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

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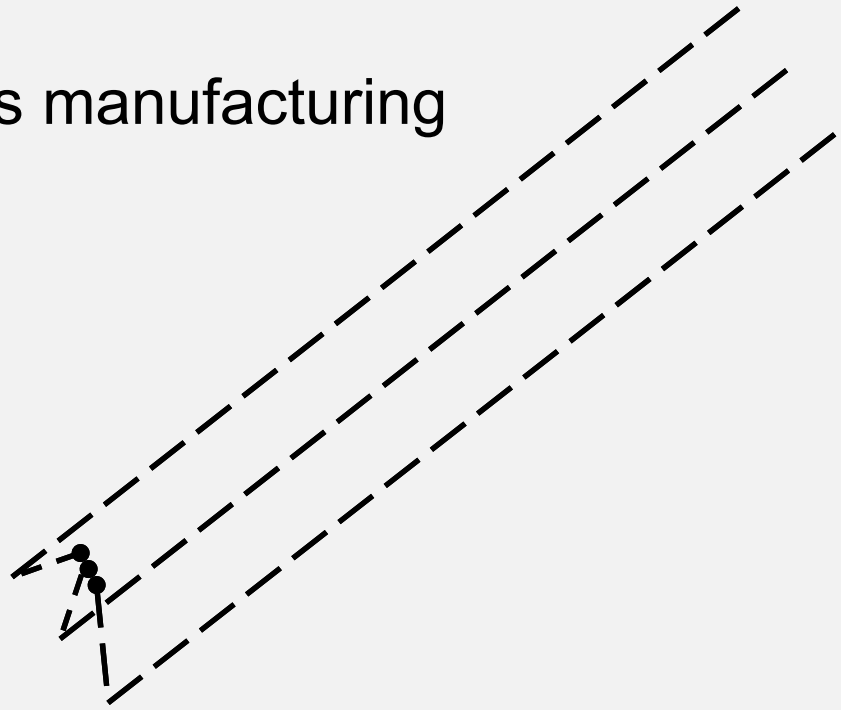
July 17th, 2018

Wells as a Product

Commoditization in high volume markets

Drilling becomes manufacturing

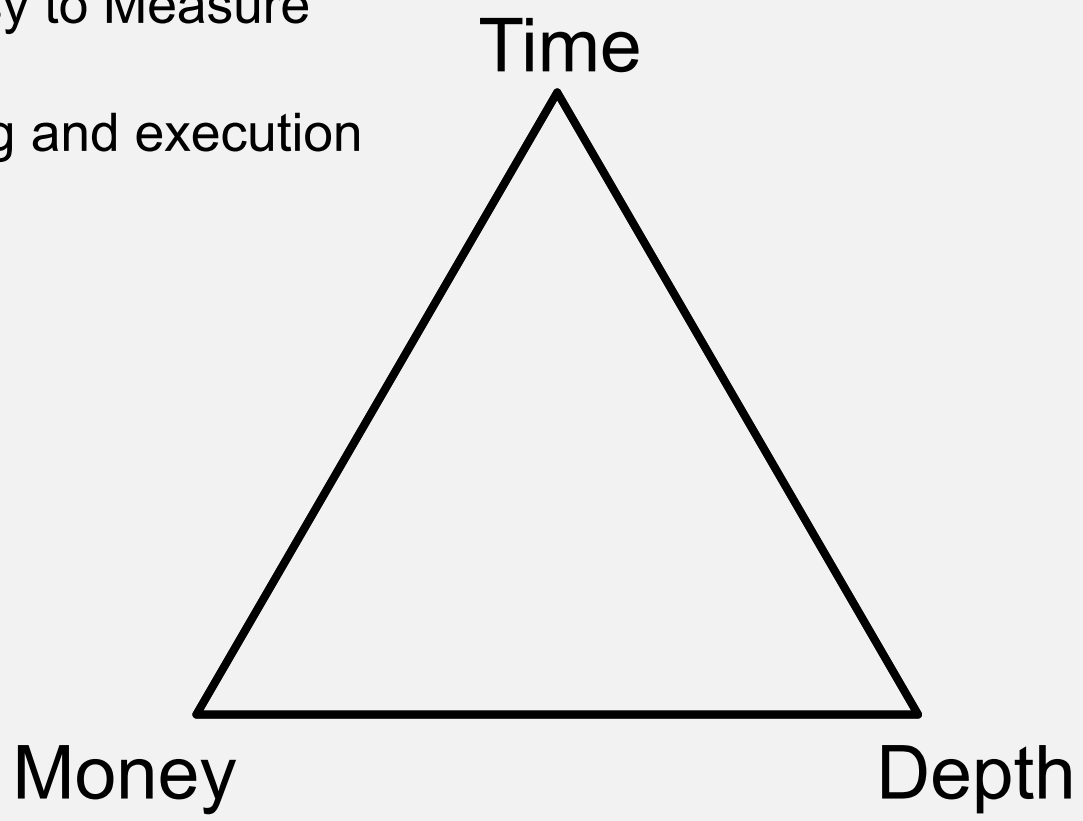
Cost vs. Quality



Cost Metrics for Drilling a Well

Well Defined, Easy to Measure

Similar in planning and execution



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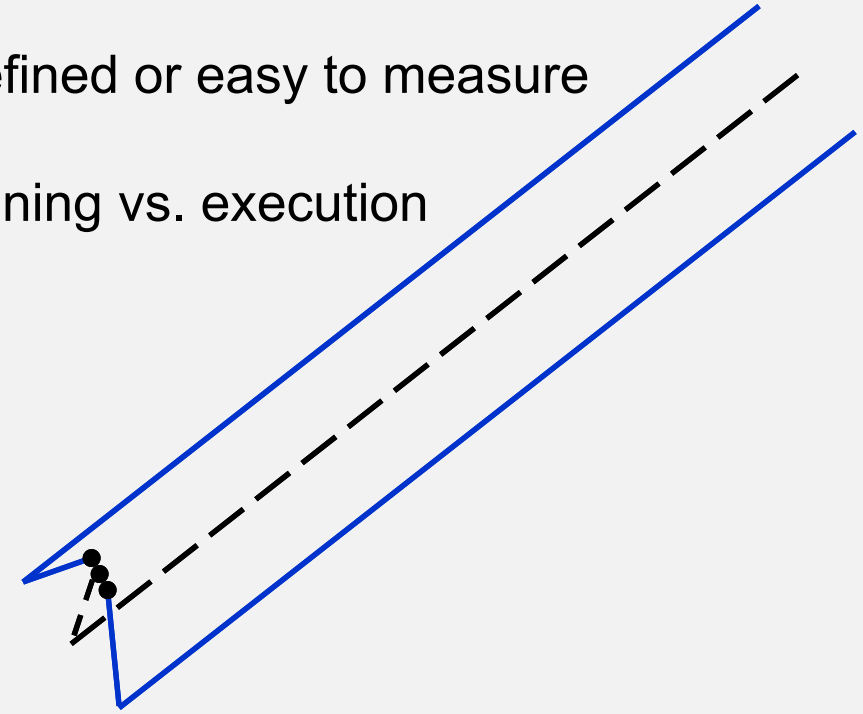
Quality Metrics for Drilling a Well

Aim to increase production volumes & decrease production costs

Not always well defined or easy to measure

Differences in planning vs. execution



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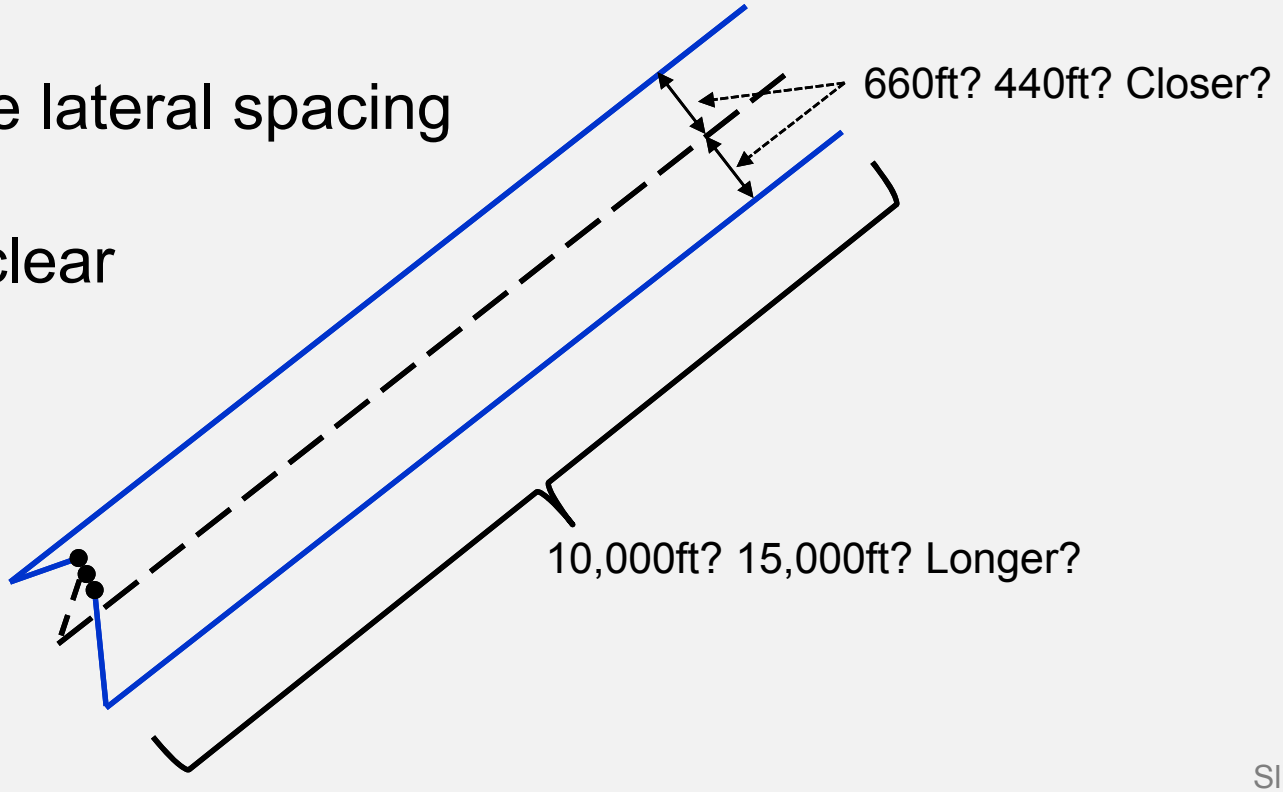
Wellbore Quality at the Planning Stage

