60th General Meeting
25th & 26th of September 2024
New Orleans, LA

Wellbore Positioning Technical Section

The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

Error Model Maintenance + Collision Avoidance Joint Sub-committee Update

Darren Aklestad & Marc Willerth

Sub-Committee Chairs

Error-Model Maintenance: Marc Willerth, H&P

- 15+ years in varying facets of wellbore positioning product support, survey corrections, & error modeling
- Marc.Willerth@hpinc.com

Collision Avoidance: Darren Aklestad, SLB

- 30+ years in Wellbore positioning, well planning, anti-collision, cartographic systems, survey corrections
- Aklestad@slb.com

Attendance

- 40 people in-person, additional 9 online attendees

Topics Covered

- Rotating Survey Error Model Framework
- Cone based Error Model Guidance
- Collision Probability and Risk Management Systems
- Unified statistical distance for CA and QC
- Travelling Cylinder Visualization

Rotating Survey Error Model Framework

- Workgroup has aligned on terms & weighting functions
- Plan to distribute draft of error model for comment
- Currently at least 3 known software implementations
  - Aim is to produce standard software test data

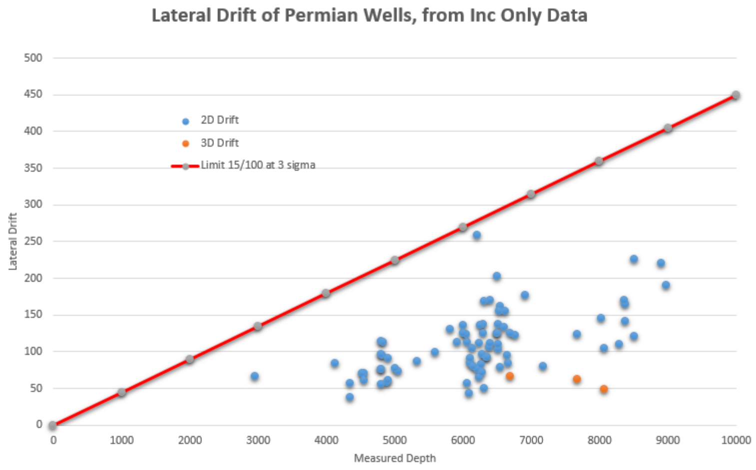
<u>Actual magnitudes for errors must come from individual vendors</u>

OWSG Prefix:	
Short Name:	Cont_Rot_6Axis_Mag+SRGM
Long Name:	Continuous Rotating Six Axis Magnetic Measurements with a S
Revision No:	0
Revision Date:	
Revision Comment:	
Source:	Schlumberger + Rotating Survey Workgroup
Application:	
Tool Type:	Magnetic
Status:	Active
Checked:	
Approved:	
Notes:	Generic Model for Testing Purposes, terms taken from existing
Revision History:	
Replaces / Replaced By:	
Inclination Range Min:	0 deg
Inclination Range Max:	180 deg
Hor East/West Exclusion:	0 deg
Range Comment:	Exclusion zone around the magnetic vector.
Tool Parameters	
Misalignment Alt:	3

