Quantifying uncertainty through the Roxar 'Big Loop'

This article has described how new technologies can help Asian asset teams achieve a closer integration throughout the seismic to simulation workflow - between the classical domains of geophysics, geology and reservoir engineering.

The foundation for this approach is the Roxar 'Big Loop' workflow and it's new evergreen, ensemble workflows that can be refined, updated and used to test various assumptions, as modelers and engineers together move through the different decision gates. The result for Asian operators will be improved information for field development planning and well placement and better investment returns from reservoirs - crucial at a time of low oil & gas prices.

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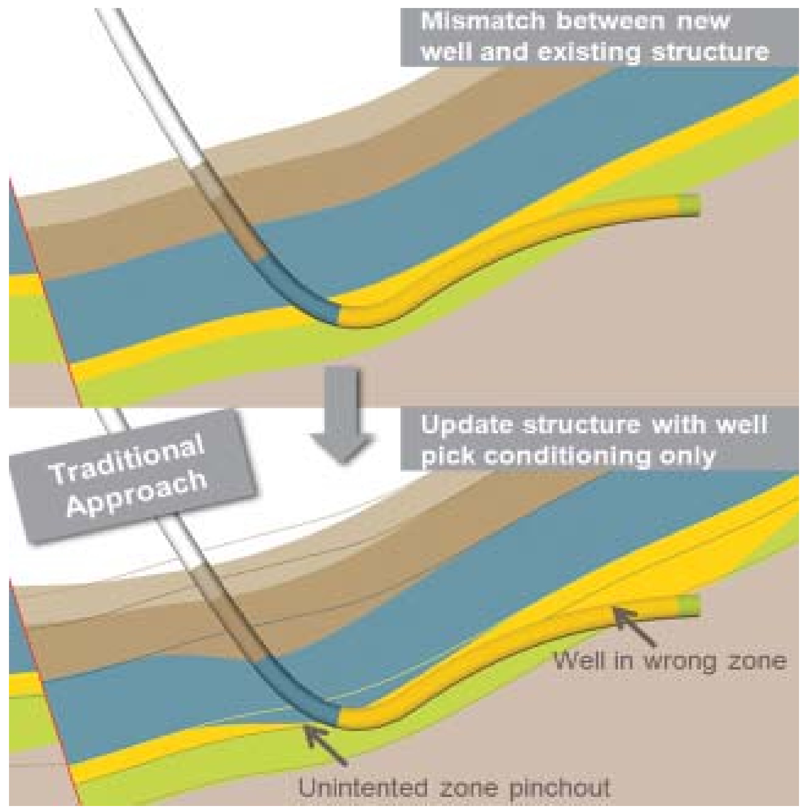
The calculating of uncertainty within the reservoir's geological structure is one of the most important factors for identifying both in-place and recoverable hydrocarbons in Asia today. Yet, while its' significance is well-known to practitioners, too often such uncertainty is overlooked.

While time and resource constraints may often be the reason for this, in many cases the structure of the reservoir modeling workflow and its integration between different domains are reasons as well.

The sequential focus of many reservoir modeling workflows and reservoir simulation's limitations (where changing the geometry of the simulation grid is almost the same as starting again) means that that the structural model is often 'locked in' as soon as the structure has been defined. This rules out future updates – even when fast changing data arrives– and can lead to a higher risk of geological inconsistencies



emerging in the simulation model(s).

Linked to this sequential approach is the lack of integration between different disciplines and domains, where uncertainties are sustained within each domain rather than being captured and propagated throughout the whole workflow.

Against the current industry backdrop of low oil prices and a need to increase investment returns, this article will argue that there is a need for improving the approach to reservoir modeling in Asia today - both to improve efficiency and to make better decisions.

This article focuses on the importance of the Roxar 'Big Loop' approach to reservoir modeling and its three main characteristics. These consist of the evergreen nature of the workflow through which customers can keep their reservoir models up to date; the ensemble workflow where the solution allows risk to be quantified across the portfolio and uncertainties propagated from where they belong to where they matter; and the collaborative approach where - through implementing the 'Big Loop'- customers can improve the efficiencies and integration of their different disciplines.

The result will be a repeatable and automated workflow that is easy to update, where uncertainties can be added at any level, and that generates crucial information for future field development and planning decisions in Asia.

