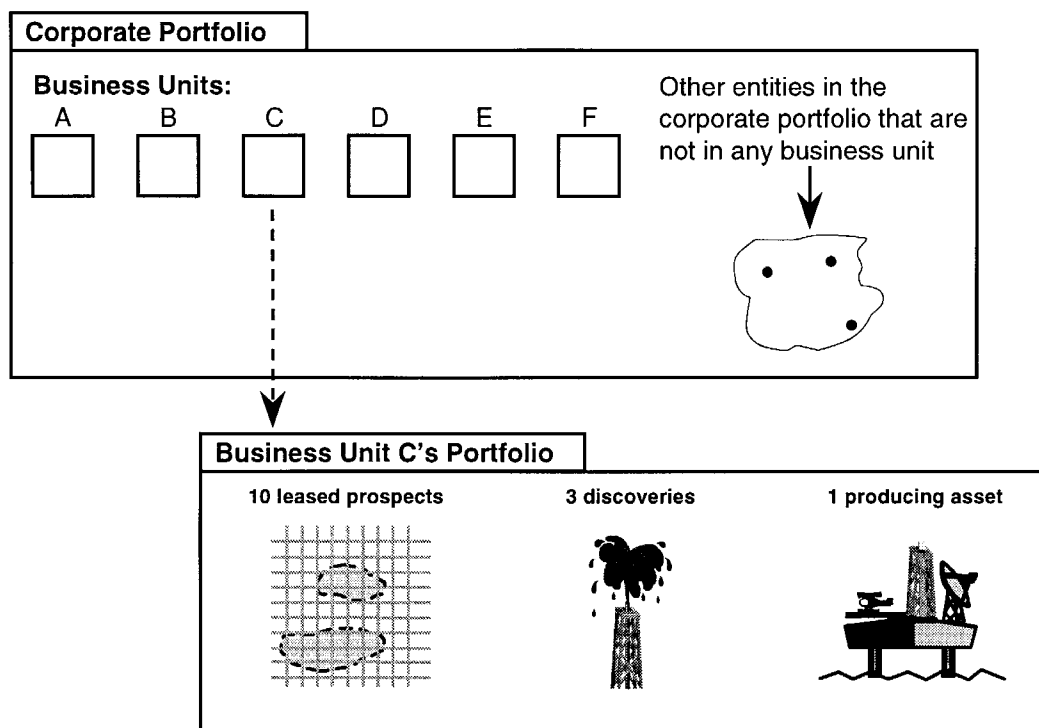


Figure 2: A corporate portfolio consists of business units and other entities that are not in any business unit. A business unit's portfolio of assets may include leased prospects, discoveries, and producing assets.

projects. An entity in a business unit portfolio is thus a single asset or project. Sometimes, an upstream oil and gas corporation may organize a business unit around a single asset, in which case the business unit portfolio consists of a single asset.

The first level of portfolio management decisions in an organization is the corporate portfolio strategy: What businesses does the organization want to be in, and how much does it want to invest in each business? Examples of decisions at this level include the acquisition of new businesses, investments in existing business units, mergers with other organizations, and divestitures.

Given a chosen corporate portfolio strategy, the next level of portfolio management is within each business unit: What opportunities or assets does the business unit want in its portfolio, and how can it best allocate resources across these assets? Examples of decisions at this level include the acquisition of new assets, investments across assets, and the timing of asset investments.

Portfolio management decisions fall within the hierarchy of decisions in an upstream organization (Figure 3). At the top of the decision hierarchy are the corporate mission, vision, and values. They are what distinguish the organization from others, and they are taken as given when discuss-

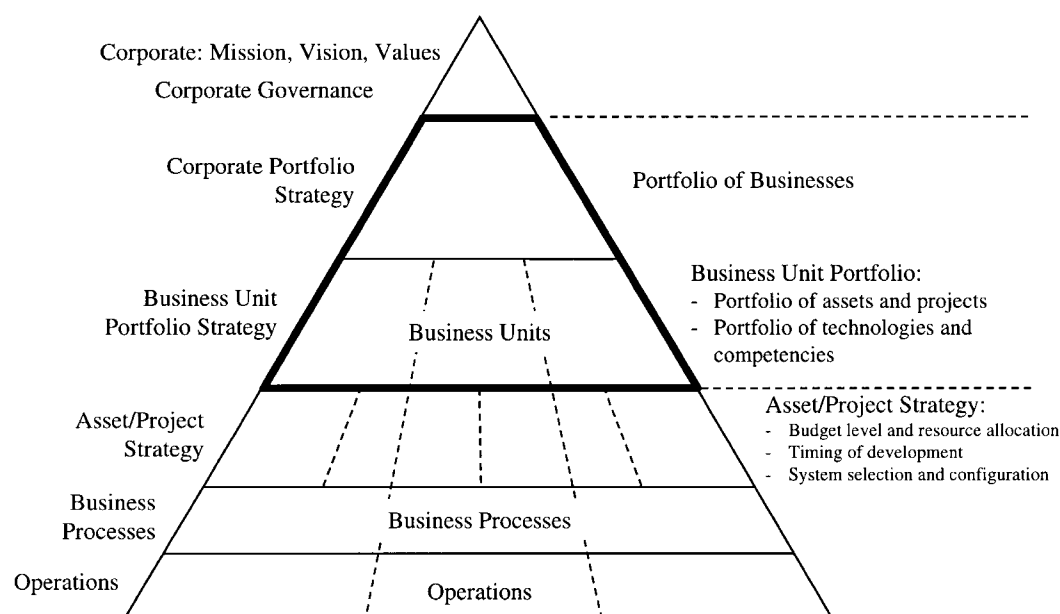


Figure 3: The two main levels of portfolio management decisions fall within the context of the decision hierarchy of an upstream organization.

ing portfolio management. At the next level down are the corporate portfolio strategy decisions. At the next level are strategy decisions for the business unit portfolio. Each level of portfolio decisions provides scope and direction for lower decisions and is fully developed through the decisions made at the next lower level. For instance, the corporate portfolio strategy is fully developed as the collection of strategies for the business units in that corporate portfolio. Similarly, the portfolio strategy for a specific business unit is fully developed as the collection of asset strategies (project strategies) for all the assets (projects) in that business unit's portfolio.

The Business Unit and Its Portfolio

Business units of major oil and gas companies operating in the Gulf of Mexico (Figure 4) oversee large portfolios of assets and manage these assets through exploration, development, and production. For

simplicity and to protect the confidentiality of my client, I describe the needs of a typical business unit in the Gulf of Mexico and refer to it as the Gulf of Mexico Business Unit (GMBU). The GMBU formed asset teams to manage the assets in its portfolio. Some teams were geographically based while others focused on assets that shared a key characteristic.