No	Code	Term Description	Wt.Fn.	Wt.Fn. Source	Type	Magnitude	Units	Prop.	P 1	P 2	P 3	Wt.Fn. Comment	Depth Formula	Inclination Formula	Azimuth Formula
1	DRFR	Depth: Depth Reference - Random	DREF	SPE 67616	Depth	0.35	m	R	0	0	0		1	0	0
2	DSFS	Depth: Depth Scale Factor - Systematic	DSF	SPE 67616	Depth	0.00056	-	S	1	0	0		MD	0	0
3	DSTG	Depth: Depth Stretch - Global	DST	SPE 67616	Depth	2.5E-07	1/m	G	1	1	1		MD * TVD	0	0
4	AN1	MWD: XY-Shock and Vibe, Term 1	AN1	Superior QC	Sensor	0.0088	m/s2	R	0	0	0	Singularity when vertical	0	0	(1/Tan(Inc) - Cos(AzM) * Tan(Dip)) / Gfield
5	AN2	MWD: XY-Shock and Vibe, Term 2	AN2	Superior QC	Sensor	0.0088	m/s2	R	0	0	0		0	-Cos(Inc) / Gfield	Cos(Inc) * Sin(AzM) * Tan(Dip) / Gfield
6	ANZ	MWD: Z-Shock and Vibe	ANZ	Superior QC	Sensor	0.0044	m/s2	R	0	0	0		0	-Sin(Inc) / Gfield	Sin(Inc) * Sin(AzM) * Tan(Dip) / Gfield
7	ASXY-ROT	MWD: X&Y-Accelerometer Scale Factor	ASXY-ROT	Superior QC	Sensor	0.001	-	S	1	0	0		0	Sin(Inc) * Cos(Inc) / 2	-Sin(Inc) * Cos(Inc) * Sin(AzM) * Tan(Dip) / 2
8	AXY-ATTEN	MWD: Accels XY-Attenuation From LP Filter	AXY-ATTEN	Superior QC	Sensor	0.0015	-	S	1	0	0		0	Sin(Inc) * Cos(Inc)	-Sin(Inc) * Cos(Inc) * Sin(AzM) * Tan(Dip)
9	ABZ	MWD: Z-Accelerometer Bias	ABZ	SPE 67616 Table 1	Sensor	0.004	m/s2	S	1	0	0		0	-Sin(Inc) / Gfield	Tan(Dip) * Sin(Inc) * Sin(AzM) / Gfield
10	ASZ	MWD: Z-Accelerometer Scale Factor	ASZ	SPE 67616 Table 1	Sensor	0.0005	-	S	1	0	0		0	-Sin(Inc) * Cos(Inc)	Tan(Dip) * Sin(Inc) * Cos(Inc) * Sin(AzM)
11	MSXY-ROT	MWD: X&Y-Magnetometer Scale Factor	MSXY-ROT	Superior QC	Sensor	0.0032	-	S	1	0	0		0	0	Sin(Inc) * Sin(AzM) * (Tan(Dip) * Cos(Inc) + Sin(Inc) * Cos(AzM))/2
12	MXY-ATTEN	MWD: Mags XY-Attenuation From LP Filter	MXY-ATTEN	Superior QC	Sensor	0.0015	-	S	1	0	0		0	0	Sin(Inc) * Sin(AzM) * (Tan(Dip) * Cos(Inc) + Sin(Inc) * Cos(AzM))
13	MBZ	MWD: Z-Magnetometer Bias	MBZ	SPE 67616 Table 1	Sensor	70	nT	S	1	0	0		0	0	-Sin(Inc) * Sin(AzM) / (BField * Cos(Dip))
14	MSZ	MWD: Z-Magnetometer Scale Factor	MSZ	SPE 67616 Table 1	Sensor	0.0016	-	S	1	0	0		0	0	-(Sin(Inc) * Cos(AzM) + Tan(Dip) * Cos(Inc)) * Sin(Inc) * Sin(AzM)
15	AMXY-PS	MWD:XY-Phase Shift Btwn Mags and Accels	AMXY-PS	Superior QC	Sensor	0.08	deg	S	1	0	0		0	0	(Cos(Inc) - Sin(Inc) * Cos(AzM) * Tan(Dip)) * PI / 180
16	EDDY	MWD: XY-Interference from Eddy Currents	EDDY	Superior QC	Mgntcs	0.06	deg	S	1	0	0		0	0	(Cos(Inc) - Sin(Inc) * Cos(AzM) * Tan(Dip)) * PI / 180
17	CA1	MWD: XY-Centripetal Accel, Term 1	CA1	Superior QC	Sensor	0.0025	m/s2	R	0	0	0	Singularity when vertical	0	0	(1/Tan(Inc) - Cos(AzM) * Tan(Dip)) / Gfield
