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Improving the Quality and Efficiency of Subsurface Workflows

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Abstract

The authors will show how a unique combination of real-time R&D coupled with strong asset team project alignment has the potential to result in significant improvements in the execution of Shell's Hydrocarbon Development (HD) and Integrated Reservoir Management (IRM) global processes in Shell's Deepwater Gulf of Mexico fields. The solution embodies technology enablers (Scenario and Options Evaluation, Decision Support Systems, Collaborative Environments), and organizational change (Intelligent Workflows, Research and Development, and new Business Models)

The solution consists of a Smart WorkFlow System (SWS), an Uncertainty Management Tool (UMT) and a Smart Collaborative Environment (SCE), all applied in the context of new collaborative work practices. The authors will elaborate how this integrated solution enables the asset teams to optimize their expenditure of scarce resources on the right reservoir scenarios and most relevant sources of risk, such as reservoir continuity or channel sand/shale geometries, all driven by group consensus. The collaborative environment improves execution of the HD and IRM processes through establishment of a common real-time team view. This view increases transparency of technical work, allows for real-time updates on progression of the risk mitigation plan, and allows for playback and critique of decisions in the context of an evolving shared earth framework. Rework is minimized, the efficiency and effectiveness of technical and business reviews are improved, and best practices are captured for global re-use.

The business model establishes a foundation for both Shell and Schlumberger to share the project risk and reward as the solution progresses from sandbox to prototype to commercialization. The authors will also elaborate on critical success factors in such a new collaborative R&D setting.

Introduction

This joint Shell-Schlumberger project is a multi-year, staged capability upgrade that will focus on developing right-time workflows for production optimization, including solutions that integrate the shared earth model with real-time production and drilling information in a 'risk-based distributed decision framework.' The primary aim of the program is to help optimize the operating performance and value of E&P assets through the implementation of integrated surveillance technologies, modeling tools, decision-support and control systems within key development and production processes.

Integrated models of reservoir systems are detailed numerical representations that have been developed by systematic linkage of the interpretations made by various geoscience and engineering disciplines. These models routinely begin with a comprehensive static reservoir description that is further enhanced by fine-tuning the property distribution so as to calibrate the model performance to the reported historical pressure, production and saturation data. Such models are generally constructed to evaluate development plans by forecasting production (both rate & composition), pressure, and saturation responses of reservoirs under various operational plans.

The real value of integration in reservoir geoscience and engineering lies in the ability to optimize this coupling between the static and dynamic components at both the appraisal and the development stages. The result of such a workflow is:

1. a reservoir model that has incorporated all known geological constraints and uncertainties,
2. a dynamic model which can accurately predict reservoir performance and provide reliable reserve estimates, and
3. high quality technical inputs for a more informed commercial decision-making process.

Partnership Characteristics

The Shell- Schlumberger partnership brings together the strengths of both companies under a an agreement that allows for joint development of new technologies, and grants each company options on how and when that those new technologies can be commercialized.

Schlumberger benefits from exposing its technical and consulting teams to leading edge complex reservoir development problems. Shell benefits from selectively applying the R&D and technical consulting depth and breadth of Schlumberger to its pressing business problems, as well as having direct input to future Schlumberger product feature plans.

The joint project team is fully integrated and works together as appropriate at Shell or Schlumberger work sites.

The work is reviewed periodically and endorsed by Schlumberger and Shell steering committees. Both companies have invested significant resources in the project, both financial and manpower.

The Current Situation

Today's asset teams are facing technical challenges in several different areas brought on a by rapidly changing landscape of field development. Most of the older "brown field" reservoirs are depleted, and many are compartmentalized and/or of poor reservoir quality. New discoveries are smaller with deeper, high pressure, high temperature, and layered reservoirs. All of this leads to vast subsurface uncertainties that add to the already complex workflow of any integrated reservoir project. Almost all these projects now require multiple field development scenarios and iterative field-level economic evaluations using enabling software that demand greater specialization. To further compound the problem, the most efficient technical workflow requires collaboration across disciplines and functions in an environment where business processes mostly exist in silos with little cross-functional integration. Finally, asset teams routinely cite data access and data management to be the number one problem frustrating progress in hydrocarbon development. Data and information is difficult to find and access and sometimes there is a poor level of confidence in the quality of the data. In addition, data is stored on users' personal drives, thus making integration and collaboration near impossible.

