Managing MWD Survey Logs

ISCWSA 40
Amsterdam, 30 October 2014

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BAKER
HUGHES

Survey "Log"

- Sequence of successive survey "stations"
- Same tool, same processing

Wellpath = Concatenated Survey Logs

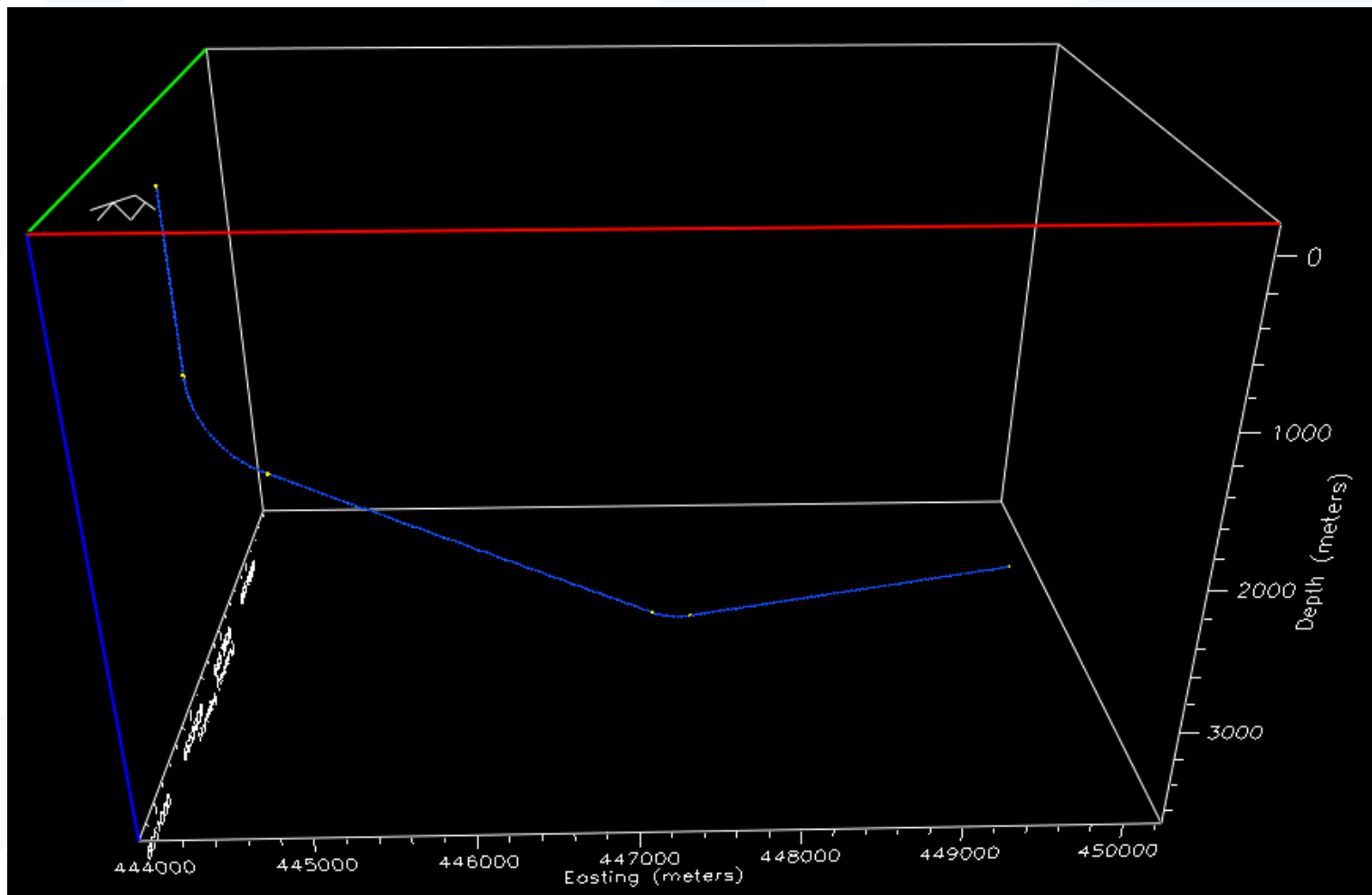- Second survey is "tied-on" to first, etc.

