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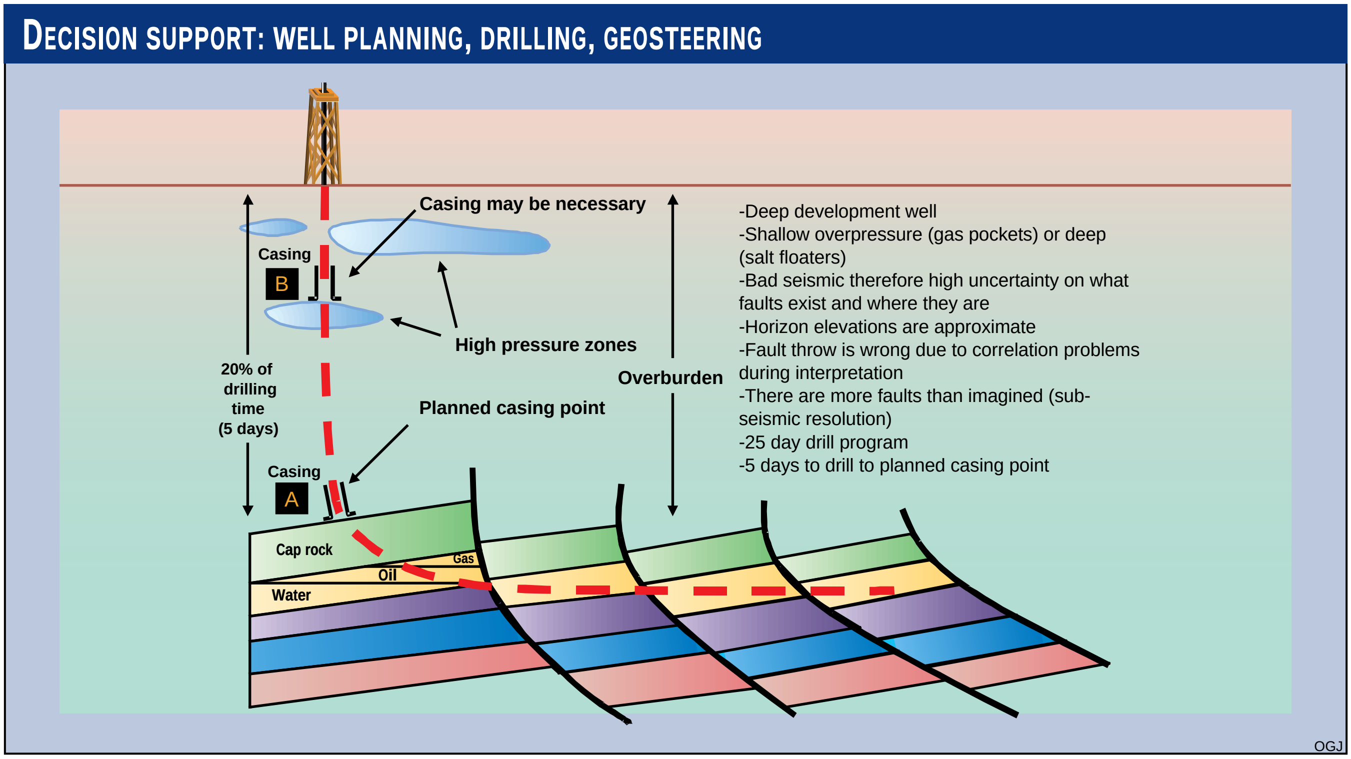
Fig. 1



OPEN COMPUTING PLATFORM DUE FOR SHARED EARTH MODELING

Dan Schenck *Petrotechnical Open Software Corp. Houston*
Steve Daum *Petrotechnical Data Systems The Hague*

An industry project with potential to change upstream oil and gas work will take an important step forward later this year with release of initial specifications for an open computing platform for shared earth modeling (SEM). The specifications will carry the trademarked name *epi*SEM.

An article in Oil and Gas Journal last November described the collaborative initiative, coordinated by the Petrotechnical Open Software Corp. (POSC).[1]

This article expands on some of the key ideas behind the project and reports on its progress.

The challenge

The POSC SEM project is a collaboration between the following sponsoring companies: Agip (ENI SPA), Chevron, Institut Français du Pétrole, Landmark Graphics, Mobil, Petrotechnical Data Systems, POSC, Schlumberger/GeoQuest, Shell, and Statoil.

