WHAT DEPTH ?

Driller's Depth Determination

Harald Bolt

45th General Meeting
March 17th, 2017
The Hague, The Netherlands

Wellbore Positioning Technical Section

The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

Speaker Information

- Harald Bolt
- What Depth ?
- March 17, 2017
- ICT Europe

Speaker Bio

- B.Sc. (Comb.Hons), MBA, SPE, SPWLA, EAGE
- Since 1982 open-, cased-hole, production logging
- Focus on depth measurement since 1984
- First SPWLA presentation, Taos, 1997
- “Wireline Depth Determination”, Rev. 4
- www.wirelinedepth.com
- Authored/co-authored 14 along-hole depth-related papers and presentations
- Team leader for API RP-78 Depth QA-QC
- Consultant on along-hole depth technologies, methodologies, discrepancies and issue resolution and data-user/data-supplier audit

ICT Europe

- Focus on depth determination
- Consulting, operations, reconciliation, audit, training
- Driller’s depth
- Wireline depth
- Uncertainty
- API RP-78 depth data compliance

What Depth ?

What Depth ?
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What issue ?? Issue to who ?

What accuracy looks like

API RP-78 – requirement for uncertainty

Driller's and wireline differences & similarities

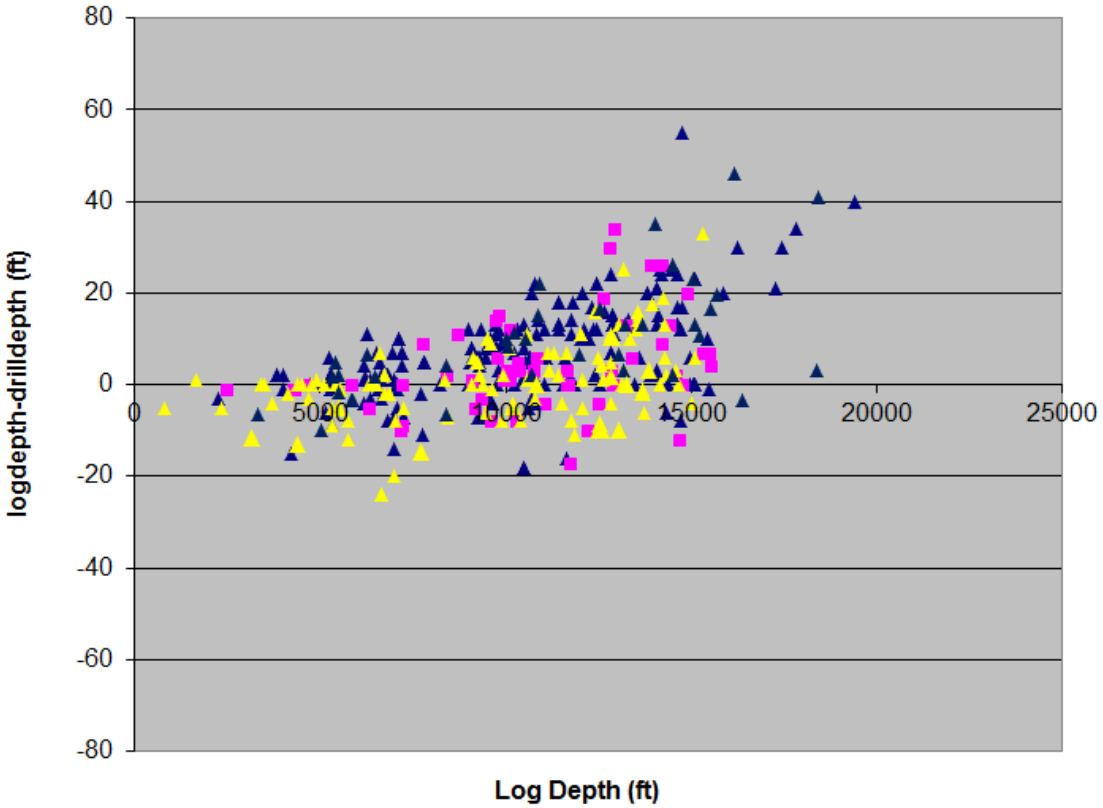
The issue of correction

Tension regime and correction

Way-point – for wireline and driller's

Can you now know what depth is ? …..

What Is The Issue With Depth ?