MD from (m)	MD to (m)	Survey type/Error Model
0	1000	Gyro (wireline)
1000	2000	EMS (drop)
2000	3000	MWD (basic)

MD from (m)	MD to (m)	Survey type/Error Model
0	1000	MWD (basic)
1000	2000	MWD (basic)
2000	3000	MWD (basic)

What difference does it make?

- ISCWSA well 1

The effect of introducing a tie-on

- ## Single log,

| MD Ref. | Datum #2 | TVD Ref. | Datum #2 | | Positional Uncertainty: Starts from Slot at | 0.00 m | Std. Dev. | 2 | Derive | While drilling (Refere ▼) |

	Tool Type	Tool Positional Uncertainty Model	Start MD (m)	End MD (m)	Override Previous	Start MD (m)	End MD (m)	Wellbore name	Comment
1	ISCWSA MWD, Rev. 3	ISCWSA MWD, Rev. 3 (Standard)	0.00	8000.00	No	0.00	0.00	ISCWSA No. 1 pwl	

Positional uncertainty summary (Reference)

Survey Interval End MD (m)	Ref. Ellipsoid Major Semi-Axis (m)	Ref. Ellipsoid Minor Semi-Axis (m)	Ref. Ellipsoid Vert. Semi-Axis (m)	Ref. Ellipsoid Min. Axis Bearing (°)	Ref. Start MD (m)	Ref. End MD (m)	Positional Uncertainty Calculation
8000.00	167.42	19.18	40.27	75.050	0.00	8000.00	ISCWSA MWD r3 0.00-8000.00

- ## 6 logs, 5 tie-ons

	Tool Type	Tool Positional Uncertainty Model	Start MD (m)	End MD (m)	Override Previous	Start MD (m)	End MD (m)	Wellbore name	Comment
1	ISCWSA MWD, Rev. 3	ISCWSA MWD, Rev. 3 (Standard)	0.00	300.00	No	0.00	0.00	ISCWSA No. 1 pwl	
2	ISCWSA MWD, Rev. 3	ISCWSA MWD, Rev. 3 (Standard)	300.00	1200.00	No	0.00	0.00	ISCWSA No. 1 pwl	
3	ISCWSA MWD, Rev. 3	ISCWSA MWD, Rev. 3 (Standard)	1200.00	3000.00	No	0.00	0.00	ISCWSA No. 1 pwl	
4	ISCWSA MWD, Rev. 3	ISCWSA MWD, Rev. 3 (Standard)	3000.00	5000.00	No	0.00	0.00	ISCWSA No. 1 pwl	
5	ISCWSA MWD, Rev. 3	ISCWSA MWD, Rev. 3 (Standard)	5000.00	6500.00	No	0.00	0.00	ISCWSA No. 1 pwl	
6	ISCWSA MWD, Rev. 3	ISCWSA MWD, Rev. 3 (Standard)	6500.00	8000.00	No	0.00	0.00	ISCWSA No. 1 pwl	

Positional uncertainty summary (Reference)

Survey Interval End MD (m)	Ref. Ellipsoid Major Semi-Axis (m)	Ref. Ellipsoid Minor Semi-Axis (m)	Ref. Ellipsoid Vert. Semi-Axis (m)	Ref. Ellipsoid Min. Axis Bearing (°)	Ref. Start MD (m)	Ref. End MD (m)	
300.00	0.63	0.63	0.78	135.000	0.00	300.00	ISCWSA MWD r3 0.00-300.00
1200.00	1.97	1.97	1.68	135.000	300.00	1200.00	ISCWSA MWD r3 0.00-300.00 : ISCW
3000.00	32.30	6.40	8.00	75.138	1200.00	3000.00	ISCWSA MWD r3 0.00-300.00 : ISCW
5000.00	67.80	11.90	14.47	75.084	3000.00	5000.00	ISCWSA MWD r3 0.00-300.00 : ISCW
6500.00	94.57	14.32	18.08	75.045	5000.00	6500.00	ISCWSA MWD r3 0.00-300.00 : ISCW
8000.00	121.12	17.29	21.15	75.027	6500.00	8000.00	ISCWSA MWD r3 0.00-300.00 : ISCW

