



Enhancing Wellbore Quality and Decision-Making Through the Analysis of Cross-Axial Magnetometer Bias Errors

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Wellbore position vs wellpath accuracy

- Which is more important?
- Implications may vary –
 - Surveys for regulatory
 - Uncertainty at TD vs along lateral
 - Casing
 - Completions hardware
 - Torque & Drag
 - Drilling decisions



“[Wellpath quality] is about the
journey, not the destination”



MWD Data

- 3 magnetometers and 3 accelerometers
 - Measure the magnetic and acceleration fields
 - Ultimately give us inclination & azimuth
- There will be errors!
 - Errors in sensors or in process
- What impacts will these have?

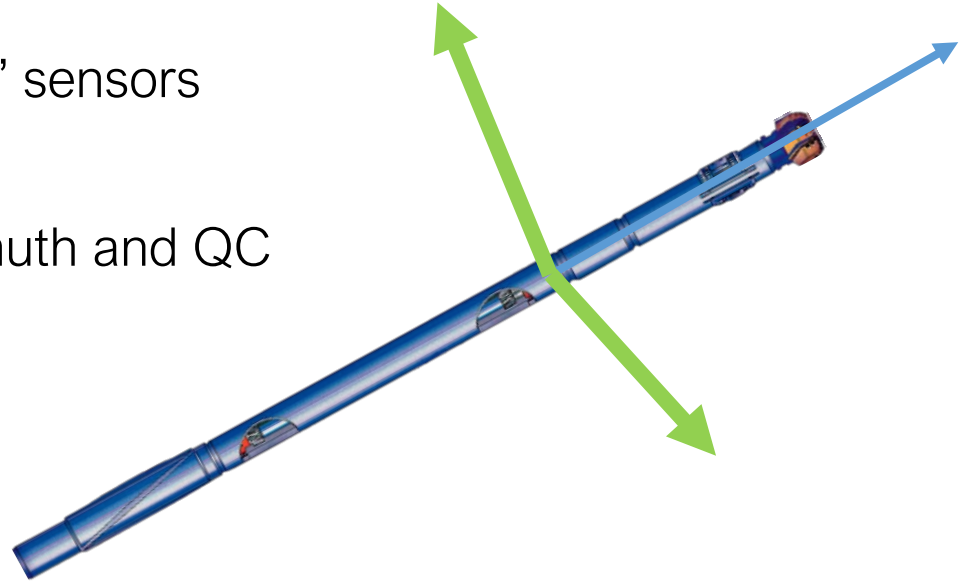


MWD Errors

- Most commonly discussed:
 - Declination (magnetic reference)
 - Drillstring interference (magnetic BHA components create axial bias)
 - These can “shift” the wellbore’s final position
- Other errors exist:
 - Cross-axial errors (accelerometers & magnetometers)
 - Bends and sensor shifts
 - These can change the path of your well

Cross-Axial Magnetometer Biases

- Affects one (or both) of the “radial” sensors
- Toolface-dependent effect on azimuth and QC





Incorrect Calculations

- Azimuth values may be erratic
 - A DD chasing an azimuth can induce undesired tortuosity (and confusion)

- Motor yield calculations may be erroneous
 - Dogleg severity between surveys is incorrect



In Practice

- Having undetected tortuosity
 - False sense of security
 - Big surprises later
- Measuring nonexistent doglegs
 - Unnecessary corrective actions
 - Can unnecessarily create undesirable paths