The sponsors have developed an understanding that a shared modeling environment is one in which the individual computer views of the subsurface, obtained through series of disparate scientific analyses, can be made to reinforce each other through iterative and interactive processes of experimentation and comparison. They believe that innovations in SEM resulting from this project will bring benefits to two communities: 1) oil and gas companies and 2) vendors of technical computing software for the exploration and production industry.

For oil companies, the goal of the POSC SEM project is to enable the earth models constructed by engineers and earth scientists to be developed more efficiently and to be used more effectively to improve decision-making. As a result, this community will benefit from increased well success, reduced time to first oil, reduced operating costs, and increased recovery rates.

For the E&P vendors, the goal of the project is to define the framework for an open computing platform for SEM. This community's benefits include the establishment of an effective mechanism for integrating current products, reduced infrastructure costs, a lowered barrier for entry to the market for niche vendors, and a vehicle for building the next generation of earth-modeling software.

Enabling the integration of the drilling domain with geological and geophysical data is emerging as one of the initial themes of the project. In the future, however, a shared modeling environment must be capable of integrating new technologies quickly and easily. An example is the emerging technology of multiwell seismic, which offers the promise of high-resolution measurement of reservoir rock properties throughout the reservoir zone and the tracking of small-scale changes as hydrocarbons are produced.

A major challenge for the project will be to design *epi*SEM with the flexibility to include support both for new technologies as well as support for the current tool suites. By incorporating a flexible design, *epi*SEM will provide a solid foundation for the development of current and future generations of earth-modeling products.

An initial challenge for the project was to decide where to focus early efforts.

How SEM might work in field development

THE PETROTECHNICAL OPEN SOFTWARE CORP. shared earth modeling (SEM) project has developed real-life scenarios for application of SEM concepts.

Schlumberger/Geoquest, a project sponsor, assembled this description of a progression of high-level use cases for the life cycle of a field development.

Case A— Exploration and prospect generation

A new area is targeted for prospect analysis, and a 3D seismic survey is shot spanning several square kilometers. There is no prior drilling activity except for some wells in remote leases several kilometers away.

Part of the survey shows some prospect potential, and the 3D seismic is interpreted for several key horizons covering that area. Only faults that are clearly visible are interpreted, although other anomalies exist which may also be faults.

Interpreted horizon and fault structure boundaries are modeled in time within the selected prospect area extent, and structures within the SEM are defined. Estimates of rock properties (velocities, porosity, etc.) are made from data from the remote wells and correlation with the geology and seismic of the new region.

From a coarse velocity model based on these estimates, the structural model is converted into the depth domain. The depth-converted structural model allows a volumetric analysis of the prospect. 2D and 3D maps of the model are documented along with other supporting data, all of which are presented for final determination of the prospect.

Case B— Well planning

It has been decided to go ahead with planning for up to three discovery wells for the Case A project. Several months have passed since the work on Case A was completed since time was needed to present to management and other investors.

The Case A project data set is recalled without any further changes to it and used as the basis for locating the trajectories of three wells. Some of the faults appear to seal parts of the formation and are critical to the process. The targets are often identified on the background of seismic information in time and subsequently depth-converted for the trajectory planning.

Well planning is completed, and the well paths and supporting data are added as part of the project.

Case C— Discovery

The first well of Case B was a hit so a new effort is begun to register the discovery with the necessary regulatory agencies, modify planning of all subsequent wells, etc. The new well brings with it significant new data, including a checkshot survey.

From this new data, the Case A project is updated, the old structural models in depth domain are discarded, and new ones are generated which honor the velocity data from the checkshot. This velocity information is carefully extrapolated, and a new depth conversion is performed. Based on this depth model the volumetrics are rerun. In this way, all aspects of the project are upgraded to reflect the discovery well data, including replanning of the other two wells.

Updated maps and data are presented to outside regulatory agencies to set up field rules (pooling acreage, drilling densities, etc.). This phase of the project is archived as the discovery version and will be retained intact for legal and other reasons.

"The problem landscape is daunting," said Dan Schenck, POSC business unit manager and project coordinator. "In many ways, shared earth modeling requires the ultimate collaborative computing environment in order to support a complex collaborative work environment. In essence, it is all about providing a new generation of decision-support tools of the quality required to fulfill current and anticipated business requirements."

Schenck said that the project would not achieve that goal if *epi*SEM imposed arbitrary technical constraints in the name of standardization or presented mandatory requirements that rendered existing software largely obsolete.

For these reasons, the team agreed to adopt a lightweight route to standardization. This means initially collaborating on specifications that provide added value to end-users by enabling integration of established and emerging products from different problem domains and developing specifications for software components that are widely viewed as "near-term" commodity.