Driller's versus wireline depths

Deeper = bigger the difference

Deeper = bigger spread

Equal spread between wireline companies

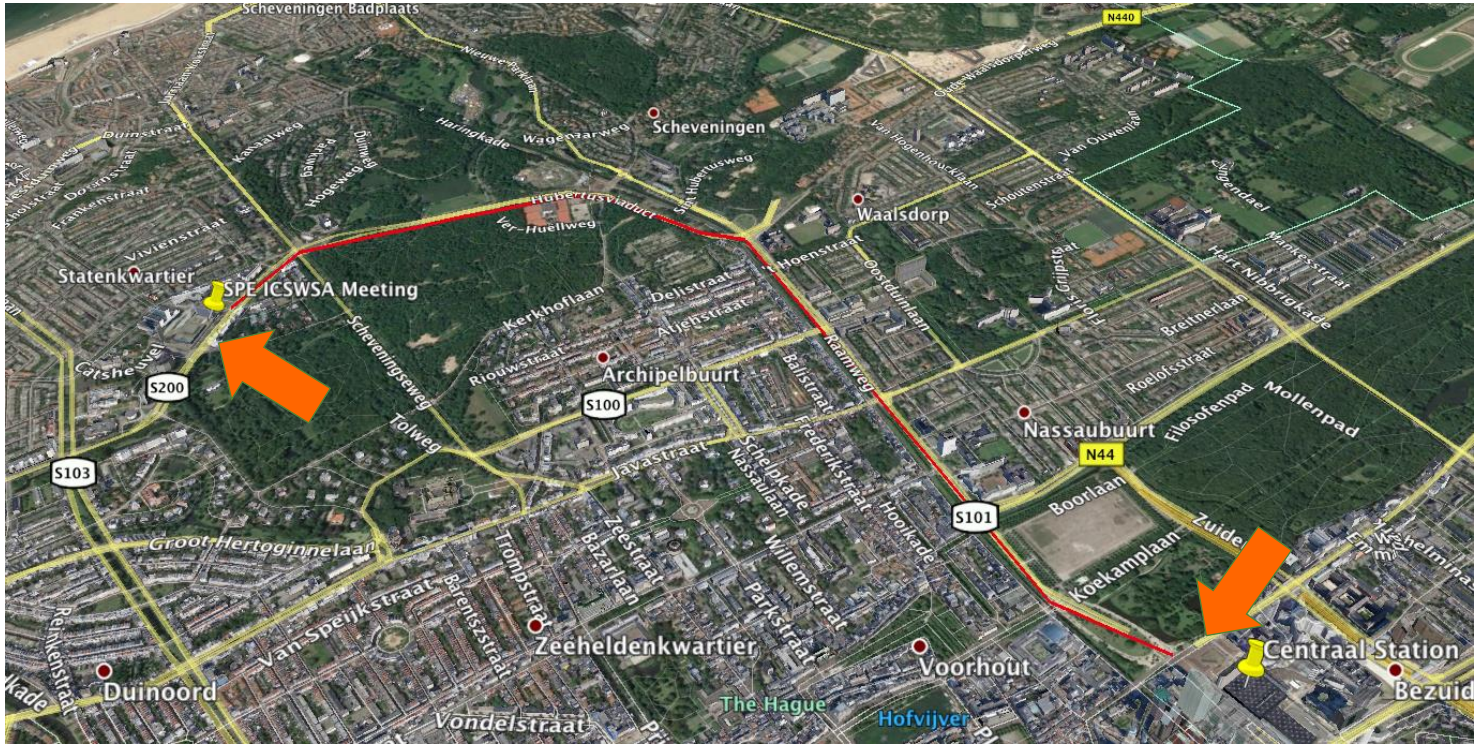
Can we rely on depth data ?

Forsyth 2013 SPWLA New Orleans

Different Methods Give Different Results

Measurement use	Domain relevance	Method	Measurement method	@10,000 ft Trueness +/-	@10,000 ft Precision +/-
Geological mapping	Major geological events	Seismic	2-way time, time/depth conversion = Indicated depth	100 ft	20 ft
Well construction	Significant reservoir events	Driller's depth	Drill pipe = Indicated depth	50 ft	6 ft
Mechanical service operations	Minor reservoir events	LWD depth	Drill pipe = Calibrated depth	30 ft	3 ft
Reservoir geometry	Major bed events	Wireline	Measurehead only = Calibrated depth	15 ft	1 ft
OWC/GWC mapping	Minor bed events		Measurehead onlt w/ st.line = Corrected depth	5 ft	0.5 ft
Detailed OWC/GWC, fracture mapping	Minor bed events		Mag. Marks w/ way-point = Corrected depth	2 ft	0.2 ft
Detailed fluid characteristics	Detailed petrophysics, compaction events		Mag.marks, way-point w/ st.coeff = Corrected depth	1 ft	0.1 ft

What Do We Mean With “Accuracy” ?



