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Engineering a Directional Well Planning Software Solution

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ABSTRACT

Engineering a software solution in a growing commercial market is driven by several factors some of which are business related such as cost to develop, time to market and the size of the market. Ultimately however, a successful implementation is about functionality, workflow, interoperability, and knowing and understanding who the end users are. In this paper the process of developing a directional well planning solution is described. We include the initial investigations into our customer's needs, the development methodology used, our early prototypes and the incorporation of the feedback gathered. We describe the implementation of an interactive visual workflow for defining a well trajectory and how this integrates with geological and numeric models and features such as temperature gradients and existing wells. The underlying calculation of how the multiple build, hold and drop section types interact is briefly summarised. Finally, insights gained along the way and the potential for future work in the directional drilling space are discussed.

1. INTRODUCTION

Interactive well planning and decision making is a crucial element of geothermal exploration and development due to the high associated costs. This is often a process where key information is passed between different stakeholders (Geoscience, Management, Drilling, Engineering) with key context between these disciplines needing to be considered. This context can be lost/changed/forgotten when transferring between these disciplines meaning that planning and decision making can likely not take into account the full high level context. Having an environment where these disciplines can communicate and provide their specific viewpoint allows the different disciplines to be considered on the same level throughout the drilling process. This paper presents an approach to the challenge utilizing a 3D subsurface modeling environment and the approach to developing these tools.

We set out to engineer a new directional well planning tool in our geological modelling software to replace or complement an existing tool. The focus was on empowering the geologist to make informed and insightful contributions to the well planning process in the context of the geological environment. The existing well planning tool supported vertical and J-shaped wells. A well trajectory was defined by a vertical hold to a kick-off depth followed by a build to a target inclination and then a hold to a specified measured depth. Feedback from customers identified the need for a more advanced tool that could support S-shaped wells or multiple section wells, define exact end of hole or end of section x,y,z targets and support visualisation of other data such as geological and numeric models along the proposed planned well trajectory.

We currently have two major software releases per year and the new tool was developed in conjunction with customers over two development cycles. Using an agile development methodology, our development team is structured into pods consisting of developers and testers. Product Owners work with the pods, specifying the functionality and designing the workflow and user interface. We developed an initial prototype to work with customers and refine our understanding of their needs and the prioritization of feature development, followed by a more functional beta. The major areas of importance include not only the functionality but also the workflow, ease of use, integration with other types of data and models and integration with other disciplines, e.g. the drilling team.

2. INITIAL INVESTIGATION

As mentioned, our existing tool supported relatively simple well geometries which our customer base was telling us no longer met the needs of their increasingly advanced drilling campaigns. In consultation with key customers, a number of improvements and additional functionality were identified including:

- set a specific x,y,z target rather than having to iteratively edit the build rate and length as available in the existing tool
- define multiple sections for more complex trajectories
- evaluate geological and numeric models on to the planned well trajectory and visualise these evaluations in 3D
- import a drilling plan from a CSV file
- export the planned well in more flexible output formats

- copy a planned well trajectory in order to facilitate creating alternative well plans
- provide visual and tabular information regarding potential collision detection with existing wells

In an ideal situation customer feedback would be consistent and have little variation due to differences in geographical region, geological environment, or end use of the resource. This is, of course, uncommon and such was the case with the new well planning tool. The key area of difference we encountered was a cross-disciplinary one; should the well planning tool be for the subsurface team of geophysicists, geologists and reservoir modellers to plan a proposed well trajectory to deliver to the drilling team or should it be for the drilling team to provide their proposed well plan to the subsurface team? Ideally, we would like to provide a solution that meets both of these needs, ultimately with the same end result but with different workflows.

3. DEVELOPMENT METHODOLOGY

Through support cases, customer visits, trade shows and user forums, we gather feedback from existing and potential customers to help us prioritise our software development.

The development of a new feature involves a product manager, product owner and one or more development pods. In our organisation, a Product Manager is typically focused on a specific sector, e.g. geothermal, environmental, civil engineering etc. We run regular internal software development forums to set the software development priorities. Once a new feature or workflow gets approval, it is scoped out in detail by a Product Owner using a feature template which includes:

- Problem description
- Success metrics
- Assumptions
- Milestones
- Requirements
- Open Questions
- Out of Scope
- References

Once the business has a good understanding of the new feature and the work has been approved for commencement it is allocated to a development pod. A pod is typically a collection of four software engineers and two QA personnel. The Product Owner introduces the feature to the pod, and they work as a group to refine the understanding of the feature before development commences, following an Agile process.

Our teams use a web-based collaborative platform to facilitate the design, development and testing process (Figure 1). The feature work is broken down into discrete testable pieces to allow incremental development. These items are tracked in an issue tracking system and form a dependency chain where some items need to be completed before others, whilst some may be developed in parallel.

In common with all substantial software projects, the source code is held in a version control system. Such a system tracks changes made to the source code in a way that enables multiple people to make changes to the same source file. When coding begins, the developer creates a new 'branch' of the code. This branch is named in a way that identifies which feature is being developed and it holds their changes separate from the 'master' branch that contains the code used to build the software releases. In an iterative process, developers make code changes to implement the designed functionality in their feature branch and create a new internal build which the pod testers QA/QC with a range of representative datasets. At the completion of a feature implementation, the developers put their changes forward for code review. The code review is a process where other developers check the implementation for correctness and potential improvements for characteristics such as maintainability and performance. Once the code passes code review, this branch can be built using the same automated build system used to build the releases. Such development builds are tested by suites of automated tests and examined manually by the QA/QC staff.

