Towards Improved Depth

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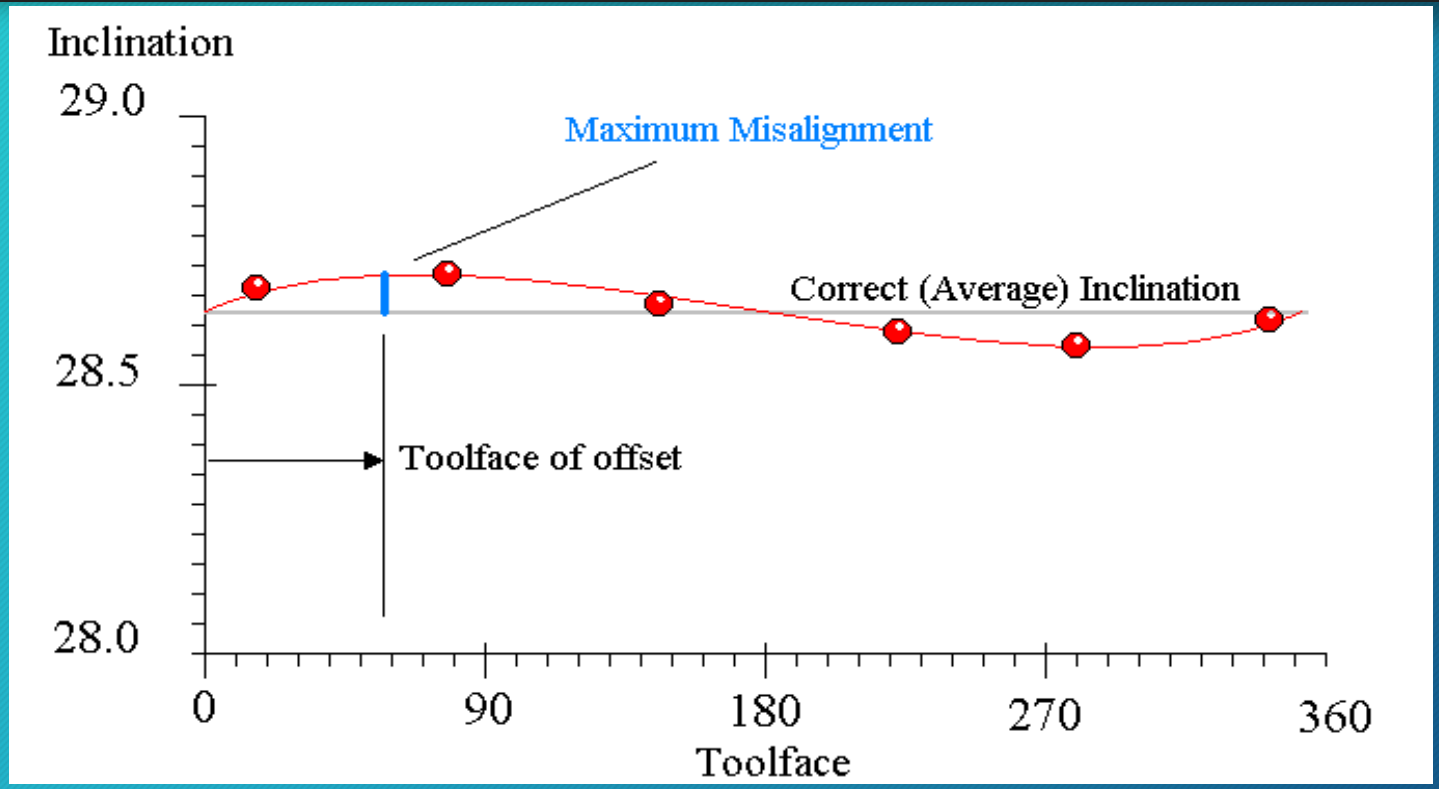
What can we do ?

