**Abstract**

One of the most significant production challenges in the Jurassic region of the North Sea is the ability to generate accurate and geologically representative reservoir models due to issues, such as fault and stratigraphic geometry, truncation behaviour and the creation of viable simulation grids.

The Heidrun is an example of such a field, however, where these challenges are being met through the Roxar RMS reservoir modelling solution from Emerson Process Management (www.emerson-process.com).

This case study will demonstrate how Roxar RMS can tackle such geological complexities through the creation of a robust and reliable production model, with no simplifications and compromises, which can have a major impact on improved reservoir decision-making in the Heidrun field as well as having significant applications in other Jurassic-based oil and gas fields.
About Statoil and the Heidrun Field

Statoil is an international energy company with over 35 years experience on the Norwegian continental shelf and operations worldwide in 34 countries.

The Heidrun field is located offshore Kristiansund in the Haltenbanken area of the Norwegian Sea. Discovered in 1985, it came online in 1995, producing both oil and gas from Jurassic sandstone reservoirs in the Garn and Ile formations with further reserves in the Tilje and Åre formations. The Tilje and Åre formations are structurally complex and more difficult to produce from.

The field had production of 165,000 barrels (26,200 m³) of oil and 650 thousand cubic meter of natural gas per day in 2004. Its production in 2006 was estimated at 3 million cubic meters of natural gas and 140,000 barrels (22,000 m³) of oil a day. Oil reserve estimates for Heidrun were reduced in 2009 with new well targets continuously being considered in an effort to increase oil recovery (Source: Norwegian Petroleum Directorate).

The Heidrun field has historically been a very difficult field to model. A number of computer models have been built over the years, but have always suffered due to the available modelling software being unable to handle the fault geometries, including Y and lambda faults and multiply truncated faults, and the inability to accurately model the truncations associated with the major Base Cretaceous Unconformity (BCU).

If operators can generate geologically sound models in the Heidrun field, where correct fault and stratigraphic geometry and correct truncation behaviour remain constant challenges, this will have a significant impact on other Jurassic regions of the North Sea that face similar challenges.

The Challenges of Modelling Complex Fault Intersections

The fault geometries and fault interactions specific to Heidrun can cause great difficulties for the majority of reservoir modelling packages.

The presence of faults which intersect both up and down dip, and faults which mutually truncate, for example, can cause significant problems to modelling solutions that use fault surfaces defined by pillars.

These pillars comprise straight line segments, which often have to be shared by intersecting faults at the point of intersection. This may warp one or other fault shape in order to get a geometric fit, since pillars may not cross. Where faults can be made to intersect correctly, the modelling process is often still a long one, with decisions on individual faults made manually and without documentation or the ability to reproduce.

The result is that the model building process is one of the major bottlenecks of the modelling workflow, leading to over simplification and inaccuracy in the final model and severely limiting the structural complexities in the field.

In the case of the Heidrun field, the field not only had many faults, but also many difficult types of intersections. As this case study will illustrate, Emerson’s Roxar RMS and its structural model building system built and then refined the initial model in just a few days. The fine-tuning consisted of not only perfecting exactly the desired intersection behaviour but also iterating through various possibilities to find the one which fitted best the available data.

The Challenges of Modelling Complex Horizon Geometries

The Heidrun field also presents challenges relating to modelling horizon geometries.

Much of the Jurassic section is partially eroded by the Base Cretaceous Unconformity (BCU) and the rest is faulted. With complex fault intersections, the presence or absence of faulted horizons can be difficult to map accurately, especially where their occurrence is in areas of limited data.

Where such sections are eroded, using isochors to constrain horizon geometry is essential, particularly as the reservoir intervals are subzones between the seismically interpreted horizons and are observed largely through well picks. The construction of such isochors is a significant task in its own right.

Furthermore, the loss of the eroded section, even where the reservoir layers are correctly truncated by the unconformity, can cause problems when building the 3D grid, as grid layers can become distorted due to insufficient information about their true geometry.
About Roxar RMS

Roxar RMS is Emerson's flagship reservoir modelling solution and comprises 13 fully integrated software modules, including mapping, reservoir modelling, well planning, reservoir simulation and uncertainty modelling tools.

Roxar RMS comes with a suite of structural modelling tools which can reduce the time required to build a structural framework from months to weeks, thereby freeing up productivity to build more scenarios and reduce uncertainty. Features include high quality grids for reservoir modelling and simulation, with Roxar RMS having the ability to capture thousands of faults in a single model, and simulation friendly grids which are suitable for accurate production predictions.

The latest versions of Roxar RMS also come with new features to cope with whatever structural or modelling complexity is thrown at it, including enhancements to the seismic architecture to allow direct reference between the reservoir models and 3D and 4D seismic data, geological well correlation improvements, and new fracture modelling capabilities.

