Updating Of Along-hole Depth Elements Of The ISCWSA Error Model

Harald Bolt, Depth Solutions

Speaker background

Depth Solutions, DwpD Ltd

35 years after trying to figure out where TD is

… now looking now at how uncertain it all is

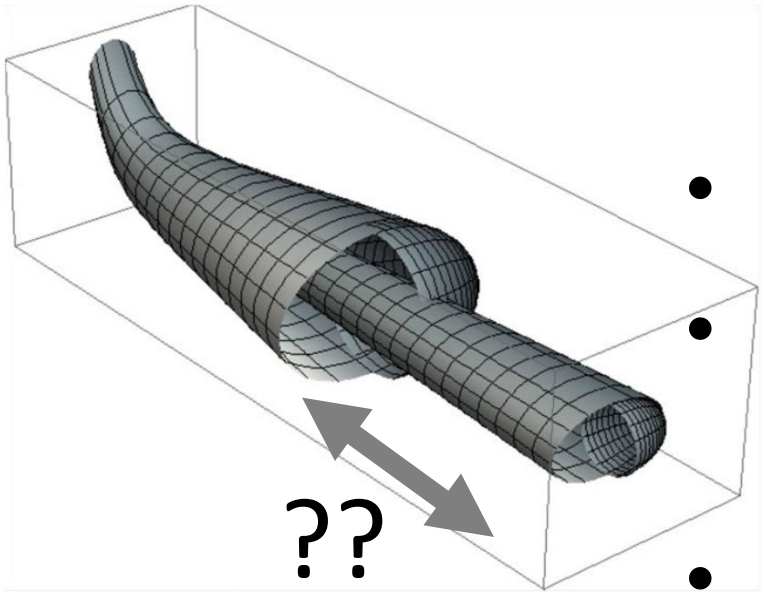
API RP-78 Depth QA-QC subcommittee member

Depth Solutions specializes in

- Along-hole depth
- Determining requirements
- Measurement and correction
- Uncertainty
- Process, audit and training

What is this all about

Paper available



- TAH depth
- Issues with the existing ISCWSA along-hole depth uncertainty models and elements
- Generic uncertainty model components
- Correction model uncertainty
- ISCWSA depth uncertainty model elements

What is True Along-hole Depth ?

Length determination
+ Correction
+/- Uncertainty
} = TAH, True Along-hole, Depth

Corrected depth … together with an uncertainty term defining the … uncertainty to one (1)-sigma.

Ref. Along-hole Depth Rev5.1, www.lulu.com

Existing ISCWSA along-hole depth uncertainty component terminology

From Brooks, Wilson, Jamieson & McRobbie SPE-956111, 2005

Reference errors – systematic (survey datum, wind, tides, weather, cable sag)

Reference errors – random (waves, weather tides/ballast, pipe stick-up, log picks)

Scale factor errors – systematic (MWD/LWD) (tape measure, measurement temperature, weight-on-bit, pump-off, differential pressure, annulus drag, nozzle thrust, rotary torque)

Scale factor errors – well by well (wireline) (wireline wheel wear, wheel slippage, marking temperature, marking accuracy)

Stretch type errors – systematic (wireline) (wireline inelastic stretch, temperature, pressure, torsion)

