Uncertainty In Depth: Reduced

Managing Along-hole Depth Measurement Uncertainty

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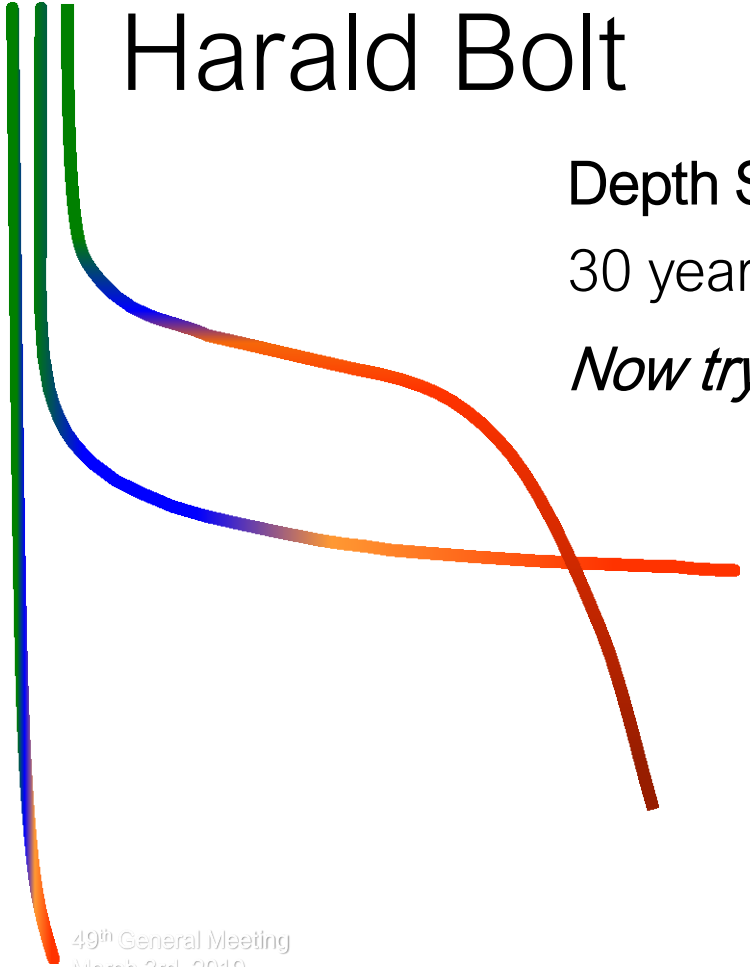
Depth Solutions

49th General Meeting
March 8th, 2019
Den Hague, The Netherlands

ISCWSA

Harald Bolt speaker background



Depth Solutions, DwpD Ltd

30 years after trying to figure out where TD is

Now trying to figure out how correct it is

DwpD Ltd. specializes in

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

Why bother ?

One end of the spectrum:

"We never have a depth problem …"

Until "the problem" occurs.

Then the other end of the spectrum:

"We had no end of depth correlation problems on the recent XXX intersect P&A well"

"The FWL's don't agree across the reservoir"

"The horizons just don't match"

"We are not actually sure if there is a fault"

"Maybe the depth is wrong ..."

Accuracy expectations

Measurement relevance	Domain relevance
Geological mapping	Major geological events
Well construction	Significant reservoir events
Mechanical service operations	Minor reservoir events
Reservoir geometry	Major bed events
OWC/GWC mapping	Minor bed events
Detailed OWC/GWC mapping **Fracture identification**	Minor bed events
Pressure gauge accuracy/resolution	Very detailed events Compaction events

How do we define expectations for along-hole depth measurement accuracy in different domains ?

Accuracy components

Requirements ! (no requirements = no accuracy !)

Measurement methodology

Calibration system

Correction model and calculation

Uncertainty model and calculation

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

Basic uncertainty relationship

$$\sum \frac{u(z)}{Z} = \sqrt{\left(\frac{u(x)}{X}\right)^2 + \left(\frac{u(y)}{Y}\right)^2 \ldots \left(\frac{u(z)}{Z}\right)^2}$$

calibration correction model

My nomenclature:
- Accuracy = proportion of a result
- Uncertainty = result value

Calibration accuracy

Measurement standards

Calibration variables

Environmental effects

Measurement effects

Shelf life

Correction calculation parameters

Thermal expansion

Elastic stretch

Other corrections

Typical accuracies

Measurement	Method	Accuracy, +/- per 10,000 ft
Drill pipe length calibration	Strapped pipe	+/- 5 ft to +/- 20 ft
	Lasered pipe	+/- 1.5 ft to +/- 2.5 ft
	On site measurement	Accuracy + 50% to 100%
Wireline length	Measurehead	+/- 3 ft to +/- 10 ft
Wireline calibration	Magnetic marks	+/- 1 ft to +/- 2 ft
ZDP pipe joint identification	Rig floor pipe stick-up	+ 0.25 ft to + 3 ft
Surface hook load	Hook load	+/- 5% to +/- 10% load
BHA mud temperature	LWD temperature	+/- 1% of measurement
Stretch coefficient	Young's Modulus for steel	+/- 5% of value
	Pipe ID/OD (from specifications)	+/- 5% of value
Thermal coefficient	Coefficient for steel	+/- 5%

