

# Developing new evaluation tools and techniques for complex projects

## A Shell team creates a more inclusive approach to planning for unconventional hydrocarbons.

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The technology required to develop the world's unconventional hydrocarbon assets encompasses a protracted value chain that tends to exceed the complexity of conventional opportunities. Planning the development of unconventional resources, while incorporating an expanded value chain and emerging technologies, presents several challenges.

The inherent limitations in conventional software planning tools and related workflow processes led Shell engineers to explore new tools and workflow approaches to business opportunity planning. In developing a business simulation software tool, a key question was whether to produce the tool internally or to purchase it commercially. To be effective, either choice required pilot testing of the new tool while adapting the team's planning process and workflow. This entailed managing the change process with leadership support, training and education. A final challenge was to evolve from old to new tools and processes gradually, while adopting the new unconventional business simulation tool.

### THE CHALLENGE

The technology addressed here is the development-planning and evaluation system composed of people, software tools and processes. The starting point was to consider unconventional oil as a worldwide business opportunity. This process is expected to need a 10-yr period that spans four phases, Fig. 1.

Early in the planning process, the unconventional team realized that the development of the planning and evaluation methods, and supporting software tools used in our industry, were no longer adequate for modeling the techni-

forced the team to consider discipline integration from the beginning.

In the early phase (2001–2006), analysis began along traditional lines. The planning team started with a few familiar ideas, based in part or largely on past experiences. Internal spreadsheet models from past projects or from specific disciplines were updated and grew into multiple, layered spreadsheets combined with scheduling and project management software.

Once a project schedule was fixed, the data elements were loaded into spreadsheets for

analysis. As the details of the unconventional business plan grew with greater understanding, including the multi-discipline technical inputs within the maturing, integrated commercial-project team, the time required to evaluate ideas lengthened, slowing progress and curtailing the ability to look at the large array of scenarios that the project's complexity demanded.

Also, because spreadsheets are flat, static files with embedded formulas, fundamental changes to the model were difficult and time consuming. Additionally, if risks or opportunities were missed when the spreadsheet-based models were set up, they tended to remain overlooked as project details grew. Figure 2 shows the need to broaden the development scenario planning perspective (project frame) early to identify and assess project feasibility and maximum opportunity value, and to prevent narrowly focused assumptions or suboptimal project deci-

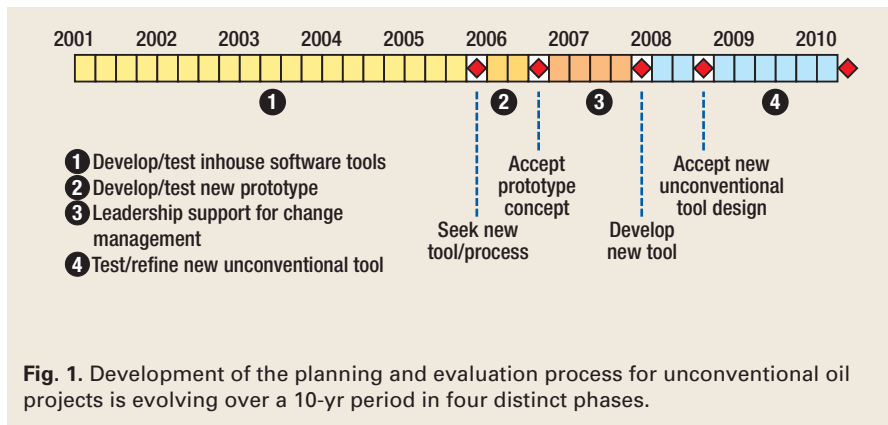


Fig. 1. Development of the planning and evaluation process for unconventional oil projects is evolving over a 10-yr period in four distinct phases.

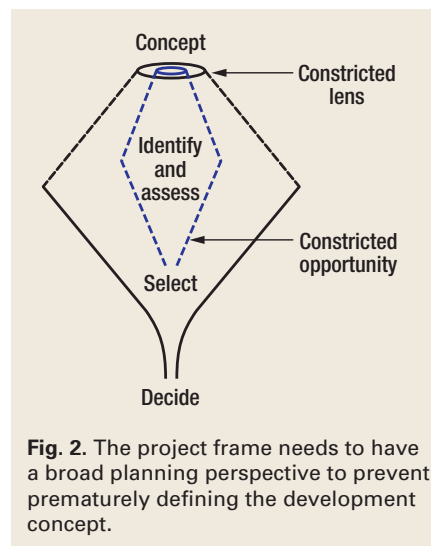


Fig. 2. The project frame needs to have a broad planning perspective to prevent prematurely defining the development concept.

cal complexity of this business. Today's opportunities are large-scale, capital-intensive, complex mega-projects that leverage emerging technologies and span the entire value chain. As such, planning

sions from prematurely defining the development concept.