Sometimes discoveries are made during development that require changes to be made to the original design; for example, improvements to workflows and user interface design may become apparent after the original conception has been implemented and tested. These improvements can be added to the list of tasks remaining for the feature and are scheduled according to their priority compared with the other remaining items.

At certain points through the implementation, enough functionality may be present to allow a prototype or beta version of the feature to be used to garner feedback from end users which help ensure we are creating a suitable solution. The earlier in the development process that feedback can be gathered, the higher the impact on the final result.

Once the developer(s) have finished the implementation, the code has passed final code review and all tests, a developer will be allowed to 'land' the feature branch into the 'master' branch. This requires carrying out a rigorous feature landing process which takes the form of a checklist of steps that must be completed, including sign offs from the product manager, product owner, testers, final code reviewer and development manager.

Directional Drilling (Geothermal)

RM LL AR Created by Rachel Murtagh
Last updated Aug 26, 2019 by Alex Rock

Target release	2019: 2
Epic	LF-30500 - Directional Drilling (Geothermal) LANDED
Prototype/EAP	LF-27981 - New Directional Drillhole Group - GT MVP LANDED
Document status	READY
Document owner	@Rachel Murtagh
POD	Gryffindor
Dev 1	Alex Rock
Dev 2	Lou Lahar
Tester	@Taylor Dacite

- New, adding & changing section types
- Slice Along Borehole
- "Hold" first row requirements
- Section types
- Scene information & Properties dialog
- Target
- Shape list UI & UX
- Import
- Export option on context menu
- General Improvements (incl. bugs)

Figure 1: Product Owner's top level feature page in a collaborative platform

4. INITIAL PROTOTYPE

Our development methodology aims to deliver a prototype to selected customers as soon as possible in the development process. At its most basic level this prototype could be an image or screenshot, a mock-up user interface or using existing functionality as an analog. The aim is to gather feedback and ensure our development team works as efficiently as possible to deliver, with an agreed prioritisation, what our customers need.

We developed a working prototype that used our existing 3D polyline editing tool as an analog for an interactive 3D well planning solution. 3D polylines can be interactively created in the 3D scene in the modelling software. Points along the polyline can be edited, moved, deleted and orientation/polarity can be changed. We modified the polyline editor so that it was constrained by maximum build and turn rates, i.e. if the user tried to extend the polyline to represent a build section with too high a build or turn rate they were prevented from doing so and needed to reselect an end of section target that met the constraints. Internal and customer testing showed that this workflow was very frustrating. Human nature meant it was better to allow the user to define a physically unachievable trajectory that they could later adjust rather than prevent them from doing so. We also found that editing an earlier part of the trajectory by moving an intermediate end of section target could also lead to unexpected changes in the later sections creating a physically unachievable trajectory that was difficult to correct (Figure 2). This led us to think about different types of build sections; one where the user specified how the curve of the build changed but without initially knowing the exact end of section and the other where the user specified the end of section but without initially knowing the build and turn rates required to get there.

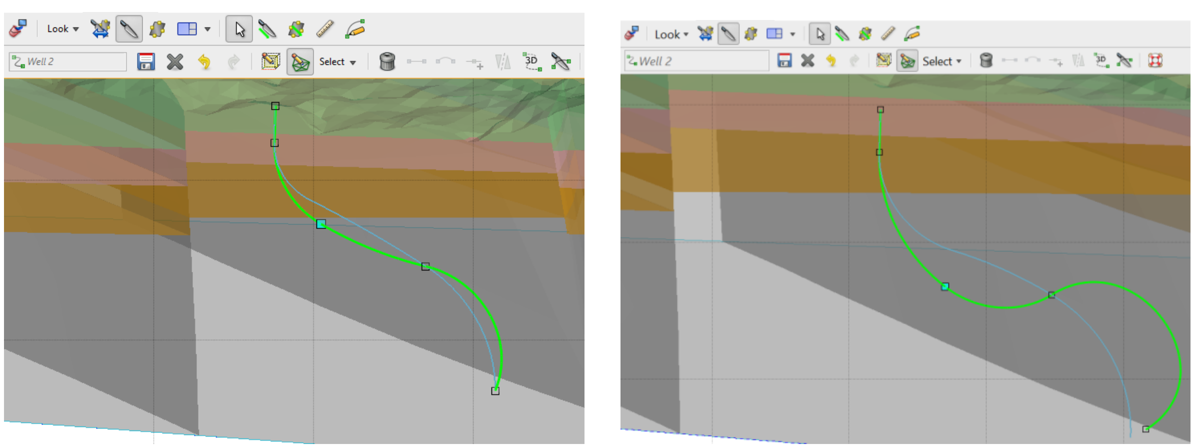


Figure 2: Behaviour of the first prototype's trajectory planning using the existing 3D polyline editor

The prototype also required providing an active UI dialog working in conjunction with editing the well trajectory in the 3D scene. Our prototype was intended to gain feedback on workflow as opposed to the user interface design. Consequently, the layout of the prototype's dialog, particularly with respect to the top location of the well and the target EOH location, was a little rough round the edges (Figure 3). However, this was, in itself, useful for obtaining UX (user experience) feedback.