The Gulf of Mexico has been the main growth area for exploration and development for several oil and gas companies in the United States. Companies lease blocks from the Minerals Management Service (MMS) through participating in lease sales administered by the MMS. Prospects may extend over several blocks. Leaseholders must drill prospects before their leases expire (most have 10-year terms); discoveries can then be held for production beyond the lease expiration date.

The GMBU portfolio consisted of many

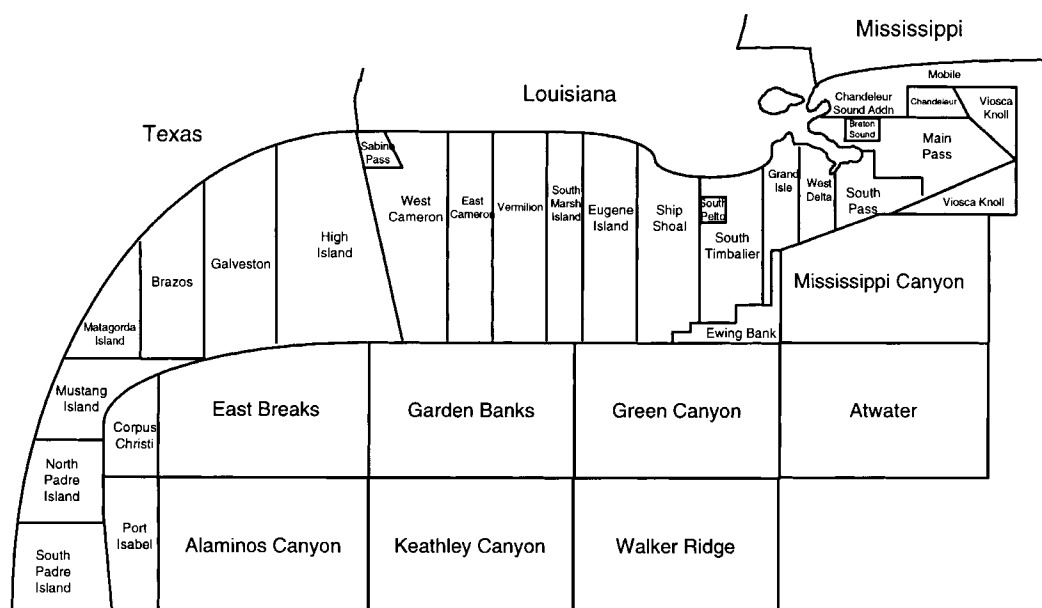


Figure 4: Map of the Gulf of Mexico showing areas of operations for the Gulf of Mexico Business Unit.

assets distributed across different stages of an asset life cycle (leads, leased prospects, risked prospects deemed ready to be drilled, discoveries, and producing assets). Managing this growing portfolio of opportunities while faced with resource constraints (rigs, staff, capital, and so on) and lease expiries was becoming complex. The GMBU management team engaged Strategic Decisions Group (SDG) to develop a portfolio management system and process that would facilitate the allocation of resources across the portfolio, provide insight into portfolio-wide issues, and be easy to use and update. The system was to help the management team and the asset teams compare decisions and assets across the portfolio, determine optimum allocations of resources, and evaluate current resource levels and support resource planning. Further, the system was to provide insights into such portfolio-wide issues as

leasing strategy, portfolio balancing, and technology investments. The system and process were to be transferred to an internal portfolio management team after training and testing.

We embarked on a six-month effort to develop the system and process, working closely with a core team of experts in the organization. During the first part of the project, we concentrated on developing the system specifications and designing the system architecture. Throughout the project, we engaged the GMBU management team at key decision and progress review points to ensure that we stayed on track to meet the project objectives.

The System Architecture

The first step in developing the system architecture was to establish what decisions and analyses the GMBU would address using the system. This determines the scope of the system and the level of

detail required. Working with the core team of experts and interacting with the management team, we established that the system should support the following decisions and analyses: (1) evaluation of portfolio strategic alternatives, (2) evaluation of various leasing alternatives and decisions on allocations to each year's lease sale, (3) risking and exploratory drilling decisions, such as deciding where to drill, establishing drilling priority, and determining how many rigs to have (*risking* is an industry term referring to the process of seismic imaging, analysis, and interpretation for the purpose of deciding whether a prospect should progress to the exploratory drilling stage), (4) evaluation of development options from a portfolio perspective, evaluation of different development configurations, and determining the timing for developing prospects, and (5) determining needed levels of resources, such as staff, rigs, and capital.

After establishing what decisions the system should support, we delineated the stages in an asset life cycle and the asset-specific decisions the system should include. We had several discussions on the work process in the organization and on asset stages. We decided to delineate stages in an asset life cycle according to the following criteria: (1) there is uncertainty about whether the asset will progress beyond that stage to a subsequent stage towards becoming a producing asset, and (2) the stage precedes a phase in the work process involving a major allocation of resources.

Figure 5 shows the different steps in the work process (at the bottom), a stage-to-

stage asset transition diagram (in the middle), and the set of key decisions in an asset life cycle (at the top). An asset starts out as a lead, with the end-success stage being a producing asset. The stages are lead, viable scoped lead, leased prospect, drill-worthy prospect, commercial discovery, and producing asset. Each of these stages, with the exception of the end-success stage, is the requisite stage for the asset to be in before we can exercise the next decision. That is, if an asset is a lead, then if management decides to scope it and it successfully passes the scoping phase, it gets to be a viable scoped lead. Once an asset is deemed a viable scoped lead, management can decide to bid on the asset, and if the lease is awarded, the asset becomes a leased prospect, and so on. At any stage, given that we decide the asset should progress, there is a probability for the asset to make a successful transition to the next stage. We numbered the stages from lead (0) to commercial discovery (4). The probability that an asset completes the scoping phase and becomes a viable scoped lead is thus P_{0-1} and so forth.

Asset Evaluation and Calculation of Resource Requirements

The value of an asset is determined using the summation of discounted projected cash flows related to the asset across its life cycle weighted with the respective probabilities of occurrence for these cash flows. (The risk attitude of the organization with respect to the portfolio decisions under discussion is that of a risk-neutral decision maker.) If the asset is a producing asset, then it is in its end-success stage and its value is a function of the projected pro-