Given the numerous development options, key uncertainties and project unknowns, it is vital to set a very wide frame at the front end. The more variables that are identified early, the wider the range of development options and outcomes that can be considered. This leads to a robust concept-selection decision and successful project delivery. Previously used tool sets and processes did not support this approach.

During this phase, the team encountered many conceptualizing challenges: how to proceed with an appropriate planning process and how to determine the correct tools. The team highlighted three challenges regarding complexity, modeling the learning effect and discipline-silo limitations.

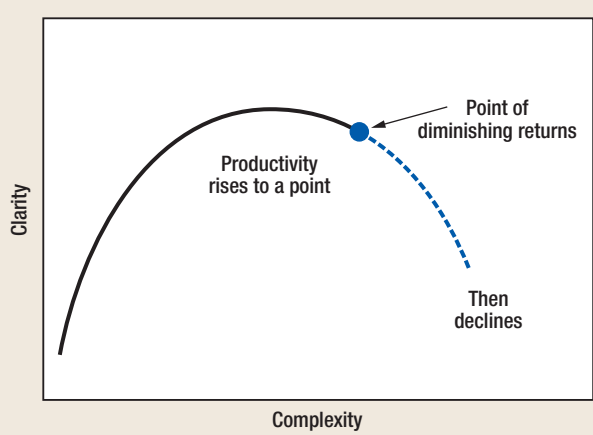
**COMPLEXITY**

For a mega-project, it is not unusual for a bank of spreadsheet models to link to a dozen or more worksheets, containing a few thousand named ranges each and including hundreds of thousands of calculations. The breakdown in this model-building paradigm occurs when logic is hard-coded into thousands of cells that are difficult to check or audit by anyone except the model builder. Multiple model builders have encoded their logic (planning rules) into the spreadsheet, based on assumptions that are not shared and are a challenge to audit.

By late 2005, the process for evaluating scenarios grew cumbersome, time consuming and error-prone. The spreadsheet-based technical model became so complex that it was difficult and unwieldy to use, and extremely difficult to either audit or maintain.

An unconventional oil opportunity of this magnitude is not a typical reserve and production game, and thus the business cannot be effectively described in those terms. Variables in several project components, notably the power resource required (and how to produce it), production of fluids (where, how and how much) and development pace (timing) could be modeled in an array of scenarios. The permutations cascaded into a myriad of development alternatives. Capturing these variables in a realistic cost, schedule, production and revenue forecast model became extremely challenging.

The first major milestone was a deci-



**Fig. 3.** Numerous attempts were made to extend spreadsheet-based tools, but these were not effective because the models lacked clarity.

sion point, Fig. 3. Numerous attempts were made to develop internal spreadsheet integrator programs to extend spreadsheet-based tools. These were not effective because the models themselves had passed the point of diminishing returns. We had fallen off the edge of complexity into declining clarity.

**LEARNING EFFECT**

Learning curves are one of the most important, controllable value drivers in a project. Since this development requires systematically drilling thousands of wells over a multi-year period, accurate drilling-cost modeling became fundamental.

Learning curves were anticipated; however, traditional spreadsheet modeling could not easily deal with both the cost impact and the schedule impact of learning curves. Simplifying assumptions made in a spreadsheet model could not include the dynamics of this learning effect, and would not accurately portray their importance.

Drilling is more likely to proceed at a faster pace with learning, as do production and electrical energy demands. Faster drilling also means that fewer rigs will be required. There is also a learning effect for energy efficiency, which means that more power will be available. This additional power can either be sold back to the grid or used for drilling and operating more wells.

The inability to model this learning for cost and time was a significant challenge. Within the confines of our first model, time was treated statically, but we found that a dynamic view of time was required.

This learning effect is an example of where business rules and simulation are

required, rather than hard-coded formulas. It suggested that a different modeling work process and technology was needed. The new process needed to be based on unit inputs of cost, timing and duration with associated rules and policies reflecting dynamic values, such as the drilling time for a well and rig availability. Using this approach, integrated project schedule and cost profiles became outputs from the analysis, as well as inputs.