Longer Laterals and In-fill drilling

More aggressive lateral spacing

Evaluation still clear



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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

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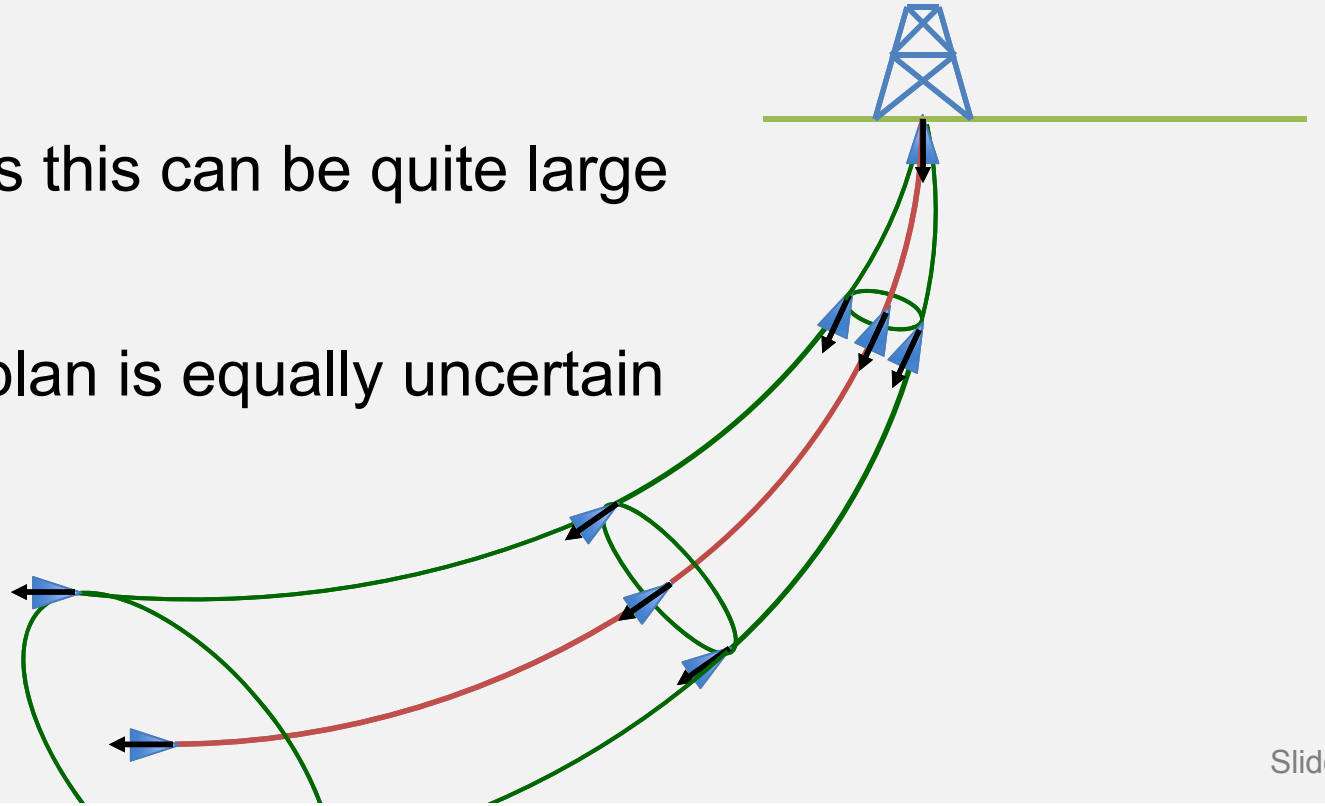
Why is Distance From Plan Hard to Measure?

Reported position has an associated uncertainty

For long laterals this can be quite large

Distance from plan is equally uncertain



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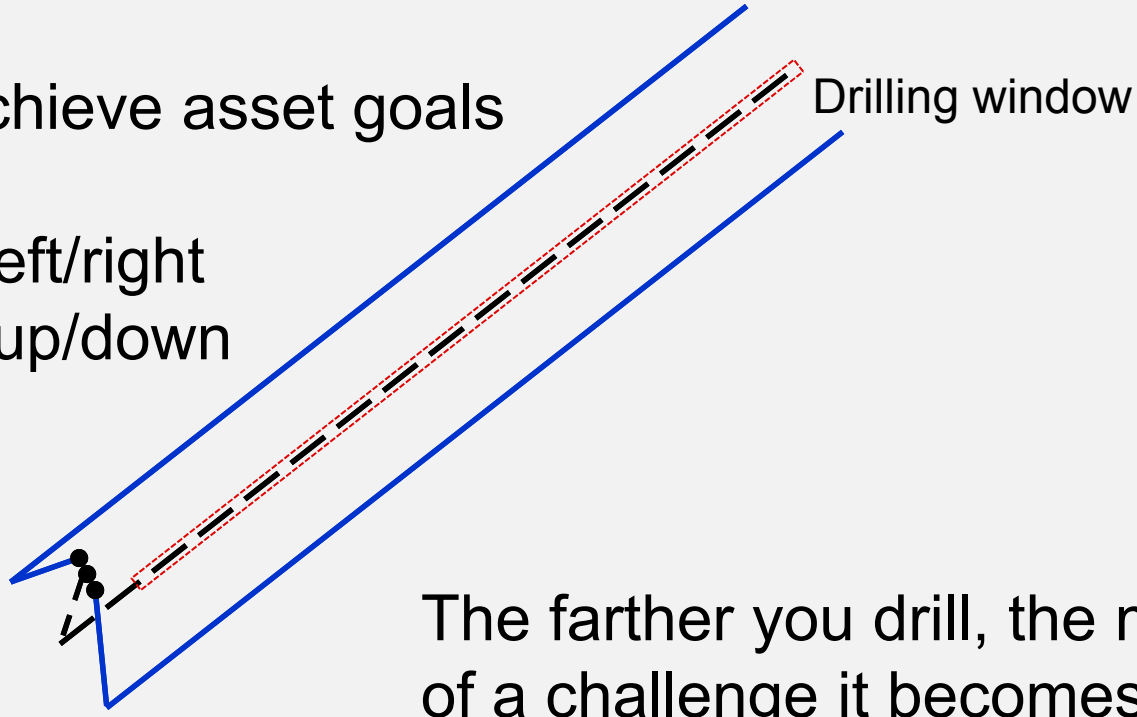
Reporting Success ≠ Achieving Success

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

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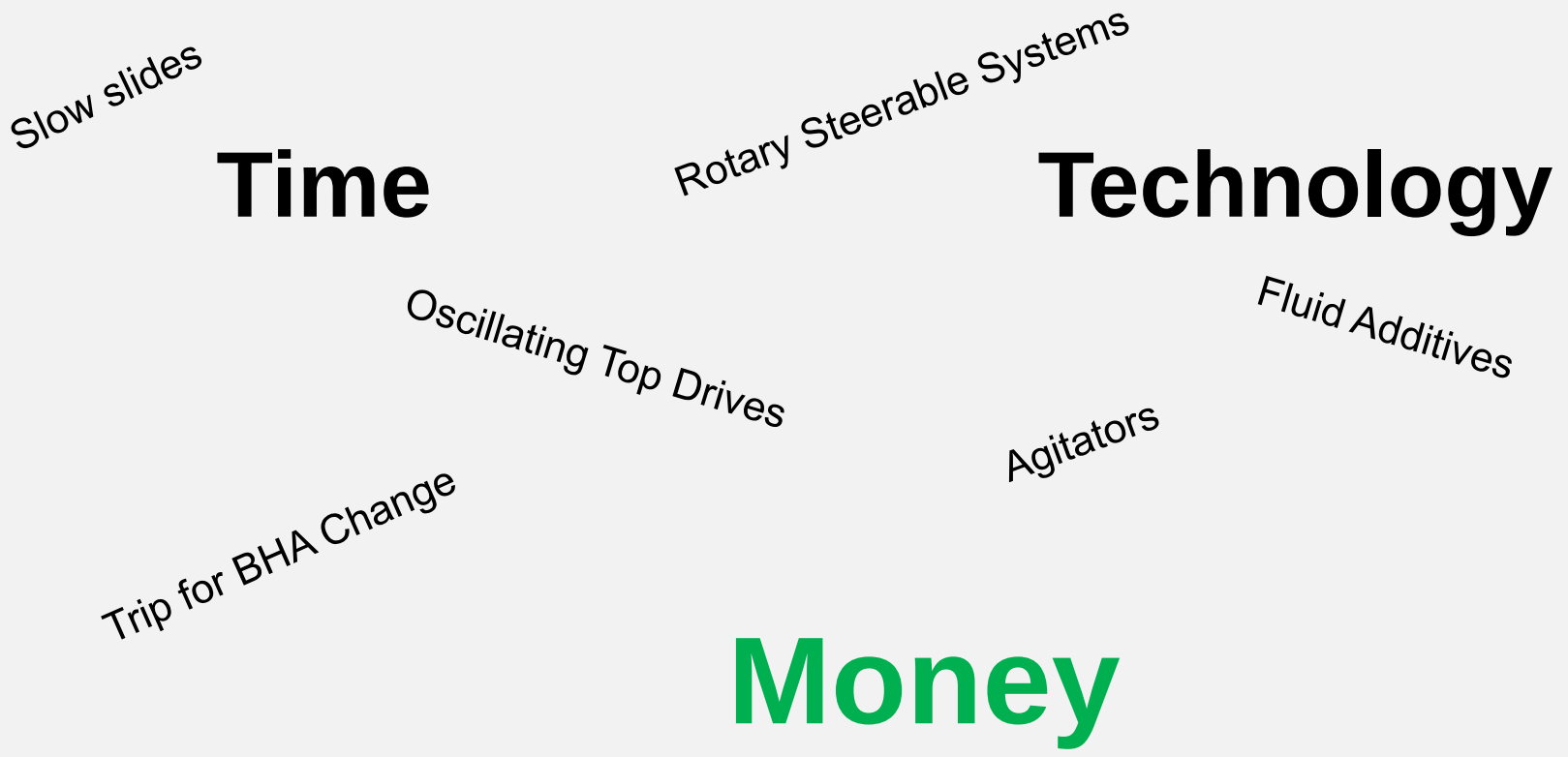
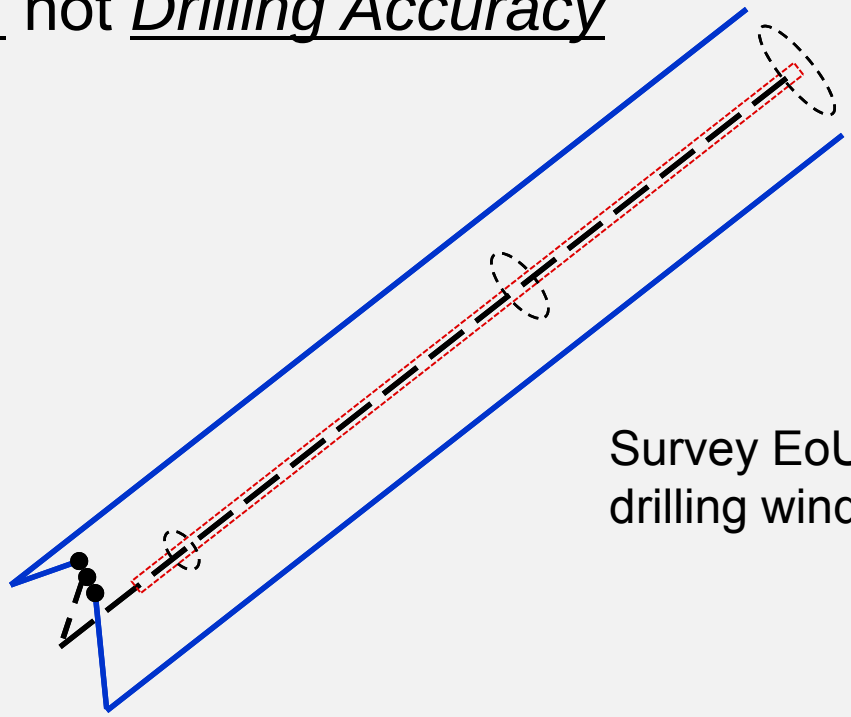
Major Efforts Are Made to *Drill More Accurately*



