61th General Meeting
6th & 7th of March 2025
Stavanger, Norway

Wellbore Positioning Technical Section

The Industry Steering Committee on
Wellbore Survey Accuracy (ISCWSA)

SPE-220834 - Estimating Likelihood of Directional Drilling Success Through a Practical Application of Projection Uncertainty Models

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Helmerich & Payne

Speaker Bio / Affiliation

Marc Willerth

- Global Research & Innovation Team, H&P

- 15+ years in varying facets of wellbore positioning product support, survey corrections, & error modeling, etc

- Marc.Willerth@hpinc.com

"Tactics is knowing what to do when there is something to do.
Strategy is knowing what to do when there is nothing to do."

-Savielly Tartakower

Directional Drilling Tactics

How we execute a steering decision

- Tool Face Control, RSS Bias Units, etc

Directional Drilling Strategy

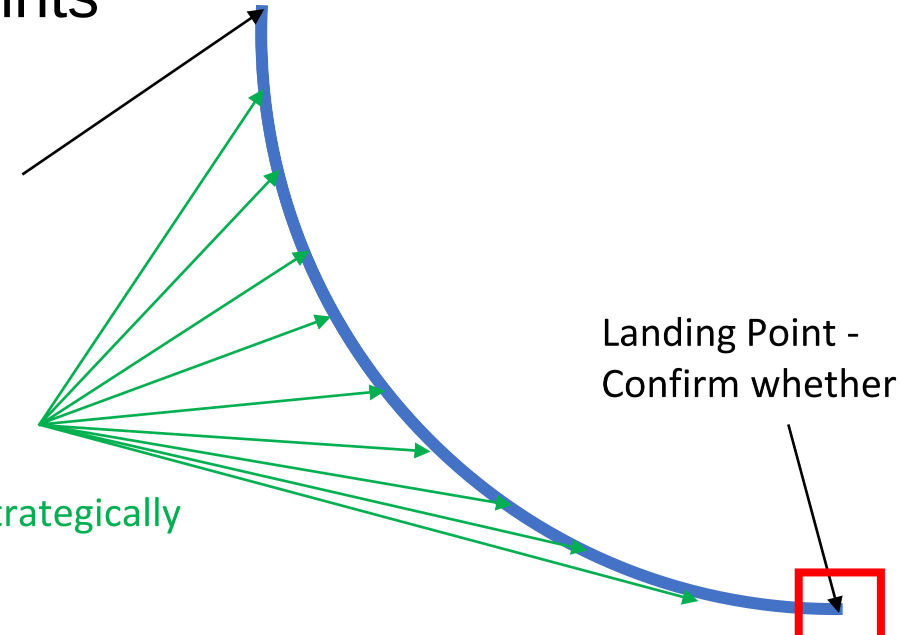
What should we be aiming for in the first place?

- Superficially the well plan

Main scope of this study – Extended Reach Curve / Laterals

Extremely common in NA - Land in target and then stay there
Only 6-10 true decision points

Kick Off-Point –
Action is pre-defined*

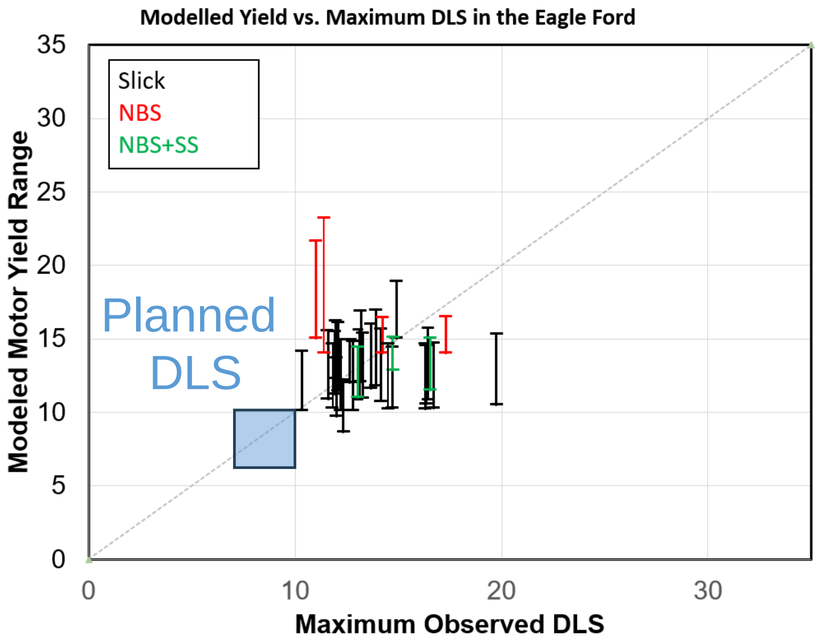


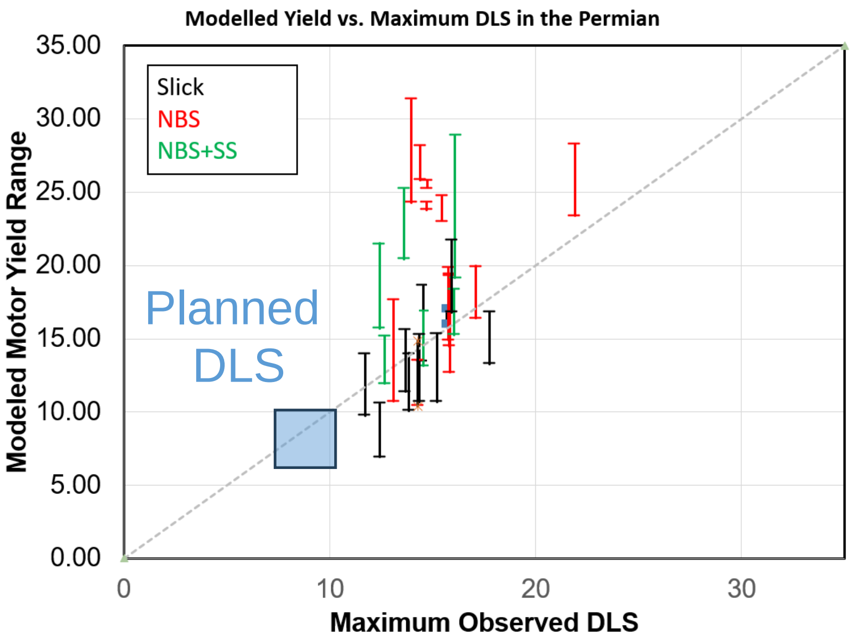
Landing Point -
Confirm whether objective is