**DISCIPLINE-SILO LIMITATION**

The typical asset modeling/planning process may be viewed as a row of desks where each one

(beginning with geoscience and the reservoir) develops a self-contained, risk-managed plan and then passes it along to the next desk. It passes through the disciplines of drilling, surface infrastructure, facilities, etc., until it arrives at petroleum economics, where a summarized forecast is rendered.

Here's the problem: The planning and risk management process within each discipline silo is based on certain assumptions or "rules" typically known only within that profession. The underlying rationale for the calculations in each one of the spreadsheet cells is not visible, is difficult to audit and is rarely captured in the model.

Changes in assumptions and learnings are constant in a complex development opportunity. A "rules-based" planning tool/process could capture the rationale in the model. Thus, when a change occurred in one discipline that affected the assumptions made in other disciplines, the integrated model could be re-run in a reasonable, timely fashion without sacrificing accuracy.

As an example, scheduling data is an input to algorithm-based (spreadsheet) planning. When a time input changes, the model becomes inaccurate unless every implication of that change can be revised in the countless calculations throughout the worksheets. A rules-based simulation program is required for scheduling to be revised as inputs change.

**FRONT-END PROJECT DELIVERY PLANNING**

Over the past decade or so, Shell has seen numerous examples where the complexities of mega-projects have severely challenged project cost and schedule.

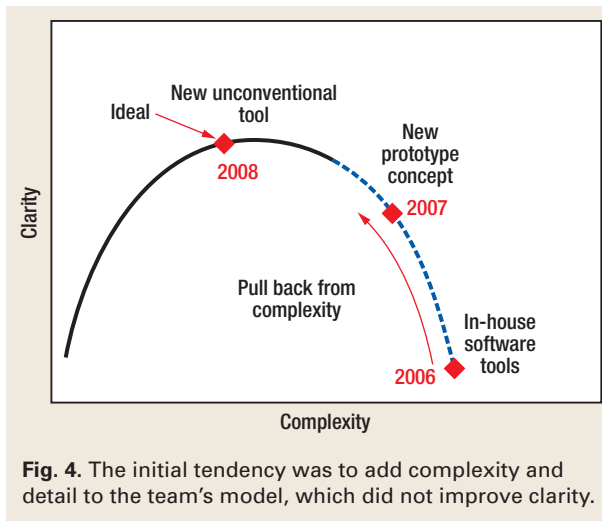
Learnings from these challenges provided Shell's unconventional team with the basis for a new approach. Example learnings include:

- Identify and incorporate subsurface uncertainties and production profile ranges into economics
- Evaluate a full range of alternative development options and concepts prior to the concept selection decision (sufficient development scenarios considered)
- Check for optimistic plans and schedules, and fully integrate across the project from technical, economic, commercial, organizational and political perspectives
- Consider entire value chain in project development effort
- Capture key risk/uncertainty insights within technical disciplines; integrate and fully evaluate as a potential risk development scenario
- Link selection criteria to project/value drivers; agree early enough to focus the project
- Enable decision makers to determine tradeoffs and consequences of selecting one alternative over others.

## A NEW APPROACH

Needing a more robust analysis and modeling tool/process, in 2006 the team began developing a new workflow process and searched for software technology tools more suitable for unconventional oil opportunities. The goal was to replace the conventional spreadsheet-based approach with a single, integrated planning and analysis platform that could simultaneously evaluate inputs from multiple disciplines. The new approach would rapidly evaluate scenarios and tradeoffs among decisions to understand their operational and financial impact. It would broaden the development planning horizon to identify a fuller set of opportunities and risks, while enabling the project schedule and cost profiles to be integrated outputs to the planning process, not necessarily inputs.

The new process would reflect business rules, not hard-coded formulas, for greater model flexibility and robustness. It would reduce the cost of supporting conventional spreadsheet-based planning, while reconciling and managing data quality within the tools and processes, not externally, as it was previously done.



**Fig. 4.** The initial tendency was to add complexity and detail to the team's model, which did not improve clarity.

## PROTOTYPE

The team considered developing software in-house, but elected to acquire and modify a commercially available product for trial use. The PetroVR Toolsuite was selected to provide the above capabilities, including integration of cost and schedule, and support of rules-based modeling.

