

TOTAL ASSET MODELING WITH INTEGRATED ASSET MODELS AND PERSISTENT ASSET MODELS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application and U.S. Patent Application Serial No. PCT/US14/18038, which is incorporated by reference, are commonly assigned to Landmark Graphics Corporation.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] Not applicable.

FIELD OF THE DISCLOSURE

[0003] The present disclosure generally relates to systems and methods for total asset modeling with integrated asset models and persistent asset models. More particularly, the present disclosure relates to total asset modeling by updating a preexisting integrated asset model in the form of a unique type model during different stages of an asset lifecycle to identify and evaluate a new asset during the asset lifecycle.

BACKGROUND

[0004] Managing the full lifecycle of an oil and gas field asset (hereinafter “asset”) involves making decisions concerning the project (e.g. development of all components required to produce oil and/or gas from the asset) based on limited information to more information that corresponds with high uncertainty to lower uncertainty, respectively. These decisions occur at key stages of the asset lifecycle and have the potential to influence the value of the asset. The potential impact of early and then successive decisions can either increase or decrease the value of the asset. It is therefore, important that these decisions are optimized over the lifecycle of the

asset as soon as possible when new information is discovered that allows a significant reduction of uncertainty and a measurable improvement in the financial outcome of a decision.

[0005] It is well understood that a conventional integrated-asset-model (IAM), which is illustrated in **FIG. 6** and models the asset from the bottom of the reservoir to a surface facility, must be updated to reflect current reservoir, well, and surface facility conditions; otherwise, it loses its value. Each IAM may include a reservoir model, well models, surface facility models and economic models. Equally important for asset owners is maintenance of their models over time, which is commonly referred to as a persistent asset model (PAM) and is illustrated in **FIG. 7**. The conventional approach to PAM, using disjoint models created at different stages of an asset's lifecycle, is a time-consuming, piecemeal strategy that produces less accurate results. Furthermore, integration of the IAM and PAM remains a goal that has still not been reached by most operators. One reason maintenance of an IAM over time is difficult is that many different people from a variety of functional areas create models of an asset at different times for different purposes. These models are, evidently, quite different and often challenging to reconcile with one another. A related cause of difficulty in IAM lifecycle maintenance is the fact that different amounts and/or types of data are available at different stages in the lifecycle of an asset because information accrues over time allowing later (e.g. production) stage models to be more sophisticated than those created at the appraisal and development stages. Therefore, lifecycle maintenance of an IAM must involve reconciliation of varied descriptions of an asset, each containing successively greater amounts of data at finer levels of granularity as the asset progresses through the different stages of its development (e.g. acquire, evaluate, appraise,

select, define, execute, produce).

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present disclosure is described below with references to the accompanying drawings in which like elements are referenced with like reference numerals, and in which:

[0007] **FIG. 1** is a flow diagram illustrating one embodiment of a method for implementing the present disclosure.

[0008] **FIG. 2** is a flow diagram illustrating one embodiment of a method for performing step **102** in **FIG. 1**.

[0009] **FIG. 3** is a flow diagram illustrating one embodiment of a method for performing step **104** in **FIG. 1**.

[0010] **FIG. 4** is a flow diagram illustrating one embodiment of a method for performing step **106** in **FIG. 1**.

[0011] **FIG. 5** is a flow diagram illustrating one embodiment of a method for performing step **108** in **FIG. 1**.

[0012] **FIG. 6** is a schematic display illustrating a conventional integrated-asset-model.

[0013] **FIG. 7** is a schematic display illustrating a conventional persistent-asset-model.

[0014] **FIG. 8** is a block diagram illustrating one embodiment of a computer system for implementing the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] The present disclosure overcomes one or more deficiencies in the prior art by providing systems and methods for total asset modeling by updating a preexisting integrated asset model in the form of a unique type model during different stages of an asset lifecycle to

identify and evaluate a new asset during the asset lifecycle.

[0016] In one embodiment, the present disclosure includes executing a project for a potential asset target by total asset modeling, which comprises: a) selecting a best profitable engineering scenario for the potential asset target and an associated type model, wherein the type model includes one or more variables related to drilling operations and one or more variables related to a capital phase of the project; b) updating the type model using a computer processor by at least one of adjusting each variable for the type model according to currently available drilling operations data and capital phase information that is related to a respective adjusted variable and adding at least one of one or more variables related to drilling operations and one or more variables related to the capital phase of the project to the type model according to the currently available drilling operations data and capital phase information that is related to a respective added variable; c) refining the updated type model by adjusting each variable for the updated type model according to any additional drilling operations data and capital phase information that is related to a respective adjusted variable; d) updating a net present value for the best profitable engineering design scenario using the refined type model; e) determining whether to operate the potential asset target based on a comparison of a rank for the updated net present value and a corporate portfolio capital spending budget; and f) repeating steps a) – e) until the capital phase of the project is complete.

[0017] In another embodiment, the present disclosure includes a non-transitory program carrier device tangibly carrying computer-executable instructions for executing a project for a potential asset target by total asset modeling, the instructions being executable to implement: a)

selecting a best profitable engineering scenario for the potential asset target and an associated type model, wherein the type model includes one or more variables related to drilling operations and one or more variables related to a capital phase of the project; b) updating the type model by at least one of adjusting each variable for the type model according to currently available drilling operations data and capital phase information that is related to a respective adjusted variable and adding at least one of one or more variables related to drilling operations and one or more variables related to the capital phase of the project to the type model according to the currently available drilling operations data and capital phase information that is related to a respective added variable; c) refining the updated type model by adjusting each variable for the updated type model according to any additional drilling operations data and capital phase information that is related to a respective adjusted variable; d) updating a net present value for the best profitable engineering design scenario using the refined type model; e) determining whether to operate the potential asset target based on a comparison of a rank for the updated net present value and a corporate portfolio capital spending budget; and f) repeating steps a) – e) until the capital phase of the project is complete.

