A Public Web API to Provide Dynamic Quality Control for the ISCWSA Error Models

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Wellbore Positioning Technical Section

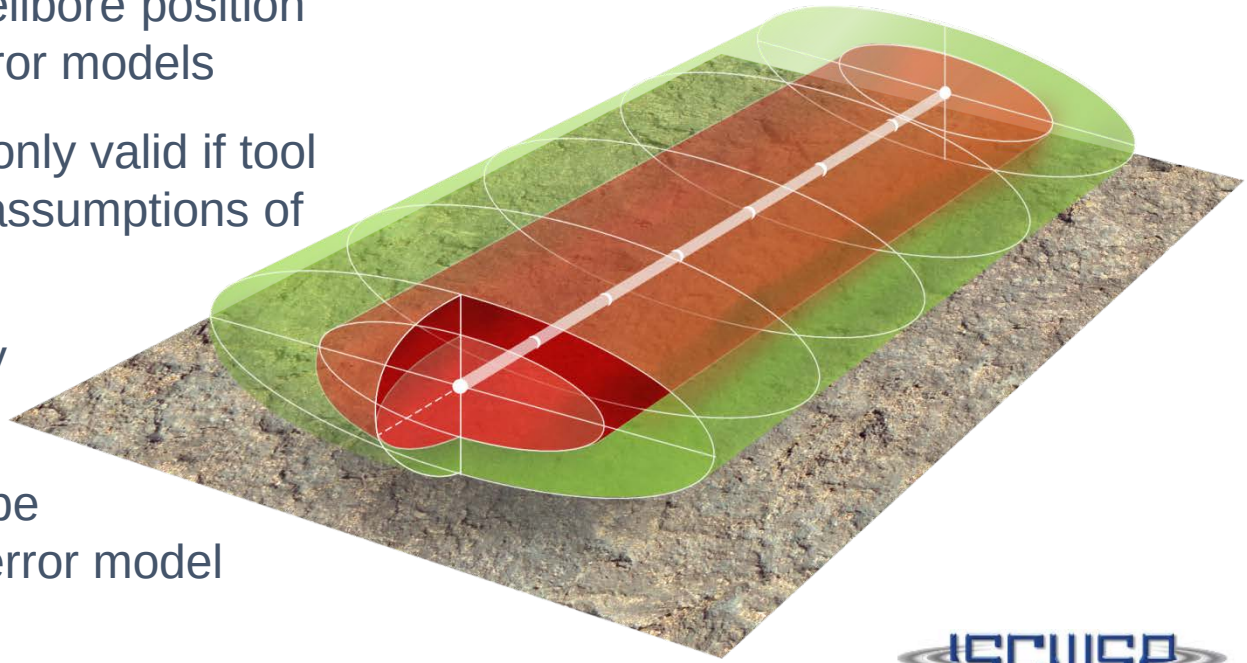
ISCWSA
The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

Speaker Information

- Stefan Maus, PhD
- Founder and CEO, MagVAR
- Senior Scientist, University of Colorado Boulder
- Interests:
  - Processing satellite, airborne and downhole survey data
  - Geomagnetic, electric and gravity field modeling
  - Error models and quality control processes

Tool Performance Verification

- The uncertainty in the wellbore position is computed from tool error models
- These uncertainties are only valid if tool performance meets the assumptions of the tool error model
- This has to be verified by Quality Control
- The QC criteria need to be computed from the tool error model



References to Prior Work

- SPE 103734 and SPE 105558 (2006), R. Ekseth, K. Kovalenko, J. Weston, T. Torkildsen, E. Nyrnes, A. Brooks, and H. Wilson) describes how to verify that the various error sources are within the assumptions of the tool code. Also contains the relevant weighting functions to compute QC thresholds from tool code.

- ISCWSA 39, Long Beach, (2014), S. Maus & R. Croke - Field Acceptance Criteria Based on ISCWSA Tool Error Models explains dynamic QC parameters

- ISCWSA 40, Long Beach, (2014), S. Maus, M. Nair, B. Carande, S. Pham & B. Poedjono - Systematic and Random Contributions to the Disturbance Field (IFR2) provides values for the magnetic disturbance field error model coefficients that were included in OWSG Rev-2.

- SPE 178843 (2016), S. Grindrod, P. Clark, J. Lightfoot, N. Bergstrom & L. Grant – Reference paper describing the OWSG Standard Survey Tool Error Model

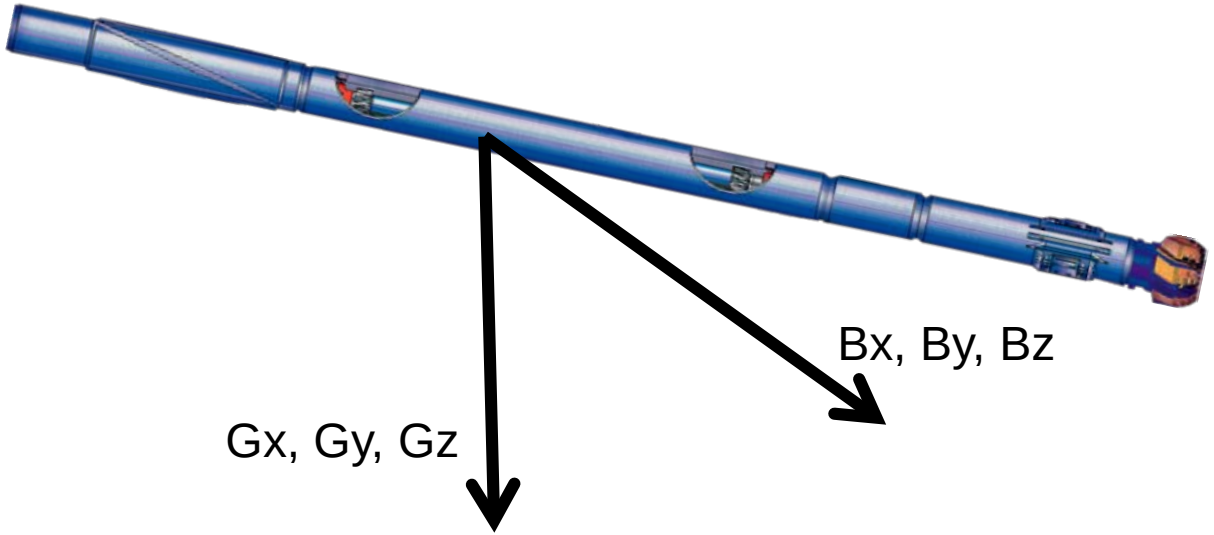
Objectives

1. Provide a simple criterion that indicates whether a survey passes or fails QC for an OWSG tool code

2. Enable production of QC plots which are intuitive and convey all needed information

→ Provide a web API to enable both of these functions

What Does the MWD Tool Measure?