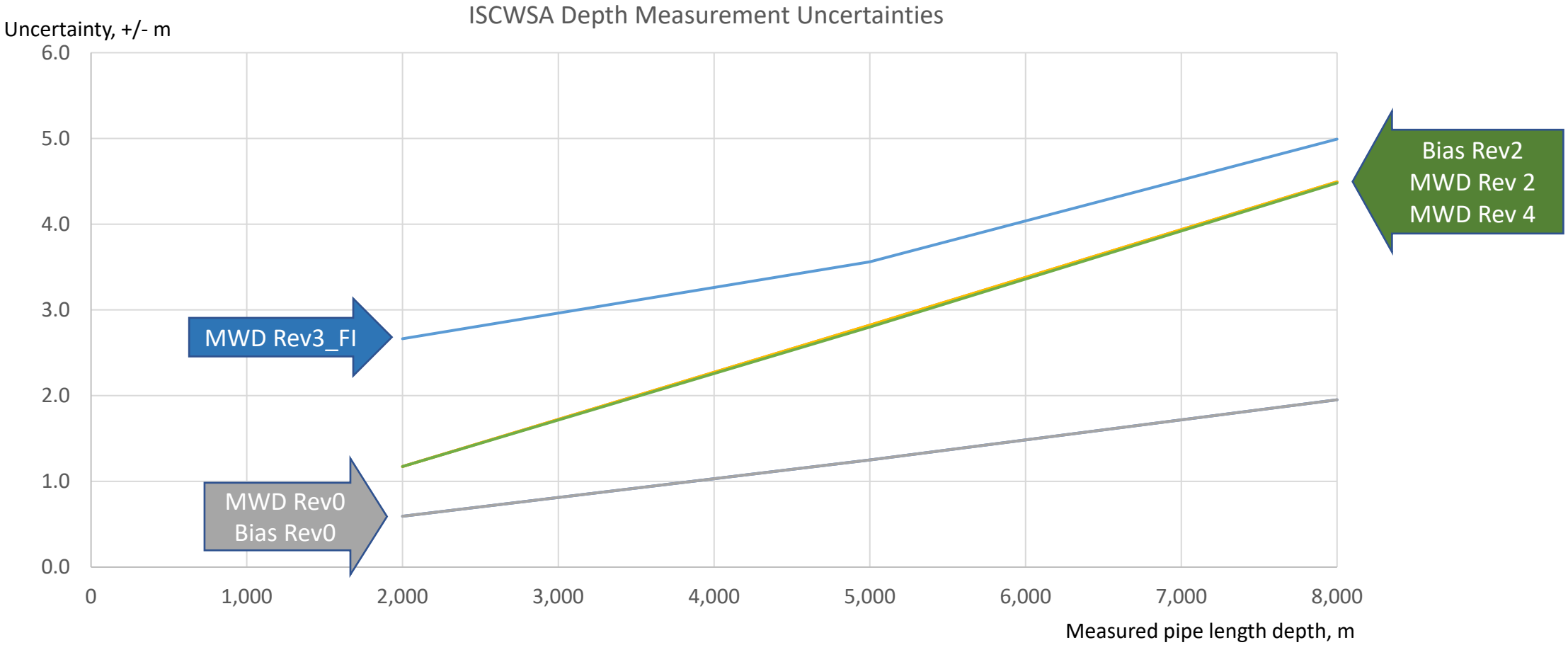
Stretch type errors – global (MWD/LWD) (drillpipe elastic stretch, temperature, hydrostatic)

Existing ISCWSA along-hole depth accuracy parameters

No	Code	Term Description	Wt.Fn.	Magnitude bias Rev0	Magnitude bias Rev2	Magnitude MWD Rev0	Magnitude MWD Rev2	Magnitude MWD Rev3_FI	Magnitude MWD Rev4	Units
1	DRFR	Depth: Depth Reference - Random	DREF	0.35	0.35	0.35	0.35	2.2	0.35	m
2	DSFS	Depth: Depth Scale Factor - Systematic	DSF	0.00024	0.00056	0.00024	0.00056		0.00056	-
2	DSFS	Depth: Depth Reference - Systematic	DREF					1		-
3	DSTB	Depth: Depth Stretch - Bias	DST	0.00000044	0.0000005	0.00000022	0.00000025			1/m
3	DSTB	Depth: Depth Scale Factor - Systematic	DSF					0.00056		1/m
3	DSTG	Depth: Depth Stretch - Global	DST						0.00000025	1/m
4	DSTG	Depth: Depth Stretch - Global	DST					0.00000025		1/m

Existing ISCWSA along-hole uncertainty results

Based on “Measured depth” only



Current ISCWSA reference terms

Reference, *Measurement/calibration*, CORRECTION

Reference errors – systematic (e.g. survey datum, wind, tides, weather)

Reference errors – random (e.g. waves, weather tides/ballast, pipe stick-up, log picks)

Scale factor errors – systematic (MWD/LWD)

Scale factor errors – well by well (wireline)

Stretch type errors – systematic (wireline)

Stretch type errors – global (MWD/LWD)

Current ISCWSA calibration terms

Reference, *Measurement/calibration*, CORRECTION

Reference errors – systematic

Reference errors – random

Scale factor errors – systematic (MWD/LWD) (e.g. *tape measure, measurement temperature*)

Scale factor errors – well by well (wireline) (e.g. *wireline wheel wear, marking temperature, marking accuracy*)

Stretch type errors – systematic (wireline) (e.g. *wireline* INELASTIC *stretch*)

Stretch type errors – global (MWD/LWD)

Current ISCWSA correction terms

Reference, *Measurement/calibration*, CORRECTION

Reference errors – systematic (CABLE SAG)

Reference errors – random

Scale factor errors – systematic (MWD/LWD) (WEIGHT-ON-BIT, PUMP-OFF, DIFFERENTIAL PRESSURE, ANNULUS DRAG, NOZZLE THRUST, ROTARY TORQUE)

Scale factor errors – well by well (wireline) (WHEEL SLIPPAGE)

Stretch type errors – systematic (wireline) (*wireline* INELASTIC *stretch*, TEMPERATURE, PRESSURE, TORSION)

Stretch type errors – global (MWD/LWD) (DRILLPIPE ELASTIC STRETCH, TEMPERATURE, HYDROSTATIC)

Current ISCWSA terms mixed

Reference, *Measurement/calibration*, CORRECTION

Reference errors – systematic (survey datum, wind, tides, weather, CABLE SAG)

Reference errors – random (waves, weather tides/ballast, pipe stick-up, log picks)