[0018] In yet another embodiment, the present disclosure includes a non-transitory program carrier device tangibly carrying computer executable instructions for executing a project for a potential asset target by total asset modeling, the instructions being executable to implement: a) selecting a best profitable engineering scenario for the potential asset target and an associated type model, wherein the type model includes one or more variables related to drilling operations, one or more variables related to a capital phase of the project and one or more

variables related to at least one of production data, well test data and production forecast data; b) updating the type model by at least one of adjusting each variable for the type model according to currently available drilling operations data and capital phase information that is related to a respective adjusted variable and adding at least one of one or more variables related to drilling operations and one or more variables related to the capital phase of the project to the type model according to the currently available drilling operations data and capital phase information that is related to a respective added variable; c) refining the updated type model by adjusting each variable for the updated type model according to any additional drilling operations data and capital phase information that is related to a respective adjusted variable; d) re-updating the refined type model by at least one of adjusting each variable for the refined type model according to currently available recovery operations data, which includes at least one of production data, well test data and production forecast data, that is related to a respective adjusted variable and adding at least one or more variables related to at least one of production data, well test data and production forecast data to the refined type model according to the currently available recovery operations data that is related to a respective added variable; e) updating a net present value for the best profitable engineering design scenario using the refined type model; f) determining whether to operate the potential asset target based on a comparison of a rank for the updated net present value and a corporate portfolio capital spending budget; and g) repeating steps a) – f) until the capital phase of the project is complete.

[0019] The subject matter of the present disclosure is described with specificity, however, the description itself is not intended to limit the scope of the disclosure. The subject

matter thus, might also be embodied in other ways, to include different steps or combinations of steps similar to the ones described herein, in conjunction with other present or future technologies. Moreover, although the term “step” may be used herein to describe different elements of methods employed, the term should not be interpreted as implying any particular order among or between various steps herein disclosed unless otherwise expressly limited by the description to a particular order. While the present disclosure may be applied in the oil and gas industry, it is not limited thereto and may also be applied in other industries to achieve similar results.

Method Description

[0020] Because major decisions regarding the identification of a new target asset at any stage, but particularly at the early stages, are primarily financial in nature rather than technical, a total asset model must include economic information. Likewise, optimization of field logistics, capture of organizational learning and knowledge transfer coupled with geological and geophysical models are additional aspects of a total asset model. Referring now to **FIG. 1**, a flow diagram of one embodiment of a method **100** for implementing the present disclosure is illustrated. The method **100** enables the identification and evaluation of a potential asset target through total asset modeling.

[0021] In step **101**, a potential asset target is identified using techniques well known in the art. The potential asset target preferably contains oil and/or gas deposits and may be a previously undiscovered asset, an asset under active exploration or development, a producing asset, or even a previously-abandoned asset. Assets that exist at early (e.g. acquisition) lifecycle stages must be studied in terms of the large-scale engineering concepts that can be used to develop them. For instance, an offshore asset might be produced through a variety of different platform designs, with compression facilities either on the platform or onshore, or using a Floating Production, Storage, and Offloading (FPSO) vessel. An onshore asset may include various stages of gas processing or fractionation, require the use of hydraulic fracturing with its associated infrastructure needs, or be designed for gas or water injection.

[0022] In step **102**, an initial list of potential conceptual engineering design scenarios for the potential asset target are evaluated to reduce the potential design scenarios in the list and

decide whether to select a single design scenario.

[0023] In step **104**, a single design scenario, which represents the potential asset target, is selected from the initial list of potential conceptual engineering design scenarios and is evaluated to determine whether to proceed to project execution for the potential asset target.

[0024] In step **106**, a project is executed for the potential asset target that includes procuring capital equipment and constructing facilities for the project and the potential asset target is evaluated based on the executed project to determine whether to begin production operations.

[0025] In step **108**, production operations are performed for the potential asset target and the potential asset target is evaluated based on the production operations to determine whether to maintain production operations.

[0026] Referring now to **FIG. 2**, a flow diagram illustrating one embodiment of a method **200** for performing step **102** in **FIG. 1** is illustrated. An initial list of potential conceptual engineering design scenarios for the potential asset target are evaluated to reduce the potential design scenarios in the list and decide whether to select a single design scenario.

[0027] In step **202**, a list of potential conceptual engineering design scenarios is manually generated for the potential asset target identified in step **101**, using the client interface and/or the video interface described further in reference to **FIG. 8**, based on the historical experience of the operating company and the judgment of individual engineers and executives. Decisions about large-scale conceptual engineering designs made at this stage of an asset lifecycle can save (or cost) billions of dollars in Net Present Value (NPV). In general, the largest

opportunities for increasing asset profitability occur at the earliest stages of the asset's life. As decisions are made, and large capital projects undertaken, technical and financial options become increasingly constrained.

[0028] In step **204**, a unique type model from a library is associated with each potential conceptual engineering design scenario from step **202**. The library includes templates that can be used to evaluate common conceptual engineering designs. Each template includes an IAM, which provides a consolidated technical description of the reservoir, wellbores, and surface production facilities associated with the potential asset target. Each template also includes baseline financial and economic data associated with the potential asset target and facilities, as well as estimates for the uncertainties associated with all variables to which the project's ultimate objective (typically either NPV or total produced hydrocarbons) are sensitive. Because the templates allow performance of a new potential asset target to be readily estimated using the "typical" performance of similar existing assets—much as production type curves do for individual oil and gas wells—the templates are called type models. One type model is included in the library for each asset/scenario pair. By using type models, unfeasible or uneconomic designs can be eliminated quickly and reliably at the earliest stages of evaluation.