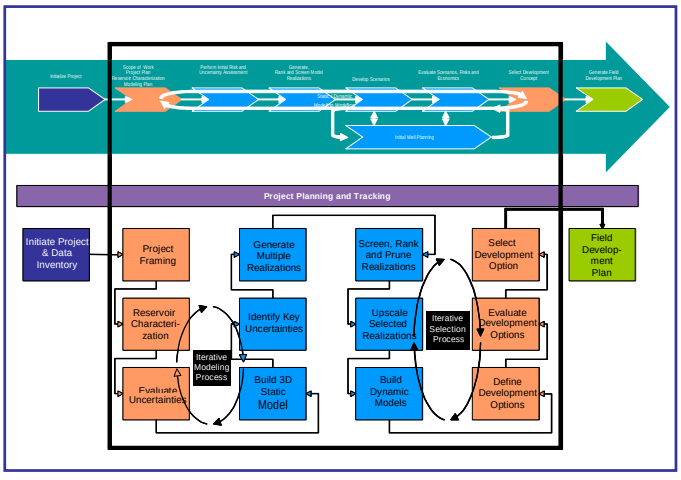

Figure1: Technical and Workflow Complexities in a typical Hydrocarbon Development Process

Future State Illustrative Scenario

Let's now examine how an asset team can work more effectively in this new environment.

Sally, the reservoir engineer and field development team leader, is working on a sidetrack well, the third well in a series in a newly producing field, and is preparing for a technical review with three of her peers (the team's geologist, geophysicist and well planner) and two technical specialists. The Hydrocarbon Development workflow has occurred as follows:

While at home over the past weekend, Sally received an email notification on her laptop PC from the production surveillance center. A custom surveillance agent, configured by Sally last month, with the help of Beau, a surveillance engineer, has been monitoring the early production data from the platform and has automatically identified variances from the input data and resulting simulation models.

Sally goes to work the following Monday, logs in to the Smart Workflow System (SWS) at her desk in the Asset Team's Smart Collaborative Environment (SCE). She launches the dynamic modeling application, accesses the QA/QC'd data set and loads it. She checks the well performance against the simulation model and fine-tunes it so that there is a match with the actual well performance

The simulation model has already been updated based upon reservoir surveillance data from downhole sensors and time-lapse Ocean Bottom Cable surveys designed to monitor an analogous waterflood project. This information gave insight on reservoir compartmentalization and continuity, which has been recorded in the SWS and is immediately available to those working on new development projects.

The development team's work to date has not gone unnoticed. The technical specialists have been following the progress of events in the SWS via notifications and automated distribution of work products after each major process step was completed. This gives them the chance to review the data and models ahead of the scheduled technical review, and provide a list of questions to the team that they want to have specifically addressed in the review. The SWS also ensures that reviewers who are unable to attend the review in person or via videoconferencing are able to provide their input. This ensures that the review progresses as planned and with the appropriate input.

The team has used the Uncertainty Management Tool (UMT) to ensure there is a consistent view of the project uncertainties as the project advances and to facilitate the way project uncertainty information is captured and utilized. The UMT provides several ways to rank and filter uncertainties and to link them to the decision making process . The process of entering information is simplified because the tool has links to all the subsurface applications used by the various disciplines. In this way, there is an audit trail in the form of

the capture and playback of uncertainty information throughout the IRM process.

Sally reviews the eight different subsurface realizations that she has chosen to represent the full range of subsurface uncertainty, based on the many hundreds she has explored over the past couple of weeks using a streamline simulator integrated into Petrel. The whole asset team has been able to seamlessly view the latest models on demand on their desktops, and in the team collaborative room, or in a high end visualization center. All of these together form the Smart Collaborative Environment, in conjunction with the information management stack. They narrow down the location of the next well to three attractive candidates. She logs this information into the SWS as complete, and the system automatically notifies the asset well engineer that the three scenarios are ready for him to run preliminary well designs and costs. The notification provides a link to the updated models and uncertainty catalogue associated with them.