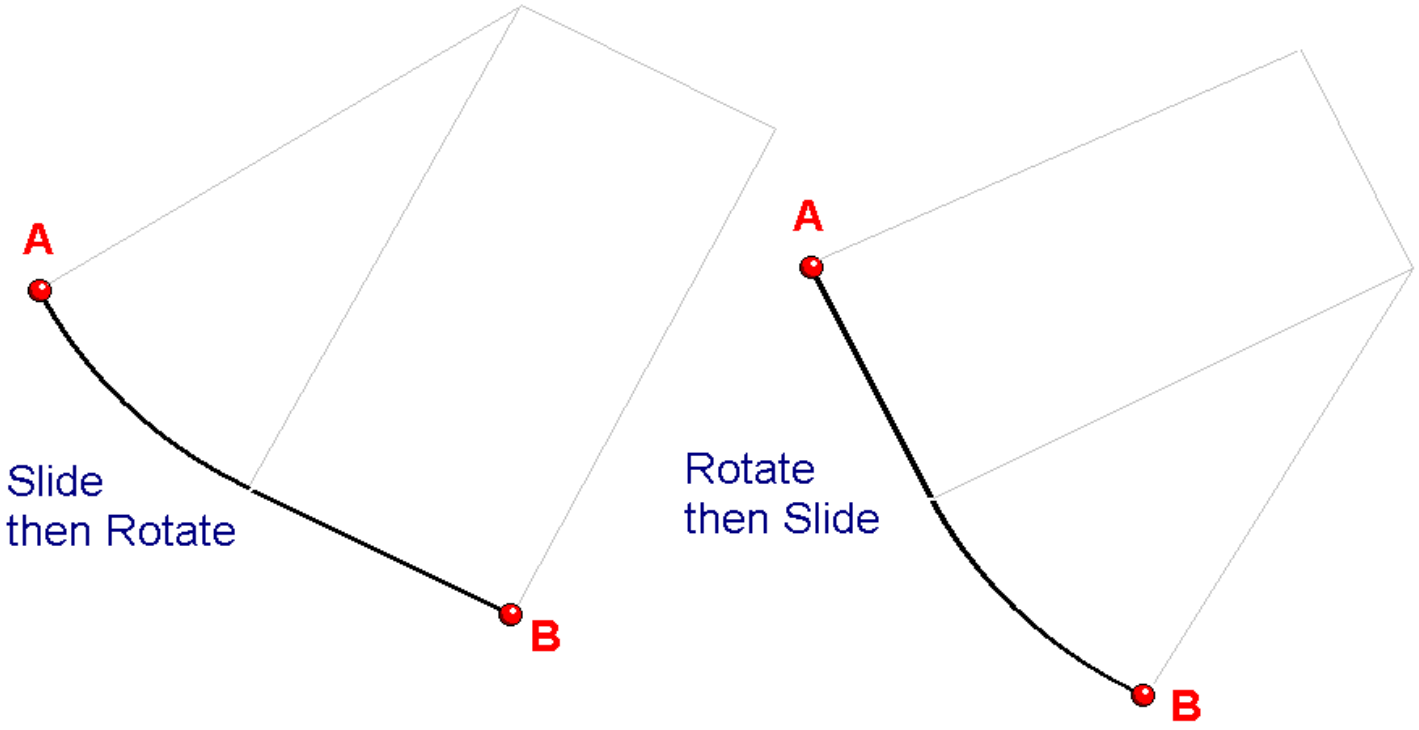
- Correct for Tool Misalignment
- Correct for long survey Intervals
- Correct for Sag
- Combine survey runs
- Correct for Temperature Effects
- Correct for Mechanical Stretch

Tool Misalignment - Observe rotational shots



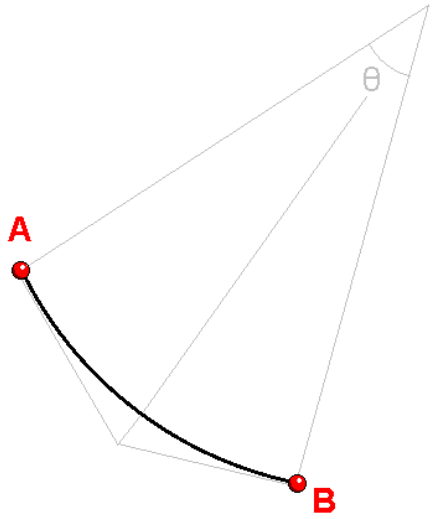
Survey Resolution

Both of these trajectories start and end with the same attitude and have the same measured depth difference.



Normal Minimum Curvature

Normal Minimum Curvature



Attitude Vector at any survey point

$\delta x = \sin(Inc)\ \sin(Dir)$
$\delta y = \sin(Inc)\ \cos(Dir)$
$\delta z = \cos(Inc)$

Angle θ subtended by arc is found from dot product of Av and Bv

$$\theta = \cos^{-1}[\delta x_A \delta x_B + \delta y_A \delta y_B + \delta z_A \delta z_B]$$

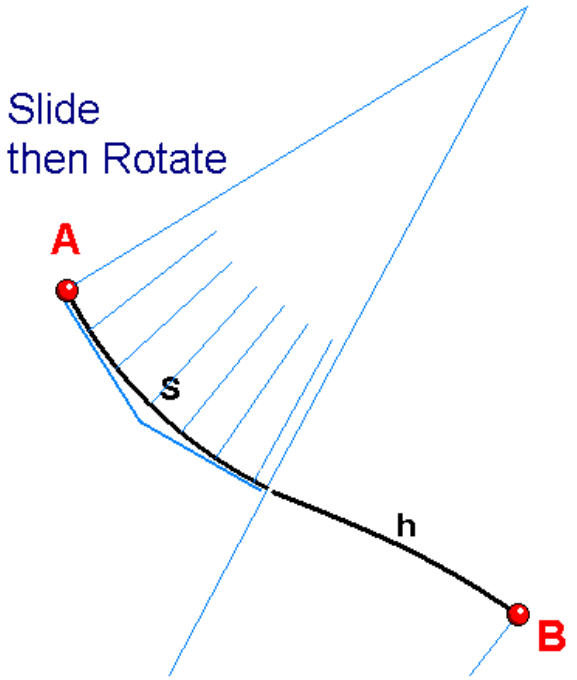
Radius = $\delta Md / \theta$

Vector from A to B is then

$R\tan(\theta/2)\ (Av + Bv)$

Use the slide sheet data to insert surveys

Biased Vector Minimum Curvature



1. Occasionally assess true dogleg severity of the BHA by observing twice in the same slide section or by lifting off botom far enough to estblish a survey point within the slide section.