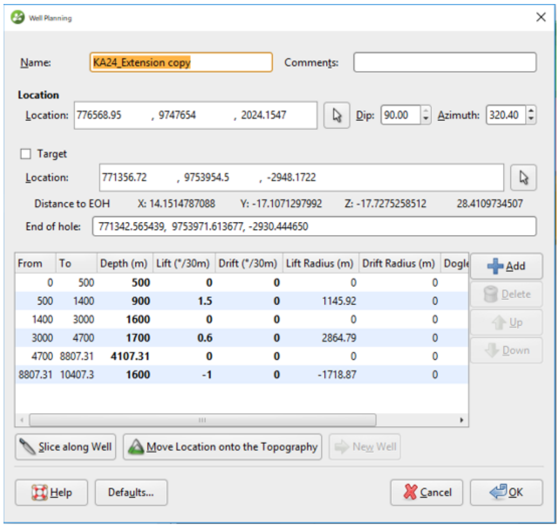


Figure 3: Prototype of the well planner dialog

5. FUNCTIONALITY

A successful implementation of a well planning tool involves getting two things right; functionality and workflow. In this section we describe the functionality.

The original feature brief can be summarized as:

'enable the user to define vertical, j-shaped, s-shaped and multiple- sectioned holes. Provide a method for exporting industry standard formats and importing information from the drilling team'.

5.1 Types of Trajectory

The existing well planning tool supported vertical and J-shaped wells. We aimed to provide a new well planning tool enabling the user to define the following types of trajectories:

- Vertical
- J-shaped well
- S-shaped well
- Multi-section well

5.2 Well and Section Definition

A planned well is defined by:

- Well name
- Top location (in projected UTM coordinates)
- A set of serially connected sections

Additional metadata such as the name of the software user, the software used, and the last modified date of the well plan is also stored but is not editable.

Six section types are implemented:

- Hold to a section length
- Build to an end of section target
- Build to a section length
- Build to an end of section inclination
- Build and hold to an end of section target
- Hold and drop to an end of section target

The first section is always a vertical hold of user specified length.

5.3 Visualisation and Model Evaluation

- Interactively define well sections in the 3D scene

- Evaluate geological models and numeric models on to the planned well trajectory
- Create a distance to existing wells numeric model and evaluate on to the planned well trajectory
- These models dynamically update when the planned trajectory is edited
- Visualise evaluated models on the planned well in the 3D scene

5.4 Import and export

Export a planned well to:

- Drilling plan CSV file with header
- Interval table CSV file (with evaluated models)
- x,y,z point CSV file (with evaluated models at a user specified sampling rate)

Create a new planned well by:

- Importing a drilling plan CSV file with header

6. WORKFLOW

The incremental workflow implemented for defining a new planned well is:

- Create a new directional well
- Specify the well name
- Define the top location, ensuring it is projected on to the topography
- Add a slice plane to scene on which to position the section targets. The slicing plane will snap to the top location. Specify the slicing planes dip and azimuth according to the planned drill hole direction.
- Define the length of the initial vertical hold section
- Add one or more additional sections from the available section types
- Edit or change section types as desired
- Save the planned well
- Evaluate geological and numeric models on to the planned well
- Visualise in the scene
- Continue to edit the planned well
- Copy the planned well in order to create alternative trajectories
- Export the planned well

Six section types are supported:

- Hold
- Build to an end of section target
- Build to a section length
- Build to an end of section inclination
- Hold and drop to an end of section target
- Build and hold to an end of section target

The workflow and the calculations required vary depending on the section type. The six section types can be divided into two groups; one where the user is defining the target destination at the end of the section and one where the user is defining the "journey" taken to reach an initially unknown destination.

Build, Hold + Drop and Build + Hold are "destination" section types while Hold, Build to Length and Build to Inclination are "journey" section types.

6.1 Destination Section Types

With destination section types, the software will calculate the required dog leg rate (comprising both build and turn rate components) to reach the end of section target destination.

A Build section type enables the user to specify the end of section x,y,z target in the 3D scene. A curved section is created, changing the direction of the well in a single simple curve, with the software calculating the dog leg rate required to reach that target and also the resulting inclination and azimuth at the target.

A Hold + Drop section type continues the planned well in the current inclination and azimuth for a certain distance, then begins to curve at a constant given rate. The user specifies an end of section x,y,z target in the 3D scene and a dog leg rate in the dialog. Making the dog leg rate tighter will increase the straight length needed to start the section before the curve starts to turn towards the target location. The dog leg rate can be reduced to the point that the straight hold part of the section vanishes and a simple curve extends from the start to the end of the Hold + Drop section.

A Build + Hold section type is similar to a Hold + Drop but with the straight and curved parts the other way around. A Build + Hold section also requires an end of section x,y,z target and a dogleg rate. Varying the dogleg rate controls the ratio of the build and hold sub-sections. Increasing the dogleg rate will shorten the build part and lengthen the hold part.

6.2 Journey Section Types

With journey section types, a user defined end of section target is not specified. Instead the user defines a combination of section length, azimuth at target and build and turn rates depending on whether the section is Hold, Build to Length or Build to Inclination.

A Hold section maintains the preceding section's inclination and azimuth for a specified section length. The build and turn rate are set to 0.0.

A Build to Length section type creates a section to a specified length, curved at a specified build rate and turn rate.