Seismic from 2-way time =

2.5 – 2.6 miles

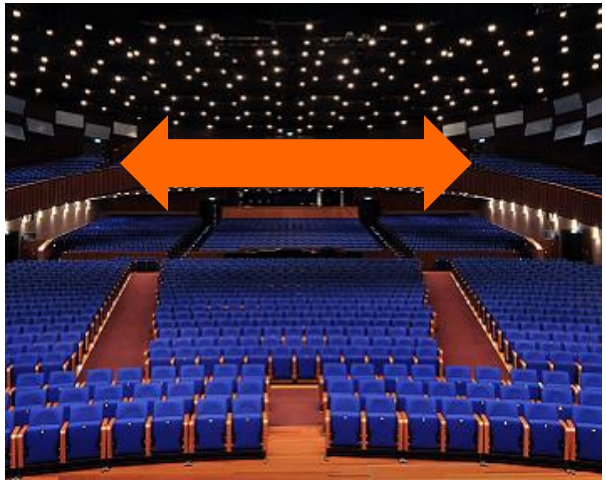
Log depth =

4,103.753 m

How far from Centraal Station to here ?

What Does Accuracy Look Like ?

5:1,000



2:1,000

1:1,000

"Accuracy" is more than a number: it is a reality

Is This What We Want Or What We Need ?

8:10,000

5:10,000

1:10,000

What is wanted ?
Who is prepared to pay for it ?

API RP-78 Depth QA-QC

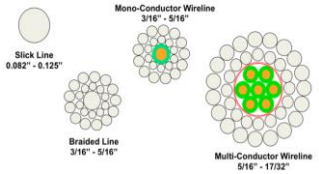
Objective:

To recommend standard practices that deliver consistency and accuracy in along-hole depth information, by minimizing errors associated with depth measurement systems, and provide data reporting standards.

Result:

API RP-78 conformant along-hole depth data will include an uncertainty statement.

Wireline Versus Driller's Depth



wireline 4 ¼" DP

driller defined pipe lengths

thermal expansion

compression/stretch

buckling

torque

linear drag

buoyancy

rotational friction

ballooning

hydraulic forces

WOB

pipe tally management

travelling block movement

measurement system

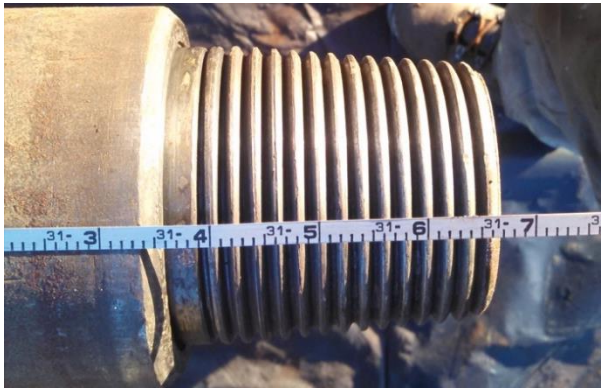
thermal correction

elastic stretch

Drill Pipe Length Calibration

Manual Strapping

+/- 0.2”/31’ ? ≈ 5:10,000 ??
(you’d be lucky !!)
max. 1:1,000 more likely



Laser Length Tally

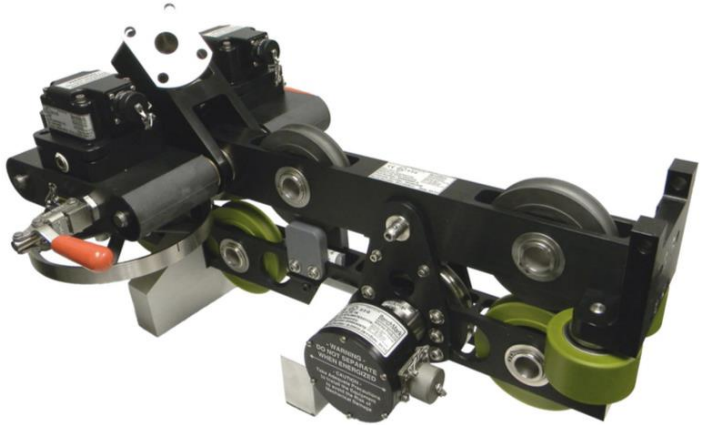
from Digi-Tally spec.s, ≈ 1.5:10,000
(shop environment ?)
max. 2:10,000 more likely

