H&P SURVEY MANAGEMENT

IN-FIELD REFERENCING (IFR) AND ADVANCED MEASUREMENT WHILE DRILLING (MWD) ANALYTICS

REDUCE WELLBORE PLACEMENT UNCERTAINTY BY UP TO 60%

When drilling in congested fields, there is significant danger of catastrophic collisions with an existing (offset) wellbore. Apart from the economic damage of destroying two valuable wellbores, a collision may also result in a health, safety and environmental event. That is why many operators maintain anti-collision policies aimed at reducing the risk of such events.

These policies define the safe distance that must be maintained between two wellbores to increase the separation factor (SF). To increase the SF between a planned wellbore and its offset wells, the planned wellbore can sometimes be moved or shortened. However, these modifications to the well plan can result in suboptimal drainage and field development, stranded reserves, added drilling complexity or additional directional work.

Instead of moving or shortening the planned wellbore, a more economical approach is to increase the positional accuracy by correcting survey measurements. The higher the confidence in their position, the more it increases the SF between the old and new wellbores - reducing the collision risk.

Therefore, before modifying the well plan to move the new wellbore to a suboptimal position, it is advised and has become widespread practice in the United States, to first increase the wellbore surveying accuracy as much as possible by employing enhanced survey management techniques.

Well-established techniques of IFR, and advanced MWD analytics corrections reduce the wellbore placement uncertainty by up to 60%*. Applying these techniques will significantly increase the SFs between new wells drilled in congested fields.

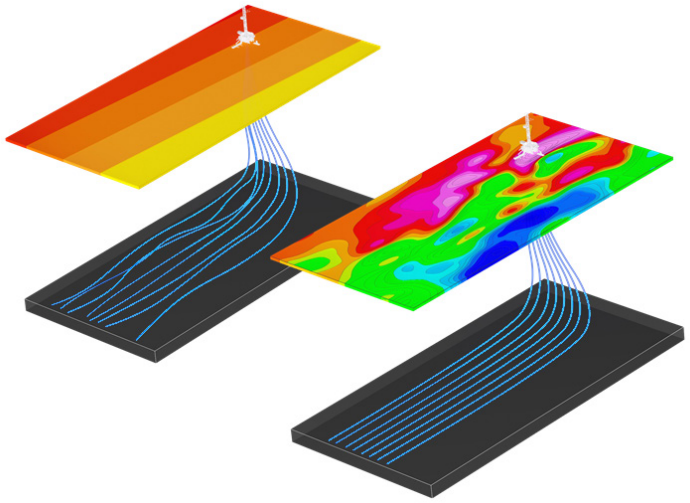
With increased SFs, fewer wells will be considered to be a collision risk. Additionally, increased SFs further improve the safety of in-fill drilling campaigns in congested environments.

NEGATIVE INFLUENCES ON SURVEY ACCURACY

ENVIRONMENTAL
- Crustal Anomalies
- Solar Storms

EQUIPMENT ISSUES
- Drillstring Interference
- Tool Misalignment
- Tool Calibration

GROSS HUMAN ERROR
- Incorrect Data Entry
- New Employees
- Lack of Training

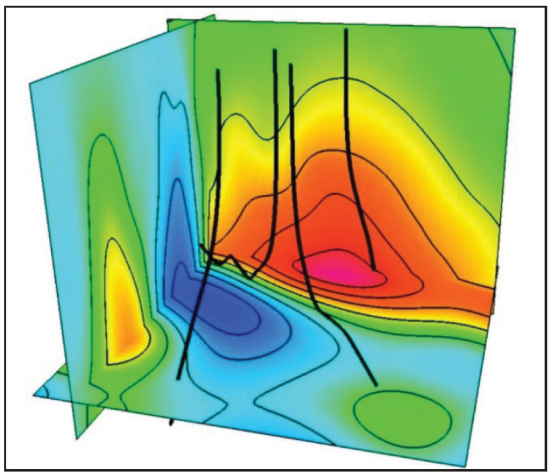


**Information is calculated based on collision avoidance reports that show a standard MWD tool on a 10,000' lateral have a 500' ellipse along the semi-major axis.*

IN-FIELD REFERENCING (IFR)

Main field geomagnetic mapping processes used in standard MWD do not capture local crustal anomalies of the geomagnetic field. IFR is a method of more accurately predicting the true magnetic field at a specific geographic location by mapping local variations in the natural field caused by magnetic minerals in the Earth's lower crust.