Intermediate surveys–
Opportunity to react strategically

Background / Prior Work

SPE 204129 – Analyzing BHA Selection and Suitability for Curves

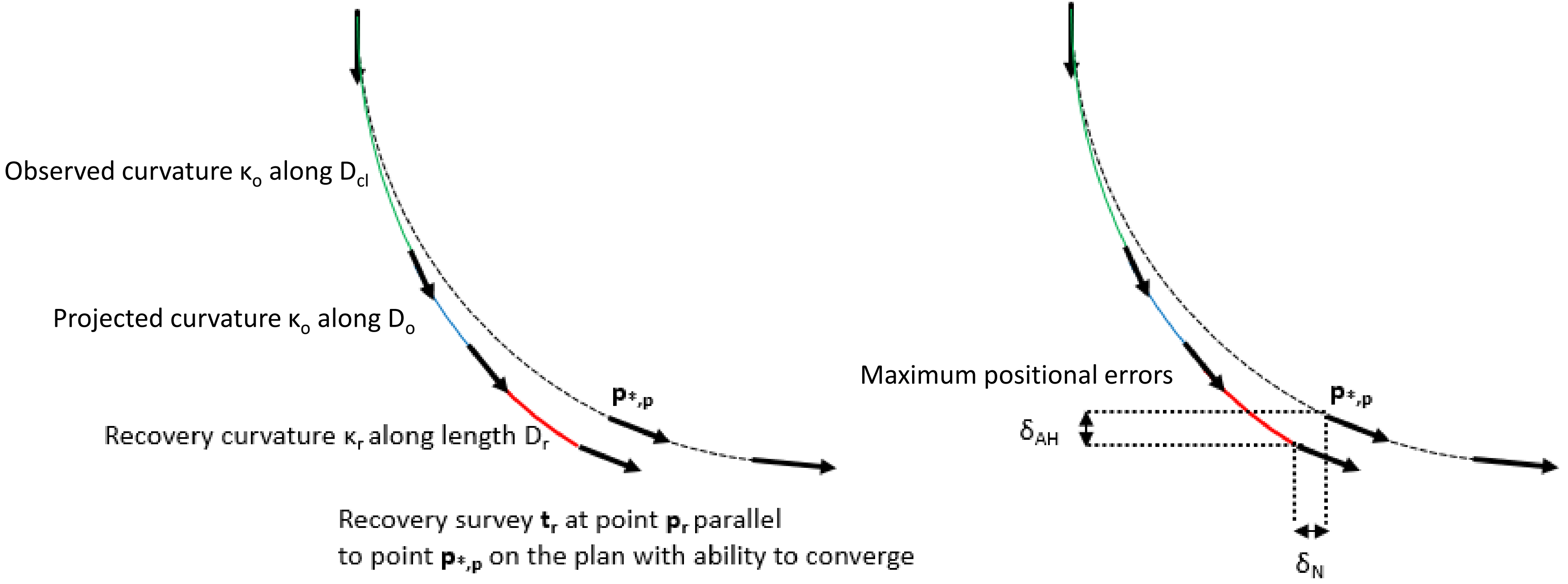




actical

Background / Prior Work(2)

SPE 217744 – Model for Analyzing Bit Projection Uncertainty

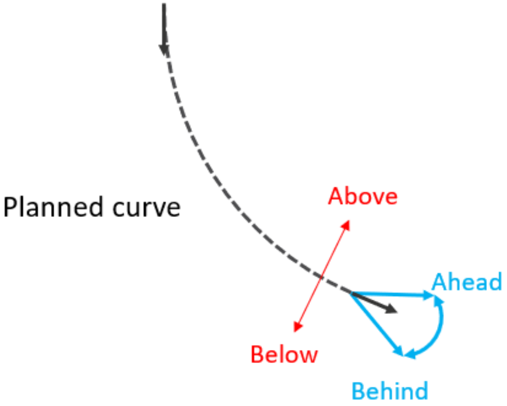


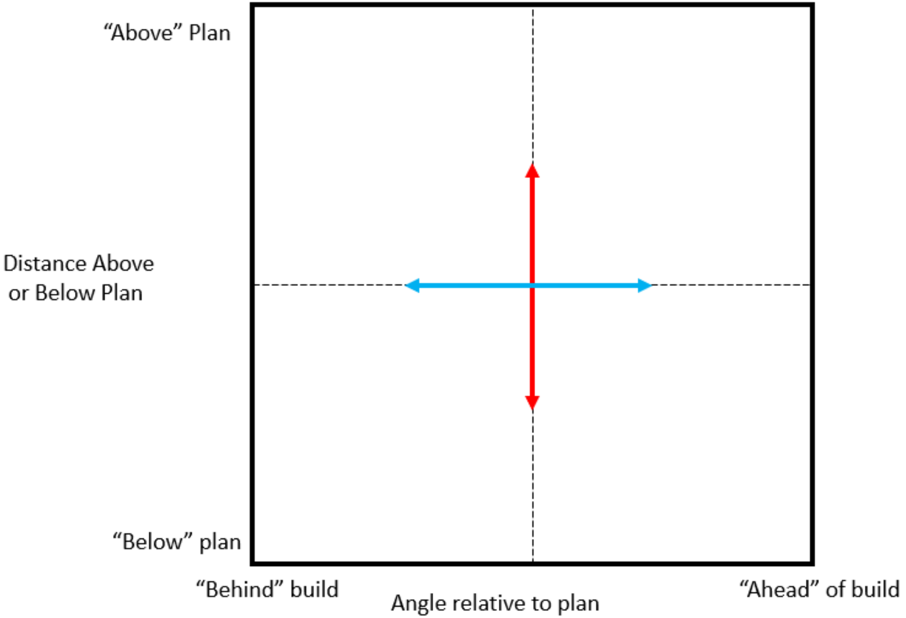
This Study – Mapping the DD Decision Space

At any given survey point there are 2 considerations:

- Inside or outside the planned curve (“Above” vs. “Below”)
- Greater or lesser amount of curve still needed (“Ahead” vs. “Behind”)

Graphically:

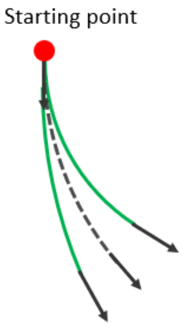




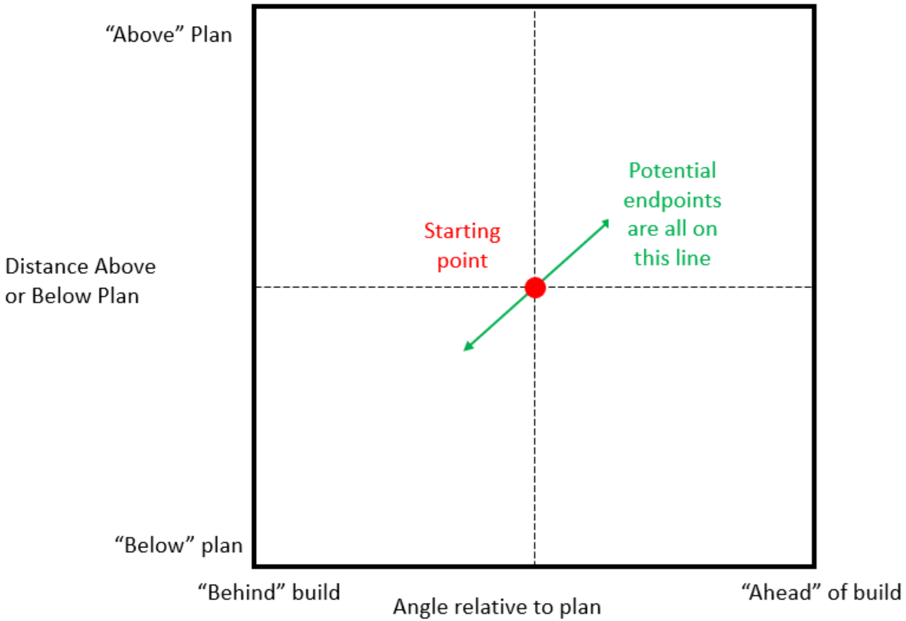
Transitions in the Directional Decision Space

Only limited movement in this space is possible

Constrained by projection equations:



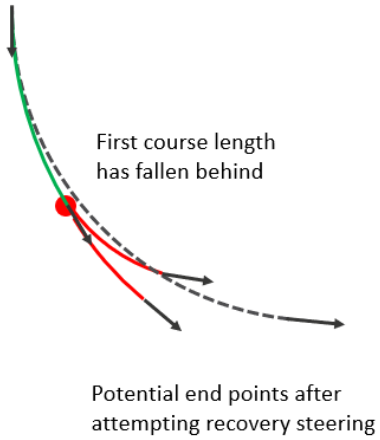
Potential endpoints for the first
course length on a well kickoff