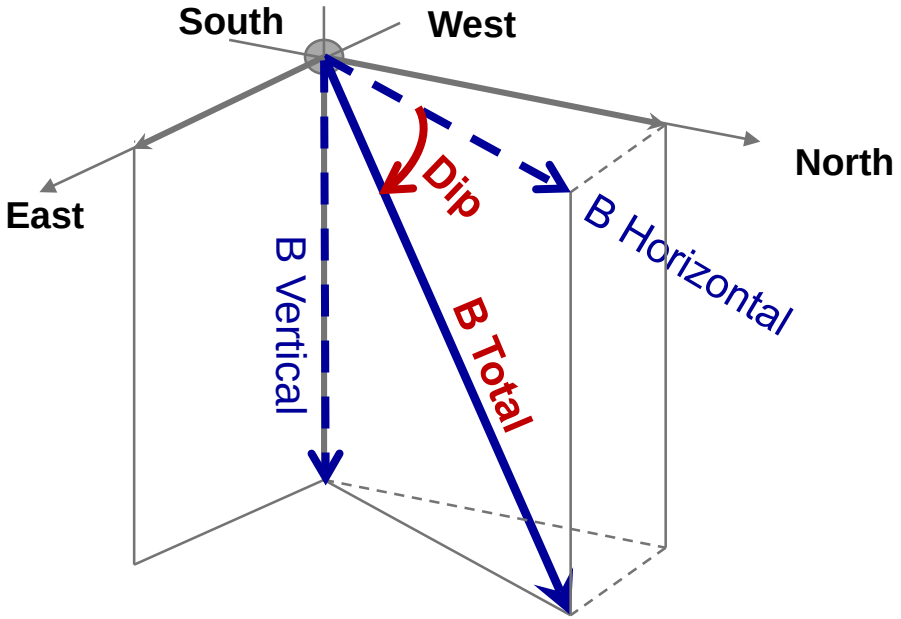
Measure 6 quantities → get 6 parameters:

- Inclination, Magnetic Azimuth, Tool Face (use for steering!)
- Gtotal, Btotal, Dip (use for QC!)

MWD QC Parameters

Accelerometer

Magnetometer

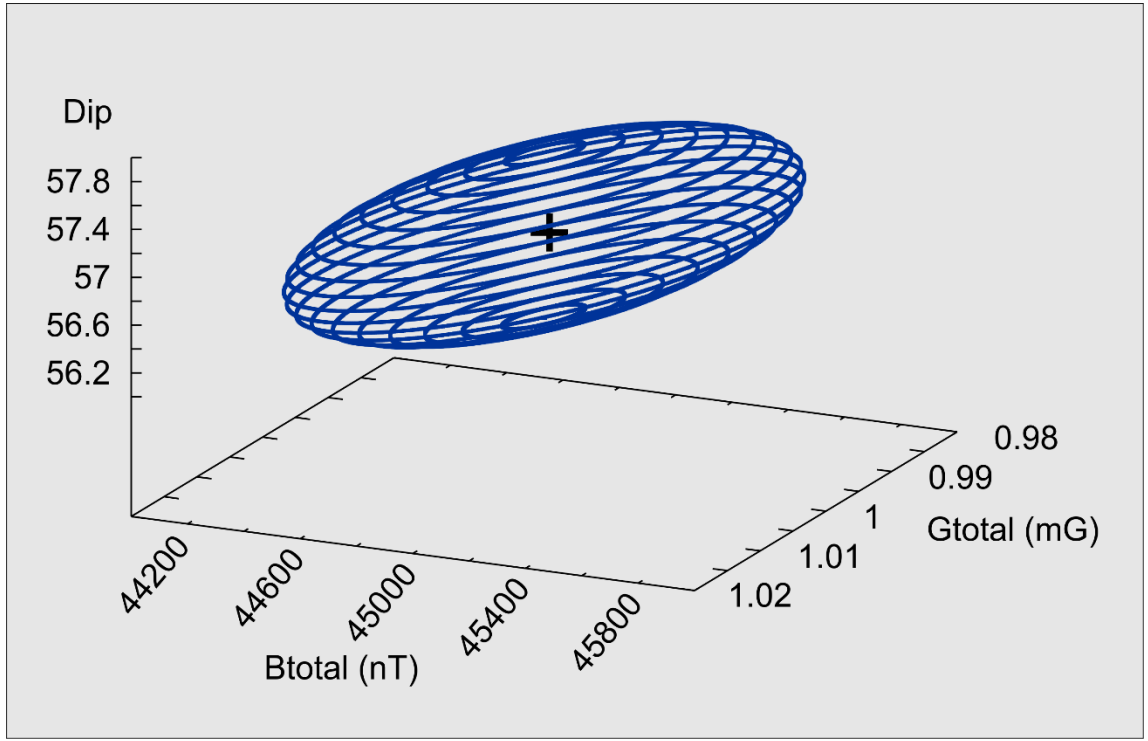


What do we need in order to QC a survey?