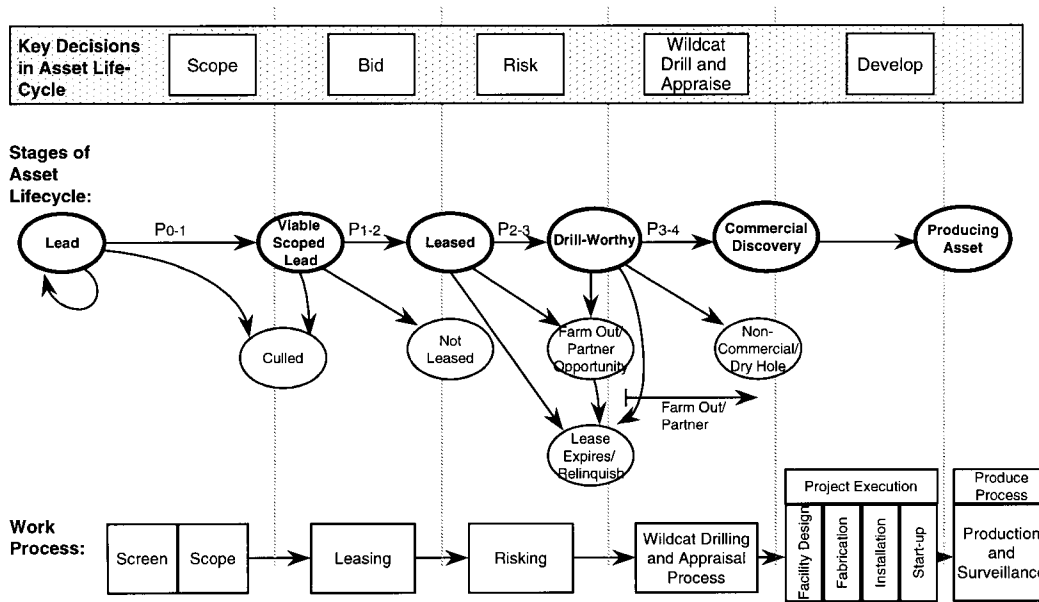


Figure 5: In this mapping of the stages and decisions in the asset life cycle built into the system to the organization's work process, the top part of the figure shows the key decisions in the asset life cycle. The middle part shows a stage-to-stage asset-transition diagram. The asset stages marked with a bold border are the requisite stages for the asset to be in before management can exercise the next decision. The bottom part of the figure shows the organization's work process.

duction volumes and the uncertainties related to its cash flows, such as oil and gas prices, operating expense variables, and required future capital expenditures. To evaluate an asset in an earlier stage, we take into account the timing of the next decision and any subsequent decisions, the probabilities of its making a successful transition to subsequent stages, and the cash flow implications of resources allocated in each decision. Essentially, this is rolling back the tree corresponding to the stage-to-stage asset transition diagram. Regarding resource allocations, if an asset is in a specific stage, such as Stage 2 (leased prospect), then once the decision is made to move the asset to the next stage, the resources required for risking are allocated with certainty. However, the probability

for the asset to successfully complete the risking phase is P_{2-3} , and we use this probability to calculate the resources required to move it beyond Stage 3.

System Logic and Flow for System Calculations

We decided to build an open-loop decision support system, as opposed to a closed-loop optimizing system. That is, for a specific portfolio plan, the system calculates the financial measures and the resource requirements. The system also provides the displays and reports to enable management to ensure the plan's feasibility and to further optimize the company's or business unit's allocation of resources within the portfolio. Thus, the system does not automatically solve for "the optimal" portfolio plan given a set of assets and a

specified level of available resources (as would a closed-loop system). The main reasons for opting for an open-loop decision support system architecture over a closed-loop self-optimizing system are the following: (1) a decision support system is more transparent and engages the expertise of the users and decision makers to a greater extent and (2) the calculation complexity in the case of a self-optimizing system would be significantly higher, thus having serious implications on run time and the overall process of portfolio analysis and management.

The core of the system consists of three input sheets (general inputs, plan inputs, and asset inputs), a sheet for processing these inputs prior to evaluation, and an evaluation section consisting of a production sheet and an economic evaluation sheet (Figure 6).

The general inputs sheet contains all the parameters that have a portfolio-wide impact, such as cost of capital, forecasts of oil and gas prices, cycle times for activities, parameters for resource use, and parameters for operating costs. For each input variable, the user specifies the 10th percentile, 50th percentile, and 90th percentile values (or time series, for a time series input) to enable range sensitivity analysis and subsequently portfolio probabilistic analysis.

The asset inputs sheet includes all asset-specific data and uncertainties, such inputs as water depth, depth to objective, lease expiry date, reserves (10th, 50th, and 90th percentiles of reserves by asset), gas-to-oil ratio, and stage-to-stage probabilities, entered by asset in a database type of structure. This sheet contains all that the com-

pany knows about the assets (including ranges on uncertain parameters).

The plan inputs sheet contains the decisions for the assets in the portfolio described in the asset inputs sheet, such as working interest, operatorship, asset activity timing decisions (scoping, bidding, risking, exploratory drilling, development start date, and so forth), and the development system type and configuration, entered by asset in a data structure parallel to that in the asset inputs sheet.

The calculated plan sheet processes the decision inputs specified in the plan input sheet using parameters from the general inputs sheet (such as cycle time parameters) and the asset inputs sheet (such as stage-to-stage probabilities); mainly, it prepares the portfolio plan for calculating asset yearly production and for economic evaluation.

The evaluation sheets are the production sheet and the economic evaluation sheet. The first calculates the constrained production for oil and gas by asset after determining the constraining fluid (whether oil or gas) at each hub and accounting for the production priority specified in the plan input sheet. The second performs the economic evaluation and calculates resource requirements and financial measures for each asset and for the whole portfolio.

Additional Notes on the System

Architecture

By including the key downstream decisions in the asset life cycle and accounting for the interdependence between an asset and other assets in the portfolio, the system captures most of the strategic flexibility for any specific asset. We have con-

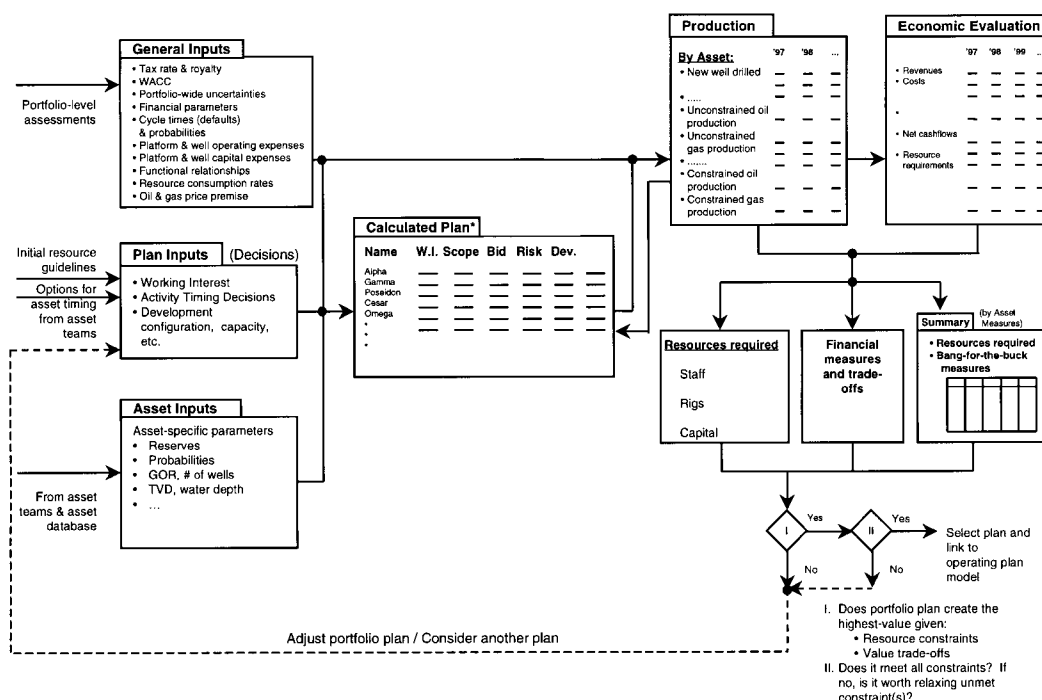


Figure 6: The core of the system consists of three input sheets (general inputs, plan inputs, asset inputs), a sheet for processing those inputs (calculated plan sheet), and an evaluation section consisting of a production sheet and an economic evaluation sheet. The system also includes several modules designed for conducting tailored analyses. These modules access the different sheets shown above to run specific analyses and produce reports.

