Improving Wellbore Position with High-Resolution Data

Marc Willerth, Shawn DeVerse,
Stefan Maus, & Andrew Brooks

45th General Meeting
March 17th, 2017
The Hague, The Netherlands

Wellbore Positioning Technical Section

The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

Speaker Information

- Marc Willerth
- VP of Survey Technologies
- March 17, 2017
- Magnetic Variation Services LLC
- Specializes in
  - Wellbore Positioning
  - Survey Corrections
  - Uncertainty Models

Company / Affiliation Information

- MagVAR / Surcon
- Services:
  - Magnetic Modelling
    - High accuracy local magnetic models (IFR1)
    - Real-time local magnetic observatories (IFR2)
    - High Resolution Global Magnetic Model (MVHD)
  - Survey Management
    - Real-time survey corrections
    - Survey quality monitoring
    - Fit-for-purpose uncertainty modelling

High Level View: Errors of Process

- Relate to the manner by which the survey is conducted
- Independent of sensor accuracy or performance
- Associated with known compromises in operations
- Comprise the largest “acceptable” error sources

Examples of Compromises

- BHA Design
  - Drillstring Interference, Sag
- Magnetic Reference
  - Crustal Anomalies, Solar Weather
- Survey Frequency
  - “Aliasing” in minimum curvature

Positional Error From Survey Frequency

Wellbore trajectories assume circular arcs between stations

Data outside of survey set can weaken this assumption

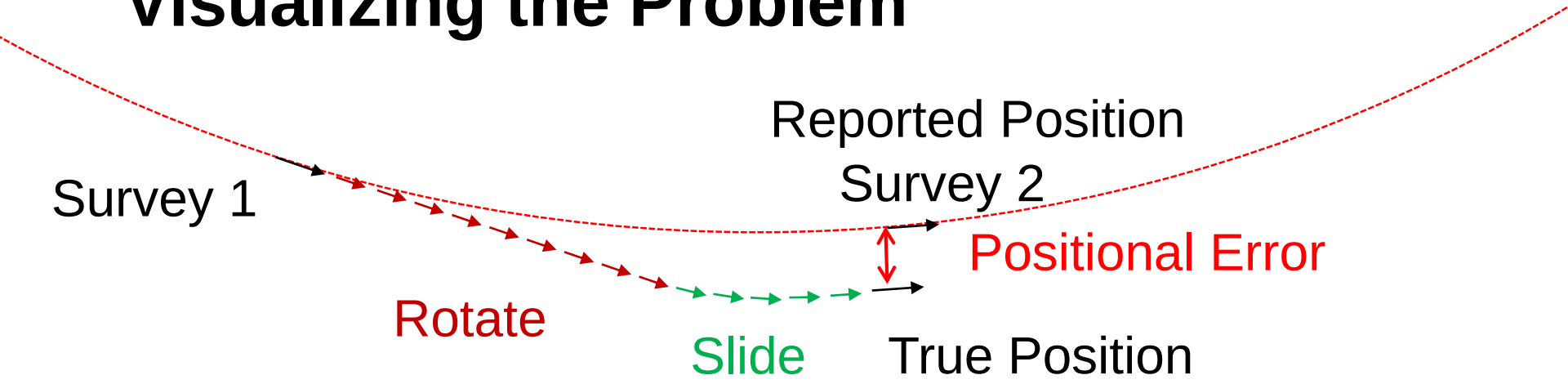
Simple solution: More frequent surveys (<30ft)

More often a compromise is made (95ft+)