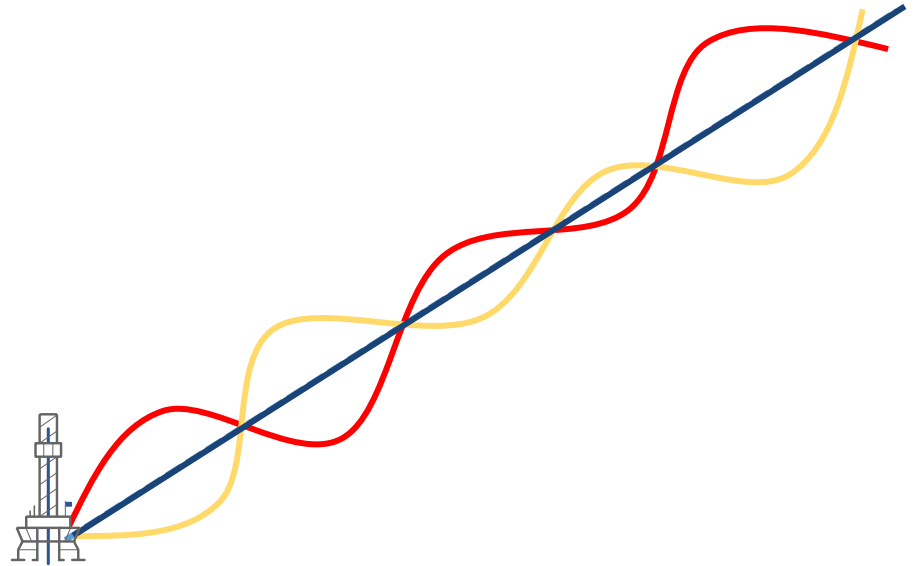
Possible Behaviors

Well plan

Pumped-up surveys (with errors)

Corrective actions from DD

Actual pumped-up surveys
(errors removed)

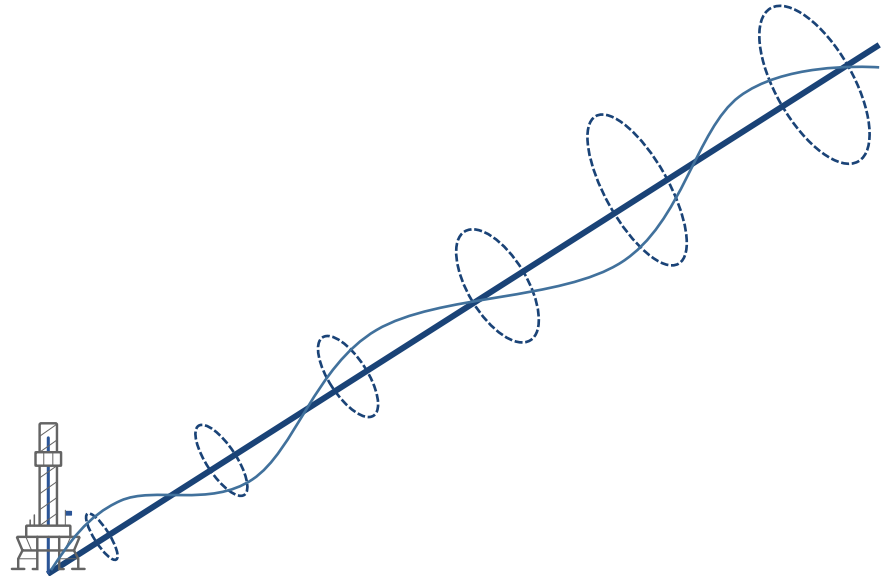


Positional Uncertainty Implication

SPE 63275 – toolface independence
on cross-axial errors (for newer
models)

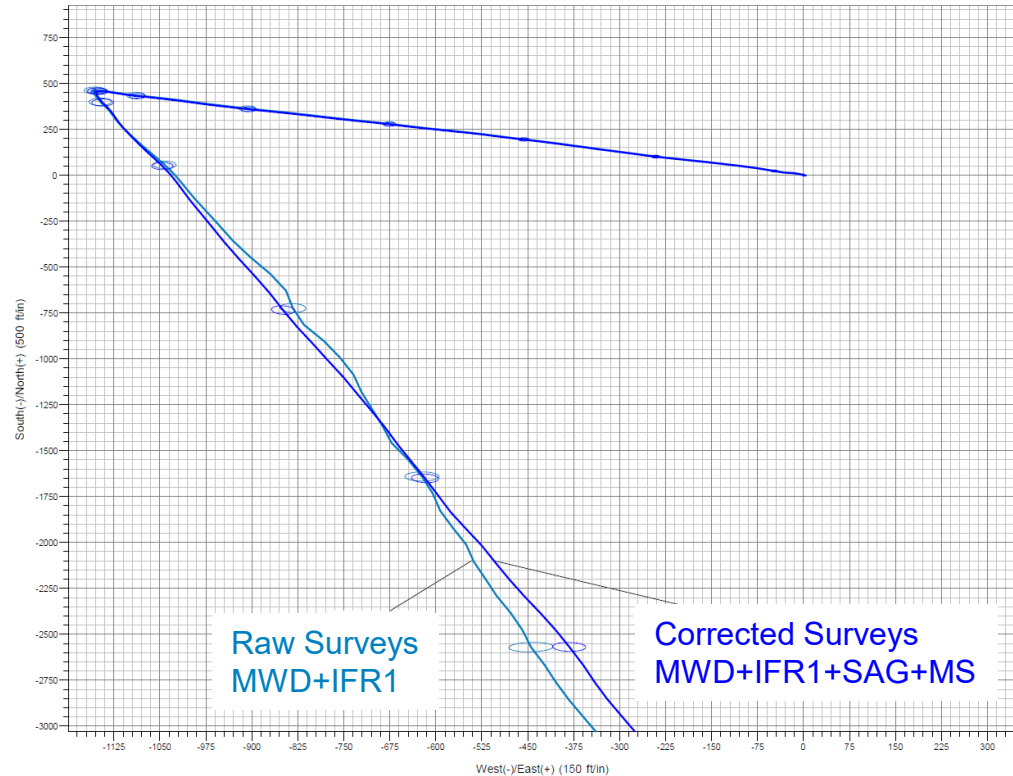
EoU encloses the wellpath with
bounding cone