Issues: temperature, vertical/horizontal, consistency, tally management

Wireline Length Calibration

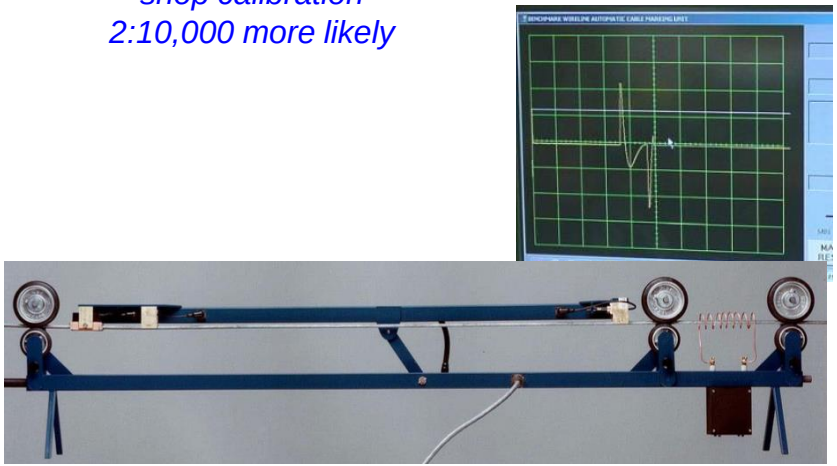
Dual-wheel “Wheels-only”

IS NOT A CALIBRATION
typically 5:10,000 claimed/implied
no verification
1:1,000 more likely



