The Effect of Survey Station Frequency on Wellbore Position Accuracy

Jerry Codling

43rd General Meeting
March 4th, 2016
Fort Worth, Texas

Wellbore Positioning Technical Section

The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

Speaker Information

- Jerry Codling
- Technical Advisor
- March 4th, 2016
- Landmark Software & Services, Halliburton

Speaker Bio

- Technical Analyst, Software Developer
  - Landmark Software & Services, Halliburton
  - Since 1983, Eastman Whipstock, Sysdrill, Collins Associates, Maersk Drilling, Landmark Halliburton (21 years).
  - BSc Mining Engineering & Geology , Nottingham University
  - Location: United Kingdom
  - Applications: Compass, Wellplan, Well Costing, Analytics
    - Specialist in Directional Planning, Surveying, Anti-Collision , Time & Cost estimation, Drill string mechanics, Real time analytics
    - Studies based on Historical data analysis

Company / Affiliation Information

- Landmark Software and Services, Halliburton
- Special thanks to Scientific Drilling & Gyrodata for providing high frequency surveys
- No survey data was harmed in the making of this study

HALLIBURTON

Landmark Software & Services

Introduction

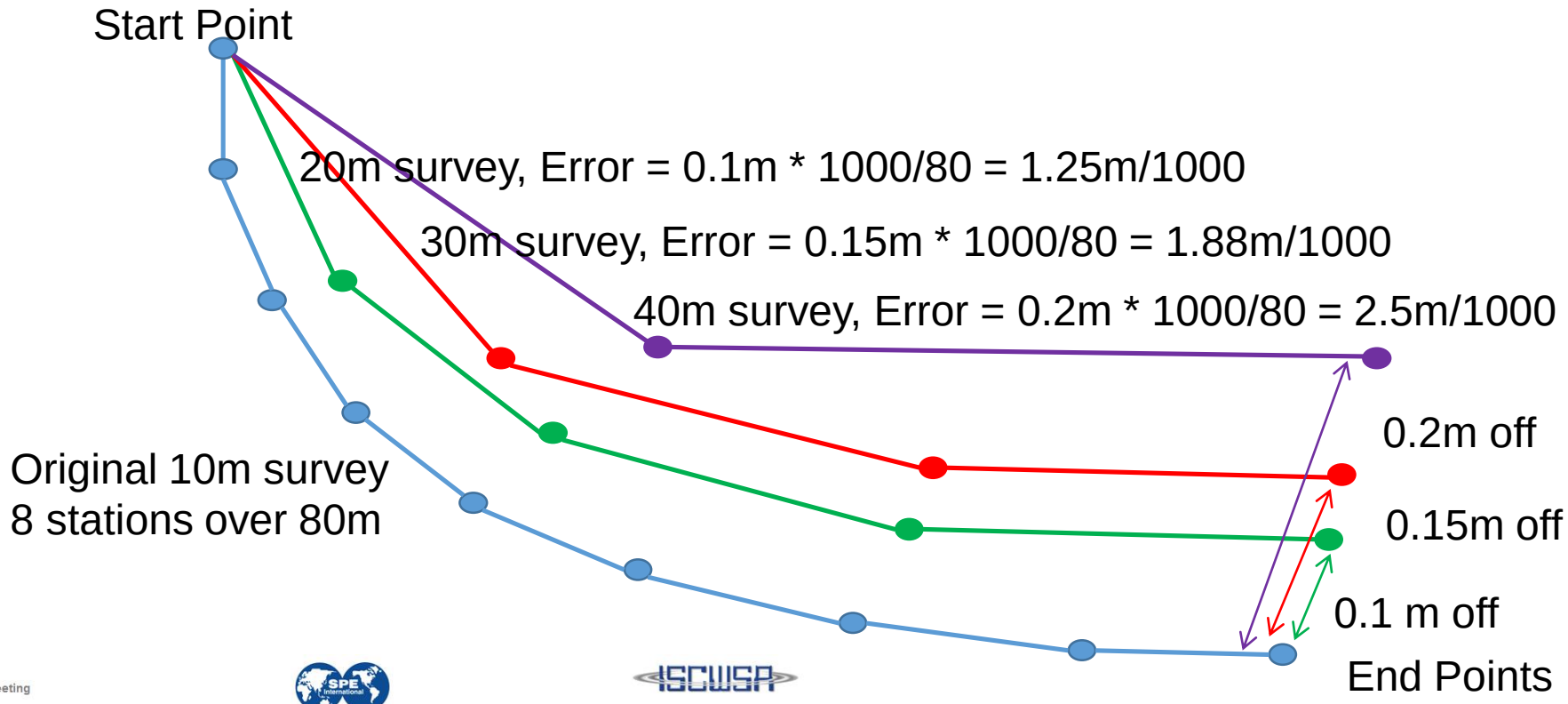
- There is concern that ISCWSA MWD error model is not sensitive to station length
- SPE67616 MWD Paper states “survey interval no greater than 100’”
- Establish the effect of survey interval length on wellbore position accuracy
- Provide systematic error terms to add to MWD error model based on station length and angle change

- Old survey data, with long intervals
- Big rigs with 120-140’ stands
- Misruns or some stations missing validation
- Pressure to survey less often – save rig time

Method Steps - Empirical

- Look at continuous Gyro surveys with stations reported at 10-30’ (5-10m) regular intervals
- Remove alternate stations, calculate the survey and note the difference in bottom location
- Divide by run length and present as Error / 1000 – Graph the results
- Compute trend line, repeat for other lengths
- Correlate to angle change (dogleg) and length

