Enhancing Reservoir Performance

Fast, accurate reservoir modeling as a practical component of field management

Improved drilling programs and advanced warning of operational challenges would be realized if all available well and other subsurface data could be rapidly incorporated into the geologic model. Yet until recently the techniques and technologies employed for geologic modeling have not been able to keep up with the quickening pace of new data acquisition. As a result, many fields are modeled infrequently and operational logistics tend to be driven by reactive rather than predictive decision-making.

The objective in building and maintaining a reservoir model is, of course, to be able to predict the future performance of the field. By interpreting data from well logs, cores, seismic and other data, geologists, engineers and geophysicists can develop a better understanding of how the reservoir functions, and can simulate flows over time. An early model can help determine the initial drilling program. Ongoing models that take into account each drilling cycle can drive adjustments and tune operational logistics as the field matures.

While most would agree with the concept, many have hesitated to adopt ongoing modeling because of two major operational constraints:

- Substantial manual intervention in the model definition has been required to get flow simulations from the initial model to match production data. This is primarily due to the difficulty in accurately modeling the geological heterogeneity between wells.
- Updating the model with new wells or changes in the structural and stratigraphic definition has typically been extremely time-consuming. In most cases, information from a new well cannot be added to the model and new simulations run before the next well must be drilled. The current linear modeling approach makes updating the structural or geologic model a lengthy process. Each discipline passes its results on to the next. There is no looking back and no consistency checks. Unconnected steps make updating the simulation model difficult.

As a result, even in large fields operated by the top oil companies, modeling has often been infrequently applied. Some fields go as much as three years between modeling efforts. This choice, based on economic realities at the time, forces a reactive stance at the field level. When the unexpected is encountered, it is handled in the moment. As time goes by, the unexpected is compounded and the subsurface is more and more uncertain.

A new approach now makes modeling and simulation a practical component of ongoing field management. It creates a highly detailed model that easily incorporates new operational data and can be updated anywhere in the workflow, from seismic to simulation. Its iterative workflow approach takes significantly less time, allowing operators to keep up

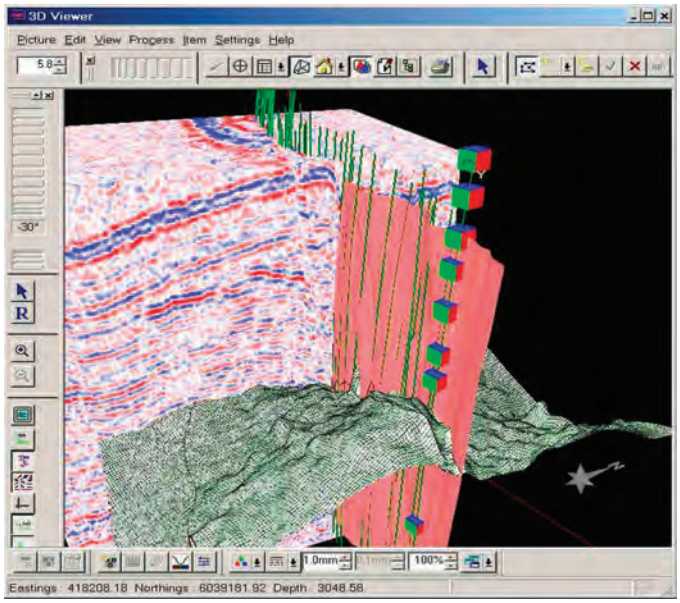

Figure 1: *UpdateAbility*™ speeds updates by modularizing and automating common functions such as fault repair and truncation against surfaces.

with drilling schedules. Real world use has shown a 3-5x speed up in modeling and maintenance tasks.

This new approach automatically records the workflow as the reservoir model is initially built and provides the framework for the model to be updated when any input is modified or any modeling parameter is changed. By taking advantage of this new approach, exploration and production managers can improve their drilling programs, production yield and predictive planning accuracy.