- Reference values (Gtotal, Btotal, Dip)
- Uncertainties (1 sigma) of all the error sources
- An actual downhole measurement that we want to Quality Control
- A QC algorithm or application that determines whether a survey passes or fails

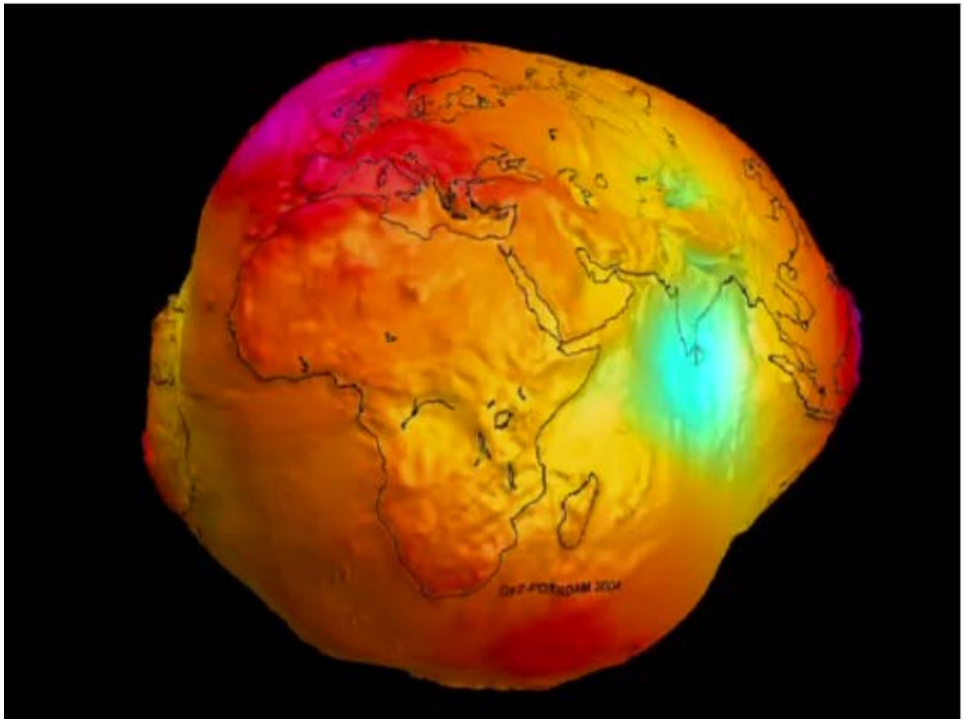
QC Threshold is the surface of a 3D Ellipsoid

- Compute 1-sigma errors in Gtotal, Btotal and Dip from tool code
- Ellipsoid depicts 3 sigma error (97% confidence in 3D)
- Surveys within the ellipsoid **pass** QC
- Surveys outside of the ellipsoid **fail** QC



Gravity Reference Accuracy

	Std Gravity	GARM*
Earth Mass	Global Mean Value	✓
Earth rotation		✓
Earth shape		✓
Topography		✓
Anomalies		✓
Depth (TVD)		✓
Water/Rocks		✓
Error (1 sigma)	**~1.6 mG**	**~0.3 mG**

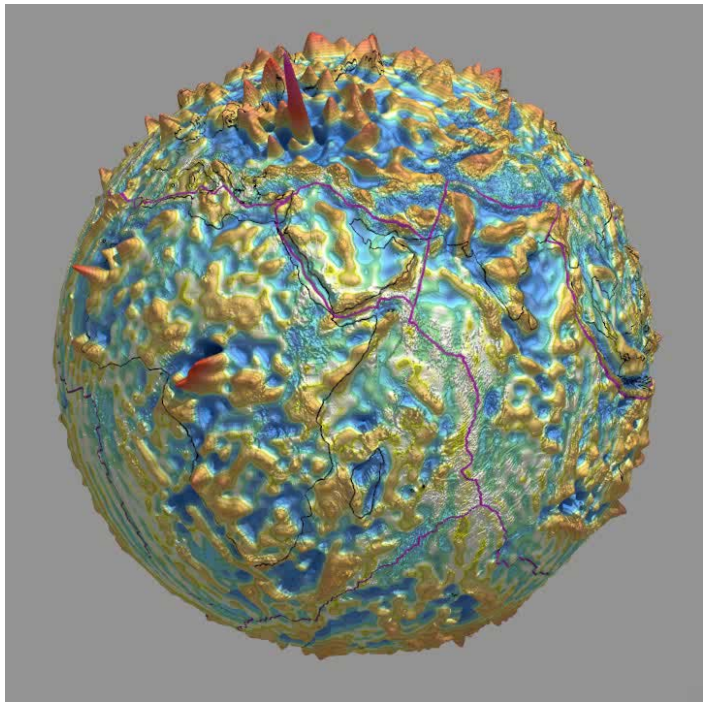


*Global Acceleration Reference Model

Animation credit GFZ Potsdam

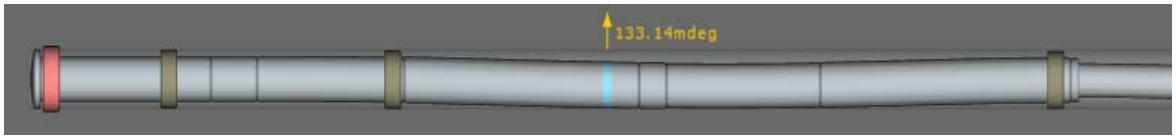
Magnetic Reference Accuracy

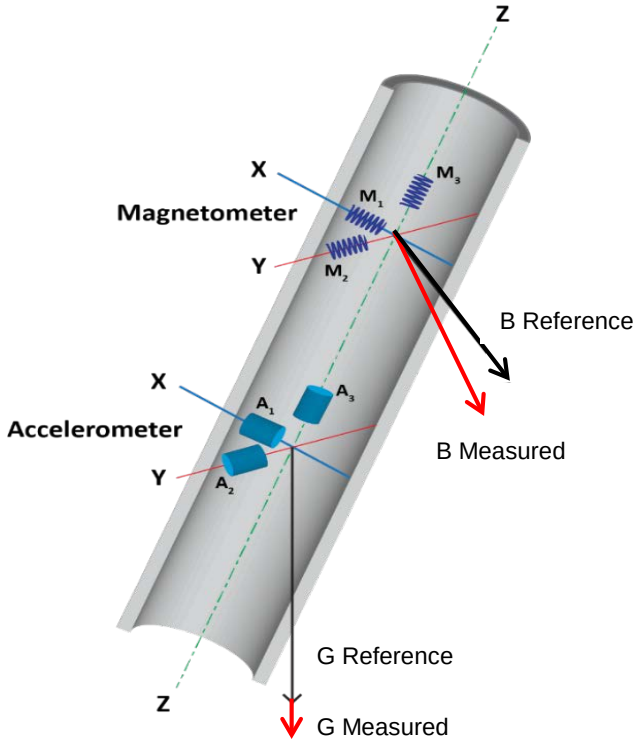
	IGRF/ WMM	Std MWD	HRGM	IFR1	IFR2
Main Field	✓	✓	✓	✓	✓
Annual update		✓	✓	✓	✓
Global crustal field			✓	✓	✓
Local crustal				✓	✓
Disturbance field					✓