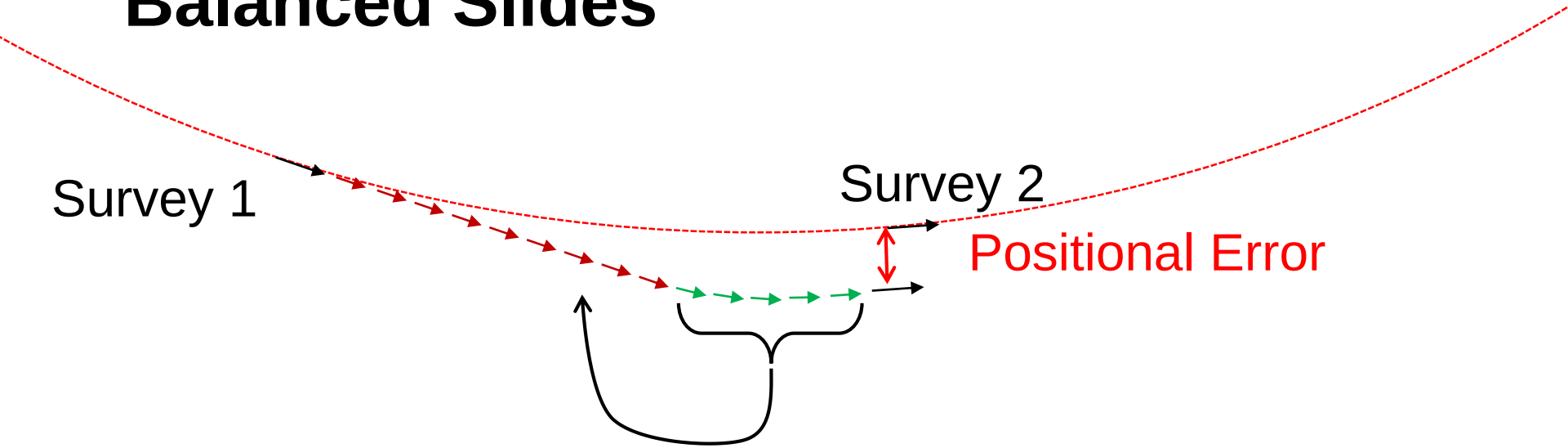
This Problem is Not New

- High-frequency gyro surveying since the late 70s
- Continuous MWD surveying since late 80s
- Formal problem statement: Stockhausen & Lesso 2003