2. During susequent slide sections, observe the approximate toolface and MD while drilling.

3. Accumulate micro survey estimates by assuming that:

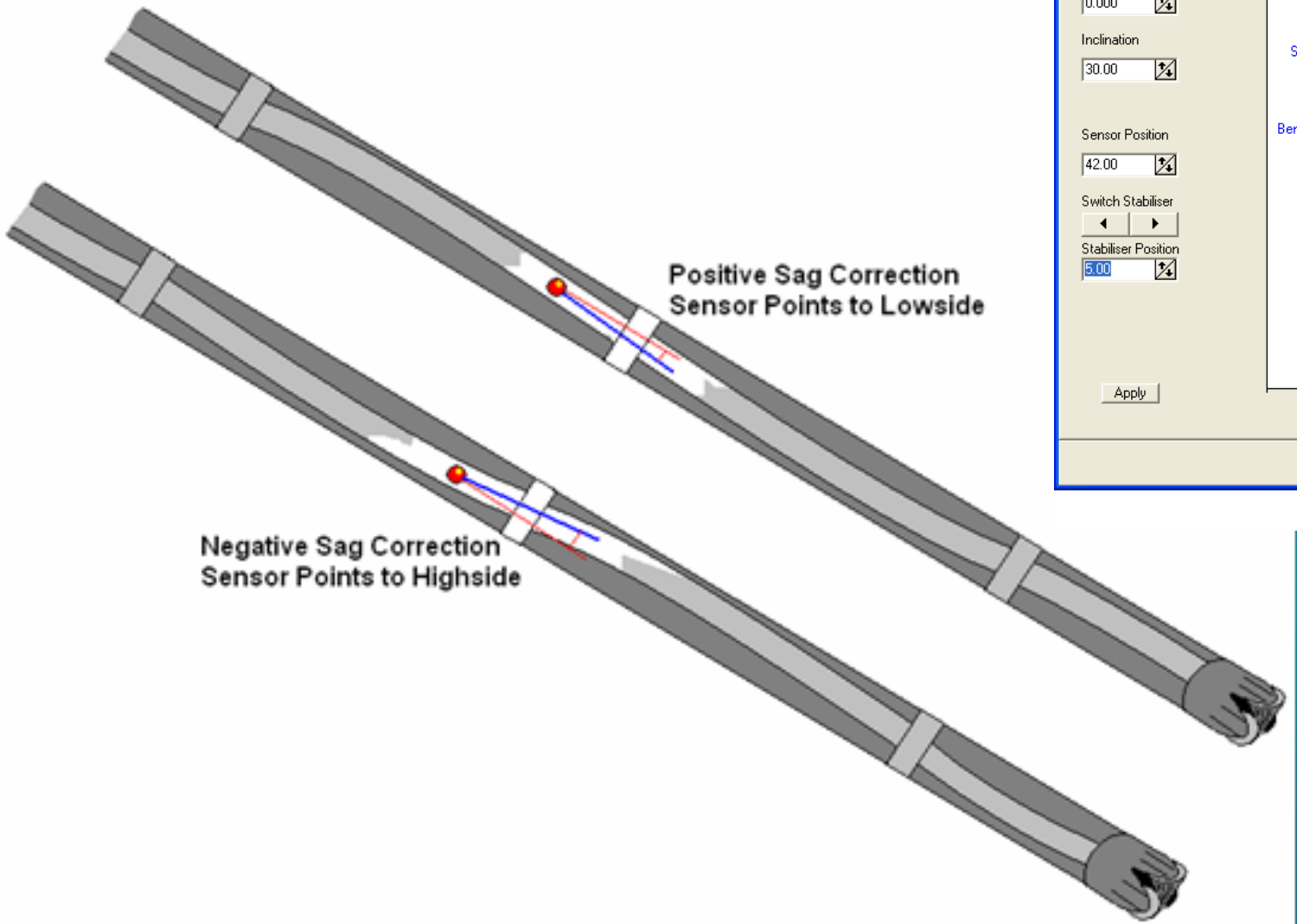
$$dInc = Dogleg\ Sev \times dm \times \cos(Tooface)$$