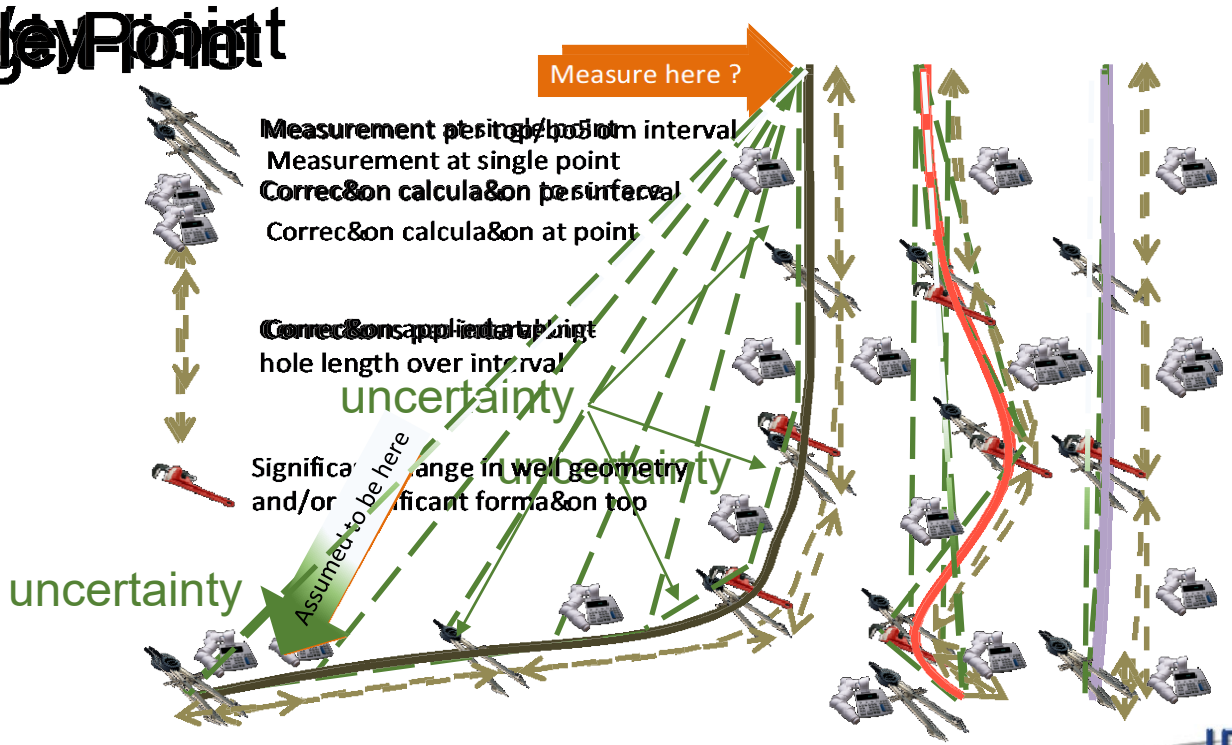
Correction model

Single point

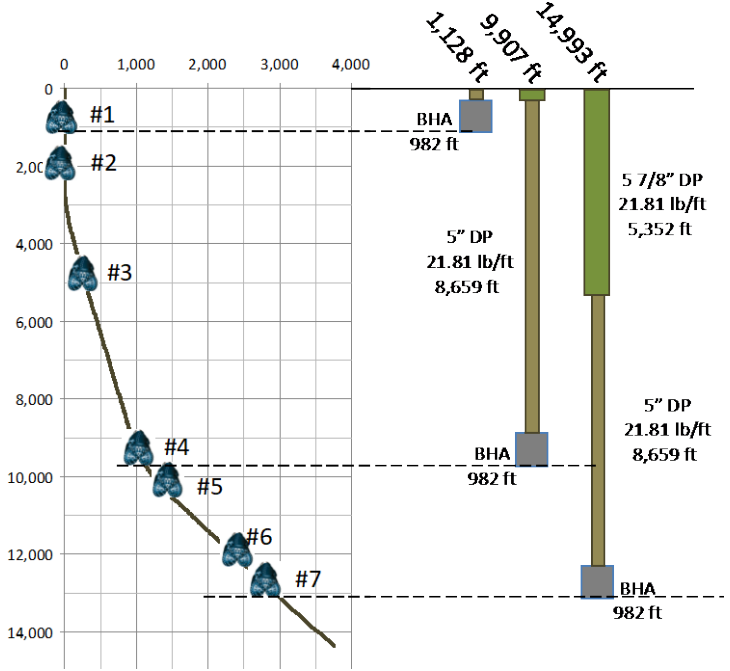
Straight line

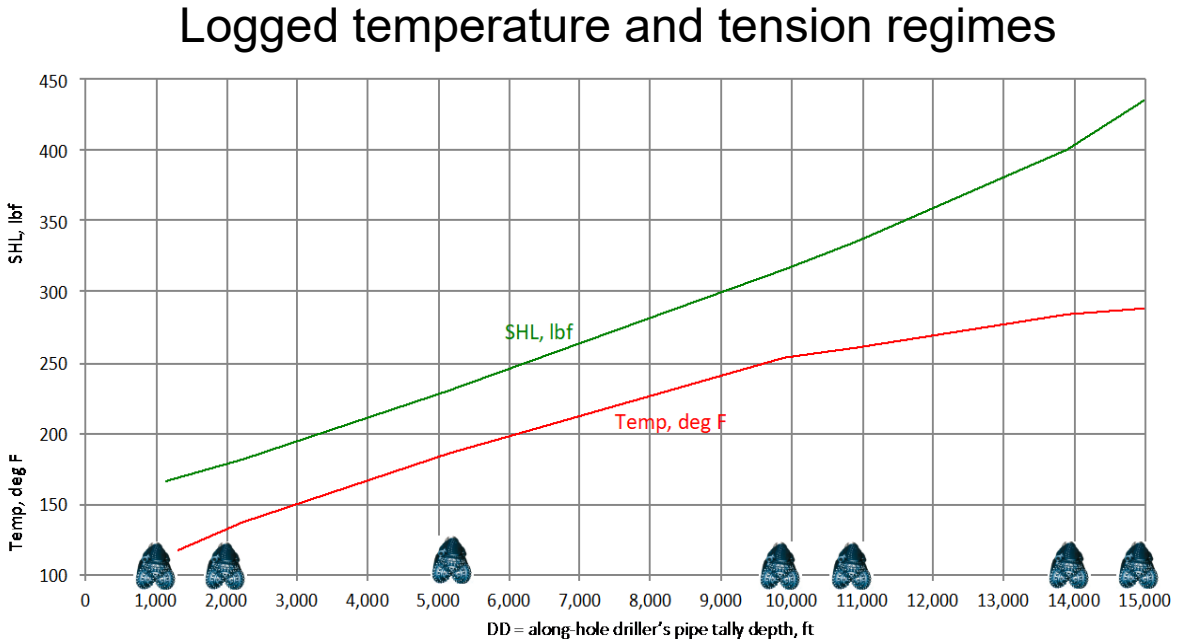
Way-point

Correction model differences



Example (N.Sea): DwpD from 15,000 ft