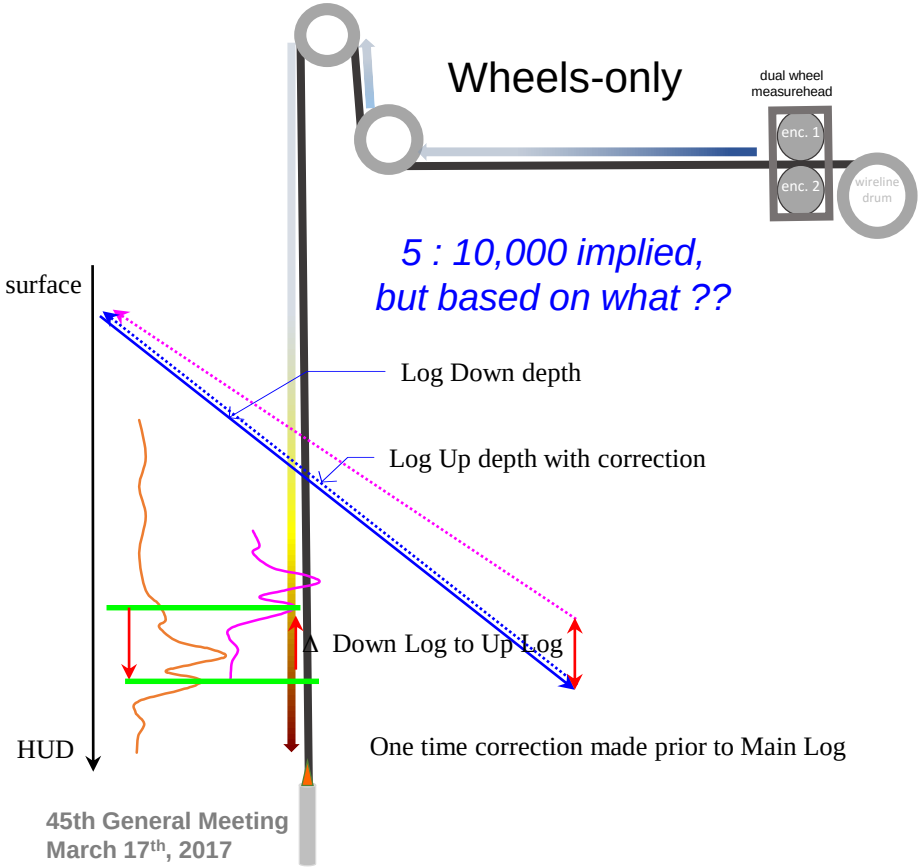
Magnetic Marking

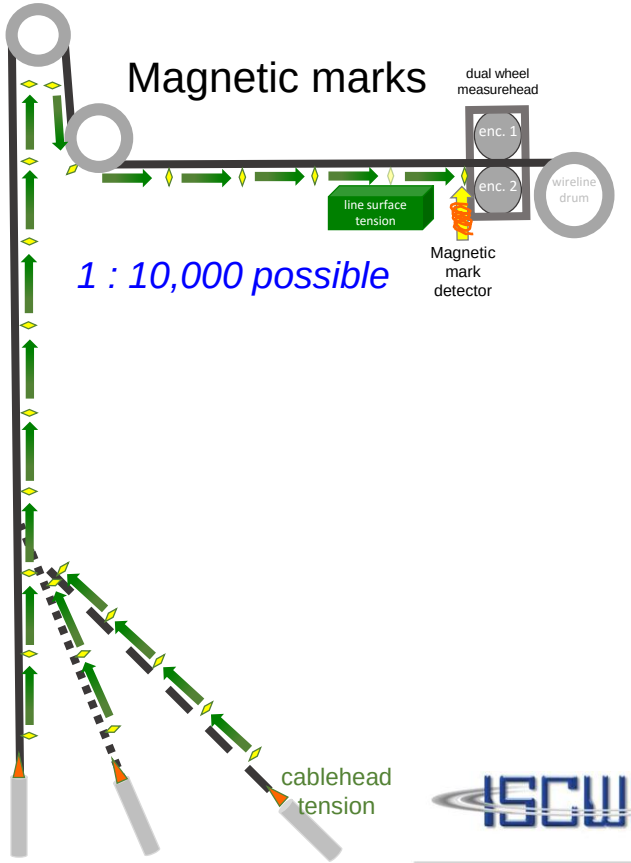
up to 1:10,000
shop calibration
2:10,000 more likely



Issues: temperature, tension, calibration stability

Wireline Depth Operations





The Issue Is Correction

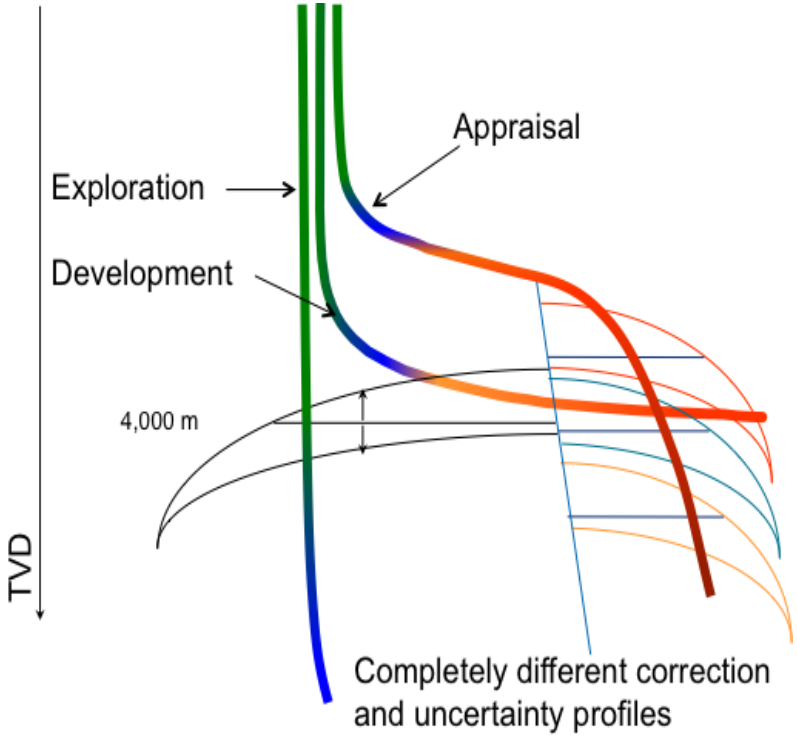