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

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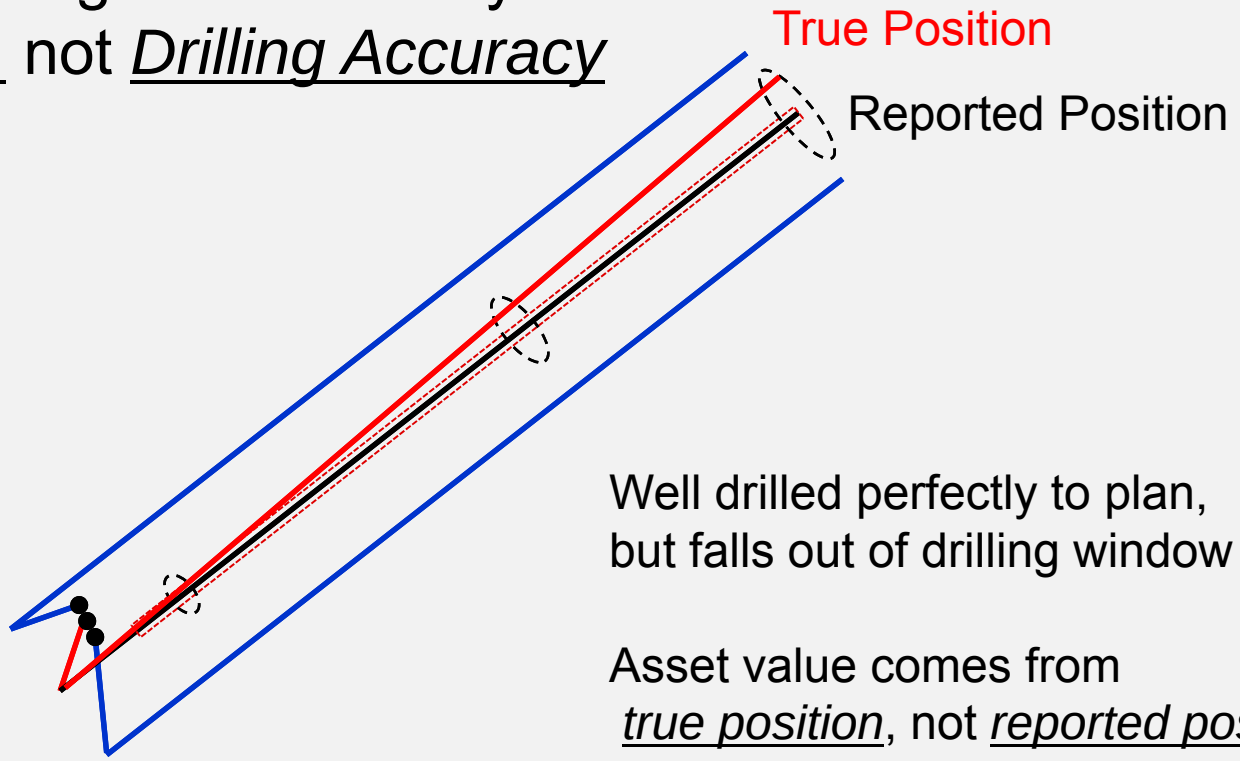

Well drilled perfectly to plan,
but falls out of drilling window

Asset value comes from
true position, not *reported position*

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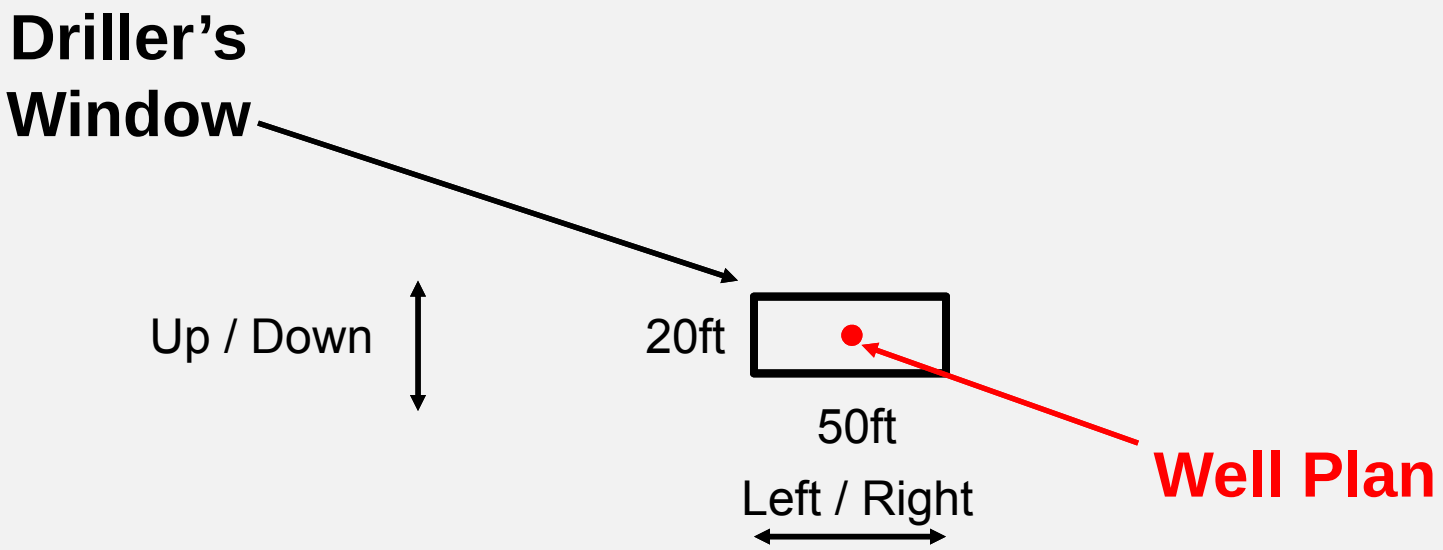
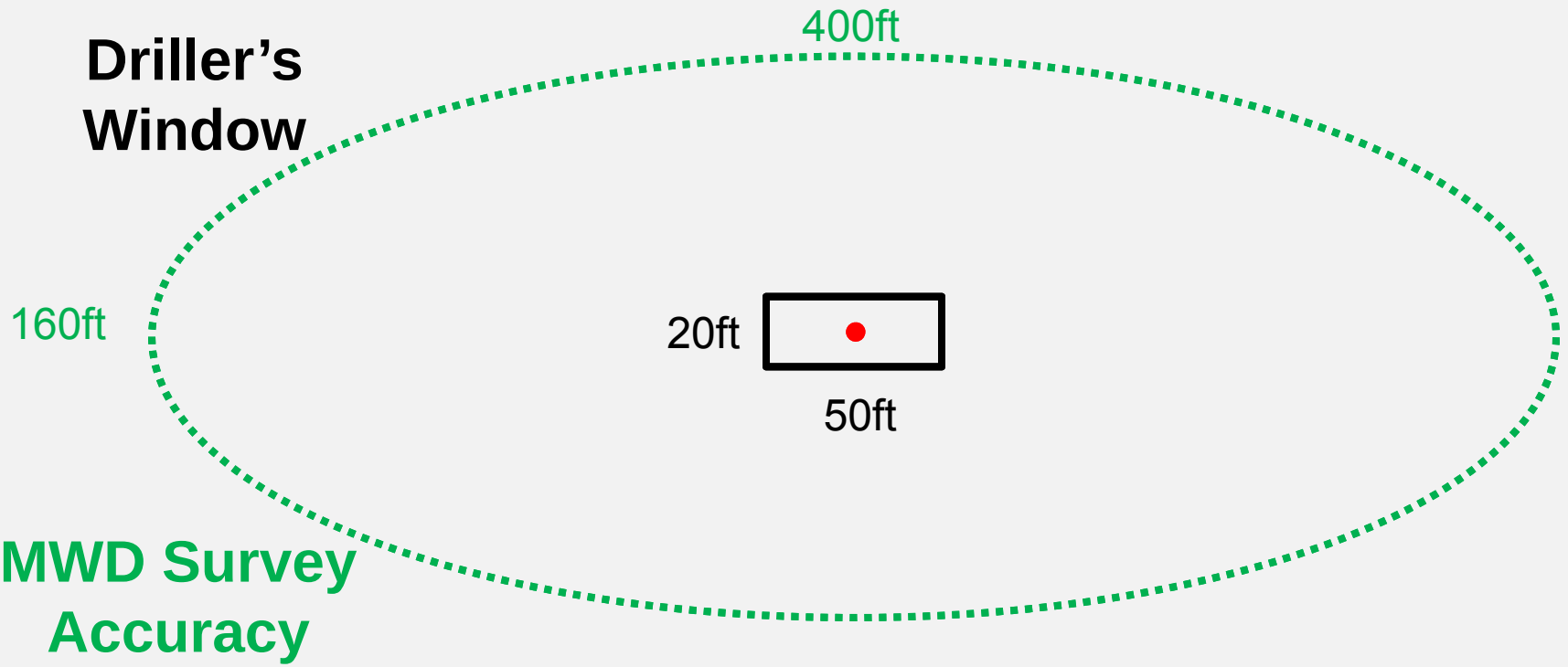
Drilling Uncertainty vs Survey Uncertainty