Through implementing the 'Big Loop' approach to reservoir modeling - customers can improve the efficiencies and integration of their different disciplines

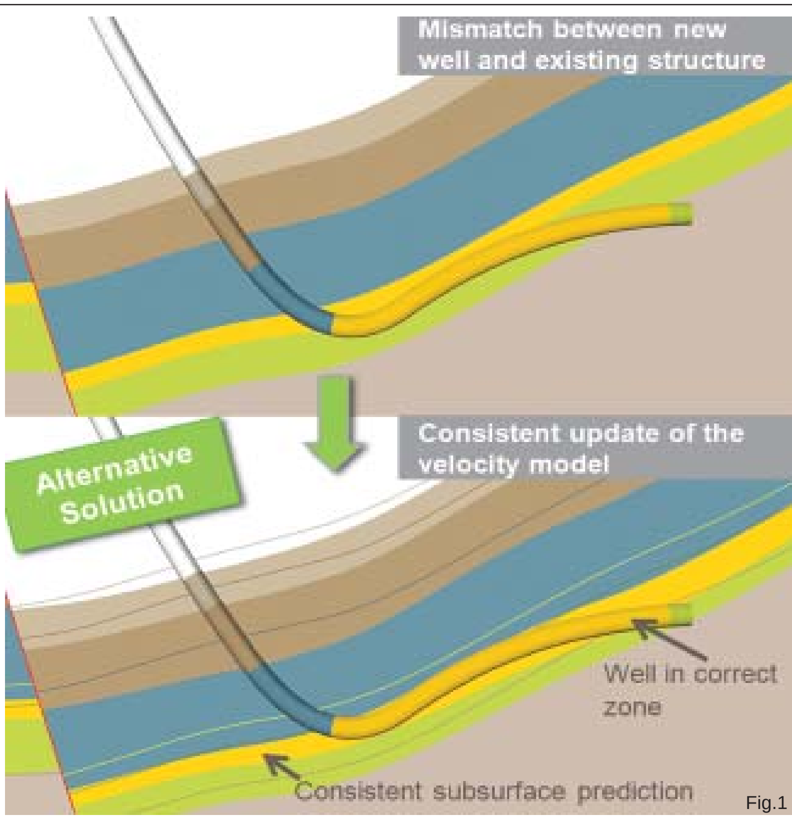


Fig.1

Updating the Velocity & Structural Model

One key part of the new workflow is the automated updating of the structural and velocity model based on a Bayesian geostatistical approach to depth conversion.

The updating of reservoir models can often be costly and manually intensive, particularly when including new well data. Traditional approaches where depth surfaces are conditioned to new well observations can also lead to unintended errors, such as zone pinch out and wells ending up in the wrong zone.

Velocity modeling and depth conversion also come with large uncertainties, mainly because there is a lack of data to condition to, particularly for estimating anisotropy or directional dependencies of seismic velocity.

Figure 1 illustrates how a new well has been drilled and where there is a mismatch between the depth information of the well and the existing structure (a and b). In such cases, the traditional handling of this problem is to condition the depth surfaces to the new well observations (c). This, however, can lead to unintended errors (zone pinch out and wells ending up in the wrong zone) as already mentioned.

Figure 1d, however, shows an alternative solution where the new data is viewed in relation to all the existing information, and predicts which changes are necessary to incorporate the new data in a robust way to ensure consistency. This can, for example, be an update of the velocity model, a local adjustment of the surfaces or a combination of both, depending on the relative uncertainties allowing for the changes.

Recent technology advances are leading to more efficient model updates of the reservoir structure (e.g. Stenerud et al. 2012)with the key outcome being a robust and integrated update of the velocity and structural model through a reusing of the existing workflow (figures 1b and d). This conditioning technique, combined with the existing modeling framework, allows Asian operators to support evergreen workflows consistent with all the latest information.

With this in mind, Emerson has developed tools for the automated incorporation of multiple structural realizations based on uncertainties in both the velocity model and seismic interpretation.

The solution is based on a Bayesian geostatistical approach to depth conversion ((e.g. Abrahamsen et al. 1991, Abrahamsen, 2005) that adds value to existing velocity modeling practices. The Bayesian approach combines all information on time interpretation, depth observations, thicknesses, surface correlations, velocity and associated uncertainties to make geostatistical predictions of the velocity model.

Figure 2illustrates how geostatistical approaches to depth conversion under uncertainty produces: a) a most likely model; b) an updated velocity model; and c) an uncertainty estimate of the prediction, given in one standard deviation. The prediction error (one standard deviation) gives a quantification of how much the horizons can shift and still be consistent with all input data.

The implemented algorithm within the Emerson approach ensures tight integration of the geophysics time/velocity domain and depth domain, strengthening model updates and uncertainty workflows. In addition, the algorithm allows for the utilization of depth information along horizontal wells – for example, conditioning the horizons to specific zones along the wells.

The benefits will be adjusted depth maps and a 3D grid that matches the new well data. This can be done quickly by adjusting the grid to maps, or through a rerun of the whole gridding and property modeling workflows, depending on how much impact the new well is predicted to make. The automated process also makes a most likely velocity model in sync with interpretation in time, depth information and their associated uncertainties.