A Build to Inclination section type creates a curve that terminates in a desired inclination angle, without regard for the section length required to achieve this result. A build rate and turn rate need to be specified to turn the well towards the desired angle.

6.3 Changing a section type

We implemented the ability to change an existing build section from one build type to another. The underlying calculations are the same but the parameters that can be varied by the user and those that are calculated change. For example, consider changing a build to end of section to a build to length. The calculated build rate, turn rate and section length now become editable. Increasing or decreasing the section length results in a change to the end of section target. Figure 4 below shows an example of how the dialog changes.

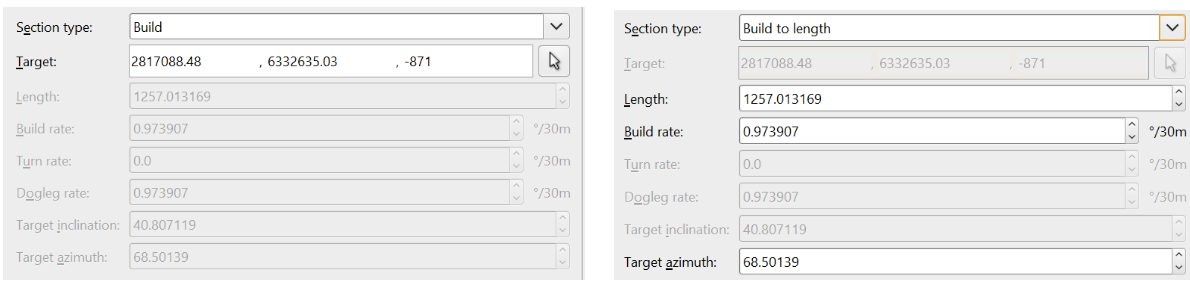


Figure 4: Changing from a destination to journey section type

6.3 Well Trajectory and Drilling Plan Tables

As the trajectory is built, comprising of a number of section types, both the Well Trajectory table (Figure 5) and the Drilling Plan table (Figure 6) in the Well Planning dialog are updated. The Well Trajectory table shows the incremental section types. Clicking on a section row in the table will highlight that section in the scene.

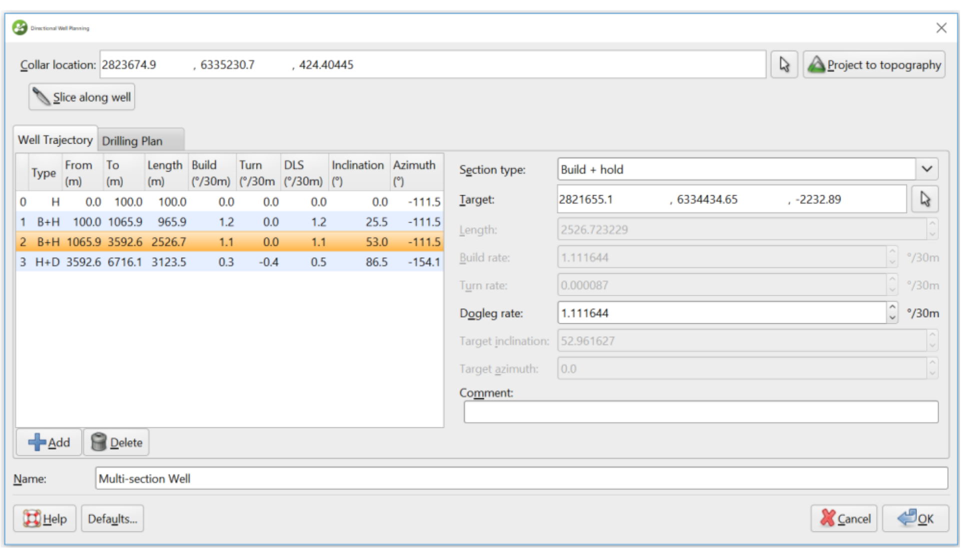
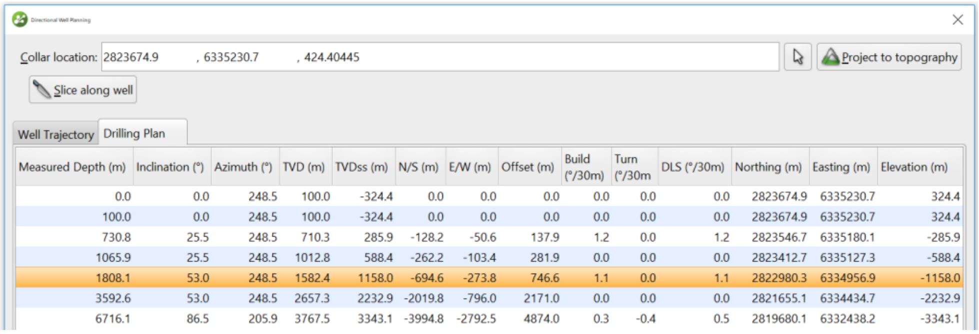


Figure 5: Updated well trajectory table

The drilling plan tab in the well planning dialog contains the data that is exported to an external drilling plan CSV file.