sciously excluded the modeling of some of the additional operational flexibility available in a single project that enables managers to later make or revise operational decisions within any phase. Trigeorgis and Mason [1987] discuss the distinction between strategic flexibility and operational flexibility. For example, the system provides the strategic flexibility of deciding when to start the development phase of a specific asset, given that it successfully makes the transition to stage 4, down to the fraction of a year (Figure 5). The system then takes the specified number of production wells for that asset and determines their timing from the development start date for the asset using an algorithm

assessed from experts in the organization accounting for drilling and completion time cycles and the availability of capacity at the supporting hub. The system includes an optimizing algorithm that delays the start of development based on when capacity becomes available at the supporting hub and the asset's priority among the assets tied to that hub. However, the system does not [easily] allow the user to specify the timing of each production well in an asset. Managers will eventually exercise this flexibility; however, it is not modeled in the system. This additional operational flexibility is valuable and is better modeled and calculated using a dedicated system, which our cli-

ents have. Attempting to account for the full operational flexibility in a portfolio management system designed to handle portfolios of hundreds of assets would dilute the focus of the system and the portfolio management process, increase run time, and potentially lead to failure.

The issue of detailed budgeting is important for assets that are in or close to production. For such assets, we added the capability within the system to download the line items for the different measures for such assets from a dedicated model that is used for detailed evaluation of one asset at a time. The user still has to enter such an asset, let's call it Sierra, in the portfolio management system and specify a minimum number of parameters required for evaluating other assets that might be tied to this asset Sierra. The details behind all this are outside the intended scope of this article. The main idea is that we allowed the user the flexibility of downloading and using the results of a dedicated single-asset model for the cases where this was deemed necessary.

The System Format

The system is a Microsoft Excel application with pull-down menus for accessing the different parts of the system and for running various tailored portfolio analyses. To further integrate the system with existing applications within the organization, we included in the system an input module that interfaced with a database application used for storing asset-specific data. Because of the system's modularity, the user can tailor the size of the system to the size of the portfolio being analyzed. Our clients have used it for analyzing a business unit portfolio of about 350 assets

and for analyzing a regional portfolio (or asset team portfolio) of less than 20 assets. The core part of the system contains a number of detailed output modules that show such measures as resource requirement and availability and by-asset bang-for-the-buck measures to facilitate portfolio management.

The system is easily linked to software packages for conducting deterministic sensitivity analysis, probabilistic analysis, and decision analysis. While the discussion here has focused on the expected value of a plan or the expected level of resource requirements, the user can easily obtain the full probabilistic distribution of any value measure or resource requirement.

Using the System as a Decision-Support Tool: Main Benefits and Features

The system architecture provides the user with the inputs and decision levers necessary to manage a specific portfolio of assets given the interdependencies that exist among them. The set of decision levers available to the user, by asset, are asset-activity-timing decisions, ownership structure and operatorship decisions, and development configuration decisions. Asset-activity-timing decisions include when to scope, bid on, lease, risk, drill, develop, or start producing a specific asset. Ownership-structure and operatorship decisions include what working interest to have in each asset and whether to operate the asset or hand it over to another operator. Development-configuration decisions include what type of development to use for a specific asset; the user can specify whether the asset is a hub (and choose among a set of hub configurations) or a subsea tied back to another hub (the term

subsea refers to a subsea development for the production wells of a producing field). These decisions have significant implications for the capital requirements and other resources needed as well as for the production profile of the asset.

The settings of these decisions across all assets in the portfolio constitute a specific portfolio plan. For each portfolio plan, the system calculates the financial measures (line items leading to yearly cash flows, net present value, and so on) and determines resource requirements for executing that specific plan. The interdependencies among assets include informational interdependencies as well as physical or operational interdependencies. For assets in mature areas, physical or operational interdependencies tend to be the important factors in improving the performance of the portfolio. Examples are subsea developments sharing the same hub and production-capacity considerations, and competition for and the sharing of resources (technical staff, capital and so forth). In frontier areas, informational interdependencies and asset-reserve uncertainties are important factors in managing a portfolio of prospects and leads. As a business-unit portfolio becomes populated with more and more mature assets, the impact of physical and operational parameters on the value of the portfolio increases accordingly.

The system supports a decision-focused iterative process for managing a portfolio of assets (Figure 7). The user starts by specifying a portfolio plan and an initial level of available resources and then uses the output of the system to increase the value of the portfolio by modifying the

plan or changing the levels of resources.

Tracking the Use of Resources

At the first level, the portfolio management system tracks various financial measures and expected resource requirements for each portfolio plan analyzed and compares the requirement levels to resource availability (Figure 8). The portfolio system provides displays for a number of resources, including rigs of different generations (capabilities), technical staff resources (different categories), and project execution staff resources. The user can then determine the value of relaxing the constraints or the sequence of plan modifications needed to meet the constraints while maximizing a specific measure. The system provides several measures and displays to help users modify a plan to meet specific constraints in an optimal (or close-to-optimal) manner (Figure 9).

