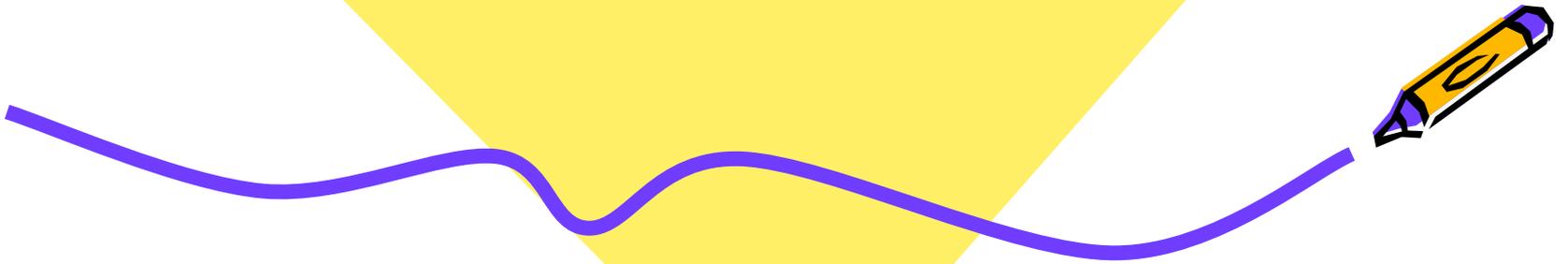


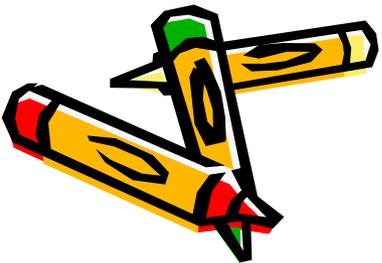
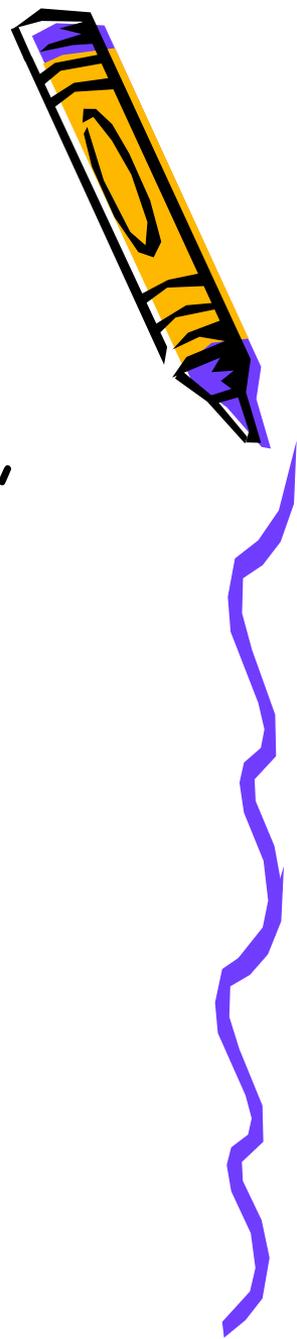
MWD Overview

Steve Grindrod

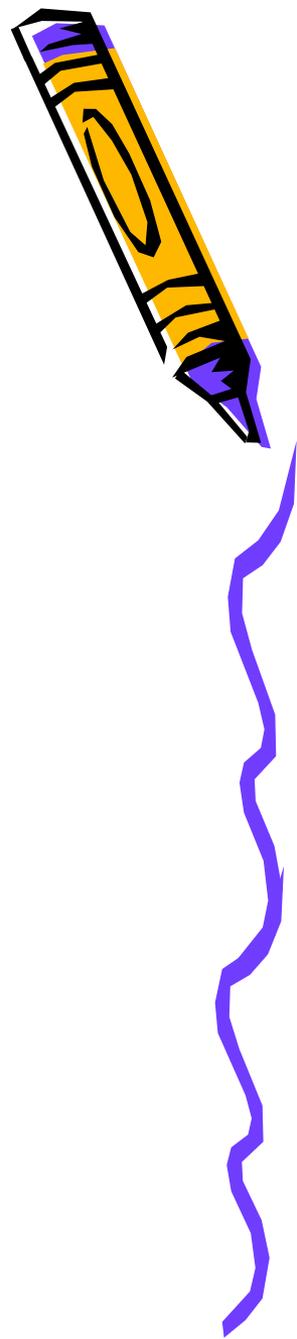
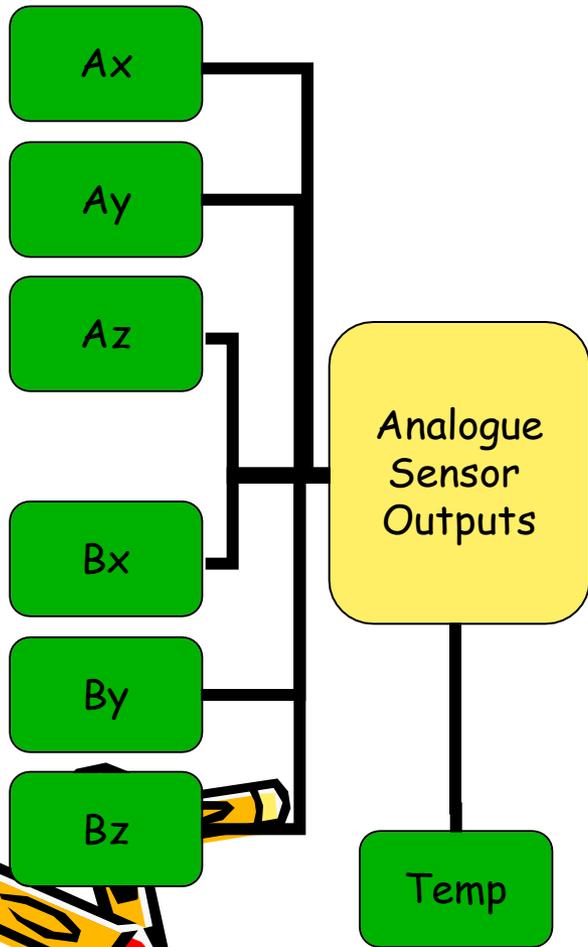