Visualizing the Problem

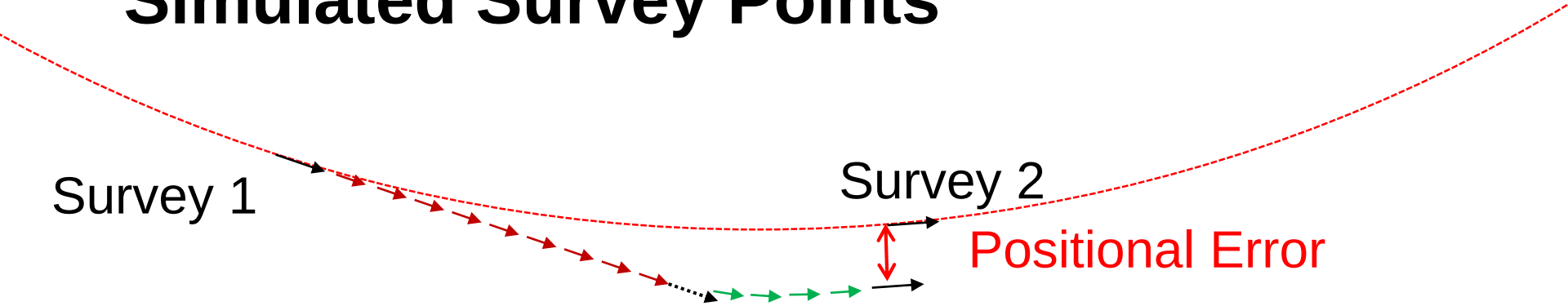


Balanced Slides



Stockhausen & Lesso, 2003

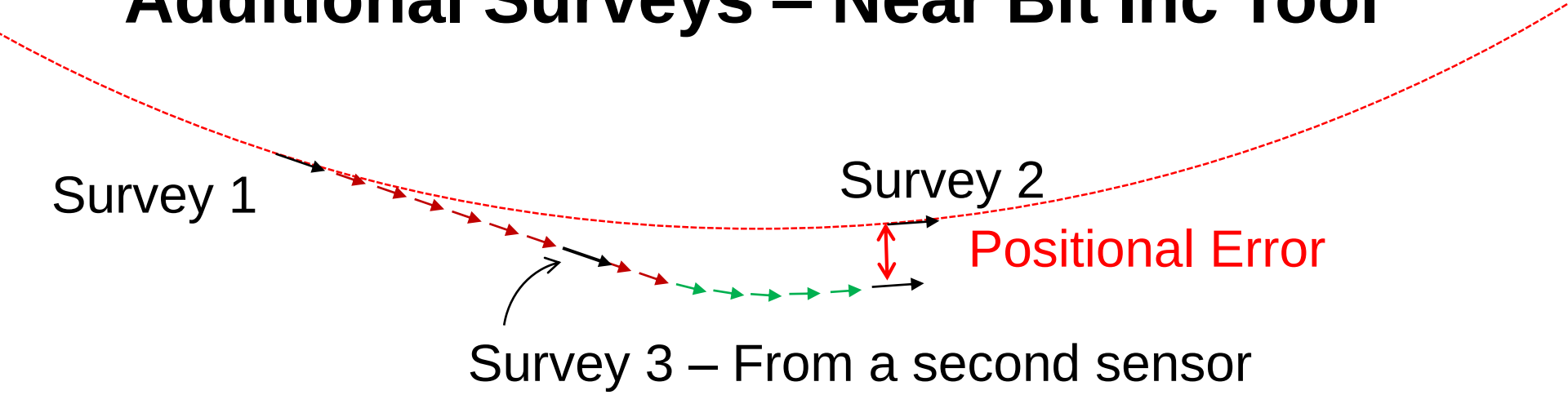
Simulated Survey Points



New “survey” based on Slide Sheet

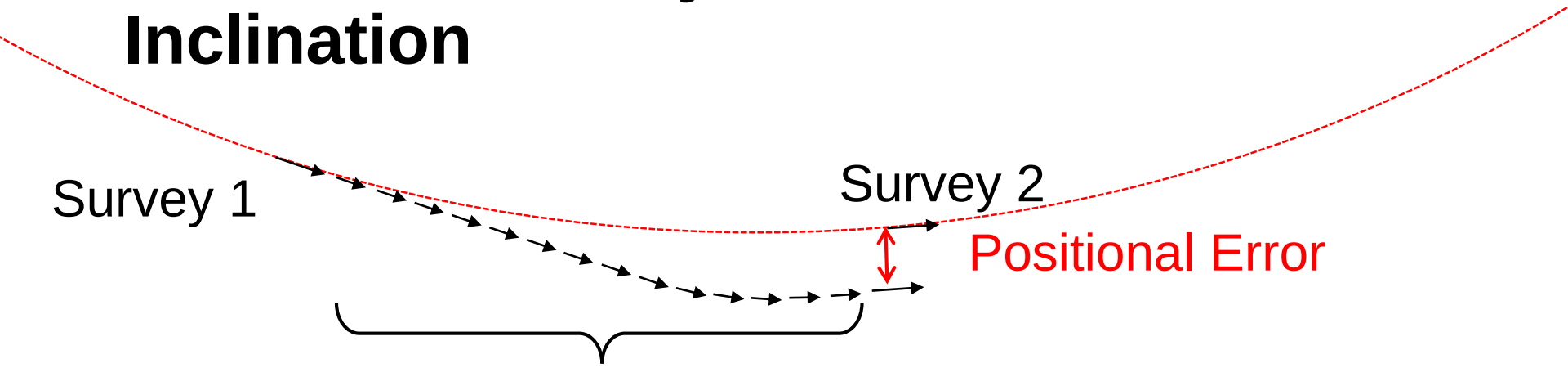
Stockhausen & Lesso, 2003

Additional Surveys – Near Bit Inc Tool



Lawrence, Mojsin, & Strachan (2010)

Additional Surveys – Continuous Inclination



Berger & Sele (1998),
Monterrosa, Rego, Zegarra, & Lowdon (2016),
Countless others…

What's the Hold-up?

- Changing drilling practices is often a non-starter
  - Altering slide placement
  - Reduce motor yield / increase slide ratio
  - Surveying more frequently

- Reluctance to add "extra" surveys
  - Particularly if they are artificial points
  - Concerns about measurement accuracy & handling large data sets

- These issues are amplified for a "Factory Drilling" environment!

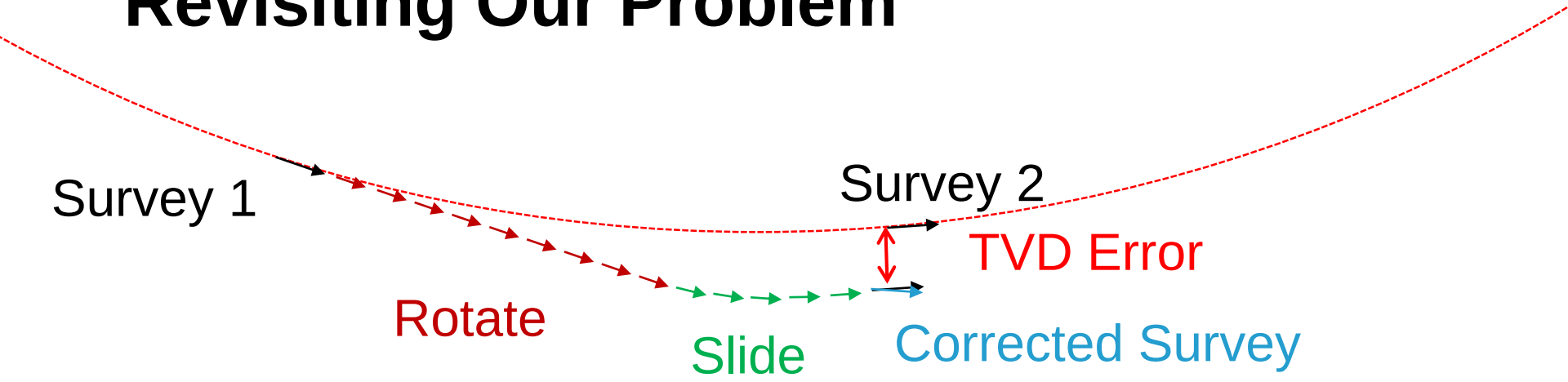
What Has Worked Before?