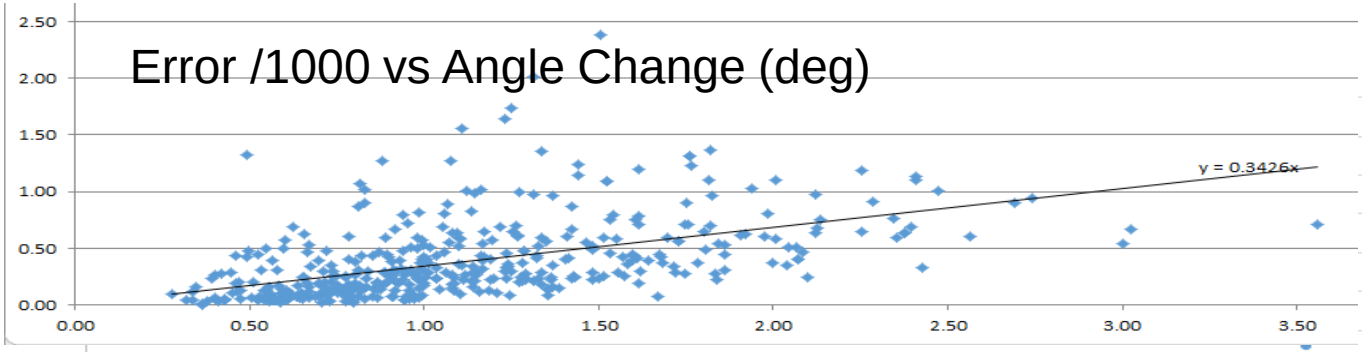
Method Illustrated

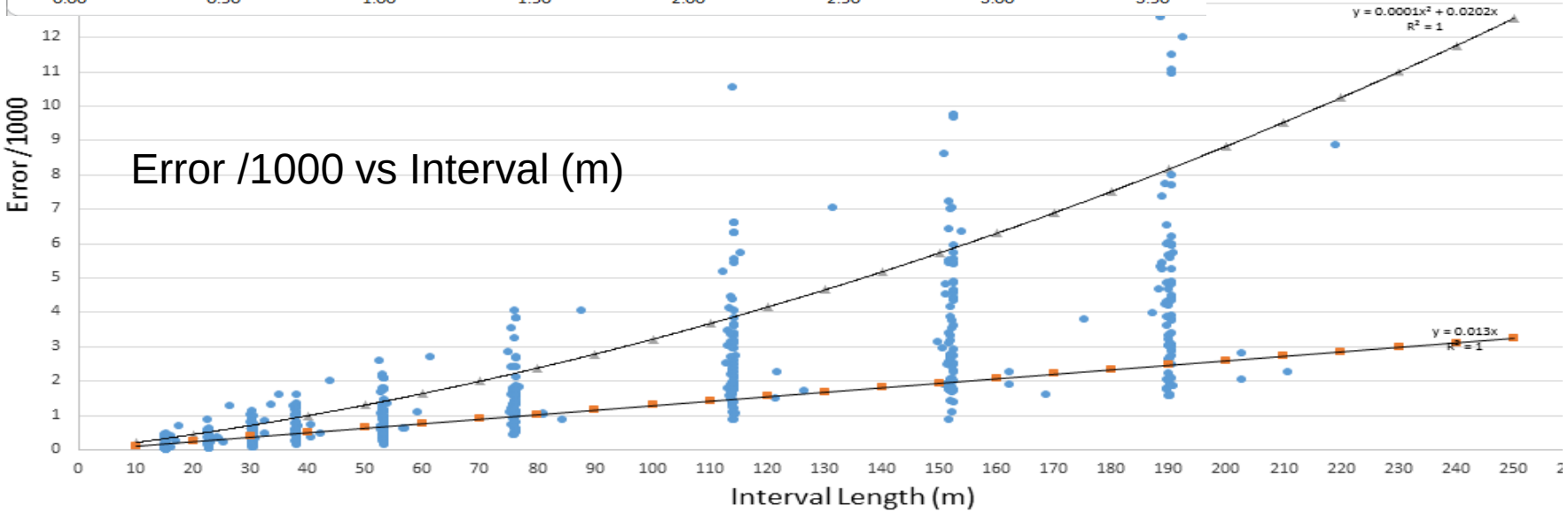


Continuous Gyro Surveys 10-20’

- 51 FINDS Inertial tool run till 1985 (1700m)
- 90 RIGS Ring Laser Gyro 1985-2000 (2200m)
- 106 Continuous Gyros: Gyrodata, SDI Finder/Keeper, GCT, UK North Sea (2900m)
- 57 SDI Continuous Gyros: Norway (2800m)
- 80 Drill Pipe Gyros Horizontal pump down (2800m)
- 24 SDI Drill Pipe Gyros run in 3 ½” drill pipe (1350)
- 53 Gyrodata 3m, some 1m surveys (2000m)

