Practical Method to Benefit from the Improved Accuracy of Combining Overlapping Wellbore Surveys

Jon Bang, Tarig Ali, Adrián Ledroz

Gyrodata, Inc.

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SPE Wellbore Positioning Technical Section

The Industry Steering Committee
on Wellbore Survey Accuracy

Speaker Biography

- Jon Bang
  - Gyrodata, Inc. since 2013
  - Around 20 years in petroleum-related research
  - MD + PhD, Norwegian University of Science and Technology, Trondheim, Norway
  - Experience:
    - Wellbore positioning
    - Uncertainty analysis, Survey quality
    - Applied physics / mathematics / statistics

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SPE-195621-MS

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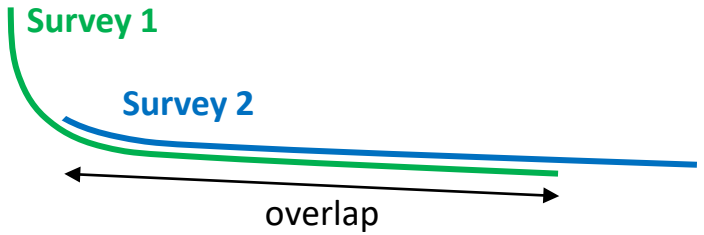
Benefits of Overlapping Surveys

- Mutual quality check and validation
- Gross error detection



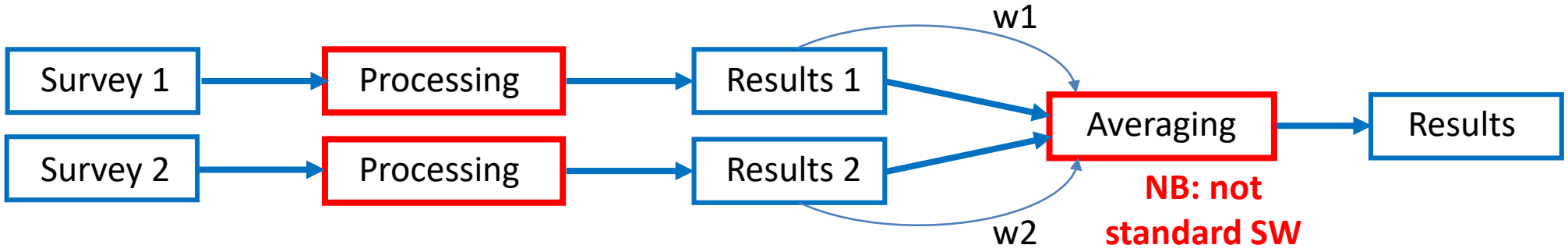
When surveys have passed validation QC:

- Weighted average gives:
  - Optimal position estimates
  - Improved position accuracy (two surveys: up to 30% reduction of EOU size)