The Evergreen, Ensemble Workflow – Automated Uncertainty Assessment

Too often in the past, there has been a tendency for domain-specific working practices to take precedence over the common goals of the modeling project. Moreover, uncertainties tend to be sustained within each of the domains, instead of a collective understanding of which parameters and input matters to achieve the project's end goals.

With an integrated framework, however, any discrepancies can be identified and fixed earlier in the process with all domains aware of the bigger picture and the modeling project's overall goals.

Emerson's solution to this challenge is to introduce the Roxar 'Big Loop' workflow that spans the relevant input data, such as seismic interpretation, right through to the end-goal of the

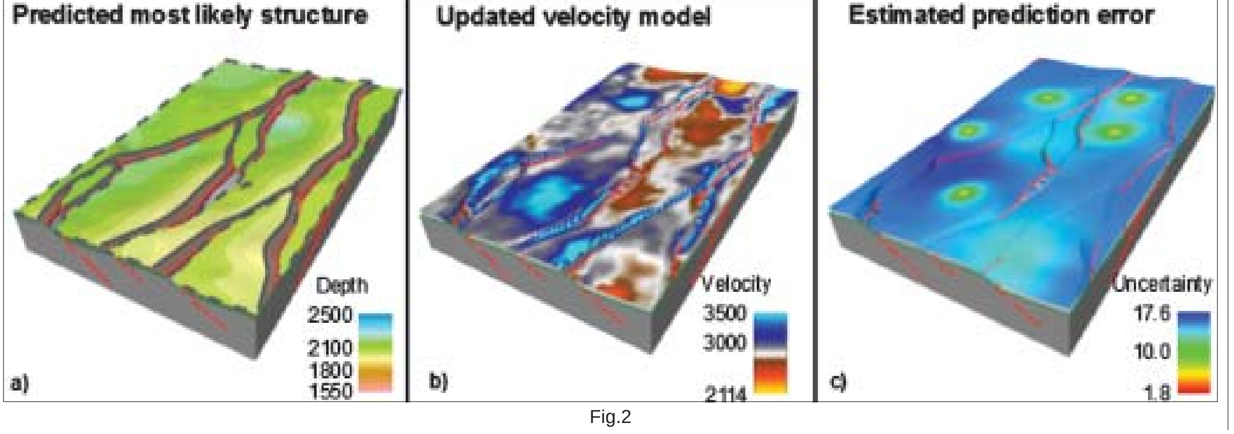
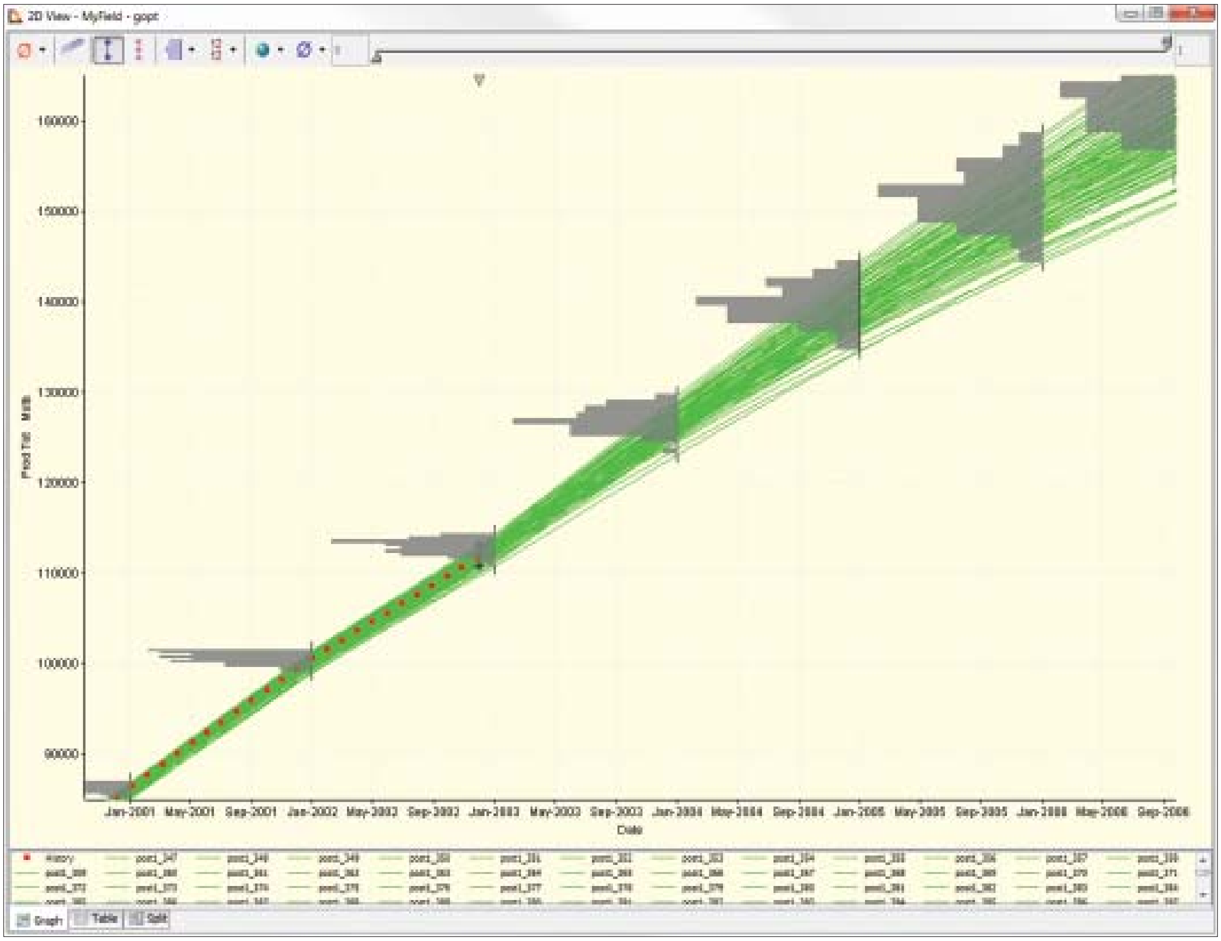