Gunbarrel View of Drilling in the Lateral

Drilling Uncertainty vs Survey Uncertainty



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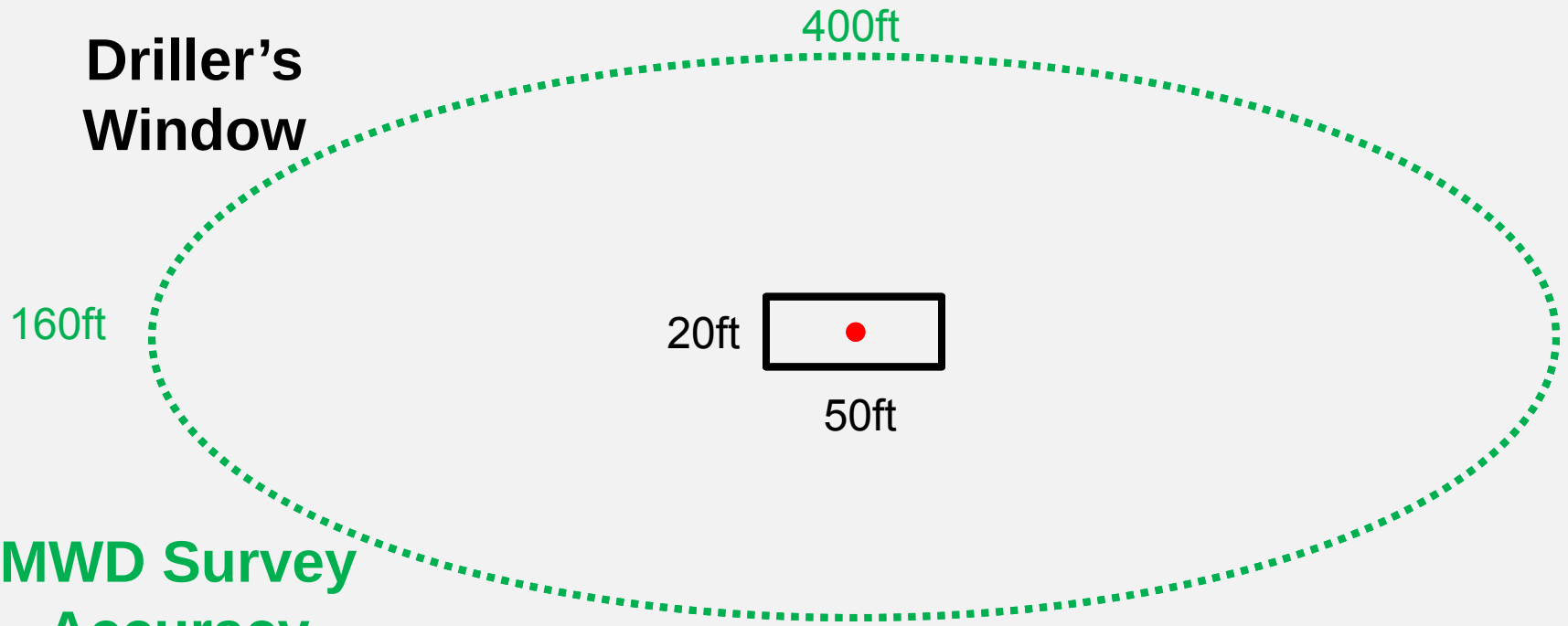

Drilled perfectly to plan, 19 out of 20 wells will not actually be in the drilling window

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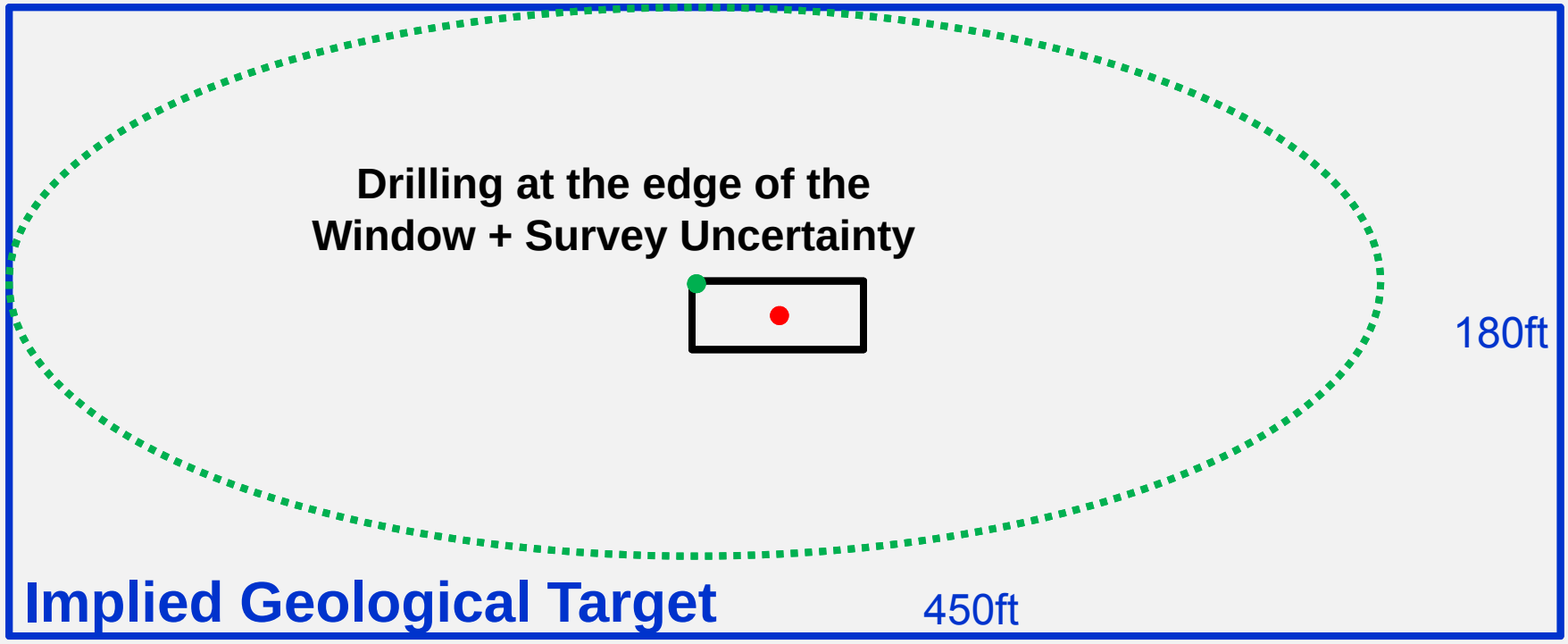
Implied Targetting



What you can ***actually hit*** while drilling is a combination of the drilling window and your survey accuracy