Fast Enough for Practical Use

A stratigraphic model grid (SMG) can be quickly created through the rapid combination of geologic information and seismic data, then updated and upscaled for simulation if required. This seismic-to- reservoir model workflow can be modified and updated every time new information is available. Modeling begins with well logs, cores, a geologic interpretation, and other operational data. A geologic model is built from this data, based on a corner point grid (CPG). This model is then reviewed by geologists and engineers to ensure it matches conditions observed in the field. Seismic data provides one of the only cost effective, laterally extensive field measurements. Techniques for acquisition and processing have evolved over the past few years, leading to better quality seismic data. At the same time, the volume of data acquired has skyrocketed, presenting a challenge for companies to take advantage of the data in a timely fashion.

Seismic inversion creates a 3D representation of the stratigraphy and lithology of the field, which is then combined with the geologic model to create a new model that honors all the data in the field. From here, engineers can upscale the model and run flow simulations when required or use the models for in fill drilling techniques.

This process is now far more integrated and substantially faster than ever before.

Fast updating is key to the new approach:

1. Updating the structure. When a geologist adds a structural feature, certain characteristics are implicit and automatic. For example, if a fault is added and it crosses a horizon, the fault horizon interface is automatically adjusted. This modularity removes much of the need for manual intervention.

2. Updating the data. New operational data can be added to the model at any time. The effect of the new data is essentially immediate because after adding the new data, the previously recorded workflow is rerun with the additional inputs.

3. Updating the recorded workflow. The geologist or engineer can revisit any decision or parameter in the workflow at any time. All changes are immediately reflected in the model.

Significant time-savings enable geologists and engineers to run multiple scenarios and simulations, resulting in a more developed model in a fraction of the time. Three scenarios or more can now be routinely simulated in the time it takes with other approaches.

Figure 2: Linear Workflow commonly used to generate reservoir models.

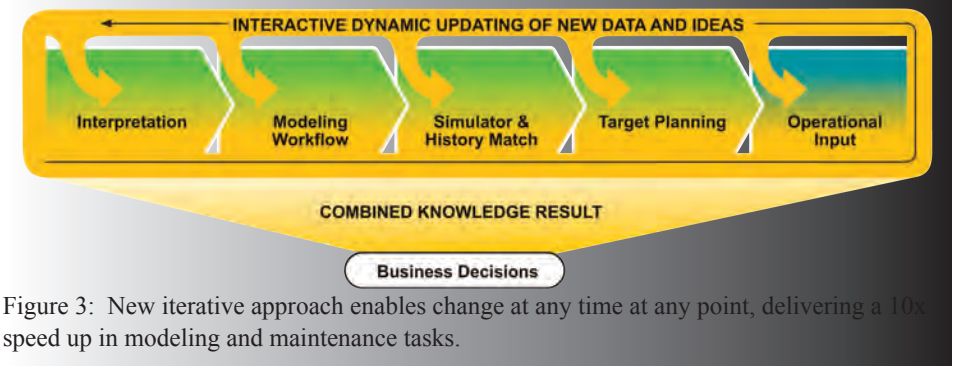

Figure 3: New iterative approach enables change at any time at any point, delivering a 10x speed up in modeling and maintenance tasks.