[0029] In step **206**, an initial technical feasibility analysis is performed on each potential conceptual engineering design scenario from step **202**, using the client interface and/or the video interface described further in reference to **FIG. 8**, by adjusting sensitive variables in the type model associated with each respective scenario using techniques well known in the art and any historical data, corporate best practices, assumptions or engineering rules of thumb.

[0030] In step **208**, each type model from step **204** is automatically updated with all of the latest (most current) exploration, laboratory (e.g. core or fluid sample), simulation results, oil price forecast and macroeconomic data related to each respective type model or may be manually updated using the client interface and/or the video interface described further in reference to **FIG. 8**. The data is used as input for variables in each type model that have a measurable impact on the performance of the type model.

[0031] In step **210**, each updated type model from step **208** is refined using the initial technical feasibility analysis performed on each scenario in step **206** by tuning the performance of each updated type model and performing a sensitivity analysis on each updated type model. Performance tuning may involve further adjustments to sensitive variables in each updated type model. Performance tuning can be performed automatically or manually using the client interface and/or the video interface described further in reference to **FIG. 8**, which can be assisted by expert systems, which are pre-programmed to include known relationships among variables and best practice decision support. Once tuned, a sensitivity analysis can be performed on each updated type model manually using the client interface and/or the video interface described further in reference to **FIG. 8** or by using automation (e.g. scripting) technologies to illustrate the feasible ranges of variable combinations and the associated global performance of each updated type model under all feasible conditions.

[0032] In step **212**, each potential conceptual engineering design scenario from step **202** is evaluated and removed if it is not technically feasible after an updated technical feasibility analysis is performed on each scenario by adjusting sensitive variables in the refined type model

from step **210** associated with each respective scenario using techniques well known in the art and any historical data, corporate best practices, assumptions or engineering rules of thumb.

[0033] In step **214**, an NPV is calculated under each technically feasible scenario from step **212** for the potential asset target using techniques well known in the art and the most current oil/gas pricing and macroeconomic data, forecasts of hydrocarbon production and operating costs.

[0034] In step **218**, the known NPV for each corporate portfolio asset and the NPV for each technically feasible scenario calculated in step **214** are ranked (low to high or high to low). The ranked NPV's are sent to the list of project stakeholders who have requested updates.

[0035] In step **220**, each ranked technically feasible scenario from step **218** that is not economical is eliminated from further consideration. This enables the evaluation of different scenarios that are expected to maximize the overall profitability of a corporate portfolio over a given time horizon. In this context, technically feasible scenarios for a potential asset target may not be economical, even though they have a positive NPV, because some may not outrank the NPV of other corporate portfolio assets or some may conflict in terms of timing or overall capital spend with alternatives scheduled for a given year. The purpose of this step, then, is to ensure that decisions made for the potential asset target currently under consideration are consistent with plans being made at a higher corporate level based on other corporate portfolio assets.

[0036] In step **222**, the method **200** determines whether to acquire the potential asset target based on the remaining technically feasible, economical scenarios from step **220**. A decision at this stage of the method **100** does not finalize the conceptual engineering design for

the potential asset target, but rather expresses confidence (or skepticism) that a suitable design envelope exists within which to execute a profitable project that meets corporate investment criteria. If the decision is not to acquire the potential asset target, then the method **200** proceeds to step **224**. If the decision is to acquire the potential asset target, then the method **200** proceeds to step **226**.

[0037] In step **224**, concept evaluation for the project is terminated and the method **200** ends. Rights to explore and/or develop the potential asset target can be sold or the project can be reconsidered at a later date.

[0038] In step **226**, the potential asset target is acquired and all remaining technically feasible, economical scenarios from step **220** are returned to step **104** along with each respective refined type model from step **210**. Through the transfer of the refined type model for each respective technically feasible, economical scenario, the method **100** i) captures the expressed intent of earlier stakeholders in a later decision making context; ii) eliminates duplication of efforts; iii) reduces human error in transcription of data; and iv) allows the corporation to audit changes in modeling assumptions made at every stage of the potential asset target's life and to understand the financial impact of those changes immediately since the NPV of each technically feasible scenario can be automatically updated after every variable change.

[0039] Referring now to **FIG. 3**, a flow diagram illustrating one embodiment of a method **300** for performing step **104** in **FIG. 1** is illustrated. Once the potential asset target is acquired in step **226**, a single design scenario is selected from the remaining technically feasible, economical scenarios and is evaluated to determine whether to proceed to project execution for the potential

asset target. This represents a key milestone in the development of the potential asset target and is perhaps the best opportunity to maximize the overall value of the potential asset target.

[0040] In step **302**, the remaining technically feasible, economical scenarios from step **226** are reviewed using the client interface and/or the video interface described further in reference to **FIG. 8** and techniques well known in the art to confirm all major assumptions therein and to make any necessary modifications based on changes in the operational or financial environment that have taken place since the potential asset target was acquired.

[0041] In step **304**, a Front End Engineering Design (FEED) study is performed on each remaining technically feasible, economical scenario from step **302** using techniques well known in the art and the client interface and/or the video interface described further in reference to **FIG. 8**. The objective of this step is to clearly articulate the technical requirements for constructing each technically feasible, economical scenario and to estimate its total investment cost. The FEED studies may be used by Engineering, Procurement & Construction (EPC) contractors as the basis for bidding on the projects.