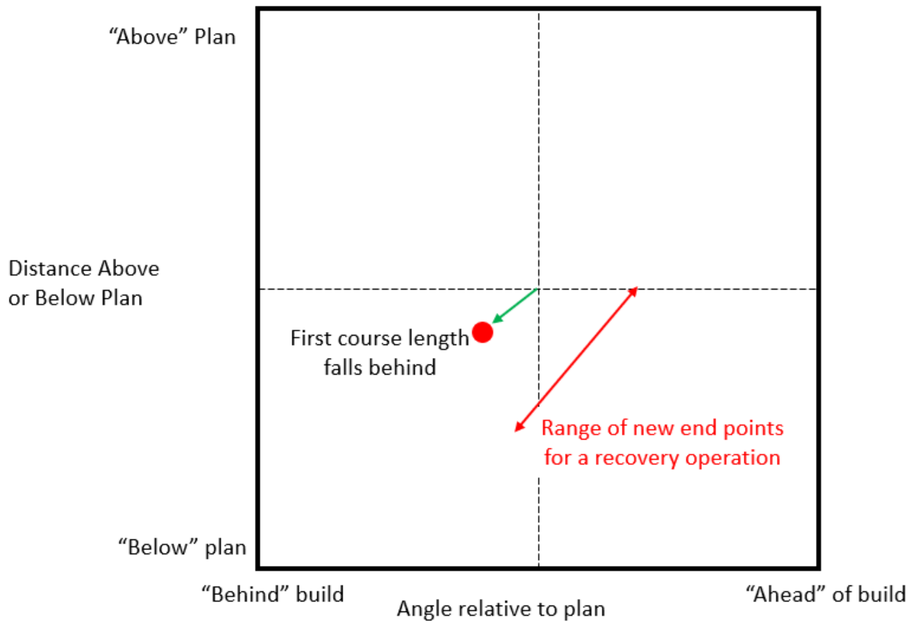


Transitions in the Directional Decision Space (2)

Once we survey, we can map the next possible move

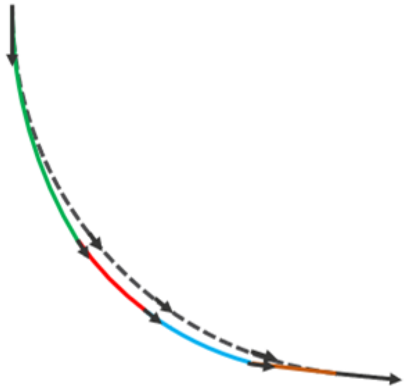
- -Using course length, possible steering curvature, steering length, etc



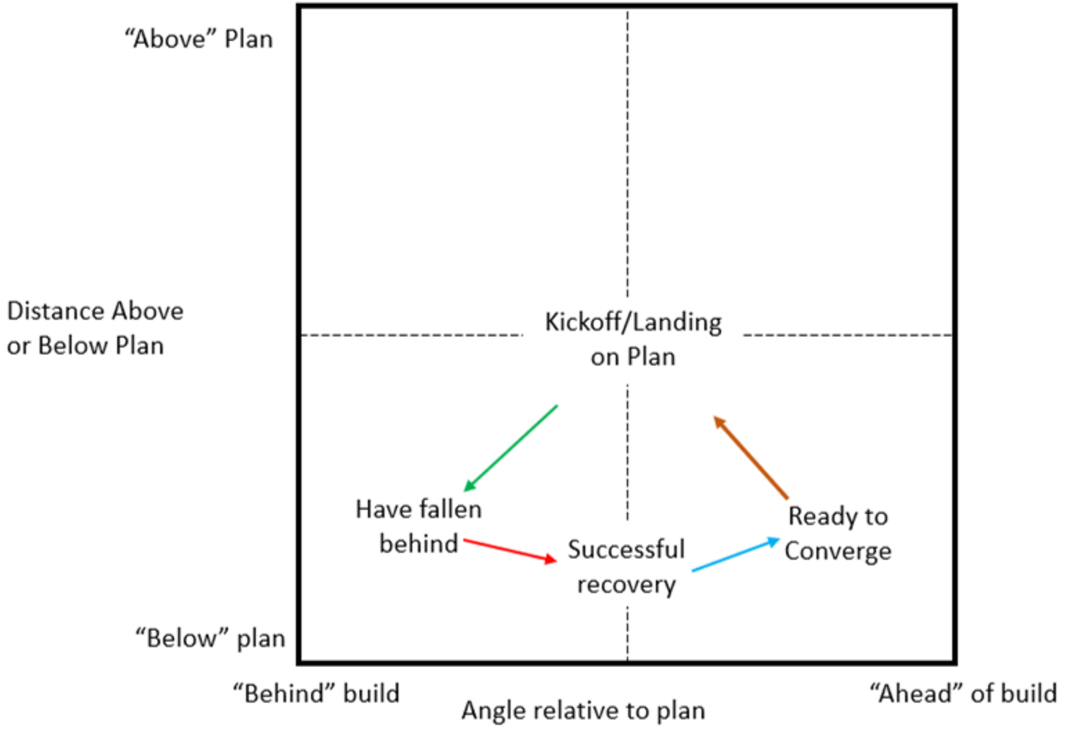


Example Movement Through Space when Drilling a Curve

Falling behind, but then recovering to plan



Drilled curve in TVD / VS

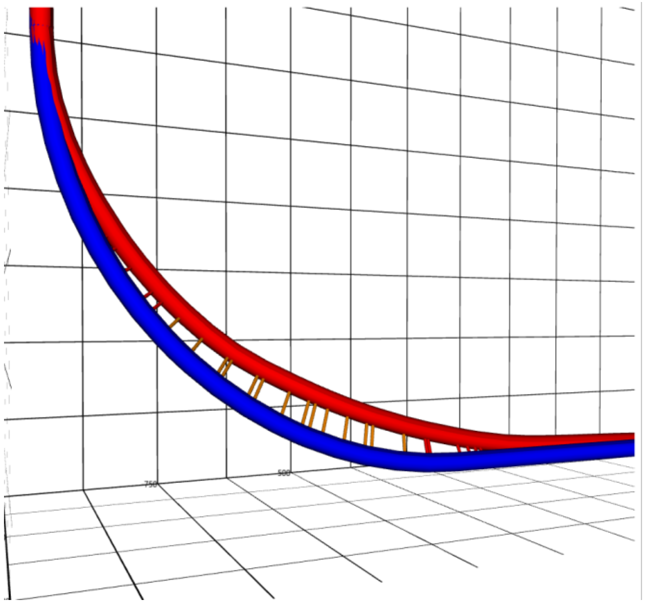


Producing This Map in Practice

Straight forward using augmented collision avoidance calculations

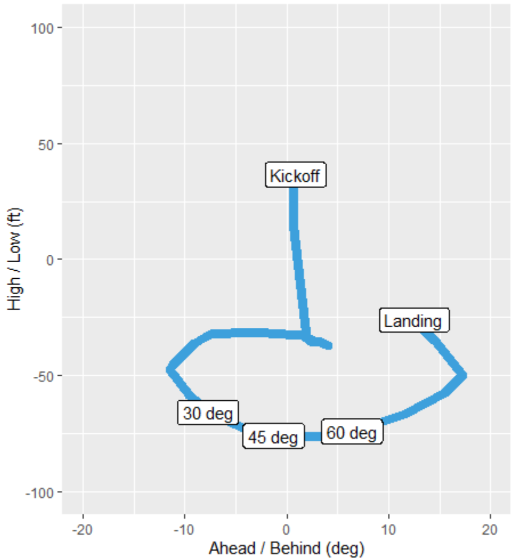
Scan Actual vs. Plan

- Look at bit-depth when surveys were taken
- Find nearest point on plan
- Check position for High / Low
- Check survey for Ahead / Behind
- Consider observed motor yields / BHA models

