JACTA Links Up with Streamline Simulation For Complete Reserve Uncertainty Assessment

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Introduction

For the latest release of JACTA 1.2, T-Surf Corporation is proud to have joined forces with Streamsim Technologies to integrate the streamline-based flow simulator 3DSL within JACTA, allowing users to go beyond volumetric uncertainty assessment and evaluate reserves uncertainty based on the dynamic behavior of the reservoir. This paper recalls the need in the oil industry for a product such as JACTA and the value it brings to reservoir modeling and management. The link with 3DSL is then detailed.

Background

With the emergence of asset teams and the advances in visualization, immersive and collaborative technologies, in which gOcad plays an important role, shared earth models are increasingly providing the basis for reservoir management decisions. In the process, they are forcing an overlap in the work performed by traditional disciplines and a consistency between geophysical, geological, and engineering models. Each element of the earth can no longer be considered as an isolated element but rather must be evaluated through the combined impact on the end result, and particularly on the estimation of uncertainties, which drives engineering and economic decisions.

Uncertainty exists at all levels of the construction and exploitation of the earth model, starting with measurements of raw data and its interpretation. There is uncertainty in seismic interpretation, and also in the velocity model, affecting time-to-depth conversion in the structural model. For the petrophysical model, uncertainty is due to poor sampling of the complex and heterogeneous subsurface. Finally, there is uncertainty on the specifications of the flow model. The combination of these uncertainties affects one's ability to understand and predict reservoir behavior and to reliably forecast reservoir production.

Assessing the cumulative effect of all these sources of uncertainty with stochastic modeling and multiple scenarios can rapidly become overwhelming, yet it must be done. This requires tools that are able to (i) account for the complete range of uncertainties, from time-to-depth conversion and structural modeling to property modeling and flow simulation; (ii) identify the critical sources of uncertainty; (iii) assess the impact of key uncertainties on specific reservoir management decisions; and (iv) assess the best course of action that will reduce these critical uncertainties, i.e. refining the interpretation models, or gathering new data. In addition, storing thousands of stochastic realizations is usually impractical, so it must be possible to recreate a limited number of realizations, which are most representative of the uncertainty affecting the reservoir management decision.

JACTA aims at providing a solution to all four issues raised in the previous paragraph. All of JACTA's new developments and strategic links make JACTA the ultimate tool for reservoir risk assessment and management.

JACTA

JACTA is the ideal tool for today's integrated asset team. It brings together geophysical, geological and reservoir engineering expertise for a better understanding of the elements contributing to the construction of a reservoir model, their nature, their interdependences, their uncertainty, but most importantly their impact on reserves estimation. By driving users systematically through all aspects of reservoir characterization and modeling, JACTA enables capturing and integrating: (i) the structural uncertainty of the reservoir derived from coarse seismic resolution and time-to-depth conversion errors; (ii) the internal architecture of the reservoir: facies, petrophysical property distribution; (iii) fluid properties; and (iv) fluid contacts. With JACTA's latest link to the streamline flow simulator 3DSL one can also investigate the flow response of high-resolution geological models, assess production uncertainty, and field development strategy. JACTA's additional new link to Microsoft's Excel allows real-time evaluation of economic feasibility.

JACTA, originally developed for TotalFinal-Elf, is a Plug-in to gOcad allowing users to access at anytime all of gOcad's functionalities: structural modeling, velocity modeling, stratigraphic grid construction, geostatistics, and state-of-the-art visualization. Users are guided in a systematic fashion through the entry of all parameters relevant to the construction of a 3D earth model as well as those contributing to static and dynamic volumetric estimations. The uncertainty associated with each parameter is also specified at that time. An element or parameter of the 3D model can either be deterministic, stochastic, or sampled from multiple (weighted) interpretation scenarios (or stochastic simulations generated externally to JACTA). The user can then execute a large number of "nested" simulations, which account for the interdependencies between the different modeling steps. Volumetrics resulting from each realization are displayed in real-time so that users can monitor the simulation schedule and stop the simulations, modify parameters, and resume the simulations without impacting previously generated realizations. JACTA's monitoring window allows users to understand the contribution of

the different modeling elements on the final volumetric estimations; it forces feedback by pointing out the largest uncertainties where a more refined modeling is required (or more data is needed) and those that are irrelevant and can be more coarsely estimated. Because JACTA has been implemented specifically to run many realizations, it is extremely efficient and fast. In addition, no 3D models are ever stored on disk or in memory, instead the user interactively asks JACTA to recreate the realizations that are relevant, or simply requests specific percentiles given the many static and dynamic ranking criteria available.