Scale factor errors – systematic (MWD/LWD) (*tape measure*, *measurement temperature*, WEIGHT-ON-BIT, PUMP-OFF, DIFFERENTIAL PRESSURE, ANNULUS DRAG, NOZZLE THRUST, ROTARY TORQUE)

Scale factor errors – well by well (wireline) (*wireline wheel wear*, WHEEL SLIPPAGE, *marking temperature*, *marking accuracy*)

Stretch type errors – systematic (wireline) (*wireline* INELASTIC *stretch*, TEMPERATURE, PRESSURE, TORSION)

Stretch type errors – global (MWD/LWD) (DRILLPIPE ELASTIC STRETCH, TEMPERATURE, HYDROSTATIC)

Existing uncertainty issues

? Realities of well conditions

? Measurement technology used

? Drill string architecture and rig state

? Measurement and correction types

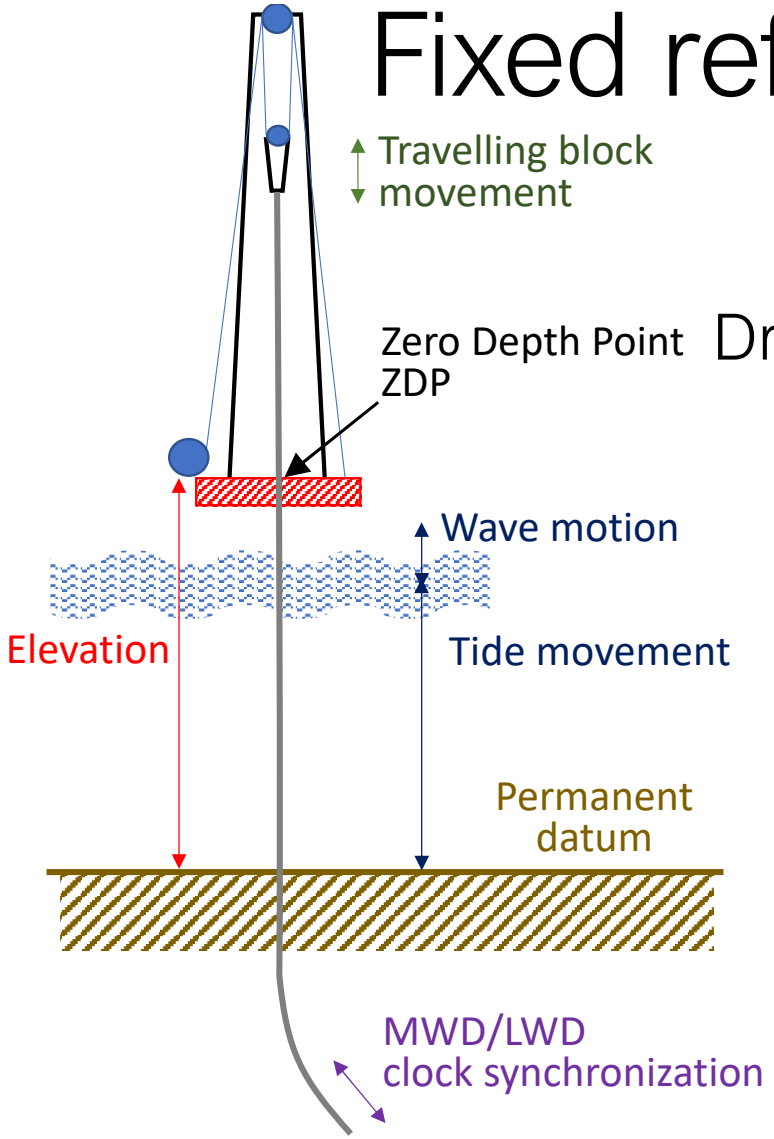
? Correction model options

? Uncertainty requirements

Generic uncertainty components

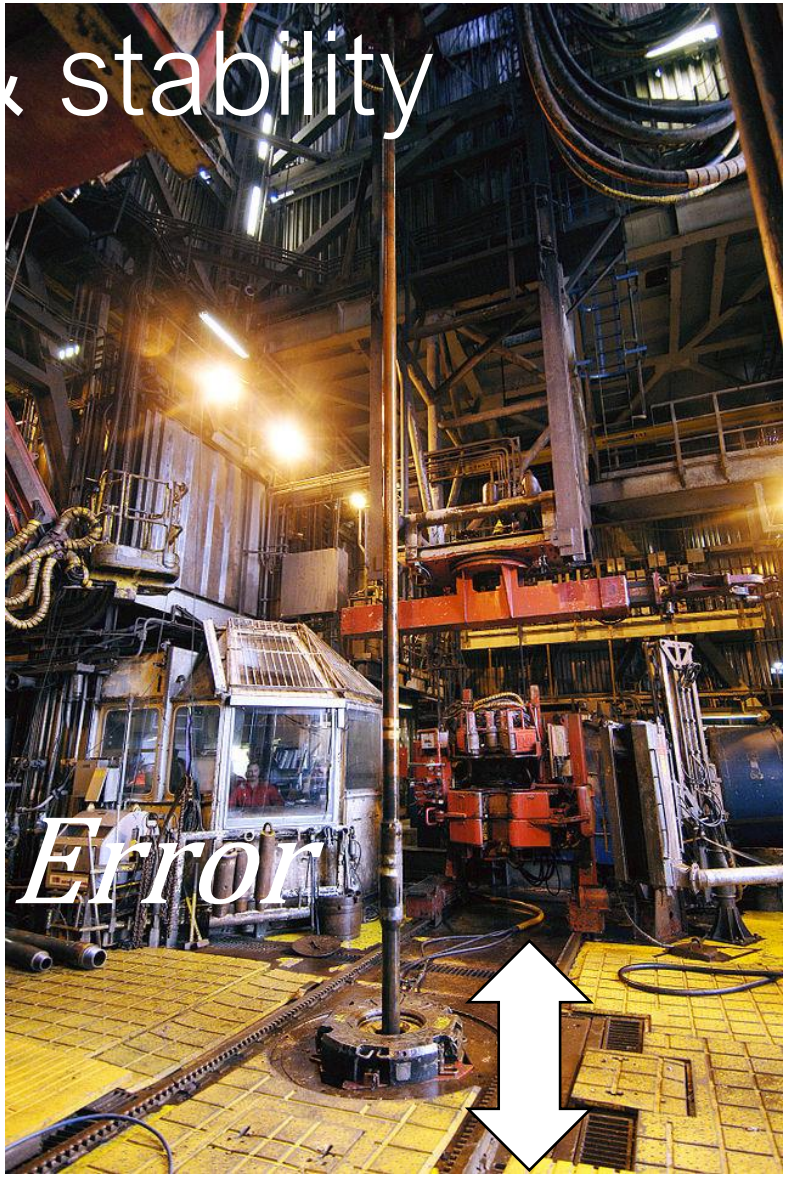
- Fixed reference integrity & stability
- Measurement and calibration accuracy
- Correction calculation accuracy
- Correction model fit
- Uncertainty calculation

Fixed reference integrity & stability



Drill pipe measurement reference point locational position and stability uncertainty

Tool Joint Error



Pipe length calibration and accuracy

Strapped	9 5/8" #36, nominal 39 ft	Lasered
39.077 ft	Length	39.103 ft
0.0357 ft	Std.dev/length	0.0086 ft
+/- 9.14 ft	1-sigma/10kft	+/- 2.27 ft

PLUS: calibration environment and process consistency influence !

Correction method choices

Correction method
Elastic stretch for pipe freely suspended (Reistle & Sikes, 1938)
Elastic stretch for mixed strings freely suspended (Reistle & Sikes, 1938)
Elastic stretch (Milan, 1992)
Elastic stretch (Esketh, 1998)
Elastic stretch and temperature (Gabolde & Nguyen, 2006)
Elastic stretch (Pedersen & Constable, 2006)
Elastic stretch (Baker Oil Tools, 2011)
Driller's Way-point Depth (Bolt, 2017)

DwpD

Typical DwpD parameter accuracies

DwpD: measurement stations, during POOH, constant speed, simple sliding motion, discrete intervals with (near) linear progression of correction parameters.