[0042] In step **306**, each refined type model from step **210**, associated with a respective technically feasible, economical scenario from step **302**, is automatically updated with all of the latest (most current) exploration, laboratory (e.g. core or fluid sample), simulation results, oil price forecast and macroeconomic data related to each respective type model or may be manually updated using the client interface and/or the video interface described further in reference to **FIG. 8**. The data is used as input for variables in each type model that have a measurable impact on the performance of the type model. It is important to realize that frequent updates to the type

models serve not only to inform current decision making exercises, but also can cast new light on prior decisions or alert previous decision makers to large deviations in expected technical or financial performance for the potential asset target. In this manner, all stakeholders - even those who are no longer currently engaged on work for the potential asset target - are provided a nearly instantaneous view of asset-level changes being driven by later decisions. This view is both an audit trail (for corporate continuous learning purposes) and a means for taking corrective action at the corporate portfolio level to ensure future profitability.

[0043] In step **308**, each updated type model from step **306** is automatically refined or may be manually refined in the same manner as step **210** using the client interface and/or the video interface described further in reference to **FIG. 8** and the FEED study from step **304** for each respective technically feasible, economical scenario from step **302**.

[0044] In step **310**, the NPV calculated in step **214** for each respective technically feasible, economical scenario from step **302** is updated using the refined type model from step **308** for each respective technically feasible, economical scenario from step **302**. If the updated NPV for a respective technically feasible, economical scenario from step **302** has changed beyond a threshold value, then send notifications to the list of project stakeholders who have requested updates.

[0045] In step **312**, a list of the most profitable, technically feasible, economical scenarios from step **302** are identified using a respective updated NPV from step **310** and techniques well known in the art. The list will be used by EPC contractors as the basis for bidding on the projects.

[0046] In step **316**, each profitable scenario identified on the list from step **312** is submitted to one or more EPC contractors and at least one bid is received for each scenario. Each bid should include technical, cost, and project timeline estimates.

[0047] In step **318**, each profitable scenario identified on the list from step **312** is evaluated and removed from the list using the client interface and/or the video interface described further in reference to **FIG. 8** if none of the respective bids from step **316** meet or exceed a predetermined acceptance criteria based on technical, cost, and project timeline requirements and/or goals. The objective of this step is to identify scenarios that, while potentially profitable, may fall outside the desired project completion window based on bids returned by the potential EPC contractors. A mismatch between timelines and expected cash flows may disqualify an otherwise attractive conceptual engineering design.

[0048] In step **320**, a best profitable scenario is selected from the profitable scenarios remaining on the list after step **318**, using the client interface and/or the video interface described further in reference to **FIG. 8**, based on the scenario and the respective bid that maximizes the overall project requirements, goals and/or constraints. The scenario will typically include, for consideration, NPV, but could also include total hydrocarbon production or some other measure while the respective bid includes, for consideration, the technical, cost and project timeline estimates.

[0049] In step **322**, the known NPV for each corporate portfolio asset and the updated NPV for the best profitable scenario from step **320** are ranked (low to high or high to low). The ranked NPV's are sent to the list of project stakeholders who have requested updates.

[0050] In step **324**, the method **300** determines whether to execute the project based on a comparison of the ranking in step **322** and the corporate portfolio capital spending budget. The project will be executed if the NPV rank for the best profitable scenario from step **320** falls above a line based on the capital spending budget. As an example, imagine that the best profitable scenario is ranked fifth and costs \$20 million. Further imagine that the capital spending budget is \$100 million. The four highest ranking corporate portfolio assets cost \$10, \$30, \$15, and \$40 million, leaving only \$5 million. If the decision is to execute the project, then the method **300** proceeds to step **328**. If the decision is not to execute the project, then the method **300** proceeds to step **326**.

[0051] In step **326**, design scenario selection for the project is terminated and the method **300** ends. Rights to explore and/or develop the potential asset target can be sold or the project can be reconsidered at a later date with or without additional investment partners to help allay expenses and share the risk.

[0052] In step **328**, the best profitable scenario from step **320**, the respective bid and the respective refined type model are accepted and returned to step **106** for project execution.

[0053] Referring now to **FIG. 4**, a flow diagram illustrating one embodiment of a method **400** for performing step **106** in **FIG. 1** is illustrated. A project is executed for the potential asset target that includes two parallel activity tracks: the capital engineering project (executed by the EPC contractor) to procure the capital equipment and build the facilities required for oil and gas production and transport (e.g. platforms, compression trains, pipelines), and the field development project (executed by oilfield service companies) to plan and drill wells and prepare

for the production and sale of hydrocarbons. The potential asset target is evaluated based on the executed project to determine whether to begin production operations. In other words, data from both activities is used to continuously update the type model because performance on both tracks directly influences NPV.

[0054] In step **401**, all capital equipment required to execute the project (e.g. that will support drilling, production, storage, and transport) are procured based on the best profitable scenario, the respective bid and the respective refined type model accepted in step **328**. Lead times for many of these items can be two years or more. This step may be performed in parallel with steps **408-416** and may pass related information to step **409**, during each iteration of step **409**, if such information has not already passed on to step **409**.

[0055] In step **403**, all facilities required to execute the project are constructed as equipment becomes available from step **401**. As well patterns are completed by the drilling operations in step **408**, wells will be connected to constructed gathering systems. This step may be performed in parallel with steps **408-416** and may pass related information to step **409**, during each iteration of step **409**, if such information has not already passed on to step **409**.

[0056] In step **405**, all facilities constructed at locations remote from the potential asset target (e.g. floating production vessels) are transported and installed at the well locations determined by the drilling operations in step **408**. Pipelines must be connected to onshore terminals and perhaps to subsea gathering or compression systems. Any change to the facilities due to this step must be reflected in the refined type model for the best profitable scenario accepted in step **328**. This step may be performed in parallel with steps **408-416** and may pass

related information to step 409, during each iteration of step 409, if such information has not already passed on to step 409.