Collar location: 2823674.9 , 6335230.7 , 424.40445

Project to topography

Slice along well

Well Trajectory | Drilling Plan

Measured Depth (m)	Inclination (°)	Azimuth (°)	TVD (m)	TVDss (m)	N/S (m)	E/W (m)	Offset (m)	Build (°/30m)	Turn (°/30m	DLS (°/30m)	Northing (m)	Easting (m)	Elevation (m)
0.0	0.0	248.5	100.0	-324.4	0.0	0.0	0.0	0.0	0.0	0.0	2823674.9	6335230.7	324.4
100.0	0.0	248.5	100.0	-324.4	0.0	0.0	0.0	0.0	0.0	0.0	2823674.9	6335230.7	324.4
730.8	25.5	248.5	710.3	285.9	-128.2	-50.6	137.9	1.2	0.0	1.2	2823546.7	6335180.1	-285.9
1065.9	25.5	248.5	1012.8	588.4	-262.2	-103.4	281.9	0.0	0.0	0.0	2823412.7	6335127.3	-588.4
1808.1	53.0	248.5	1582.4	1158.0	-694.6	-273.8	746.6	1.1	0.0	1.1	2822980.3	6334956.9	-1158.0
3592.6	53.0	248.5	2657.3	2232.9	-2019.8	-796.0	2171.0	0.0	0.0	0.0	2821655.1	6334434.7	-2232.9
6716.1	86.5	205.9	3767.5	3343.1	-3994.8	-2792.5	4874.0	0.3	-0.4	0.5	2819680.1	6332438.2	-3343.1

Figure 6: Drilling plan table

6.4 Model Evaluations

Geological models, numeric models and combined models can be evaluated on to the planned well once the well trajectory has been saved. These are implicit models built using radial basis functions and can be evaluated at any x,y,z point in space. For the evaluation of numeric models, you can specify an interval length. These model evaluations can then be visualised on the planned wells in the scene (Figures 7 and 8). Updates to geological or numeric models or a change to the trajectory of the planned well will trigger dynamic updating of the evaluation of these models on to the planned well.

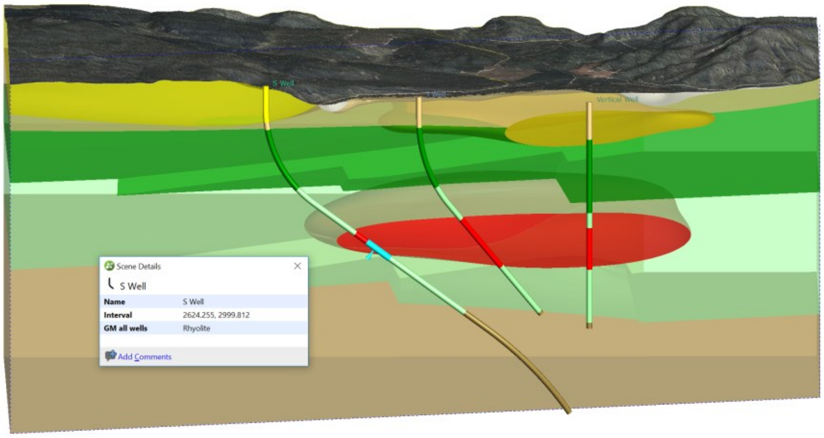


Figure 7: Visualisation of geological model evaluated on to planned wells

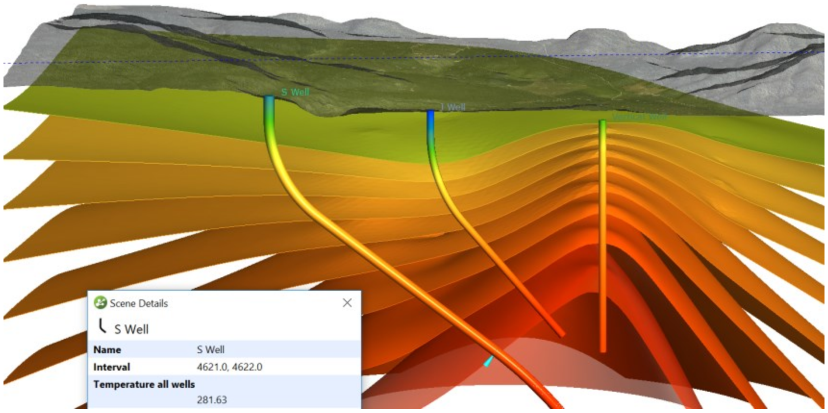


Figure 8: Visualisation of temperature model evaluated on to planned wells

7. IMPORT AND EXPORT FORMATS

A planned well can be exported in three forms:

- drilling plan CSV file with header
- interval table CSV file (with evaluated models)
- x,y,z point CSV file (with evaluated models at a user specified sampling rate)

The drilling plan CSV format includes a simple header which includes the well ID and top location followed by the trajectory information (Figure 8)

Exporting to interval tables creates three or more CSV files for the planned well; a collar file, a survey file and a number of evaluations file.

