More Than Painting The Line: Optimizing Asset Value With Wellbore Placement

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July 17th, 2018
Wells as a Product

Commoditization in high volume markets

Drilling becomes manufacturing

Cost vs. Quality
Cost Metrics for Drilling a Well

Well Defined, Easy to Measure

Similar in planning and execution
Quality Metrics for Drilling a Well

Aim to increase production volumes & decrease production costs

Not always well defined or easy to measure

Differences in planning vs. execution
Wellbore Quality at the Planning Stage

Longer Laterals and In-fill drilling

More aggressive lateral spacing

Evaluation still clear
Wellbore Quality at the Execution Stage

Footage in Zone

Accumulated Tortuosity

Distance From Plan

Can be hard to define, or hard to measure
Wellbore Quality at the Execution Stage

Footage in Zone

Accumulated Tortuosity

Distance From Plan

Can be hard to define, or hard to measure
Why is Distance From Plan Hard to Measure?

Reported position has an associated uncertainty

For long laterals this can be quite large

Distance from plan is equally uncertain
Reporting Success ≠ Achieving Success
Drilling Window:

Allowable deviation from the planned spacing

Tight limits to achieve asset goals

Example: 50ft left/right  
20 ft up/down

The farther you drill, the more of a challenge it becomes
Major Efforts Are Made to *Drill More Accurately*

- Time
  - Slow slides
  - Oscillating Top Drives
  - Trip for BHA Change
- Technology
  - Rotary Steerable Systems
  - Agitators
  - Fluid Additives
- Money
The Conundrum for Long Laterals

Ability to hit a target is limited by **Survey Accuracy**, not **Drilling Accuracy**

Survey EoUs are much larger than drilling windows
The Conundrum for Long Laterals

Ability to hit a target is limited by *Survey Accuracy*, not *Drilling Accuracy*

Well drilled perfectly to plan, but falls out of drilling window

Asset value comes from *true position*, not *reported position*
Drilling Uncertainty vs Survey Uncertainty

Driller’s Window

Up / Down

20ft

50ft

Left / Right

Well Plan

Gunbarrel View of Drilling in the Lateral
Drilling Uncertainty vs Survey Uncertainty

Driller’s Window

MWD Survey Accuracy

400ft

160ft

20ft

50ft
Driller's Window

MWD Survey Accuracy

Drilled perfectly to plan, 19 out of 20 wells will not actually be in the drilling window.

The limitation is on the survey, not drilling practices.
What you can actually hit while drilling is a combination of the drilling window and your survey accuracy.
This is the well on paper, but it is not the well that is delivered.
Product Perspective – What the Customer Gets

This is what can actually be guaranteed for delivery to the asset team.

20ft  
50ft  
180ft  
450ft
What Drives MWD Survey Uncertainty?

- Mapping Magnetic North (Reference Errors)
- Steel in the BHA (Drillstring Interference)
- Tool alignment with the Borehole (Sag)

These errors are not specific to a vendor, drilling style, or drilling technology, they are a consequence of MWD surveying.
How Do We Reduce Uncertainty?

Reference Errors → Better Mapping: *In-Field Referencing*
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DSI → Processing Survey Data: *Multi-station Analysis*
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DSI → Processing Survey Data: *Multi-station Analysis*

Sag → BHA Modelling: *Sag Corrections*

All solutions are data-driven, not a drilling practice change. Reduces vertical and horizontal uncertainty by ~50%
Survey Corrections in the Permian (10k Lateral)

~900 real wells
~20 operators
~25 vendors
Motors & RSS

Median Difference: ~44ft
95th Percentile: ~206ft
99th Percentile: ~317ft
Corrections Outside the Permian (10k Lateral)

~400 real wells
~20 operators
~15 vendors
Motors & RSS

Median Difference: ~47ft
95th Percentile: ~240ft
99th Percentile: ~320ft
Differences are Explained by Drilling Direction

Permian Azimuth Distribution

Other Azimuth Distribution
The Uncertainty is Real!
What This Means For the Asset

Drilling more accurately is limited by surveying
- Survey corrections often larger than a typical drilling window

Value can be driven through survey practice improvements
- Enable greater flexibility on drilling

Any discussion of spacing should start with surveying
Revisiting Our Target

More Accurate Survey

Better survey practices can cut the positional uncertainty in half
Revisiting Our Target

Bigger Driller’s Window

More Accurate Survey

This enables opening up the drilling window
Revisiting Our Target

Bigger Driller’s Window

More Accurate Survey

Smaller Implied Target

Final target still lands in an overall smaller space
Revisiting Our Target

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Bigger Driller’s Window

Smaller Implied Target

More flexibility in drilling *and* more certainty in spacing
Easier to drill with a higher value for the asset
Recap

Product quality is inherently limited by how well it is measured.

True drilling accuracy is limited by survey accuracy.

Reducing positional uncertainty is vital to asset value.

Open up drilling windows while still delivering more consistency.
Thank You! Questions / Discussion?

Difference Between Reported and Corrected Positions at 10,000 ft
(Permian Basin, n=901 wells)

Difference Between Reported and Corrected Positions at 10,000 ft
(Assorted Basins, n=403 wells)