Error Model Maintenance Group Update

March 8th 2019
ISCWSA#49, The Hague

ISCWSA

Speaker Bio

- Andy McGregor
  - Technical Director, H&P Technologies UK.
  - 25 years in navigation and positioning
  - 12 years in wellbore survey
  - Previously with Tech21, Weatherford, AJC
  - Inverness, Scotland
  - Specialised in survey management, algorithms, error modeling,

Agenda

- XCL Terms
- Revision of Misalignment Terms & SAG
- WITSML Data Transfer
- BGGM Uncertainty Estimates
- Shell Model Standardisation
- Correlation Between Geomagnetic Reference Terms

XCL Models

- Jerry Codling updated us on proposed formulae for XCL

- $XCL_h \quad \sigma_{xclh}(D - D_{k-1})max\left(\text{abs}(I_k - I_{k-1}), \text{T}(D - D_{k-1})\right)$

- $XCL_a \quad \sigma_{xcll}(D - D_{k-1})\, max(\text{abs}(A_k - A_{k-1}), \text{T}(D - D_{k-1})/\sin \text{I}_k)$

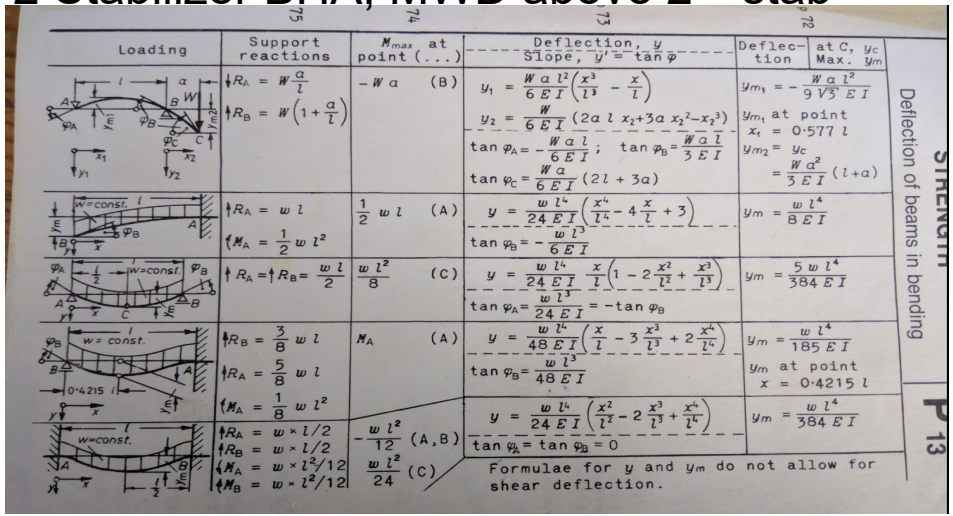
- Based on tangential rather than balanced tangential approx.
- Document produced
- Landmark and HPT have validated. Others to check.
- Details to be checked
  - Irregular survey spacing
  - Very long intervals
  - High frequency continuous data
- Provisionally accepted for next release of model

Revision of Misalignments

- Belief that current misalignments may be overly conservative
- Any changes to be evidence based
- Jerry Codling has being working on this and proposed:
- XYM3/4 term magnitudes increase to 0.3 deg and become random
- Seemed to fit available data better.
- Sign of a low inclination sag
- Misalignment and sag value a package of terms together