DwpD correction calculation

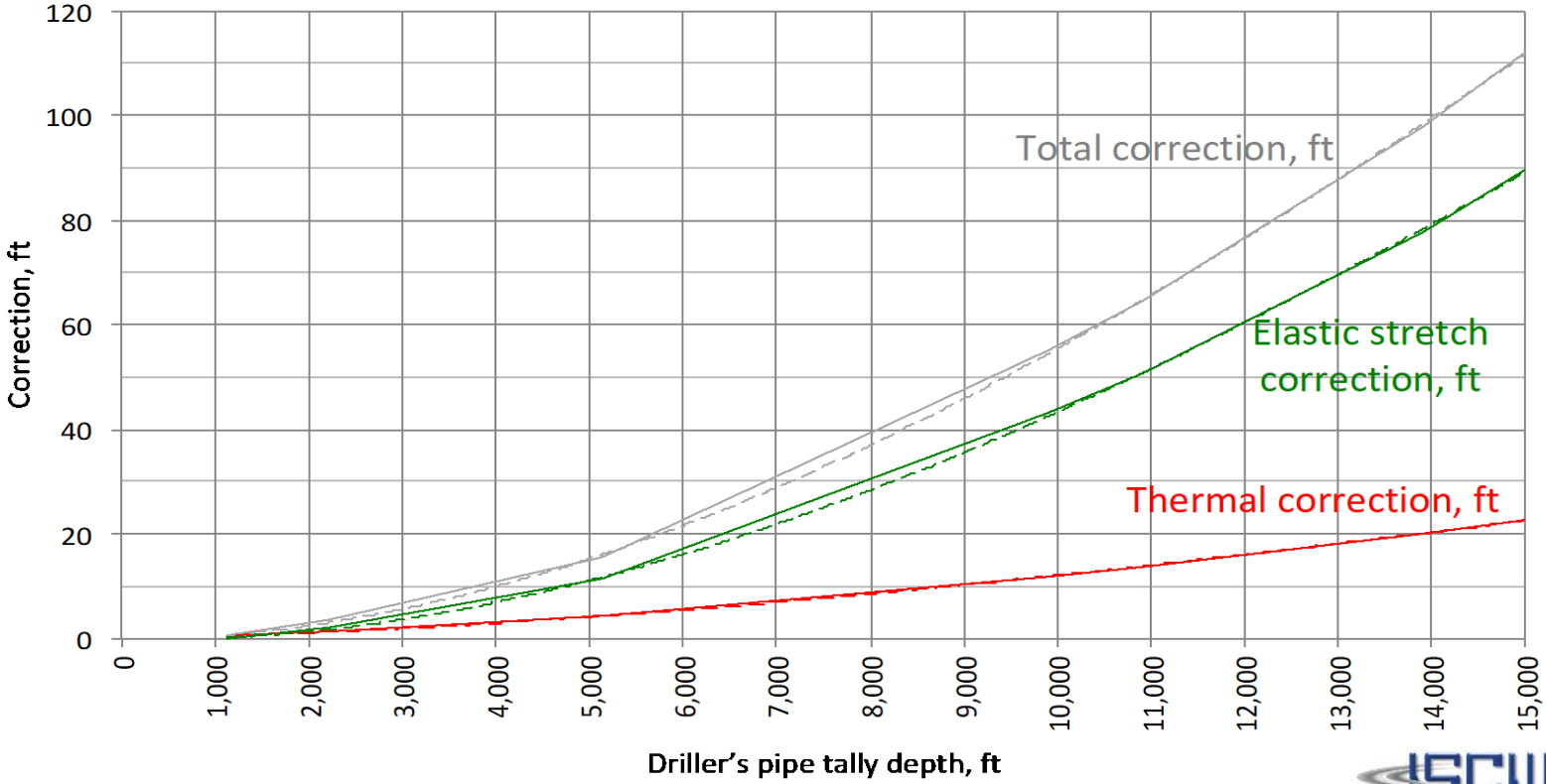
Thermal correction

$$TotalThermalElongation = \sum_{HUD}^{TieIn} \left(\left(\left(\frac{BHT_{TopSeg.} + BHT_{BtmSeg.}}{2} \right) - Temp_{Calb} \right) \times Calb.Length_{Seg} \times Th.Coeff_{Seg} \right)$$