Doesn't attempt to map shape



Example #1

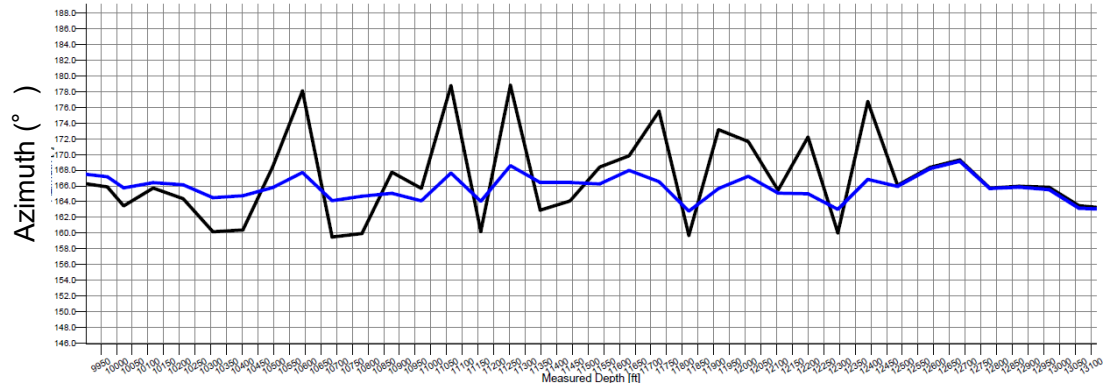
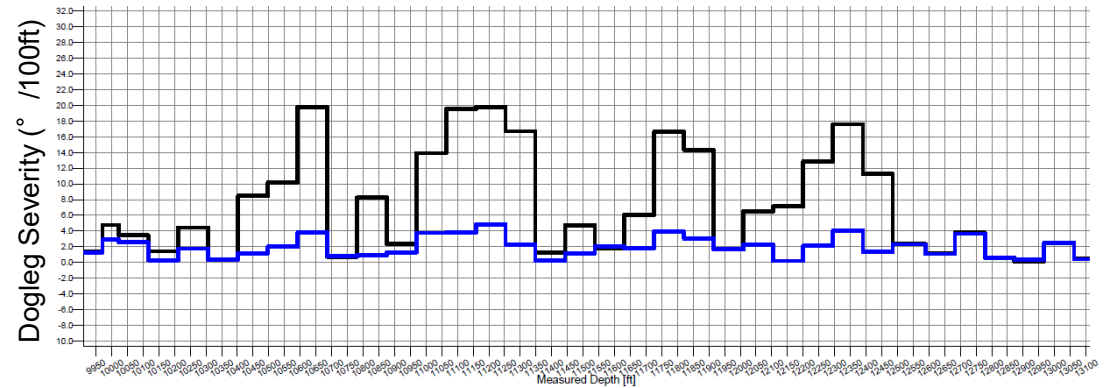
- MBX = 1780nT
- MBY = 3790nT
- Displacement from AMIL
- Oscillating shape from MBXY
- EoU implication negligible