- Other process errors are being successfully managed
- Drillstring interference → Multi-station analysis
- BHA Sag → Sag Corrections
- Adjustment to existing surveys is an acceptable compromise

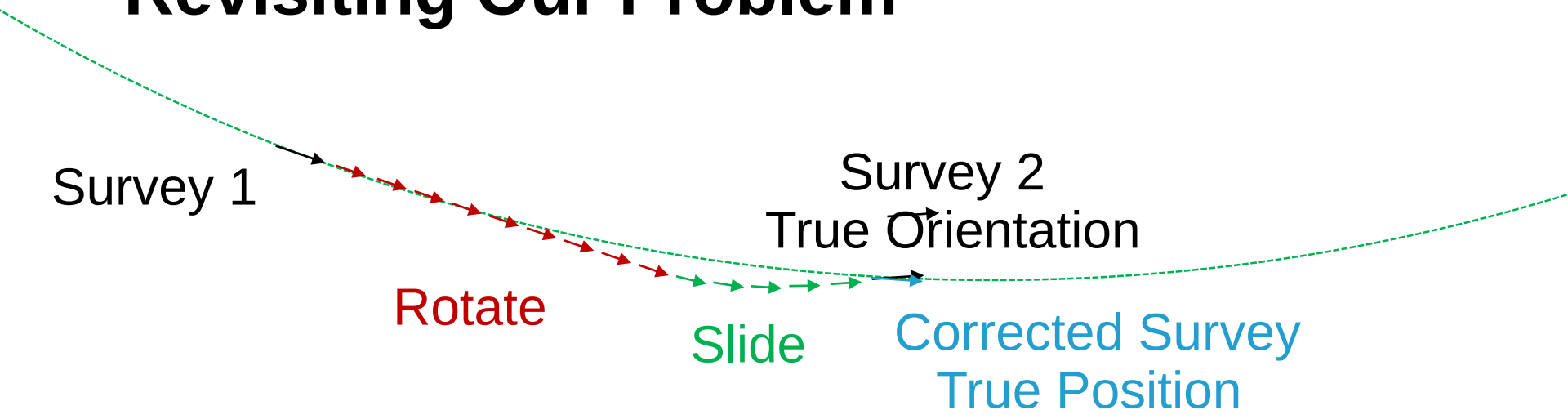
Can This Really Be Corrected For?

- Current corrections improve the measurement accuracy
- This is not a measurement issue, orientation is accurate
- But orientation is not the primary product of a wellbore survey
- What if we correct thinking about *position* instead?