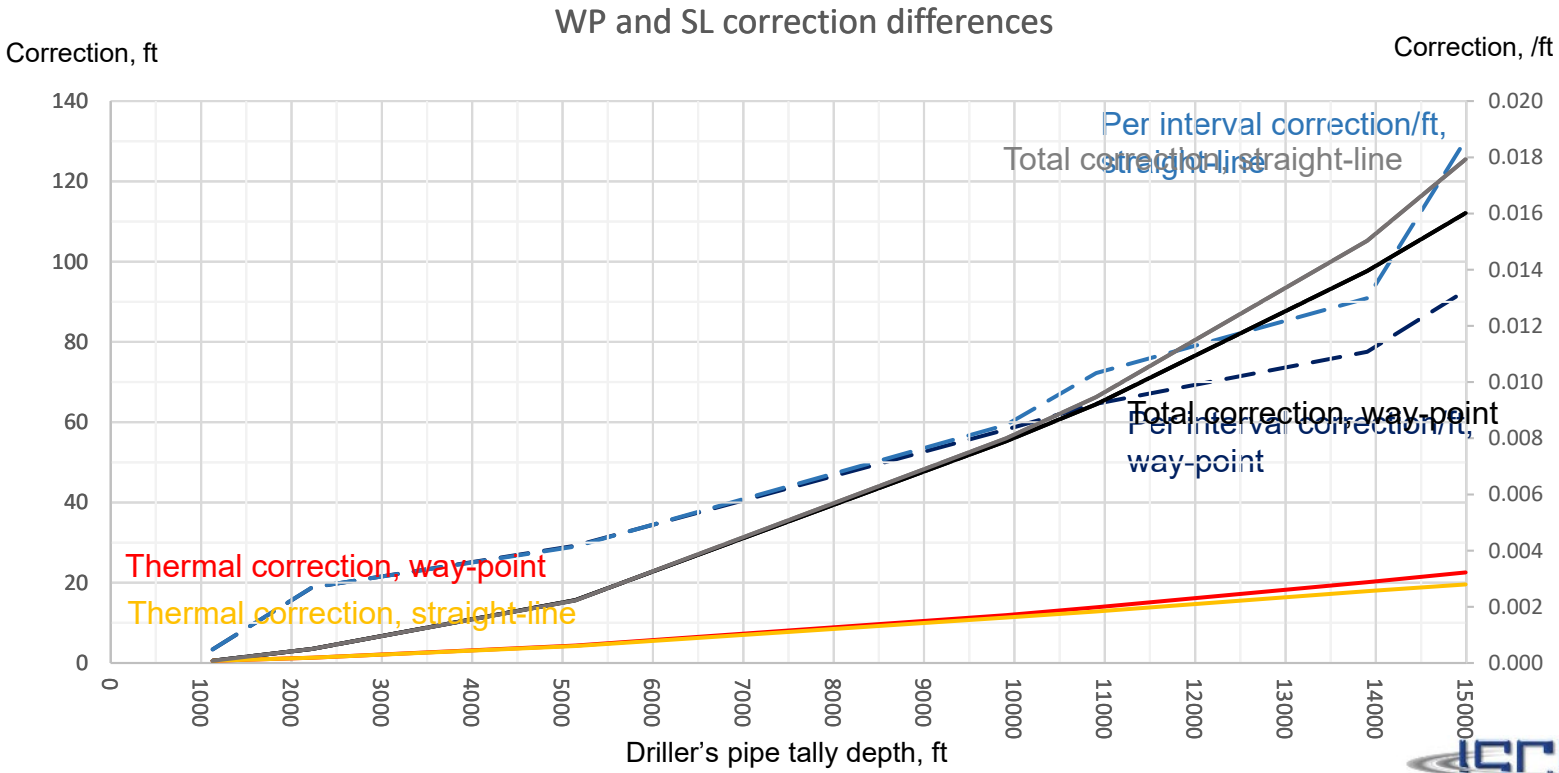
Elastic stretch correction

$$TotalElasticStretch = \sum_{HUD}^{TieIn} \left(\left(\left(\frac{Surf.Ten_{TopSeg.} + Surf.Ten_{BtmSeg.}}{2} \right) - Ten_{Calb} \right) \times Calb.Length_{Seg}^{1} \times St.Coeff_{Seg} \right)$$