Drill Pipe Corrections

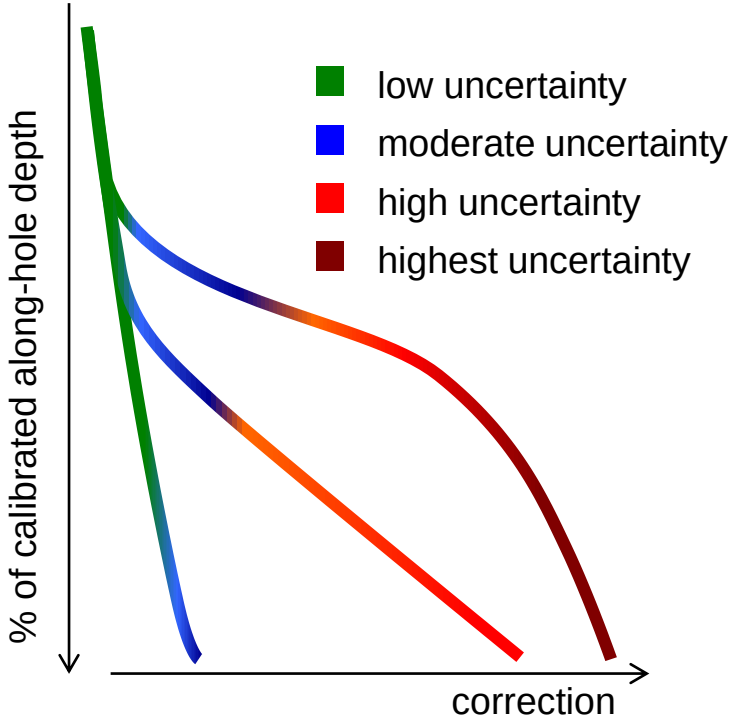
- model used, parameters
- repeatability of drilling measurement, verification,
- thermal expansion
- compression/stretch, WOB
- torque, helical buckling, sinusoidal buckling
- hydraulic forces, buoyancy, fluid flow,
- rotation friction, sliding friction

