zeus
TECHNOLOGY
magazine

A Focus on the Full Spectrum of IT Solutions for Oil & Gas

Reducing Uncertainty in Reservoir Management

Volume 4 Number 1
Excerpt from January 2009

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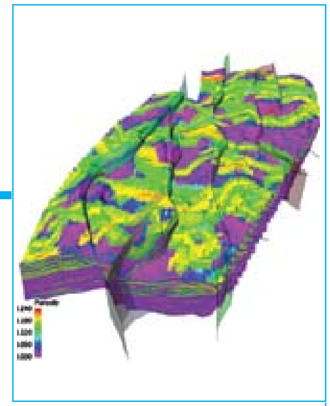

When it comes to making economic decisions around reservoir management, whether it be bid valuations, new field development decisions, or well planning and operational plans, there is one thing that today's E&P operators can be certain about: there will be a large element of uncertainty in their decisions.

The financial risk of too much uncertainty in one's oil and gas fields can be significant. According to a May 2003 Norwegian Petroleum Directorate report, reserves have either increased or decreased by more than 50% from initial estimates in more than 40% of North Sea fields. This has resulted in having to drill 60% to 80% more wells than originally anticipated in the field development planning process, directly affecting the financial return of each project.

So if uncertainty is inevitable, how can one better quantify uncertainty in reservoir management?

The Rise of 3D Modeling

An important means of quantifying and reservoir uncertainty is to create realistic geological and structural models through 3D modeling, updating these models in real time. Furthermore, operational and strategic field development decisions are increasingly aided by models of the asset. However, a major challenge is keeping these models up to date as new data arrives from a multitude of field sensors, gauges and meters, offering information on everything from pressure to flow to potential well paths for drilling.

The Structural Model

The structure of a field, where you are defining the size and shape of the subsurface reservoir, is a critical component of the reservoir model. Get the structural model wrong and reserves calculations, production predictions, well placement and field development planning will all be impacted. Delays when producing structural models can also be highly damaging, leading to delays in production, the missing of bid dates, or incomplete models going to simulation.

A successful and robust structural model, on the other hand, will allow operators to speed up the structural modeling process and improve the quality of their models further along in the workflow.

To date, many structural modeling processes have been long, cumbersome and labor intensive – the domain of a few specialist reservoir geologists or geophysicists. The length of the process has also been highly dependant on the type of field and the number and complexity of the faults. Typically, the higher and more complex the number of faults, the longer the process takes.

To meet the challenges of structural modeling, Roxar has developed a new technique for structural framework building. This approach to model building is not just a new method of creating a fault framework, but also applies to the creation of the horizon model and the reservoir grid. The process involves three steps:

- Creating the fault framework;
- Creating the horizon model; and
- Creating a 3D reservoir grid.

The method does not require compromises or simplification in:

- Types of faults, numbers of faults or types of intersections;
- The horizon modeling of complex shapes such as repeat sections; or
- Creating the reservoir grid, such as limiting the types of intersections that can be made.

The simplicity of building and editing the fault relationships, creating the horizon model and building the reservoir grid means that all members of the asset team can easily update a model, test different interpretations and use the model for both geological and engineering applications. At a time when there are growing staff shortages and a need to increase productivity, this is incredibly valuable.

Local updating of the structural model is carried out directly onto the 3D grid, based upon new structural horizons or a difference map. This allows for the rapid local updating of the gridded structural model, without the need to rebuild the structural framework. More significantly it also retains the existing property models, allowing for them to be updated, as well.

The speed of this technique, along with a streamlined workflow, an intuitive graphical user interface, optimized defaults and minimal manual editing, can also reduce cycle time from months to weeks. This frees up workforce productivity to build more scenarios and reduce uncertainty.

Local Updating of the Reservoir Model

Although structural modeling is at an early stage in the field development planning phase, higher quality, faster and updatable structural models are crucial components of production optimization and productivity today, as well as for creating better 3D models.

Another important new development in reservoir management as a means of reducing uncertainty is the ability to update both the structural and geological model locally. In the past, the building of history-matched static and dynamic models from raw data and updating these models based upon newly acquired data proved to be a time-consuming process. The process from drilling a new well through to the updating of the static model and history matching of the new model could take up to a year or longer.

A powerful alternative to an updating of the full reservoir model, however, is local property model updating. At Roxar, we have developed a methodology to update the geological model based upon new data or interpretations. The method applies to both object and indicator (pixel) based facies modeling as well as petrophysical properties, such as porosity and permeability.

For example, in object modeling, the new updating algorithm will make minimal changes to the existing model while conditioning it to the new well data. This is achieved by attempting to make existing objects match the new, mismatched data. Only in cases where this is impossible are new objects generated, helping ensure the final volume fraction is as close as possible to the original.

Indicator facies models can also be updated, where the algorithm ensures an accurate match not just to the new well data but also the statistics of the existing model, including smooth integration into the existing realization.

Petrophysical property models, such as porosity and permeability, can also be locally updated. To generate the updated model, the model is initially rerun using the existing and new data to produce a new petrophysical simulation. Other model settings will typically remain unchanged, but could also be updated, if required.

Updating the Model in Real Time

These new workflows can also be applied in real time to provide geosteering capabilities within the 3D reservoir model. This will help reduce delays between the analysis and integration of real-time drilling data and the updating of geological models.

Roxar's modeling applications allow for real-time access to data on the desktop and the ability to monitor real-time logging-while-drilling data through WITSML (Wellsite Information Transfer Standard Markup Language).

In this way, the reservoir model can be compared to the reservoir data and updated in real time. It would be impossible to make these updates and associated decisions in real time without the ability to update the model locally, as rerunning the whole model would be too slow.

A high-resolution geological model around the wellbore allows forward modeling of real-time log data, enabling wellsite geologists to see what log responses to expect. There are also links to the target and trajectory planning process, allowing "look ahead" trajectories and targets to be updated in real time.

In an era of complex wells and a need for greater efficiencies in drilling operations, effective well planning and accurate wellbore placement is a vital tool in reducing uncertainties, whether they be seismic, structural or geological.

Big Loop Workflow and History Matching

This approach of updating the static model locally can also be combined with dynamic models to create a "big loop" workflow of reservoir management – a single, updatable workflow that carries uncertainties and details in the geologic model through to simulation.

Closing the loop is the ultimate goal of reservoir management. In this way, geometrically accurate models can be built up and then created into simulation models, consistent with all known geological information. This equates to uncertainty management across the complete static and dynamic workflow.

One essential tool for closing the loop, particularly in an existing reservoir, is history matching – the act of adjusting a reservoir model until it closely reproduces its past behavior. Computer-assisted history matching allows the engineer to focus on developing an understanding of reservoir mechanisms and their relative impact on production behavior. Through such history matching tools, match modifiers are updated intelligently, there is automatic parameter sensitivity analysis, and runs are even submitted when engineers are away from their desks – a means of increasing productivity and coping with manpower shortages.

Having the Tools Available

Through robust structural modeling, the local updating of the model, and the ability to rapidly update the model in real-time as production data arrive, reservoir engineers now have the tools to make crucial, real-time reservoir management decisions based on the latest available information.

At a time when the industry is looking for reservoir management solutions that optimize production from increasingly marginal assets and meet the criteria of proactive asset management, this is most welcome!

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