MWD Survey Corrections

Some example tool codes	MWD +IFR1+AX	MWD +IFR1+MS	MWD +IFR2+SAG+MS
Axial interference	✓	✓	✓
Cross-axial interference, instrument biases and scale factors		✓	✓
BHA Sag			✓



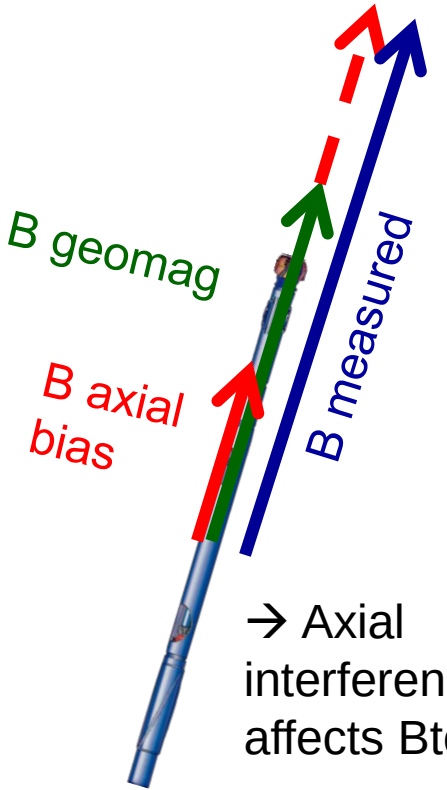


QC Parameter Dependencies

Which error sources influence which QC parameters?

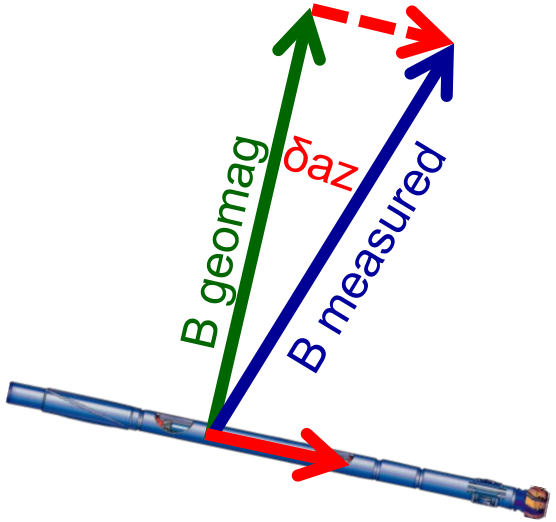
Error source	Gtotal	Btotal	Dip
Reference model	x	x	x
Accelerometer Bias	x	-	x
Accelerometer Scale	x	-	x
Accel-Magn Misalignment	-	-	x
Magnetometer Bias	-	x	x
Magnetometer Scale	-	x	x
Drill string interference	-	x	x

