

CASE STUDY: MicroPulse 3 Continuous Inclination/Azimuth

CHALLENGE

Continuous inclination and azimuth provide vital information to the driller in between surveys, allowing the wellbore to stay on target and in the zone. Without accurate and reliable continuous inclination and azimuth measurements wellbore position uncertainty is high since assumptions must be made about what the wellbore looks like between survey stations. But how can you evaluate whether continuous inclination and azimuth measurements are accurate? How do we know whether the continuous measurements from the MWD are actually representative of the wellbore trajectory? Some measurements are too smooth, and others too noisy. To truly evaluate the performance of continuous measurements, they must be compared against an accurate baseline.

SOLUTION

One of our customers offered us the opportunity to run the latest MicroPulse 3 continuous inclination and azimuth algorithm on a well where a 1ft spacing gyro would be run in the cased well. To maximize the value of this opportunity, we equipped the MicroPulse 3 with a Flight Recorder, this board significantly expands the memory of the MicroPulse 3, allowing high-frequency (125Hz) six-axis measurements to be logged from the accelerometers and magnetometers. This highfrequency log is invaluable in improving and assessing the continuous measurements, with this data, hundreds of iterations of the continuous measurement algorithms can be tested and verified before going downhole. This process greatly accelerates the rate of algorithm improvement and enables us to fine tune our algorithms with real downhole data.

The MicroPulse 3 continuous inclination and azimuth measurements are calculated using a state of the art Kalman filter that utilizes all of the accelerometer and magnetometer measurements to provide accurate and consistent continuous measurements. This algorithm overcomes the short comings of other approaches and is able to calculate continuous inclination and azimuth at all inclination and all azimuths, without any restrictions on drilling due north.

The lateral section of the well was drilled with a Flight Recorder equipped MicroPulse 3 which logged high-frequency six-axis measurements along with providing real-time measurements to surface. After casing the well, a 1ft spacing wireline gyro was run, allowing the MicroPulse 3 continuous inclination and azimuth measurements to be compared against an accurate baseline that was measured without the effects of drilling shock and vibration.

RESULTS

After the MicroPulse completed the lateral run, the well was cased and a 1ft spacing wireline continuous gyro tool was run. The MicroPulse continuous inclination and azimuth logs with respect to time are shown below in Figure 1.



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Both the continuous inclination and azimuth measurements track smoothly between survey points while exhibiting low measurement noise. Looking at the time-series data, one could wonder, how much of this is real? We might like to believe that wellbores are perfectly straight, unfortunately that is never the case, but without a baseline truth to compare to, it's difficult to say what's real and what's not.

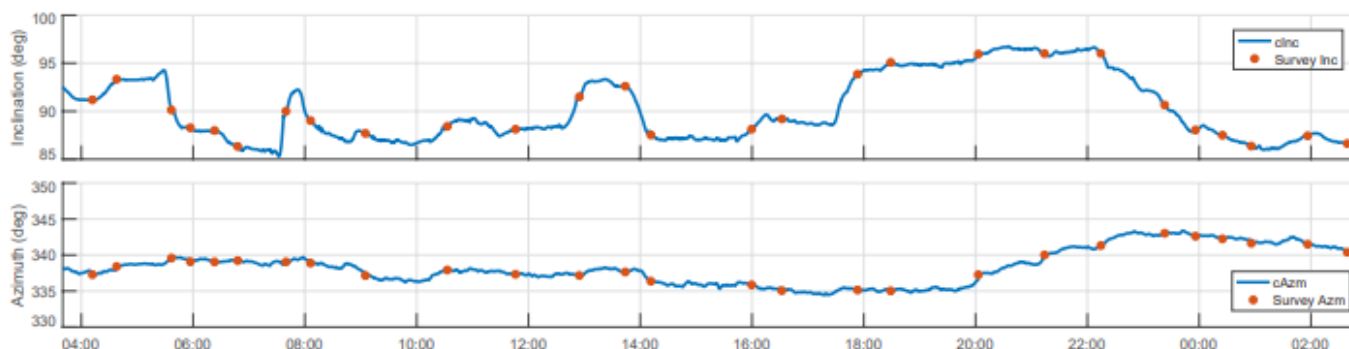


Figure 1: Time-based MicroPulse 3 continuous inclination (top) and azimuth (bottom) measurements. Survey inclination and azimuth marked in orange.

That's where the wireline gyro comes in. The wireline gyro measurements are taken in a cased wellbore and without the presence of any shock and vibration to corrupt the measurements. To compare the MicroPulse continuous inclination and azimuth measurements to the gyro, the MicroPulse measurements were depth correlated to the EDR surface data. The comparison between the depth-based gyro inclination and azimuth logs and the MicroPulse 3 continuous inclination and azimuth logs is shown below in Figure 2.

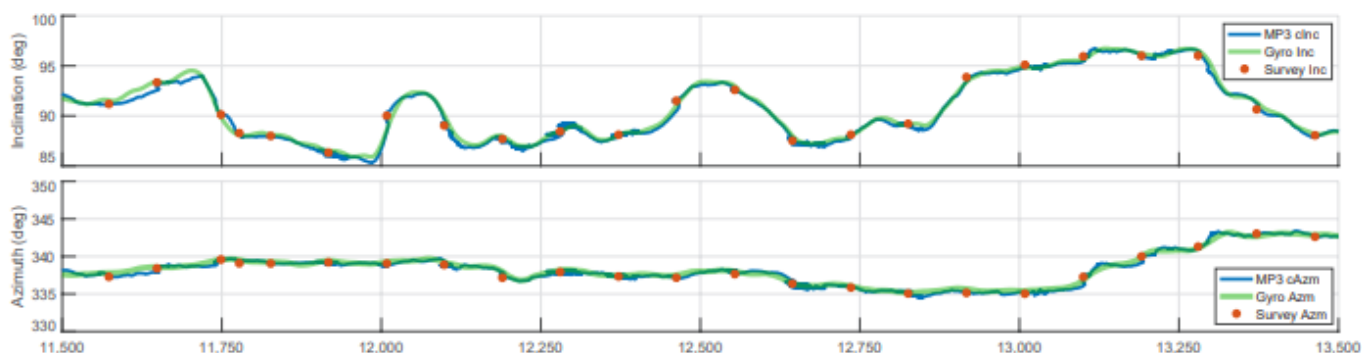


Figure 2: Depth-based inclination and azimuth comparison. Top graph shows the MicroPulse 3 (blue) versus gyro (green) inclination. Bottom graph shows the MicroPulse 3 (blue) versus gyro azimuth (green). MicroPulse 3 survey inclination and azimuth marked in orange.

The MicroPulse 3 continuous inclination and azimuth measurements matched the gyro very closely. The inclination error between the gyro and the MicroPulse 3 was 0.15° RMS, and 0.11° RMS for azimuth. There are some small deviations in the exact shape of the two curves, these differences can be attributed to the difference between open hole and the cased wellbore, pipe stretch/buckling, and minor time/depth correlation discrepancies. Overall the MicroPulse 3 continuous measurements matched very closely to the wireline gyro, demonstrating the accuracy and the reliability of continuous inclination and azimuth on the MicroPulse 3 platform. MicroPulse 3 provides trusted and verified measurement to help you hit your target.