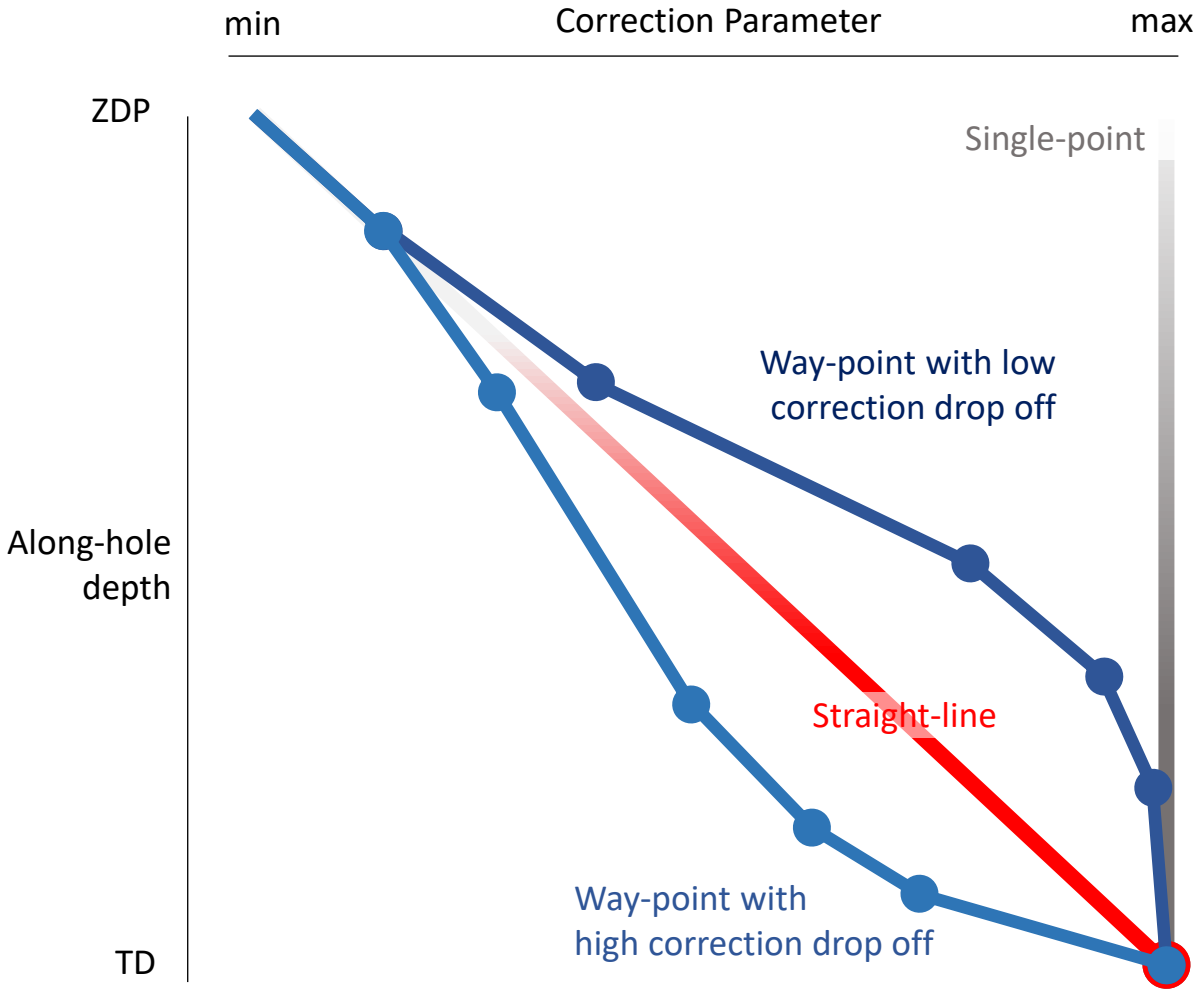
Measurement	Method	Typical accuracy
Pipe length calibration	Strapped pipe	+/- 0.05% to 0.2%
	Lasered pipe	+/- 0.015% to 0.02%
	Additional on-site variance	Accuracy +50% to +100%
Tool joint error	Rig floor visual	+1 ft to +3 ft
Surface hook load	Dead weight sensor	+/- 5% to +/- 10%
BHA mud temperature	LWD sensor	+/- 1%
Stretch coefficient	Young's Modulus for steel	+/- 5%
Thermal expansion coefficient	Thermal coefficient for steel	+/- 5%

Correction model and the real-world

The correction model = how the correction is applied.

Correction model accuracy = the difference between the real-world and the correction model used.

How corrections are applied – the model



!!! IMPORTANT !!!

