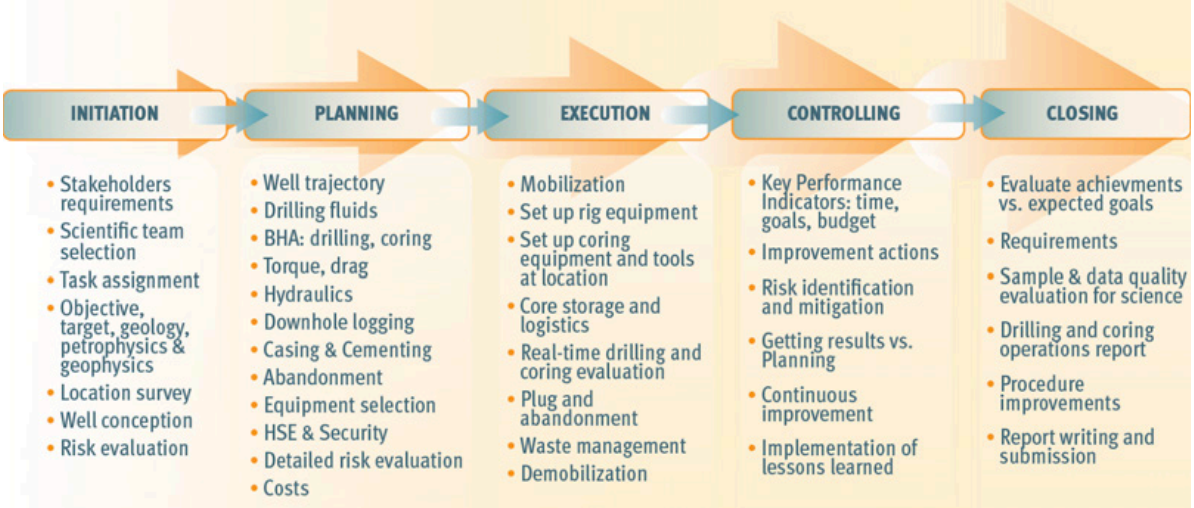

Fig. 4.2.6: Planning phases and well life cycle

These well planning software solutions are most often delivered as single, unified applications with integrated multiple software components. A description of the modules associated with the planning steps to plan a well is provided in the following paragraphs.

Geology and geophysics module

Modern Geology and Geophysics software for drilling planning takes subsurface information to generate geological knowledge and parameters out of these diverse data sources. The power of today's advanced computers, combined with broad data integration, allows geologists to apply many methods and technologies to evaluate their science data (Figs. 4.2.7 and 4.2.8). The final goal is to achieve a geologically consistent base for a thorough engineering project planning process.

These processes can be evaluated and qualified for the uncertainties that are inherent in both the input data and the variability of geology. The full capability of today's advanced geological interpretation and modelling software is generally defined by a few distinct functionalities:

- The efficient and thorough processing and interpretation of borehole measurements for optimal formation evaluation
- Advanced modelling tools used to construct structural and stratigraphic models, in order to validate and refine the geologic interpretation utilizing digital structural analysis tools
- The capacity to handle any amount of complex faults, under avoidance of simplifications
- Application of multiple geostatistical methods in order to assess and mitigate data uncertainties, and
- A seamless integration with seismic, oil field production and other data sources that enrich geological workflows, towards a direct process for generating geo-cellular simulation grids

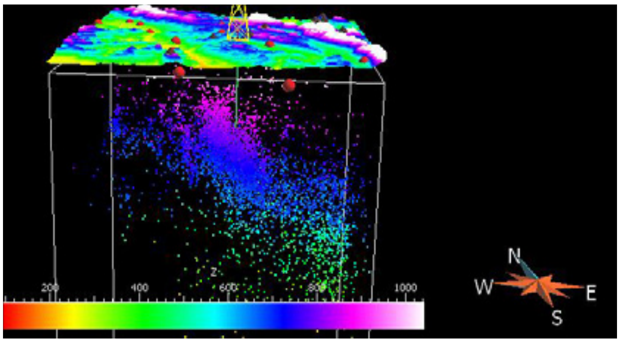

Fig. 4.2.7: 3D attribute integration in a model

When a project starts, the initial data screening will evaluate geologic formations and petrophysics of the projected subsurface area. In the project definition phase, the basic questions that a geologist will initially be challenged with are, for example, facies classification, borehole image interpretation from offset wells, lithological core interpretation and saturation determination.

In order to build the 3D geologic model, correlation and building of geologic cross sections will initially have to be performed. Interpreted well sections will be constructed from wireline logs that carry the data needed to perform stratigraphic correlation, while seismic data may also be incorporated at this stage. The G&G software then constructs net thickness maps while markers are interpreted and geologic zones of research interest identified. Stratigraphic information created during this interpretation phase is then directly used for the construction of the 3D stratigraphic model.