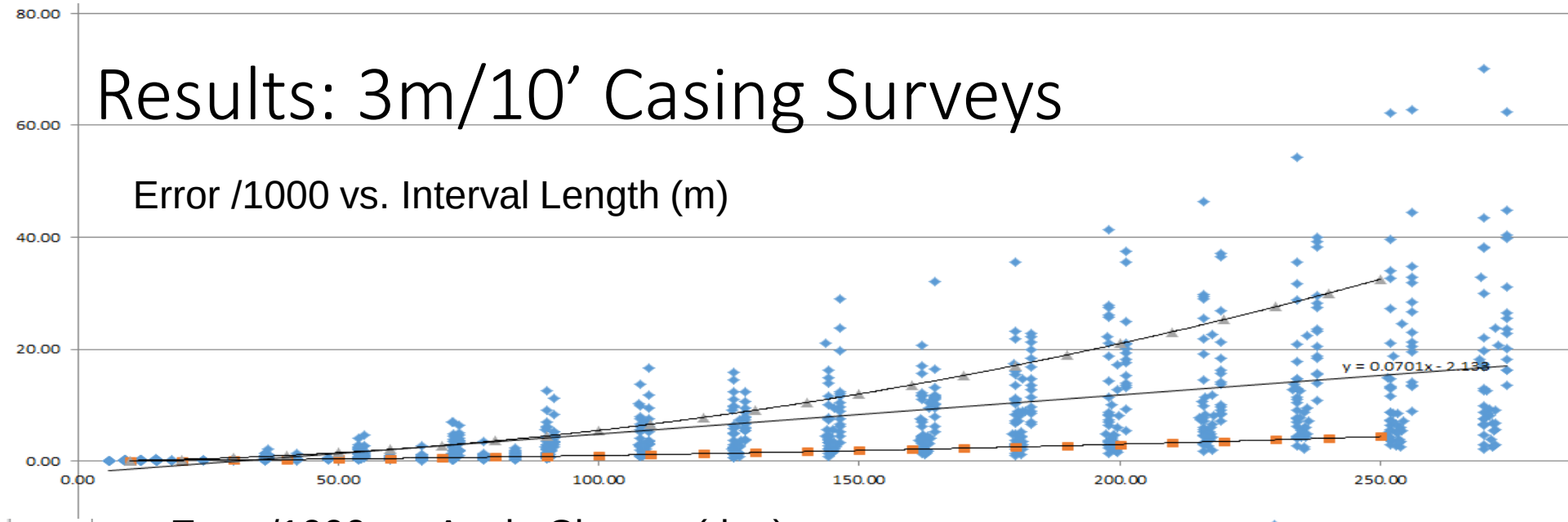
Results: Horizontal Pump Down Gyros



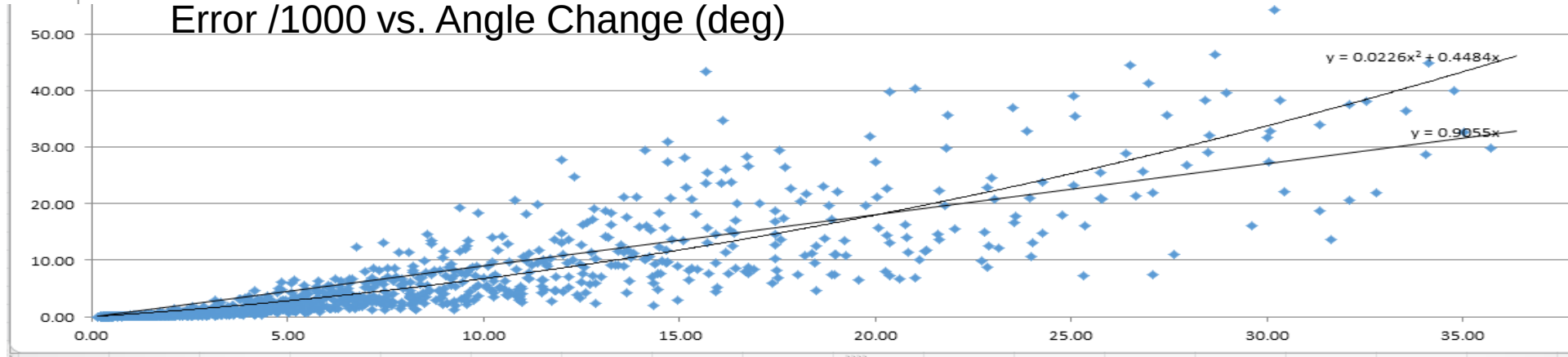


Results: 3m/10’ Casing Surveys

Error /1000 vs. Interval Length (m)

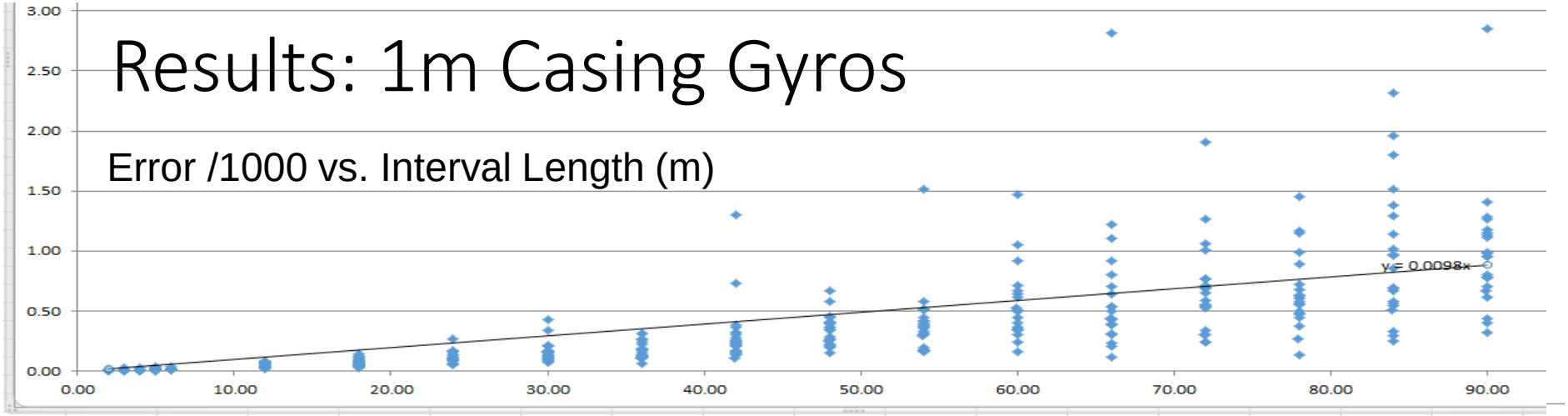


Error /1000 vs. Angle Change (deg)