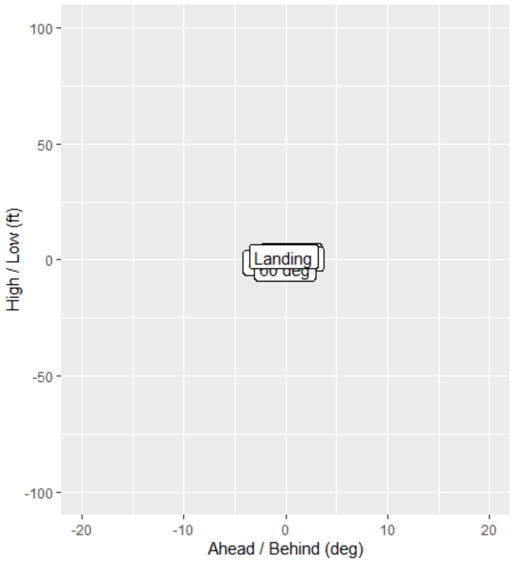


Use this data to infer the **DD strategy**

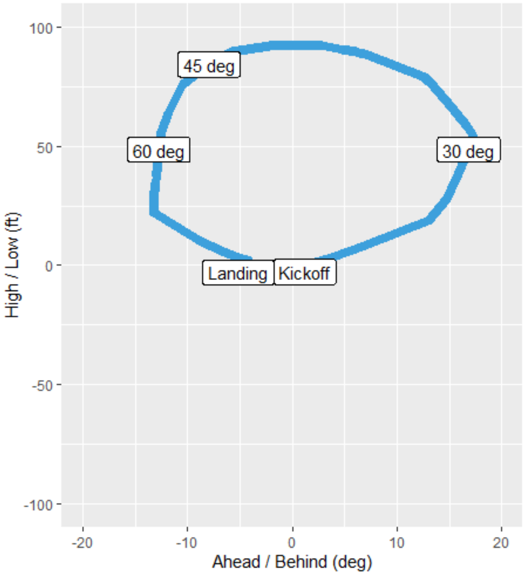
What Strategies Happen in Practice? (>20 NA wells)



Fall behind and recover



Paint the line

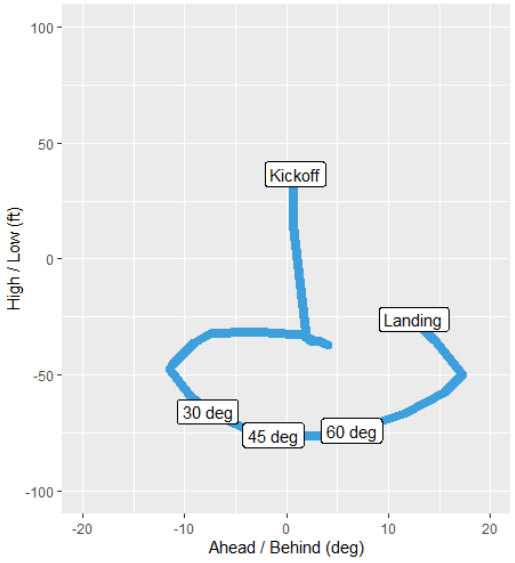


Get ahead and land long

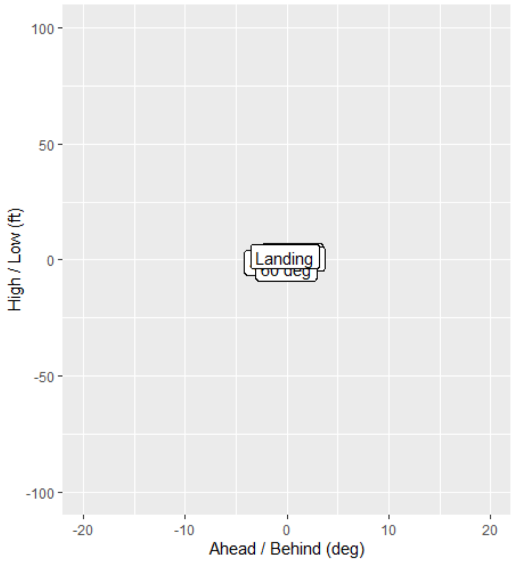
SPE-220834 - Estimating Likelihood of Directional Drilling Success Through a Practical Application of Projection Uncertainty Models; Willerth, McGregor, Cook, Landrio

What Strategies Happen in Practice? (>20 NA wells)

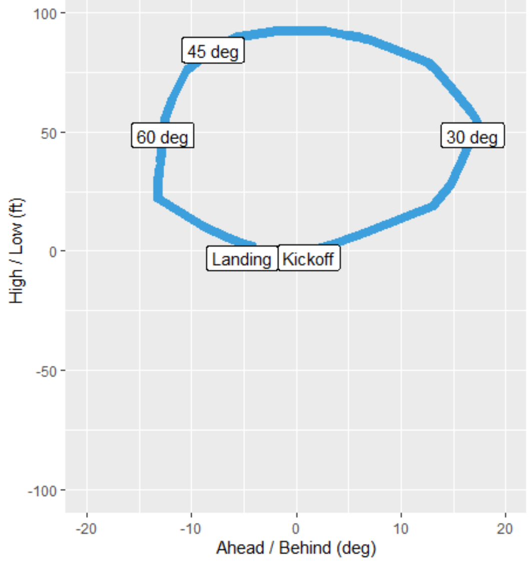
By far the most common in the US!



Fall behind and recover



Paint the line



Get ahead and land long

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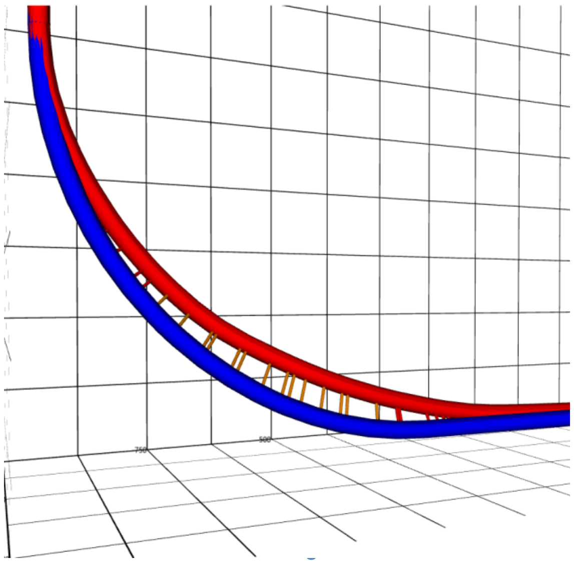
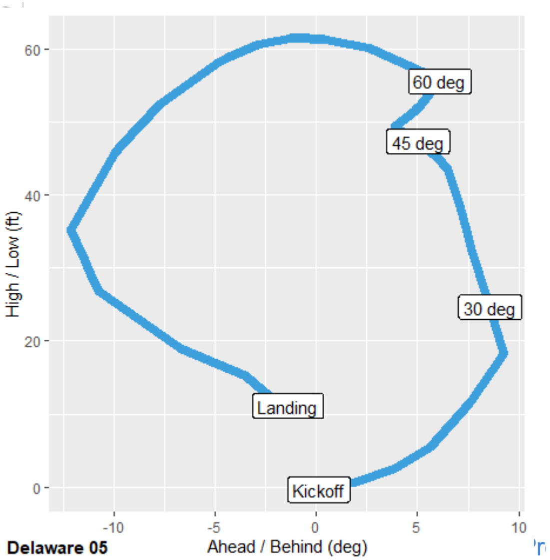
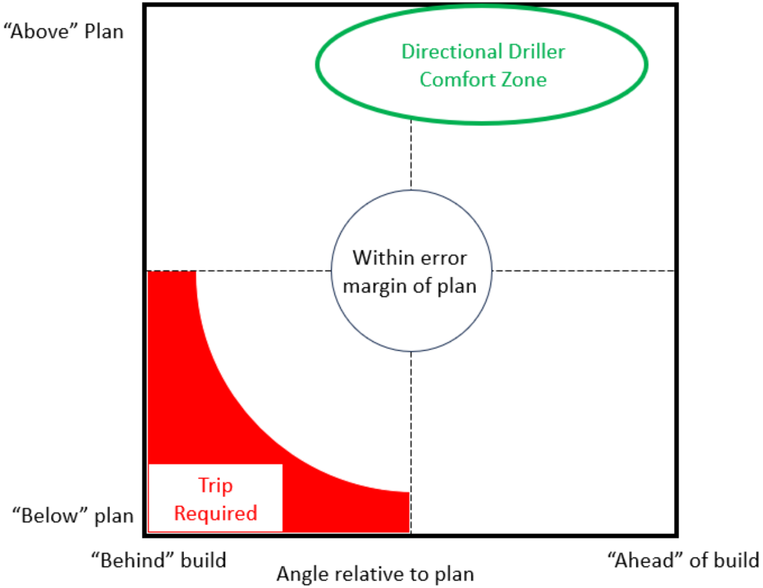
The North American Directional Drilling Strategy