MWD Objective

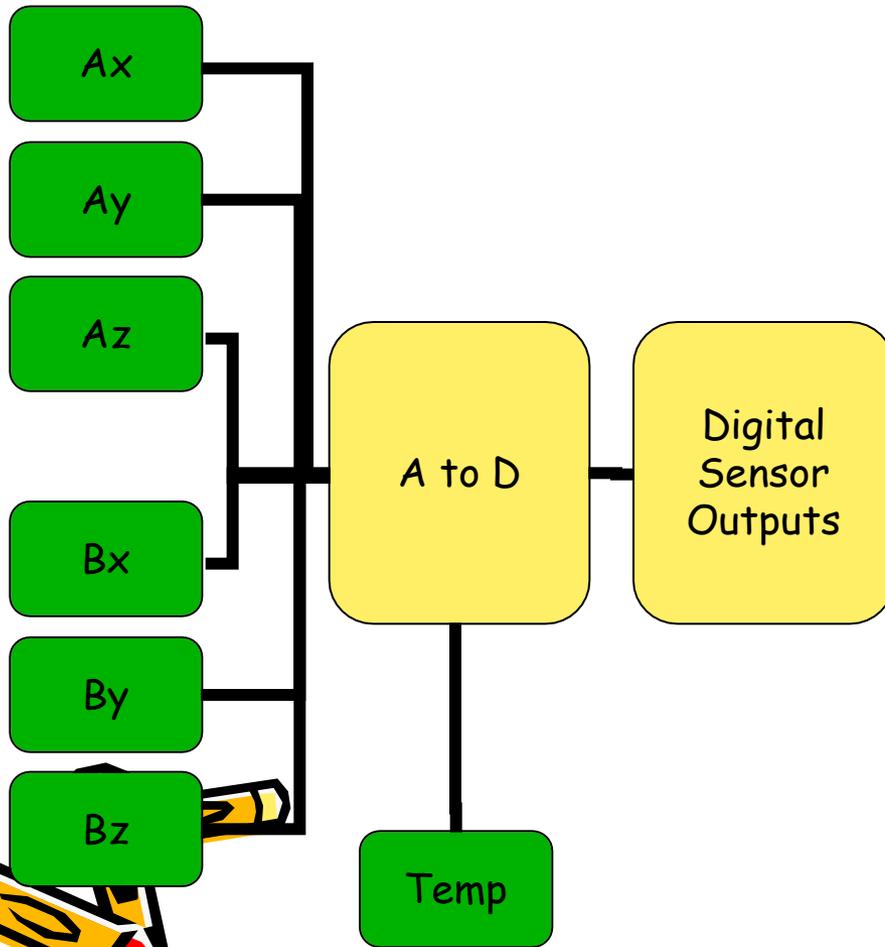
- Get downhole Inclination, Azimuth, Toolface and Data Quality to Directional Driller as quickly as possible.