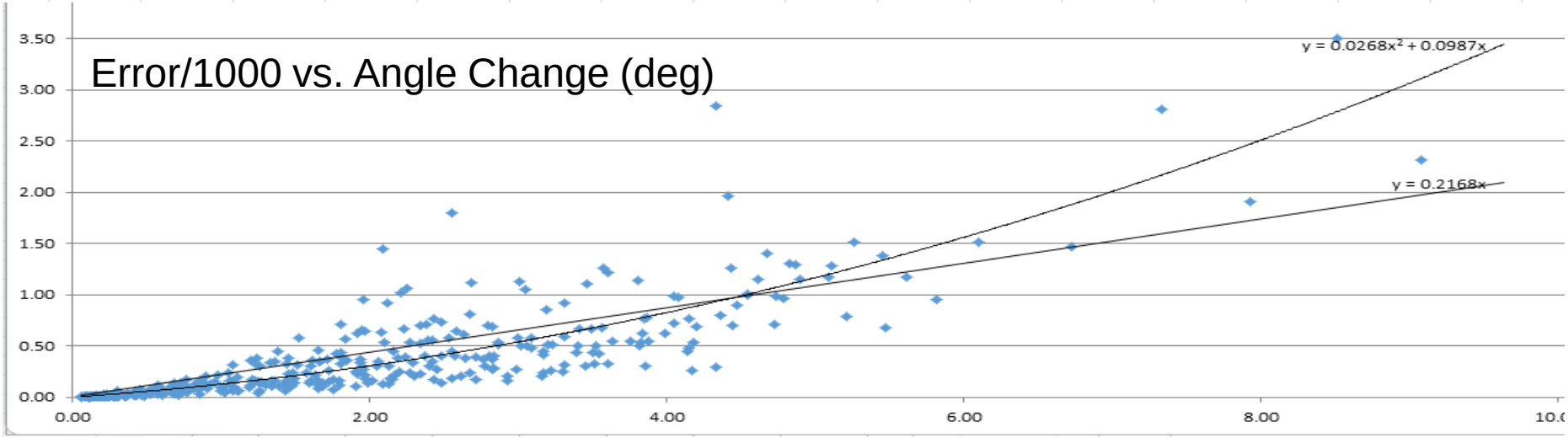


Results: 1m Casing Gyros

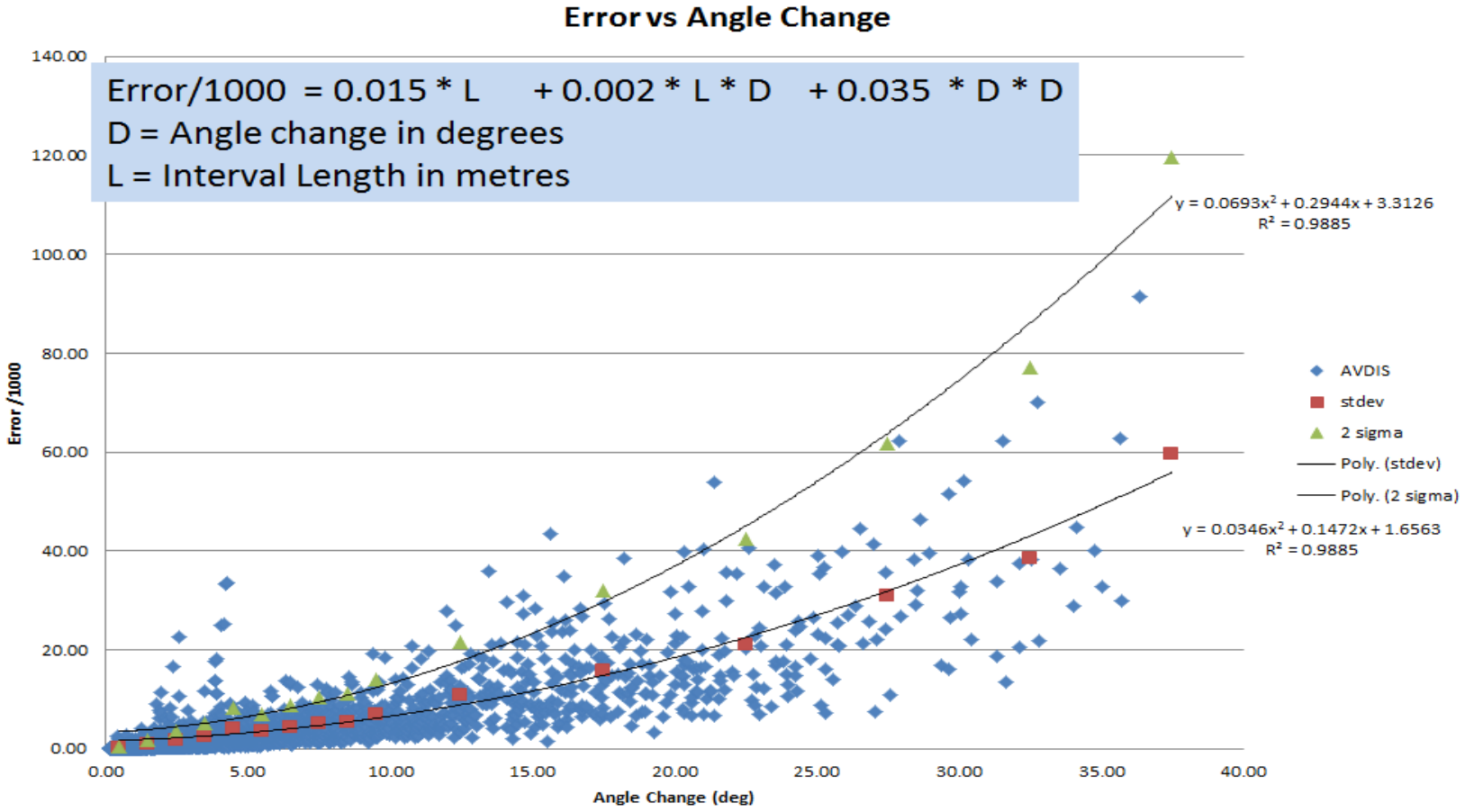
Error /1000 vs. Interval Length (m)