[0057] In step 407, all facilities are prepared ("commissioned") for live operation by making final connections ("hook up") after the facilities are installed and all initial production and injection wells are completed by the drilling operations in step 408. This step may be performed in parallel with steps 408-416 and may pass related information to step 409, during each iteration of step 409, if such information has not already passed on to step 409.

[0058] In step 408, drilling operations begin according to the refined type model for the best profitable scenario accepted in step 328. Drilling is time intensive, particularly in deep-water offshore or arctic environments, and the number of available drilling rigs may be limited. The drilling operations anticipate having an expected number of wells ready to produce at the point the facilities are commissioned in step 407. Additionally, information from steps 403, 405 and 407, such as changes to the trajectory of pipelines or the sizing of pumps, may affect the well locations, the well patterns and the initial production/injection wells determined and completed by the drilling operations because the drilling operations for this step may persist through each step of the method 400.

[0059] In step 409, the refined type model for the best profitable scenario accepted in step 328 is automatically updated with i) all of the latest (most current) development, laboratory (e.g. core or fluid sample), simulation results, oil price forecast and macroeconomic data related to the refined type model accepted in step 328; ii) the drilling operations data (e.g. actual reservoir data from flowing wells) from step 408; and iii) information from the current capital

phase of the project represented by steps **401**, **403**, **405** and/or **407**, or may be manually updated using the client interface and/or the video interface described further in reference to **FIG. 8**. The data is used as input for variables in the refined type model that have a measurable impact on the performance of the refined type model.

[0060] In step **410**, the updated type model from step **409** is automatically refined or may be manually refined in the same manner as step **210** using the client interface and/or the video interface described further in reference to **FIG. 8**, any additional changes as a result of steps **405** and **407**, and the drilling operations data (e.g. actual reservoir data from flowing wells) from step **408**.

[0061] In step **412**, the NPV from step **310** for the best profitable scenario accepted in step **328** is updated using the refined type model from step **410**. If the updated NPV for the best profitable scenario accepted in step **328** has changed beyond a threshold value, then send notifications to the list of project stakeholders who have requested updates.

[0062] In step **414**, the known NPV for each corporate portfolio asset and the updated NPV for the best profitable scenario from step **412** are ranked (low to high or high to low). The ranked NPV's are sent to the list of project stakeholders who have requested updates.

[0063] In step **415**, the method **400** determines whether to operate the asset based on a comparison of the ranking in step **414** and the corporate portfolio capital spending budget. The project will be executed if the NPV rank for the best profitable scenario from step **412** falls above a line based on the capital spending budget. As an example, imagine that the best profitable scenario is ranked fifth and costs \$20 million. Further imagine that the capital

spending budget is \$100 million. The four highest ranking corporate portfolio assets cost \$10, \$30, \$15, and \$40 million, leaving only \$5 million. If the decision is to operate the asset, then the method **400** proceeds to step **416**. If the decision is not to execute the project, then the method **400** proceeds to step **418**.

[0064] In step **416**, the method **400** determines whether the capital phase of the project is complete based on whether step **407** is complete. If the capital phase of the project is not complete, then the method **400** returns to the current step in the capital phase of the project for current information, which is then passed on to the next iteration of step **409**. If the capital phase of the project is complete, then the method **400** proceeds to step **420**.

[0065] In step **418**, execution of the project is terminated and the method **400** ends. The entire potential asset target can be sold or a controlling interest can be sold to a partner or independent contractor that takes over production operations for the project.

[0066] In step **420**, the updated NPV from step **412** and refined type model from step **410** are returned to step **108** for production operations, and operating control of the commissioned facilities in step **407** is taken over from the EPC contractor.

[0067] Referring now to **FIG. 5**, a flow diagram illustrating one embodiment of a method **500** for performing step **108** in **FIG. 1** is illustrated. Production operations are performed for the potential asset target and the potential asset target is evaluated based on the production operations to determine whether to maintain production operations. Production operations includes recovery operations and entails working on the field development plan described by the type model, making day-to-day and week-to-week adjustments as necessary to respond to

unforeseen events such as equipment failures or deviations between projected and actual reservoir behavior, and devising strategies for maximizing long-term production as the asset matures.

[0068] In step **502**, primary oil/gas recovery operations are initiated for the potential asset target using the natural energy of the reservoir and the initial pattern of wells drilled during step **408**. This step may be performed in parallel with steps **510-527** and may pass related information to step **510**, during each iteration of step **510**, if such information has not already passed on to step **510**.

[0069] In step **504**, secondary oil/gas recovery operations are initiated for the potential asset target to increase production (e.g. further infill drilling, additional injection). This step may be performed in parallel with steps **510-527** and may pass related information to step **510**, during each iteration of step **510**, if such information has not already passed on to step **510**.

[0070] In step **506**, tertiary oil/gas recovery operations are initiated for the potential asset target to further increase production. Tertiary recovery operations will be technologically complex and expensive. The economic justification for them will become increasingly challenging as the potential asset target matures. This step may be performed in parallel with steps **510-527** and may pass related information to step **510**, during each iteration of step **510**, if such information has not already passed on to step **510**.

[0071] In step **508**, oil/gas recovery operations are initiated for the potential asset target to further increase production. Post-tertiary recovery operations will also be technologically complex and expensive. The economic justification for them will also become increasingly

challenging as the potential asset target matures. This step may be performed in parallel with steps **510-527** and may pass related information to step **510**, during each iteration of step **510**, if such information has not already passed on to step **510**.

[0072] In step **510**, the refined type model from step **410** is automatically updated with i) all of the latest (most current) development, laboratory (e.g. core or fluid sample), simulation results, oil price forecast and macroeconomic data related to the refined type model from step **410**; ii) production data from the recovery operations in steps **502, 504, 506** and/or **508**; iii) well test data from the recovery operations in steps **502, 504, 506** and/or **508**; and iv) production forecast data from the recovery operations in steps **502, 504, 506** and/or **508**, or may be manually updated using the client interface and/or the video interface described further in reference to **FIG. 8**. The data is used as input for variables in the refined type model that have a measurable impact on the performance of the refined type model.