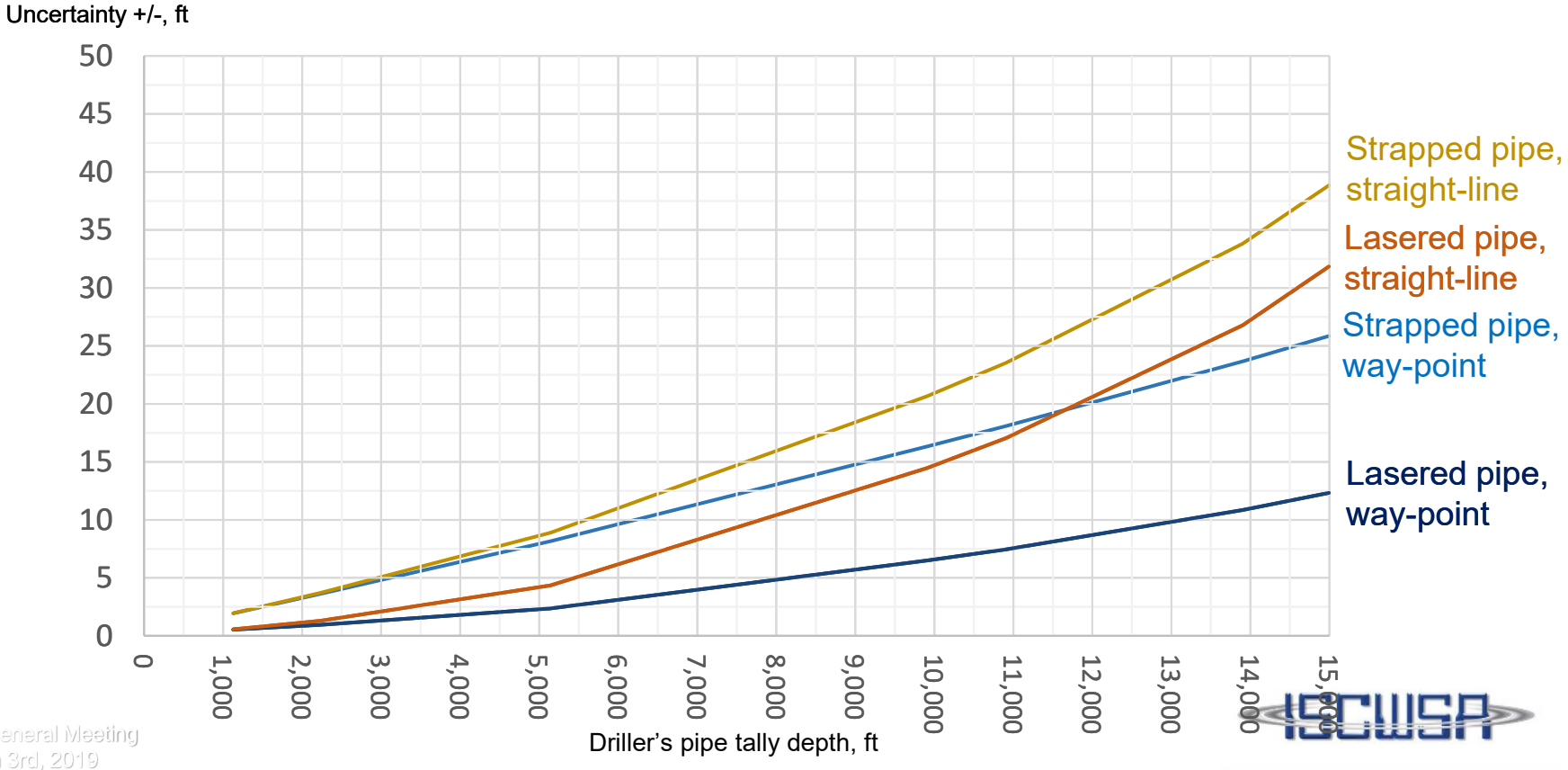
Calculated DwpD correction



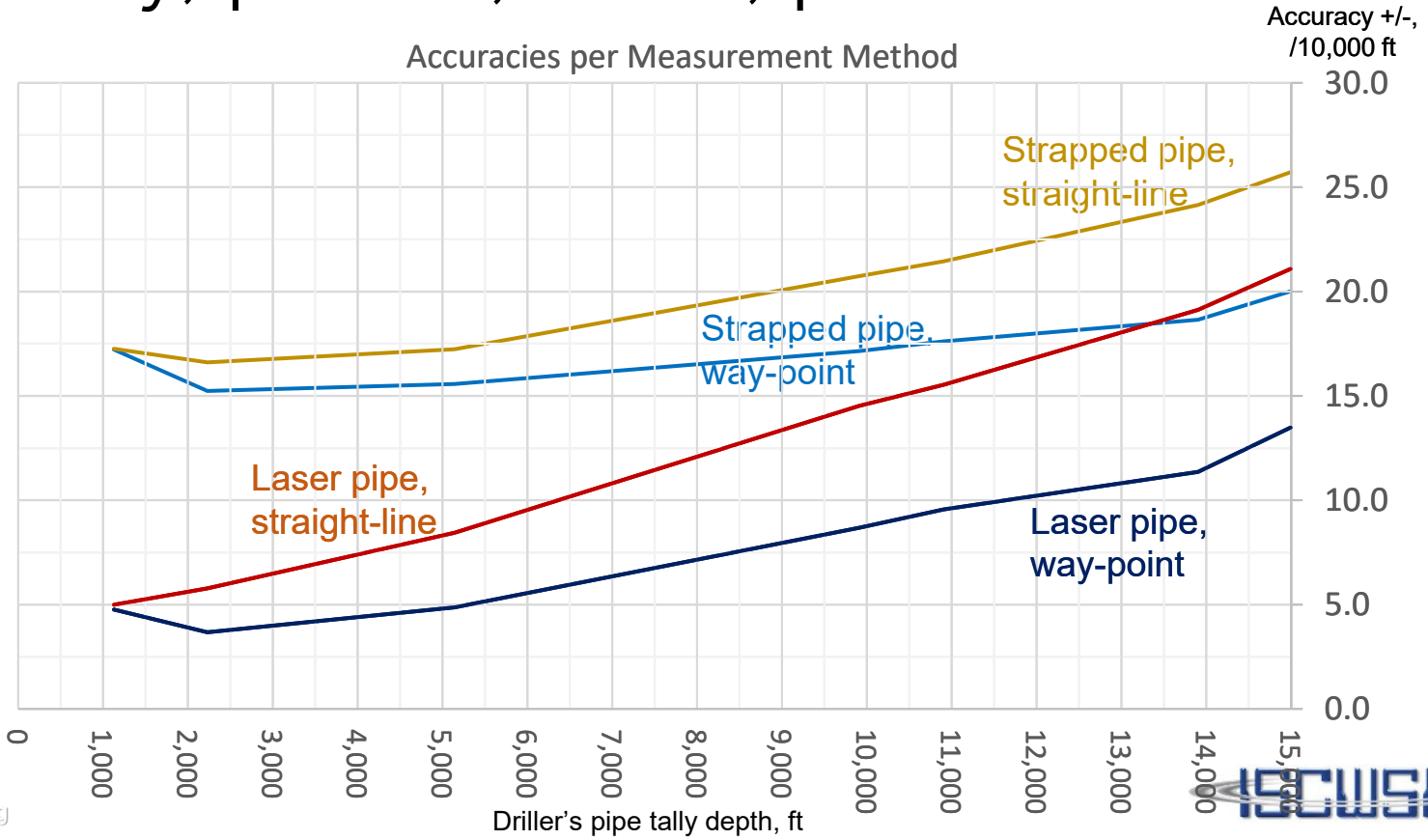
Differences in correction models