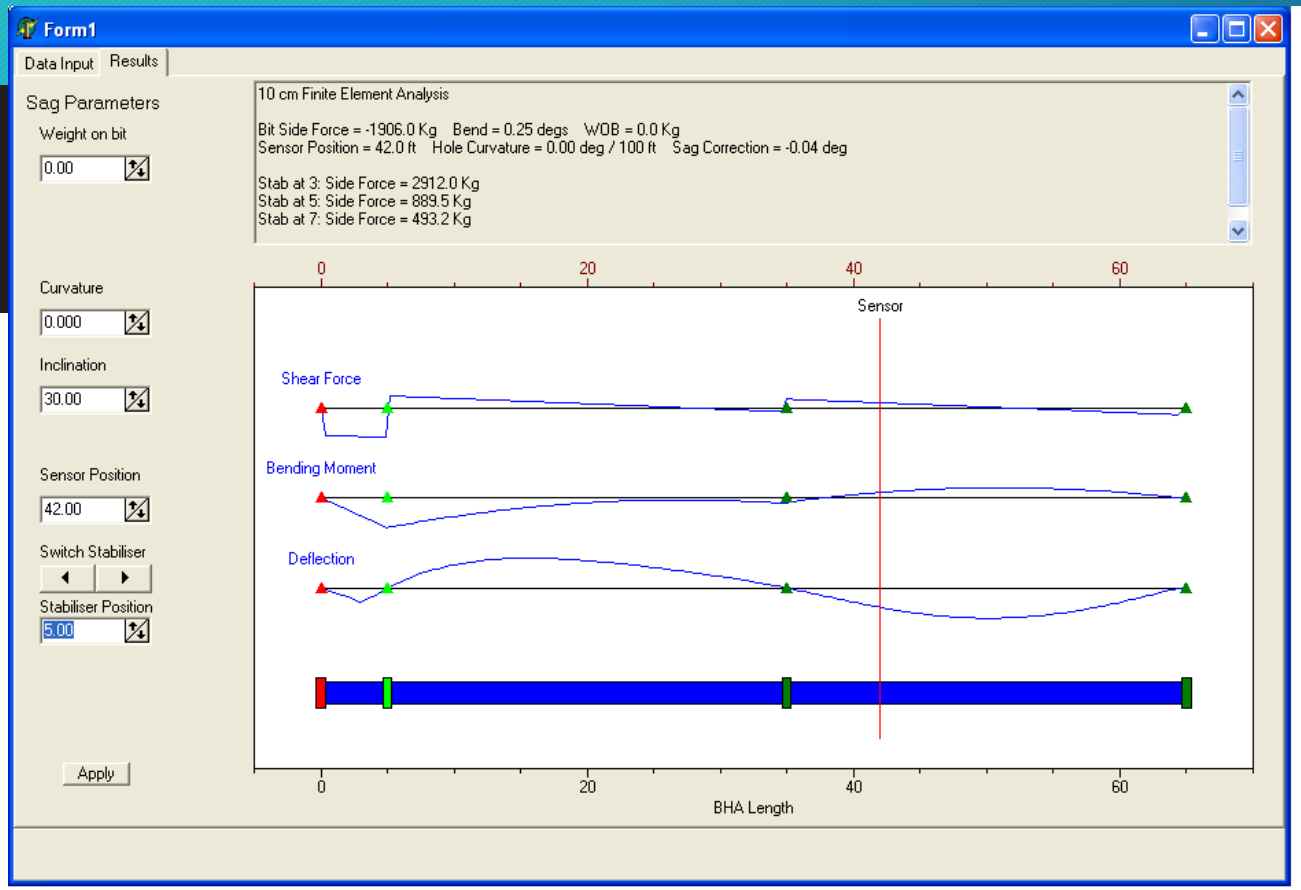
$$dAzi = \frac{Dogleg\ Sev \times dm \times \sin(Toolface)}{Sin(Inclination)}$$