- Virtually always kick off early (30-100’) – Often with a *full slide*
- Get way above and ahead of the well plan – DD Comfort Zone
- Minimize risk of landing low / missing the landing



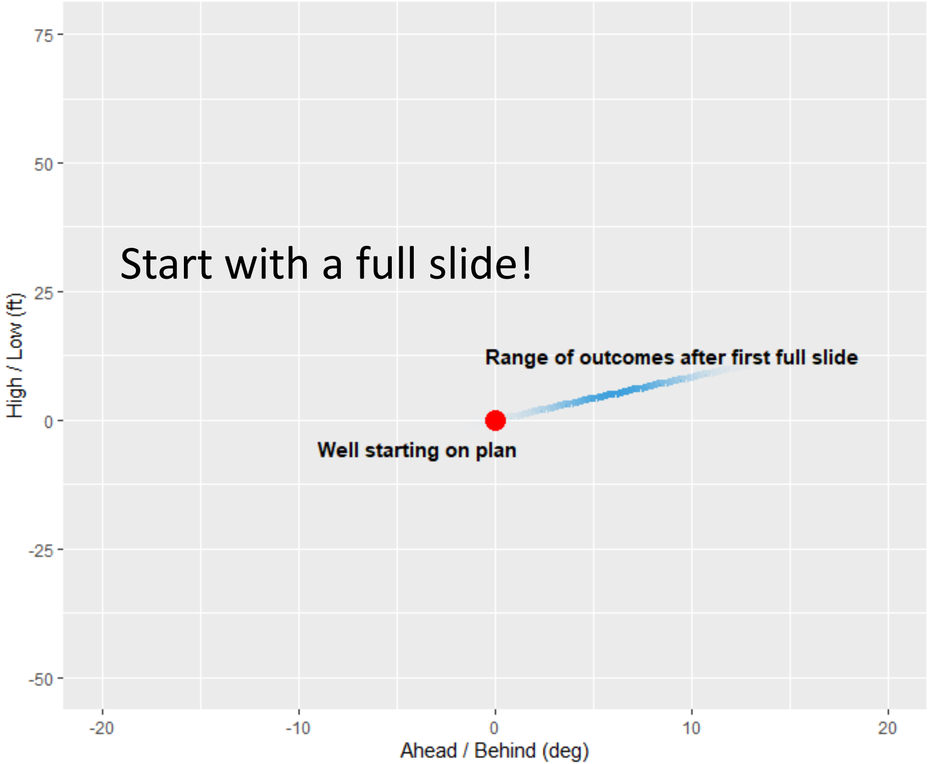




But What Does This Look Like *During Drilling?*

Visualizing the strategy

- Motor yield is a random variable



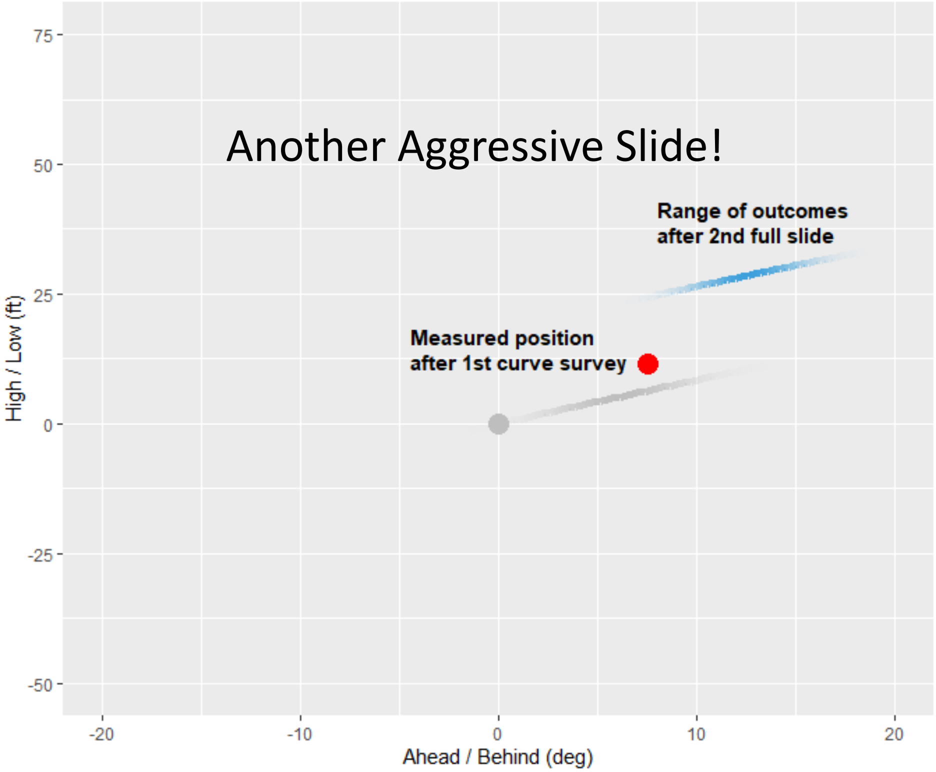
But What Does This Look Like *During Drilling?* (2)

Visualizing the strategy

- Motor yield is a random variable

Update expectations as we get data

- Still executing conservatively



But What Does This Look Like *During Drilling?* (3)

