Well Path Design – Part I

This TIPS&TRICKS is the first of a three-part series intended to aid the geoscientist working in Petrel and tasked with providing proposed well paths to a well engineering department for further analysis as part of an exploration or development project.

Well planning in Petrel can be done automatically or interactively. The automatic method uses a well path optimizing program to generate a number of well paths or scenarios to choose from based on a set of criteria you define. Proposed well paths can be created interactively by clicking on an object displayed in a 3D window to place design points. Design points can be edited either graphically in a 3D window or through the well trace spreadsheet. This article highlights the interactive method using the Well path design process in Petrel 2011.1. All well planning in Petrel can only be done in the depth domain.

Interactive Well Design

Interactive well path design is probably the most common method used in Petrel. With this method a proposed well can be created interactively in a 3D window by digitizing target points that are used by the Advanced Design Trajectory algorithm to create a proposed well path. The target points are snapped to a visible object in a 3D window such as a general intersection, seismic line, or 3D model property, when digitized using the mouse. The Well path design process activates a set of interactive tool bar icons giving the interpreter considerable control over the results and has relatively few parameters that need to be set.

Proposed wells are stored in a folder named Proposed wells. The folder is created automatically if no previous well proposals exist. These proposed wells are treated somewhat differently from actual wells in the project. One noticeable difference is the way they are presented in the well spreadsheet. The spreadsheet of actual wells can be interpolated at user specified depth increments and different depth domains, whereas proposed wells cannot.

To create a well plan interactively:

1. Open a 3D window and display an object to be used to snap the targets to.
   a. This can be a general intersection, seismic line, or 3d grid property. Position the general intersection or seismic line in the direction you want the well trajectory to follow.
   b. Do not clip in front of or behind the intersection plane because it also clips the digitized target points.
   c. If the desired well path does not follow the intersection or seismic line the entire length of the well path you can reposition them anytime during the process and continue.
   d. Filter the 3D model property as needed to visualize the optimum property locations.
2. Click once on the Well path design process in the Processes tab of the Petrel Explorer to activate the well planning tool bar icons. Double click on the Well path design process to open the Settings dialog window.

3. Go to the Dogleg severity tab and adjust the parameters. Dogleg severity (DLS) is the number of degrees a well trajectory changes over 100 feet of measured depth. If the DLS is too great you run the risk of sticking drill pipe. Consult a drilling engineer or your well engineering department for guidelines and common practice for setting the maximum DLS.

   ![Well path design dialog](image)

   a. The Requested upper parameter is the upper limit of the DLS for the Petrel trajectory algorithm. This will be the default DLS used by the algorithm in calculating the trajectory of the initial interactive target points.

   b. The Lower parameter is the minimum DLS used by the trajectory algorithm. This parameter is used only when the points are edited after initial placement.

   c. The Maximum parameter is optional. If checked, the DLS may exceed the Requested upper parameter with no warning or error. If unchecked, the Requested upper parameter is used as the maximum DLS.

   d. It is not recommended to use the Ignore DLS constraints option. If you do exceed the parameters you will be given the opportunity to deal with the problem as described below in step 6.

4. Click on the Add new well icon in the tool bar.

5. Click on an object to place the target points that define a simple well path.

   a. Simple in the sense that no surface location needs to be specified.

   b. Try to keep the number of target points to a minimum. Use just enough to avoid any subsurface hazards and reach the reservoir objective. You will connect the proposed path to the surface later in the workflow.

6. If the DLS parameters are exceeded when calculating the trajectory for your digitized target points, a message window will appear to inform you and give you the opportunity to ignore the point or the DLS parameter.
a. If you answer Yes to this, the algorithm will ignore the bad points and use only the points that will satisfy the parameter setting.

b. If you answer No, the algorithm will ignore the DLS parameter settings and calculate the trajectory using all of the target points.

c. If you answer Cancel or if it is impossible for the algorithm to calculate the well trajectory, another window will appear informing you of an error in the calculation. You must click on OK and the last point that caused the error is removed.

7. Double click on the new proposed well located in the Input tab in a folder named Proposed wells to open the Settings dialog window.