- However, existing calculation procedures are complicated and impractical

Weighted Averaging Procedure, for Uncertainties

Rigorous (SPE-85111-PA; 2003): Analyze surveys separately, average results



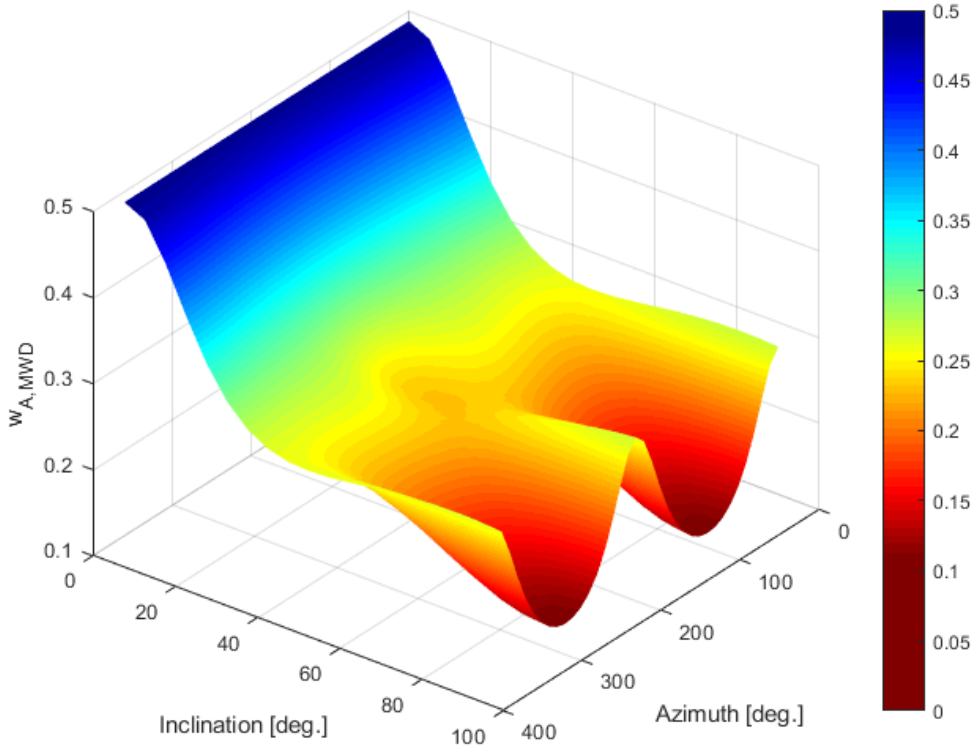
"Averaged IPM file" (SPE-178826-PA; 2016): Modify input files => results equal to rigorous

- Method is feasible
- But: Limited validity of averaged IPM file, because weights are constant

Improvement to the Averaging Procedure

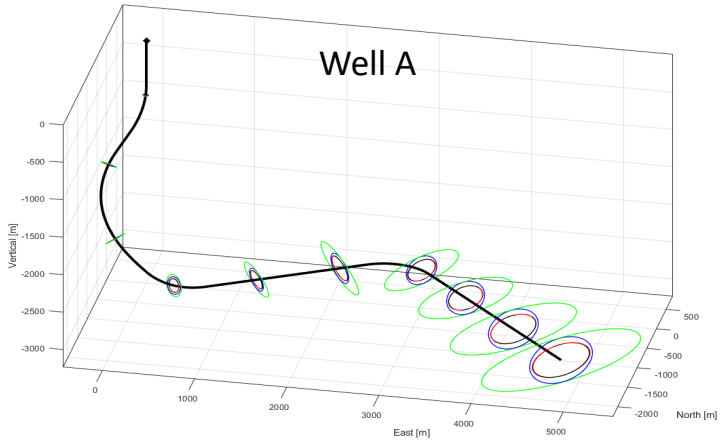
- Weights that vary with the wellbore's directions (Inc and Azi)

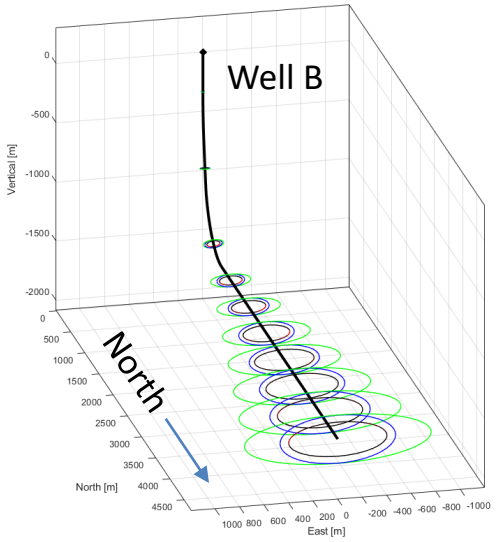
- Averaged IPM valid for all Inc / Azi combinations:
  - curved wellbores
  - any directions
  - possibly over several oil fields