The effect of introducing tie-ons

Survey Interval End MD (m)	Ref. Ellipsoid Major Semi-Axis (m)	Ref. Ellipsoid Minor Semi-Axis (m)	Ref. Ellipsoid Vert. Semi-Axis (m)
8000.00	167.42	19.18	40.27
8000.00	121.12	17.29	21.15

Why?

- The error model

ISCWSA MWD basic rev 3

ISCWSA MWD, Rev. 3 (Standard) Details

Term	Value (1 sig...)	C	I.	A	Description	Depth weightin...	Inclination weightin...	Azimuth weighting function	Prop. Method
ABX...	0.004 m/s²	1	1	1	xy accelerometer bias, random	0	- cosI/Gt	(tanq*cosI*sinAm)/Gt	Random
ABX...	0.004 m/s²	1	1	1	xy accelerometer bias, random	0	0	(- tanq*cosAm + cotI)/Gt	Random
ABZ	0.004 m/s²	1	1	1	z-accelerometer bias	0	- sinI/Gt	tanq*sinI*sinAm/Gt	Systematic
AMID	0.6 °	1	1	1	Axial magnetic interference, systematic	0	0	p/180*sinI*sinAm	Systematic
AMIF	0.25 °	1	1	1	Axial magnetic interference, fixed	0	0	p/180	Systematic
ASX...	0.0005 fract	1	1	1	x-accel scale factor, Systematic	0	(sinI*cosI)/Sqrt 2	- (tanq*sinI*cosI*sinAm)/Sqrt 2	Systematic
ASX...	0.0005 fract	1	1	1	x-accel scale factor, Random	0	(sinI*cosI)/2	- (tanq*sinI*cosI*sinAm)/2	Random
ASX...	0.0005 fract	1	1	1	x-accel scale factor, Random	0	0	(tanq*sinI*cosAm-cosI)/2	Random
ASZ	0.0005 fract	1	1	1	z-accelerometer scale factor	0	- sinI*cosI	tanq*sinI*cosI*sinAm	Systematic
AZ	0.36 °	1	1	1	Magnetic declination uncertainty	0	0	p/180	Global
DBH	5000 deg-nT	1	1	1	Magnetic declination uncertainty	0	0	p/180/(B*cosq)	Global
DREF	0.35 m	1	1	1	Depth reference, random	1	0	0	Random
DSF	0.00056 fract	1	1	1	Depth scale factor, systematic	D	0	0	Systematic
DST	2.5e-007 1/m	1	1	1	Depth stretch/temperature, global	D*V	0	0	Global
MBX...	70 nT	1	1	1	xy mag bias, random	0	0	- cosI*sinAm/(B*cosq)	Random
MBX...	70 nT	1	1	1	xy mag bias, random	0	0	cosAm/(B*cosq)	Random
MBZ	70 nT	1	1	1	z-magnetometer bias	0	0	- sinI*sinAm/(B*cosq)	Systematic
MSX...	0.0016 fract	1	1	1	xy-magnetometer scale factor, Systematic	0	0	sinI*sinAm*(sinI*cosAm + tanq*cosI)/Sqrt 2	Systematic
MSX...	0.0016 fract	1	1	1	xy-magnetometer scale factor, Random	0	0	sinAm*(tanq*sinI*cosI - cos2I*cosAm - cosAm)/2	Random
MSX...	0.0016 fract	1	1	1	xy-magnetometer scale factor, Random	0	0	(cosI*cos2Am - cosI*sin2Am - tanq*sinI*cosAm)/2	Random
MSZ	0.0016 fract	1	1	1	z-magnetometer scale factor	0	0	- sinI*sinAm*(sinI*cosAm + tanq*cosI)	Systematic
MXY...	0.06 °	1	1	1	xy tool misalignment, systematic	0	p/180*[1 + FIw*(sinI...	0	Systematic
MXY...	0.06 °	1	1	1	xy tool misalignment, systematic	0	0	- p/180*[1 + FIw*(sinI - 1)]/sinI	Systematic
MXY...	0.06 °	1	1	1	xy tool misalignment, systematic	0	p/180*FIw*|cosI|*co...	- p/180*FIw*|cosI|*sinAt/sinI	Systematic
MXY...	0.06 °	1	1	1	xy tool misalignment, systematic	0	p/180*FIw*|cosI|*sin...	p/180*FIw*|cosI|*cosAt/sinI	Systematic
SAG	0.2 °	1	1	1	BHA sag	0	p/180*sinI	0	Systematic