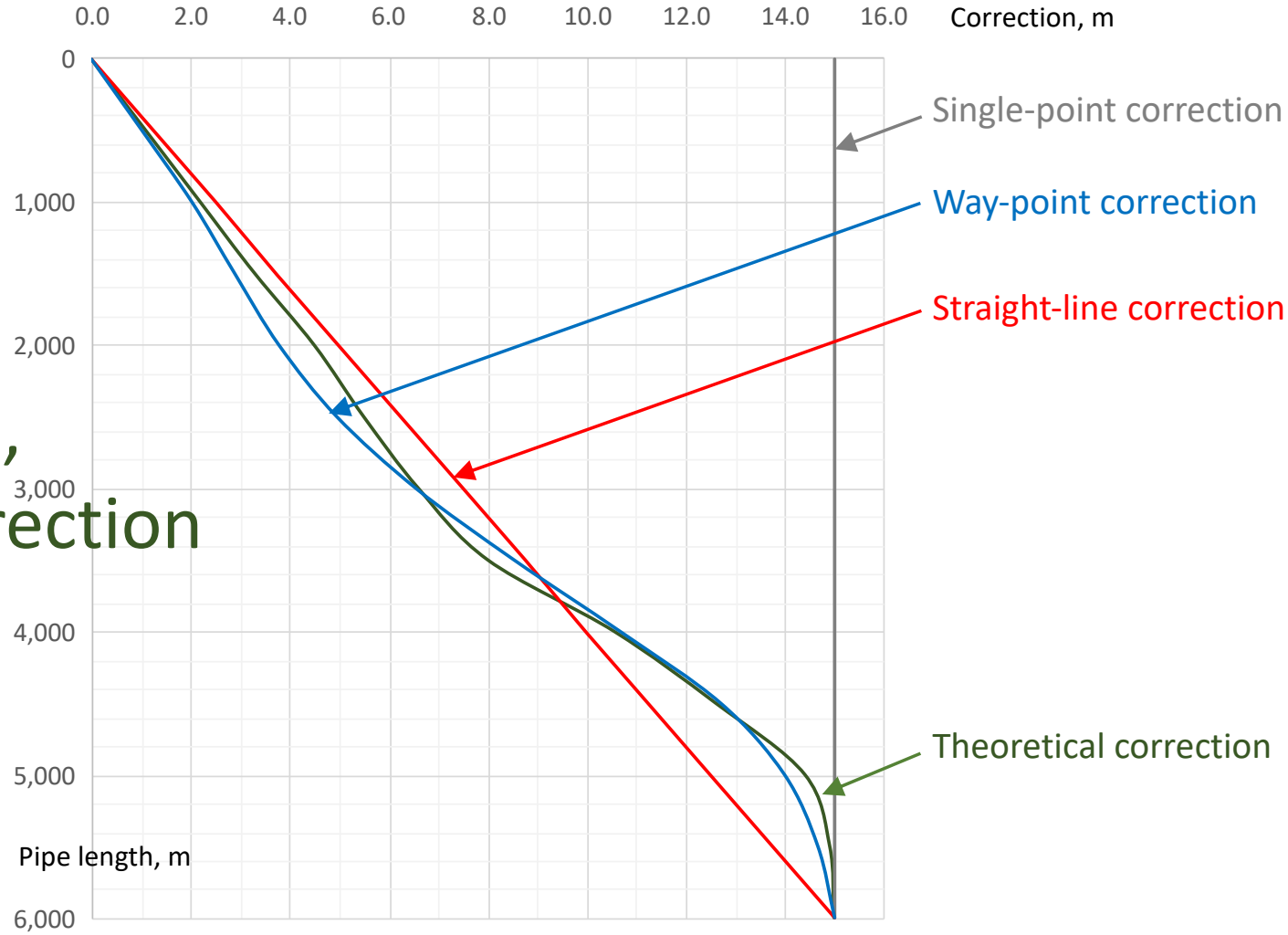
Measurement correction is only applicable to the measurement itself and cannot be extrapolated to where the measurement not is.

Surface tension is measured at surface, so elastic stretch correction is valid at surface.

Bit temperature is measured at the bit so temperature correction is valid where the bit is.

Example differences between models

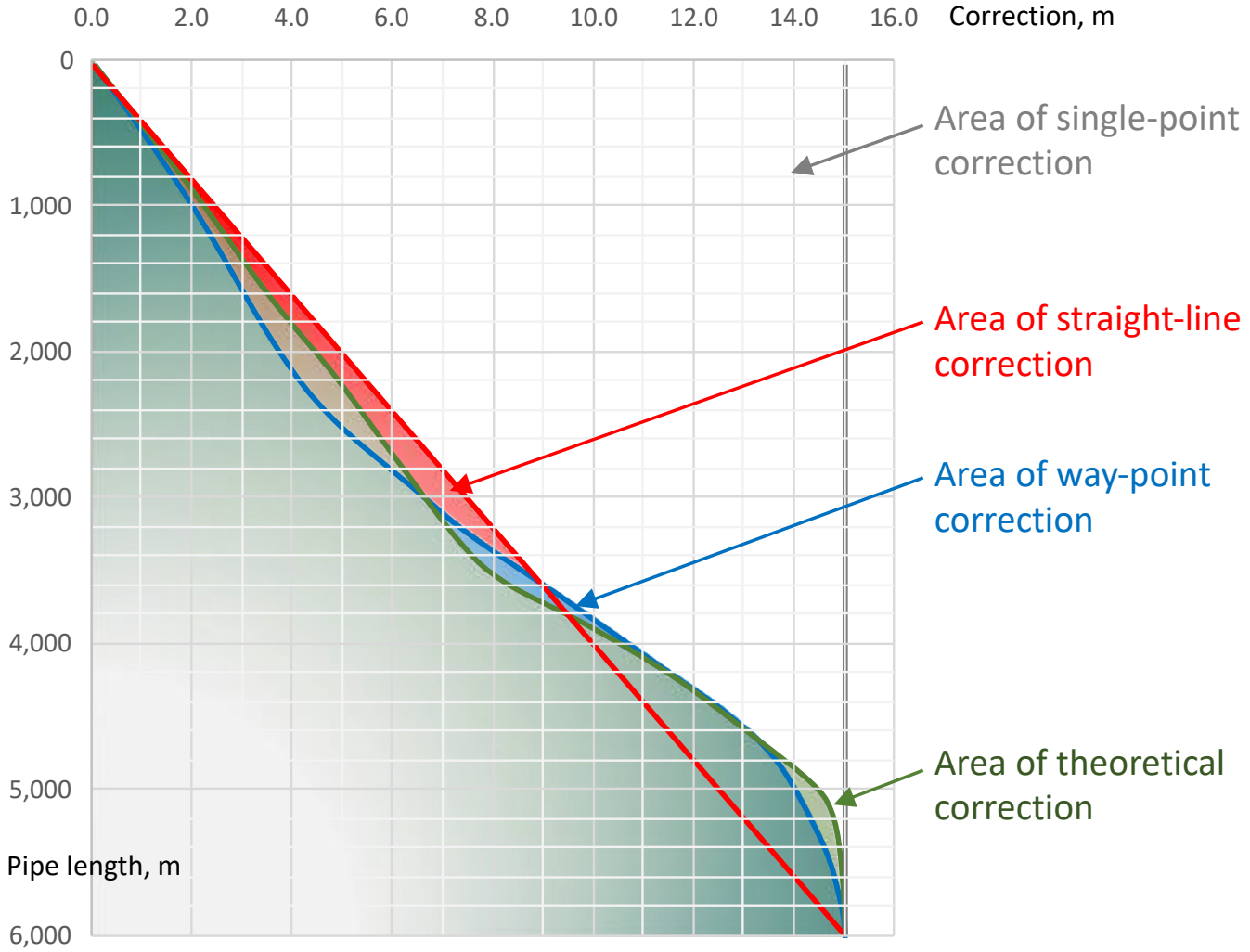
Theoretical = real world, actually necessary, correction



