What Depth? More accurate Driller’s Depth
DwpD field results
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Depth Solutions, DwpD Ltd.
Introduction
Depth Solutions, DwpD Ltd
+35 years trying to figure out where TD is
Aston University, Birmingham UK, BSc.,
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Special interests
Along-hole depth measurement
• Calibration systems
• Correction methodologies
• Uncertainty determination
• TAH depth
Depth Solutions, DwpD Ltd.

Along-hole depth measurement
Calibration, correction and uncertainty
Consulting
Training
Audit
Depth data review and resolution

Logo represents the variances in correction and uncertainty in different well bores
Understanding Depth And Uncertainty

- Depth as an issue
- Assumptions and expectations
- Drilling depth measurement
- Calibration and correction
- Way-point method and uncertainty
- First field test results
- The value model
Later Observations – 2013 – 75 Years Later

- Unsure accuracies
- Inconsistent correlations
- Geological inconsistencies
- Reservoir description issues
- Diminished certainty
- Cost
- Asset valuation compromise

Driller’s Depth 101

Pipe depth = pipe tally and surface travelling block movement.

Surface travelling block movement is used to control WoB and RoP, so block position is not necessarily related to changes in bit position.

LWD is based on bit position, recorded while drilling down, inferred from pipe tally and surface travelling block movement.
Calibration ??

What is the accuracy associated with the calibration process for measurement of driller’s depth?

- Calibration conditions
- Process consistency
- Results recording

1:1,000 (if you’re lucky) 1.5:10,000 (conditions dependant)
Applying Corrections

Single Point

Measurement at single point
Correction calculation at point
Correction applied at point

Way-point

Measurement per top/bot of interval
Correction calculation per interval
Corrections per interval
Significant change in well geometry and/or significant formation top

Straight-line

Measurement at single point
Correction calculation to surface
Corrections per data along-hole length over interval

Incremental

Measurement per data step
Correction calculation per measurement
Corrections per data step
Corrections while drilling vs POOH

LENGTHENING EFFECT

Tension profile (incl. sliding friction)
Temperature profile

same model as wireline!

SHORTENING EFFECT

Sliding frictional forces
Differential pressure
Compressional torqueing
Tensile torqueing
Mud density
Mud velocity
Weight On Bit
Bit hydraulic pressure
Rotational frictional forces
Mud pressure
Way-point With Drill Pipe

Correction between any two stations is the correction applicable to that length of pipe

Interpolate corrections along sections of similar gradient.

Significant changes in deviation/azimuth or top of formation of interest, or change of pipe.

Bit positions at way-points.
Log LWD GR, LWD temp. and SHL
Way-point POOH correction

Straight-line model – but applied over discrete intervals

Thermal correction

\[
T_i = \ln \frac{H_{UD}}{s_{eg}} \times Th.\, Coeff_{Seg}
\]

Elastic stretch correction

Calb. Length\(^{1}\) includes Thermal Corr

\(\text{material constant} \neq 0\)
Well 1 N. Sea, 30 deg TD ~14,000 ft

Temperature and tension regimes

\[ y = 1E-07x^2 + 0.0174x + 152.73 \]
\[ R^2 = 0.9993 \]

\[ y = 3E-11x^3 - 1E-06x^2 + 0.0233x + 93.907 \]
\[ R^2 = 0.99967 \]
Well 1 DwpD Corrections

Total correction
\[ y = 3.906E-07x^3 + 1.275E-03x - 4.405E-01 \]
\[ R^2 = 9.997E-01 \]

Elastic stretch correction
\[ y = 3.407E-07x^3 + 1.054E-03x - 9.939E-01 \]
\[ R^2 = 9.993E-01 \]

Thermal correction
\[ y = 1.359E-11x^3 - 2.482E-07x^2 + 1.854E-03x - 6.173E-01 \]
\[ R^2 = 9.987E-01 \]
Well 1 DwpD Correction and Uncertainty

- Strapped pipe uncertainty, $\sigma, \text{ ft}$
- Lasered pipe uncertainty, $\sigma, \text{ ft}$
- Total correction/ft
- Strapped pipe $\Delta$uncertainty/ft
- Lasered pipe $\Delta$uncertainty/ft
Well 1 $\Delta_{\text{correction}}$ and $\Delta_{\text{uncertainty}}$

The uncertainty is determined per way-point.
Well 1 Investing in accuracy

The uncertainty is improved through improved measurement accuracy.
Well 2 N.Sea 15 & 30 deg TD ~15,000 ft

Temperature and tension regimes
Well 2 DwpD Correction and Uncertainty

The graph illustrates the correction and uncertainty of the wellbore position as a function of the driller's pipe tally depth (DD). The graph shows the relationship between the uncertainty, ft, and the driller's pipe tally depth, ft, for both the strapped and lasered pipe corrections and uncertainties.
Accuracy Expectations?

1 : 1,000 The easiest?

5 : 10,000 Believe it?

2 : 10,000 Takes effort!

= mentioned by Reistle & Sikes, 1938
~ equivalent to the best wireline accuracy!!
The Value Model

The Value Model

can it be delivered?

Low technical/operational complexity

High

Accuracy

1:1,000

5:10,000

2:10,000

1:10,000

requirements?

1:500

strapped pipe

manually

no corrections

1:10,000

The Value Model

what is it worth?

Less effect on drilling budget, $

More
Conclusions of Understanding Depth And Uncertainty

- Depth is an issue
- Understand assumptions and expectations
- Drilling depth is a measurement
- Calibration and correction must be done seriously
- Way-point method and uncertainty is an option
- First field test results show that it works
- Consider the value model