Visualizing the strategy

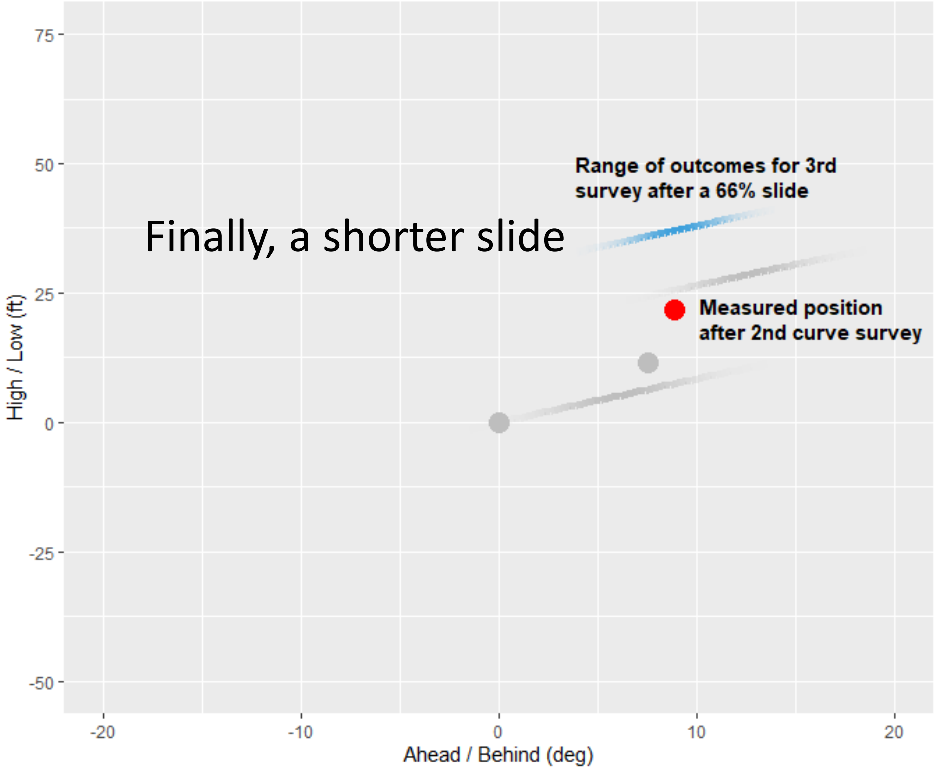
- Motor yield is a random variable

Update expectations as we get data

- Still executing conservatively

Finally back off a bit on the 3rd slide

- Still getting further from plan



But What Does This Look Like *During Drilling? (4)*

Visualizing the strategy

- Motor yield is a random variable

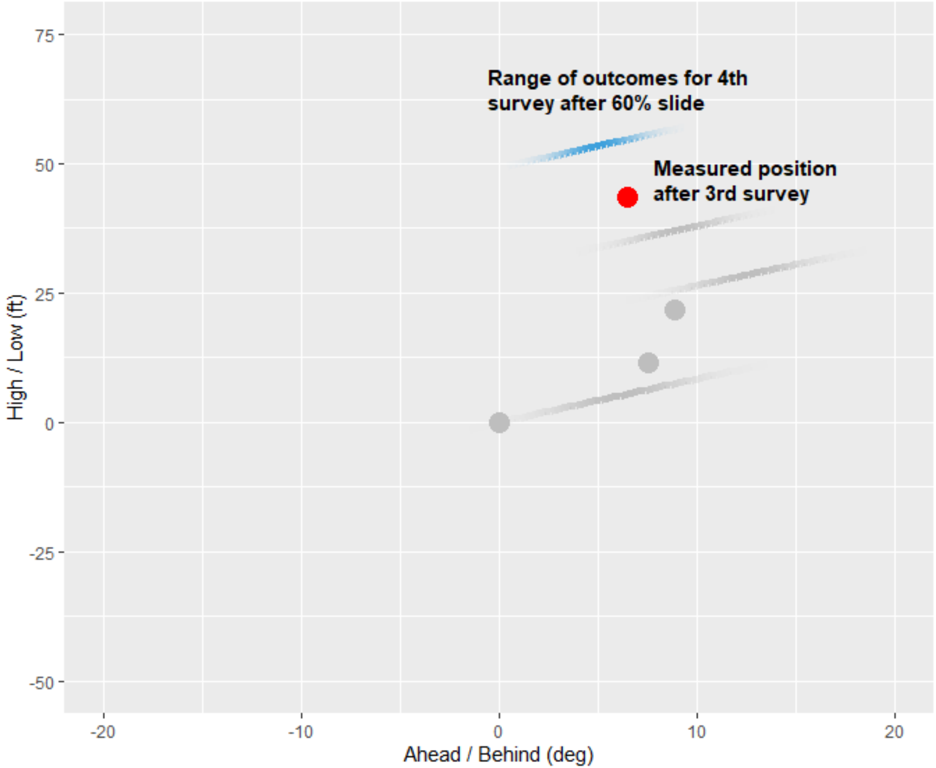
Update expectations as we get data

- Still executing conservatively

Finally back off a bit on the 3rd slide

- Still getting further from plan

Eventually we will float back to plan



Problems with this Strategy

Loss of completable vertical section

- Often 100ft or more

Large deviations from plan

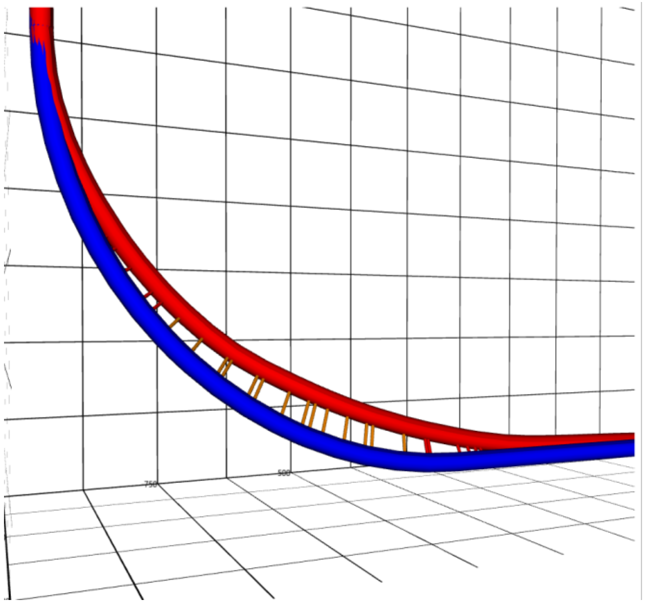
- Complicating collision avoidance

Needlessly conservative

- Can stay closer and not risk landing low

Philosophically unsettling

- Isn't the plan *what we wanted*?!?



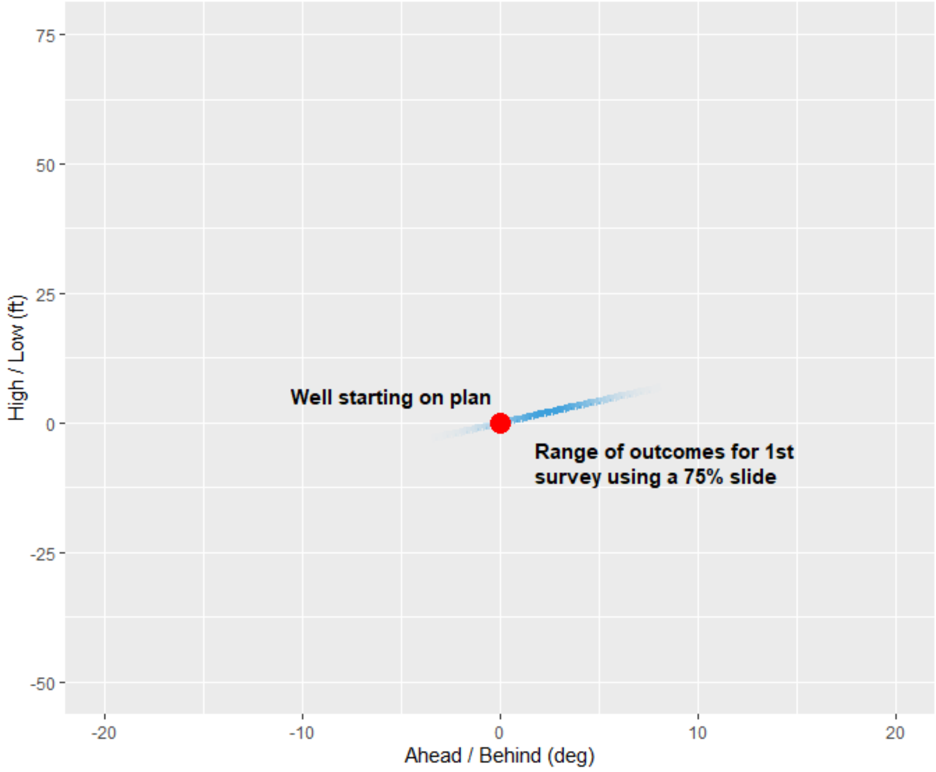
If North American DDs were Taxi Drivers:

But it's our "best practice" to stay at least 30ft ***ahead of the highway!***

Following the plan without too much risk: (1)