[0073] In step **514**, the updated type model from step **510** is automatically refined or may be manually refined in the same manner as step **210** using the client interface and/or the video interface described further in reference to **FIG. 8** and i) all of the latest (most current) simulation results, oil price forecast and macroeconomic data related to the refined type model from step **410**; ii) production data from the recovery operations in steps **502, 504, 506** and/or **508**; iii) well test data from the recovery operations in steps **502, 504, 506** and/or **508**; and iv) production forecast data from the recovery operations in steps **502, 504, 506** and/or **508**.

[0074] In step **516**, the NPV from step **412** is updated using the refined type model from step **514**. If the updated NPV has changed beyond a threshold value, then send

notifications to the list of project stakeholders who have requested updates.

[0075] In step **518**, the known NPV for each corporate portfolio asset and the updated NPV from step **516** are ranked (low to high or high to low). The ranked NPV's are sent to the list of project stakeholders who have requested updates.

[0076] In step **527**, the method **500** determines whether there is any further economic potential from the recovery operations in steps **502**, **504**, **506** and/or **508** based on the rank of the updated NPV from step **518**. If there is further economic potential from the recovery operations in steps **502**, **504**, **506** and/or **508**, then the method **500** returns to the current step of the recovery operations for current information, which is then passed on to the next iteration of step **510**. If there is no further economic potential from the recovery operations in steps **502**, **504**, **506** and/or **508**, then the method **500** proceeds to step **532**.

[0077] In step **532**, production operations for the project are terminated and the method **500** ends. Rights to the potential asset target can be sold or the project can be abandoned.

[0078] The method **100** represents a total asset model that effectively couples the IAM and the PAM so that the IAM is maintained over the lifecycle of the potential asset target. In this manner, the following factors contributing to lost production value in most conventional models are addressed and mitigated: i) the asset's full potential may be initially compromised during field development planning and during the design process; ii) the asset may be further compromised during construction resulting in a sub-optimal installed potential; iii) at completion and commissioning and thereafter, key production wells, equipment and facilities may experience performance degradation; iv) due to inevitable down time or sub-optimal

maintenance planning, the production facilities actually available at a given period are often sub-optimal; v) throughout the daily, real time production cycle, equipment set points and operating parameters are frequently not consistent with the optimal value production profile; vi) unforeseen behaviors and events result in loss of production over and above the accepted operating envelope that informs production targets; and vii) historically increasing production without due regard to reservoir constraints has been at the expense of ultimate recovery and potentially to the detriment of the ultimate NPV of the asset.

[0079] The total asset model represented by the method **100** is initiated earlier in the asset lifecycle and is maintained over the entire asset lifecycle, which may be used to support: i) dynamic portfolio management, whereupon portfolio decisions are validated or iterated at the point in the project where sufficient data becomes available to do so; ii) dynamic asset planning based upon when project data becomes available, thus supporting the earliest possible optimal decision outcome and project change control; and iii) dynamic production system management, in order to operate at the asset's inherent potential.

[0080] The total asset model therefore, will: i) extend the uncertainty estimation/reduction framework to multiple time scales (lifecycle stages), well models, and production facility networks; ii) create formalized object models, data structures, and communication protocols designed to bridge the gaps among separate teams operating at different asset lifecycle stages, which will enable later stage teams to confidently use results generated earlier in the asset lifecycle and allow earlier assumptions to be validated/updated with results generated later in the asset lifecycle; iii) extend the time-space data transform function

concept for geological models and for integrated asset models to fully span the geological, geophysical, production, and economic spaces; and iv) continuously optimize the asset with respect to selected physical or financial objectives at every lifecycle stage, and re-optimize early stage variables or decisions wherever possible using the latest results from later stages.

System Description

[0081] The present disclosure may be implemented through a computer-executable program of instructions, such as program modules, generally referred to as software applications or application programs executed by a computer. The software may include, for example, routines, programs, objects, components and data structures that perform particular tasks or implement particular abstract data types. The software forms an interface to allow a computer to react according to a source of input. FieldPlan[®], which is a commercial software application marketed by Landmark Graphics Corporation, may be used as an interface application to implement the present disclosure. The software may also cooperate with other code segments to initiate a variety of tasks in response to data received in conjunction with the source of the received data. The software may be stored and/or carried on any variety of memory such as CD-ROM, magnetic disk, bubble memory and semiconductor memory (e.g. various types of RAM or ROM). Furthermore, the software and its results may be transmitted over a variety of carrier media such as optical fiber, metallic wire and/or through any of a variety of networks, such as the Internet.

[0082] Moreover, those skilled in the art will appreciate that the disclosure may be practiced with a variety of computer-system configurations, including hand-held devices,

multiprocessor systems, microprocessor-based or programmable-consumer electronics, minicomputers, mainframe computers, and the like. Any number of computer-systems and computer networks are acceptable for use with the present disclosure. The disclosure may be practiced in distributed-computing environments where tasks are performed by remote-processing devices that are linked through a communications network. In a distributed-computing environment, program modules may be located in both local and remote computer-storage media including memory storage devices. The present disclosure may therefore, be implemented in connection with various hardware, software or a combination thereof, in a computer system or other processing system.

[0083] Referring now to **FIG. 8**, a block diagram illustrates one embodiment of a system for implementing the present disclosure on a computer. The system includes a computing unit, sometimes referred to as a computing system, which contains memory, application programs, a client interface, a video interface, and a processing unit. The computing unit is only one example of a suitable computing environment and is not intended to suggest any limitation as to the scope of use or functionality of the disclosure.