Revisiting Our Problem



Revisiting Our Problem

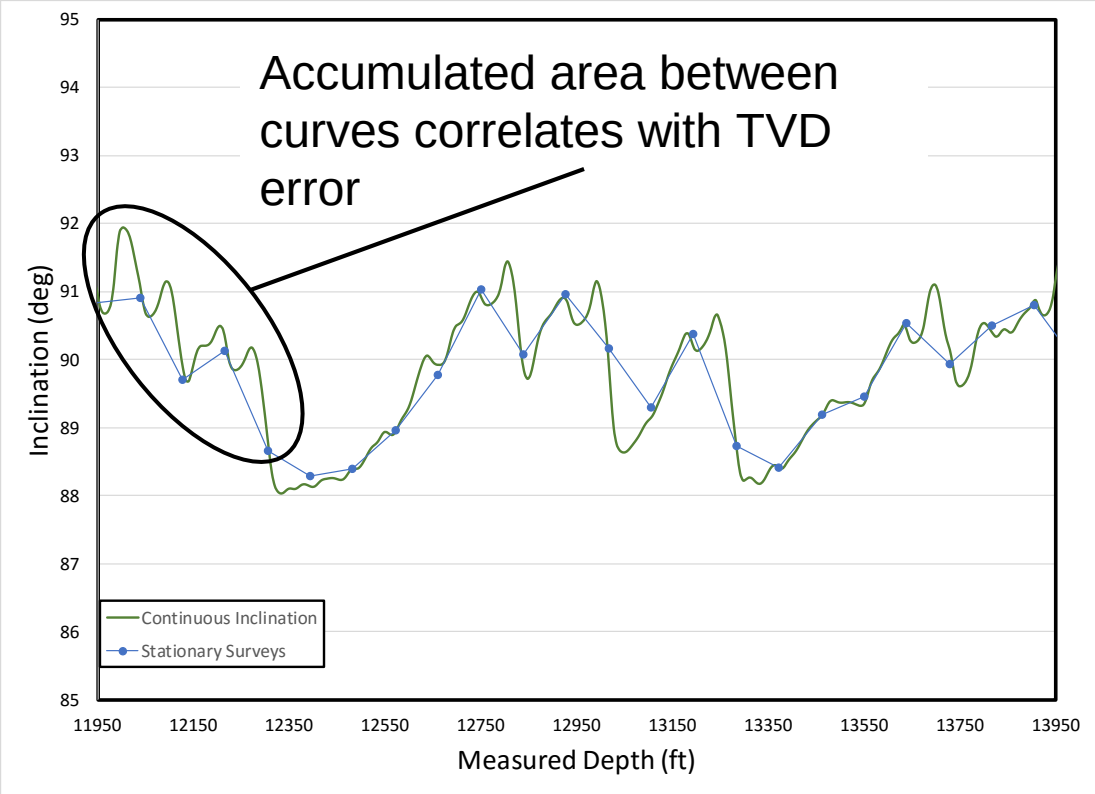


Optimizing Position, not Orientation!

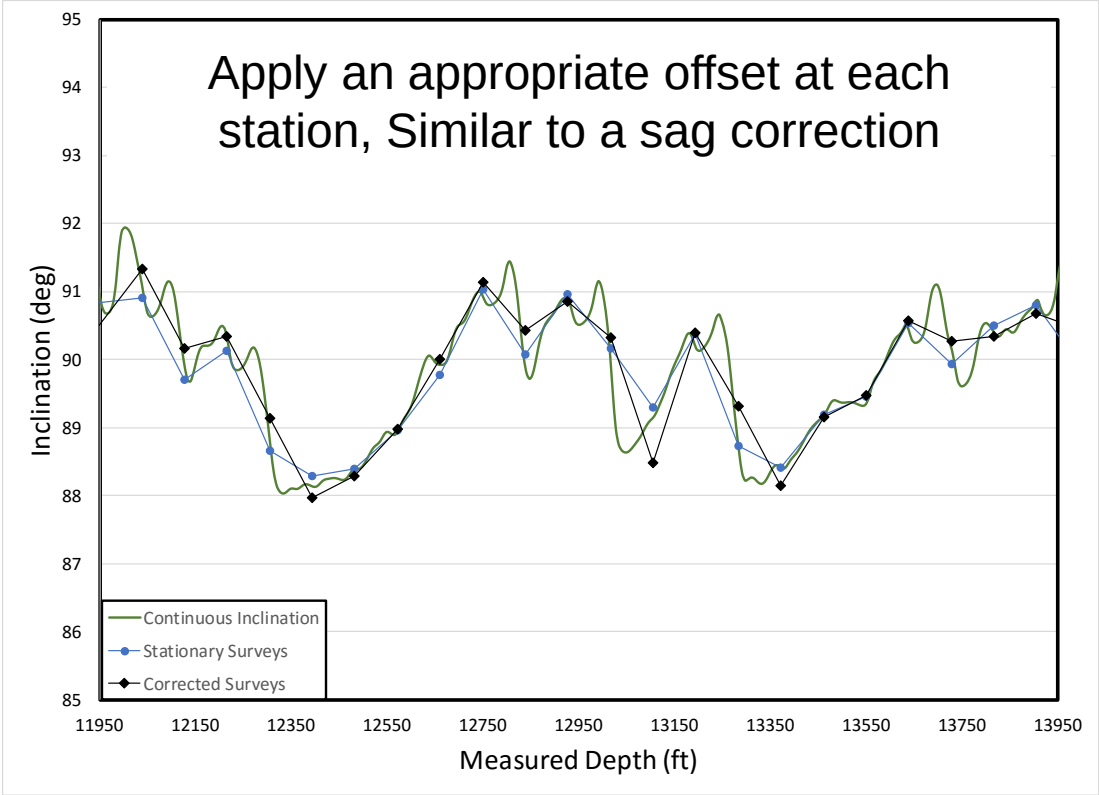
Implementation

- Utilize desired data sources to determine optimum position
- Could be continuous survey, slide sheet, or other data
- Optimize a minimum curvature survey to get there
- Apply the appropriate correction to the measured survey