Fig.2



Calculation of prediction uncertainty from an ensemble within Roxar Tempest

project, such as in-place volumes or production forecasts.

This is achieved by providing a direct link between the geomodeling workflow and simulation and developing an automated workflow that combines the Roxar RMS reservoir modeling software suite with the Roxar Tempest reservoir engineering software suite and its uncertainty analysis tool, Tempest ENABLE.

Once the workflow has been set up, it can be run automatically to produce as many realizations and simulation runs as needed. The outcomes from these processes can then be used to understand the sensitivity and interplay of the many parameters involved. Hence, uncertainties can be added in the domain where they belong (for example, static), and propagated to where they matter (for example, production).

While Roxar RMS has an extensive workflow manager that supports automated workflows with the export to flow simulators a key outcome, Tempest ENABLE can control the generation of input parameters and their distributions, as well as the import of simulation results from all common simulators.

For each simulation run, for example, Tempest ENABLE calls Roxar RMS to automatically run the workflow with specified parameters and couples the output to simulation. This automated setup is the foundation for generating ensembles of models

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encompassing the many uncertainties, including those from the geophysical, petrophysical or geological domains.

With such an effective and automated ensemble-based workflow, more time can then be spent where it really matters, such as analyzing input data, testing assumptions for improved understanding, and optimizing the field's development strategy.

Another positive by-product of the new workflow is that of increased collaboration between asset members and different domains.

With the new approach, all asset members will share a common workflow and contribute in the same time frame. The simulator, for example, can immediately pick up changes in the geomodel and its' impact can be utilized for predictions. In this way, each specialist can see the direct influence of his or her domain on the bigger picture.

In addition, what is carried out in one domain can be automatically tested with a shared responsibility for tasks across asset members who must collaborate in choosing the correct parameters. This allows for uncertainties to be added in the domain they apply to, quality controlled by the domain specialists, and further propagated throughout the workflow to evaluate the sensitivity relative to uncertainties in other domains.

Concluding Thoughts

This article has described how new technologies can help Asian asset teams achieve a closer integration throughout the seismic to simulation workflow - between the classical domains of geophysics, geology and reservoir engineering.

The foundation for this approach is the Roxar 'Big Loop' workflow and it's new evergreen, ensemble workflows that can be refined, updated and used to test various assumptions, as modelers and engineers together move through the different decision gates.

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References

Abrahamsen, P. [2005] Combining Methods for Subsurface Prediction. In Leuangthong, O. and Deutsch, C.V. (Eds.) Geostatistics Banff 2004, Vol. 2, Springer, Dordrecht, 601–610.

Stenerud et al, 2012, SPE 159746 "Added Value by Fast and Robust Conditioning of Structural Surfaces to Horizontal Wells for Real-World Reservoir Models. dewjournal.com

about the author

Based in Kuala Lumpur, Eirik is Regional Director Asia Pacific for Roxar Software Solutions, part of Emerson Process Management, where he is responsible for the sales and service of all Roxar software products throughout the region. Eirik has been at Roxar since the year 2000 with previous roles including Software Engineering Manager, Marketing Manager and Principal Software Engineer. Eirik is a graduate of the University of Oslo.