Conservative, but not full 1st slide

- Biased to getting ahead



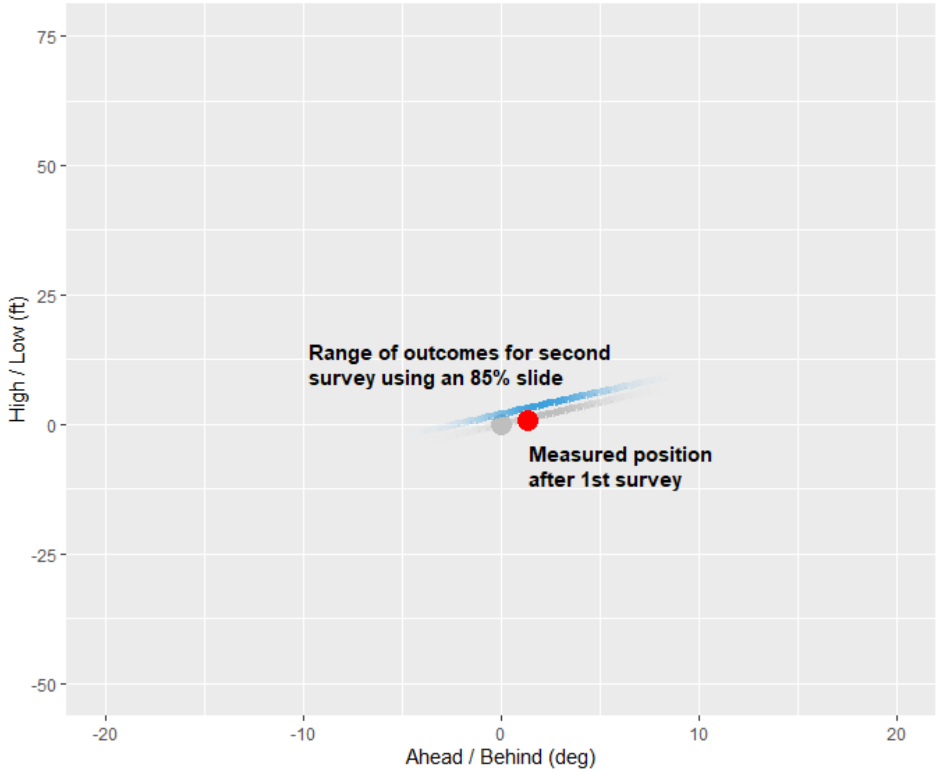
Following the plan without too much risk: (2)

Conservative, but not full 1st slide

- Biased to getting ahead

Manage risk based on surveys

- Adjust slide length as needed



Following the plan without too much risk: (3)

Conservative, but not full 1st slide

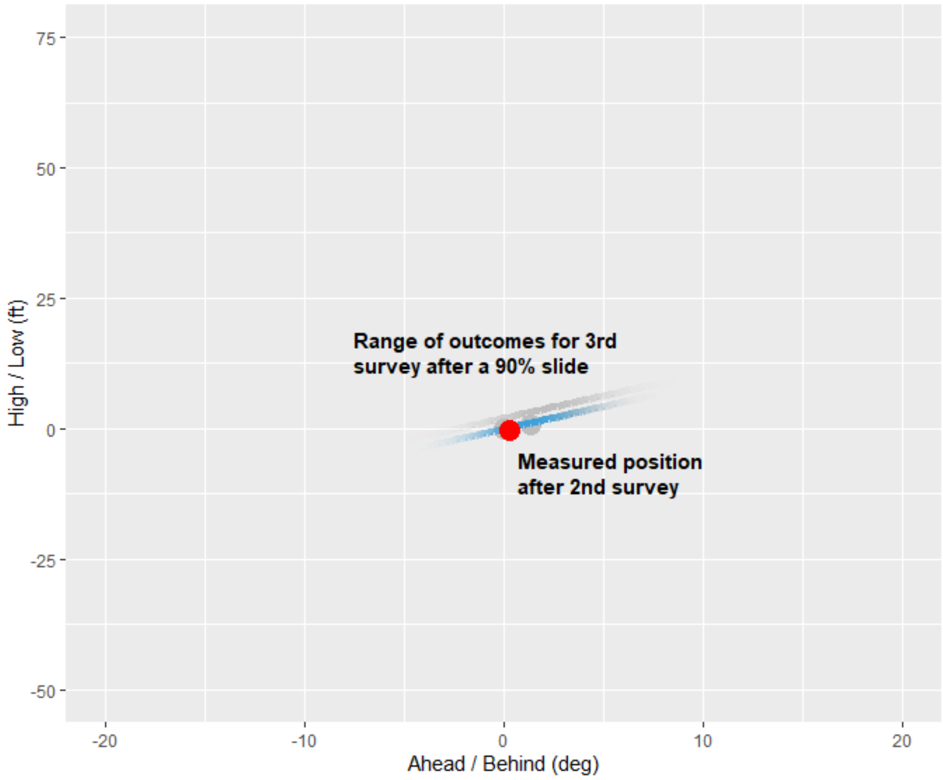
- Biased to getting ahead

Manage risk based on surveys

- Adjust slide length as needed

Continue on to landing

- Manage risk if "dead zones", etc



Following the plan without too much risk: (4)

Conservative, but not full 1st slide

- Biased to getting ahead

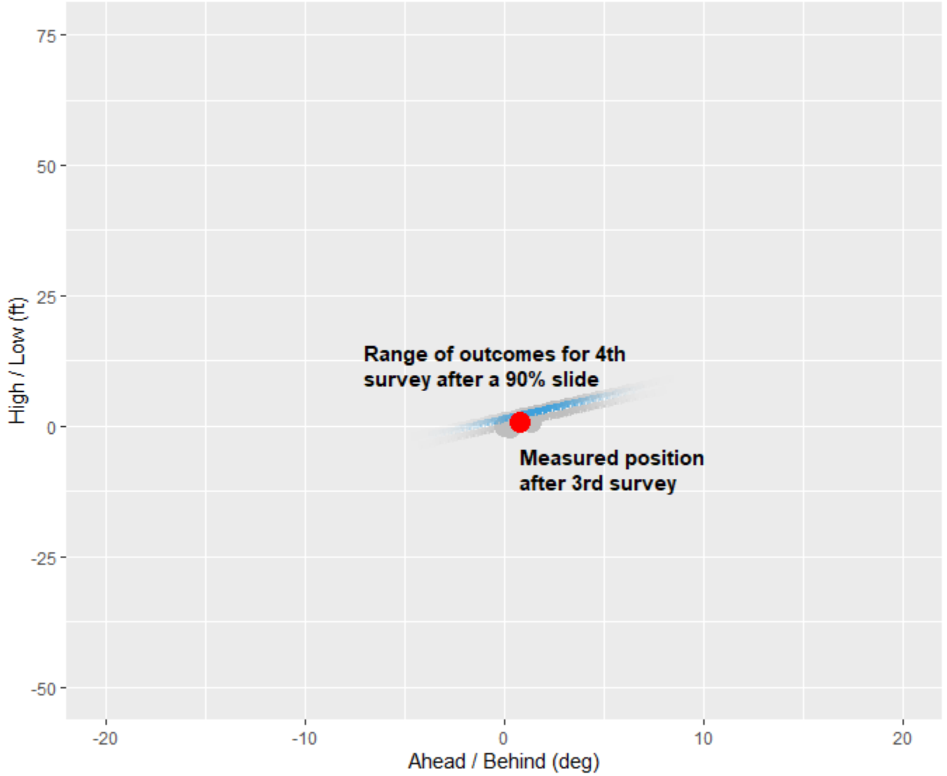
Manage risk based on surveys

- Adjust slide length as needed

Continue on to landing

- Manage risk if “dead zones”, etc

No need for large deviations!