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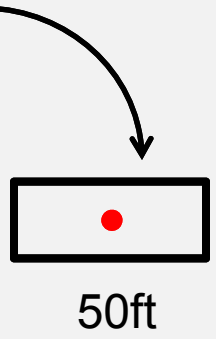
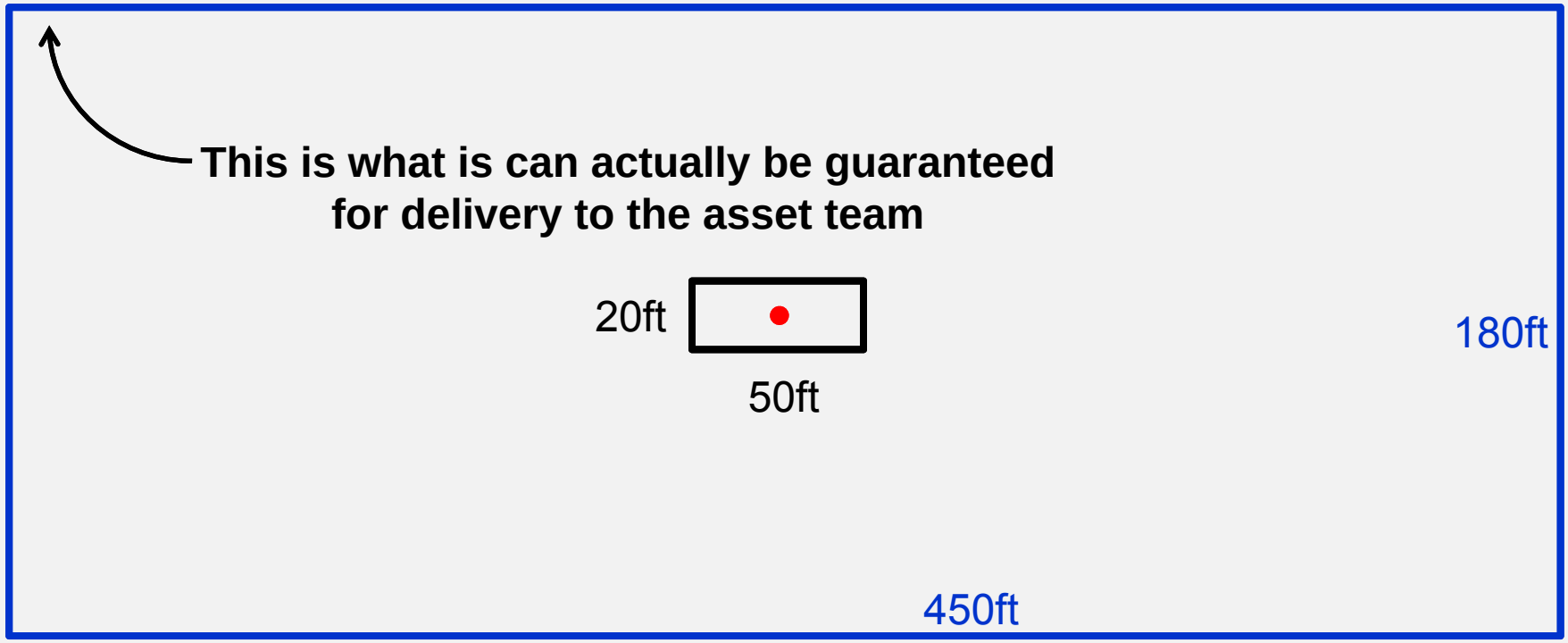
Product Perspective – What the Customer Gets

This is the well on paper, but it is not the well that is delivered



Product Perspective – What the Customer Gets



What Drives MWD Survey Uncertainty?

Mapping Magnetic North (Reference Errors)

Steel in the BHA (Drillstring Interference)

Tool alignment with the Borehole (Sag)

} External to the surveying tool

These errors are not specific to a vendor, drilling style, or drilling technology, they are a consequence of MWD surveying

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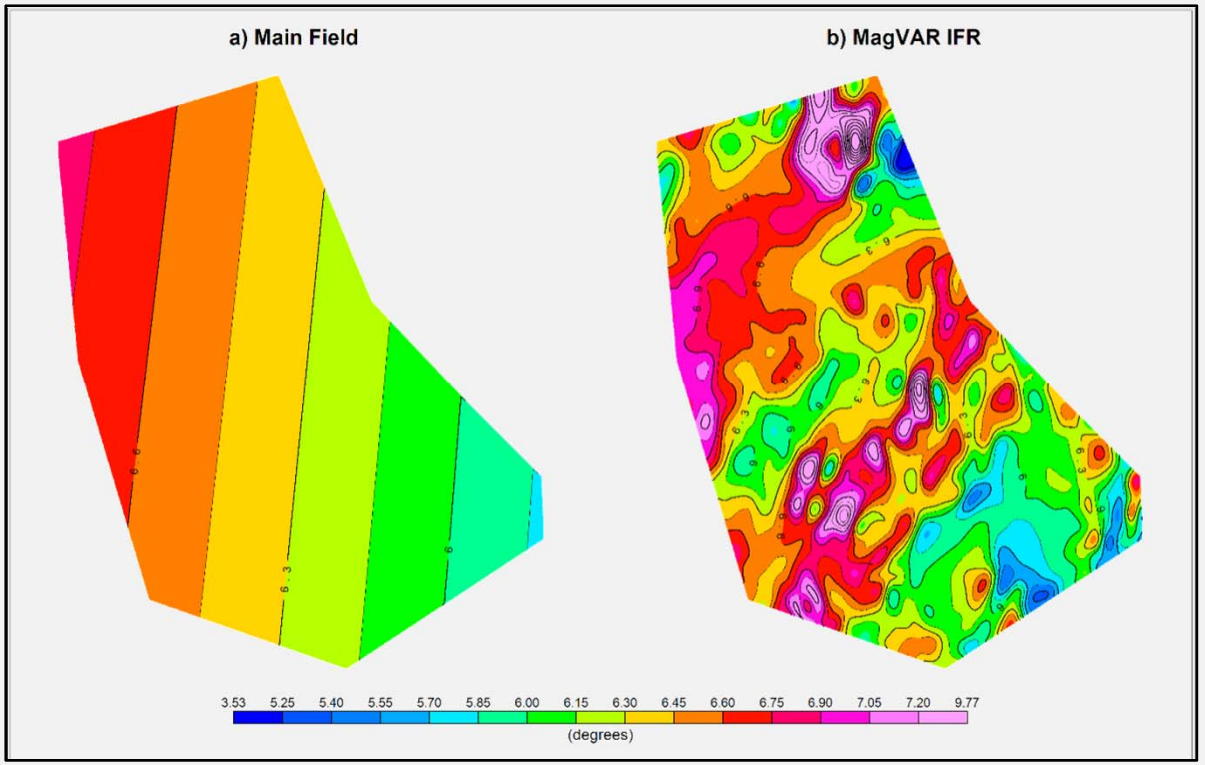
How Do We Reduce Uncertainty?

Reference Errors → Better Mapping: *In-Field Referencing*



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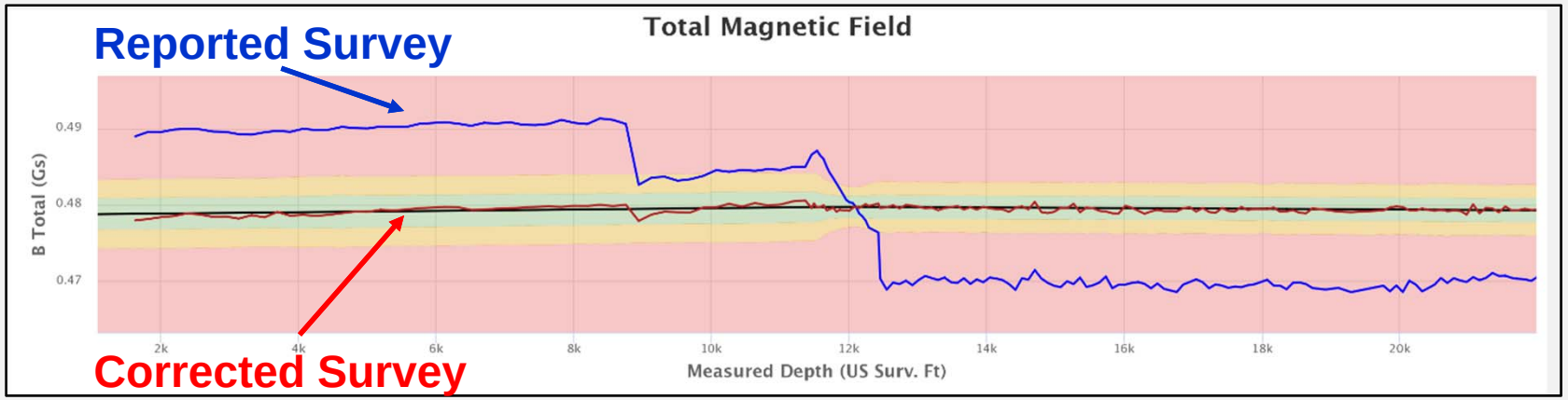
How Do We Reduce Uncertainty?

Reference Errors → Better Mapping: *In-Field Referencing*

DSI → Processing Survey Data: *Multi-station Analysis*



How Do We Reduce Uncertainty?

Reference Errors → Better Mapping: *In-Field Referencing*

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%

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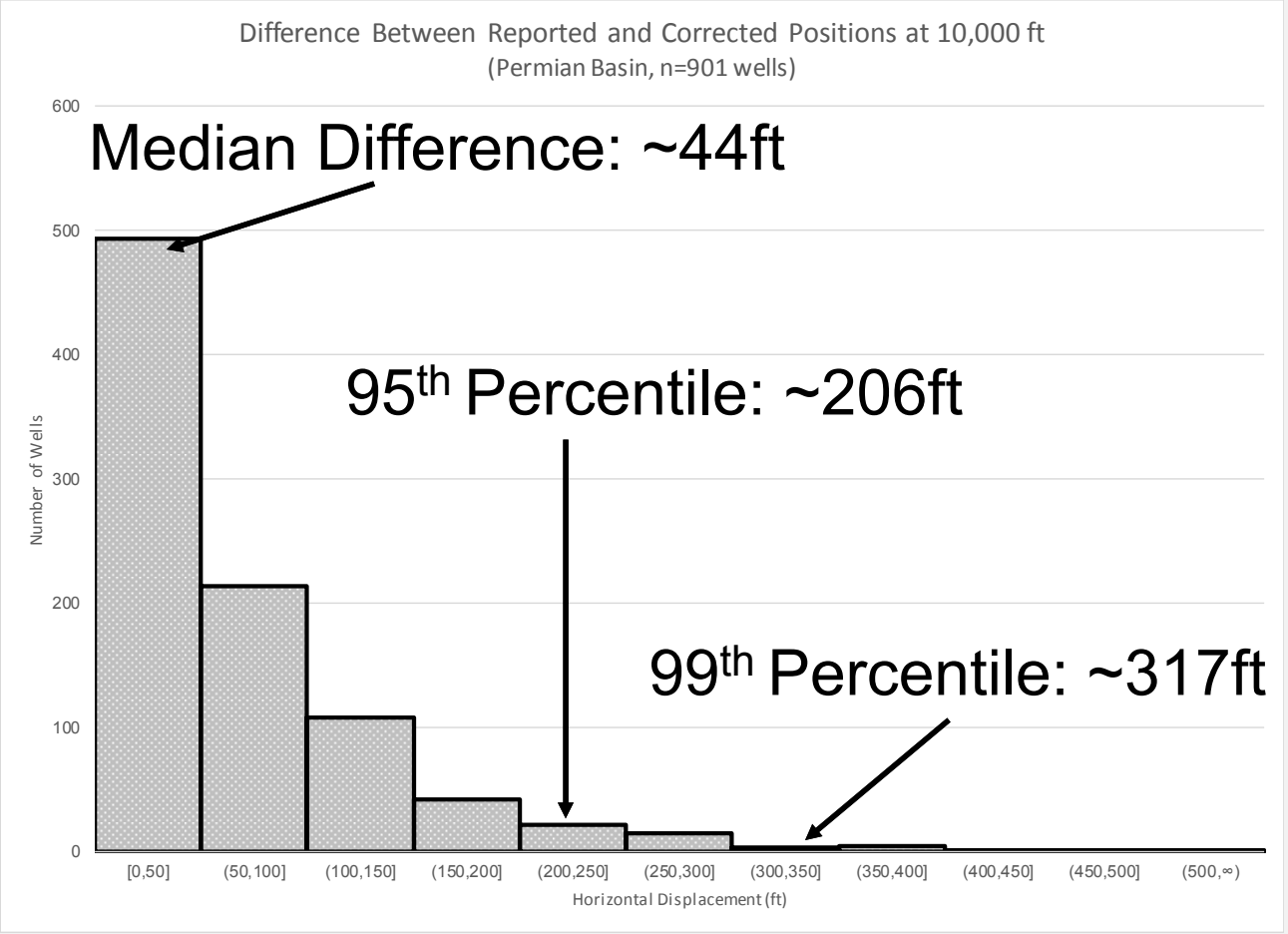
Survey Corrections in the Permian (10k Lateral)