Low Angle SAG Error

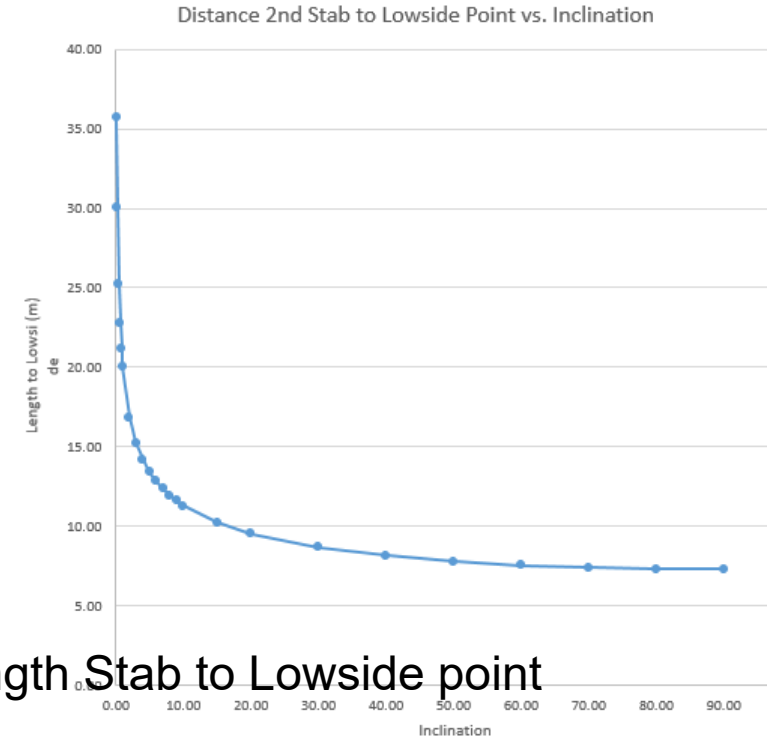
2 Stabilizer BHA, MWD above 2nd stab



Loading	Support reactions	M_{max} at point (...)	Deflection, y Slope, $y' = \tan\varphi$	Deflection at C, y_c Max. y_m
	$R_A = W\frac{a}{l}$ $R_B = W\left(1+\frac{a}{l}\right)$	$-Wa$ (B)	$y_1 = \frac{Wal^2}{6EI}\left(\frac{x^3}{l^3} - \frac{x}{l}\right)$ $y_2 = \frac{W}{6EI}(2al\,x_2 + 3a\,x_2^2 - x_2^3)$ $\tan\varphi_A = -\frac{Wal}{6EI}$; $\tan\varphi_B = \frac{Wal}{3EI}$ $\tan\varphi_C = \frac{Wa}{6EI}(2l+3a)$	$y_{m_1} = -\frac{Wal^2}{9\sqrt{3}EI}$ y_{m_1} at point $x_1 = 0{\cdot}577\,l$ $y_{m_2} = y_c = \frac{Wa^2}{3EI}(l+a)$
	$R_A = wl$ $M_A = \frac{1}{2}wl^2$	$\frac{1}{2}wl$ (A)	$y = \frac{wl^4}{24EI}\left(\frac{x^4}{l^4} - 4\frac{x}{l} + 3\right)$ $\tan\varphi_B = -\frac{wl^3}{6EI}$	$y_m = \frac{wl^4}{8EI}$
	$R_A = R_B = \frac{wl}{2}$	$\frac{wl^2}{8}$ (C)	$y = \frac{wl^4}{24EI}\frac{x}{l}\left(1 - 2\frac{x^2}{l^2} + \frac{x^3}{l^3}\right)$ $\tan\varphi_A = \frac{wl^3}{24EI} = -\tan\varphi_B$	$y_m = \frac{5wl^4}{384EI}$
	$R_B = \frac{3}{8}wl$ $R_A = \frac{5}{8}wl$ $M_A = \frac{1}{8}wl^2$	M_A (A)	$y = \frac{wl^4}{48EI}\left(\frac{x}{l} - 3\frac{x^3}{l^3} + 2\frac{x^4}{l^4}\right)$ $\tan\varphi_B = \frac{wl^3}{48EI}$	$y_m = \frac{wl^4}{185EI}$ y_m at point $x = 0{\cdot}4215\,l$
	$R_A = w \times l/2$ $R_B = w \times l/2$ $M_A = w \times l^2/12$ $M_B = w \times l^2/12$	$-\frac{wl^2}{12}$ (A,B) $\frac{wl^2}{24}$ (C)	$y = \frac{wl^4}{24EI}\left(\frac{x^2}{l^2} - 2\frac{x^3}{l^3} + \frac{x^4}{l^4}\right)$ $\tan\varphi_A = \tan\varphi_B = 0$	$y_m = \frac{wl^4}{384EI}$

Formulae for y and y_m do not allow for shear deflection.