Resource Allocation and Bang-for-the-Buck Measures

The portfolio-management system helps managers faced with resource constraints to compare investment opportunities and to allocate resources among assets in the portfolio. To improve the performance of the whole portfolio, they can use bang-for-the-buck measures to compare assets within a specific stage in the asset life cycle. Examples of bang-for-the-buck measures are the ratio of expected net present value (NPV) to expected development capital expenditures required, the ratio of expected NPV to expected drilling resources required, and the ratio of expected NPV to expected requirements for technical staff in person-years. The objective is to ensure that a certain resource is used most efficiently across assets in the same stage;

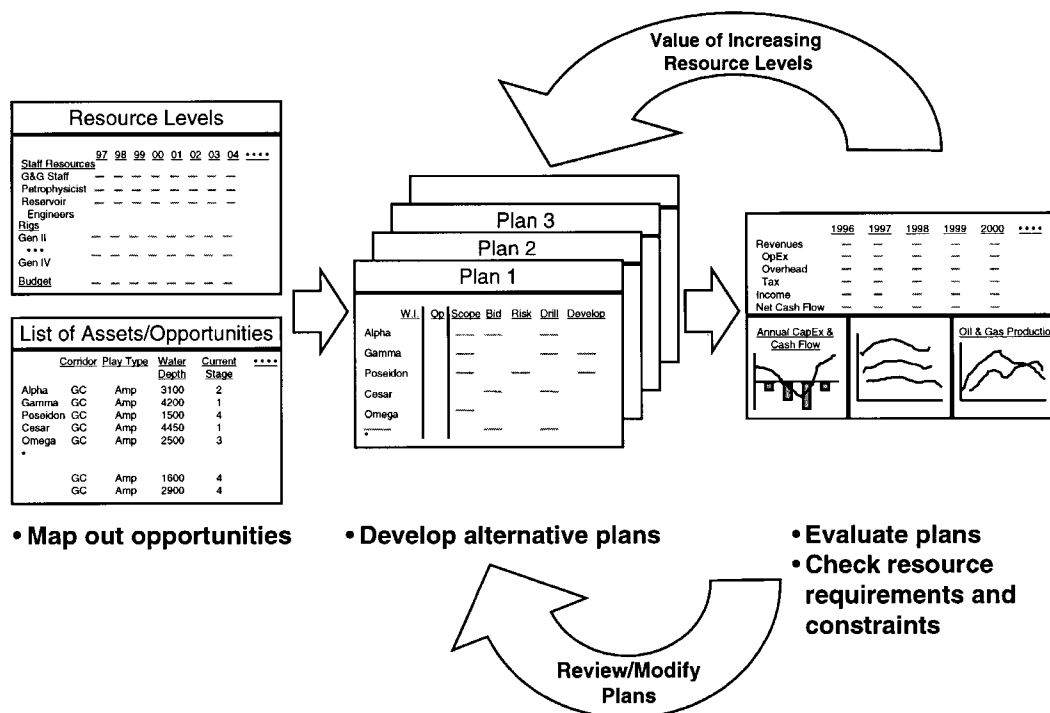


Figure 7: The portfolio-management system supports an iterative portfolio management process. The user starts by specifying a portfolio plan and an initial level of available resources and then uses the output of the system to increase the value of the portfolio by modifying the plan or changing the levels of resources.

the system compares these assets using a bang-for-the-buck ratio with the resource requirement by asset in the denominator.

In using bang-for-the-buck ratios, we must compare assets that are in the same stage in the asset life cycle. These are only ratios and not the ultimate value measures that we are seeking to maximize for the whole portfolio. If we compared an asset early in its life cycle (such as a lead) with one in a late stage (such as a discovery undergoing development), the total resource requirements for the first asset to reach the producing stage (given that it successfully moves through the requisite stages) would be much greater than those needed for the second. In addition, most of the resources

required for an asset close to production have been spent, that is, are sunk costs and are not included in the analysis.

After determining bang-for-the-buck measures for the set of assets in a specific stage, we can plot them from highest to lowest (Figure 10). In some cases, because of a physical interdependency, the company cannot pursue a high bang-for-the-buck asset (such as Gamma in this example) without pursuing another asset that has a measure below the intended cutoff point (such as Zeus). In such cases, the decision maker would look at the bang-for-the-buck measure for the combination to make a call. If the user inadvertently tries to exclude Zeus from the plan, the system

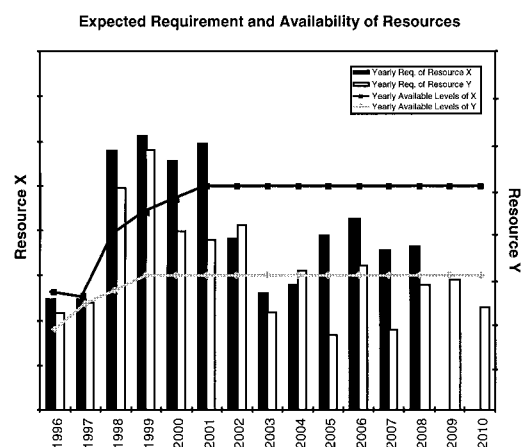


Figure 8: The portfolio management system tracks expected yearly resource requirements for a specific team's portfolio plan and identifies changes needed to ensure its feasibility. This shows the resource requirements of two resources, X and Y, calculated for a specific unconstrained portfolio plan and compares the resource requirements to their projected levels of availability.

will warn her that asset Gamma is tied to Zeus. The user can then look for another hub to support Gamma and exclude Zeus from the plan, analyze the alternative of excluding Gamma and Zeus from the plan, or analyze other plans that would include both assets and then make a decision.

With multiple resource constraints, the decision maker must consider displays for the different resource constraints. Because use of resources shows some correlation, a decision maker rarely needs to use more than two such displays at a time.

Identifying Key Value Drivers and Quantifying Their Effects at the Portfolio Level

Managers often debate issues and specific uncertainties without any systematic way to quantify their effects on their business and distinguish the key value drivers

requiring management's attention. For example, in a given discussion, a management team may touch upon the increasing competition in the industry, the uncertainty on the reserves of a specific asset, the increase in a certain operating-cost parameter, and other issues. In the absence of a method for quantifying the effects of such issues and uncertainties, these discussions usually end and resurface without contributing any quality to the decision-making process. The purpose of a range sensitivity analysis is to help management identify the key value drivers in the business and provide insight for further analysis and decision making.

The portfolio-management system enables the user to conduct range sensitivity analyses (tornado analyses) on any set of portfolio-wide and asset-specific variables. For each variable, the user specifies a base value (usually the 50th percentile), a low value (the 10th percentile), and a high value (the 90th percentile). For time-series inputs, such as yearly forecast oil prices, the low (base, high) would be a series of yearly prices that designated experts forecast as low (base, high) (the 10th, 50th, 90th percentile scenarios). For a specific portfolio plan, the system calculates the base-case value using user-specified base values for all the inputs entering the evaluation of that plan. Then, taking one variable at a time, a system module changes its value from base to low, and then to high, and calculates the resulting swing in the value of the plan. Sorting these swings across variables from highest to lowest and plotting them produces a tornado diagram (Figure 11).