The Solution

Ultimately, the primary purpose for any numerical reservoir model is to guide decision-making in asset development. Delays or misjudgments in decision-making can cost millions and even make the difference between success and failure.

The reservoir modeling and concept selection phase of a hydrocarbon development (HD) project is where there is the highest possibility of making decisions which will erode significant value from the field, thus requiring a high level of input from multiple members on the asset team. An exhaustive number of uncertainties and a variety of development options must be considered. The evaluation time normally ranges from months to years.

The integrated reservoir modeling (IRM) process is an iterative one in which reservoir models are built and successively refined, beginning with a first pass model and ending with a fit-for-purpose detailed model or models. The goal of the first pass model is to gain a quick understanding of data availability, quality, and model sensitivities to the key uncertainties. Often asset teams build reservoir models that are not developed at the appropriate level of detail to support the required decision-making. The models take too long to build and have an unknown quality to them because the uncertainties identified and assumptions made are only understood on a discipline by discipline basis.

A unique combination of real-time R&D coupled with strong asset team project alignment has the potential of yielding significant improvements in the execution of Shell's Hydrocarbon Development (HD) and Integrated Reservoir Management (IRM) global processes on the Shell's Deepwater Gulf of Mexico MARS field. The solution embodies both technology enablers and organizational change Specifically, the solutions consist of a Smart Work Flow System (SWS), an Uncertainty Management Tool (UMT) and a Smart Collaborative Environment (SCE), all applied in the context of new collaborative work practices.

Finally, enhanced data management is considered a necessary foundational requirement upon which the above mentioned solutions are built.

Data Management

The Data Management efforts focus on functionalities that are above and beyond that currently provided by Shell's data management architecture and SLB's commercially available DecisionPoint standard functionality allowing the following data management enhancements:

- the construction of a common and consistent data architecture with an associated set of technical workflows for accessing and managing the data
- the creation of a document store for unstructured data associated with the project work.

A standard corporate data architecture and project data store with role-based access tools will be used consistently across projects within the organisation and a standard data quality workflow approach will support consistency. The official project data will be archived in the standard project data store and access to shared data is easy through a desktop web interface.

The Smart Workflow System

Shell have defined a standard integrated reservoir modeling (IRM) process in an effort to drive quality and consistency. However, the only tools to enact IRM workflows are application and discipline specific and so shortfalls typically exist. Examples of these shortfalls are non-transparent project tracking, poor audit trail of the multi-disciplinary decision rationale associated with the HD/IRM process, and lack of prompting of workflow guidance and best practices from within the application suite.

The basic premise of the Smart Workflow System is to provide an integrated framework where skills, application tools, data, knowledge and work processes combine to bring improved effectiveness, efficiency and visibility to the hydrocarbon maturation process. We have developed a Smart Workflow System prototype with the following capabilities:

1. guides the workflows from a decision support-based perspective;
2. facilitates the capture and storage of relevant data, decisions, rationale, and work results
3. manages events (e.g. notifications and approvals) during the process
4. supports project planning, resource management, progress tracking and reporting functions;
5. integrates Shell intellectual capital (guidelines, standards and knowledge) into the workflows.

The SWS user-interface is a web-based environment that uses Schlumberger's DecisionPoint application. The underlying business process modeling is based on a pure .NET Business Process Management Engine called AgilePoint. AgilePoint is a scalable BPM Engine, which, through reuse of process assets, supports both human workflow and automated processes.

The SWS provides role-based login and access to features, tracking of portfolios, projects, tasks, notifications of to-do lists and pending decisions. It will also be a launching point for applications (e.g. Petrel, MoRes, etc.). It will be fully integrated with the Smart Collaborative Environment and any Decision Support solutions