QC Criteria Depend on Wellbore Orientation



Example:
Contribution of axial interference to error in Btotal

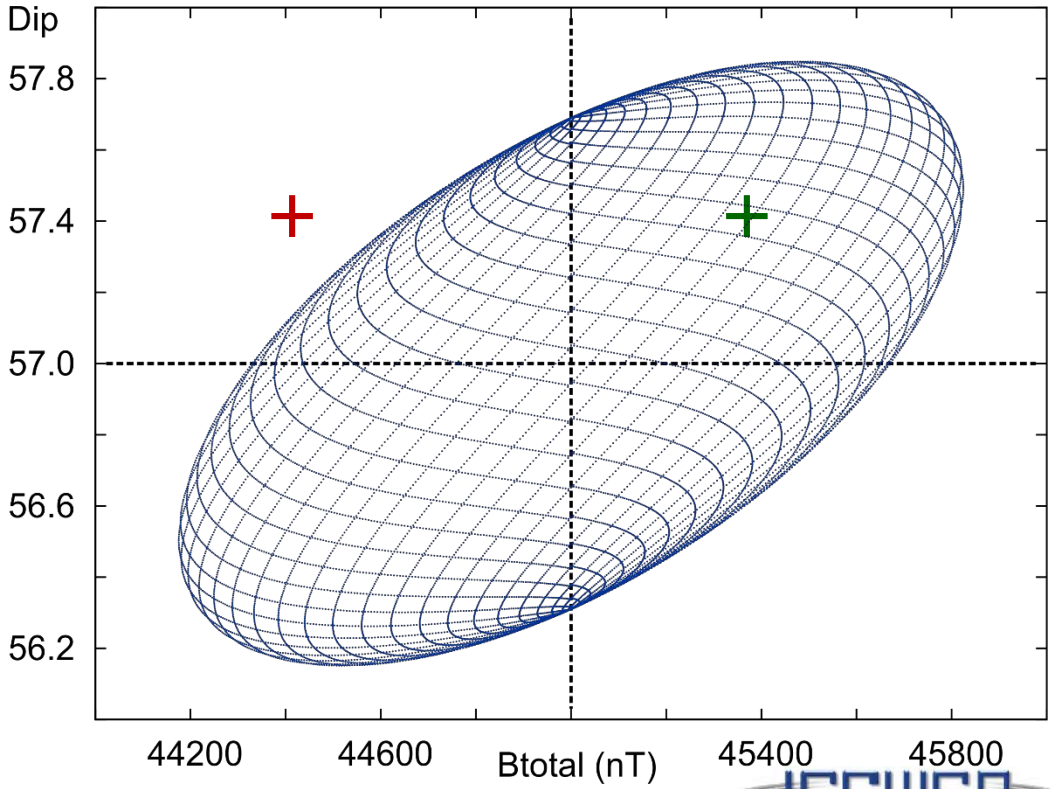
→ Axial interference affects Btotal



→ Axial interference not seen in Btotal

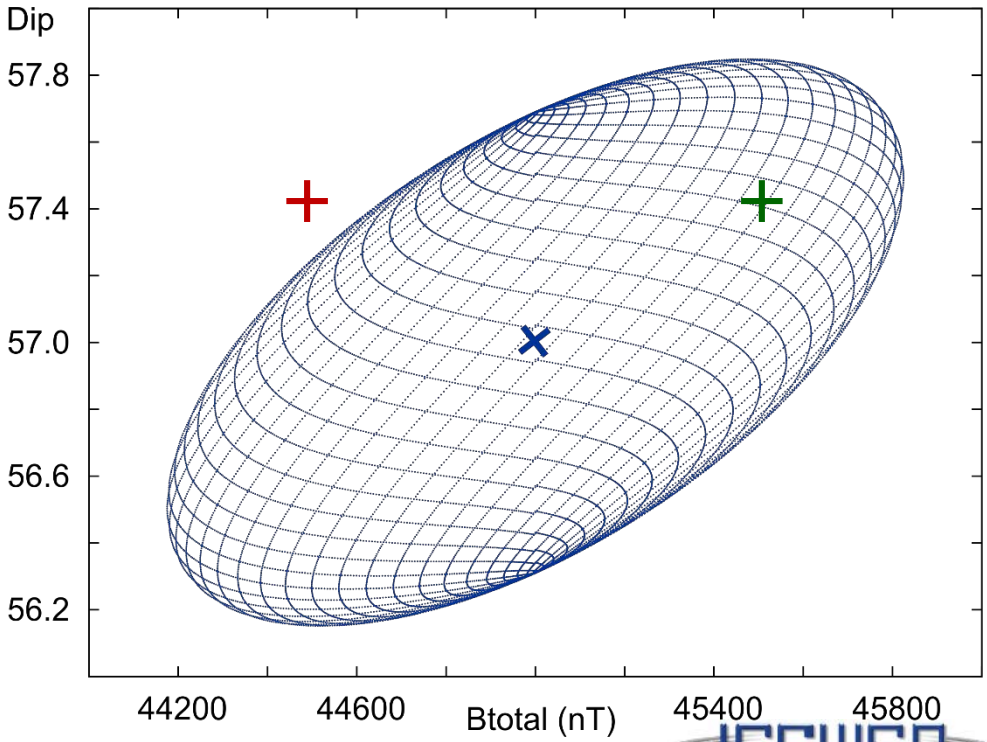
Parameter Errors are Correlated

- Errors in Gtotal and Btotal are correlated with errors in Dip
- Depends on orientation of wellbore relative to magnetic field
- The same Dip value can be inside or outside the ellipsoid, depending on Btotal and Gtotal values

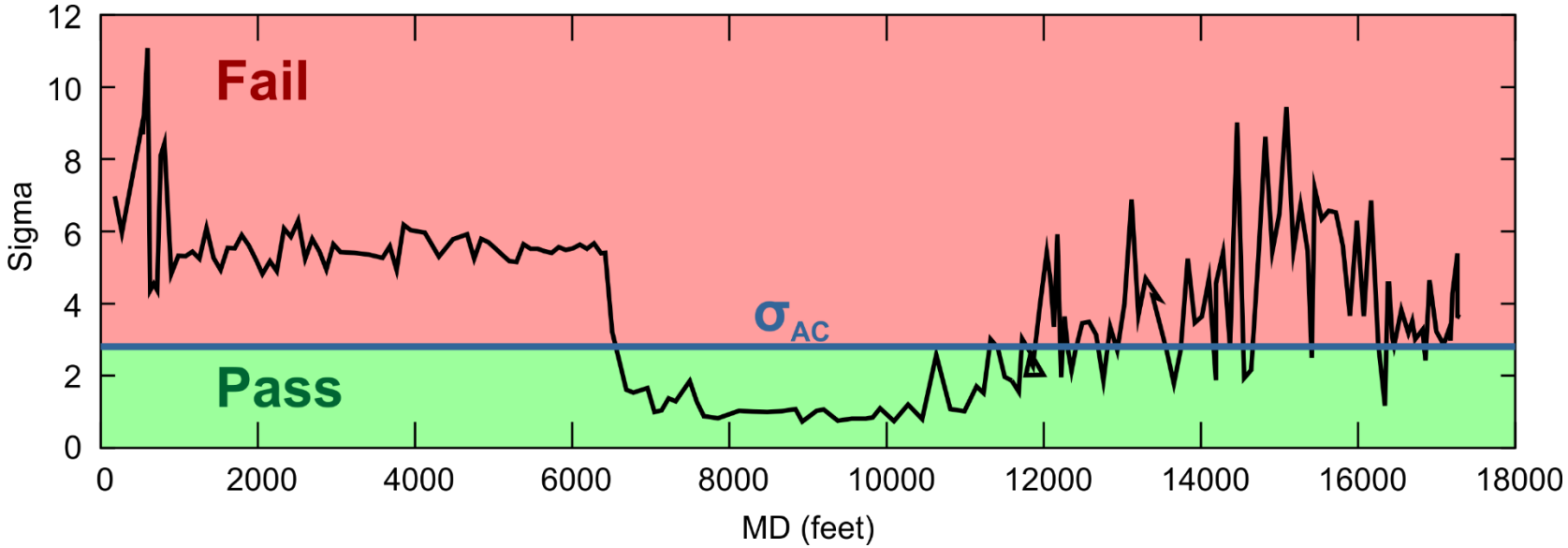


Is a Survey Inside or Outside of the Ellipsoid?

- Define a statistical distance σ from the center **X**
- All points on the ellipsoid have same distance $\sigma = \sigma_{AC}$
- Each survey has one statistical distance σ_{survey}
- Pass: $\sigma_{survey} < \sigma_{AC}$
- Fail: $\sigma_{survey} > \sigma_{AC}$