The range-sensitivity analyses focuses

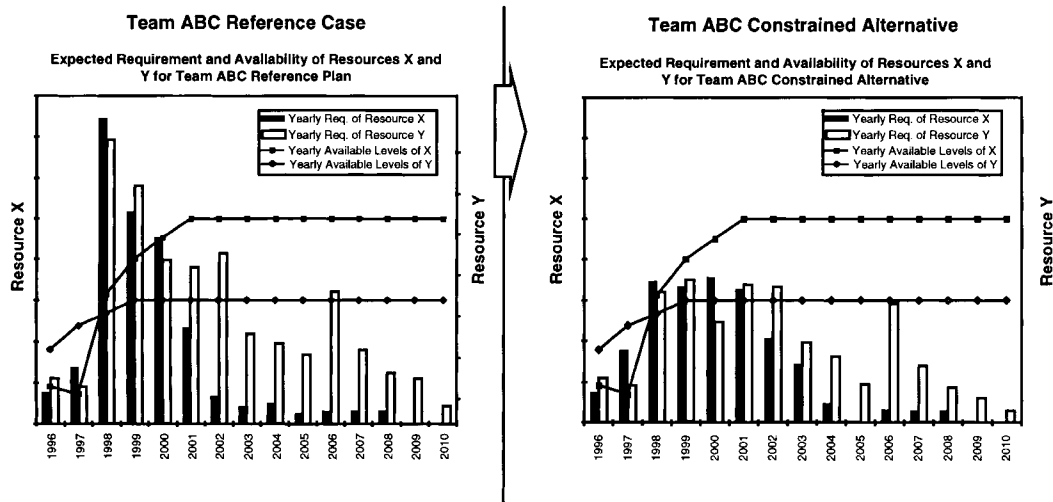


Figure 9: Using the system displays, the user can develop an alternative plan to meet certain constraints on the availability of resources.

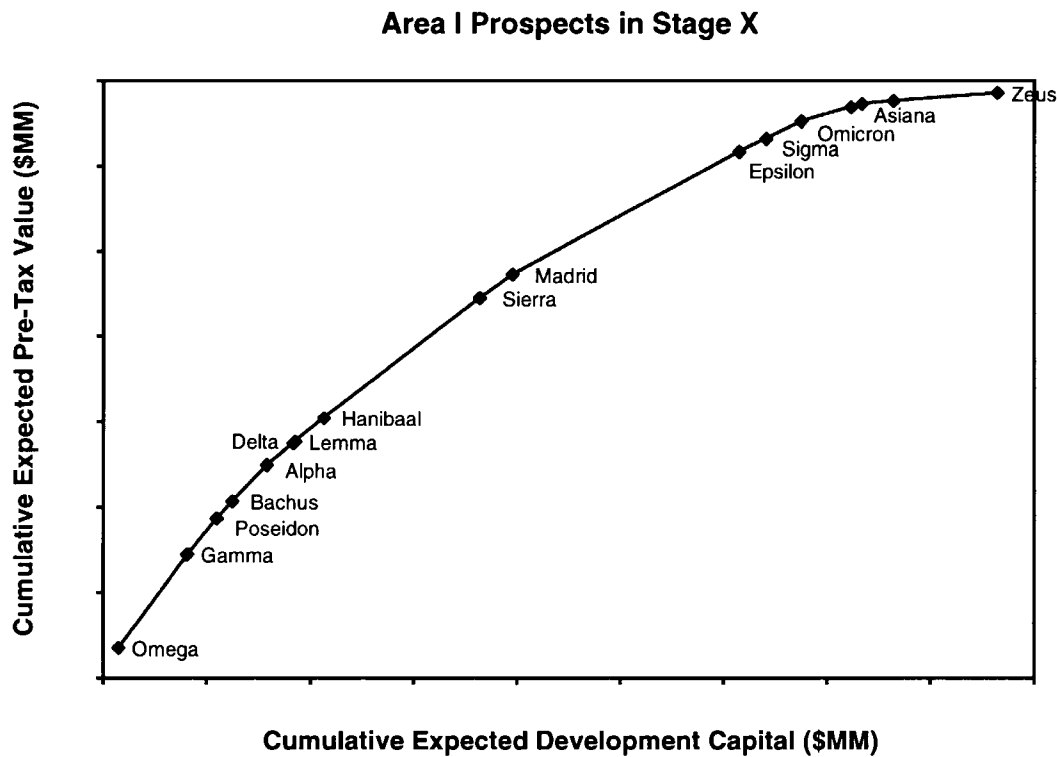


Figure 10: As an illustration of the use of bang-for-the-buck measures, in this plot, the system ranks assets within the same stage in the asset life cycle by the ratio of pretax value to required development capital. For a budget constraint on development capital available for Area I prospects in Stage X, decision makers can use the system to decide which assets to fund.

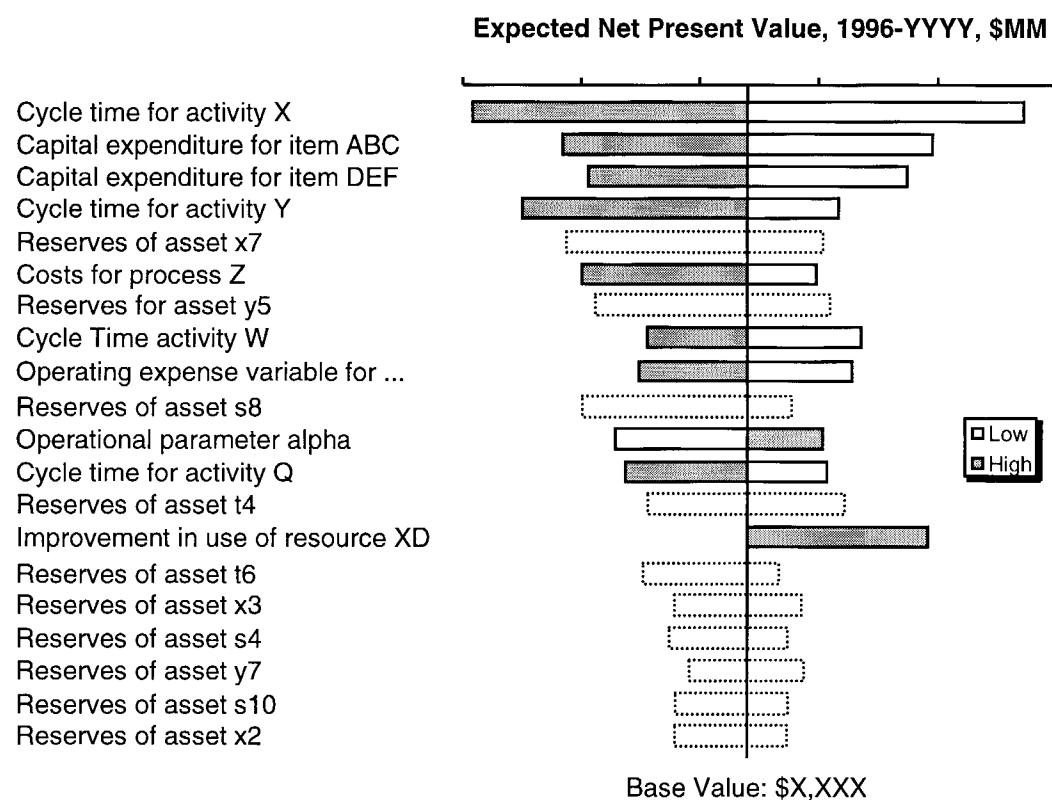


Figure 11: A tornado diagram shows the range sensitivity analysis results for a specific portfolio plan. All variable names have been disguised and all absolute numeric values have been removed to maintain confidentiality. Dotted bars indicate swings resulting from ranges on reserves of specific assets. The variations in plan value due to oil and gas price fluctuations have been omitted from the tornado for the purpose of this discussion.

managers' attention on the few variables that drive most of the variation in portfolio value. The top six to eight variables account for a great portion of the variation in that portfolio plan's value (Figure 11). The variation in the portfolio plan's value from uncertainty on an asset's reserves (such as asset x7, the fifth bar on the tornado in Figure 11) is generally smaller than the variation from other operational and cost-related variables. This becomes clearer as we realize that several of these operational or cost-related parameters have a portfolio-wide effect, whereas un-

certainities on asset reserves are predominantly asset-specific. By focusing on some of the top variables in the tornado, which are operational, the management team of that portfolio has an opportunity to create additional value comparable to that created by adding a large discovery to the portfolio.