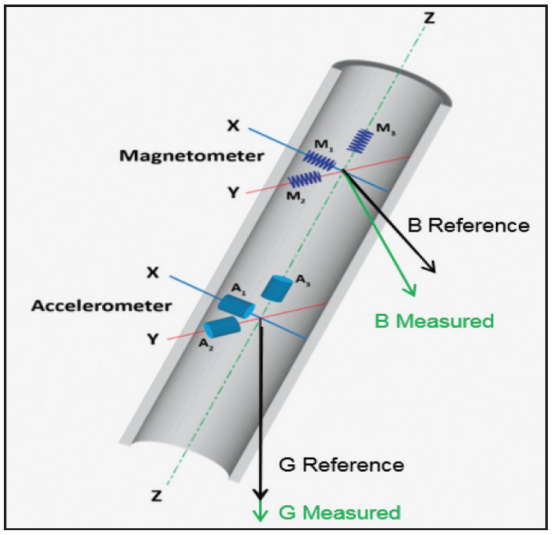
It is used to enhance MWD surveying by providing a more accurate reference frame for azimuth calculation. Additionally, IFR better defines the dip and total field strength, enabling improved survey quality control. IFR is also a prerequisite for advanced MWD analytics corrections.



ADVANCED MWD ANALYTICS

Advanced MWD Analytics is a process of correcting MWD surveys for common sources of error. These include external magnetic interference from the drillstring and magnetized mud, as well as internal sensor errors, such as biases, scale factors and misalignments. By comparing the magnetic and gravity measurements of an MWD survey set against the reference values predicted by an IFR model and Global Acceleration Reference Model (GARM), systematic measurement errors can be resolved for the MWD accelerometers and magnetometers.

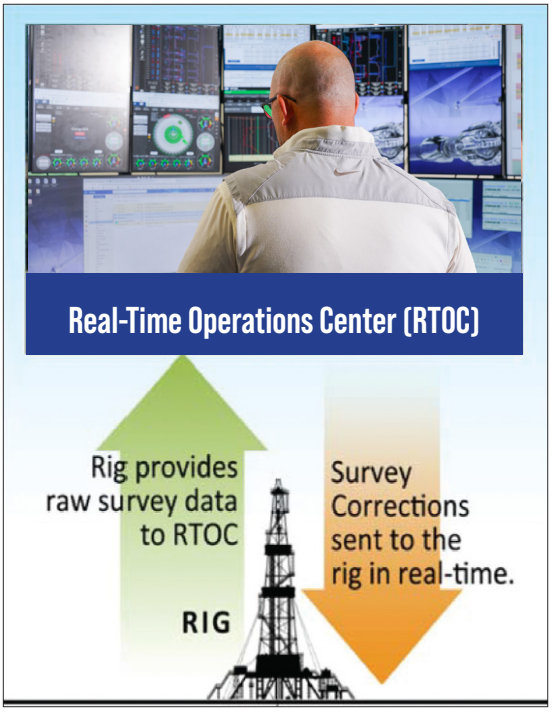
This enables a more accurate inclination and azimuth to be calculated from the corrected raw MWD sensor measurements. This process greatly reduces potential error from poor instrument calibration, magnetic drill string interference, toolface dependent misalignments and magnetic mud.



REAL-TIME OPERATIONS

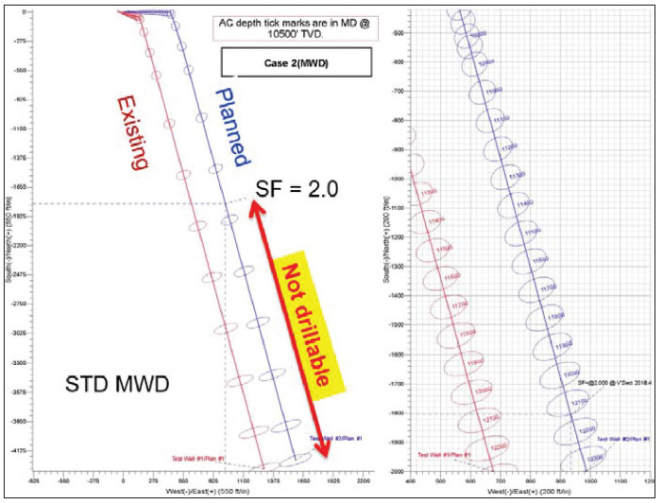
Advanced MWD survey corrections can be performed operationally while drilling to help ensure the well is drilled as accurately as possible. Surveying professionals at the rig site upload MWD surveys into a web application after each survey is taken.