~900 real wells

~20 operators

~25 vendors

Motors & RSS



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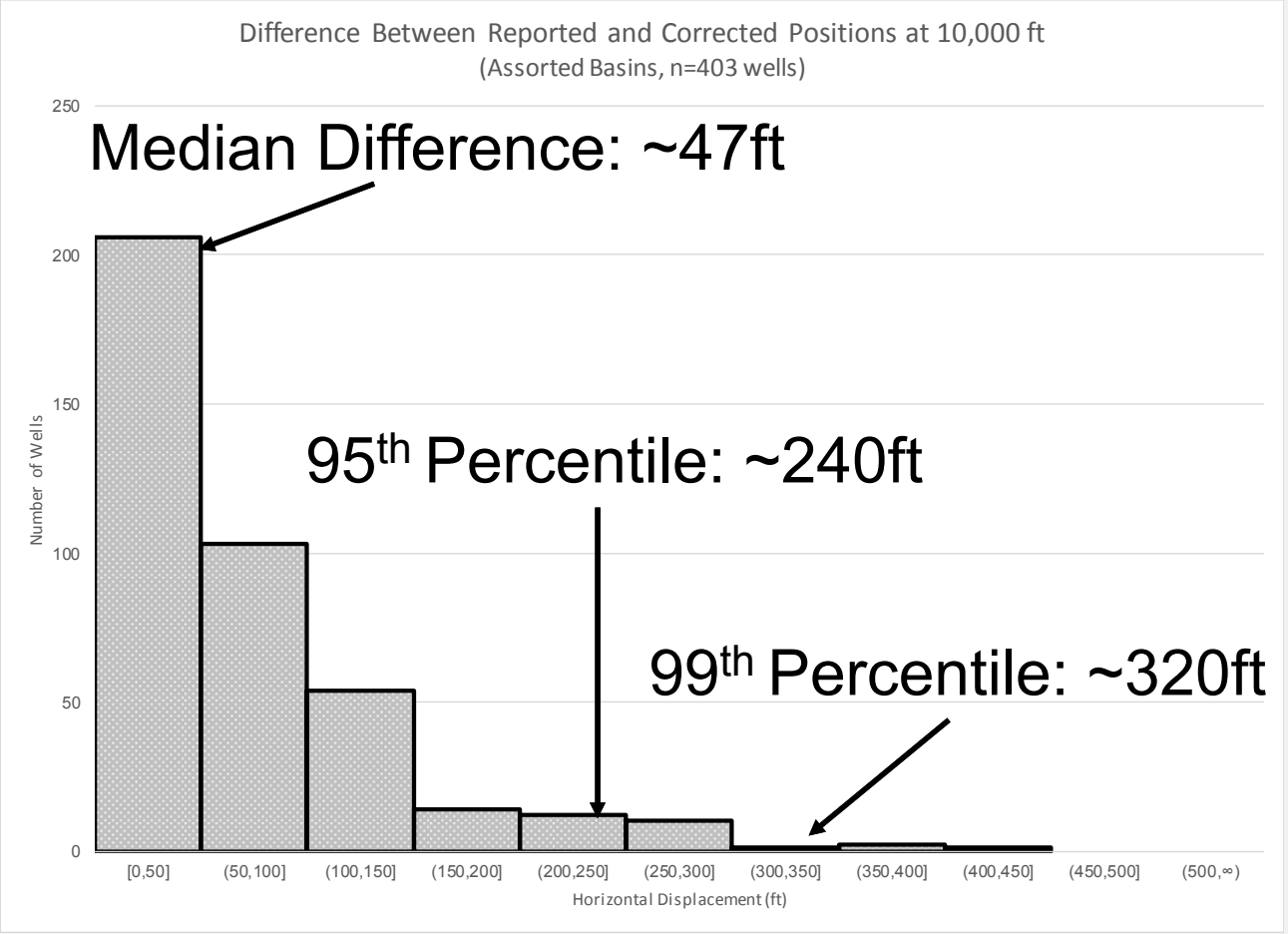
Corrections Outside the Permian (10k Lateral)