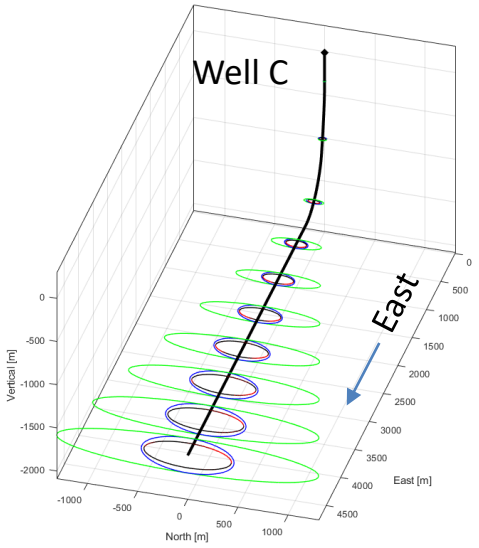


Weight for Azi terms of magMWD, when averaging magMWD/gyro surveys

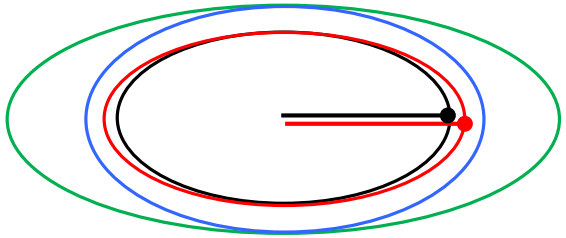
Results 1

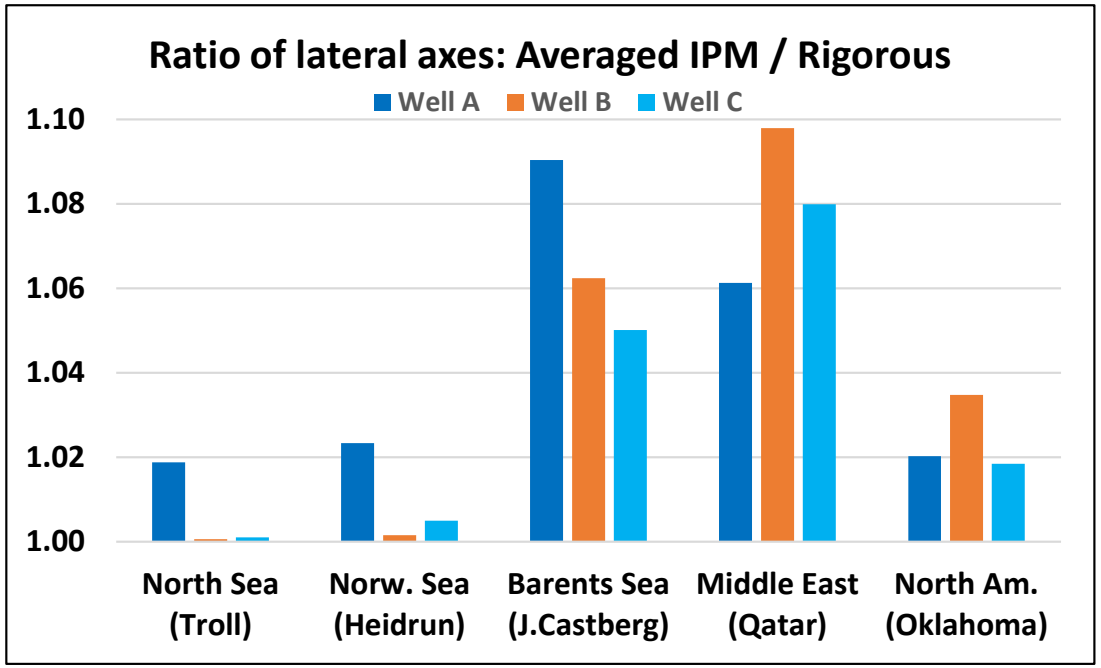