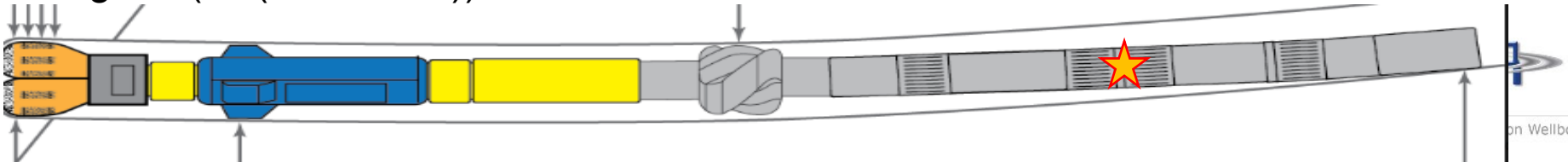
STRENGTH — Deflection of beams in bending — P 13



SAG Angle ≈ (Hole Size – Collar Size) / Length Stab to Lowside point

Deflection ≈ Weight.Length^4/384.EI

Angle ≈ (sin(inclination))^0.25



Misalignments and SAG

- Also tentatively accepted
- Want to compare to previous proposal from Pathcontrol
- Working group to compare the two
- Decide on the better solution
- Committee will accept the decision of this working group

Bottom Hole Numbers – ISCWSA#2

	MWD – ISCWSA Rev 4			MWD NEW – 100' STATIONS			MWD NEW – 300' STATIONS		
TERM	HIGH	LAT	AH	HIGH30	LAT30	AH30	HIGH100	LAT100	AH100
XYM3	6.37	10.37	9.06	2.20	2.85	2.99	3.67	4.72	4.94
XYM4	5.11	12.84	8.21	1.62	3.53	2.61	2.71	5.86	4.30
SAG'	14.13	0.77	5.95	16.94	0.42	10.82	16.97	0.42	10.82
XCLY				2.86	2.04	2.55	14.18	9.87	12.58
XCLX				1.83	4.52	3.17	8.62	22.16	14.93
TOTAL	19.12	31.67	16.52	20.12	27.84	15.41	26.15	37.17	25.11

Update to Global Mag Sources

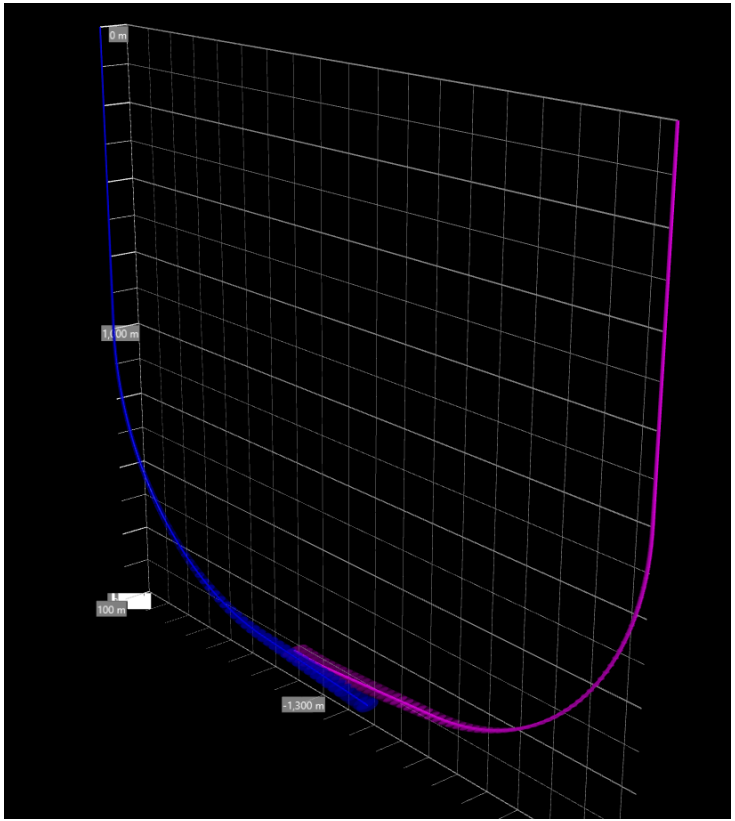
- Last meeting I presented a method to deal with non-integer correlations by adding new error sources.
- That work based on an early version of work from Stefan Maus.
- Some changes made to correlation of crustal omission errors.
- Required a number of additional sources to be added.
- For example existing DECG term replaced by 4 terms in most models
- Similar for DBH, MDI, MFI
- Existing random terms retained
- Total of possible 28 terms (compared with 8 currently)