~400 real wells

~20 operators

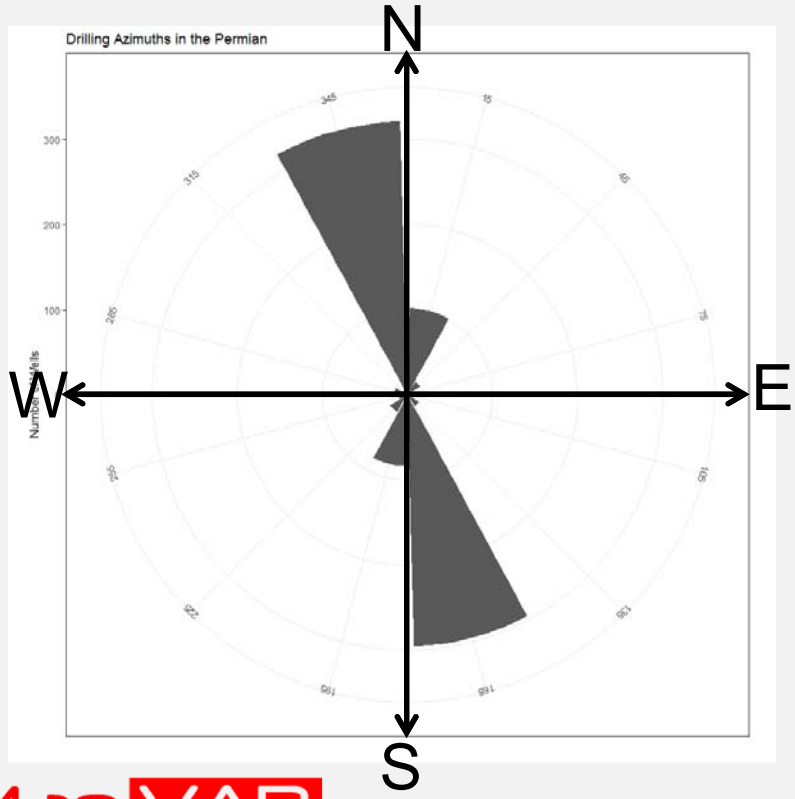
~15 vendors

Motors & RSS

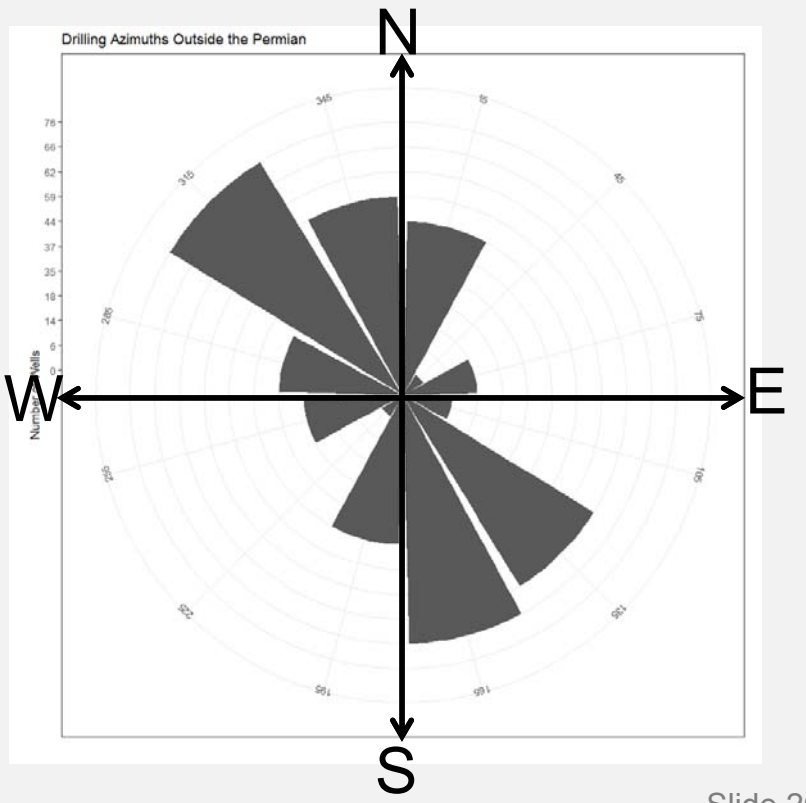


Differences are Explained by Drilling Direction

Permian Azimuth Distribution



Other Azimuth Distribution



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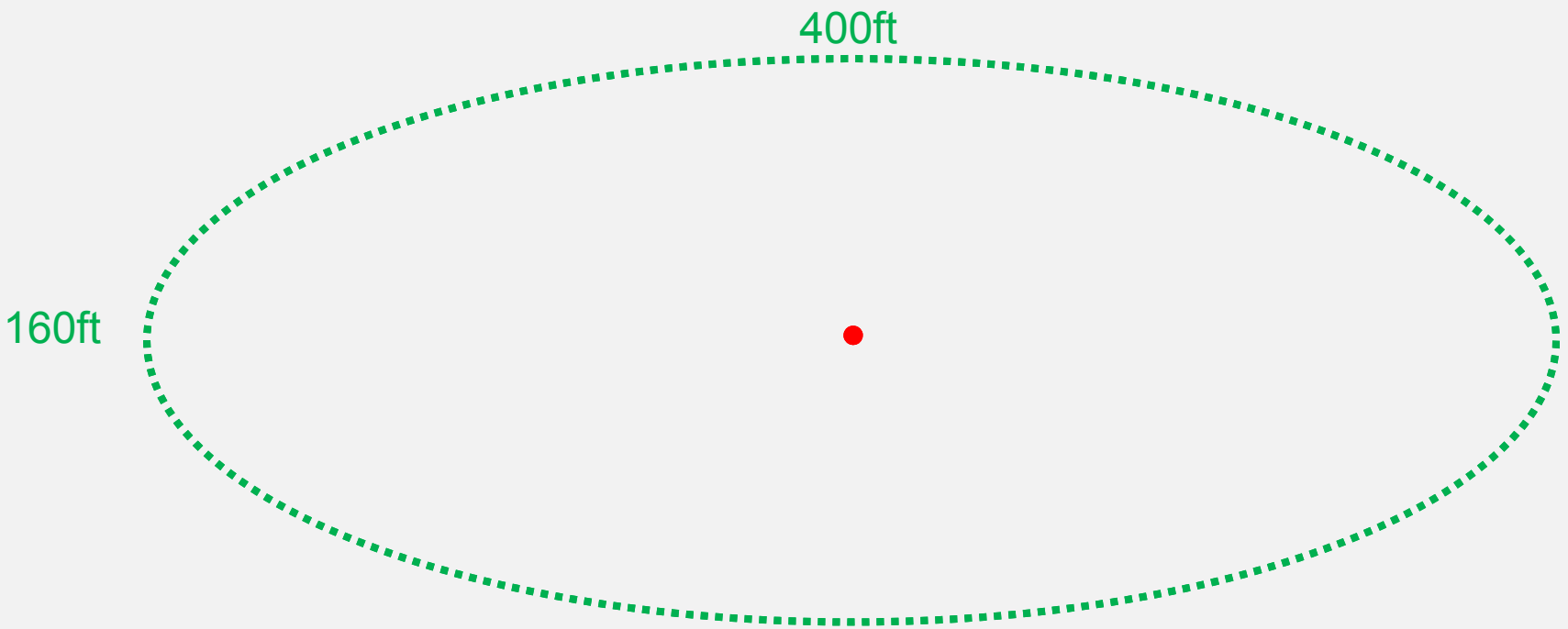


The Uncertainty is Real!

What This Means For the Asset

Drilling more accurately is limited by surveying

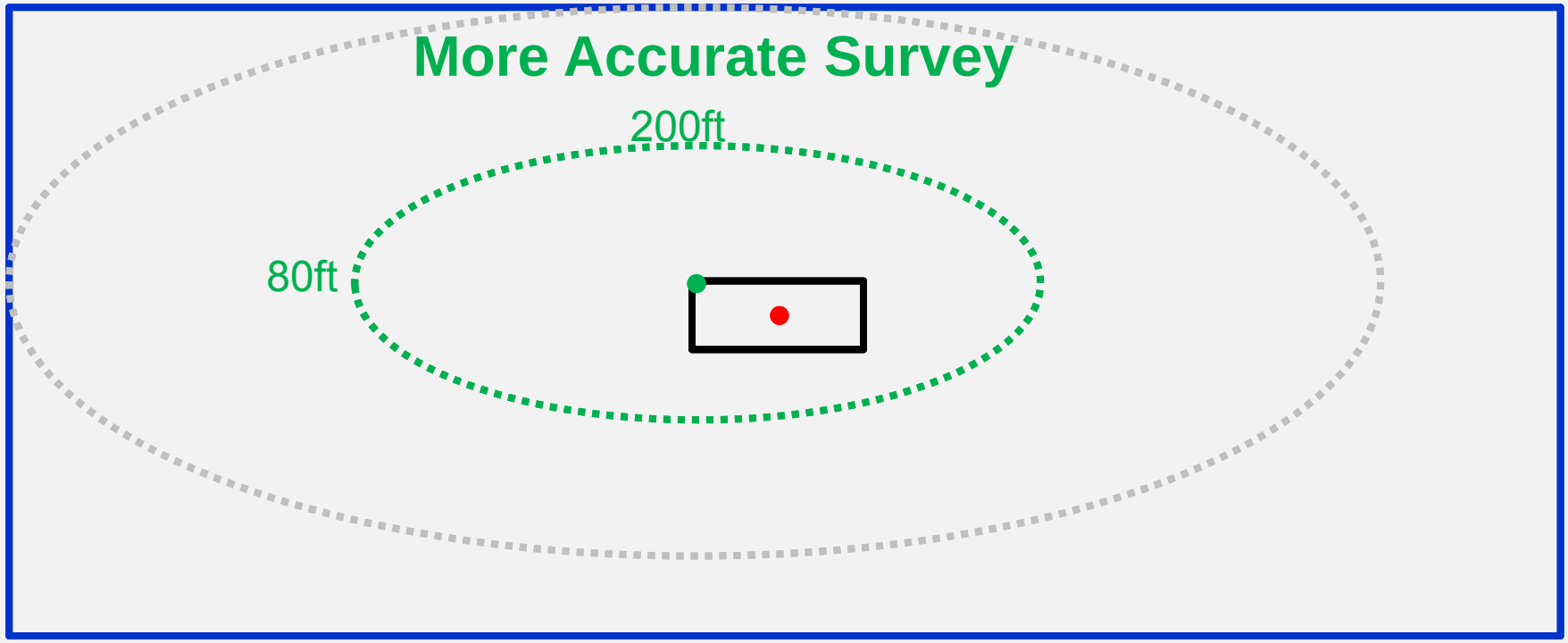
- Survey corrections often larger than a typical drilling window

Value can be driven through survey practice improvements

- Enable greater flexibility on drilling

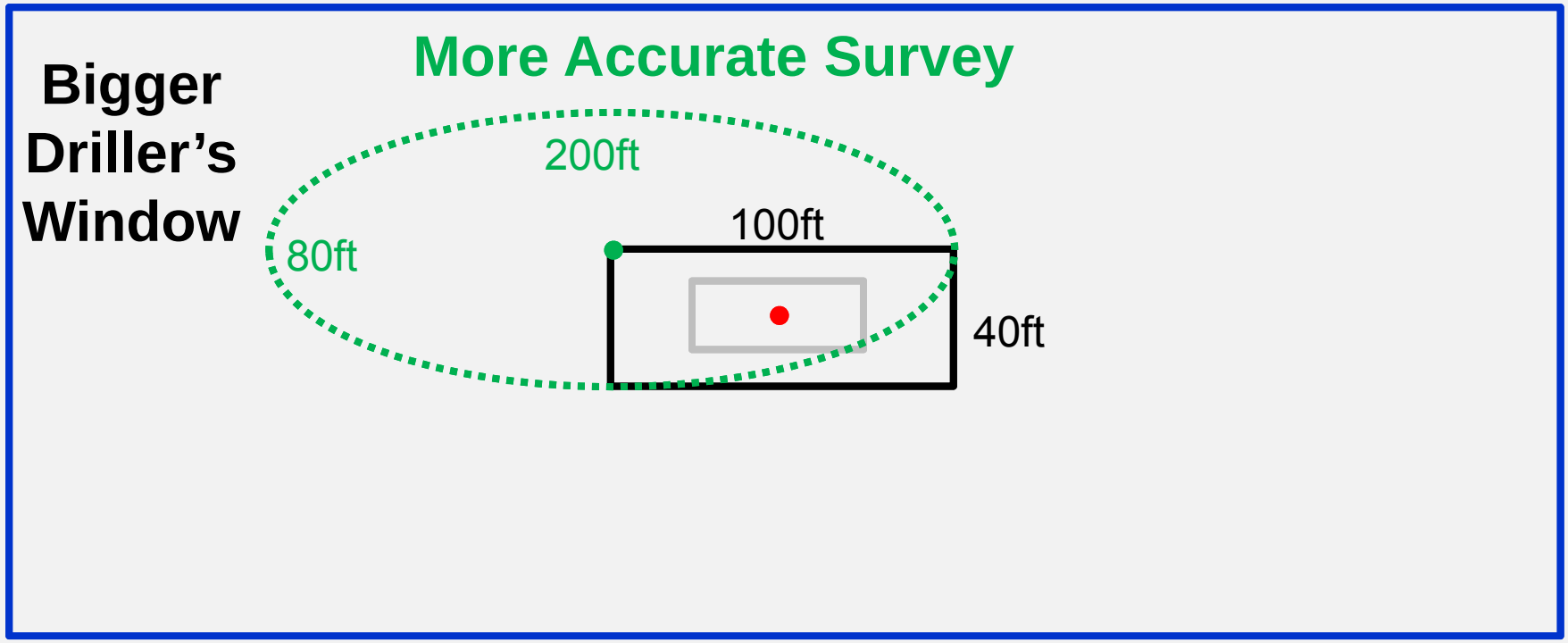
Any discussion of spacing should start with surveying