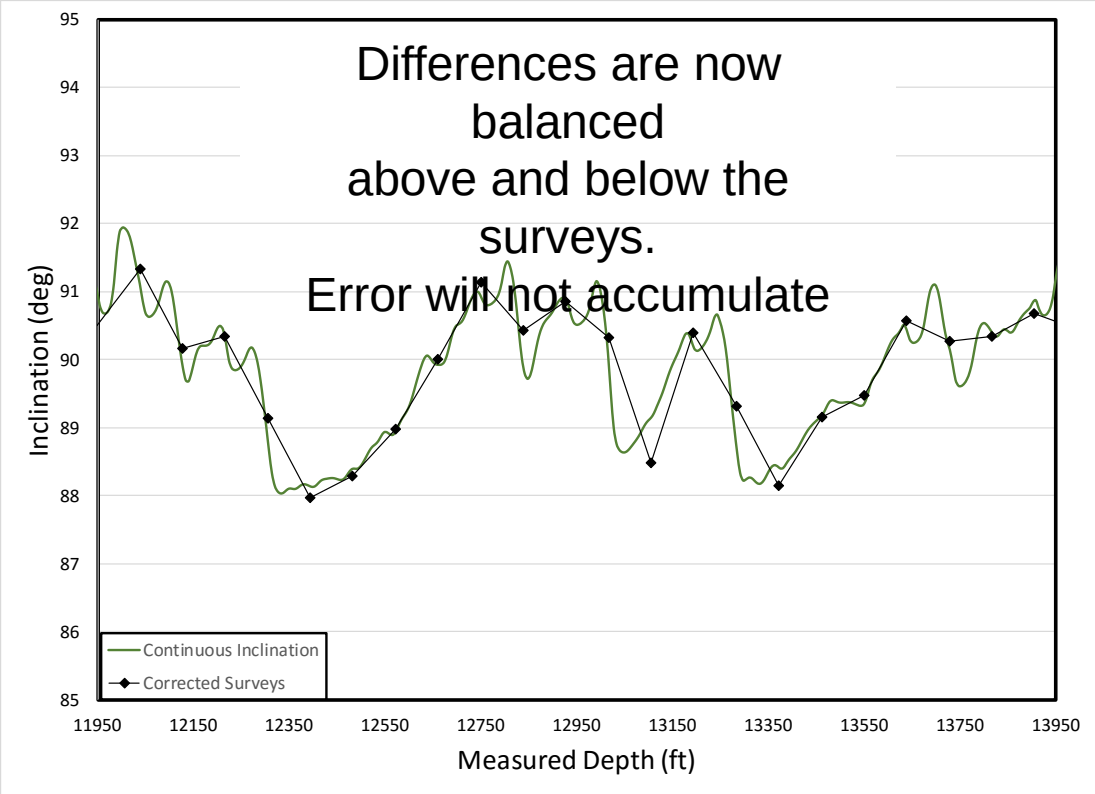
Example Correction with Continuous Data



Example Correction with Continuous Data

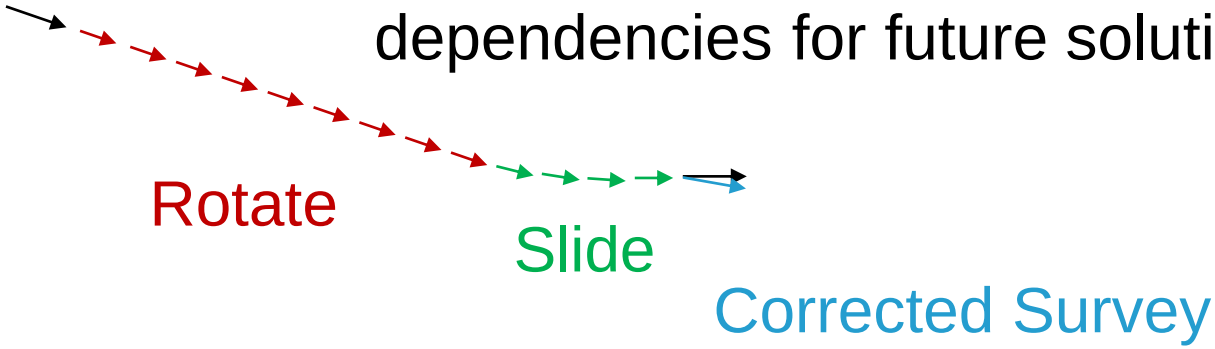


Example Correction with Continuous Data



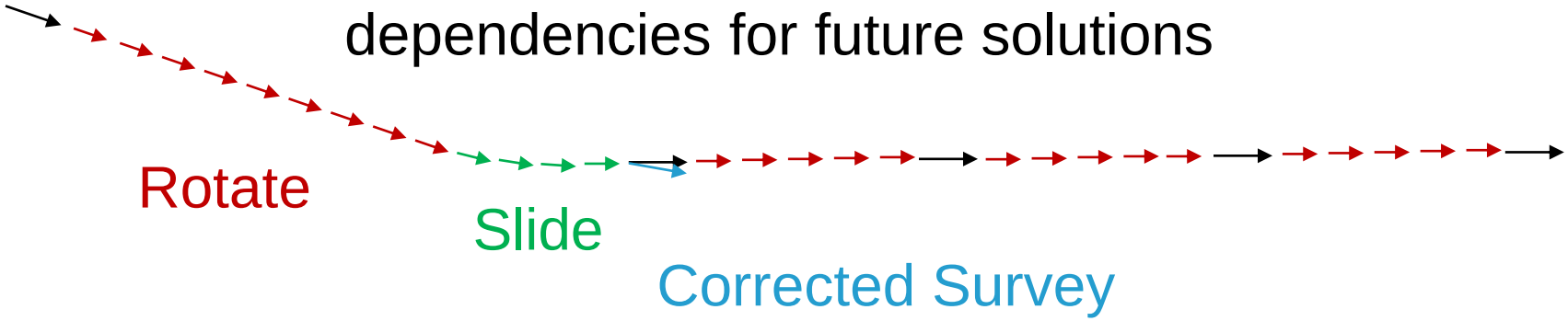
Challenge: Optimizing for Real-Time

Real-time corrections can create dependencies for future solutions