Value of Technology Investments

To determine the value of investing in a particular technology, the user or facilitator must first obtain assessments from a designated expert regarding the different degrees of technical success of that tech-

nology. Then for each of these degrees, the user or facilitator must determine what system parameters will change and assess their new values. A breakthrough resulting from an investment in technology may cause any of the following changes in system parameters: a reduction in the cycle time of an activity, an increase in the probability that an asset will make the transition from one stage to another (for example, due to improved imaging or interpretation technology), a reduction in a capital-cost parameter, an improvement in the production rates of a certain class of structures, and so forth. The user can then determine the value of the portfolio corresponding to each degree of technical success. For a technology that has a significant effect on the portfolio, the optimized portfolio plan corresponding to a specific degree of technical success may be different from that corresponding to another degree of success (one of these degrees would represent the failure of the technology). Weighting these values by the probability of each degree of technical success, the user is able to determine the value of the portfolio with the technology investment. To compute the value of the technology, the user would increase the cost of the technology up to the point of indifference between investing in the technology and not investing.

Developing and Evaluating Different Business Unit Portfolio Strategies

To a great extent, the portfolio management system has facilitated the process of developing and evaluating alternative business-unit-portfolio strategies. A large business unit would include several asset teams, each managing its own portfolio of

assets. Some teams may be regionally based, others may focus on assets with certain characteristics, and others may focus on a single large asset and its surrounding area. From the business-unit-portfolio perspective, each team constitutes an aggregate decision area. Working with these asset teams, we facilitate the development of team-strategy alternatives, which become the building blocks of alternative strategies for the whole business-unit portfolio (Figure 12).

The set of all decision areas spanning the scope of decisions the business unit is to address forms what we call a strategy table [Howard 1988]. These include team-specific and non-team-specific decision areas. The latter include such decision areas as technology-investment decisions, portfolio-level acquisition decisions, and business-unit-level supplier decisions. Under each decision area is a set of choices. Managers develop a business-unit strategic alternative by stringing a path across the strategy table, selecting choices across the decision areas that support a specific strategic theme.

For asset-team decision areas, each strategic choice corresponds to a specific asset plan that is entered into the portfolio management system. A dedicated module in the system then allows the user to store and retrieve alternative plans under each decision area to form the whole business-unit portfolio. As previously discussed, the architecture of the system, through its database structure, allows this scaling up in the size of the portfolio plan. From the evaluation side, the system treats a large business unit portfolio plan in the same manner as a small team plan. Specific

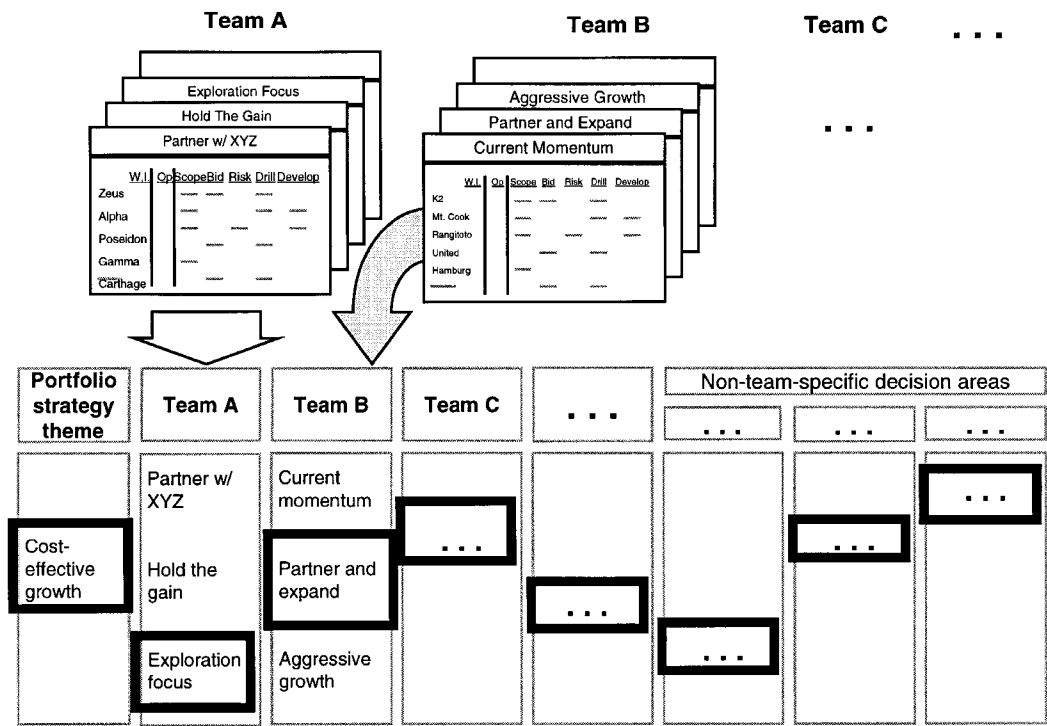


Figure 12: A strategy table consists of the various decision areas in an organization, with different creative yet doable choices under each area. A specific strategy theme consists of a coherent set of choices across the decision areas. This is illustrated here using an example of a business unit portfolio strategic alternative, under the theme “cost-effective growth,” with a specific path across the decision areas in the table.

modules for the analysis of a large business unit portfolio allow the user to mine for more insight by comparing the evaluation of different portfolio-strategy alternatives.

The Portfolio Management Process

We designed an overall portfolio management process that would provide a forum for decision-focused dialogues between senior management and asset teams. The portfolio management system supports the process and provides the analytical evaluation necessary to facilitate decisions regarding resource allocation and asset-portfolio strategy.

The GMBU formed a portfolio manage-

ment core team under the leadership of a portfolio advisor to serve as the facilitator and keeper of the process. The portfolio advisor, a senior geophysicist with extensive experience in decision analysis, finance, and overall project management, had a full-time commitment to the portfolio management process. The team included a reservoir engineer and a financial analyst (both at half-time commitment) and a business and information analyst with a full-time commitment.