DECG

Description	Code	Prop	WtFn	IGRF WMM	Standard Models	High Def Models	IFR1	IFR2
MWD: Declination - Global	DECG	G	AZ	0.43	0.36	0.3	0.15	0.15
MWD: Declination - Random	DECR	R	AZ	0.1	0.1	0.1	0.1	0.05
MWD: Declination Uncorrelated Errors	DEC-U	W	AZ	0.29	0.16	0.16	0.11	0.11
MWD: Declination Crustal Commission HD Models	DEC-CH	G	AZ			0.13		
MWD: Declination Crustal Commission IFR Models	DEC-CI	G	AZ				0.09	0.09
MWD: Declination Crustal Omission Standard Models	DEC-OS	G	AZ	0.24	0.24			
MWD: Declination Crustal Omission HD Models	DEC-OH	G	AZ	0.20	0.20	0.20		
MWD: Declination Crustal Omission IFR Models	DEC-OI	G	AZ	0.05	0.05	0.05	0.05	0.05
MWD: Declination - Random	DECR	R	AZ	0.1	0.1	0.1	0.1	0.05

Status

- Now fully implemented in one software
- With ISCWSA A-C Rule
- All the expected functionality is demonstrated
- Sf increases for parallel wells
- Sf decreases for opposing wells.
- Needs documentation, diagnostics and other implementation to validate.



Steps for Releasing a New Revision

- Rev4 was released 4 years ago
- Improved documentation since then
  - Create release note identifying changes
  - Update error model definition document
  - Diagnostic files
  - Update spreadsheet defining 8 ISCWSA MWD models
  - Update ISCWSA example calculation spreadsheets
- Place on website and inform all members of release
- Liaise with OWSG\Energistics

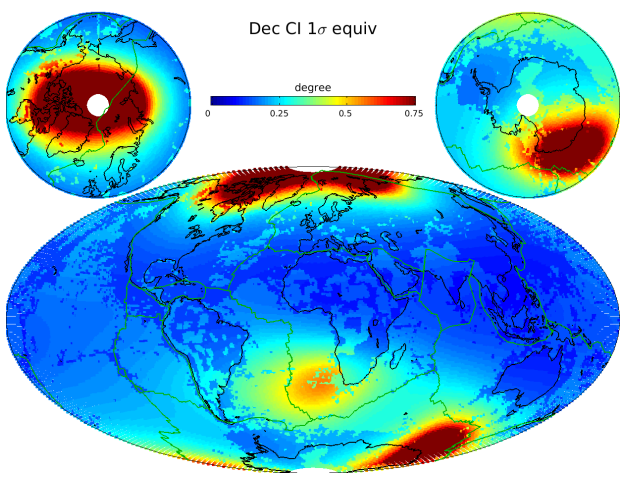
WITSML

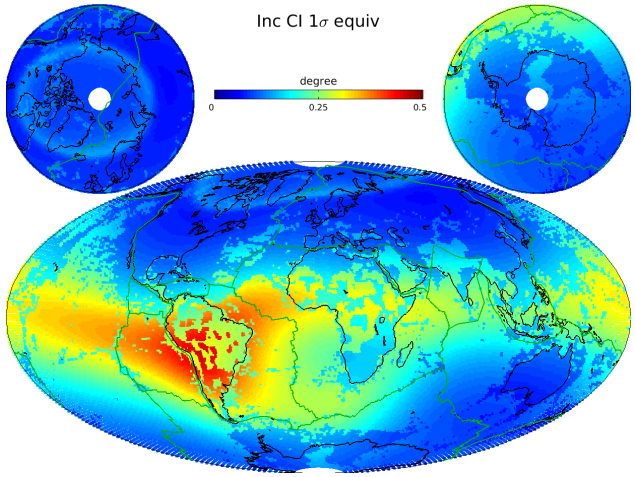
- Energistics release schedule, WITSML 2.1:
  - April: ILAB and SIG meeting
  - September: ILAB and final testing
  - Target release **Q4 2019**
  - Relies on testing
    - Resources on the horizon but commitment to be made
- Next steps
  - Documentation to be reviewed
    - Commitments made
  - Testing of read/import
    - Significant work