Example #1

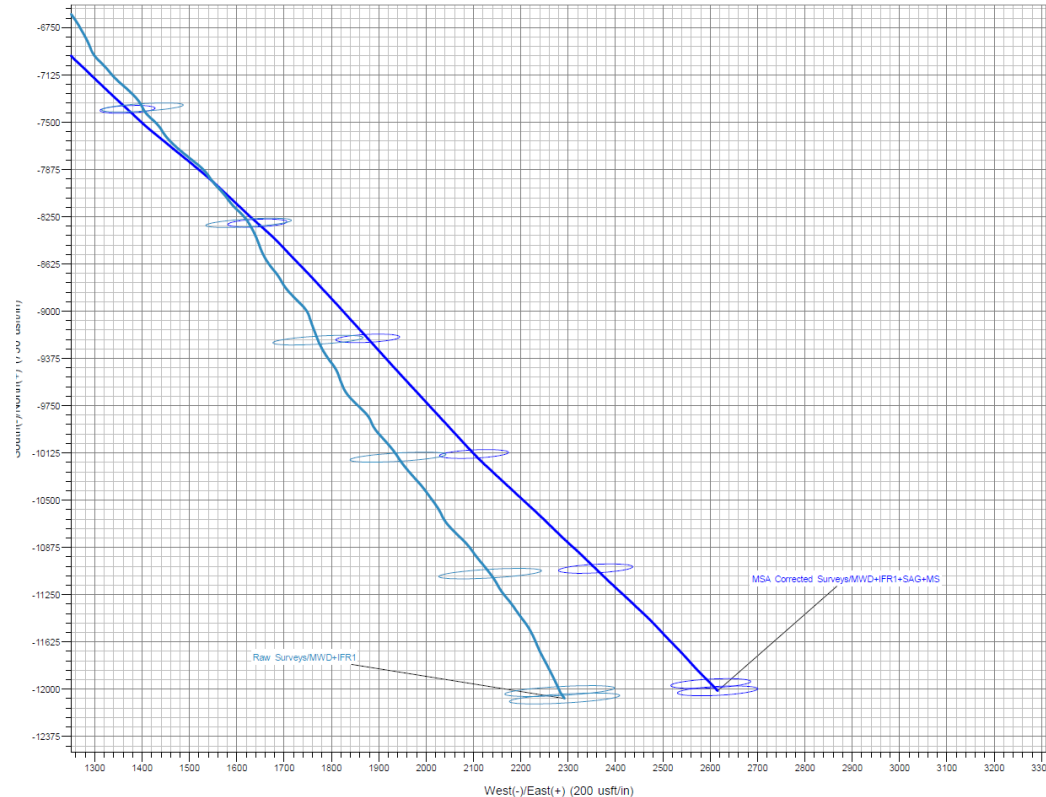
- Observed DLS > 20°/100ft
- True DLS < 5°/100ft

- Unrealistic azimuth swings
- ~18° in 90ft



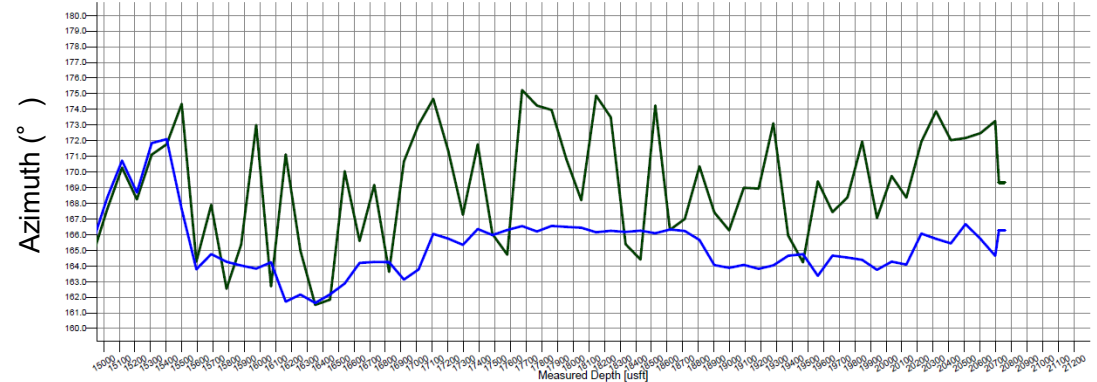
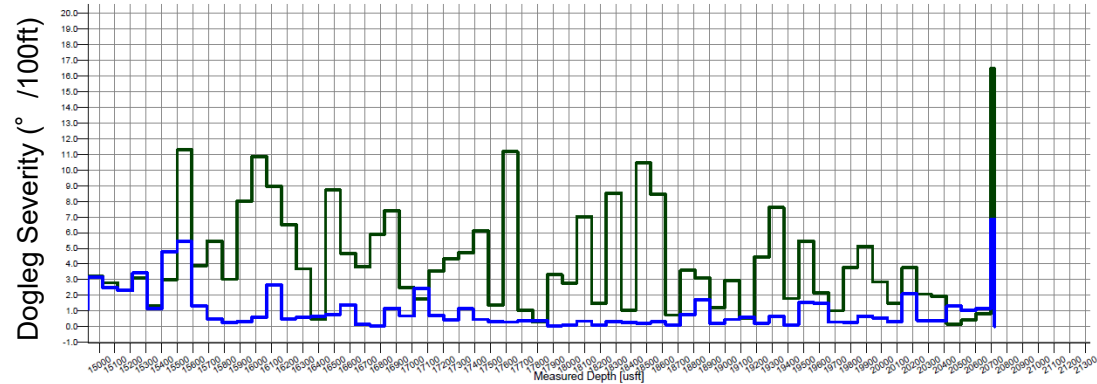
Example #2