4. Use a proper survey at the end of the stand.

5. Use minimum curvature to calculate the total vector from A to B.

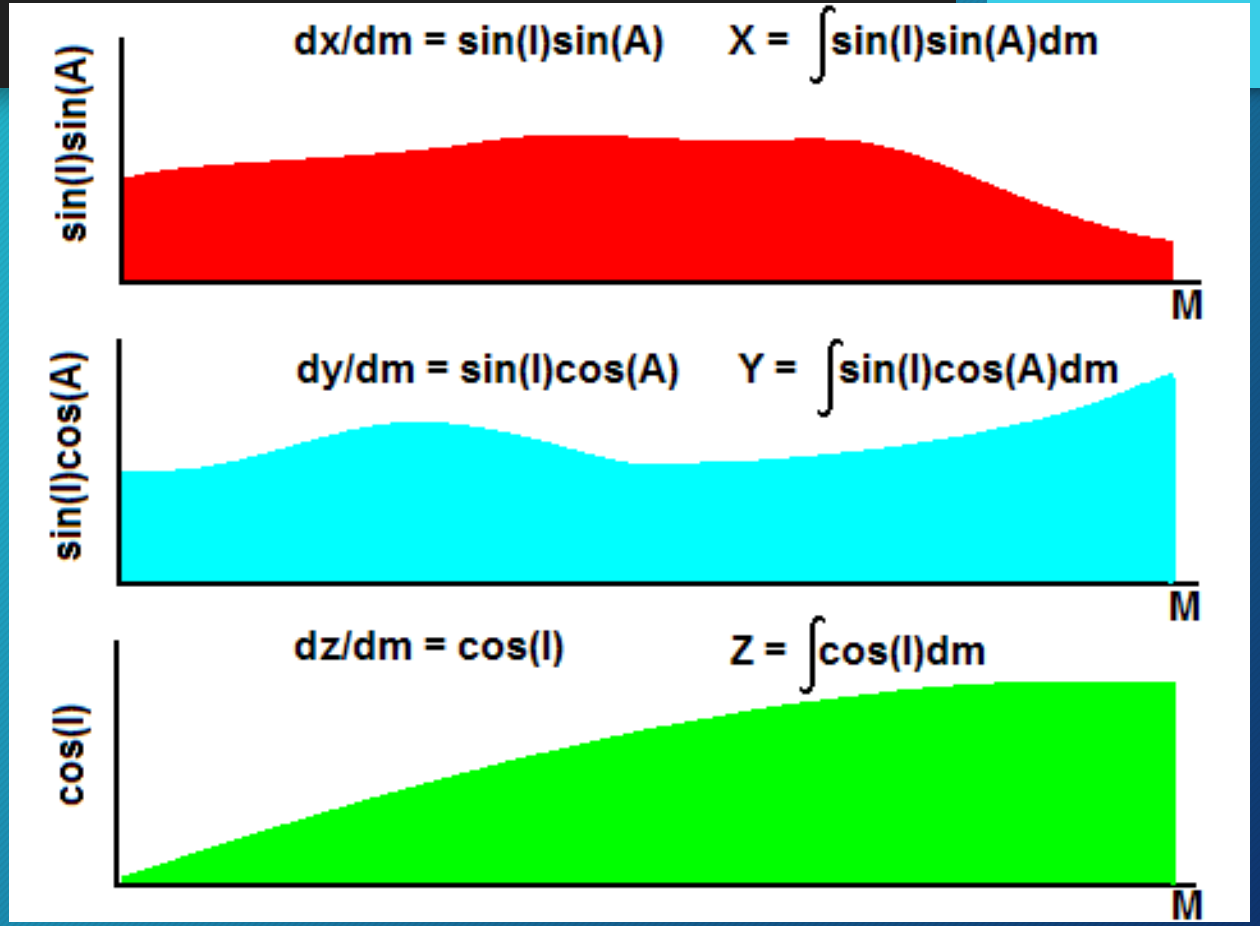
Apply Sag Correction



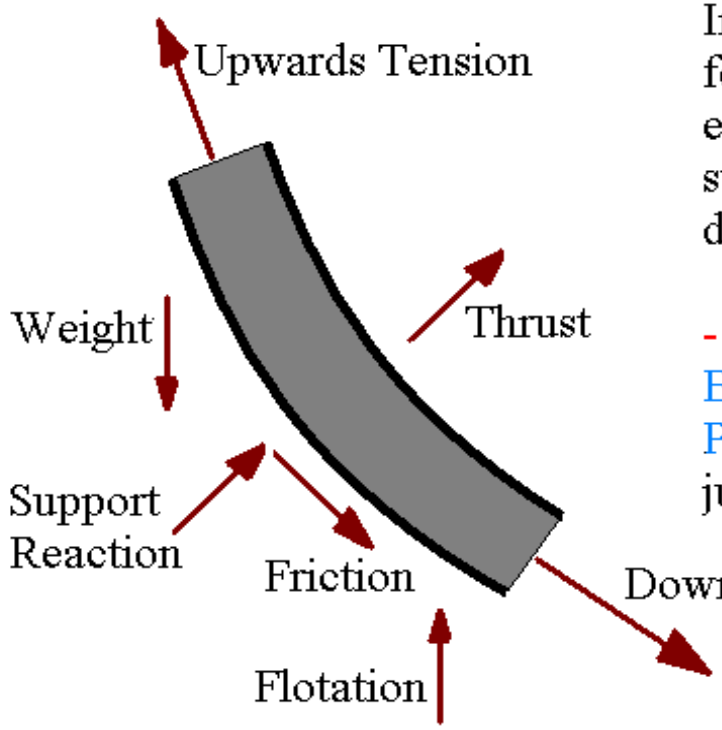


Definer Survey Technique

- Use all MWD data available
- Include recorded data
- Use all gyro surveys available
- Include in-run and outrun
- Apply weights to each survey
- Interpolate weighted averages
- Recalculate the ‘Best Fit’ Survey



Mechanical Stretch



Integrate the effect of all forces acting on each finite element to determine the strain stretch at each survey depth and correct in the field