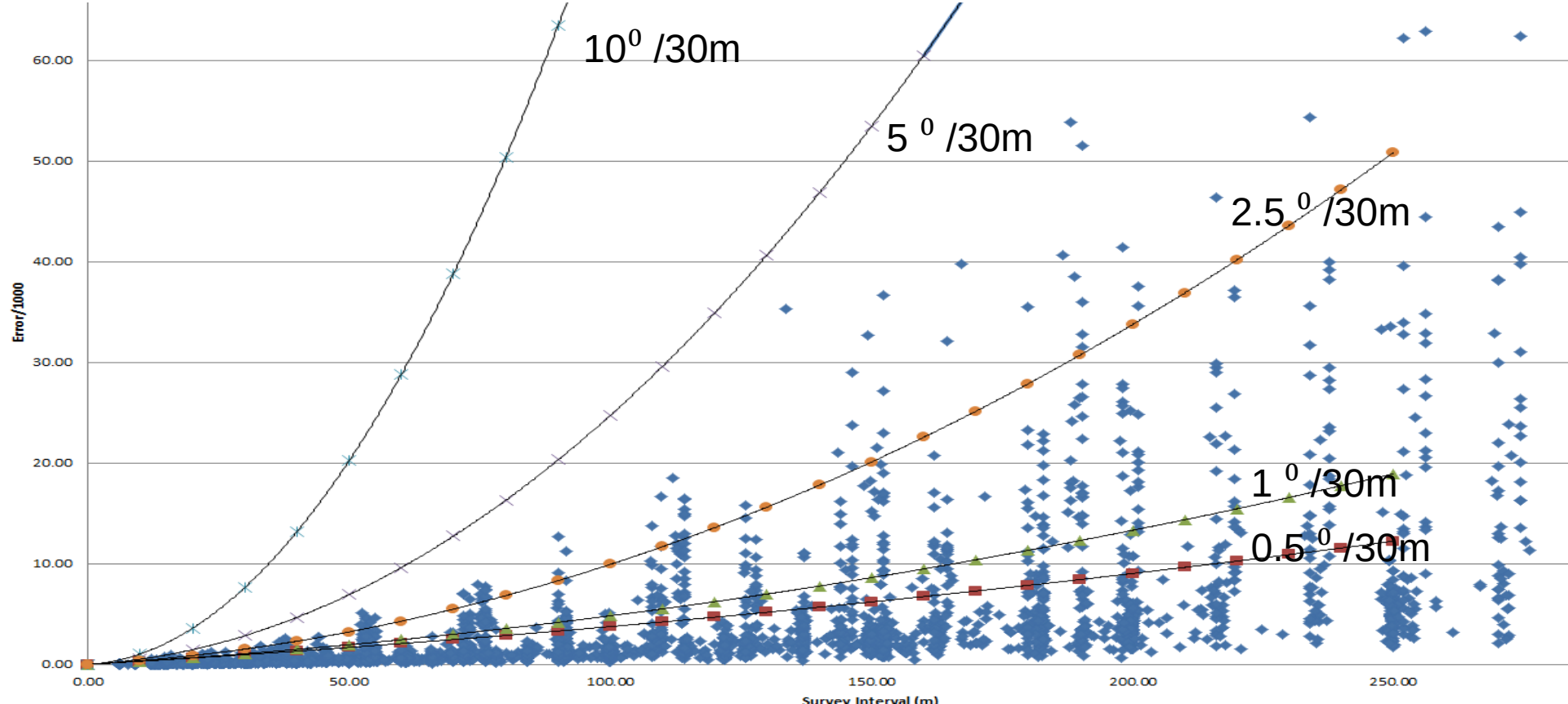
Error/1000 vs. Angle Change (deg)