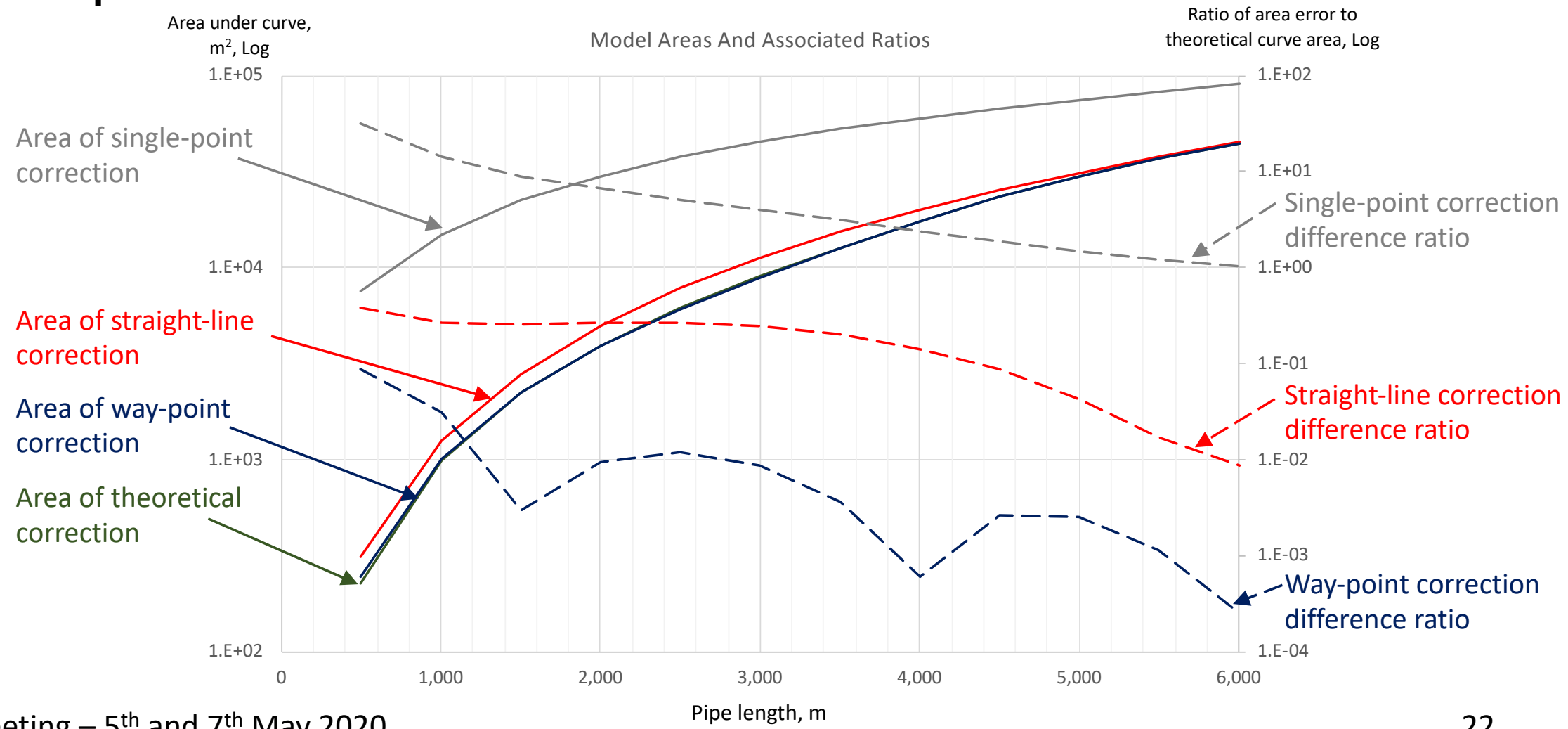
Example differences between model areas

Area under the curve is the average value over the area

Error is the difference between curve value and the real-world or theoretical value.