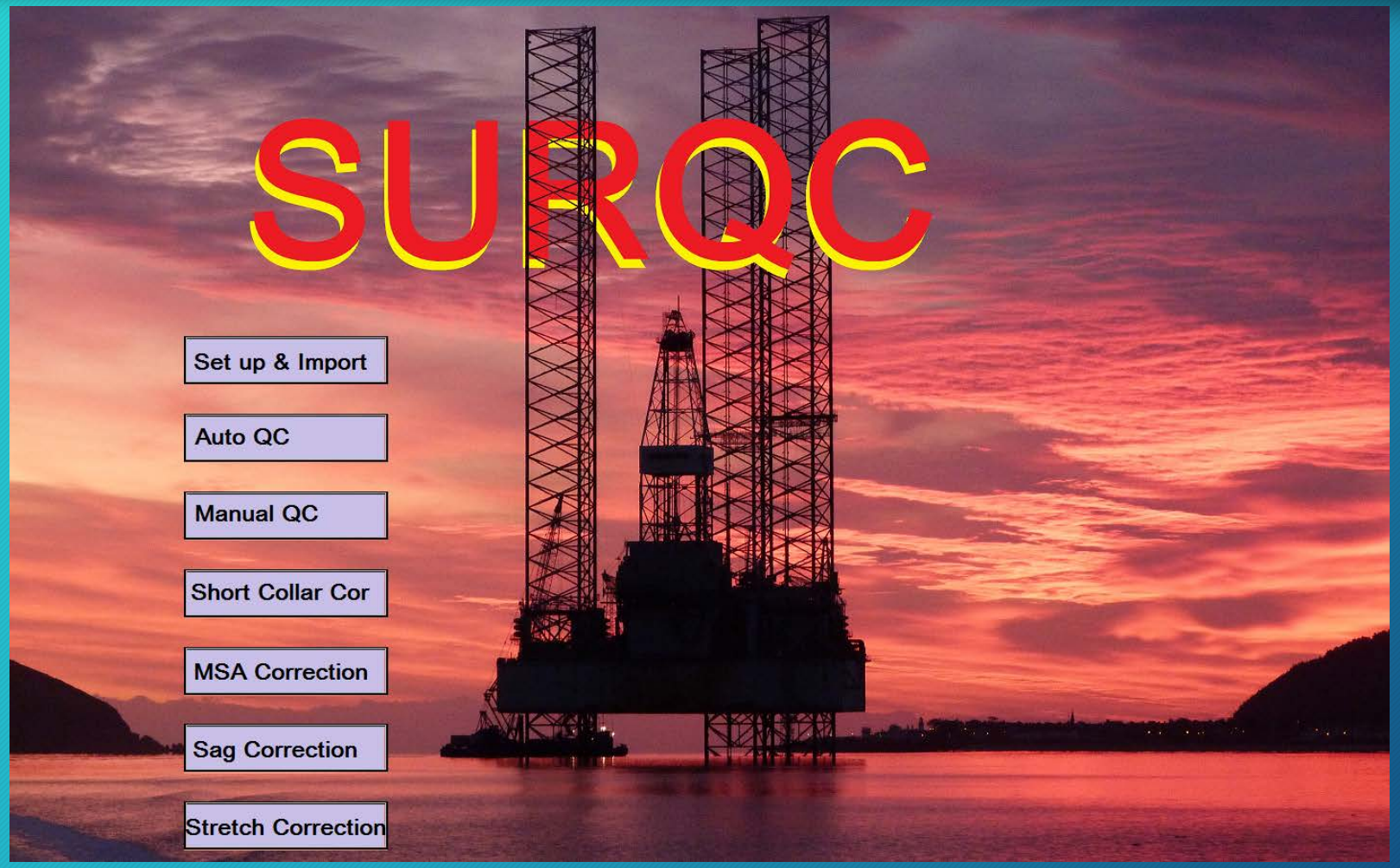
- requires
BHA weight Mud Weight
Pipe Weight Coeff Friction
just as for torque and drag

Temperature Effects

- Steel will stretch by

1.3m / 1000 / 100 degs C

Stretch Correction software is not difficult



Stretch Input Data

- Approximate Drillstring
- Estimated friction factors
- Mud weight
- Temperature Profile

1	Stretch Correction Parameters				
2					
3	length	Desc	OD	ID	Mat
4	7125.00	5" DP	5.00	2.88	Steel
5	800.00	5.5 HWDP	5.50	2.88	Steel
6	125.00	8" DC	8.00	3.00	Steel
7	30.00	MWD	8.00	3.00	Nmag
8	40.00	RSS	8.00	3.00	Nmag
9					
10	Meas D	Desc	Friction	ID	Mat
11	600.00	20 C	0.18	20.00	Steel
12	2800.00	13 3/8 C	0.18	13.38	Steel
13	6218.00	9 5/8 C	0.18	9.68	Steel
14	8120.00	Open H	0.30	8.50	Open
15					
16	Mud Weight		9.25 lb/g		OBM
17					
18	Meas D	Temp C			
19	0	18			
20	600	22.8			
21	2800	36.7			
22	6218	48.1			
23	8210	67.5			