[0084] The memory primarily stores the application programs, which may also be described as program modules containing computer-executable instructions, executed by the computing unit for implementing the present disclosure described herein and illustrated in **FIGS. 1-5**. The memory therefore, includes a total asset modeling module, which enables the methods described in reference to **FIGS. 1-5**. The total asset modeling module may integrate functionality from the remaining application programs illustrated in **FIG. 8**. In particular, FieldPlan® may be

used as an interface application to serve as a central hub for interacting with all of the components of the integrated and persistent asset models, visualizing conceptual designs such as platform and pipeline layouts, producing technical and economic reports, and loading or exporting data from/to external systems, which includes steps **202, 204, 218, 220, 302, 304, 322, 418** and **516** in **FIGS. 2-5**. Although FieldPlan[®] may be used as an interface application, other interface applications may be used, instead, or the total asset modeling module may be used as a stand-alone application. In addition, integrated asset models, being combinations of reservoir, well, surface facility, and economics sub-models, may be built using the Petroleum Experts IPM suite (for the engineering functionality) and Landmark ARIES[™] (for the economics functionality). IPM and ARIES[™] are used wherever analyses are performed or changes are made to the type model associated with any scenario, which includes steps **206, 208, 210, 214, 302, 306, 308, 310, 412, 414, 416, 510, 512** and **514** in **FIGS. 2-5**.

[0085] Although the computing unit is shown as having a generalized memory, the computing unit typically includes a variety of computer readable media. By way of example, and not limitation, computer readable media may comprise computer storage media and communication media. The computing system memory may include computer storage media in the form of volatile and/or nonvolatile memory such as a read only memory (ROM) and random access memory (RAM). A basic input/output system (BIOS), containing the basic routines that help to transfer information between elements within the computing unit, such as during start-up, is typically stored in ROM. The RAM typically contains data and/or program modules that are immediately accessible to, and/or presently being operated on, the processing unit. By way of

example, and not limitation, the computing unit includes an operating system, application programs, other program modules, and program data.

[0086] The components shown in the memory may also be included in other removable/nonremovable, volatile/nonvolatile computer storage media or they may be implemented in the computing unit through an application program interface (“API”) or cloud computing, which may reside on a separate computing unit connected through a computer system or network. For example only, a hard disk drive may read from or write to nonremovable, nonvolatile magnetic media, a magnetic disk drive may read from or write to a removable, nonvolatile magnetic disk, and an optical disk drive may read from or write to a removable, nonvolatile optical disk such as a CD ROM or other optical media. Other removable/nonremovable, volatile/nonvolatile computer storage media that can be used in the exemplary operating environment may include, but are not limited to, magnetic tape cassettes, flash memory cards, digital versatile disks, digital video tape, solid state RAM, solid state ROM, and the like. The drives and their associated computer storage media discussed above provide storage of computer readable instructions, data structures, program modules and other data for the computing unit.

[0087] A client may enter commands and information into the computing unit through the client interface, which may be input devices such as a keyboard and pointing device, commonly referred to as a mouse, trackball or touch pad. Input devices may include a microphone, joystick, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit through the client interface that is coupled to a system bus, but

may be connected by other interface and bus structures, such as a parallel port or a universal serial bus (USB).

[0088] A monitor or other type of display device may be connected to the system bus via an interface, such as a video interface. A graphical user interface (“GUI”) may also be used with the video interface to receive instructions from the client interface and transmit instructions to the processing unit. In addition to the monitor, computers may also include other peripheral output devices such as speakers and printer, which may be connected through an output peripheral interface.

[0089] Although many other internal components of the computing unit are not shown, those of ordinary skill in the art will appreciate that such components and their interconnection are well known.

[0090] While the present disclosure has been described in connection with presently preferred embodiments, it will be understood by those skilled in the art that it is not intended to limit the disclosure to those embodiments. It is therefore, contemplated that various alternative embodiments and modifications may be made to the disclosed embodiments without departing from the spirit and scope of the disclosure defined by the appended claims and equivalents thereof.

CLAIMS

1. A method for executing a project for a potential asset target by total asset modeling, which comprises:

a) selecting a best profitable engineering scenario for the potential asset target and an associated type model, wherein the type model includes one or more variables related to drilling operations and one or more variables related to a capital phase of the project;

b) updating the type model using a computer processor by at least one of adjusting each variable for the type model according to currently available drilling operations data and capital phase information that is related to a respective adjusted variable and adding at least one of one or more variables related to drilling operations and one or more variables related to the capital phase of the project to the type model according to the currently available drilling operations data and capital phase information that is related to a respective added variable;

c) refining the updated type model by adjusting each variable for the updated type model according to any additional drilling operations data and capital phase information that is related to a respective adjusted variable;

d) updating a net present value for the best profitable engineering design

scenario using the refined type model;

e) determining whether to operate the potential asset target based on a comparison of a rank for the updated net present value and a corporate portfolio capital spending budget; and

f) repeating steps a) – e) until the capital phase of the project is complete.

2. The method of claim 1, wherein the updated net present value is ranked together with a net present value for each corporate portfolio asset.

3. The method of claim 1, wherein the potential asset target contains at least one of oil and gas deposits, which is one of a previously undiscovered asset, an asset under active exploration or development, a producing asset and a previously abandoned asset.

4. The method of claim 1, wherein each unique type model represents an integrated asset model, which includes a consolidated technical description of at least one of a reservoir, a wellbore and surface production facilities associated with the potential asset target, and baseline economic data associated with the potential asset target.

5. The method of claim 1, wherein the type model includes one or more variables related to at least one of production data, well test data and production forecast data.