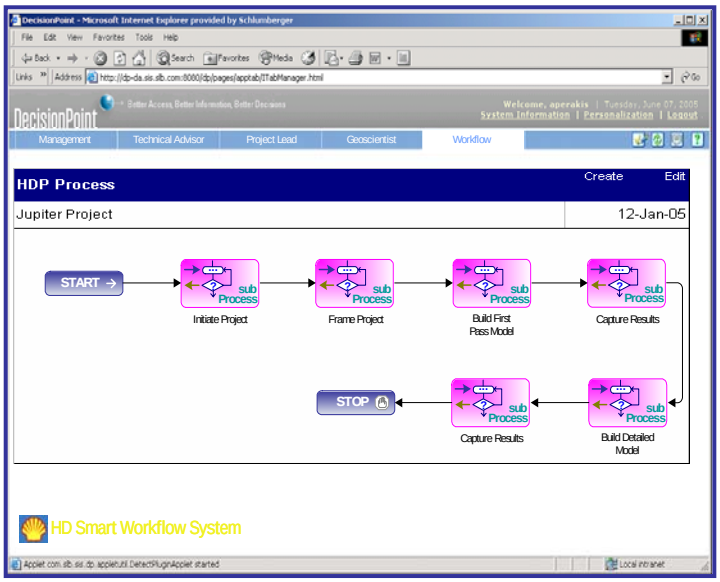

Figure 2: HD Smart Workflow System

Process tracking makes project progress visible to project managers and improves team and organizational efficiency by managing the status and notifications generated during the course of the IRM process. Specifically, data notifications from the following sources will be supported:

1. New wells, well logs, or interpreted tops are available in the project database.
2. New seismic interpretation data available in project database.
3. New static models are available for use in dynamic simulation.
4. New production histories are available.

Uncertainty Management Tool

One of the key objectives in the Shell-Schlumberger program is improving the handling of uncertainties and risks in the Hydrocarbon Development and Integrated Reservoir Modeling processes. In the current IRM process, Shell geoscientists and engineers use applications (e.g. Petrel, MoReS) to help them model uncertainties in a quantitative way. However, none of those tools allow the users to capture and manage uncertainty in a qualitative way. Information such as rationale, assumptions, and confidence levels behind uncertainties are lost during the modeling process and therefore impair the decision-making process.

We therefore have developed an Uncertainty Management Tool (UMT) which captures and manages contextual information on uncertainties, and is integrated with other applications capturing the quantitative details. The UMT has the following capabilities:

- it eliminates and replaces an inconsistent process with a centralized, knowledge and information capture solution.
- it enables in integrated and collaborative team to rapidly define key uncertainties, documents decisions, risks and comments as well as elaborates action plans and tasks.
- Provides visualization techniques to track the progression and reduction of uncertainty & risk during field development.
- It promotes the decision-making process in the modeling phase through consolidating information through screening and ranking multiple realizations then pruning options to a reasonable number of realizations.
- it provides an auditable process for determining decisions made during the hydrocarbon development process and the rationale behind them.
- It provides a mechanism that documents the relationships between uncertainties and decisions.

Throughout the life of a hydrocarbon reservoir, from discovery to abandonment, a great number of decisions (e.g. which development option with which recovery mechanism? pipeline capacity? number of wells?) depend on incomplete and uncertain information. These uncertainties are also case dependant and, for a given field, they depend on its stage of development (initial appraisal, initial development, complementary development). Therefore uncertainties affect the decisions.

One of the biggest challenges facing asset teams is understanding the relationships between uncertainties and decisions. In an effort to reduce cycle time, this tool attempts to promote a change in the way asset teams view uncertainties and the effort spent in analysing them. Due to of the lack of clarity around what constitutes a key uncertainty in the context of the decision that is needs to be made, often there is too much time spent in analyzing uncertainties that ultimately prove to have no or little impact on viable field development options.

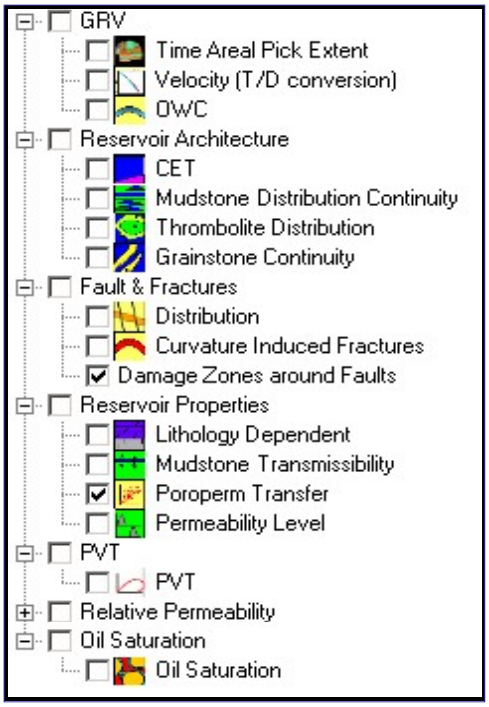

Figure 4: Example Uncertainty Catalog Entries

The UMT will improve integrated decision making by providing the foundational base that will help enable better understanding of the relationship between decisions and uncertainties by clarifying the links between these two key elements in field development planning.