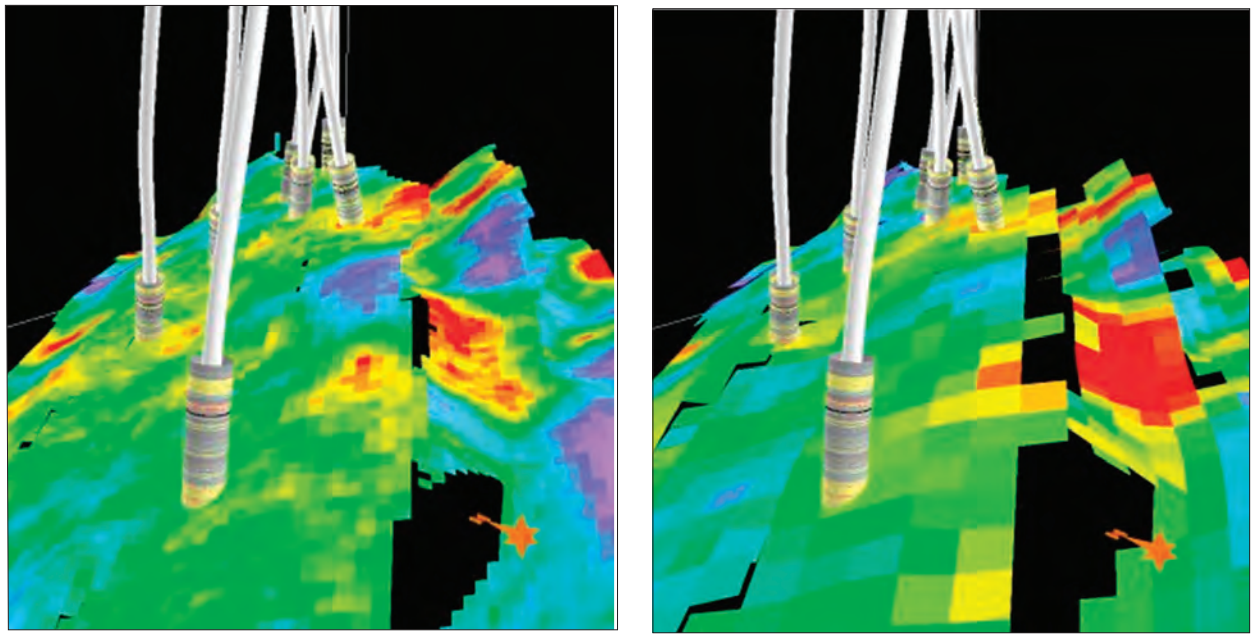

Figure 4: Finescale Model (left) and Upscaled Model (right). *EarthModel FT* offers comprehensive upscaling options for petrophysical properties plus RockScale technology for upscaling from trace-based seismic grids to corner-point grids.

Up-to-Date Model Supports Operational Logistics

The value of ongoing modeling to ongoing operations is tremendous. However, a common complaint when modeling infrequently is that the realities in the field no longer match the predictions of the model. To take advantage of the opportunity for better field management, two key changes are required:

1. Reservoir models must incorporate all field data as quickly as possible. In the past, models were not able to keep up with the volume or pace of data acquisition. Models and operations got out of sync. To be truly useful, models must be current.

2. Modeling and simulation must become a regular component of field management.

With the new approach, both of these changes can and should be made.

Consider the case of a new fault discovery. This will likely have an effect on flow and may drive the need for an additional well. If the new condition could be quickly incorporated into the reservoir model, the operator could determine the best course of action to preserve or enhance the field's production. Similarly, if the gas flow from a field is increasing, modeling can help predict the downstream facilities needs and timing.

Preventing the drilling of one dry well through ongoing modeling can save $10 million. Anticipating the needs of surface and downstream facilities can save substantially more than that.

Detailed and Accurate Models Yield Better History Match

While models provide insight into the subsurface, many uncertainties remain. A great deal of this uncertainty is removed by starting with the most detailed initial model that honors all input data. When modeling itself is a less time consuming process, multiple scenarios can be modeled and simulated, further reducing uncertainty.

Accurate models are achieved by creating a detailed gridding system, based on both seismic and well data. Porosity and lithology information derived from the seismic data is combined with the well data in the initial geologic model. Models built with both the seismic and well information typically require