6. The method of claim 5, further comprising:

re-updating the refined type model by at least one of adjusting each variable for the refined type model according to currently available recovery operations data, which includes at least one of production data, well test data and production forecast data, that is related to a respective adjusted variable and adding at least one or more variables related to at least one of production data, well test data and production forecast data to the refined type model according to the currently available recovery operations data that is related to a respective added variable.

7. The method of claim 6, wherein the recovery operations data is obtained from at least one of primary, secondary, tertiary and post-tertiary recovery operations.

8. The method of claim 7, further comprising:

a) re-refining the re-updated type model by adjusting each variable for the re-updated type model according to any additional production data, well test data and production forecast data that is related to a respective adjusted variable;

b) re-updating the updated net present value for the best profitable engineering design scenario using the re-refined type model;

c) ranking the re-updated net present value for the best profitable engineering design scenario with a net present value for each corporate portfolio

asset;

d) determining whether there is any further economic potential from the recovery operations based on the rank of the re-updated net present value; and

e) repeating steps a) – d) until there is no further economic potential from the recovery operations.

9. A non-transitory program carrier device tangibly carrying computer-executable instructions for executing a project for a potential asset target by total asset modeling, the instructions being executable to implement:

a) selecting a best profitable engineering scenario for the potential asset target and an associated type model, wherein the type model includes one or more variables related to drilling operations and one or more variables related to a capital phase of the project;

b) updating the type model by at least one of adjusting each variable for the type model according to currently available drilling operations data and capital phase information that is related to a respective adjusted variable and adding at least one of one or more variables related to drilling operations and one or more variables related to the capital phase of the project to the type model according to the currently available drilling operations data and capital phase information that is related to a respective added variable;

c) refining the updated type model by adjusting each variable for the updated type model according to any additional drilling operations data and capital phase information that is related to a respective adjusted variable;

d) updating a net present value for the best profitable engineering design scenario using the refined type model;

e) determining whether to operate the potential asset target based on a comparison of a rank for the updated net present value and a corporate portfolio capital spending budget; and

f) repeating steps a) – e) until the capital phase of the project is complete.

10. The program carrier device of claim 9, wherein the updated net present value is ranked together with a net present value for each corporate portfolio asset.

11. The program carrier device of claim 9, wherein the potential asset target contains at least one of oil and gas deposits, which is one of a previously undiscovered asset, an asset under active exploration or development, a producing asset and a previously abandoned asset.

12. The program carrier device of claim 9, wherein each unique type model represents an integrated asset model, which includes a consolidated technical description of at least one of a reservoir, a wellbore and surface production facilities associated with the potential asset target, and baseline economic data associated with the potential asset

target.

13. The program carrier device of claim 9, wherein the type model includes one or more variables related to at least one of production data, well test data and production forecast data.

14. The program carrier device of claim 13, further comprising:

re-updating the refined type model by at least one of adjusting each variable for the refined type model according to currently available recovery operations data, which includes at least one of production data, well test data and production forecast data, that is related to a respective adjusted variable and adding at least one or more variables related to at least one of production data, well test data and production forecast data to the refined type model according to the currently available recovery operations data that is related to a respective added variable.

15. The program carrier device of claim 14, wherein the recovery operations data is obtained from at least one of primary, secondary, tertiary and post-tertiary recovery operations.

16. The program carrier device of claim 15, further comprising:

a) re-refining the re-updated type model by adjusting each variable for the re-updated type model according to any additional production data, well test data

and production forecast data that is related to a respective adjusted variable;

b) re-updating the updated net present value for the best profitable engineering design scenario using the re-refined type model;

c) ranking the re-updated net present value for the best profitable engineering design scenario with a net present value for each corporate portfolio asset;

d) determining whether there is any further economic potential from the recovery operations based on the rank of the re-updated net present value; and

e) repeating steps a) – d) until there is no further economic potential from the recovery operations.

17. A non-transitory program carrier device tangibly carrying computer-executable instructions for executing a project for a potential asset target by total asset modeling, the instructions being executable to implement:

a) selecting a best profitable engineering scenario for the potential asset target and an associated type model, wherein the type model includes one or more variables related to drilling operations, one or more variables related to a capital phase of the project and one or more variables related to at least one of production data, well test data and production forecast data;

b) updating the type model by at least one of adjusting each variable for the type model according to currently available drilling operations data and capital phase information that is related to a respective adjusted variable and adding at least one of one or more variables related to drilling operations and one or more variables related to the capital phase of the project to the type model according to the currently available drilling operations data and capital phase information that is related to a respective added variable;

c) refining the updated type model by adjusting each variable for the updated type model according to any additional drilling operations data and capital phase information that is related to a respective adjusted variable;

d) re-updating the refined type model by at least one of adjusting each variable for the refined type model according to currently available recovery operations data, which includes at least one of production data, well test data and production forecast data, that is related to a respective adjusted variable and adding at least one or more variables related to at least one of production data, well test data and production forecast data to the refined type model according to the currently available recovery operations data that is related to a respective added variable;

e) updating a net present value for the best profitable engineering design scenario using the refined type model;

f) determining whether to operate the potential asset target based on a comparison of a rank for the updated net present value and a corporate portfolio capital spending budget; and

g) repeating steps a) – f) until the capital phase of the project is complete.

18. The program carrier device of claim 17, wherein the updated net present value is ranked together with a net present value for each corporate portfolio asset.

19. The program carrier device of claim 17, wherein the potential asset target contains at least one of oil and gas deposits, which is one of a previously undiscovered asset, an asset under active exploration or development, a producing asset and a previously abandoned asset.

20. The method of claim 17, wherein each unique type model represents an integrated asset model, which includes a consolidated technical description of at least one of a reservoir, a wellbore and surface production facilities associated with the potential asset target, and baseline economic data associated with the potential asset target.