Exporting to points gives you the option of selecting which model evaluations to export and the sample spacing. The export creates a simple CSV file format.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Well ID	MKWell												
2	Name	Brennan Williams												
3	Software	Leapfrog Geothermal v4.0.0												
4	Date	4/09/2019 13:01												
5	Location	2816431.2	6334045	706.09896										
6	Kick-off Depth	210.56												
7	Units	m (meters)												
8	Rate Per	30												
9	Total Measured Depth	9517.3												
10	Total Vertical Depth	5244.18												
11	Horizontal Offset	7139.1												
12														
13														
14	Measured Depth	Inclination	Azimuth	Build Rate	Turn Rate	TVD	TVDSS	N/S	E/W	Vertical Section	DLS	Northing	Easting	Elevation
15	0	0	104.13	0	0	0	-706.1	0	0	0	0	2816431.2	6334045	706.1
16	210.56	0	104.13	0	0	210.56	-495.54	0	0	0	0	2816431.2	6334045	495.54
17	1626.6	53.05	104.13	1.12	0	1432.81	726.71	591.53	-149	609.99	1.12	2817022.7	6333896.05	-726.71
18	2826.6	53.05	104.13	0	0	2154.23	1448.13	1521.44	-383.1	1568.93	0	2817952.6	6333661.9	-1448.13
19	4779.53	47.44	72.18	-0.09	0.49	3421.9	2715.8	2986.26	-353	3007.05	0.38	2819417.5	6333692.01	-2715.8
20	5852.26	84.11	142.19	1.03	-1.96	3903.6	3197.5	3797.07	-699.5	3860.97	2	2820228.3	6333345.47	-3197.5
21	7016.41	65.92	90.39	-0.47	1.33	4223.86	3517.76	4752.23	-1196.4	4900.51	1.36	2821183.4	6332848.64	-3517.76
22	9517.3	65.92	90.39	0	0	5244.18	4538.08	7035.46	-1212	7139.1	0	2823466.7	6332832.99	-4538.08

Figure 8: Exporting a drilling plan creates a csv file containing the contents of the drilling plan table and a header.

The export drilling plan format is also used for importing an existing drilling plan. The well trajectory in a drilling plan CSV file is over specified as it includes depth, inclination and azimuth survey data as well as x,y,z point data and also build and turn data. We use the depth, inclination and azimuth data, combined with the top location of the well to define a set of "journey" section types for the imported planned well. This imported planned well can then be visualised, edited and evaluated on.

8. CALCULATIONS

Following, Sawaryn and Thorogood (2003) and Sawaryn and Tulceanu (2007), we use an industry standard minimum curvature method to calculate the well section curvature.

For a build to end of section target the starting point, the initial inclination and azimuth, and the end of section x,y,z are known. The build and turn rate required and the resulting inclination and azimuth at the end of the section are unknown. The minimum curvature method is used to calculate the build and turn rates required (and hence also the dogleg severity) in order to reach the specified target. These build and turn rates remain constant for the length of the section. The resulting inclination and azimuth are also calculated.

For a journey section type such as a build to length, the initial starting point, inclination and azimuth are known. The end of section x,y,z, inclination and azimuth are unknown. The user specifies the build rate, turn rate and measured length of the section. The build and turn rates are constant for the length of the section. The end of section x,y,z, inclination and azimuth are then calculated.

As the "destination" and "journey" section types are based on the same minimum curvature method calculations, changing from build to end of section to build to length does not cause any change in the section trajectory.

9. EXAMPLE USE CASE

St1, Finland

St1 is drilling to a depth of around 6.5 km in the bedrock under Espoo in Finland. The goal of the St1 Deep Heat pilot project is to build the first industrial-scale geothermal heat plant in Finland at Fortum's heat plant in Otaniemi. Two wells are drilled into the ground. One of the wells pumps water down to the bedrock in order to heat it as a result of the warmth in the earth's crust. The hot water is pumped up via the other well, and the produced heat is captured.

VSP and downhole geophysical survey data indicate a variably dipping, 300 to 400 m thick reflection structure coinciding with weak rock encountered during drilling of the production borehole (OTN-3). Its surface projection outcrops some 2.5 km to the east of the drill site, where it appears to have diverted a seismic station borehole along its 340-350° strike. At 4000 to 6000 m depths, the reflective structure dips about 50° in the 70-80° direction. Internal reflections within this zone form approximately orthogonal sets, suggestive of orthorhombic fractures (90° angles between fracture planes). Based on 3D modelling, it appears the production borehole (OTN-3) was drilled slightly below or at the edge of this structure. This structure also coincides with the uppermost of three main clusters of induced seismic events, the two lower clusters appearing to lie immediately below, or at its edge. The injection borehole (OTN-2) is planned to penetrate the middle layer of this reflective structure (Figures 9, 10, 11 and 12).

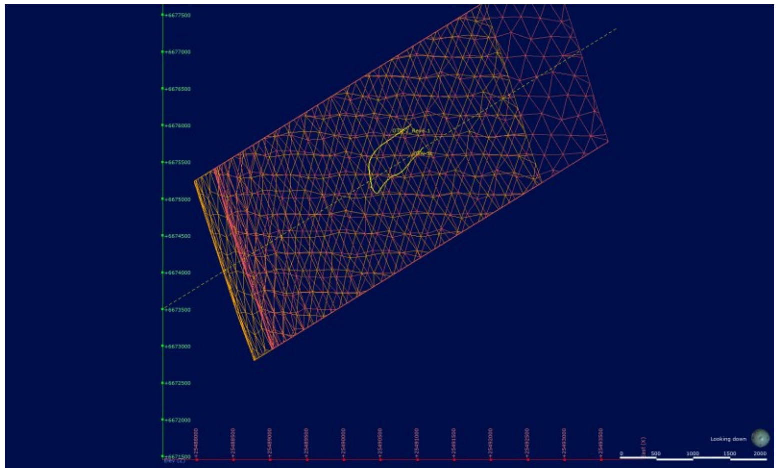


Figure 9: Map view of the reflective structure (red and orange meshes). Injection (OTN-2) and production (OTN-3) wells in yellow.