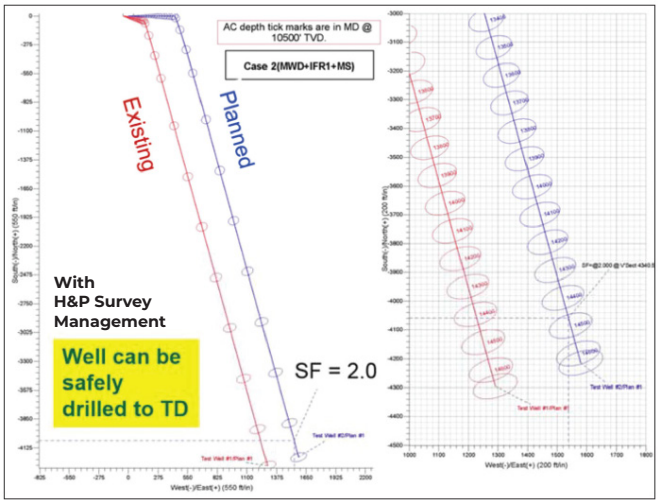
The survey data is automatically validated through independent quality checks to prevent clerical mistakes and identify gross errors. Survey quality engineers with specialized training and tools evaluate the MWD data from a remote operating center and make any needed corrections for observable systematic errors. Surveys are re-calculated from the corrected data and posted to the rig web interface for steering and distribution.

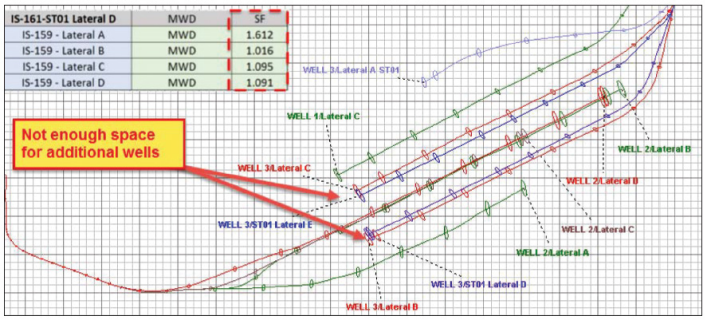


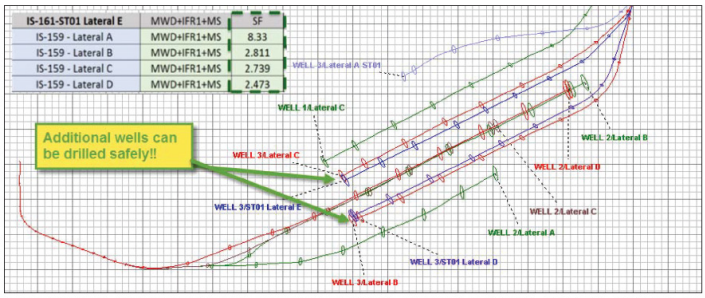
CASE STUDY - LATERAL SPACING

An operator was pad drilling horizontal wells with multiple surface locations on the same pad. Ideal lateral spacing for hydrocarbon extraction was not feasible due to the desired wellbore placement failing anti-collision rules of SF < 2.0 at approximately 2,700ft measured depth (MD) from planned well total depth (TD). The operator could not drill under SF < 2.0 and would have needed to increase spacing. Used operationally, IFR and advanced MWD analytics increased SF to > 2.0 for the entire length of the lateral without the need to shorten or move the wellbore.









CONTACT US

For more information on how H&P Survey Management can help you achieve better drilling outcomes, contact an H&P sales representative today or contact us through our website at **helmerichpayne.com/contact**.

It's time to follow through on your drilling performance potential.

PAST PERFORMANCE IS NOT A GUARANTEE OF FUTURE RESULTS. ANY STATEMENTS REGARDING PAST PERFORMANCE ARE NOT GUARANTEES OF FUTURE PERFORMANCE AND ACTUAL RESULTS MAY DIFFER MATERIALLY.
HPFS012

©2022 H&P INC. FS_SURVEY_MANAGEMENT_2022_11