Wireline Corrections

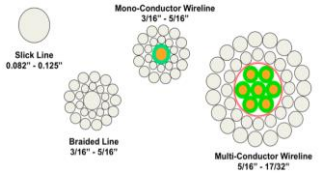
- model used, parameters
- verification

Why Is Correction An Issue ?





Pull Out Of Hole Correction



wireline 4 ¼" DP

driller defined pipe lengths

thermal expansion ✓

compression/stretch ✓

buckling ✗

torque ✗

linear drag ✗

buoyancy ✗

rotational friction ✗

ballooning ✗

hydraulic forces ✗

WOB ✗

pipe tally management

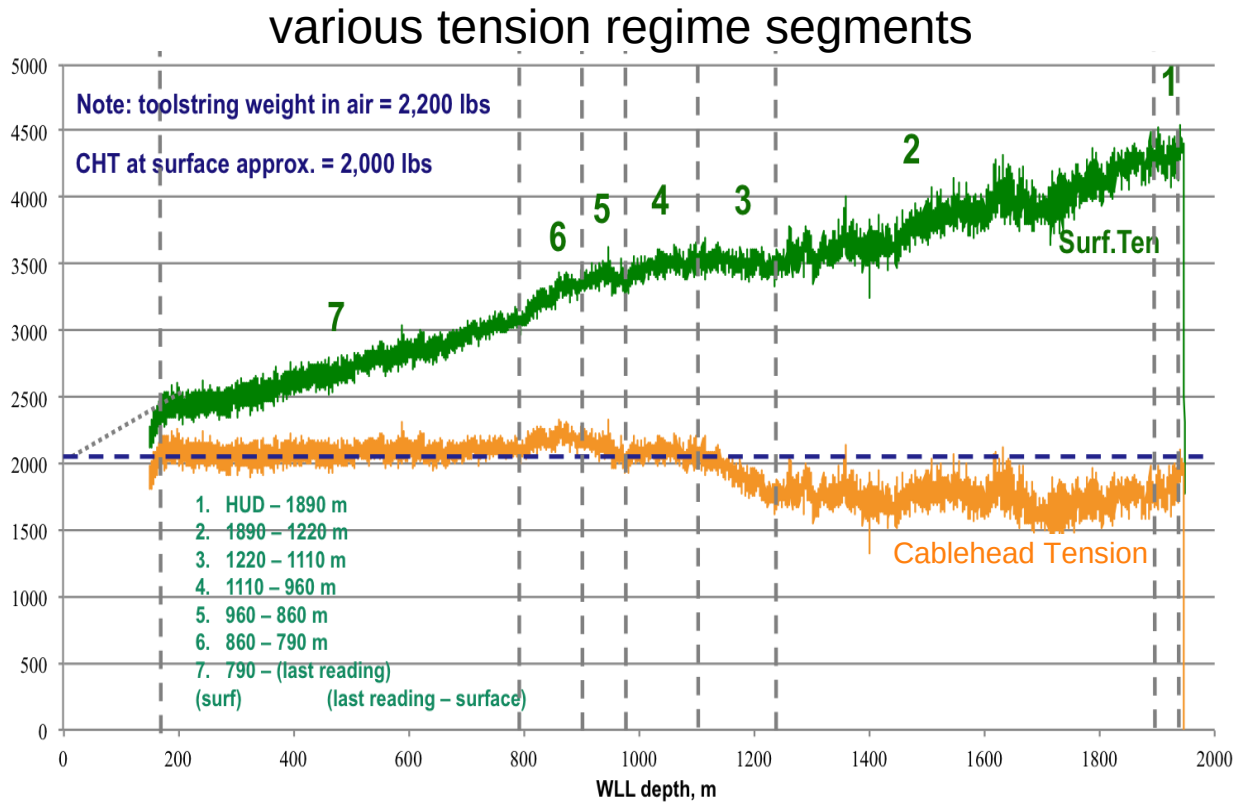
travelling block movement

measurement system ✓

thermal correction ✓

elastic stretch ✓

Correction Based On POOH Tension



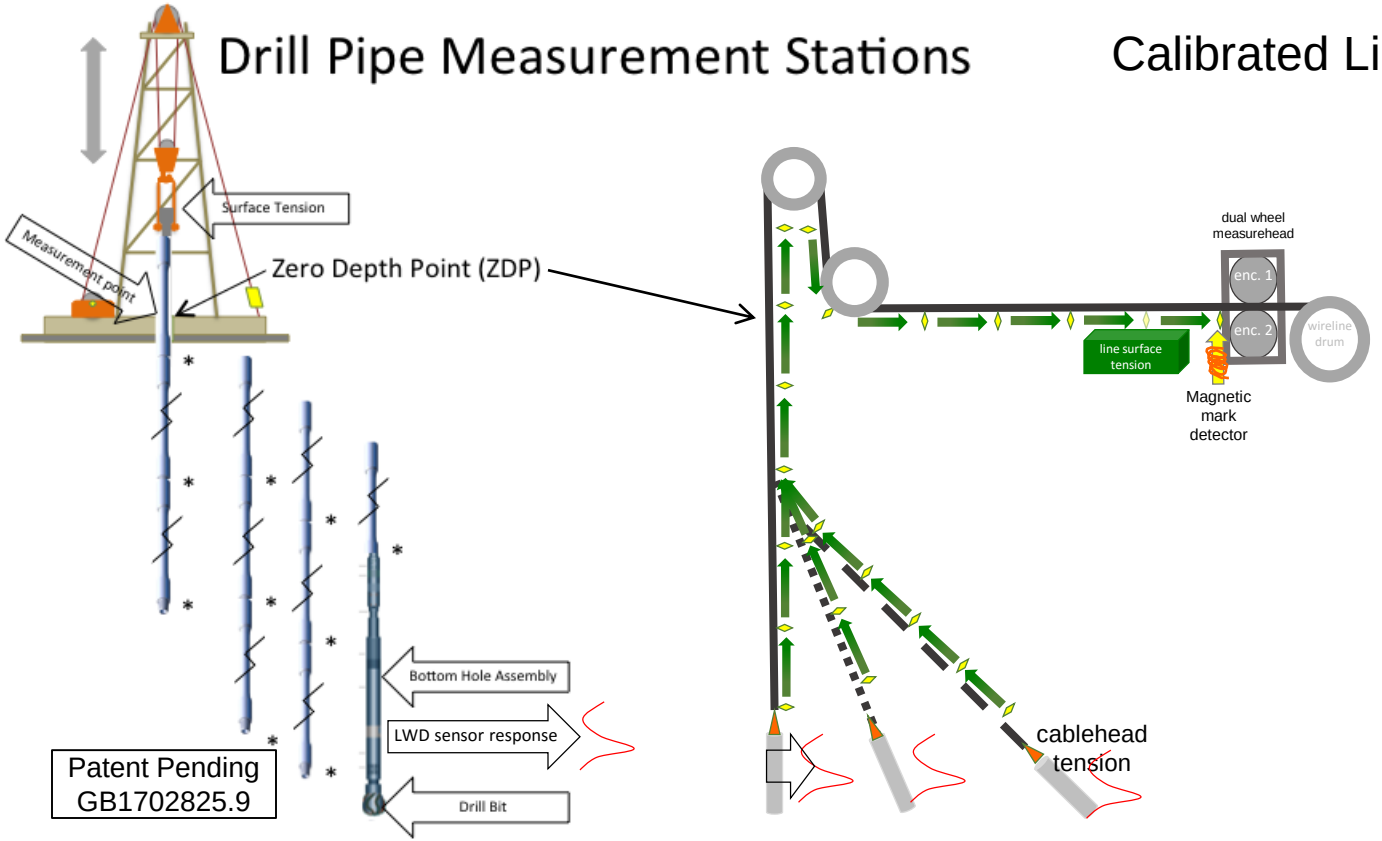
Tension regime describes the tension behaviour per section of the well bore