Smart Collaborative Environment

The Smart Collaborative Environment (SCE) implements a number of changes to the current working environment that will attract the asset work team to a natural, real-time collaborative environment. It is a network of collaborative spaces (from the desktop, to team collaboration room to high end visualization centers), technologies and means of interacting between stakeholders. It includes the IT, data and knowledge management aspects that are foundational building blocks for collaborating effectively.

The SCE consists of five key components i.e. 1) The Physical Environment 2) Visualization 3) Data Management 4) Business Process/Project Management and 5) Knowledge Management.

Shell is currently developing a Smart Collaborative Environment (SCE) which is a network of:

1. Individual offices – essentially the secure desktop,
2. Development Team rooms – an information hub and collaborative workspace linked to real-time drilling and production surveillance centers.
3. Satellite team rooms - remote parties to connect for collaborative review sessions
4. High end 3D visualisation facilities (e.g. CAVE)

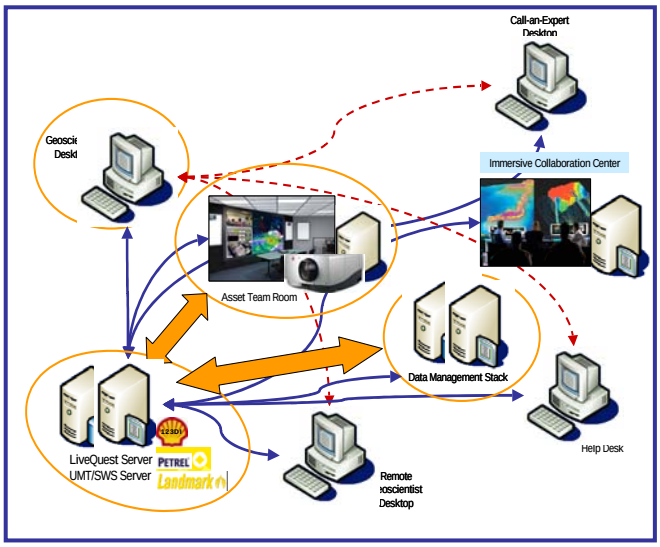

Figure 5: Collaborative Environment

The SCE is intended to facilitate collaboration that Shell have identified as essential for connecting the operational capabilities of its Hydrocarbon Development process. This will be achieved by providing:

- easier data access and management than is currently available,
- visualization for data, documents, models and applications spanning desktop, team room, and visualization facilities,
- support—consistent with Shell's T&OE practices—for single user technical workflow management, integrated with multi-user project workflow that uses standard BPM tools,
- knowledge management integrated within technical and project workflows, to help users save, find, and share findings, learnings, and rationale (in association with the SWS)
- decision support (in association with the SWS) that tracks prior decisions and provides context to evaluate their quality, associates current activities with pending decisions, highlights and visualizes key information required to help make good decisions, such as multiple scenarios and uncertainties, and project portfolio progress monitoring for managers and Functional Discipline Leads.

Development would take place on an asset team project basis with participating extended team members co-located with their asset team counterparts. In addition, participating professionals would be able to login and access their account, data and models from multiple locations, ideally from any enabled HD workspace, so that they can move around within the collaborative network, while still being able to do their work with the necessary privacy on an individual or team basis. Look, feel and ease of access and tools would be standardized to a degree so that HD professionals could work in familiar environment whether co-located together, on different floors in the same building, in Houston or New Orleans.

Conclusions

Upon implementation, we believe that the solutions described above will transform and improve integrated decision making by providing the foundation towards better understanding of the relationship between decisions and uncertainties, providing technical review visibility, allowing virtual expert collaboration and foster greater asset team collaboration. Ultimately, the Smart Fields solutions will optimise the operating performance and value of Shell's hydrocarbon assets.

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