- $MBX = 2300nT$
- $MBY = 1370nT$
- How would this look if corrections were not performed in real-time?



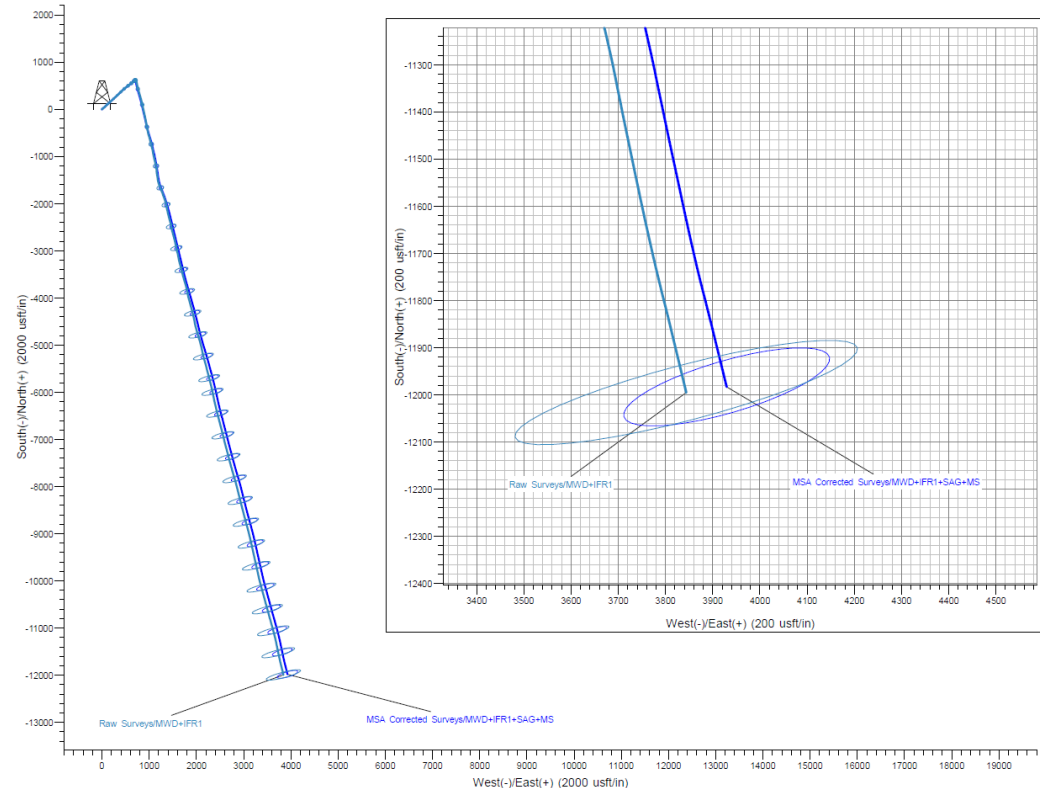
Example #2

- Corrections achieve consistency in DLS
- Shift in azimuth from DSI
 - Position
- Fluctuations from cross-axial biases
 - Path