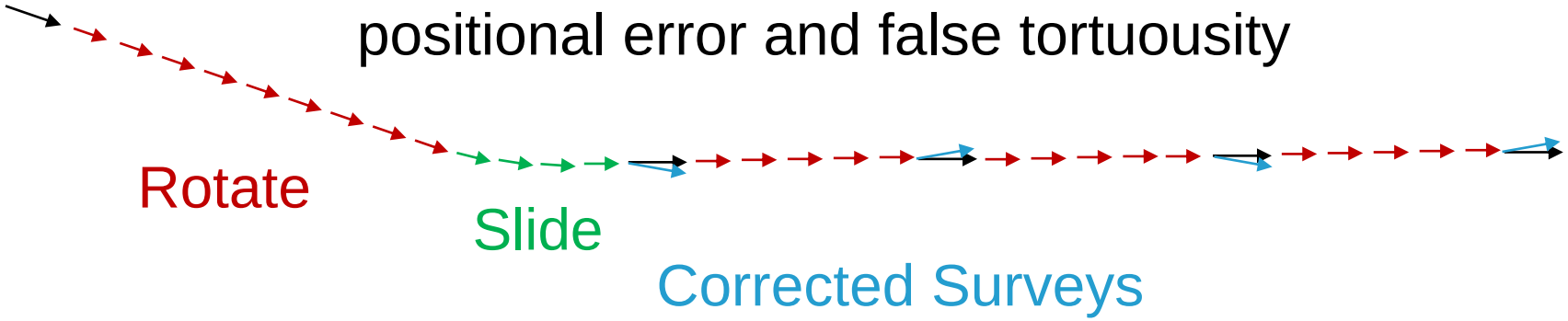
Challenge: Optimizing for Real-Time

Real-time corrections can create dependencies for future solutions



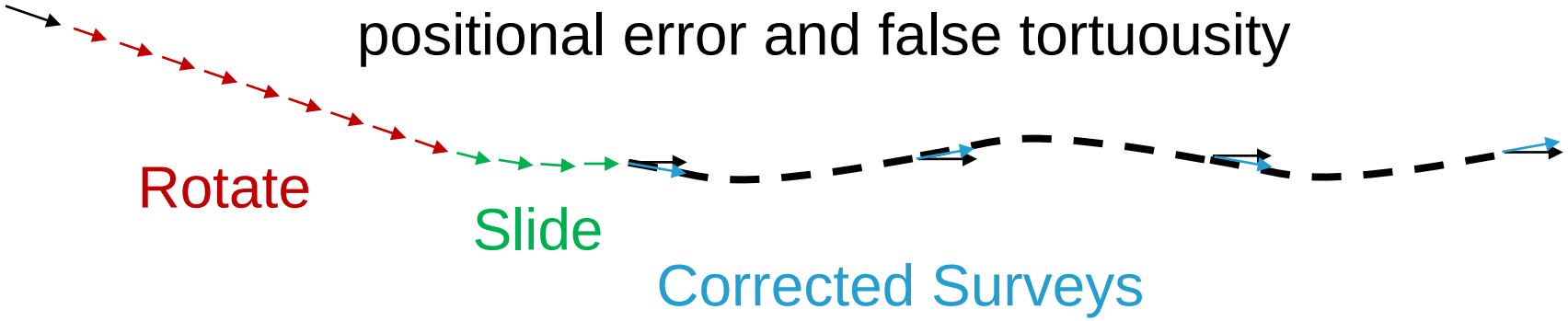
Challenge: Optimizing for Real-Time

Naïve application of corrections can induce positional error and false tortuousity