Revisiting Our Target



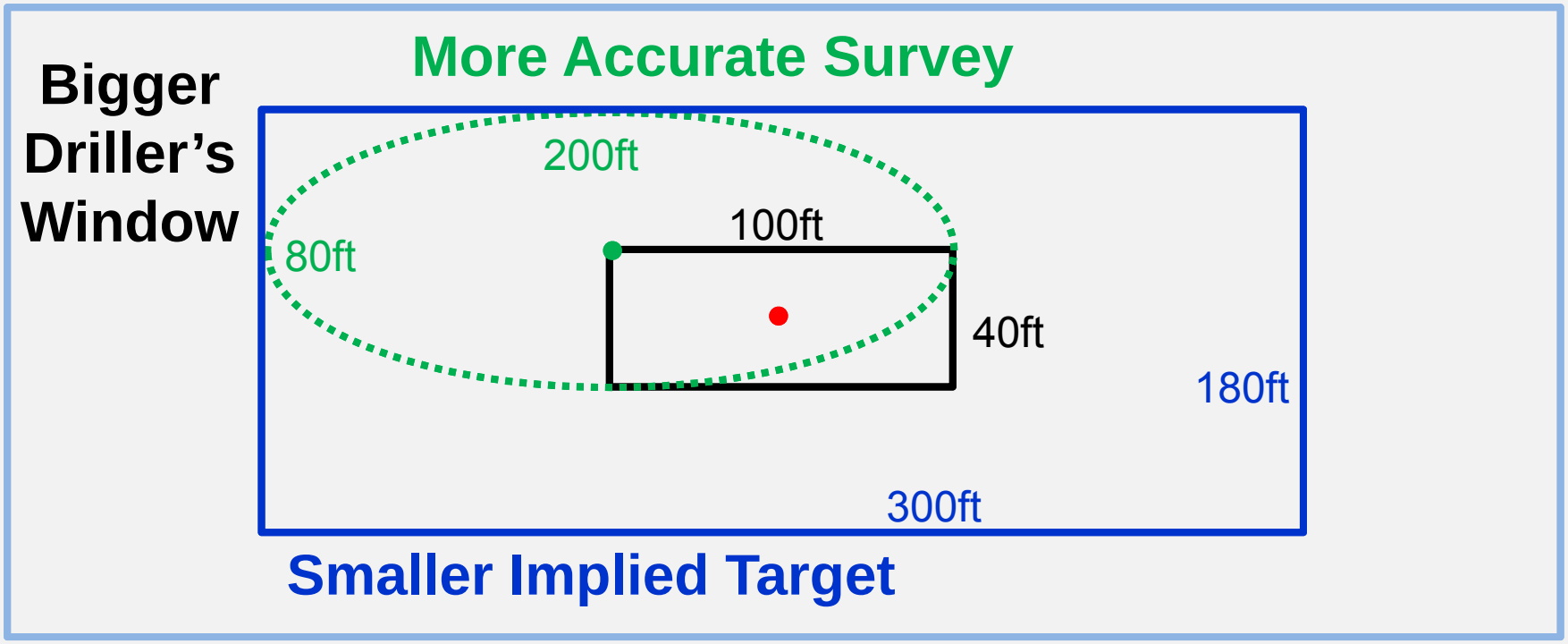
Better survey practices can cut the positional uncertainty in half

Revisiting Our Target



This enables opening up the drilling window

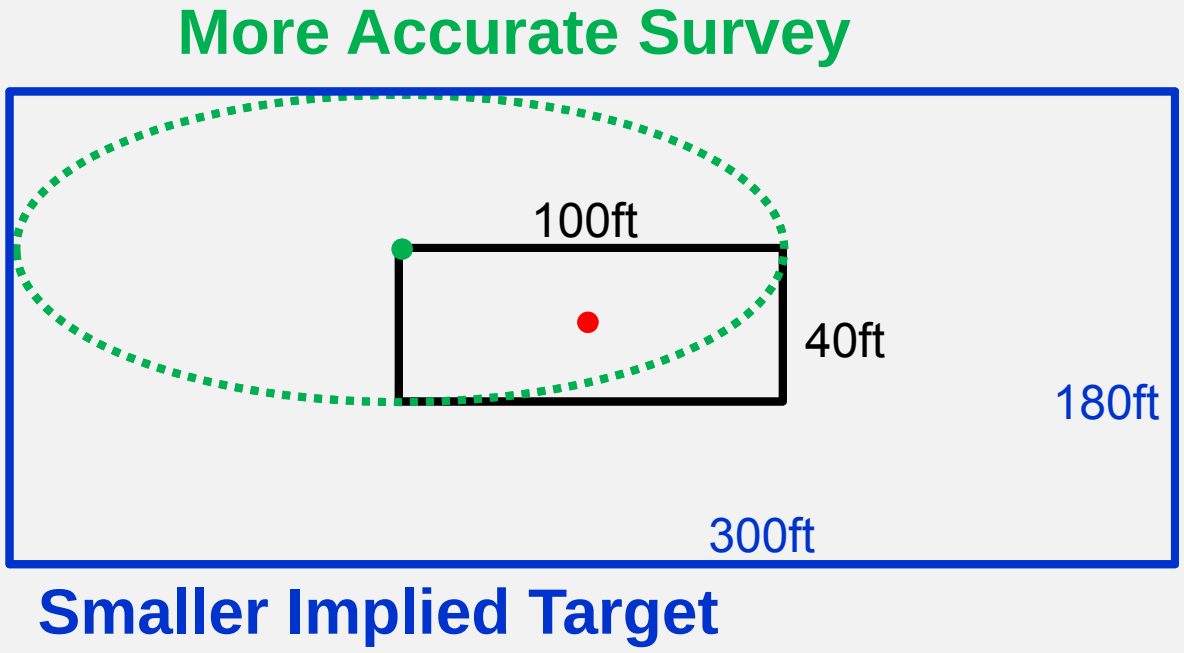
Revisiting Our Target



Final target still lands in an overall smaller space

Revisiting Our Target

Bigger Driller's Window



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

Recap

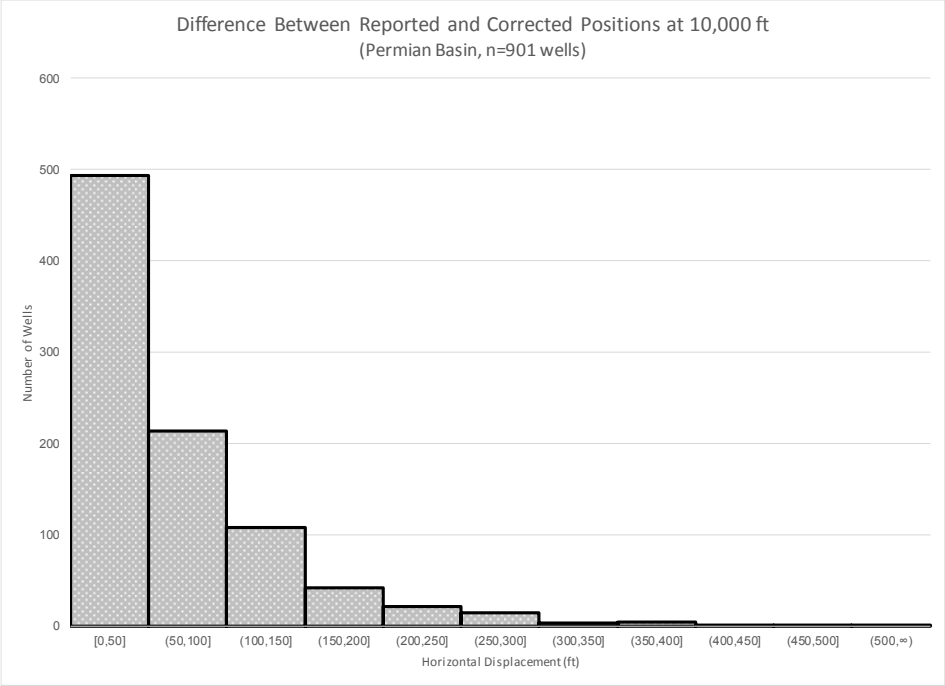
Product quality is inherently limited by how well it is measured

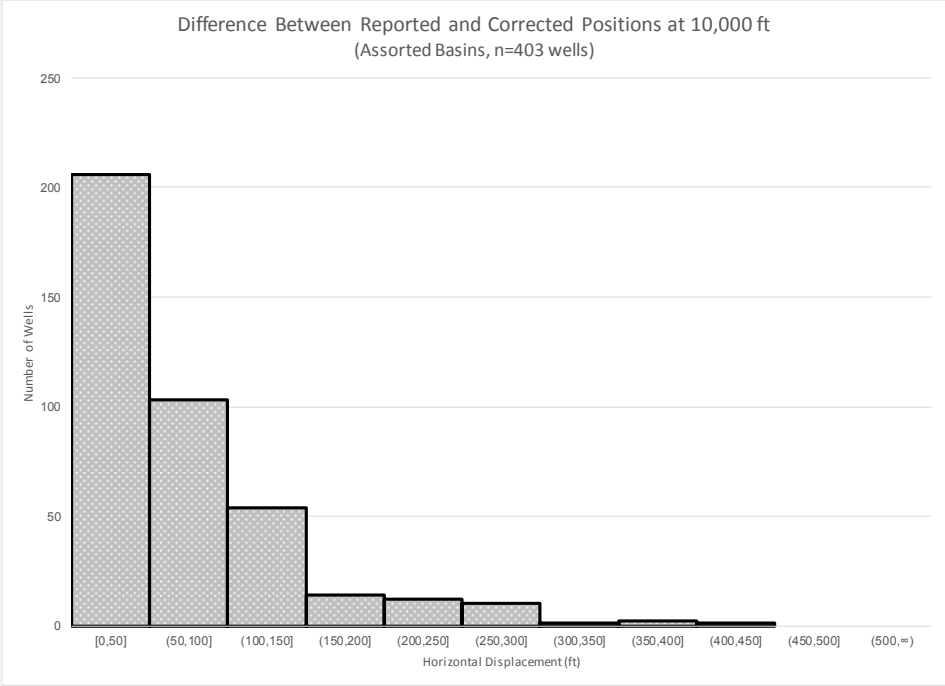
True drilling accuracy is limited by survey accuracy

Reducing positional uncertainty is vital to asset value

Open up drilling windows while still delivering more consistency

Thank You! Questions / Discussion?





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