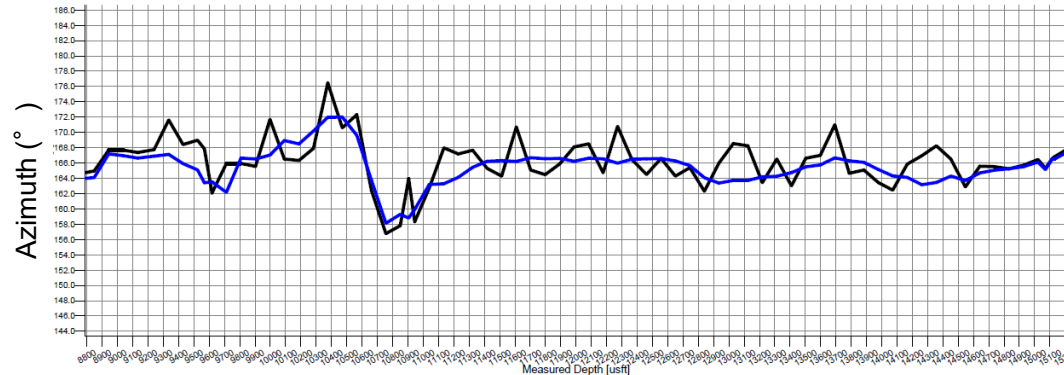
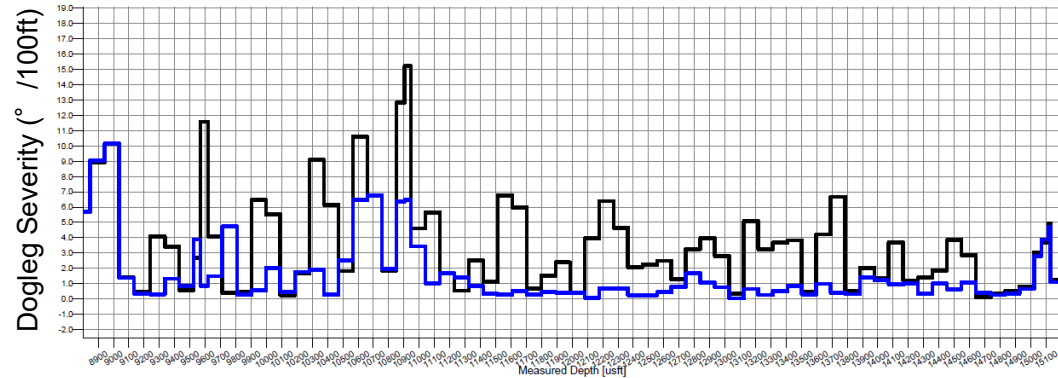
Example #3

- MBX = 1585nT
- MBY = 190nT
 - Asymmetrical biases
- Less DSI = less displacement
 - Statistically, same position