The sponsors' vision is that the industry migrates to what Tim White, director of strategic earth modeling initiatives at Landmark Graphics Corp., calls "model-centric" ways of working. In this paradigm, the shared "models" regularly add value to the work flow by integrating data, interpretations, and associated knowledge, thereby providing guidance and support for the asset team throughout the asset's life cycle.

Steve Daum, managing director of Petrotechnical Data Systems in The Hague, added, "Some would argue that too often the value has flowed in the opposite direction: technicians producing ever more sophisticated, complex, and expensive subsurface models which cannot be shared and therefore fail to effectively support cross-discipline decision-making. Too often we tend to get distracted by the technology and lose our sense of perspective. Effective sharing of earth models should provide the means to keep perspective: to balance the facts, the findings, and the views of the asset team members."

An SEM platform is a prerequisite for White's vision of a "model-centric" E&P organization. To be effective, models need to be synchronized, but the team has recognized that the real problem entails much more. It means maintaining data dependencies; capturing the who, what, where, when, why, and how of change; quantifying uncertainty; ensuring accessibility; unifying wide variances in time and distance scales; and allowing different perspectives on the same information.

Drilling down

Much of the project's early work has been focused on generating requirements by developing domain-specific scenarios.

Robin Getty, project requirements engineer and principal consultant with Petrotechnical Data Systems, tasked with developing the requirements-gathering approach and coordinating a workshop program, adopted a two-phase approach.

"First we got everyone on the same page via a comprehensive questionnaire (38 open questions) designed to identify

Case D—Field development

In this post-discovery phase, as new wells are drilled, the project database is continuously updated to support well planning, drilling, and production activities, and these updates are done on a clone of the discovery version.

Any intermediate versions are kept as snapshots only at key milestones in field development as required by management or for legal purposes. Where necessary, the layer velocity properties are updated, and the depth models are locally corrected to honor the effective depths of the drilled events. Reservoir characterization is kept as current as possible with all known data by continuously updating a field development version of the project.

Structural models are periodically rerun to update the SEM. The arrival of checkshot survey and other new sources of velocity data supports a higher-quality mapping from time to depth domain. This iterative procedure should be tracked in some meaningful way, possibly by versioning.

Case E—Field production

To optimize well production and field drainage, gas injection wells are introduced. Locating these wells requires a flow-simulation analysis of the reservoir, which it turn requires a 3D model of key reservoir properties.

The SEM must contain all the necessary structural boundary elements required to drive 3D property modeling. The SEM is updated to include the 3D property distribution, then used to drive flow simulation.

Case F—Field production optimization

The usefulness of a time-lapse 3D seismic survey is investigated by sensitivity analyses.

The preproduction well logs and well logs obtained after some production time are used to estimate the effective parameters to be used in the fluid-substitution modeling. Synthetic seismic responses are modeled. The observed changes were regarded large enough to be visible through surface seismics.

This sensitivity analysis is also extended to a simulated time model in the SEM. The theoretical changes are mapped, and the areas where the expected effect is above a given threshold are considered as 3D time-lapse seismic targets.

A new 3D seismic survey is shot. The surface installations, which were not present in the preproduction survey, caused illumination and coverage problems in the time-lapse survey. The new survey is carefully calibrated by correlation of known events. A correction field is developed and applied to the entire seismic survey in the SEM. The calibrated time lapse and the original seismic survey are now correlated.

Differences are attributed to the model components where production effects originate (parts of layers in the SEM). The results are compared to the SEM flow model. The flow model is subsequently updated to include the findings of the time-lapse survey. Undrained compartments are identified. They are targeted by some high-angle boreholes that efficiently drain a series of small reservoir compartments.

In another area, a gas reservoir is obscuring the lower parts of the reservoir. The deployment of permanent cables with 4-component sensors is considered. The SEM serves the necessary data for a sensitivity analysis by elastic modeling. The cable length can be optimized to the reservoir.

The first 4-component service is used to set up the SEM with elastic parameters (compressional [C] and shear [S] velocities). The conventional seismic time is complemented by P-S converted and pure S-S reflection travel times, effectively providing the SEM two additional time property models.

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the priorities within the sponsor companies," Getty said. "We are currently following through with a series of multidisciplinary workshops with the sponsors' domain specialists."

Project sponsors have contributed a wide range of background material to the project. This includes their individual business processes, study reports, and visions on a range of earth science and business activities. The project is using this material to develop realistic scenarios that reflect significant problems and to stimulate further analysis of solutions (see sidebar).