The Requirements

Statoil commissioned Emerson to provide a new model for the Heidrun field using Roxar RMS and its integrated structural modelling system. Whereas Statoil had previously utilised two software packages to model the field, they were now dependent on Roxar RMS achieving the operator's goals on its own.

Statoil wanted the system to improve the model of the Heidrun field which would form the basis of a future reservoir management strategy and help increase production from the field.

Statoil wanted to see an accurate model - a model which showed all the fault intersections as interpreted and that showed the horizons truncated according to the seismic. They also required a full 3D grid without a significant pinching out of the cells under the unconformity, enabling reservoir simulation engineers to pick the grid up and use it without the need for further editing. Modelling time, ease of use and reproducibility were also key criteria.

Stage 1 - Model Building

After importing the data, the first stage of the workflow was to step through the fault population and build the first model. In the Heidrun field, there were multiple sources of data for some faults.

A selection was made of the more problematic faults and the required input data defined - on an individual fault basis where necessary. Having built the initial fault surfaces, the fault model was examined for its intersection behaviour with the user able to specify extrapolation limits beyond available interpretation.

The precise line of intersection can either be accepted from the default model or manually adapted, using control points. Whilst this may sound cumbersome, the ability to handle all types of intersections automatically means that most faults could be accepted in their default geometry. Intersection lines were identified by Roxar RMS and the user has only to scan the fault model for places where the obvious choice may not really be the right one. If such incidents occur, then the truncation decision can be reversed and a new choice made.

Only where the data quality was too poor to adequately define the fault intersection was it necessary to make manual adjustments, such as inserting control points. Where control points are needed, the work is only done once, since the control points are stored as separate, additional data that can be used in later modelling iterations or even in completely different versions of the model.

As one can see, the majority of the modeller's tasks in this case was to quality control the model rather than construct it. In this way, Roxar RMS enables geologists and modellers to focus the majority of their time on making geological decisions about the model, rather than working around the limitations of the reservoir modelling software.

Stage 2 - The Stratigraphic Modelling

With a complete and accurate fault model being built and Quality Controlled in just a few days, the modeller can now move on to the stratigraphic modelling phase.

Given the well-developed faulting, faults were sometimes so closely spaced that high quality stratigraphic interpretation was not possible. To ensure that these areas were adequately dealt with to meet Statoil's high standards, an initial model was built and isochors extracted to check that they were geologically consistent. The input data was refined through a filtering of data points and amplified with the addition of control points until the seismic horizon geometry was precisely and reliably defined.
This provided the seismic scale stratigraphic framework with the reservoir intervals themselves resolvable only in well data. From this well data, isochors and vertical thickness maps were built to define the reservoir intervals. After some additional filtering and trimming, these were extrapolated to cover the full area, representing the original uneroded thickness and extent of the interval.

With these restored thickness maps, the horizon modelling can be set up as a single job, taking in the seismic interpretation, the isochors and any well data or other control data and using it all to build the model.

**Stage 3 - Developing the Grid**

The Base Cretaceous interpretation can be defined as an unconformity which allows it to truncate any underlying horizons it may encounter, whether they are derived from seismic interpretation or from isochore maps. The horizon model ‘remembers’ the geometry of the uneroded stratigraphy, however, and this can be used by the gridding tool to guide the construction of grid layers in the 3D grid, ensuring that the 3D grid is as geologically accurate as the horizon and fault models.

The erosion truncations, built through stratigraphic modelling, can be further refined by the input of pinch-out or erosion polygons, which help the algorithms identify precisely where the eroded section goes to zero thickness. This can be added in, similarly to adding additional data into the fault modelling - individually by horizon or as a global data source.

This allows the Roxar RMS modelling system to take advantage of every form of data that is likely to be available. Together, these features generate an extremely precise and watertight model that is immediately ready to start adding confidence and value to field production decisions, as was the case with the Heidrun model.

**Conclusions**

The ability to build geologically sound models in real-world, complex regimes has been a longstanding source of difficulty and delays.

In the Jurassic region of the North Sea, for example, the issues of fault and stratigraphic geometry, truncation behaviour and the creation of viable simulation grids are shared by many fields and have played their part in impeding field management for decades.

The Roxar RMS integrated structural modelling system allows geomodellers to rapidly build models, to spend more of their time refining their models and quality controlling them, and to achieve much more accurate results with much less effort than previously. Roxar RMS can also cope with more geological complexities in its model building with no compromises or simplifications.

As operators are faced with deeper and more challenging geological settings, any reservoir model that oversimplifies the obvious geological complexities is not going to deliver the vital information operators require for well planning and reservoir management today.

As this Heidrun case study shows, Emerson’s Roxar RMS is able to generate a highly accurate and geologically representative model – often in areas of poor data resolution – which accommodates all available data and geological complexities. This allows the Roxar RMS modelling system to succeed where other systems simply can’t cope.

To learn more please visit www.roxarsoftware.com or email us on rss@roxar.com