18	CA2	MWD: XY-Centripetal Accel, Term 2	CA2	Superior QC	Sensor	0.0025	m/s2	R	0	0	0		0	-Cos(Inc) / Gfield	Cos(Inc) * Sin(AzM) * Tan(Dip) / Gfield
19	DSC	MWD: Depth Shift Compensation	DSC	Superior QC	Sensor	0.08	deg	R	0	0	0	Singularity when vertical	0	1	1 / Sin(Inc)
20	DEC-U	MWD: Declination Uncorrelated Errors	AZ	SPE 67616	AziRef	0.16	deg	W	1	1	0		0	0	1
21	DEC-OS	MWD: Declination Crustal Omission Error Standard Models	AZ	SPE 67616	AziRef	0.24	deg	G	1	1	1		0	0	1
22	DEC-OH	MWD: Declination Crustal Omission HD Models	AZ	SPE 67616	AziRef	0.21	deg	G	1	1	1		0	0	1
23	DEC-OI	MWD: Declination Crustal Omission IFR Models	AZ	SPE 67616	AziRef	0.05	deg	G	1	1	1		0	0	1
24	DECR	MWD: Declination - Random	AZ	SPE 67616	AziRef	0.1	deg	R	0	0	0		0	0	1
25	DBH-U	MWD: BH Dependent Declination Uncorrelated Errors	DBH	SPE 67616	AziRef	2350	deg.nT	W	1	1	0		0	0	1 / (BField * Cos(Dip))
26	DBH-OS	MWD: BH Dependent Declination Crustal Omission Standard Models	DBH	SPE 67616	AziRef	3359	deg.nT	G	1	1	1		0	0	1 / (BField * Cos(Dip))
27	DBH-OH	MWD: BH Dependent Declination Crustal Omission HD Models	DBH	SPE 67616	AziRef	2840	deg.nT	G	1	1	1		0	0	1 / (BField * Cos(Dip))
28	DBH-OI	MWD: BH Dependent Declination Crustal Omission IFR Models	DBH	SPE 67616	AziRef	356	deg.nT	G	1	1	1		0	0	1 / (BField * Cos(Dip))
29	DBHR	MWD: BH-Dependent Declination - Random	DBH	SPE 67616	AziRef	3000	deg.nT	R	0	0	0		0	0	1 / (BField * Cos(Dip))
30	AMIL	MWD: Axial Interference - SinI.SinA	AMIL	Halliburton	Mgntcs	220	nT	S	1	0	0		0	0	Sin(Inc) * Sin(AzM) / (BField * Cos(Dip))
31	SAGE	MWD: Sag	SAGE	ISCWSA	Align	0.2	deg	S	1	0	0		0	(Sin(Inc))^0.25	0
32	XYM1	Misalignment: XY Misalignment 1	XYM1	SPE 90408 Table 9 - Alt. 3	Align	0.1	deg	S	1	0	0		0	Abs(Sin(Inc))	0
33	XYM2	Misalignment: XY Misalignment 2	XYM2	SPE 90408 Table 9 - Alt. 3	Align	0.1	deg	S	1	0	0		0	0	-1
34	XYM3E	Misalignment: XY Misalignment 3	XYM3E	ISCWSA	Align	0.3	deg	R	0	0	0	Singularity when vertical	0	Cos(Inc) * Cos(AzT) * Ma:	(Cos(Inc) * Sin(AzT) / Sin(Inc)) * Max(1, sqrt(10/(MD-MDPrev)))
35	XYM4E	Misalignment: XY Misalignment 4	XYM4E	ISCWSA	Align	0.3	deg	R	0	0	0	Singularity when vertical	0	Cos(Inc) * Sin(AzT) * Max(	(Cos(Inc) * Cos(AzT) / Sin(Inc)) * Max(1, sqrt(10/(MD-MDPrev)))
36	XCLA	Depth: Long Course Length XCL - Azimuth	XCLA	SPE 187249 Jerry Codling	Depth	0.167	-	R	0	0	0	Tangential Calculation. Si	0	0	Max(Sin(Abs(AzT-AzPrev)), XCLTortuosity * (MD-MDPrev) / Sin(Inc))
37	XCLH	Depth: Long Course Length XCL - Inclination	XCLH	SPE 187249 Jerry Codling	Depth	0.167	-	R	0	0	0	Tangential Calculation. Fc	0	Max(Abs(Inc-IncPrev), X(	0