JACTA-3DSL

The link to 3DSL brings tremendous value to the JACTA workflow. Because 3DSL is a streamline-based flow simulator, it is ideally suited to simplified flow physics modeling on high-resolution geological models allowing for run speeds orders of magnitude faster than finite-difference flow simulators. 3DSL can rapidly simulate the flow performance of *all* realizations allowing one to rank and screen each model based on dynamic data, such as cumulative oil production, water breakthrough, or oil rate. Once all models are processed one can either perform increased physics simulations using 3DSL on some statistically representative models or export the representative models to a conventional simulator.

By integrating 3DSL inside the JACTA loop, 3DSL flow results (e.g. oil produced, water-cut…by well or field…) can be used for ranking purposes, in the same manner as other static JACTA volumetric results, to select key models for further detailed analysis. As Figure 1 demonstrates, the rank of a particular model can vary drastically depending on whether ranking is based on a static property such as oil volume, or a dynamic property such as oil recovered. For most purposes the ranking and screening of realizations should be deduced from dynamic properties such as oil recovery as these properties most directly affect project economics.

JACTA-3DSL also results in a product well suited to reservoir management studies. With JACTA-3DSL one can quickly investigate alternative field development strategies, such as well placement of infills, all in the face of uncertainty.

Pressures and saturations distributions as well as streamlines can be viewed and animated in gOcad, giving users a real feel for the dynamic behavior of the fine-scale reservoir models directly within the gOcad environment, see Figure 2. By avoiding the need to upscale in order to perform conventional flow simulations, geologists and engineers can straight-away understand the flow response of the fine-scale models, allowing them to identify potential problem areas early on.

Furthermore, a link to Microsoft's Excel has been developed to export all JACTA volumetric results seamlessly to one of the most popular commercial spreadsheet application, see Figure 3. Those same results can be displayed dynamically in Excel as the simulations are performed. 3DSL's production information as a function of time is

also available in Excel per well and on a field basis and production plots are automatically generated. What this means is that after or even during a JACTA run, economic models can be plugged-in to Excel to capture simulated volumetric and production profiles in a straight forward fashion. In addition to exporting all volumetric results from JACTA to Excel, summary statistics, as well as cross-plots and tornado charts exhibiting possible correlations between the different simulation levels, are automatically generated. The contribution of the uncertainty of each of the modeling stages to the total variability of the system is also computed.

In this first release of JACTA-3DSL, only the Tracer functionality of 3DSL is utilized; subsequent releases will include 3-phase immiscible and black-oil models.

Conclusion

The integration of JACTA and 3DSL yields a very powerful tool not only for reserve estimation but also for true reservoir management. JACTA-3DSL tackles the complexity of a 3D heterogeneous reservoir, uncertainty, and fluid flow in one integrated loop. It is designed for today's integrated asset team, where geophysicists, geologists, reservoir engineers and management interact together to construct a reliable, consistent model of the earth that can be used and updated throughout the life of the reservoir, from exploration to abandonment.