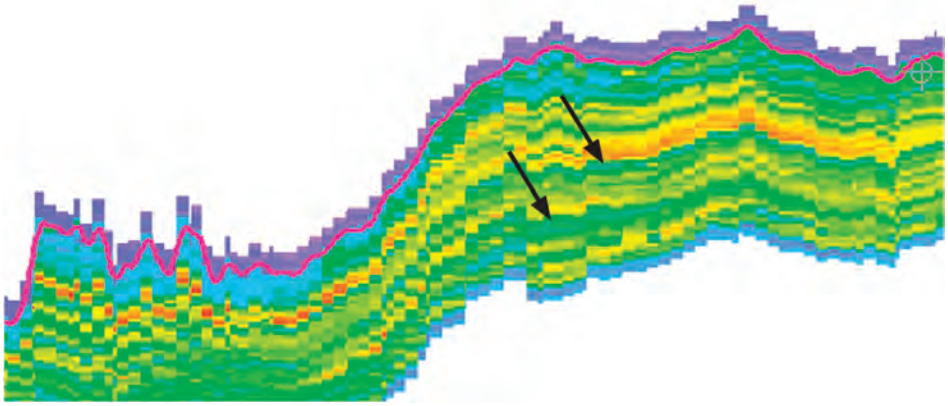

Figure 5a: Regular gridded output with seismic derived rock properties (red line is interpreted horizon).

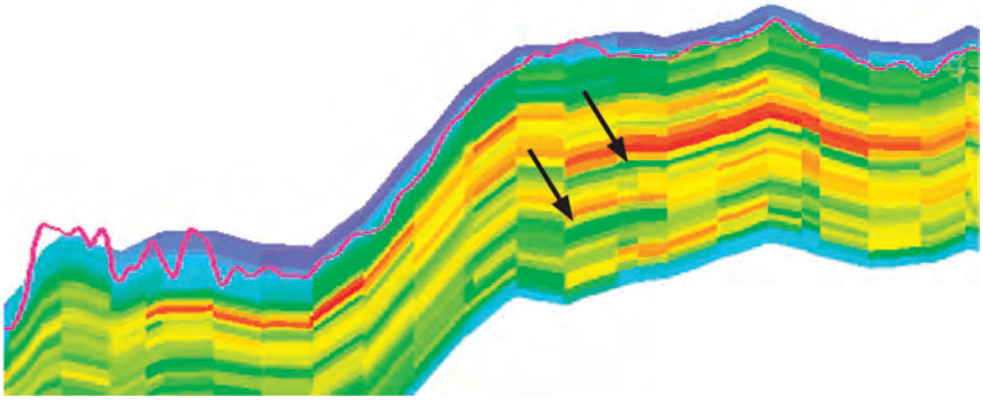

Figure 5b: Incorrect geometrically resampled result. Light blue layers are gone.

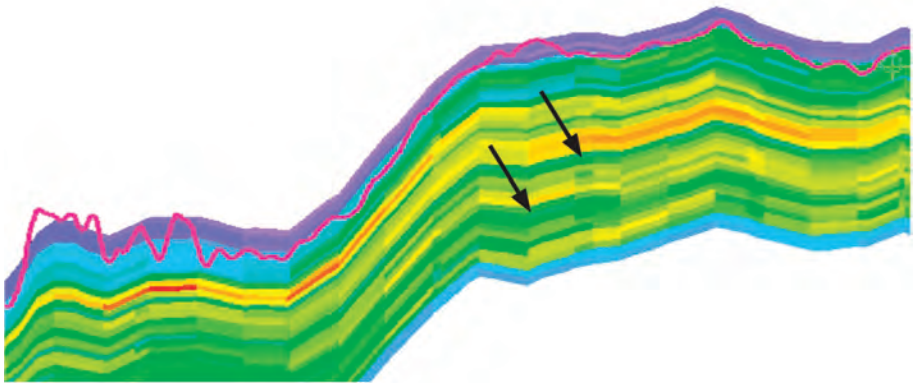

Figure 5c: Flow units and associated net to gross are properly preserved using Zonal Adjustment.