Modern software suites will construct structural 3D models automatically based on the stratigraphic column, as well as on interpreted faults and salt body structures. They are capable of defining fault-fault and fault-salt contacts automatically, and they can build horizons following the rules of sequence stratigraphy.

Horizons and faults will be identified by the software in order to create and suggest a sealed model that can be used later to generate consistent maps, velocity models, geological and flow simulation grids. An advanced 3D model should have none of the limitations of pillar-based models. It should be able to handle any kind of faulting, and can therefore efficiently represent any stratigraphy between horizons.

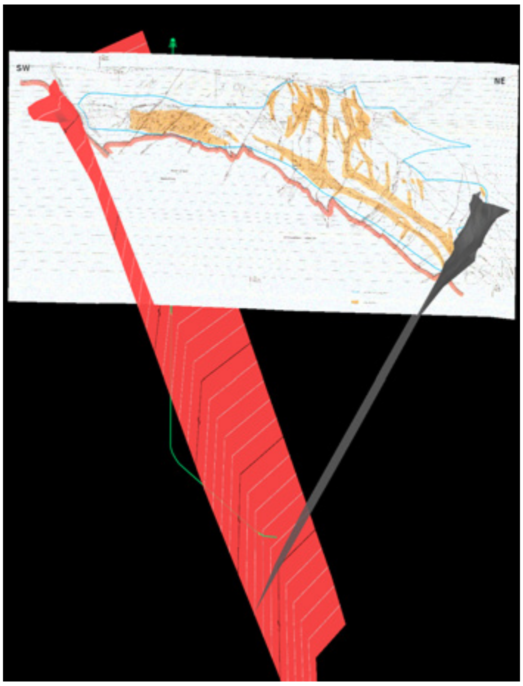

Fig. 4.2.8: Fault (red, grey) visualization in geologic section with well path (green) of Schneeberg-1 research well (courtesy: LfULG, State of Saxony)

The 3D geologic model contains further information about the paleo-geographic coordinates of all the cells of the geologic grid created inside the 3D model. Geostatistical algorithms may then be run inside the paleo-space in order to undo post-deposition deformation.

By applying a dynamic uncertainty-considerate workflow, the user can construct, based on this analysis, a reservoir property model by first performing a facies distribution per each layer, using a complete set of categorical simulation algorithms. For each facia, it should be possible to populate all the petrophysical parameters needed using kriging (statistical) or simulation methods.

As data uncertainty always heavily hampers or influences geological interpretation due to sparse information and being very interpretative, a uniform approach to uncertainties in petrophysics, structure and properties is therefore required. Uncertainty is not only present in the algorithm that the modeller chooses to apply; it is also present in all the parameters and the data used in those algorithms. Uncertainty about correlation coefficients, variogram range, or with porosity distributions requires a sensitivity analysis of all modelling input parameters. When dealing with uncertainty, the most important factor is to know which parameters govern and dominate a geological setting or model, so that the workflow can be optimized and steps can be taken to reduce this uncertainty. Integrated G&G software suites can help and guide the user in this process to substantially reduce model uncertainty.

The ultimate output resulting from a G&G software is the mathematical transform from static to dynamic models. The 3D model may be discretized to automatically construct a flow simulation grid, where all necessary faults are taken into account and all cell geometries are optimized for a high-performance flow simulation. Up-scaling between the fine-scale geologic grid and the coarser flow simulation grid should assure spatial integrity.

As the final step in modelling, the reservoir flow simulation grid can now be constructed in any geological setting for reservoir simulation and a so-called history matching. This includes fault geometry or fault inclusion in the flow simulation model by incorporating all faults, which are needed to perform an acceptable history matching. This is crucial and critical in all reservoir characterization tasks.

Most of the software application suites are built atop of a multi-user, multi-site and multi-OS data management platform. All modelling processes are encapsulated inside workflow management guides to also assist the occasional user, as well as to store all the parameters used to construct a model for audit ability and QC purposes.

Special attention should be given to the fact that all software applications are open, allowing outside vendors to add proprietary or third-party technologies as added on software solutions. This can involve plugins that have full access to other data models or an open framework for a fast prototyping environment that allows developers to creating new commands into the 3D visualization window and dialog boxes, and insert them into existing menus. Some G&G solutions even offer a high-level programming language to add new algorithms and processes directly within the user interface.

Well planning and management module

A well planning package is used to plan trajectories of new wells or side-tracks, multilaterals, and re-entry from existing wells. The trajectories simulations start from existing wellbore information and trajectories stored in the common database (Fig. 4.2.9). All critical well information, like local boundaries, lease lines, casing sizes, borehole sections, comments and survey tools error margins can be defined and visualized at this stage of the planning process.

Engineers usually start the well planning process with the collection of topographical field information, e.g., available GIS data and the global position of fields, sites and borehole locations in geographic coordinates (Fig. 6.8). On the computer screen the planner visualizes and identifies targets, including their shape, dimension, thickness, rotation, dip and offset in that planning stage.

Geological surfaces and faults can also be incorporated at this stage for visualization, and intersections by the simulated well