Tool param...	Value	Description	Correcti...		
FIw	1 fract	Flag to set misalignment ...	Standard		

Correlation coefficients – Propagation Mode

ISCWSA Propagation Mode	Correlation coefficient		
	Stn to stn	Log to log	Well to well
Random	0	0	0
Systematic	1	0	0
Per Well	1	1	0
Global	1	1	1

0 = uncorrelated

1 = correlated

Correlation coefficients – Propagation Mode

ISCWSA Propagation Mode	Correlation coefficient		
	Stn to stn	**Log to log**	**Well to well**
Random	0	0	0
Systematic	1	0	0
Per Well	1	1	0
Global	1	1	1

Why?

Why?
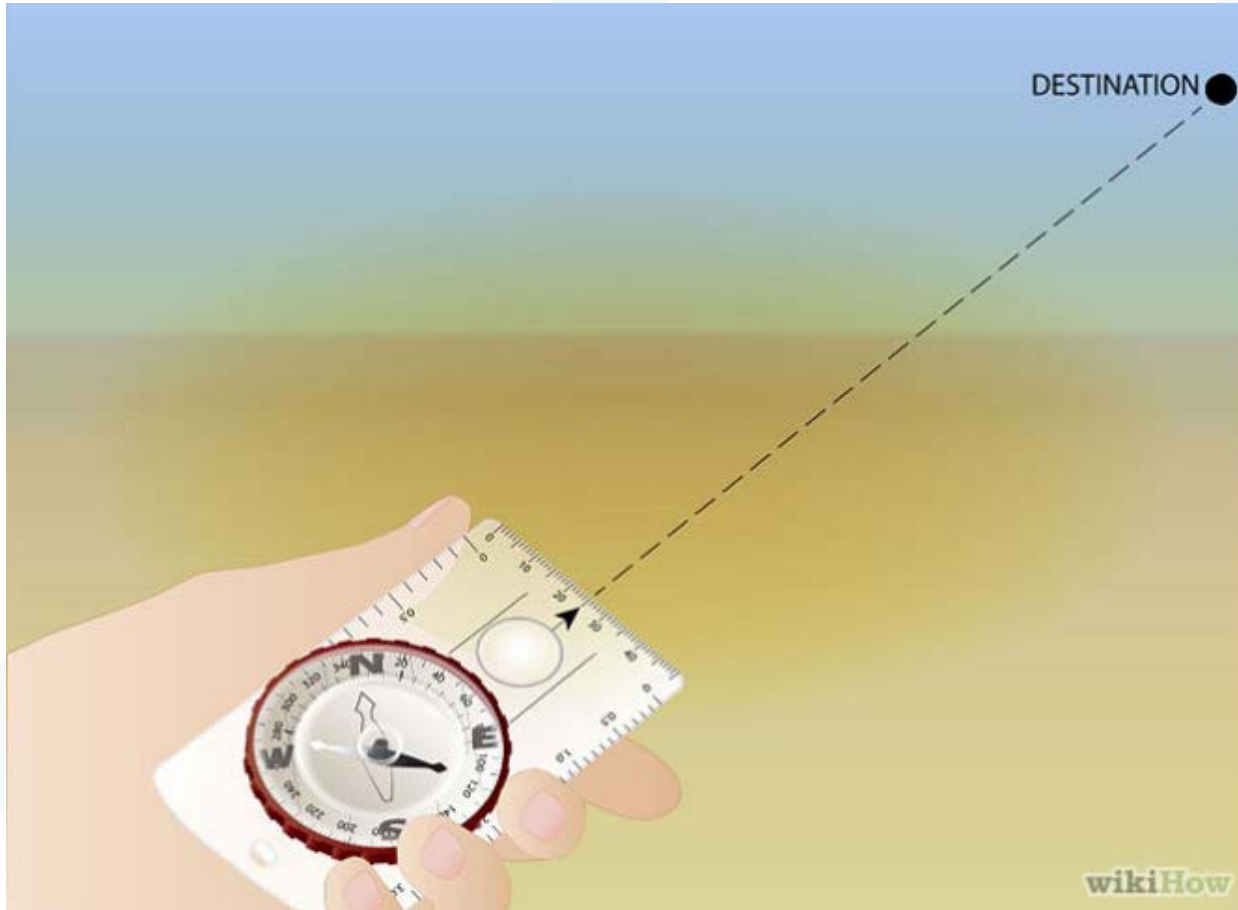
Error source	± 1 σ	Propagation
Instrument	0.5°	Systematic
Observer	0.5°	Systematic
Observer repeatability	1.0°	Random