8. Go to the Settings tab to adjust the DLS constraints if desired and specify how to connect the simple well path to the surface, either as a standalone well or designate it as a sidetrack of an existing well.
9. If you select *Standalone*, you need to enter a surface location either by typing it in or getting it from an existing well. You also need to specify a *Well KB* elevation and a *Kick-off MD*. Petrel will enter default values for these two parameters, but is best to enter your own. You also have the option of generating the well path from either the kick-off point or the well head.
10. To designate the proposed plan as a sidetrack you must select a main well from the existing wells in the **Input** tab. The **Starting point MD** parameter is the tie point with the main well. The first design point of the proposed well is placed here. The **Kick-off depth** parameter is the measured depth distance below the first design point to begin deviation. You can select to include the main well trajectory by activating the **Include main well** option. By default the well trajectory is generated for the side track only, beginning at the first design point designated by the **Starting point MD** parameter.

Once you select either standalone or sidetrack and press apply, new points are added to the design at the kick-off point and surface location. If you decide to change the main well you must click the **Undo** icon in the tool bar first. Petrel does not automatically remove points from the previous execution if the type of well path is changed without clicking the Undo icon first.

Petrel adds target points sequentially to the proposed well trajectory spreadsheet. When you choose standalone or sidetrack, the design algorithm will reverse the order if it needs to connect the nearest digitized target point with the designated starting point.

If you make a mistake designating the surface location, the easiest way to delete the point is using the **Undo** icon in the tool bar. If you choose to edit the trajectory spreadsheet instead, you must first choose **Simple** in the **Settings** dialog for the proposed well and click **Apply**. The starting point you designated by error and any reordering of the digitized targets remains in the spreadsheet. You must then delete the first point and the target points return to their original order.
When you add new points to the design it will place them either at the end or the beginning of the spreadsheet depending on which point is nearest the new one.

**Editing Design Points**

Well path design points can be edited graphically in a 3D window or through the well trace spreadsheet. Graphical editing is good for repositioning design points. The spreadsheet is used more for adjusting the DLS and well path angle through the design point.

To edit design points graphically:

1. Click the *Select/pick mode* icon in the toolbar and select the point you want to edit. An editing widget appears allowing you to reposition the point spatially.

2. There are three modes of movement when editing points, *Free movement*, *Move in vertical plane only*, and *Move along line tangent only*. Editing targets in 3D space can be tricky. The actual result may not be the desired result. The *Undo* icon proves invaluable. Sometimes deleting the point and re-digitizing is quicker and easier.

3. Hitting the *Ctrl* key on the keyboard changes the orientation of the movement plane.

4. Moving the white arrow will change the angle of the well path at the design point.

5. Clicking on the *Fix/unfix design point tangent* icon will return the angle to the optimum. Remember there are multiple undos but no redos in well path design.

6. Making vertical adjustments is easy. Click on the *Z-value selector* icon in the toolbar and you can either set the Z value of the selected point or move it up or down a specified increment.
Proposed well path design points can also be edited through the well trace spreadsheet.

1. Right click on the proposed well name in the Input tab and select Spreadsheet.

2. Only the X, Y, and Z values of the actual target points can be edited.

3. The tangent, or angle of the well path through the design point, can be locked by placing a check mark in the Tangent column.

4. The DLS limits can be specified manually and locked by placing a checkmark in the Fix DLS column and entering a value.

5. To add new points, click the appropriate icon ( , , ) to enter a new row, then enter points manually or paste from an Excel spreadsheet.

6. Activating the Stations radio button displays the target points along with other points used by the trajectory algorithm to define the well trajectory. This display is for viewing purposes only and cannot be edited.
7. Activating the All points in the well trace radio button displays all the points needed to accurately draw the proposed well path and cannot be edited.

Interactive well path design is probably the most popular method used by interpreters. Its popularity is due to the simplicity of the process and the user's full control over which target points are assigned to each individual well path. Part II in this series will cover the automatic method using a well path optimizer program. Optimization criteria are entered by the user and the program calculates a number of possible scenarios to choose from.