Analysis: Convert to Standard Error

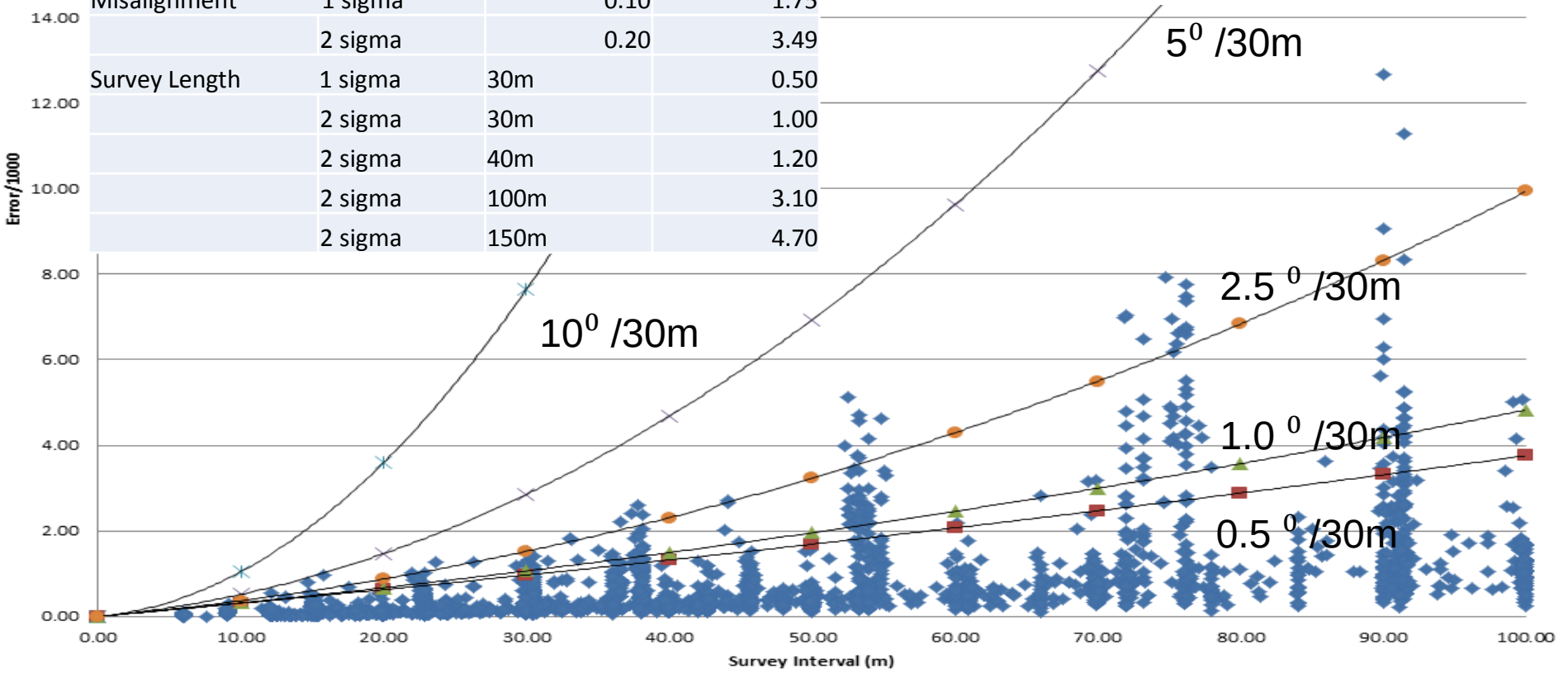


Analysis : 2 Sigma Errors ~ 95%



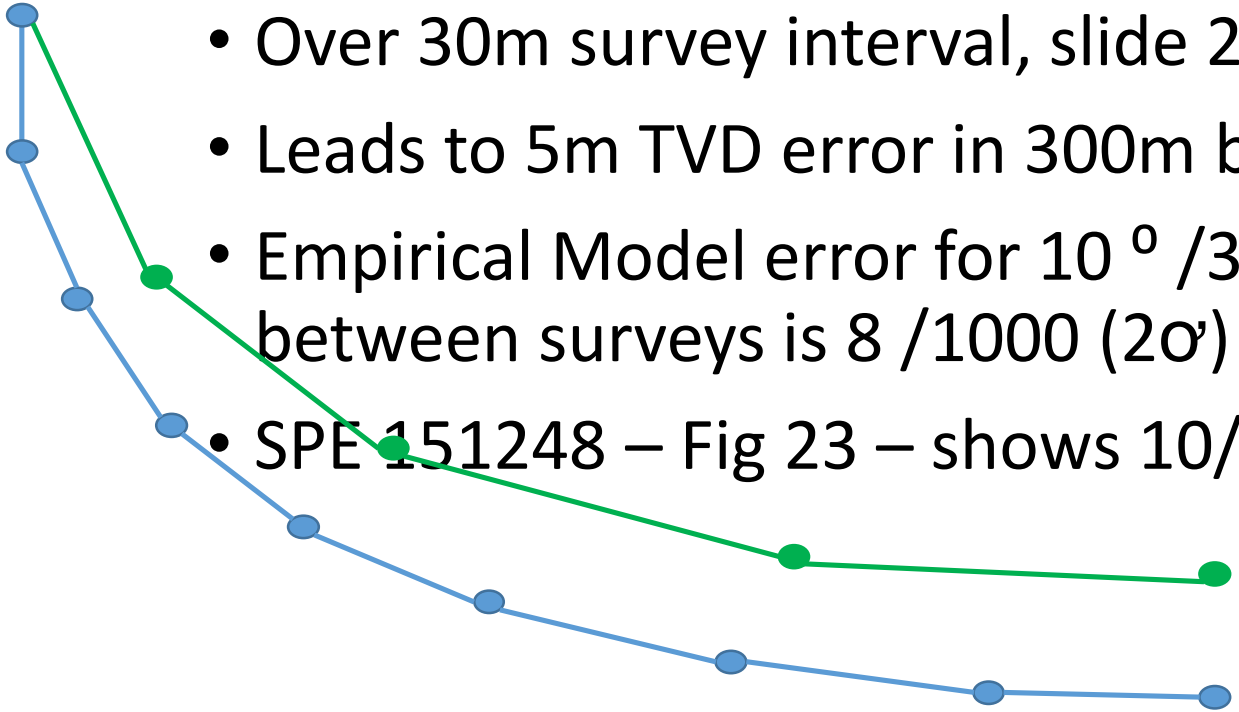
Analysis : 2 Sigma Errors 0-100m

Error Comparison at 0.5/30m		deg	X/1000
Misalignment	1 sigma	0.10	1.75
	2 sigma	0.20	3.49
Survey Length	1 sigma	30m	0.50
	2 sigma	30m	1.00
	2 sigma	40m	1.20
	2 sigma	100m	3.10
	2 sigma	150m	4.70