DESTINATION

wikiHow
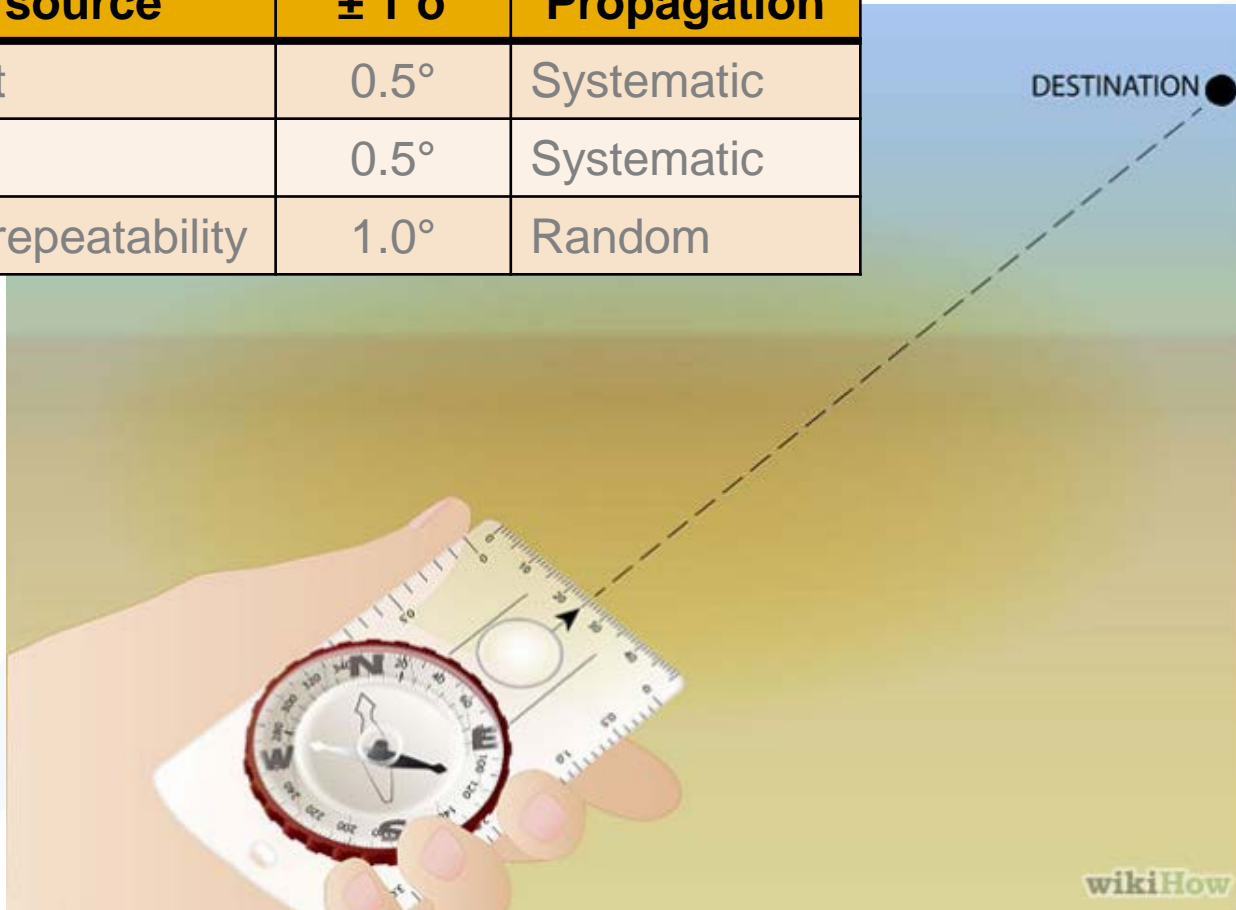
Which terms are affected by tie-on?