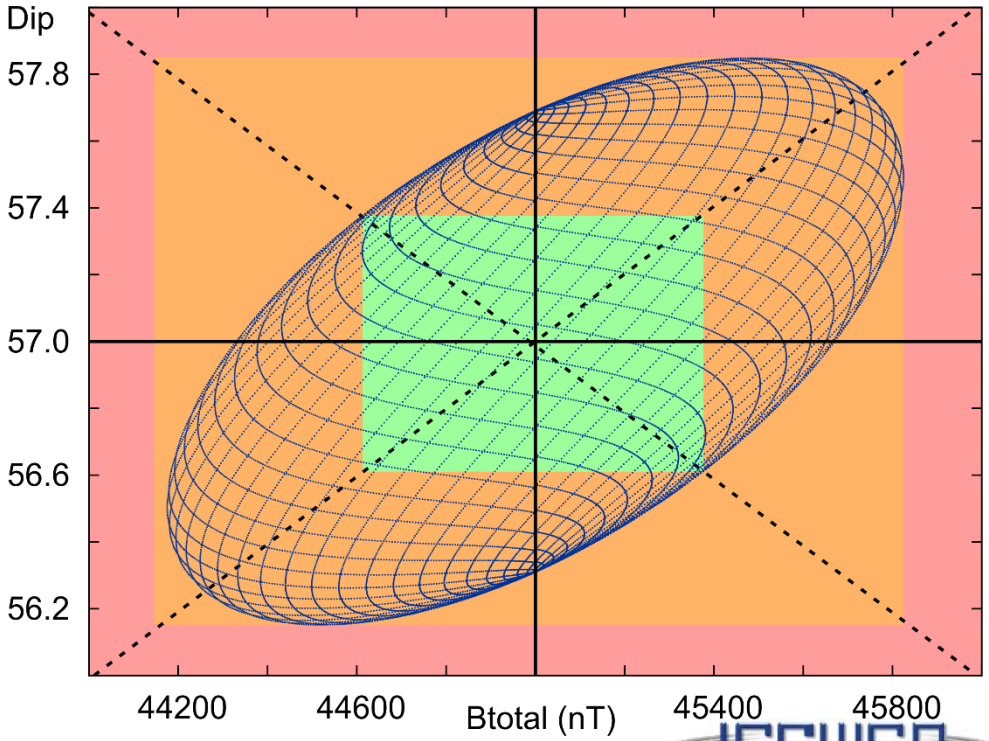
A Single Survey Quality Control Criterion



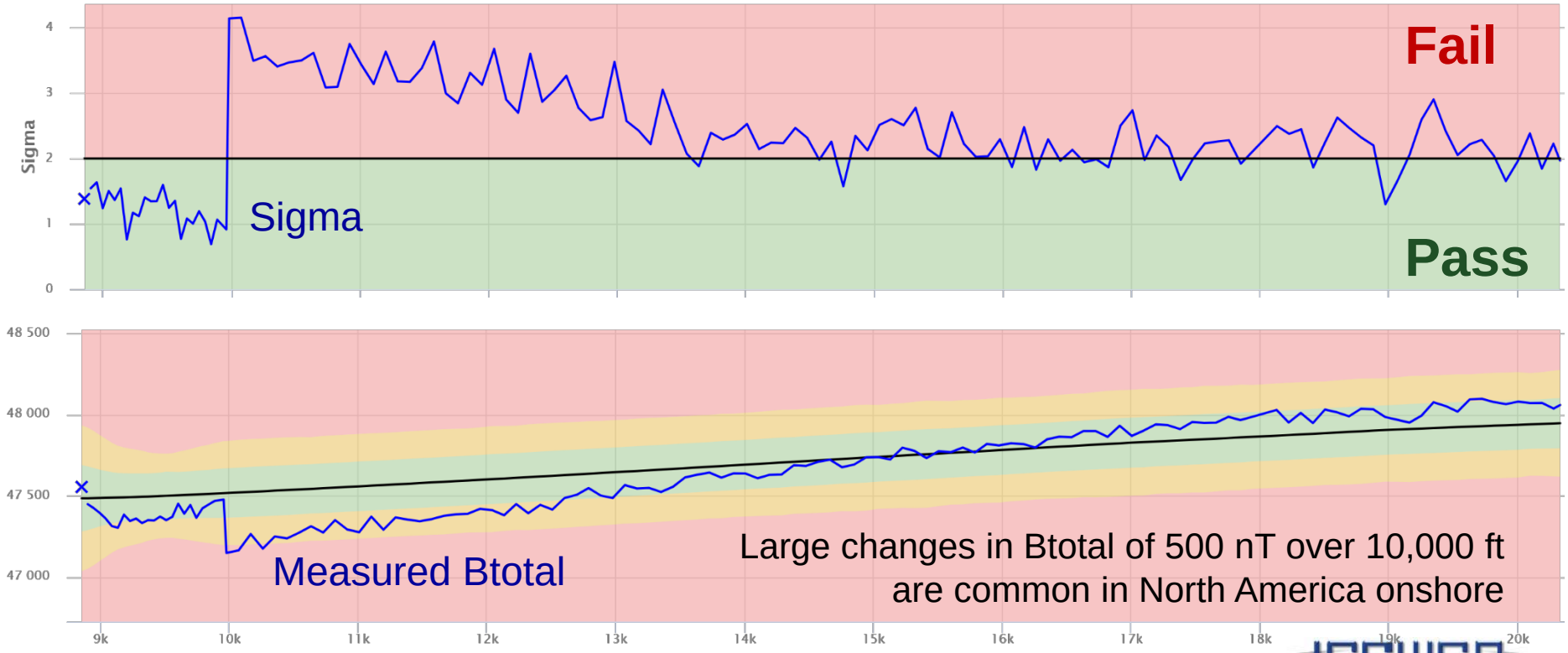
A survey fails QC if its statistical distance from the reference values is larger than the sigma value σ_{AC} used for anti-collision