The business-simulation software provides an integration platform. Its simulation tool captures basic project information (unit costs, time, etc.) and provides a platform to describe and codify technical and business rules. The program then runs simulations honoring all input parameters, while creating an integrated view of projects (model). E&P companies use the program to visualize multiple opportunity-framing variations, integrate work flow in teams, evaluate cost and schedule uncertainty, evaluate production volume uncertainty, evaluate decision tradeoffs, provide a consistent modeling approach for portfolio evaluation and mentor new problem solvers.

During the first half of 2006, the simulation tool was adapted for trial use on an unconventional oil project evaluation. The goal was to quickly develop a proof-of-concept to determine whether this simulation tool could be adapted to meet the needs of a large, unconventional oil project. It was designed to mimic the spreadsheet-based technical model, and even though the model was overly complex, the team needed to do this to mimic results and functionality, "proving" the concept and gaining acceptance for the new tool. In about six months, the unconventional team was successful in adapting the tool to model previous evaluations and run a full set of scenarios.

## LEADERSHIP SUPPORT

Having proved the technical concepts of the simulation-tool prototype, the challenge in July 2006 became changing the work-stream processes across the technical discipline teams to implement the new tool and processes. This was a slow and somewhat protracted process. At all times it was critical to obtain and maintain leadership support for the change process. Throughout this period, the prototype continued to be used and modified.

Although a complete, finished version of the tool was necessary to move forward, the slow change process allowed the organization to learn and become comfortable with new working methods. This would ultimately allow a quick uptake of the finished tool. This was a critical phase in the change-management process and could not have been hurried or ignored.

Rules-based, integrated business modeling offers decision makers value that also requires a change in expectations. Decision makers gain a line-of-sight visibility of risk and value drivers, which was previously eclipsed by silos. A larger number of "what-if" scenarios can be presented more quickly, with greater timeliness and accuracy. On the flip side, decision makers must adapt their thinking to this new view and learn to ask new questions.

Three examples of key value levers in this unconventional opportunity are: electrical power (how much and from where), production fluids (what types, where produced, production rate and volume) and development pace (timing and implications on investments, cost and revenue).

There are dozens of "value levers" available in this and most opportunities. With these as "levers to pull" in competing development scenarios, the decision maker has better control of the asset and of the challenge to adapt to a new way of thinking.

## COMPLEXITY/SIMPLICITY

Many projects have a "drive to complexity," which is especially true in unconventional oil. The team needed to continually find ways to "pull back" without sacrificing insight or understanding. Figures 3 and 4 describe this "drive to complexity" and also how the unconventional team confronted and is attempting to solve the problem. In each

subsequent tool/process model, they expanded the model-building approach to find the “sweet spot” on the clarity/complexity curve.

The team’s initial tendency was to add greater complexity and detail to the model than was needed. Part of the reason for this was to test the model’s efficacy by comparing results to those from the former processes and spreadsheet-based tools. The team understandably had to reach a level of confidence in the new results. Another reason was the perception that secondary or tertiary factors had material impact on the output and those too had to be evaluated. Greater detail could be more easily reflected and evaluated in the model, which also invited over-complexity.

**PEOPLE/TECHNOLOGY**

While the software technology required to support complex opportunity planning is a success factor, technology alone is not a solution. As important as the business integration tool is to project success, without care and feeding of the people experiencing technology change, there is no solution. Several key roles were played across management and team members. It is helpful to describe two of these roles: the Trailblazer and the Super Users.

The Trailblazer was the development planner/integration manager who served as the “bleeding edge” adopter of the new tool and process. This member was well known and trusted. The “new” models being built were used simultaneously with the “old” models for some period, so as not to shock the team by removing their comfort zone all at once. The Trailblazer was the first to let go of the old tools completely. Once the group saw that it worked and worked better than the old tools, their comfort was raised and they were ready to become early adopters.

Super Users were analysts hired from outside the unconventional group that were focused solely on using the new software tool. Their role was to advance tool use and succeed quickly. Success benchmarks are key in change management.

**RULES-BASED VERSUS ALGEBRAIC-BASED**

Data integration was not a solution in this planning environment. Using algebraic calculations (such as in spreadsheets) to integrate data across disciplines (the value chain) does not provide asset-wide integration and does not reveal risk

interdependencies.

By integrating the planning rules (assumptions) that modelers applied when writing the formulas, cost and schedule visibility was revealed. Rules-based integration requires an advanced business simulator because of integration and the time required to run multiple scenarios.