- "Systematic" terms

Term	Value (1 sig...	C	I.	A	Description	C	I.	A...	Prop. Method
ABXY-TI1R	0.004 m/s²	1	1	1	xy accelerometer bias, random	0	-.	(...	Random
ABXY-TI2R	0.004 m/s²	1	1	1	xy accelerometer bias, random	0	0	(...	Random
ABZ	0.004 m/s²	1	1	1	z-accelerometer bias	0	-.	t...	Systematic
AMID	0.6 °	1	1	1	Axial magnetic interference, systematic	0	0	p...	Systematic
AMIF	0.25 °	1	1	1	Axial magnetic interference, fixed	0	0	p...	Systematic
ASXY-TI1S	0.0005 fract	1	1	1	x-accel scale factor, Systematic	0	(.	-...	Systematic
ASXY-TI2R	0.0005 fract	1	1	1	x-accel scale factor, Random	0	(.	-...	Random
ASXY-TI3R	0.0005 fract	1	1	1	x-accel scale factor, Random	0	0	(...	Random
ASZ	0.0005 fract	1	1	1	z-accelerometer scale factor	0	-.	t...	Systematic
AZ	0.36 °	1	1	1	Magnetic declination uncertainty	0	0	p...	Global
DBH	5000 deg-nT	1	1	1	Magnetic declination uncertainty	0	0	p...	Global
DREF	0.35 m	1	1	1	Depth reference, random	1	0	0	Random
DSF	0.00056 fract	1	1	1	Depth scale factor, systematic	C	0	0	Systematic
DST	2.5e-007 1/...	1	1	1	Depth stretch/temperature, global	C	0	0	Global
MBXY-TI1R	70 nT	1	1	1	xy mag bias, random	0	0	...	Random
MBXY-TI2R	70 nT	1	1	1	xy mag bias, random	0	0	c...	Random
MBZ	70 nT	1	1	1	z-magnetometer bias	0	0	-...	Systematic
MSXY-TI1S	0.0016 fract	1	1	1	xy-magnetometer scale factor, Systematic	0	0	s...	Systematic
MSXY-TI2R	0.0016 fract	1	1	1	xy-magnetometer scale factor, Random	0	0	s...	Random
MSXY-TI3R	0.0016 fract	1	1	1	xy-magnetometer scale factor, Random	0	0	(...	Random
MSZ	0.0016 fract	1	1	1	z-magnetometer scale factor	0	0	-...	Systematic
MXYaS	0.06 °	1	1	1	xy tool misalignment, systematic	0	p	0	Systematic
MXYbS	0.06 °	1	1	1	xy tool misalignment, systematic	0	0	-...	Systematic
MXYcS	0.06 °	1	1	1	xy tool misalignment, systematic	0	p	-...	Systematic
MXYdS	0.06 °	1	1	1	xy tool misalignment, systematic	0	p	p...	Systematic
SAG	0.2 °	1	1	1	BHA sag	0	p	0	Systematic

ISCWSA MWD, Rev. 3 (Standard) Details

Which terms are affected by tie-on?