With so many issues and concepts to be considered, the project has converged on specific requirements through the use of formally structured problem statements. These outline the symptoms of the problem, summarize the source of the problem, describe who's impacted, catalog the implications, and define a vision of an ideal solution. Statements gathered to date focus on problem areas such as using geological models for geosteering, well planning and uncertainty, knowledge capture, immersive visualization, model management, change management, and shared services.

The analogy of a blackboard[2] has been used in the workshops to help establish requirements for computer-system services to support the dynamic collaboration between modelers and modeling software. Imagine a group of domain specialists gathered around a blackboard working through a significant multistage problem. The blackboard is more than just a space for writing; it represents an area that is simultaneously shared between all collaborators, and it also contains all the artifacts of the collaborative activity.

Collaborators can look at the current state of the solution and contribute to interim solutions as and when they are able. They can cross out or change interim results, create new results, and scribble notes on their current assumptions. Social graces, the number of bits of chalk, and the nature of the problem all determine the degree to which the interim solutions can be worked on in parallel. However, the progression of steps toward a solution of the initial problem is there for all to see.

Treating the SEM as a sort of blackboard during the workshops with project sponsors has proved to be fruitful. Issues with versioning, change management (notification, propagation, and acceptance), long transactions, logging, locking, audit, replay, and knowledge-capture all become very tangible problems in this paradigm. These are driving essential requirements for a common framework to support SEM activities.

The sponsor workshops have also been developing detailed descriptions of how an ideal SEM environment could be used to support real, practical, and high-value business decisions. Underlining one of the main interest areas of the project, Shell International Exploration & Production BV in The Hague led the development of illustrations of how SEM would improve decision-making at three key stages of well planning and drilling:

• In planning, illustrating how *epi*SEM might support optimization of well path, well design, and drilling program.

• In drilling through overburden, illustrating how *epi*SEM might support incorporation of measurement while drilling (MWD) into a pseudo real-time multidisciplinary decision support system for performance optimization and accurate placement of casing at first sealing fault (multiple slip fault scenario).

• In horizontal (multilateral) drilling and completing of multiple blocks separated by slip faults, illustrating how *epi*SEM might support use of MWD to optimize well path and completion design and provide decision support should a block turn out to be dry (Fig. 1). This could be pseudo real-time decision support for a drilling plan update or—more ambitiously—reevaluation of the field development plan options including implications for production forecast, facilities design, and expected monetary value (EMV).

The contributed background material, the workshop analyses, and supplementary research are all providing rich sources of valuable requirements for input to the design phase of the project.

Paul Maton, principal consultant with POSC Europe and chief *epi*SEM architect, said, "We are specifying e*pi*SEM in several forms. The first is in terms of geological and engineering things and their behaviors. The second are dialogs of interactions between *actors* representing the *epi*SEM user and the computer (known as use cases). These will be expressed in natural language and thus will be independent of any computer language or technology. Subsequent forms will involve computer-intelligible languages such as the unified modeling language (UML), which can lead to implementations using current computer technologies, for example COM+ and Java. The natural language forms are intended to remain useful indefinitely, being capable of accommodating evolution in E&P technology and of being recast in future computing technologies."

Software technology has begun moving in the right direction to support the sharing of earth models. Vendors have been integrating their own product suites, and the software industry is contributing open middleware standards—for example, Microsoft's COM / DCOM and the Object Management Group's CORBA—that are helping developers design and build truly shareable applications.

By defining an open *epi*SEM platform based on a firm understanding of the oil and gas decision-making process and designing it to take advantage of emerging middleware standards, the project will accelerate the arrival of compatible SEM products in the E&P marketplace. The POSC SEM project sponsors believe this will allow oil and gas professionals to achieve the ambitious goals we have envisioned.

The Authors

Dan Schenck is business unit manager for Petrotechnical Open Software Corp. Before joining POSC he worked for 8 years as a data management consultant with Texaco's Exploration & Production Technology Department and, before that, for 19 years with Cities Service/Occidental, where he was manager, technical systems support. Schenck holds a BS in geology from Wichita State University.

Steve Daum is managing director of Petrotechnical Data Systems, which he founded in 1993 after working as divisional manager for EDS Energy & Chemicals, Northern Europe. Earlier he worked as a field seismologist and research geophysicist for Seismograph Services Corp. and Geco. He holds a master's degree in natural sciences from Cambridge University.

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