Tension is repeatable

Correction per ft/m is not constant per section

Sum of correction of all sections is the total correction

Way-point Principle Applied



The Main Corrections

Elastic stretch correction

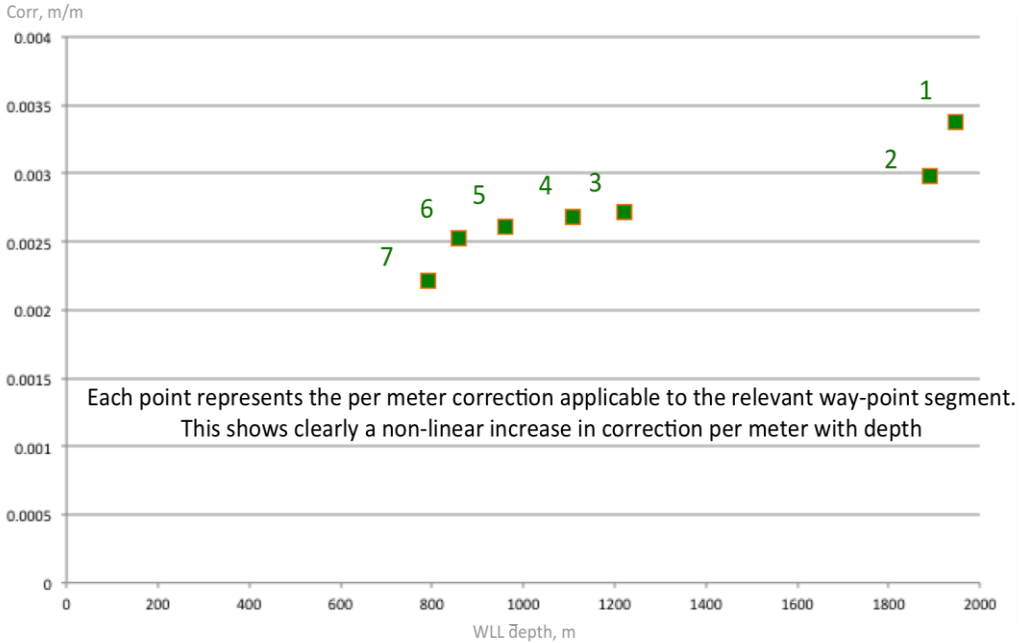
$$ElasticStretch.Corr = \left(\left(\left(\frac{Surf.Ten + CHT}{2} \right) - Ten_{Calb} \right) x\, Calb.Length^{1}\, x\, St.Coeff \right)$$

Thermal correction

$$Thermal.Corr = \left(\left(\left(\frac{Surf.Temp + BHT}{2} \right) - Temp_{Calb} \right) x\, Calb.Length\, x\, Th.Coeff \right)$$

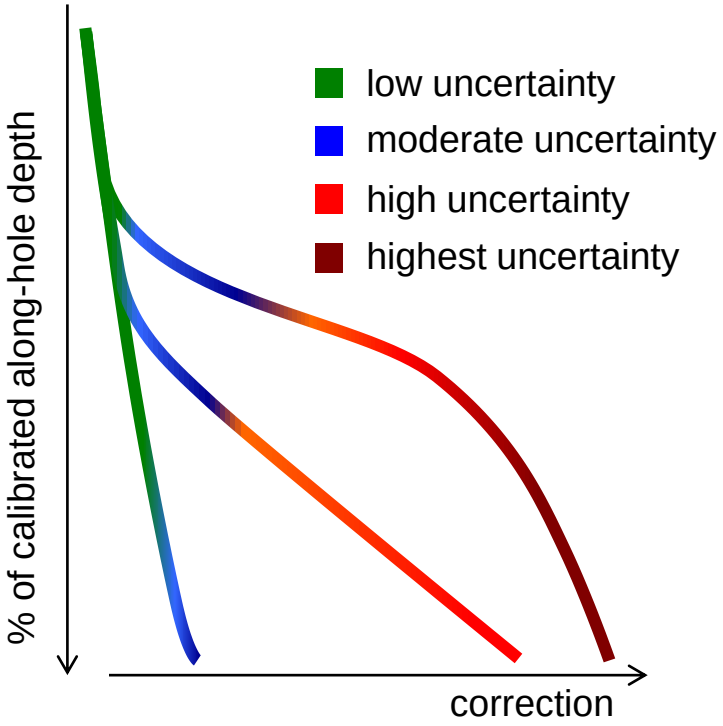
Elastic Stretch Correction Per Station

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



Each point represents the per meter correction applicable to the relevant way-point segment.
This shows clearly a non-linear increase in correction per meter with depth

Driller's Depth Way-point Correction



Key concept is depth is POOH determined

- Way-point used in driller's depth
- Same model for driller's and wireline
- Corrected depth for LWD
- LWD and wireline depths are compatible
- Understandable parameters
- Calculable uncertainty
- Driller's True Along-hole Depth

Conclusion

What Depth ?
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- Consistency of along-hole depth measurement
- Coherency of measurement methodology
- Correction method for both wireline and drill pipe
- Compliance with (proposed) API RP-78