Reference Field	No
Sensors	z axis (and one xy SF)
BHA Axial Interference	Yes
BHA Sag	Yes
Misalignment	Yes
Depth	Only SF

When is it justified to initiate a MWD tie-on?

Terms	"Systematic"?
Reference Field	No
Sensors	z axis (and one xy SF)
BHA Axial Interference	Yes
BHA Sag	Yes
Misalignment	Yes
Depth	Only SF

- Mid BHA run?
- Bit trip?
- MWD tool change?
- BHA change?

Summary

- Error
  - Co
  - Do
  - *W*ons
  - So
- Error
  - Or
  - Of e-on

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Term	Value (1 sig...	C	I.	A	Description	D	I.	A...	Prop. Method
ABXY-TI1R	0.004 m/s²	1	1	1	xy accelerometer bias, random	0	-.	(...	Random
ABXY-TI2R	0.004 m/s²	1	1	1	xy accelerometer bias, random	0	0	(...	Random
ABZ	0.004 m/s²	1	1	1	z-accelerometer bias	0	-.	t...	Systematic
AMID	0.6 °	1	1	1	Axial magnetic interference, systematic	0	0	p...	Systematic
AMIF	0.25 °	1	1	1	Axial magnetic interference, fixed	0	0	p...	Systematic
ASXY-TI1S	0.0005 fract	1	1	1	x-accel scale factor, Systematic	0	(.	-...	Systematic
ASXY-TI2R	0.0005 fract	1	1	1	x-accel scale factor, Random	0	(.	-...	Random
ASXY-TI3R	0.0005 fract	1	1	1	x-accel scale factor, Random	0	0	(...	Random
ASZ	0.0005 fract	1	1	1	z-accelerometer scale factor	0	-.	t...	Systematic
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MBXY-TI1R	70 nT	1	1	1	xy mag bias, random	0	0	...	Random
MBXY-TI2R	70 nT	1	1	1	xy mag bias, random	0	0	c...	Random
MBZ	70 nT	1	1	1	z-magnetometer bias	0	0	-...	Systematic
MSXY-TI1S	0.0016 fract	1	1	1	xy-magnetometer scale factor, Systematic	0	0	s...	Systematic
MSXY-TI2R	0.0016 fract	1	1	1	xy-magnetometer scale factor, Random	0	0	s...	Random
MSXY-TI3R	0.0016 fract	1	1	1	xy-magnetometer scale factor, Random	0	0	(...	Random
MSZ	0.0016 fract	1	1	1	z-magnetometer scale factor	0	0	-...	Systematic
MXYaS	0.06 °	1	1	1	xy tool misalignment, systematic	0	p	0	Systematic
MXYbS	0.06 °	1	1	1	xy tool misalignment, systematic	0	0	-...	Systematic
MXYcS	0.06 °	1	1	1	xy tool misalignment, systematic	0	p	-...	Systematic
MXYdS	0.06 °	1	1	1	xy tool misalignment, systematic	0	p	p...	Systematic
SAG	0.2 °	1	1	1	BHA sag	0	p	0	Systematic

Rule of thumb?

- New MWD log for each hole section
- Avoid re-running MWD tool in deeper hole section
- Avoid changing corrections within hole section

Positional uncertainty summary (Reference)

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5000.00	67.80	11.90	14.47	75.084	3000.00	5000.00	ISCWSA MWD r3 0.00-300.00 : ISCV
6500.00	94.57	14.32	18.08	75.045	5000.00	6500.00	ISCWSA MWD r3 0.00-300.00 : ISCV
8000.00	121.12	17.29	21.15	75.027	6500.00	8000.00	ISCWSA MWD r3 0.00-300.00 : ISCV

Comments/Questions