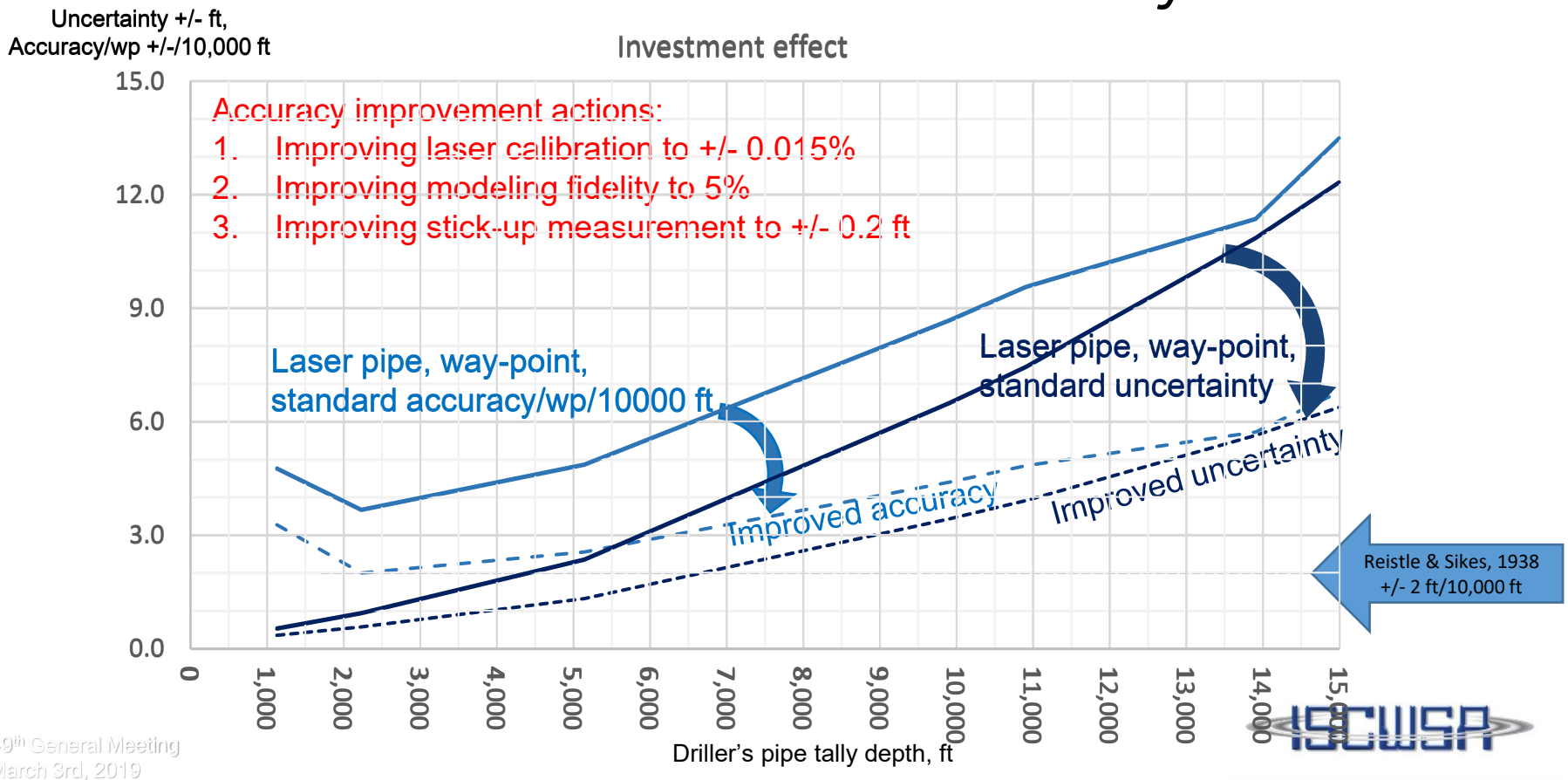
Uncertainty, ft, per method



Accuracy, per 10,000 ft, per method



Decision influence on uncertainty