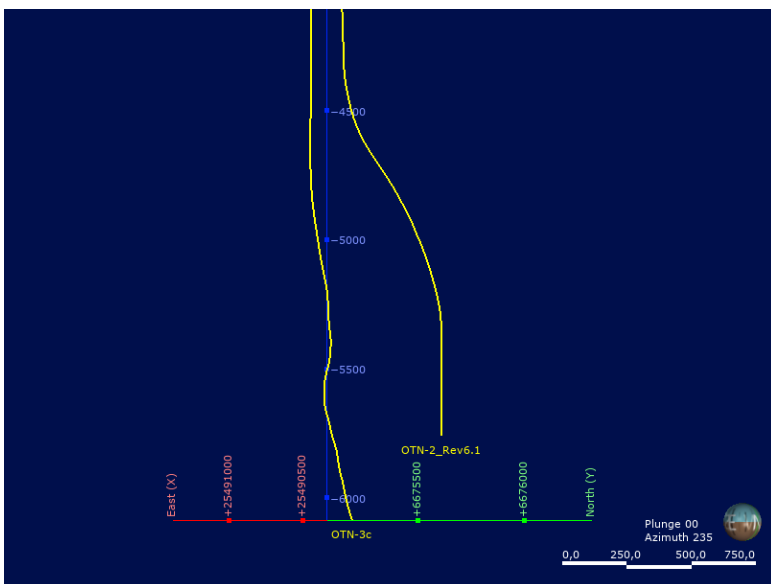


Figure 10: Injection (OTN-2) and production (OTN-3) wells. View towards SW.

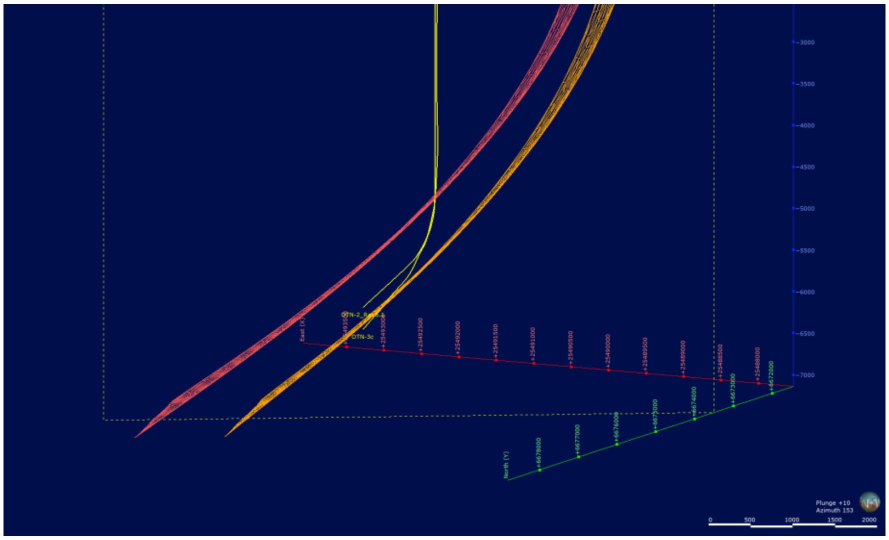


Figure 11: Approximate locations of reflective structure hanging wall (red mesh) and foot wall (orange mesh). Injection (OTN-2) and production (OTN-3) well trajectories in yellow. View towards SE.

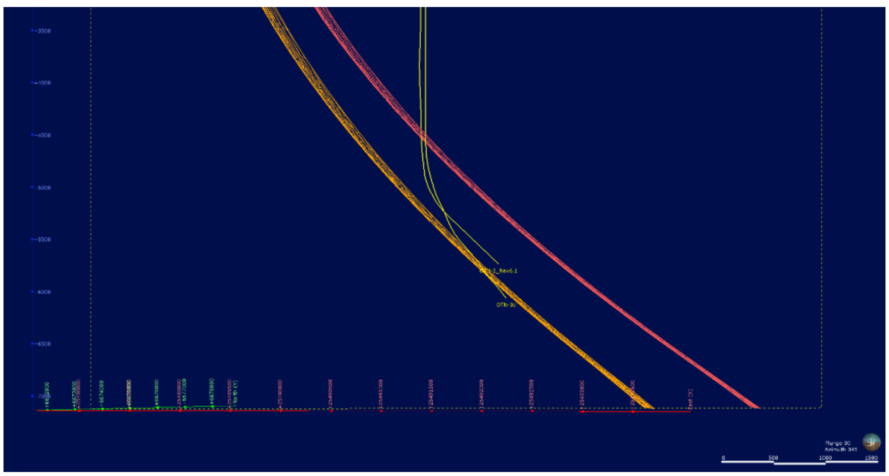


Figure 12: Approximate locations of reflective structure hanging wall (red mesh) and foot wall (orange mesh). Injection (OTN-2) and production (OTN-3) well trajectories in yellow. View towards NNW.