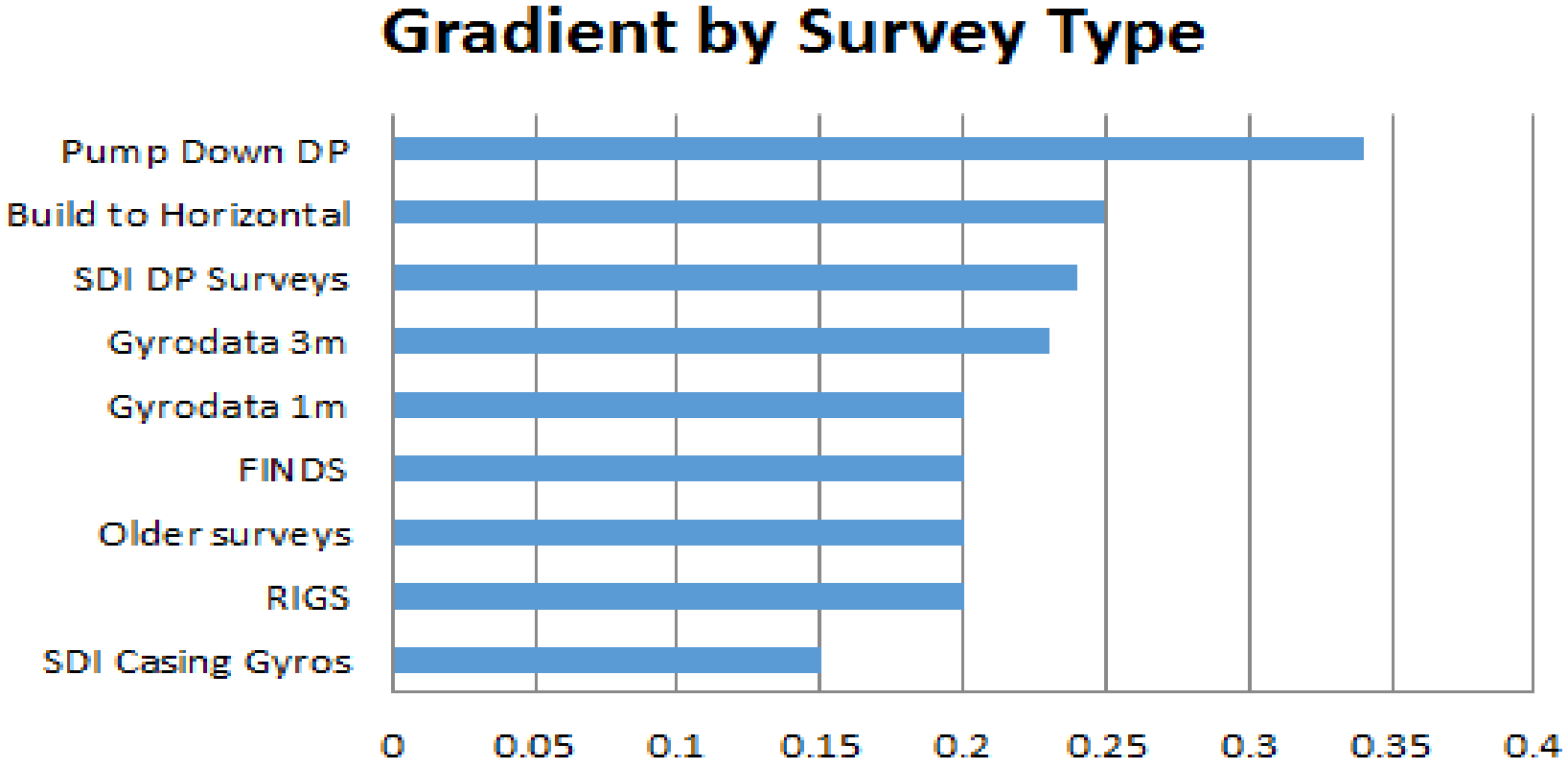


Example: Slide Rotate to 90º in 1000’

- Its not a worst case model: For comparison,
- Over 30m survey interval, slide 2, rotate 1
- Leads to 5m TVD error in 300m build
- Empirical Model error for 10 º /30m build at 9º between surveys is 8 /1000 (2º)
- SPE 151248 – Fig 23 – shows 10/1000 (2º)