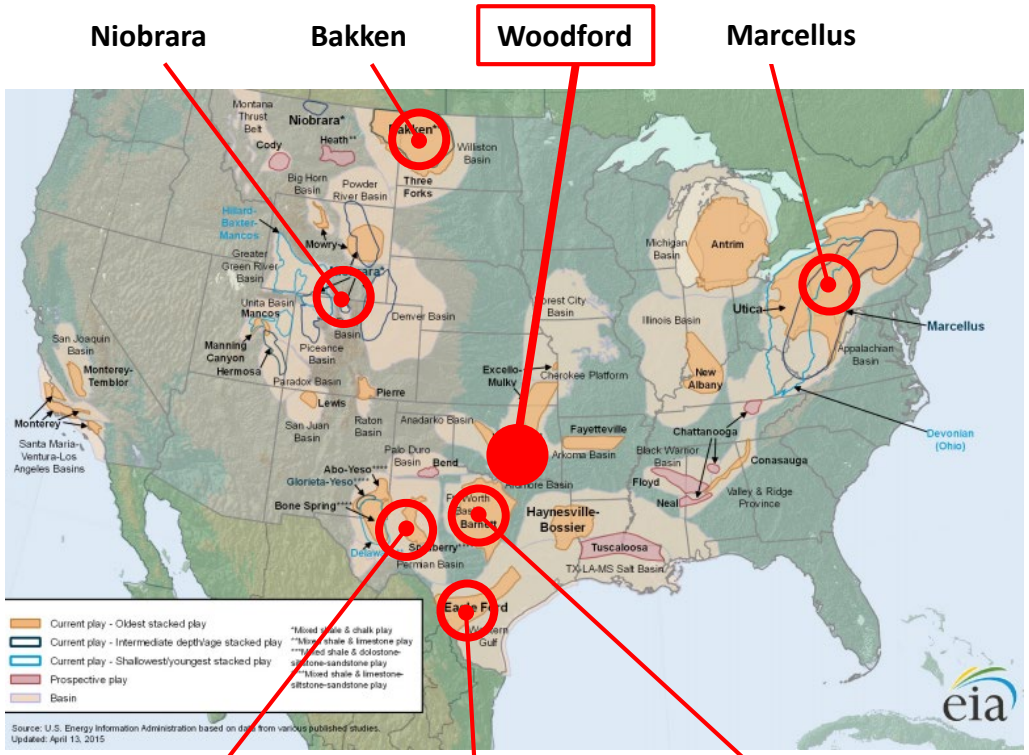
Survey 1 (mag. MWD)
Survey 2 (gyro)
Rigorous average
Averaged IPM (North Sea)



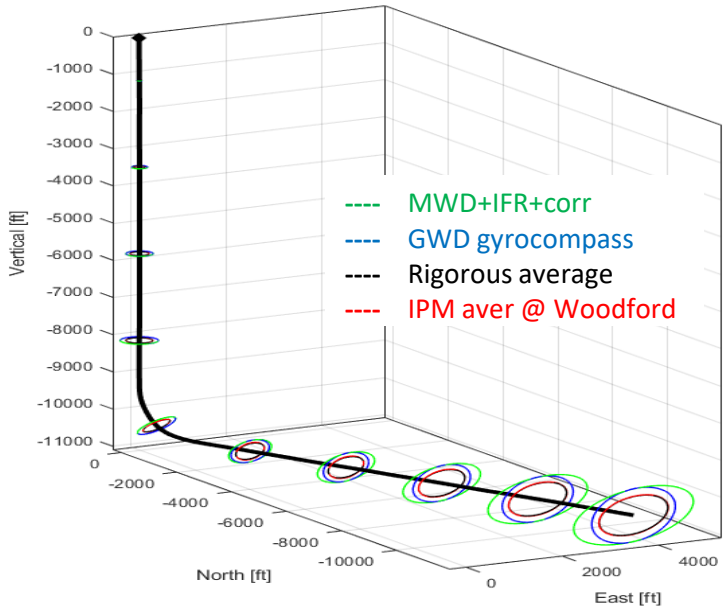


Results change because location (latitude, mag. field) change.

