Tips and Tricks: High Performance Remote Geosteering via Citrix

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Drilling horizontal wells is a 24 hour a day, seven days a week operation. New drilling data is constantly being generated and must be interpreted quickly and accurately to keep the well on target. Additionally, the interpretation of the horizontal well should update the project database to constantly refine the geomodel so that new drilling programs are planned with the most up-to-date and accurate geomodel possible. All of this work must be able to be performed seamlessly anywhere and at any time of the day.

GeoGraphix Geosteering solution (smartSTRAT) via a wireless Citrix connection fulfills the need for high performance remote Geosteering. It is natively integrated with the GeoGraphix project Geosteering within GeoGraphix enables geomodeling while drilling thus keeping the geomodel updated with the latest drilling data. A Citrix connection to the home office GeoGraphix project and interpretation application (smartSECTION) through a fast wireless or broadband internet connection enables remote geosteering from any location at any time of the day.

The following workflow description outlines the procedure and configurations which were tested to support high performance remote geosteering. GeoGraphix (smartSECTION/smartSTRAT) is accessed remotely via Citrix XenApp 6.0 server. Even though the workflow is specific to the demonstration project, the steps are generic and will equally apply to your projects.

Technology Infrastructure

Wireless Internet Connection
The Internet connection in support of the workflow described below was via a cable modem on a 12/4MB upload/download connection. The access to the servers in the home office was through a secure VPN connection.

Citrix XenApp 6.0 Server
This particular Citrix XenApp 6.0 server test environment is one XenApp farm, a license server and GeoGraphix 500.0.2.5 on a single machine. The Citrix XenApp 6.0 installation and setup is a basic default configuration with only GeoGraphix Discovery Project Explorer published out of all the available GeoGraphix applications.

The recommended workflow is that Project Explorer is launched and then all other GeoGraphix applications are launched from the Project Explorer right app panel.
This is the recommended way to publish GeoGraphix on Citrix XenApp to obtain the best end-user experience.

It is recommended to allow the XenApp users to choose to reconnect.

At the XenApp 6.0 Server side, in Citrix Web Interface Management > Session Settings enable "Display Setting button to users":

At the user’s web interface, confirm that "Reconnect at logon:" is checked:
**XenApp 6.0 server virtual machine - hardware:**

- Four Cores
- 4 GB RAM
- 300 GB System Disk

Hypervisor: Microsoft Server 2008 R2 Hyper-V, Version: 6.1.7601.17514

- Eight Cores
- 24 GB RAM
- 470 GB System Disk
- 1.36 TB Virtual Machine Working Disk

**GeoGraphix Project and Interpretation**

The GeoGraphix Project in this demonstration is located on the home office Project Server and consists of 86 wells, 84 horizontal and 2 vertical, drilled into a shale gas field. These wells were logged and completed in the target shale unit. A vertical section projected cross section use for geosteering was defined along the horizontal reach of one of the wells.

For best performance it is recommended that large projects be subsetted to the smallest practical *Area of Interest* and that the *Load on Demand* feature in the interpretation application (**smartSECTION**) be configured to load only the required wells into the geomodel (Framebuilder).

**Initial Setup**

Begin by logging onto the Citrix **XenApp** server through your web browser.
Citrix XenApp presents the Main tool bar showing all of the published applications. In this case in addition to ProjectExplorer, the Calculator, Excel, Word, and Notepad applications are shown.

Clicking on the ProjectExplorer icon launches GeoGraphix database (Discovery). The demo Chuck J. White project is the active project.

From this his point onward, the workflow is virtually the same as with a locally accessed project. The performance is only limited by the bandwidth of the Internet connection.

Clicking on the interpretation application (smartSECTION) icon on the GeoGraphix Discovery toolbar launches the application. The Chuck J. White Full Horizontal Demo interpretation is activated.
There are two predefined vertical section Cross Sections listed. The Vertical Section with Pilot well.ssd will be used for this example. Notice that the pilot well and the horizontal well share a common surface hole location and VS=0 origin on the vertical section. The A-E surfaces on the cross section show the intersection of the 3D geomodel (FrameBuilder) with the plane of the vertical section.
Geomodeling While Drilling Workflow

The following workflow demonstrates the geosteering, data loading, and target line definition process.

- Correlate the drilling well and update the geomodel
- Add new survey and LWD curve data to the project database and update the drilling well
- Correlate the new segment and update the geomodel
- Draw new Target Line
- Repeat the procedure until the well is completed.

Geosteering with GeoGraphix

GeoGraphix offers an extension to the interpretation application smartSECTION to enable cross section views and contains all of the horizontal well correlation tools necessary for geosteering horizontal wells. This extension is called smartSTRAT is launched by clicking the smartSTRAT icon on the smartSECTION tool bar.

The Vertical Panel displays the Type Log and the TVT representation of the LWD segment being correlated. The Horizontal Panel displays the LWD curve and the curve representing the predicted response of the type log based upon the dip/fault model and the borehole geometry.