**COLLABORATION/KNOWLEDGE OWNERSHIP**

An inherent aspect of planning any hydrocarbon development is the depth of professional, technical domain knowledge and expertise required. Grouping expertise within “knowledge disciplines” makes perfect sense and is necessary. A natural outgrowth of this planning model is knowledge ownership. The corresponding dynamic is team collaboration, which does not come naturally in a “deep domain knowledge” planning environment. To achieve effective team collaboration, while protecting the value of deep domain knowledge within disciplines, requires ongoing team facilitation and effective management.

Table 1 presents the project learnings, shown as comparisons between the old

and new methods. Some of these were hypotheses prior to the unconventional planning project. As a whole, however, the full extent of these learnings was not known and arose from the process.

**COMPLETION AND TOOL ACCEPTANCE**

The change management process took the better part of a year. Toward the end of 2007, the unconventional team reached a point of clarity. Moving forward required an ongoing workflow process change in conjunction with the development and completion of a customized, unconventional planning tool, based on the successful simulation-tool prototype.

The proposal was accepted in early 2008, and the initial three-month software development cycle was completed during spring 2008. The new unconventional tool was designed and implemented to meet the exact needs of unconventional opportunity planning, as defined by the unconventional team. Extensive interviews were conducted to help software developers understand the critical knowledge in each discipline, what plan-

**TABLE 1. Comparison of rules- and algebraic-based learnings**

<b>Learnings by category</b>	<b>Business simulation (rules based)</b>	<b>Spreadsheets (algebraic based)</b>
<b>Time</b>		
Time to build a model	Days	Unknown (quarters or years)
Time to evaluate a new idea or scenario	Minutes	Several days
<b>Knowledge capture</b>		
Data capture	Limited to relevance of project scope	Excessive
Domain expertise captured (rules)	High	Low
Ability to incorporate decision rules in a model (simulation)	High (because of simulation architecture)	Limited (based on use of complex macros)
Knowledge transfer	High	Low
<b>Auditability/visibility</b>		
Ability to perceive an error (input or computational)	High	Low
Time to understand and correct an error	Brief	Protracted
Ability to perceive dependencies	High	Low
<b>Learning curve</b>		
Ability to model time-based learning	Significant (because of simulation architecture)	None (because of algebraic architecture)
<b>Flexibility</b>		
Model flexibility	Limited by domain knowledge and logic	Infinite
<b>Resources cost</b>		
Human resources required to support model/processes	One	Several
Software purchase cost	Significant investment	Very low
Perceived level of change management	High	None
Commitment to training	Days	None
<b>Job satisfaction</b>		
User experience by project team	High	Low

ning rules are applied, what decisions are made, and how they are made (decision context). The exact workflow that the team streamlined was simulated in the software tool.

The entire software development period is expected to take eight quarterly cycles of enhance/review/test and should be completed in winter 2010. With each iteration the processes are streamlined.

## CONCLUSION

Since the development of a new work process and acceptance of new tools for unconventional oil has only early results, Shell can only generally address the expected business results to be gained. Pilot work using the new processes and tools demonstrates these sources of value:

- Wider view of options at the beginning of opportunities
- Shorter planning-time cycles
- Improved understanding/insight of risk versus value
- More credible business plans that reveal decision tradeoffs and opportunities.

Using the new process and technology, each discipline will have access to the model to do its own what-if analysis. Development planners are provided with an integrated scenario at a macro level. Each element of the opportunity is made available to all the disciplines. Leads for the disciplines will be able to query the tool and make edits to their respective areas, while seeing the impact to the project revenue, cost, schedule and operational elements.

The ability to address a much wider range of concepts and the quality of those insights are much higher. Now the team can plan learning in relation to time, which dramatically portrays opportunities' lifecycle cost. The depth of analysis is greater. There is also tremendous learning potential through scenario analyses, which are embedded in the new tools. The effect is a more representative project profile.

While the development of unconventional resources is a complex value chain, the new tools and processes Shell unconventional oil has implemented are applicable to conventional opportunities where there is a portfolio of projects to be managed. In these instances, the same tools and processes outlined here enable a portfolio of multiple wells to be more effectively managed at a higher aggregation level. If a portfolio contains multiple individual projects with dependencies and common resources (constraints), it is

a candidate for more effective modeling using the dynamic business-simulation planning processes.

Although it is difficult to quantify in monetary terms, Shell expects staff and time savings in the millions of dollars, separate from any potential monetary benefits in operations. **WO**

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