Results 2: USA gas fields

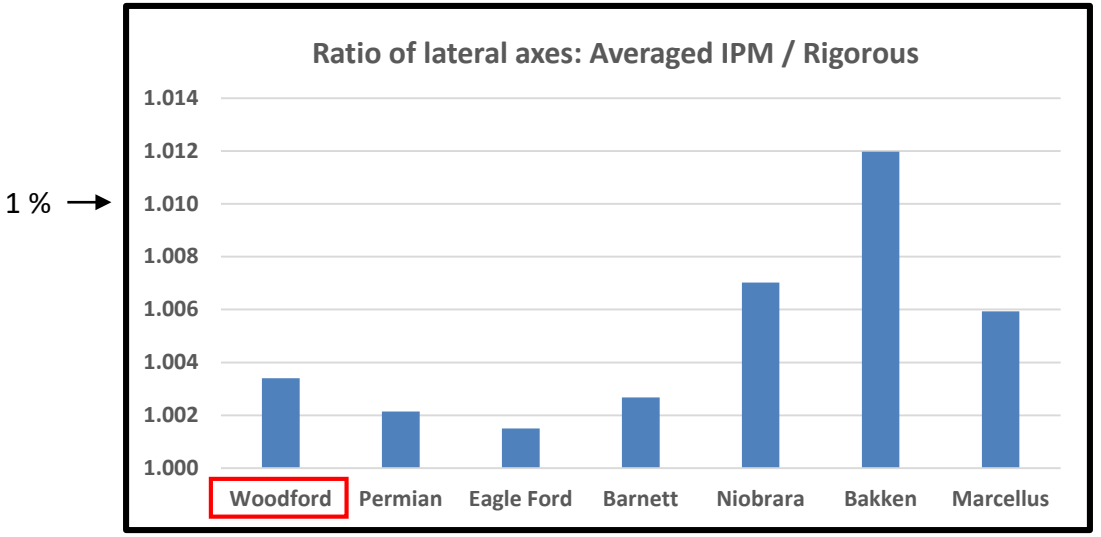


Map: Courtesy of U.S. Energy Information Administration



Key results (USA example*):
* Limited evaluation

- **Rigorous vs. GWD: 20% reduction in lateral axis**
- **IPMaver vs. Rigorous: Equal**
- **Using IPMaver across USA: Only small degradation**



Conclusions

- Benefits of averaging overlapping surveys:
  - Systematic procedure to make use of all information
  - Optimal position estimates
  - Improved position accuracy
    - Two surveys: up to 30% reduction from single EOU size (demonstrated: 20%)
    - More surveys: even more reduction

- Averaging of overlapping surveys is practically achievable:
  - One averaged IPM file valid for all well profiles, and over at least an entire oil field
  - Simplification of data management and analysis procedures

Applications

- Optimize survey programs
- Small geological targets
- Long extended reach wells
- Highly congested fields
  - e.g. collision avoidance analysis: requires high position accuracies, and practical/efficient calculation procedures
- Development of new surveying tools:
  - IPM for upcoming tools with fixed multiple-sensor combinations

Acknowledgements

Thanks to:

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Thank You

RESERVE SLIDES

IN CASE OF QUESTIONS

The averaged IPM file

- Valid for exactly those surveys tools for which it was developed
  - Most often two tools; but more tools are possible

- Correlated error terms:
  - External to the tool sensors: mag. field; some depths terms
  - Do not improve accuracy
  - Can be handled separately; no need to average

- Uncorrelated error terms:
  - Typical for sensors: accelerometers / magnetometers / gyroscopes
  - Averaging means accuracy improvement

Earth parameters

- Magnetic instruments: Mag. field strength, declination, dip
- Gyroscopic instruments: Latitude
- The parameters change with geographic location
  - Hence, uncertainty results change
  - Also for averaged IPM file
  - This limits the geographic validity of each averaged IPM file
- Empirical studies needed:
  - Mag. + mag. / gyro + gyro / mag. + gyro
  - How much deviation from rigorous results is acceptable?