Example #3

- Azimuth swings centered about the corrected azimuths



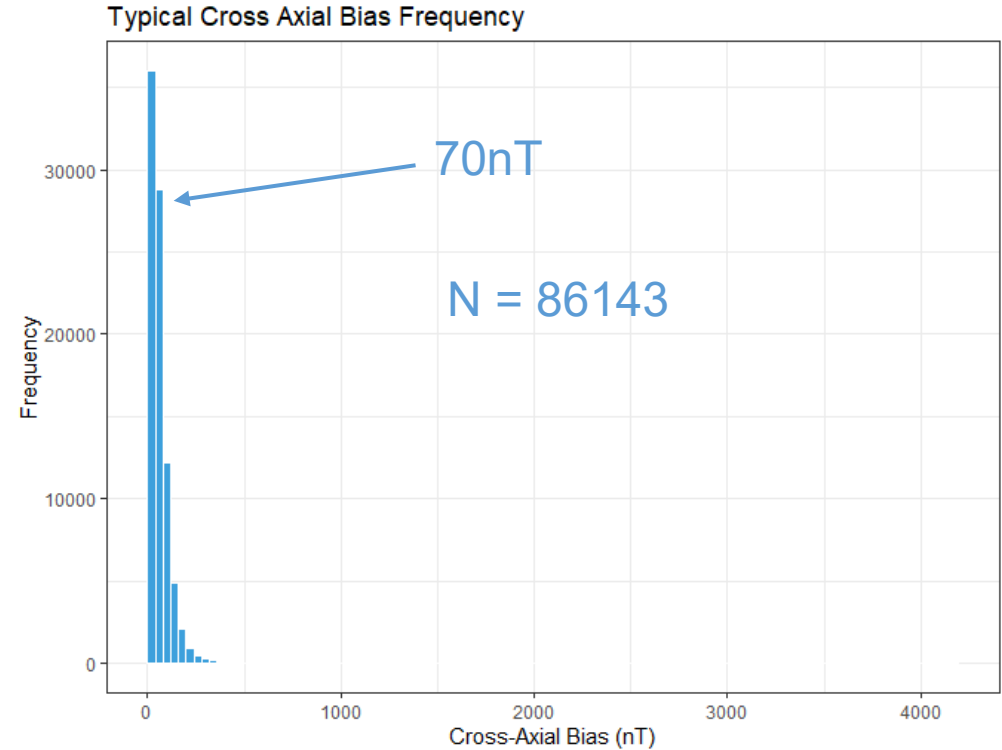


Decision Making Impact - Recap

- Inducing doglegs by chasing an azimuth?
- Trip out because of inconsistent measurements?
- Inadvertently cross a lease line?

How Common is This?

- Expected magnitude
(MWD+IFR1) – 70nT at 1-Sigma

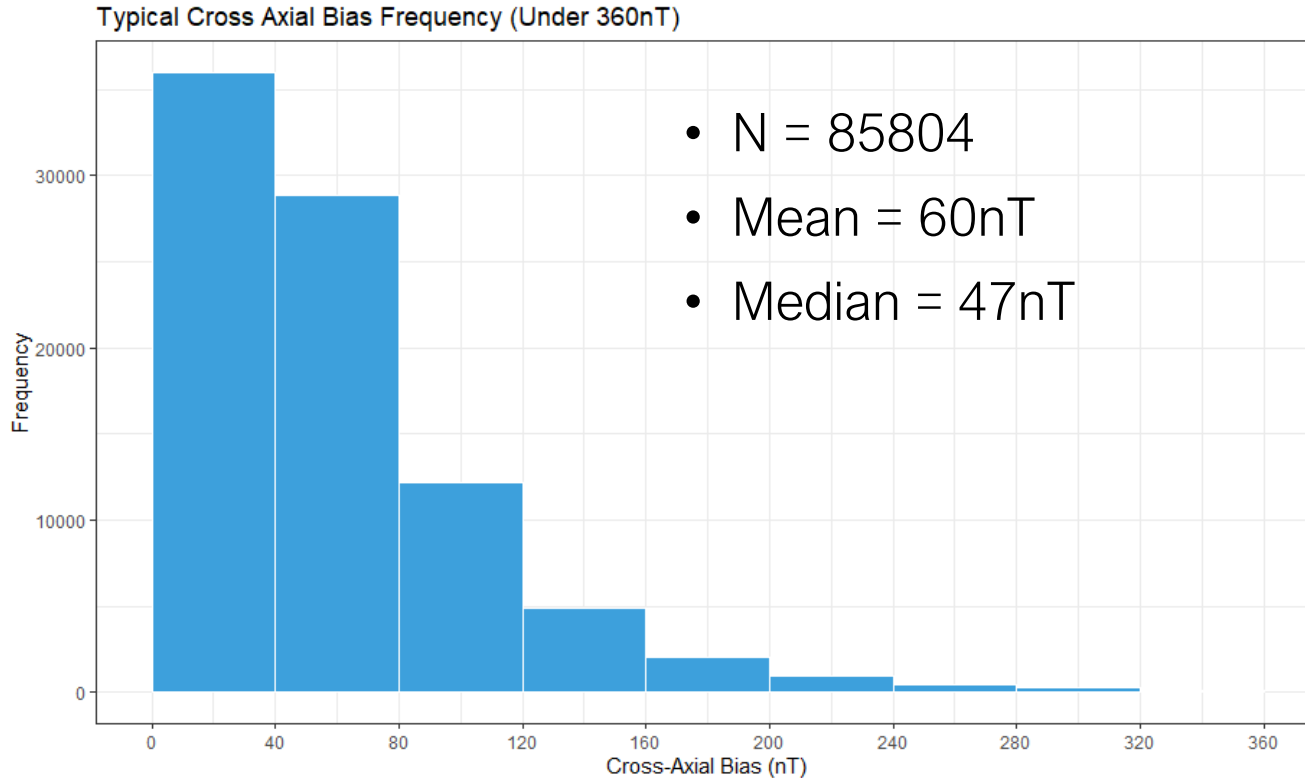




Wellbore Positioning Technical Section



The Industry Steering Committee on
Wellbore Survey Accuracy (ISCWSA)