The smartSTRAT Options dialog is launched by clicking the options icon at the upper left of the Horizontal Panel. The Main tab displays the well ID, the active surface and the current 2D dip model being interpreted.
The **Tie Points** tab displays the current model’s dip/fault segment geometries. By using the **Dip** and **Fault** sliders, each drilling segment can be modeled in both the **Vertical** and **Horizontal Panels**.

The first segment is modeled using the local type log as the standard log although offset type logs may be used. By matching the LWD curve with the predicted curve in the **Horizontal Panel** the initial dip of the active surface is established. This initial dip defines the TVT geometry of the local type log in the **Vertical Panel**.
New segments are added by right clicking on the Horizontal Panel and selecting Add Tie Point from the popup menu. The Dip and/or the Fault Slider Bar is used to “dial” in the dip that cause both the LWD and Predicted Curves in the Horizontal Panel to match and the Type Log and the TVT of the LWD segment to match. By adding new segments down the well bore, the horizontal well can be accurately correlated with the geology.
Updating the 3D GeoModel

Once the 2D model is constructed, the active surface is used as a template to update the 3D geomodel (FrameBuilder). The **Add Surface Points** icon on the **smartSECTION** tool bar activates the picking tool. A series of inter-well points picked along the **Active Surface** of the 2D model ties the 2D model to the active 3D surface and updates the geomodel. Faults can be added with the **Add Fault Points** tool.
The 3D geomodel is automatically updated with the addition of new surface data points. If the Conformance Tool is activated and the Surface Constraints of the modeled surfaces is configured in the GeoSurface Model Properties dialog box, the entire 3D geomodel can be updated by simply editing the controlling conformance surface. In the case below, the $B$ surface controls the conformance of the $A$, $C$, $D$, and $E$ surfaces.
Adding New Drilling Data

Between updates the GeoGraphix project, Interpretation, and vertical section models can be left open on the server. By preserving this state, new data can be quickly loaded into the project and the well geosteered without having to endure the overhead of reopening the GeoGraphix project, interpretation, and vertical section tools. By properly configuring Citrix, the state of the project on the server can be maintained even if the client connection is broken. If the user loses the connection for any reason, the user can quickly and easily reconnect to Citrix session in the same state as the project was when the connection was lost.

When new drilling data arrives, the new LWD curves and survey data can easily be loaded into the GeoGraphix project using the standard data loading tools. The curve data in LAS format can be loaded either through the ProjectExplorer or GeoGraphix advanced geological interpretation system (PRIZM) import menus. Simply launch the LogCurve LAS import utility, browse to the LAS file, Open the file, and overwrite the Import1 curve set.
The survey data can be loaded via the *Spreadsheet loader utility, Cut and Paste* into the *Survey Table* in *WellBase* from an *Excel* spreadsheet, or by a custom *Defcon* import. The method shown below is by pasting the survey from an *Excel* spreadsheet into the *WellBase* survey table.

From *smartSECTION* the selected well can be opened in *WellBase* by the `<Ctrl><Shift><W>` hot key combination. Once *WellBase* opens to the drilling well, delete the survey records from the *Survey Tab*. 
Copy the survey from the Excel spreadsheet and Paste it onto the top five cells in the empty Survey table.
Update the survey calculation to recalculate the position log in WellBase.

Return to the open smartSECTION and update the smartSTRAT vertical section by clicking the Refresh icon on the tool bar. This action updates the vertical section with the new data.
Repeat the correlation process until end of the well is reached. Update the geomodel, load any new data, and repeat the process until the well is completed.
Adding Target Lines to the Vertical Section

As the well is drilled and correlated, the borehole may wander off-target. The **Target Line Tool** may be used to draw a new or edit an existing target line to generate the drilling parameters for the drillers to get the well bore back on track. Additionally, if seismic is available, a depth-converted and scaled seismic backdrop is available to assist with drawing the target line in front of the borehole. The seismic backdrop can be toggled on or off with the Seismic Backdrop icon or by right clicking on the vertical section and selecting *Seismic Backdrop* from the popup menu.

The **Target Line Tool** is launched by clicking the **Create Wellbore Target Line** icon on the toolbar. A target line is drawn by clicking and dragging the cursor over the distance to draw the target line. Once the left mouse button is released, the **Target Line Properties** dialog box displays the $KBTVD@VS=0$, *Inclination*, *Distance*, and other parameters.
The **Copy to Clipboard** button copies these parameters so that they can be easily pasted into an email to the drillers.

**Summary**

**GeoGraphix geosteering capabilities** accessed via a high-speed **Citrix XenApp** connection enables high performance geosteering of horizontal wells from anywhere at any time. Additionally, GeoGraphix supports **Geomodeling while Drilling** so that the horizontal well interpretation updates the home project and 3D geomodel thus ensuring that future well plans are designed within the most accurate geomodel possible.