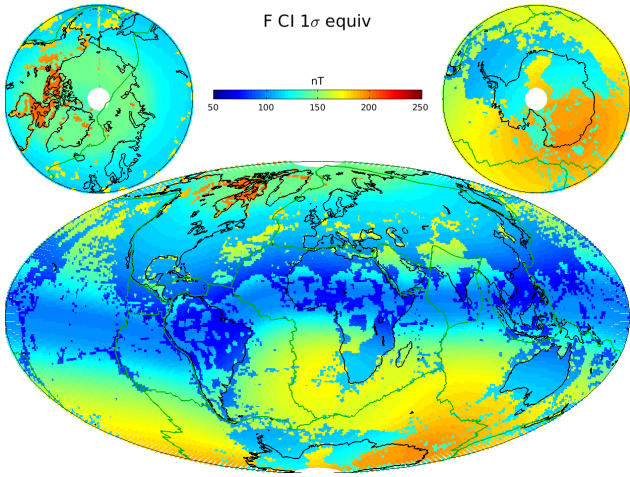
Conversion to DIF

1 sigma CI equiv. RMS	Dec (°)	Inc (°)	F (nT)
L = 1440/28 km*	0.22	0.15	91

* latitude weighted







+AX MDIG = 0.2°

+AX MFIG = 130 nT

ISCWSA Rev 4 (SPE 67616, Williamson, 2000)

Fit of ISCWSA model to D uncertainty

2-parameter model

$$Dec = \sqrt{DECG^2 + \frac{DBHG^2}{H^2}}$$

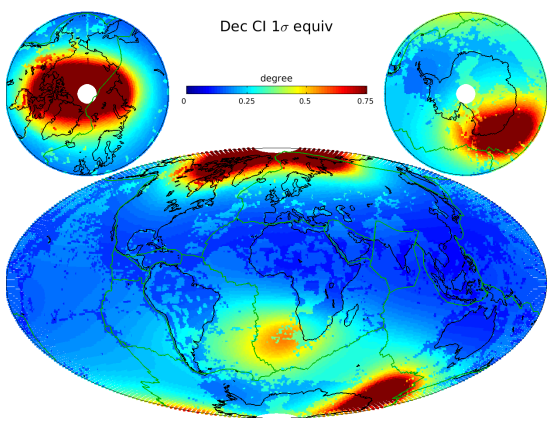
Using latest D uncertainty estimates solve (least-squares) for DECG and DBHG. Best fit:

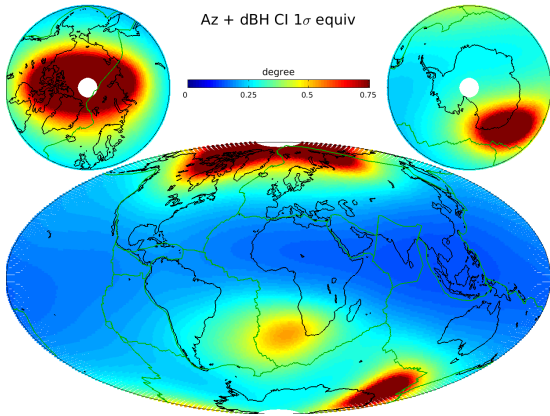
DECG = 0.07°, DBHG = 5055 ° nT

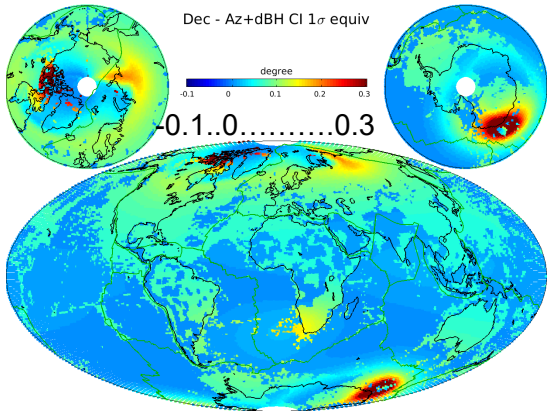
Fit not ideal as under-estimating in satellite-only area, over-estimating in N auroral zone and S. Africa

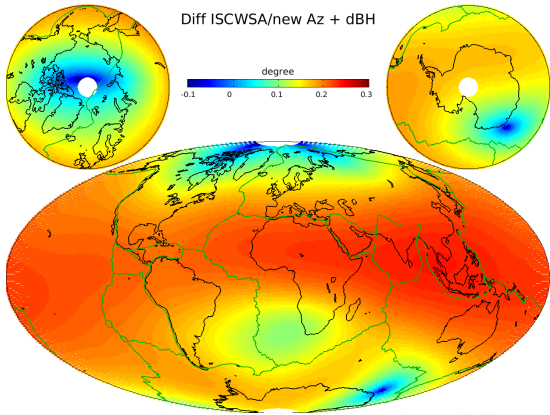
ISCWSA Rev 4 values (SPE 67616, Williamson, 2000) are:

DECG = 0.36°, DBHG = 5000 ° nT



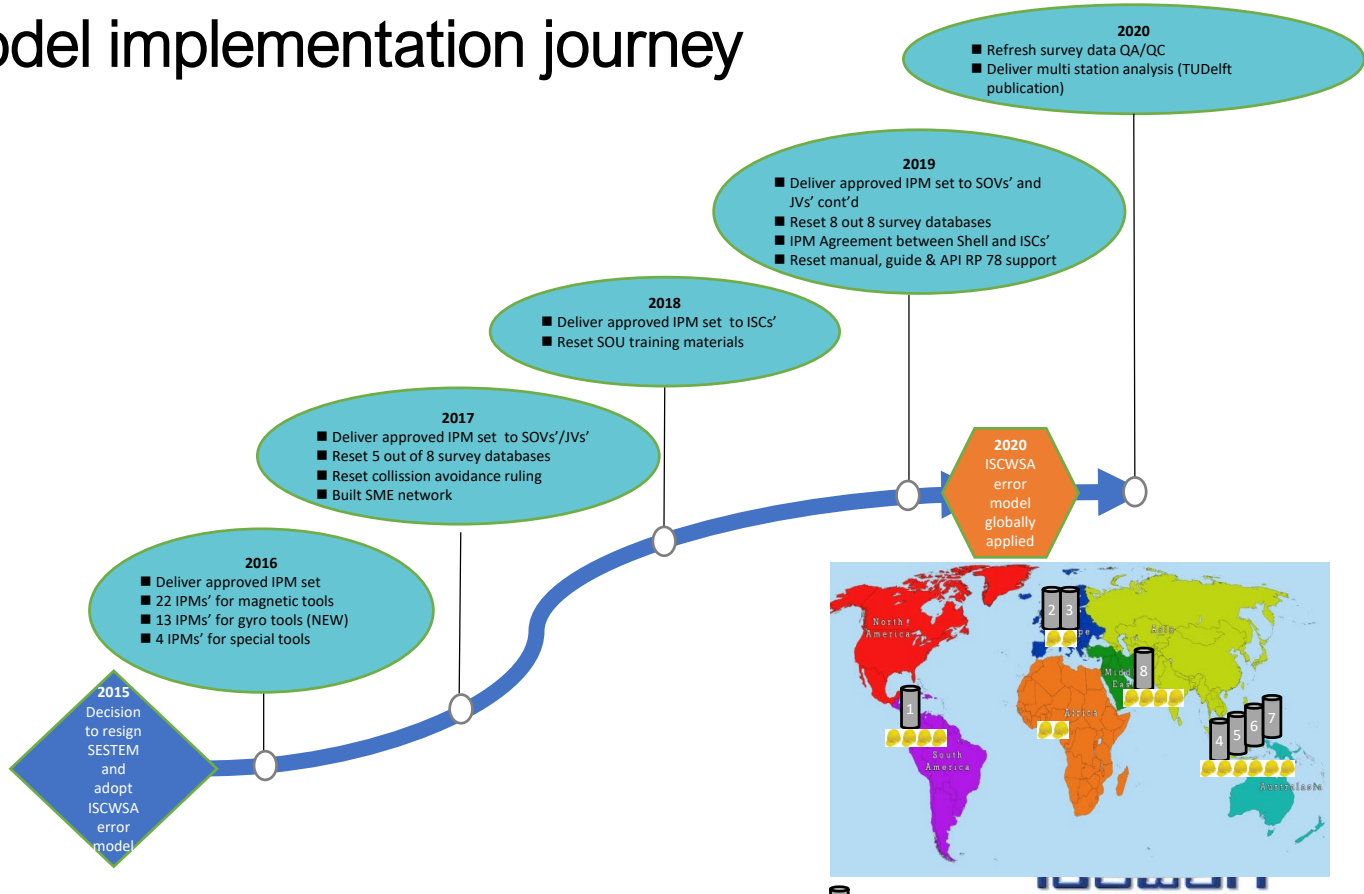






ISCWSA error model implementation journey

- Business goal
- ISCWSA error model implementation drives a significant simplification on directional well planning, collision avoidance modelling and monitoring for the SOVs' and Shell operated JVs' when working with the ISCs' on directional drilling and borehole surveying activities



Any Other Business

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