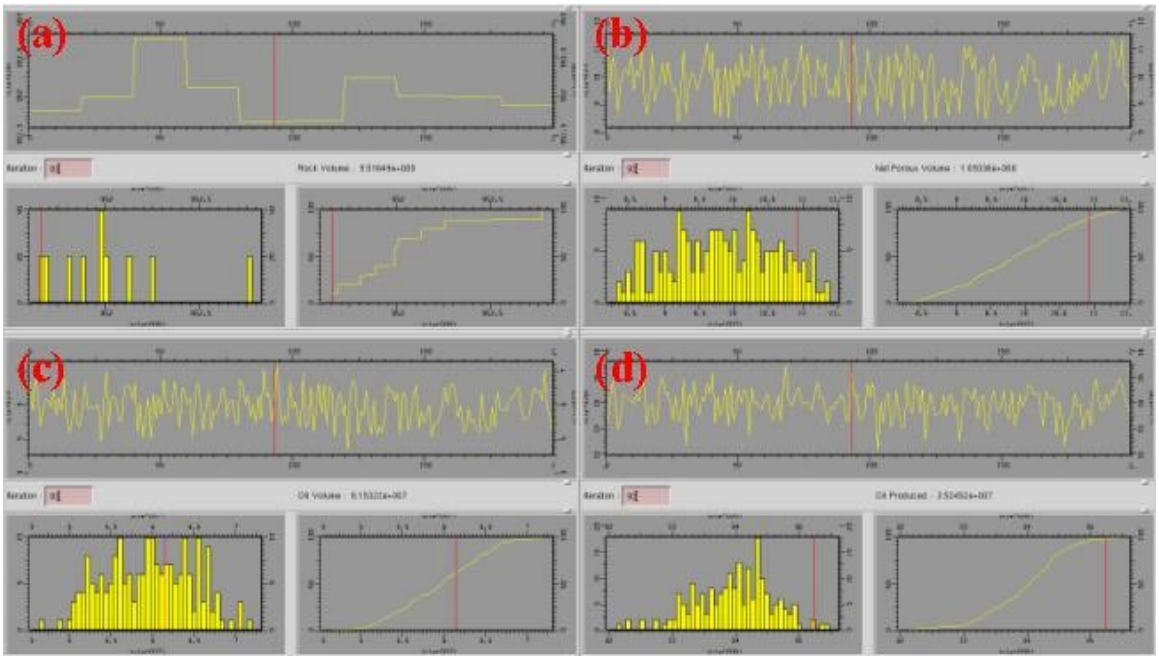

Figure 1: Results of a JACTA run showing that a same realization will have a different rank depending on the chosen criteria, the CDF (right bottom plot of each picture) graphically shows the rank of the realization : (a) Gross Rock Volume – lowest rank; (b) Net Porous Volume – high rank; (c) Oil Volume – average rank; (d) Oil Produced – highest rank.