Example differences between area errors



Calculating uncertainty

$$\sum Uncertainty_{Measurement} = \sqrt{d.Length_{Calb}{}^2 + d.Corr_{Corr}{}^2 + d.Corr_{Model}{}^2}$$

$$Uncertainty_{Depth} = \sum Uncertainty_{Measurement} + ToolJointError$$

Length determination
+ Correction
+/- Uncertainty

} = TAH, True Along-hole, Depth

ISCWSA model upgrade recommendation

Term No	Depth Term Description	Comment	Proposed nomenclature	Units
1	Depth Reference Uncertainty	(Tool Joint Error) Including ZDP to Permanent Datum uncertainty, stability of measurement platform and stability of length measurement	DREF	m
2	Depth Calibration Accuracy	Calibration Accuracy Accuracy of the drillstring (and wireline) length measurement process	DCAL	1/m
-	Depth Reference – Systematic	(not required)		-
-	Depth Stretch – Bias	(not required)		-
-	Depth Scale Factor – Systematic	(not required)		-
3	Depth Correction Value Accuracy	Accuracy of thermal and elastic stretch corrections derived from individual measurement parameter accuracies based on correction calculation equation	DCORR	1/m
4	Depth Correction Model Accuracy	Accuracy of the applicability of the correction model compared to the reality of the wellbore environment including temperature and tension profiles	DCORM	1/m

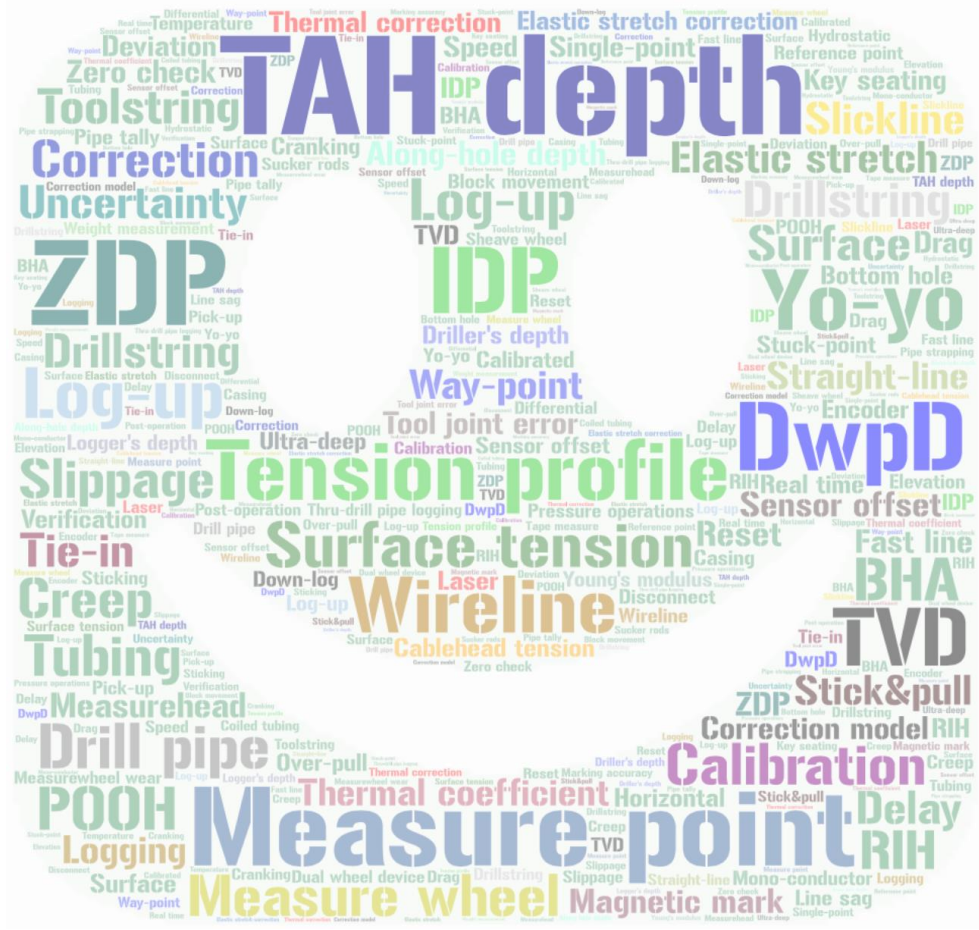
Conclusions

ISCWSA should adopt TAH depth as the standard for along-hole depth portrayal.

Uncertainty variables are:

- fixed reference error
- measurement/calibration accuracy
- correction calculation and measurements
- correction model used

And with the greatest certainty: your questions and comments



Paper available

harald@depth.solutions