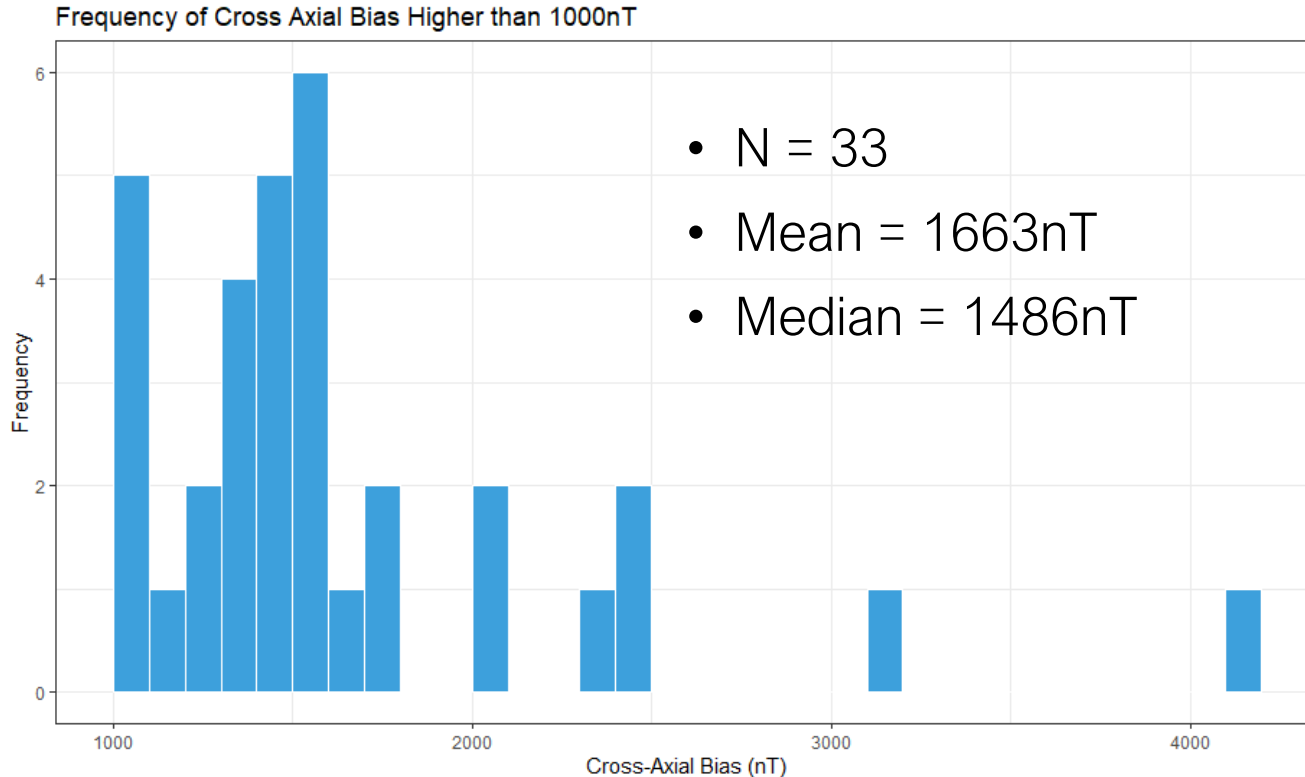




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Causes of Cross-Axial Magnetometer Biases

- BHA design is crucial
 - Correlation between additional BHA components near the MWD and large cross-axial biases
 - Care should be taken when adding components (non-magnetic, sufficient spacing)
- Can also be hardbanding, stabilizers, UBHOs, etc...



Mitigation

- Traditional multi-station survey corrections consider cross-axial biases
- Real-time corrections reduce the probability of poor decision making
- Corrected data can confirm driller's intuition and prevent unnecessary sliding
- Graphical diagnosis is relatively trivial with toolface analysis or linear regression



Conclusion

- These errors are rare, but can have significant implications
- Decision making in real-time can easily be helped with cross-axial corrections
- Positional uncertainty does not concern itself with these path changes
- BHA components/drilling tools can have impacts on measurements



Discussion! & questions