The portfolio advisor and the SDG team jointly led the system design and development phase. During the initial design phase of the system, we developed an un-

derstanding of the existing portfolio management process and worked on drafting a new process that would engage the various stakeholders in the organization while benefiting from the capabilities of the system. We further tailored the process to the needs of the organization after running a pilot version of the system.

In the new process, the portfolio management core team, led by the portfolio advisor, facilitates the decision-focused dialogue between the decision team (mainly senior managers) and the asset teams (Figure 13). The process of developing a portfolio strategy starts with a peer review of the current asset plan and an understanding of the business challenges to be addressed in developing a strategy and ends with an alignment on the selected portfolio strategy. In the joint decision-review meetings that bring together senior man-

agers and asset team leaders to review the progress made to a specific stage in the process, senior managers contribute to the quality of the portfolio decisions early in the strategy process instead of waiting until the end and trying to inspect quality into the proposed plans.

After the asset teams perform a peer review of the asset base plans and assessments to ensure consistency in the assessments of volumes and probabilities, the portfolio-management core team conducts a preliminary diagnostic analysis of the portfolio base plan. A meeting is then held to present the results of the diagnostic analysis to the decision team and elicit challenges to be addressed in the portfolio strategy. The portfolio-management core team then works with the asset teams to develop team-level alternatives and conduct preliminary evaluations of these al-

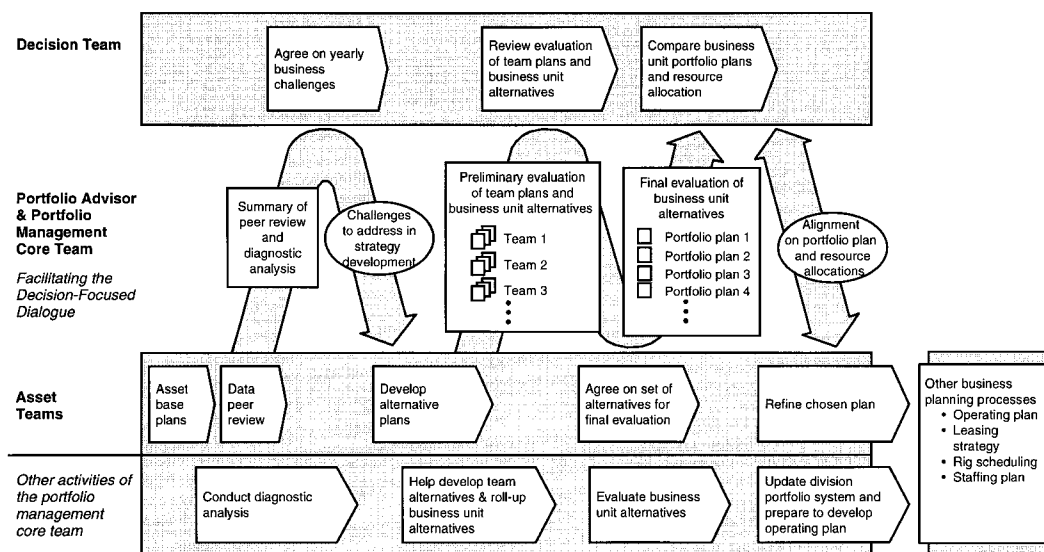


Figure 13: The process of developing a portfolio strategy starts with a peer review of the current asset plan and an understanding of the business challenges to be addressed and ends with an alignment on the selected portfolio strategy. The arrows in the diagram represent the joint decision-review meetings that bring together senior managers and asset team leaders to review the progress made to a specific stage in the process.

ternatives. The decision team and the asset-team leaders meet to review the preliminary evaluation of team-level alternatives and develop portfolio strategic alternatives. Thus, the expertise of senior managers on the decision team is engaged to a great extent through this development of portfolio strategic alternatives. After reaching agreement on the set of portfolio strategy alternatives to be fully evaluated, the portfolio-management core team conducts the analyses while working again with asset teams. Evaluating the portfolio-strategy alternatives may take several iterations. Often, insights gained in the evaluation process help teams to adjust their plans (each plan being a choice in that team's decision area, that is, a building block of the portfolio alternatives). Finally, the decision-team members and the asset-team leaders meet to review the results of the final phase of evaluation and to decide on the portfolio strategy and resource allocations. Based on the alignment they achieve, the asset teams work on refining the chosen plan and preparing for implementation.

The company has implemented this portfolio-management process and is currently using it as part of the business unit's decision-making process. The portfolio-management core team and SDG worked together to train users designated by each asset team to use the system and to update asset data and plans. These people work on portfolio management while interfacing with the different stakeholders in the organization, gaining experience in both process and content that they retain and transfer back to the asset teams. Portfolio management is thus becoming a core

competence of the organization.

Organizational Impact

The portfolio-management process has enabled the organization to establish a systematic approach to developing its business-unit strategy. In the past, the ad hoc process favored the asset-team leader with either the strongest arguments or the most optimistic asset plan. Now the organization has a process that engages asset teams and senior management from day one in identifying the best portfolio strategy for the business unit. Peer reviews ensure consistency in asset-specific data (such as reserve distributions and stage-to-stage transition probabilities) early in the process. As a result, once the process gets to the review of evaluated business unit alternatives, people have confidence in the quality of the inputs and the consistency across team data, and can focus on deriving insights from the analysis and improving the set of alternatives. The shared understanding of the value implications of the different alternatives builds commitment to action behind the selected strategy.

The portfolio-management process and system helped reduce the time for developing regional strategies and business unit portfolio strategies. This is largely because the integration of the process and system with the organization's business processes has led to keeping the system up to date almost continuously. For instance, the portfolio-management core team is now able to work with a large asset team and facilitate the development of a regional strategy in about two to three weeks (assuming that most of the technical and asset-specific data is available within the

first week of the effort). Without the portfolio-management process and system, an effort of this size formerly took three to five months. Without the portfolio process and system, the facilitator and analyst team would have conducted many more assessments. They also would have had to design, build, and debug a new dedicated model for the effort. The power of a process that is integrated into the organization's business processes cannot be overemphasized.

The portfolio-management process and system have also enabled the organization to examine any investment decision or urgent acquisition opportunity from an overall portfolio perspective. This has affected the way the asset teams work and encouraged asset-team leaders to consult with the portfolio advisor (the leader of the portfolio management core team). By tracking resource requirements for any portfolio plan, the process and system also help management ensure implementation success for any strategic move the organization undertakes.

The value added from strategic alternatives developed using the process and system is in the hundreds of millions of dollars. The process and system just support the decision dialogue among asset teams, senior management, and the portfolio management core team. The insights that lead to identifying sources of value and building up to the selected business unit portfolio strategy come from the participants in the process. The process and system are only enablers that reduce organizational barriers and analytical barriers to this dialogue and provide the essential performance measures to guide the devel-

opment of the portfolio strategy.

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