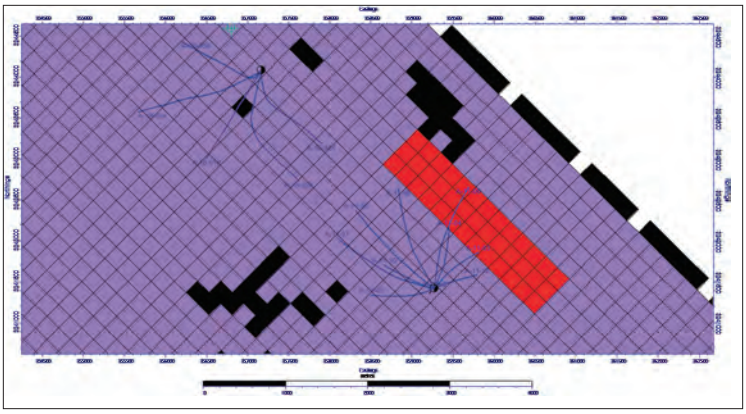

Figure 6: One dZ layer showing changes in permeability.

"EarthModel FT lets you solve localized history match problems in one of two ways. Using UpdateAbility, you can efficiently change the underlying geologic model to obtain a better match. Alternatively, you can interactively change the model parameters using traditional tools in EarthModel FT."

dramatically less intervention to obtain satisfactory history matches with the production data, and any changes needed are usually a result of the coarseness induced in the upscaling process.

The resulting model is kept current by including ongoing operational data as it is acquired.

Quickly Address Subsurface Challenges

Modeling is a critical component in answering such questions as:

1. Are there 'hidden' reservoirs that were missed?
2. What impedes flow?
3. What is the best way to leverage secondary recovery techniques?
4. How can overall recovery be optimized?
5. What downstream facilities will be needed in the next few years?
6. What surface facilities will be needed to deal with extra water, higher gas mix, cutover to other wells, and other operational changes?
7. Is there a risk of 'surprise wells'?

Reservoir modeling and simulation is now a practical solution for addressing these questions on an on-going basis. Accurate models created and updated in a fraction of the time previously required can help improve operational logistics and overall field production.

Rapidly Build and Maintain Accurate Models with EarthModel FT and RockScale

Jason offers EarthModel FT and RockScale to integrate:

- Structural Modeling: support for General Corner Point Gridding.
- Reservoir Property Modeling: determines lithofacies, porosity, permeability and other reservoir properties.
- UpdateAbility™: updates the model instantly as new data arrives and enables 'what if' scenarios.

RockScale easily manages structural changes and scenarios through its unique regridding and scaling techniques (Zonal Adjustment). Structural models can be continually updated using EarthModel FT. At the same time, seismically derived reservoir properties can be used to constrain and improve geologic models.

This solution enables fast, accurate reservoir modeling. Customers report a 3-5x speed up in model building and maintenance tasks.

Fast Workflow for Fast Model Building and Simulation

Unlike a linear approach, Jason features an iterative workflow that enables geologists to import horizons from any source, create a geologic model including seismic, upscale the results and analyze the reservoir over time using any simulator. UpdateAbility enables this unique workflow, automatically recording all steps and parameters. Any input can be modified; any parameter changed.

Fast Reaction to 'Surprise Wells'

Even the most thorough model can miss an uncertainty that results in a 'surprise well'. With UpdateAbility, EarthModel® FT can quickly incorporate the 'surprise well' into the model, speeding reaction time from months to weeks. This same capability makes it easier to model a wide range of uncertainties, reducing the risk of 'surprise wells'.

'What If' Support for Greater Accuracy

'What if' scenarios are easily modeled:

- Set up a Monte Carlo run using 'drag and drop' to identify items to be varied and forecast.
- Investigate various options for production wells—this is just a different forecast.
- Explore multiple models and interpretations by switching inputs.

The level of control and investigation introduces knowledge management to the modeling process.

Innovative Approach

Jason solutions go beyond traditional seismic inversion and modeling to solve problems like:

- Fine scale interpolation between closely-spaced wells
- Estimation of uncertainty to assess risk
- Improvement of the resolution and detail of standard seismic inversions
- Generation of lithotype (e.g., sandstone, shale) volumes
- Estimation of porosity from impedance
- Integration of high resolution well data with low resolution seismic
- Creation of inputs for reservoir simulation

EarthModel FT and RockScale® provide the speed and accuracy required to make ongoing reservoir modeling a practical component of field management.

For more details on EarthModel FT and RockScale, visit www.cgg.com/jason.