SurQC

Survey Measurements

- ○ Measurements
- ○ Manual QC
- ○ Basic QC
- ◉ Plots

Plot Type

◉ Original ○ MSA ○ Both

Standard Plots

○ Survey ◉ Derived

◉ Absolute ○ Delta

Toolface vs Measured Depth

Plot Data | Add Plot

User Defined Plots

X Axis

◉ Survey ○ Derived

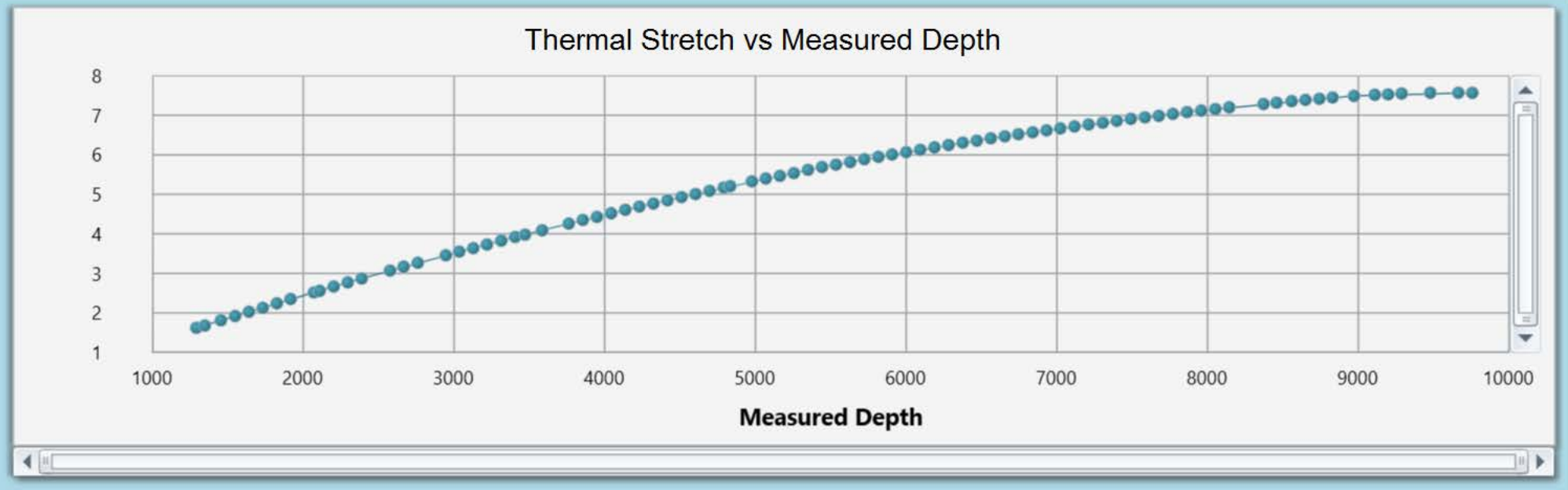
◉ Absolute ○ Delta

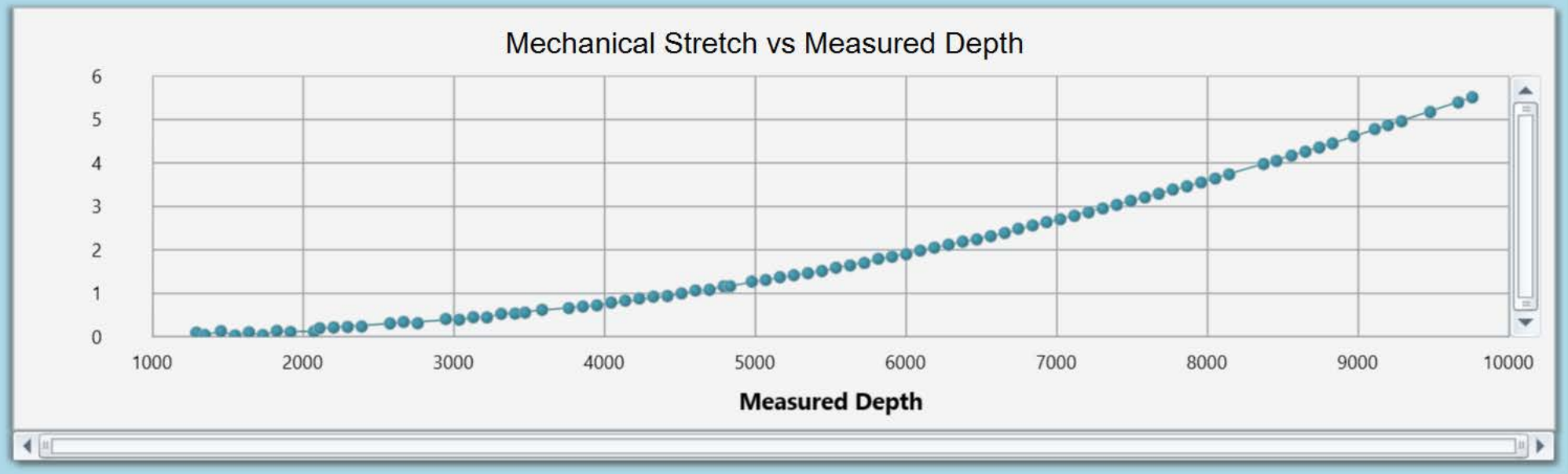
Measured Depth

Y Axis

◉ Survey ○ Derived

◉ Absolute ○ Delta





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Survey Measurements

- (●) Measurements
- ( ) Basic QC
- (●) Auto QC
- ( ) Manual QC

- ( ) Original Data
- ( ) Short Collar Corrected
- (●) MSA Corrected
- (●) Sag Corrected
- (●) Stretch Corrected