Define Thresholds for Gtotal, Btotal and Dip

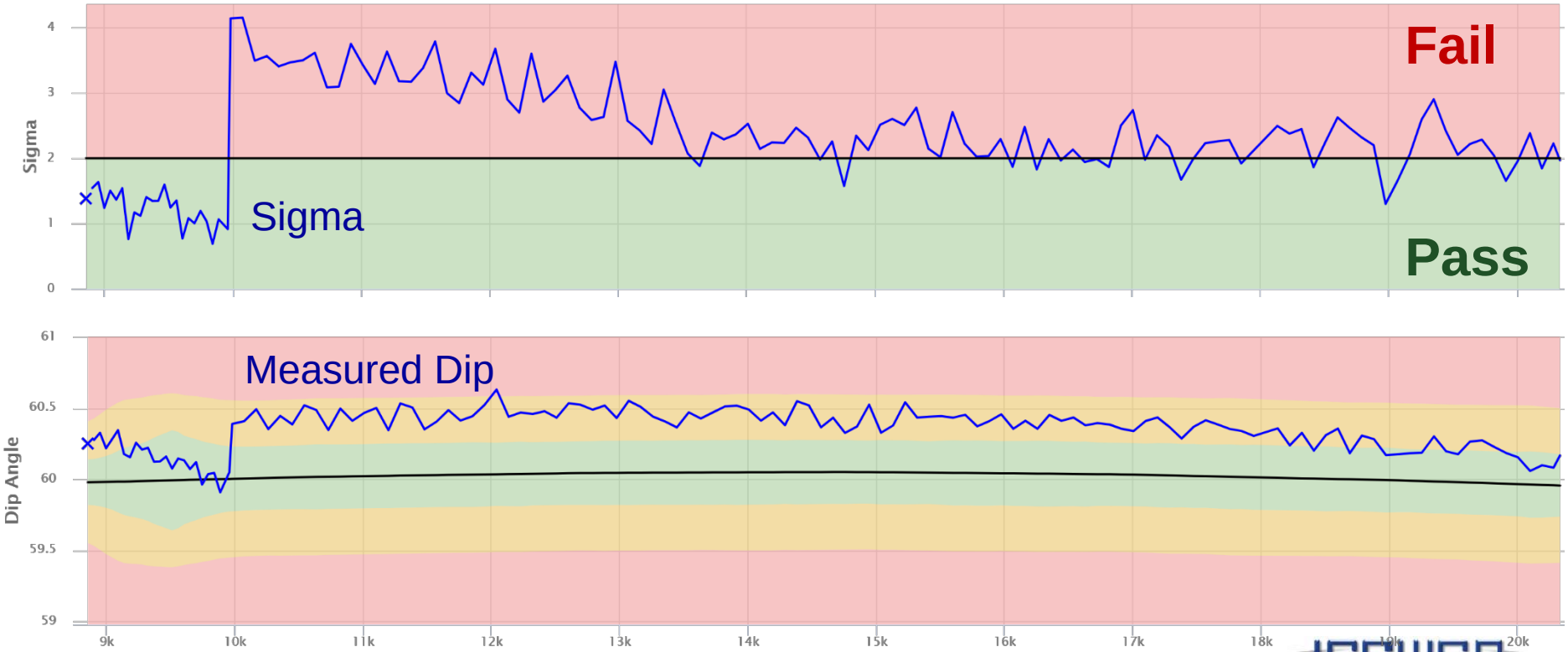
- Cannot define exact QC thresholds for parameters
- But can define a “green” range, an “orange” range and a “red” range
- Green is pass
- Orange may pass or fail
- Red fails for sure



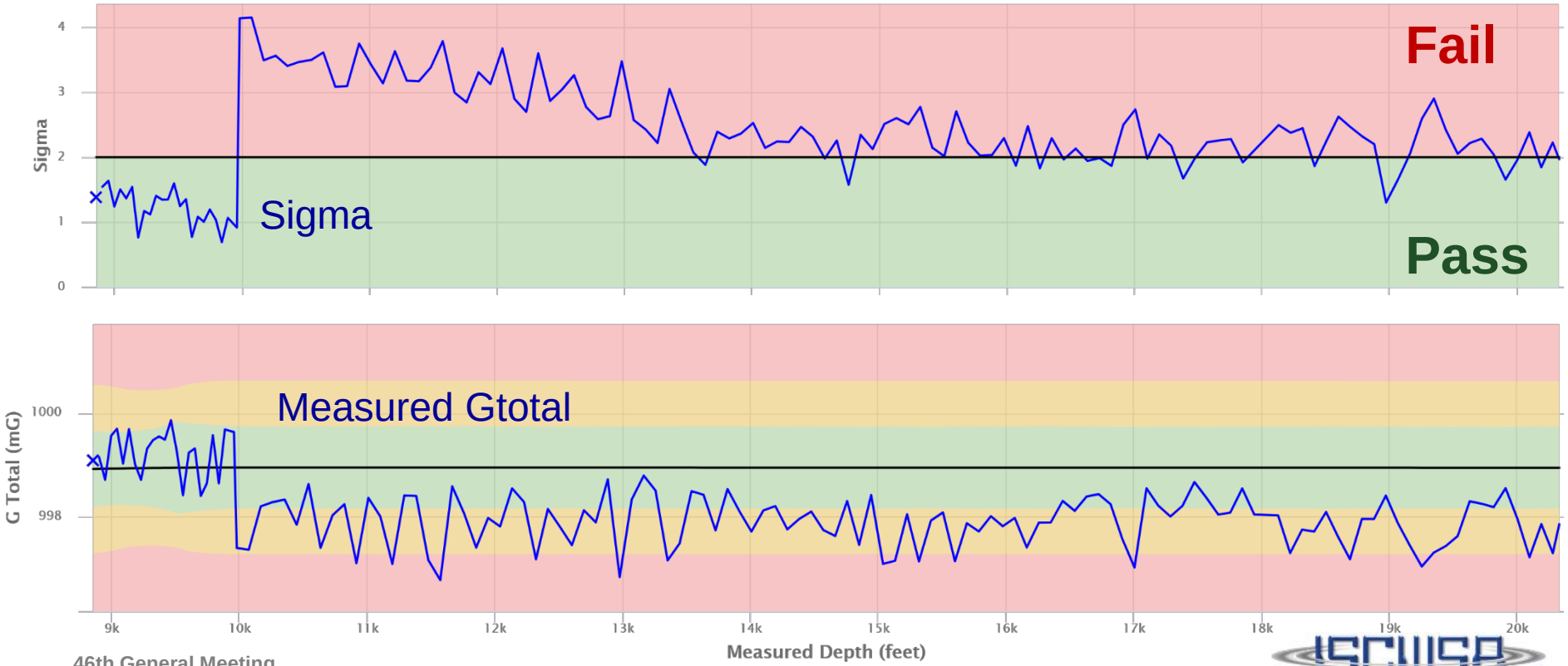
Example QC Plots of Sigma versus Btotal



Example QC Plots of Sigma versus Dip



Example QC Plots of Sigma versus Gtotal



The Benefit of a Calibrated Accelerometer

Most MWD accelerometers are not calibrated to an absolute reference

- Measured Gtotal does not agree with the actual Gtotal at location
- QC thresholds are set very large (+/- 3 milli-G) to account for offsets
- Noisy accelerometer data not flagged due to generous tolerances

Recommended accelerometer calibration procedure:

- Calibrate the accelerometer in the shop to absolute Gtotal
- Down hole, use an accurate reference field model for Gtotal, such as the Global Acceleration Reference Model (GARM)

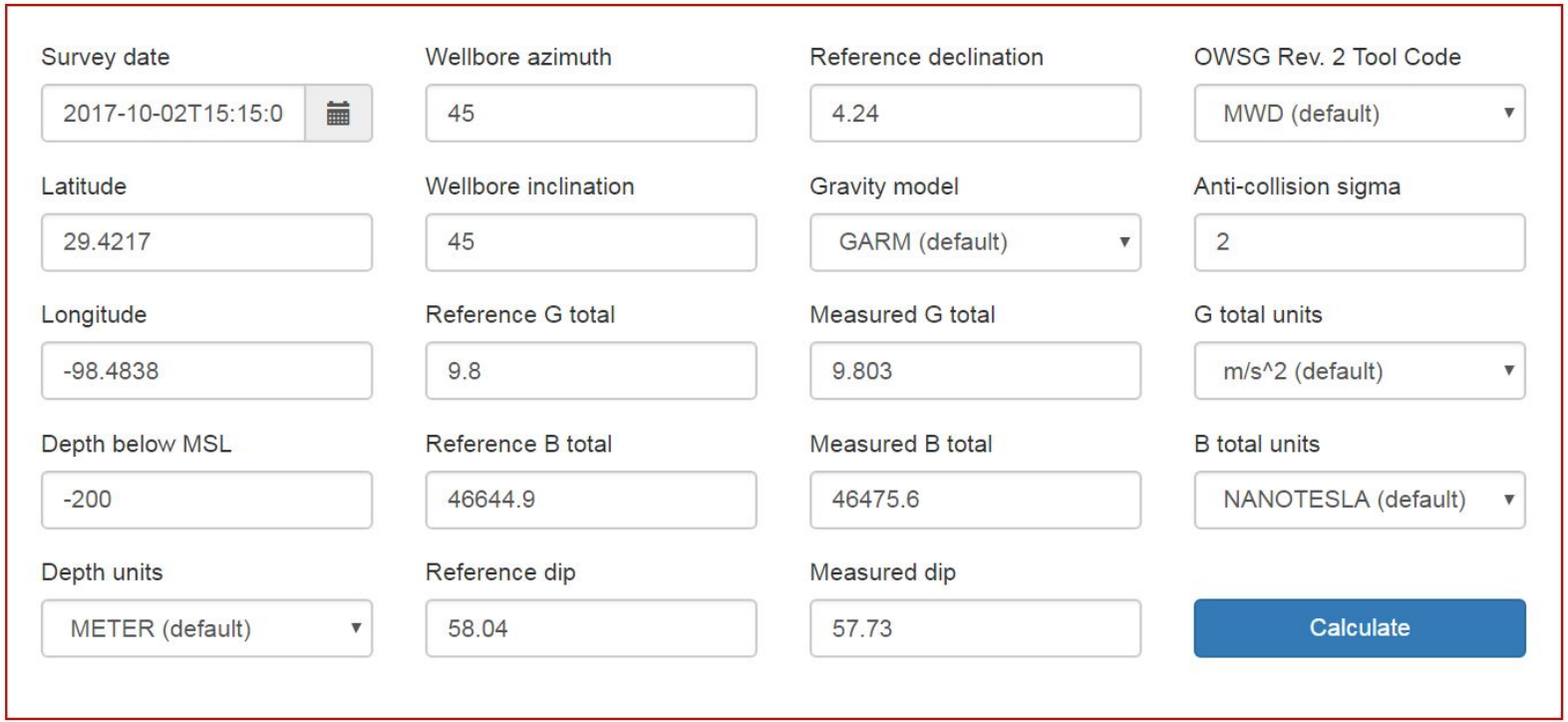
  → Helps to identify noisy data and Gz bias errors

What if Surveys fail QC?

- The reasons could be
  - A defective tool
  - Interference from the drill string
  - Interference from an offset well
  - Inaccurate reference values
- Try using a more accurate reference model
  - Should account for field changes along wellbore
  - If Dip and Btotal references are inaccurate, then the declination is probably also wrong!
- Don’t be tempted to bypass QC by adjusting the reference values to match the MWD data

Texas sharpshooter fallacy

Dynamic QC Calculator for Wellbore Surveys



http://fac.magvar.com/

Calculator Output

Validation Results	Sigma distance:	AC Sigma:	Survey Validation:
	1.61	2	PASS
Delta GTotal:	G total green threshold:	G total orange threshold:	G total validation result:
0.0030	0.0060	0.0212	GREEN
Delta BTotal:	B total green threshold:	B total orange threshold:	B total validation result:
-169	290	1033	GREEN
Delta Dip:	Dip green threshold:	Dip orange threshold:	Dip validation result:
-0.31	0.27	0.95	ORANGE
Error Model Inc Uncertainty Systematic:	Error Model Inc Uncertainty random:	Error Model Azi Uncertainty Systematic:	Error Model Azi Uncertainty random:
0.35	0.00	1.11	0.31

Write your own QC software which calls the API

http://fac-api.magvar.com/:

MagVAR Survey Validation API

This web API implements dynamic quality control for the ISCWSA OWSG Rev-2 error model tool codes. Users can upload MWD surveys and receive the relevant QC information for the selected tool code. Apart from the sigma-distance indicating pass or failure of the survey, the API also returns the random and systematic uncertainties in the measured inclination and azimuth taking the location and wellbore orientation into account. The API enables single queries via a web interface, as well as programmatic access by user software. Please also see http://fac.magvar.com for a user friendly front end calculator.

Created by Magnetic Variation Services LLC
See more at https://www.magvar.com
Contact the developer

survey-validation-controller : Survey Validation and QC

Show/Hide | List Operations | Expand Operations

GET /uncertaintyValues — Obtain survey validation info

Response Class (Status 200)
Successfully retrieved survey validation info

Summary and Conclusions

- Public calculator enables simple QC for MWD surveys
- Survey fails if its computed Sigma > AC Sigma
  - Accounts for error model tool code used
  - Accounts for geometry and location of wellbore
- Recommendations:
  - Use accurate reference values to achieve reliable tool QC
  - Calibrate accelerometers to absolute reference Gtotal
- In support of ISCWSA standards, MagVAR provides this calculator and API as a free and open service