Managing expectations

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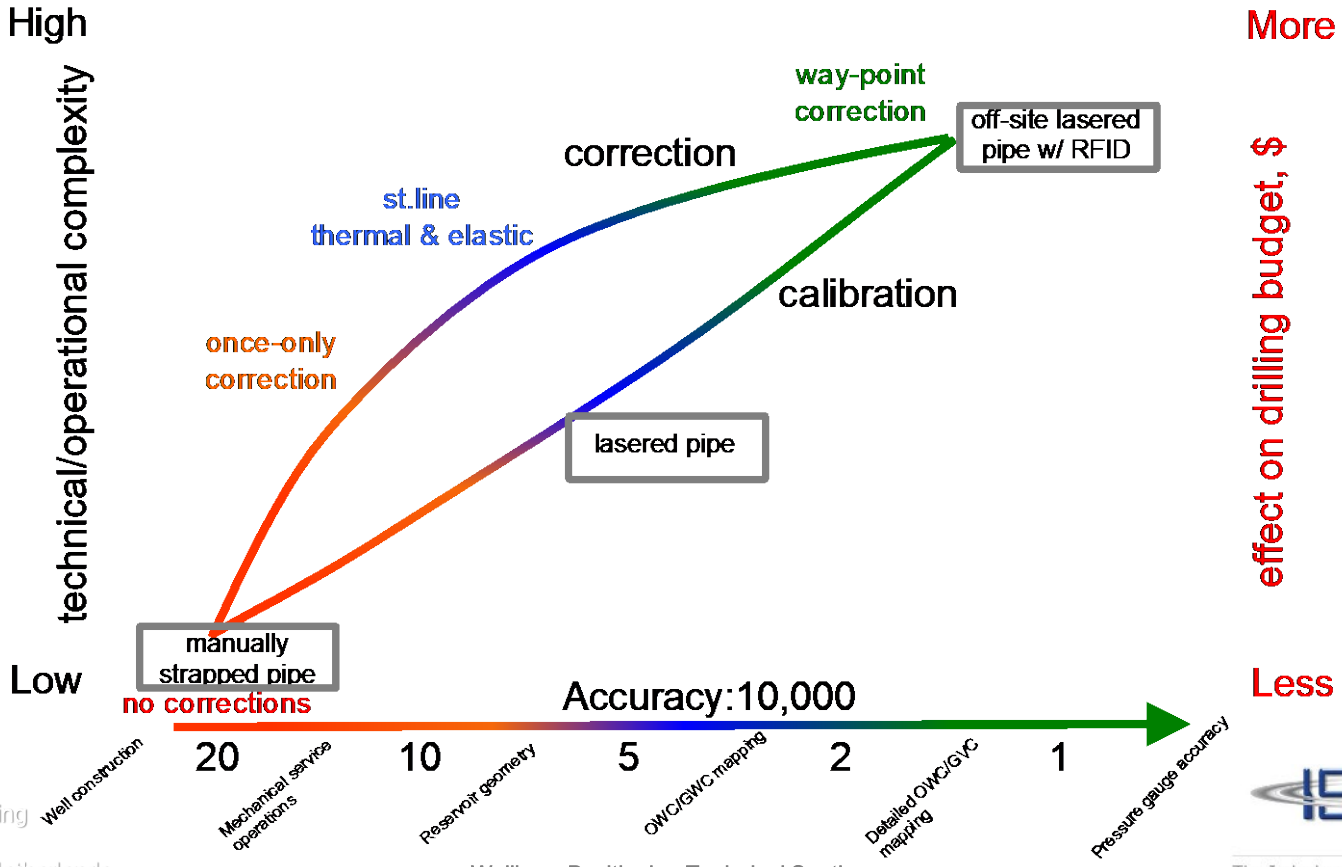
Understanding the model