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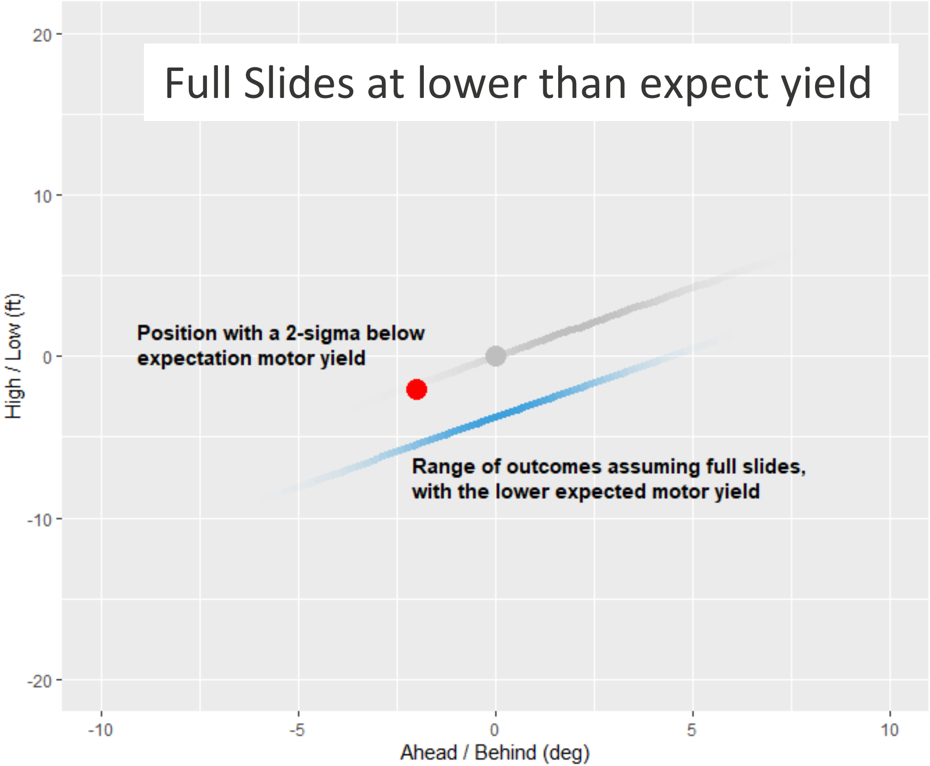
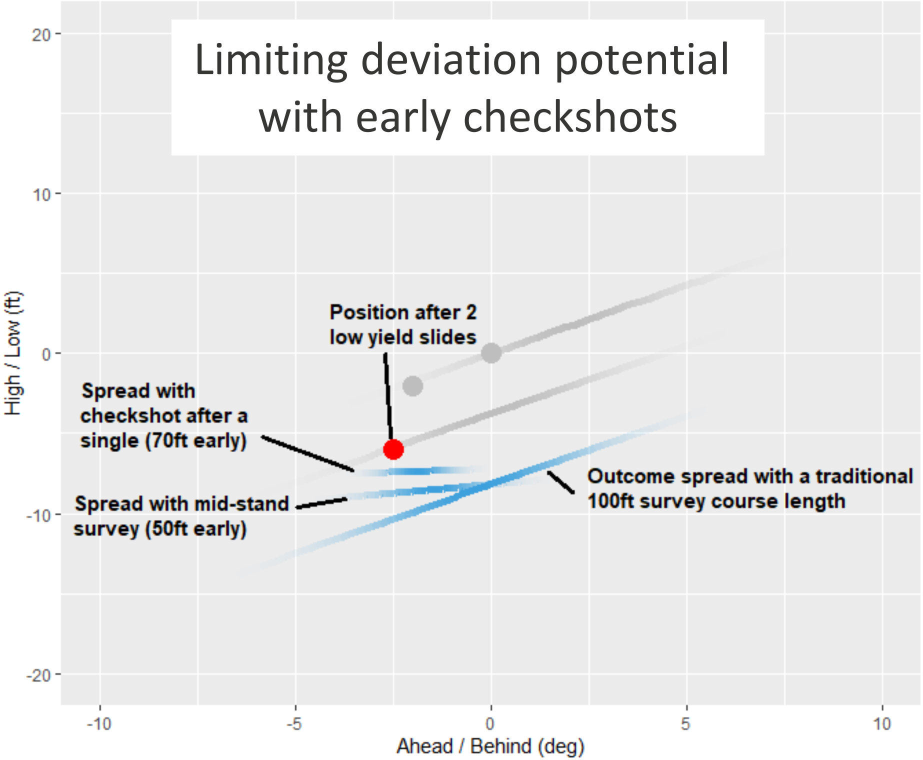
If you fall behind: Mitigating actions are still available!





Alternate Application: Lateral Drilling

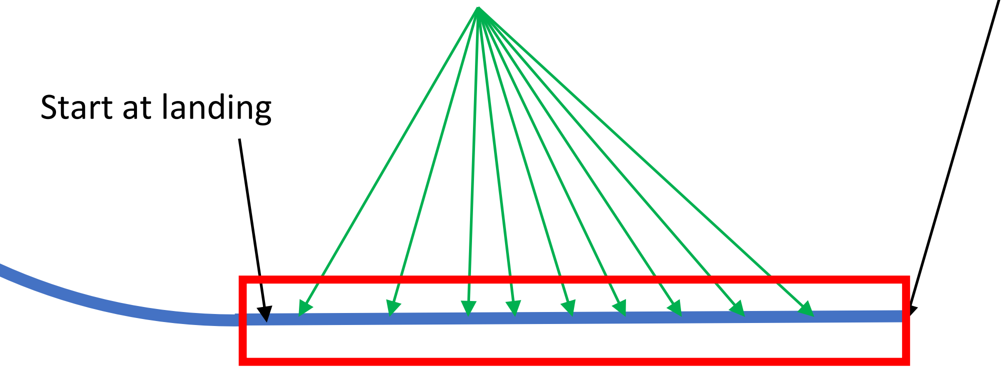
Variable number of decision points (depending on lateral length)

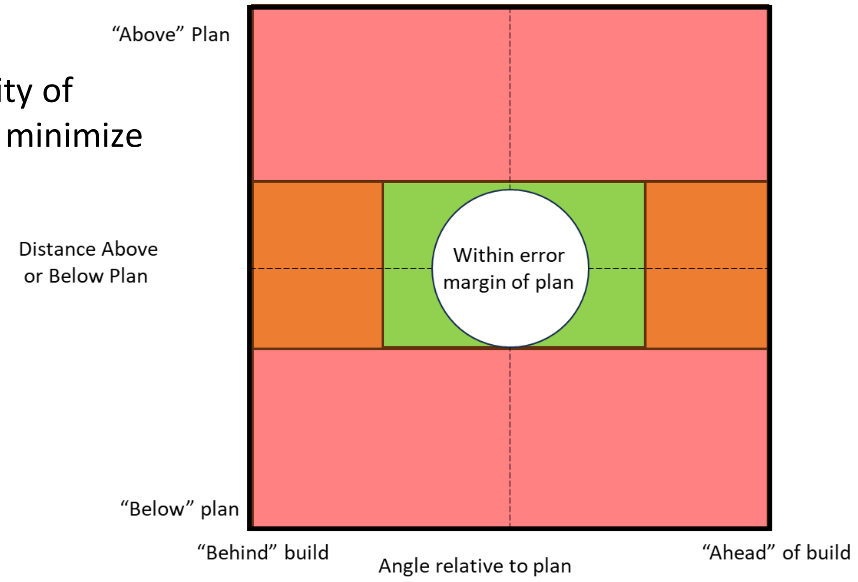
Goal – *Stay in a window*

Intermediate surveys–
Opportunity to react strategically

Maximize probability of staying in window, minimize need to slide

Start at landing





Conclusions

Proposed a method for classifying directional drilling strategies

- Enables risk assessment / probability of success calculations
- Can evaluate future operations or historical “look-back”

Current common practice in North America is extremely conservative

- Early kickoff, full slides, aggressive assemblies
- Often leads to landing long and losing completable footage

Improved plan-following strategies are possible and practical

- Let the plan define the true objectives, and manage risk from there

Thank you!

Questions?