MD (m)	Inc (°)	Az (°)	TVD (m)	North (m)	East (m)	Gx (G)	Gy (G)	Gz (G)	Bx (nT)	By (nT)	Bz (nT)	B Total (nT)	Dip (°)
1,290.00	1.62	0.10	1,283.00	12.86	-3.28	-0.0008	-0.0283	0.9996	474	15,759	47,449	50,000	70.00
1,346.00	1.68	0.04	1,338.98	14.47	-3.28	-0.0009	-0.0293	0.9996	495	15,708	47,466	50,000	70.00
1,453.00	1.81	0.13	1,445.93	17.73	-3.27	-0.0010	-0.0316	0.9995	533	15,599	47,501	50,000	70.00
1,547.00	1.92	0.03	1,539.88	20.79	-3.27	-0.0012	-0.0335	0.9994	565	15,507	47,531	50,000	70.00
1,639.00	2.03	0.10	1,631.82	23.97	-3.26	-0.0013	-0.0354	0.9994	597	15,414	47,561	50,000	70.00
1,731.00	2.13	0.04	1,723.76	27.30	-3.26	-0.0015	-0.0371	0.9993	632	15,330	47,588	50,000	70.00
1,824.00	2.24	0.14	1,816.69	30.85	-3.26	-0.0016	-0.0391	0.9992	664	15,237	47,617	50,000	70.00
1,915.00	2.35	0.11	1,907.62	34.50	-3.25	-0.0018	-0.0410	0.9992	698	15,144	47,646	50,000	70.00
2,070.00	2.52	0.12	2,062.48	41.08	-3.23	-0.0021	-0.0439	0.9990	753	15,000	47,691	50,000	70.00
2,108.00	2.56	0.20	2,100.44	42.77	-3.23	-0.0021	-0.0446	0.9990	764	14,966	47,702	50,000	70.00
2,201.00	2.67	0.22	2,193.35	47.01	-3.21	-0.0023	-0.0465	0.9989	800	14,872	47,730	50,000	70.00
2,294.00	2.77	0.23	2,286.24	51.42	-3.20	-0.0025	-0.0483	0.9988	833	14,787	47,756	50,000	70.00
2,387.00	2.87	0.24	2,379.13	56.00	-3.18	-0.0027	-0.0500	0.9987	865	14,702	47,782	50,000	70.00
2,575.00	3.07	0.31	2,566.88	65.74	-3.13	-0.0031	-0.0535	0.9986	934	14,530	47,833	50,000	70.00
2,665.00	3.17	0.34	2,656.74	70.64	-3.10	-0.0033	-0.0552	0.9985	966	14,444	47,858	50,000	70.00
2,759.00	3.27	0.31	2,750.59	75.92	-3.07	-0.0036	-0.0569	0.9984	1,002	14,358	47,884	50,000	70.00
2,945.00	3.46	0.41	2,936.27	86.84	-3.00	-0.0040	-0.0602	0.9982	1,066	14,194	47,931	50,000	70.00
3,034.00	3.55	0.39	3,025.11	92.28	-2.97	-0.0043	-0.0618	0.9981	1,100	14,116	47,953	50,000	70.00
3,127.00	3.64	0.45	3,117.92	98.11	-2.92	-0.0045	-0.0633	0.9980	1,133	14,038	47,976	50,000	70.00
3,218.00	3.73	0.45	3,208.74	103.96	-2.88	-0.0048	-0.0649	0.9979	1,166	13,960	47,998	50,000	70.00
3,313.00	3.83	0.53	3,303.53	110.22	-2.82	-0.0050	-0.0666	0.9978	1,200	13,873	48,022	50,000	70.00
3,405.00	3.92	0.53	3,395.32	116.44	-2.77	-0.0053	-0.0682	0.9977	1,232	13,794	48,044	50,000	70.00
3,471.00	3.98	0.56	3,461.16	120.99	-2.72	-0.0055	-0.0692	0.9976	1,259	13,741	48,058	50,000	70.00
3,584.00	4.09	0.62	3,573.88	128.94	-2.64	-0.0058	-0.0711	0.9975	1,299	13,645	48,085	50,000	70.00
3,761.00	4.26	0.66	3,750.41	141.82	-2.50	-0.0064	-0.0740	0.9972	1,365	13,495	48,125	50,000	70.00
3,854.00	4.35	0.70	3,843.15	148.81	-2.41	-0.0067	-0.0756	0.9971	1,398	13,416	48,146	50,000	70.00
3,948.00	4.43	0.72	3,936.87	156.00	-2.33	-0.0070	-0.0769	0.9970	1,432	13,345	48,165	50,000	70.00
4,042.00	4.52	0.79	4,030.59	163.34	-2.23	-0.0073	-0.0785	0.9969	1,470	13,264	48,186	50,000	70.00
4,136.00	4.61	0.83	4,124.29	170.82	-2.12	-0.0076	-0.0800	0.9968	1,502	13,185	48,207	50,000	70.00
4,229.00	4.69	0.88	4,216.98	178.36	-2.01	-0.0079	-0.0814	0.9967	1,537	13,113	48,225	50,000	70.00

For and against applying stretch

- Every other industry does it
- More accurate absolute TVD
- Improved Geo model
- Improved horizontal landing
- Can save early water cut
- Better match with wireline
- Easy to do

- We’ve never done it before
- It introduces possible error
- It will mess up legacy data
- It will change the geology