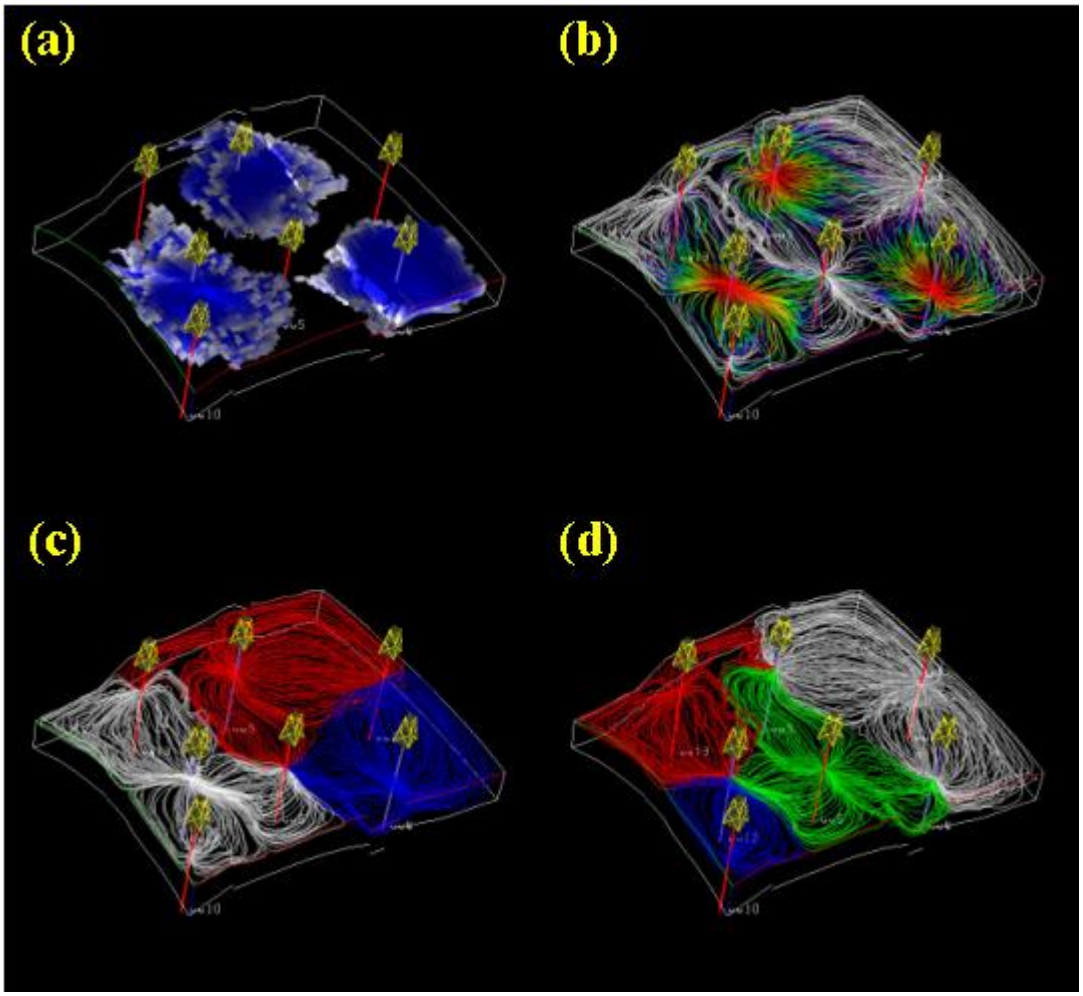

Figure 2: Visualization in gOcad of 3DSL flow simualtion results (3 injectors in blue and 4 producers in red): (a) 3D animation of saturation profile; (b) Streamlines with time-of-flight displayed; (c) Streamlines showing areas contacted by each injector; (d) Streamlines showing areas drained by each producer.

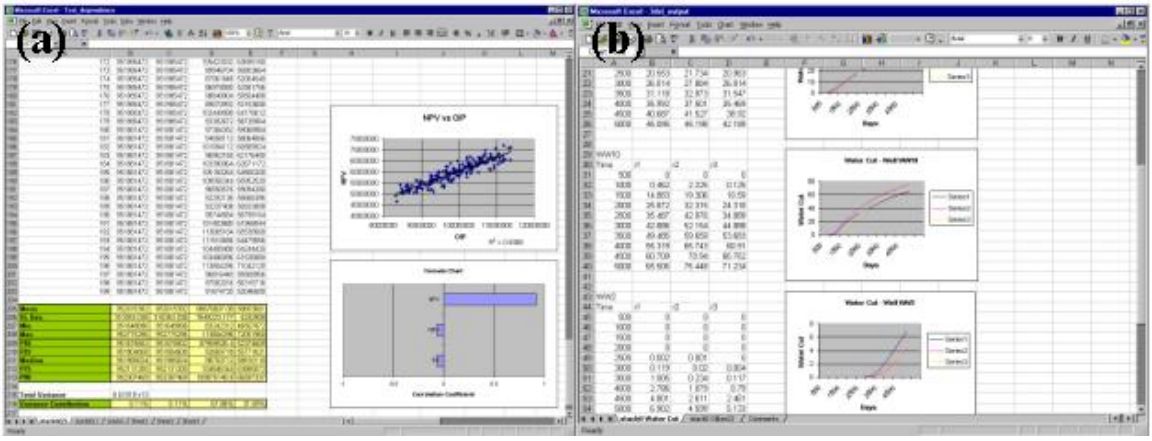

Figure 3: JACTA-3DSL results exported dynamically to Excel: (a) Simulation results with summary statistics, cross-plot and tornado chart; (b) 3DSL results and graphs of production information, e.g. cumulative oil produced, water-cut...