10. INSIGHTS AND FUTURE WORK

10.1 Insights

Due to resources and timeframes it is often not possible to include all the desired functionality. However, existing functionality or code can sometimes be repurposed. In this first implementation we were not able to include full collision detection. However, existing functionality provides some useful visualisation to provide a basic collision detection capability. The distance function is a numeric model that allows you to calculate the distance from a given object or objects, for example the existing wells that have been previously drilled. This distance function can then be evaluated on to the planned well and the planned well can be visualised and colour coded by this distance, for example using a red to blue colourmap (Figure 13).

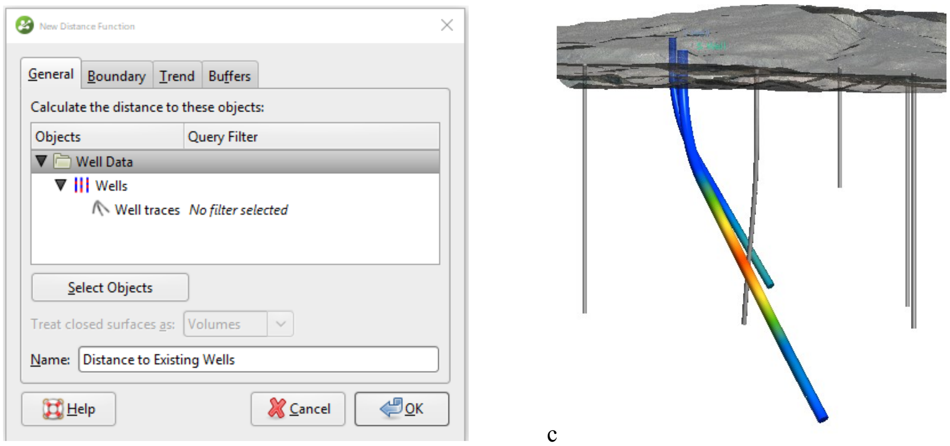


Figure 13: Colour coding planned wells by distance to existing wells.

We found a similar approach could also be used for fault intersection. A distance function model of the distance to a fault is created and then evaluated on to the planned well trajectory. This can be visualised in the 3D scene and can also be exported as a column to a point CSV file (Figure 14).

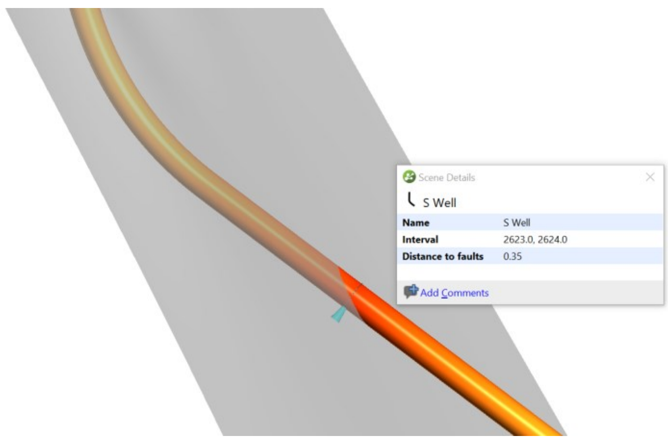


Figure 14: Colour coding a planned well by distance to a fault

Early in the development process, we recognised the need to focus on approaching this from the perspective of the geologist using the geological modelling software to create a draft well plan that can then be passed to the drilling team. The alternative approach of a drilling team provided a proposed plan to the subsurface modelling team was identified as a secondary workflow and the tool supports the ability to import a trajectory in inclination, azimuth, depth format.

We had initially planned that this well planning tool would also be a mining drillhole planning tool as the underlying calculations are based on the same mathematics. However, the difference in drilling technologies means that, whereas in geothermal the build and turn rate are by design, the lift and drift rate in mining is dependent on the geology being drilled through. This leads to a different user experience (UX) with a different workflow and different user interface. However, our geothermal well planning tool is being used as a prototype in order to gather feedback from our mining customers.

10.2 Future Work

Customers are key in the prioritization of the development of new functionality. By definition, they are also key in obtaining feedback after a period of initial use about potential future work. This could include such areas as workflow, import and export formats, additional visualisation or more integrated collaboration support with other disciplines such as the drilling team. To date, with more feedback to be gathered, we have identified but not prioritized the following as potential enhancements:

- sharing proposed well plans in a collaborative visual environment
- reporting and visualisation of the intersection of a planned well trajectory with faults
- casing design specification and visualisation
- collision detection – direction and distance to nearby wells within a search radius
- defining multi-lateral well trajectories and side-tracks

- visualising the uncertainty of the well trajectory
- optimising a well trajectory based on constraints

11. CONCLUSIONS

Actively involving customers during the development of a new feature is critical, both in order to deliver what end users need as opposed to what the developer thinks they want, and to make efficient use of the valuable development resources. Compatibility with other software components in a customer's environment and integration with other disciplines, both upstream and downstream, is also crucial.This must be balanced with the fact that a considerable number of other features are being implemented concurrently in the same development cycle and the resulting software release must be well architected, stable and backwards compatible with the customers' data and projects.

In order to achieve this, an agile software development process needs to be followed. The ability to show customers early prototypes and later beta versions in a timely manner helps keep the development process agile and able to incorporate suggested improvements to the workflow and user interface design prior to release.

An added benefit is the repurposing, sometimes with little or no modification, of existing functionality to meet customer needs. This repurposing may also prompt customer feedback that leads to a later implementation with a more advanced and useable workflow.

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