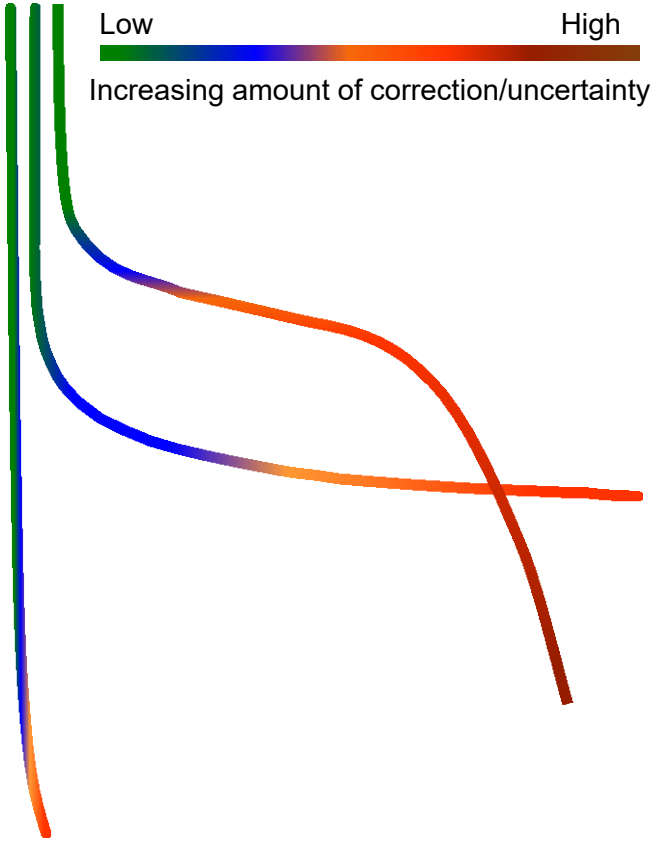
Conclusions

Accuracy is determined by requirements

Uncertainty variables are:

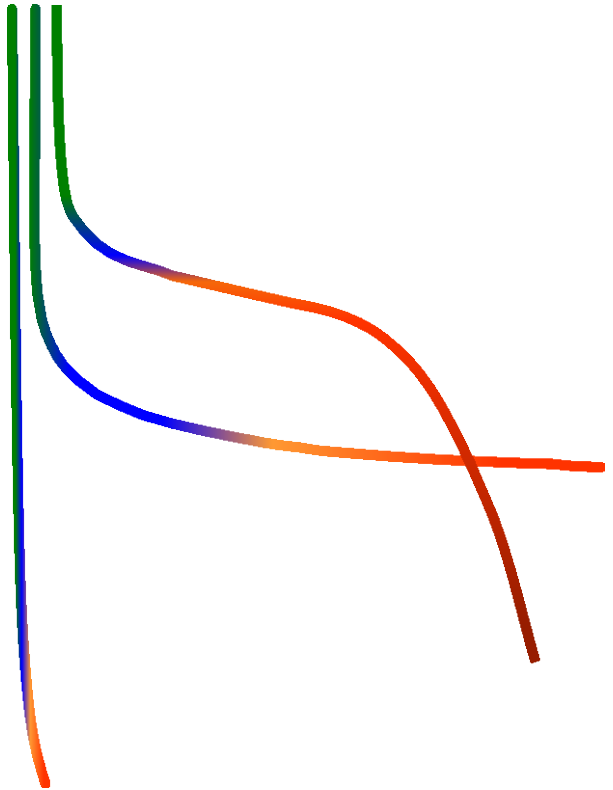
- measurement method used
- calibration methodology
- correction model
- correction elements

The result depends on the investment



Further uncertainties

Your comments on accuracy …




cable twisting
calibrated wheel
magnetic marks
viscous drag
elevation model
Policy
creep
key-seating
stick-slip
stretch correction
yoyo
DIFF
surface tension
rig up correction
Z-chart
down log
ballooning
speed correction
stuck point
slippage
cranking
head tension
depth reset
zero check
driller's tally
measure points
computer crash