Challenge: Optimizing for Real-Time

Naïve application of corrections can induce positional error and false tortuousity



Optimizing for Real-Time

- Viable real-time solutions have added challenges
- Minimal “future” data -- Cannot strictly solve for position
- Ideally avoid introducing future errors into position
- Solution: Balance positional accuracy & correction stability

Verifying the Correction Quality

- Derive expression for TVD error from Continuous Survey:

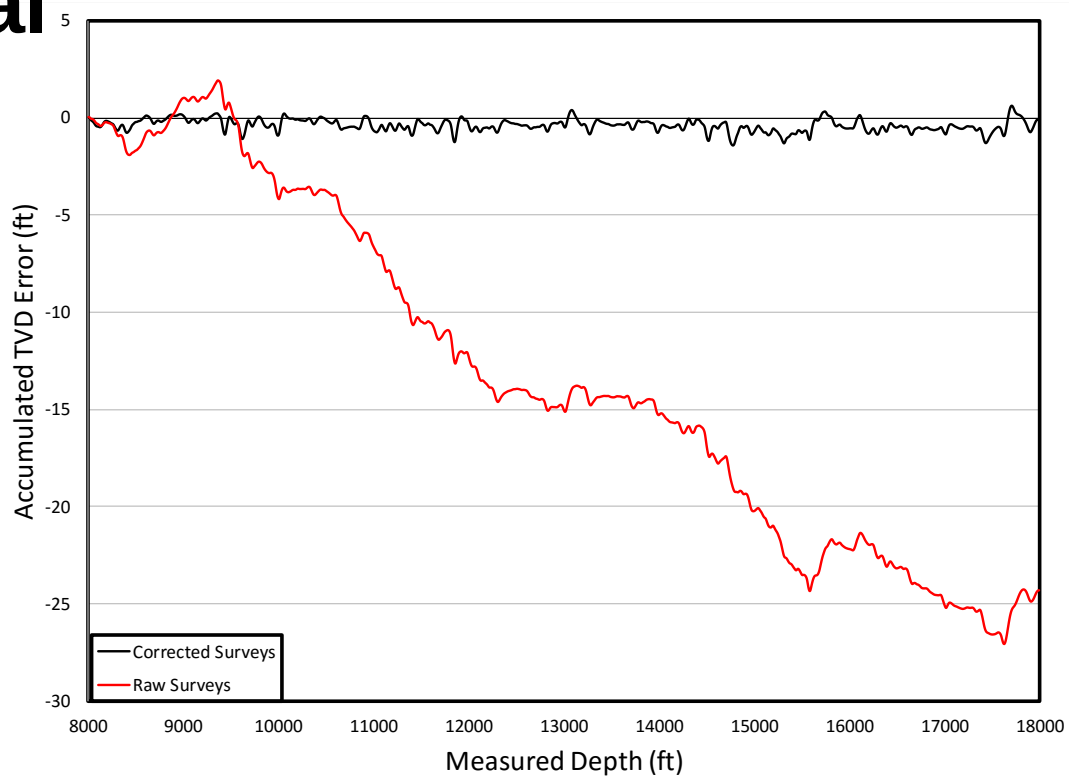
$$\Delta TVD = \frac{1}{2}\sum_{i=2}^{n-1}(MD_{i-1} - MD_{i+1})\left(\sin I_i\,(I_i - I_i^*)\right)$$

- Similar to Appendix A in SPE 67616

- Compare accumulated error between survey sets

Error Accumulation Across a 10,000ft Lateral

Raw surveys show errors of ~2.5 ft / 1000ft



Corrected surveys are nearly equivalent to a continuous inc. derived survey

Correction Caveats

- Corrected surveys are less accurate for orientation
- Should not be used for motor yield, projection to bit, etc
- Data that feeds the correction is subject to its own QC
- Corrected surveys are only as accurate as the source data

Conclusion

- Drilling & surveying priorities conflict on survey frequency
- Prior solutions have idiosyncrasies preventing their adoption
- Equivalent accuracy achievable via corrections to existing stations
- Remove the error in a method acceptable to current workflows

Questions?