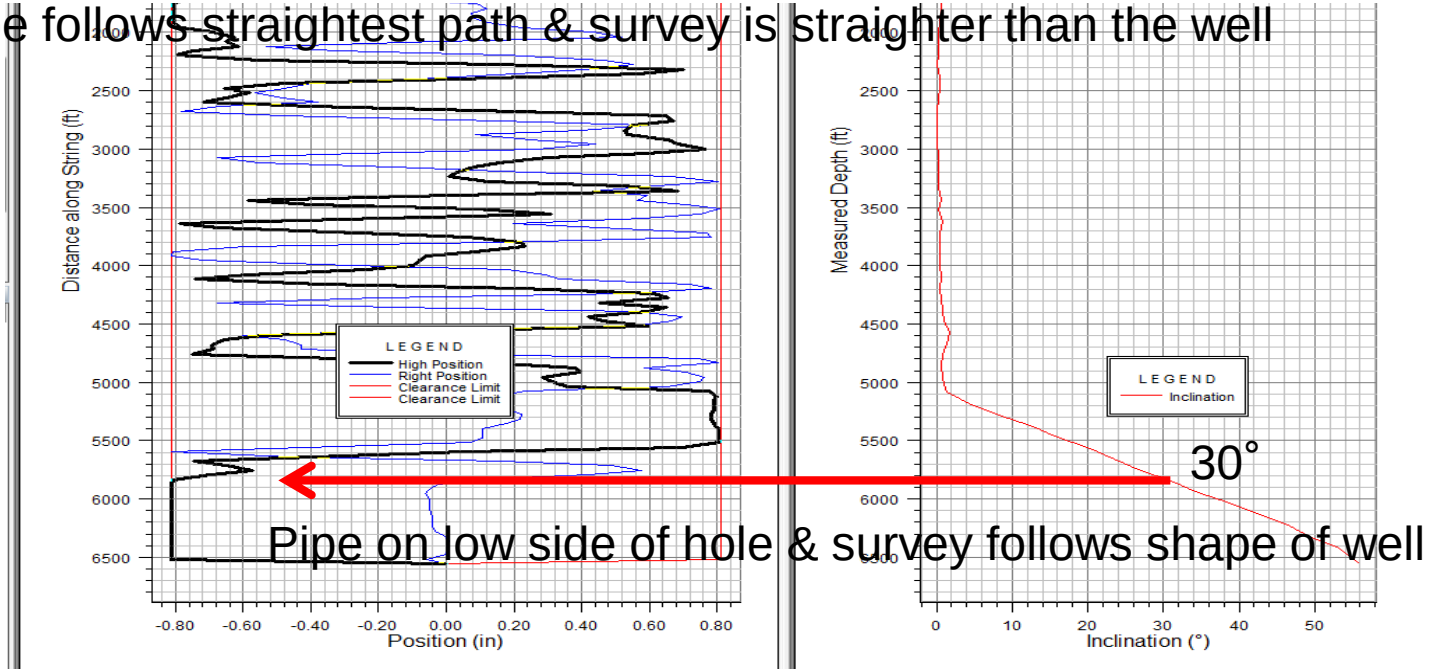
Results - Comparison



Casing Surveys - Smoothing

- Casing Gyros above 30 degrees, seem to be more sensitive.
- Angles above 30 degrees casing sits on low side
- Angles below 30 degrees casing finds straightest path

Pipe follows straightest path & survey is straighter than the well



Pipe on low side of hole & survey follows shape of well

Error Terms – For ISCWSA MWD Model

- These terms are systematic
- Not like any existing weighting function
- 0.25 *abs(din)/dtr
  - Din = change in inclination over station
  - Daz = change azimuth over station

#Name	Vector	Tie-On	Unit	Value	Formula
drfr	e	r	m	0.35	1.0
drfr	s	r	m	2.2	1.0
drfs	s	s	m	1	1.0
dsfs	e	s	-	0.00056	tmd
dstg	e	g	im	2.5e-007	tmd*tvd
clin	i	s	t	0.25	abs(din)/dtr
claz	a	s	t	0.25	abs(daz)/dtr
w_12	n	n	-	1	sin(inc)
w_34	n	n	-	1	sqrt(1-(w_12)^2)
xym1	i	s	d	0.1	w_12
xym2	l	s	d	0.1	w_12

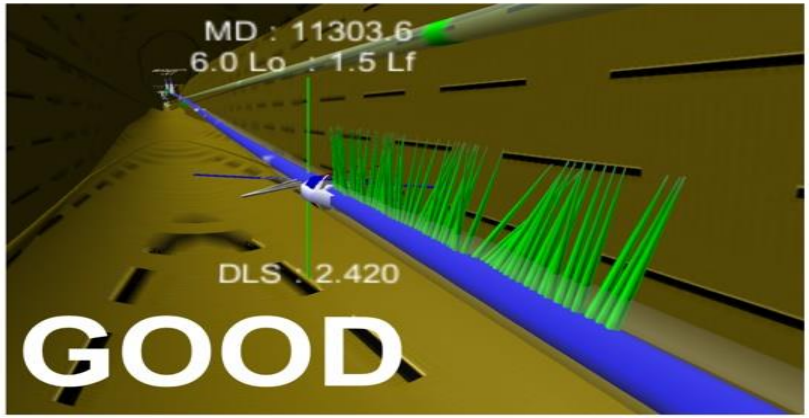
These are example terms in the Compass IPM format…

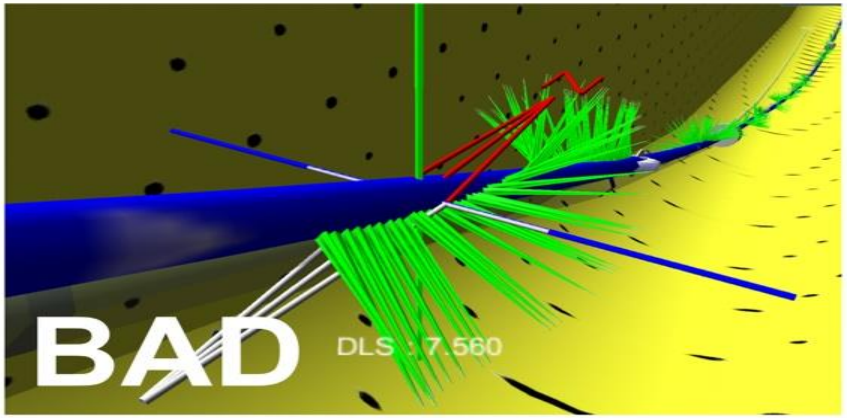
Warning: These are example terms and don't reflect the current function

Conclusion

- Publishing error terms for infrequent stations may lead to abuse. Its not as bad as expected
- Scope of study is for intervals of 20m to 250m.
- Study is empirical and statistical based on historic data – its not an exclusion zone
- Error terms will be defined in the ISCWSA SPE 67616 format.
- Its different for plans – use minimum tortuosity of 0.5/30m – no well is straight!

Guidance System Slide Tracking/Visualization





Not All Slides Are Created Equal!

- **Eliminate unnecessary tripping.**
- **Visual transparency**
- **Automated slide tracking/grading**
- **Improved operational efficiency.**