Cone Based Error Model Guidance

- Draft document from Jerry Codling
- Process for using historical data to estimate a cone
- Describes how to construct a cone of arbitrary size
- Intent is enable operators to build their own cones if desired



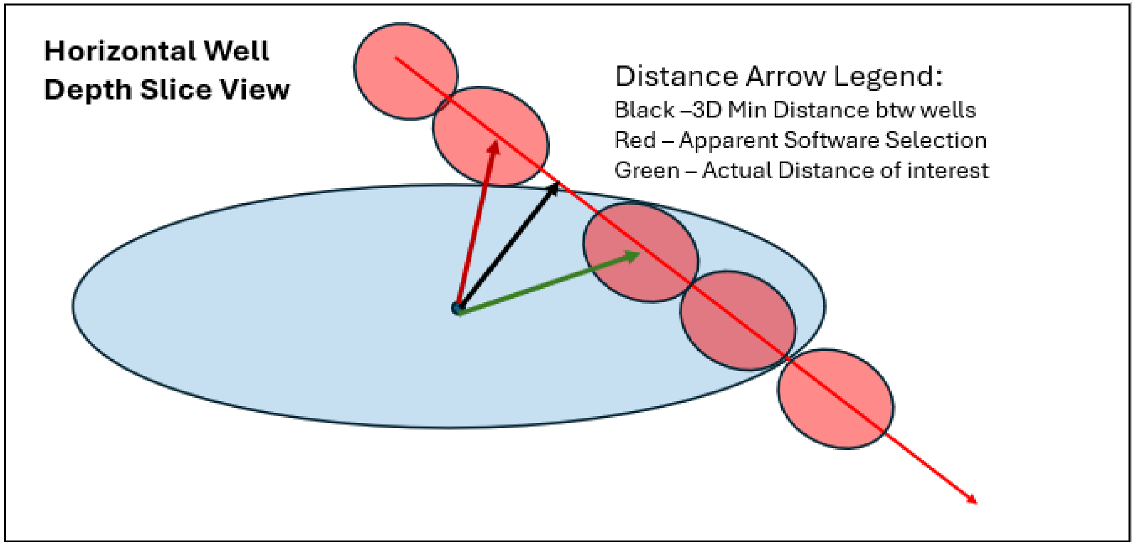
Probability & Risk Management

- Presentation by Koen Noy
- Risk Assessment Matrix and need for collision frequency estimation on economic risks
- Desirable to standardize probability across vendors

		Category	CONSEQUENCE ESTIMATION				
		Consequence category is set by Company					
FREQUENCY ESTIMATION							
Quantitative Interpreatiton Guidance	Quantitative interpretation	Category	Negligible	Minor	Modate	Major	Severe
		Very unlikely					
		Unlikely					
		Possible					
		Likely					
		Frequent					

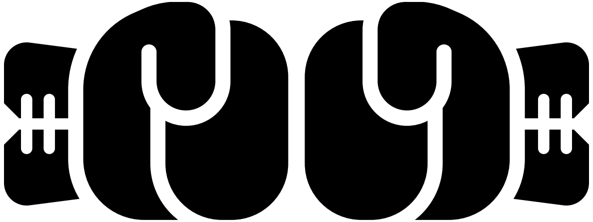
Unified Statistics for SF and Survey QC

- Presentation by Michael Caulkins
- Challenges with pedal curve projection and point selection
- Do we need more precise scanning methods?



Travelling Cylinder Visualization

- Presentation by Dalis Deliu and Jerry Codling
- Challenges in using various TC projections uniformly
  - In particular using a North-referenced TC for a lateral
- Are being held back by sticking to old plot practices?



Thanks and Discussion