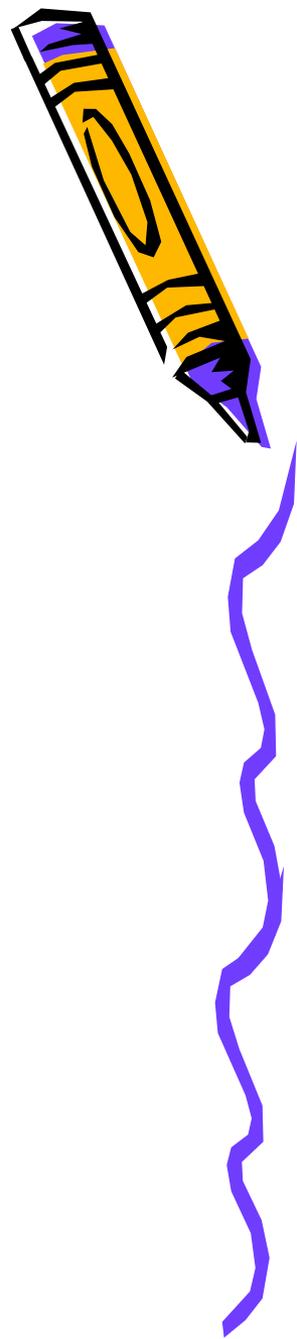
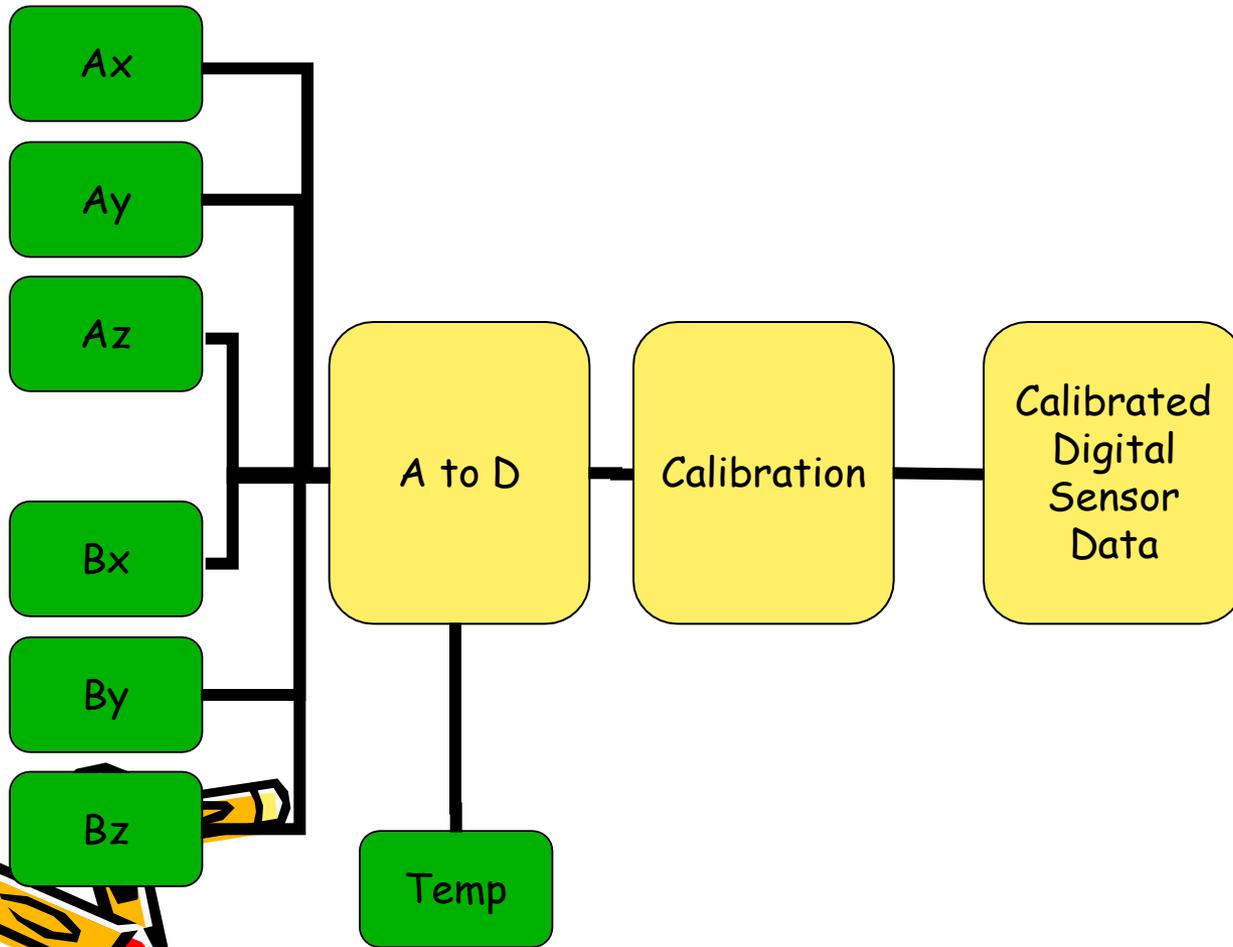
Analogue Sensors



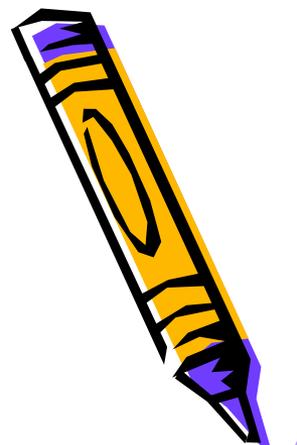
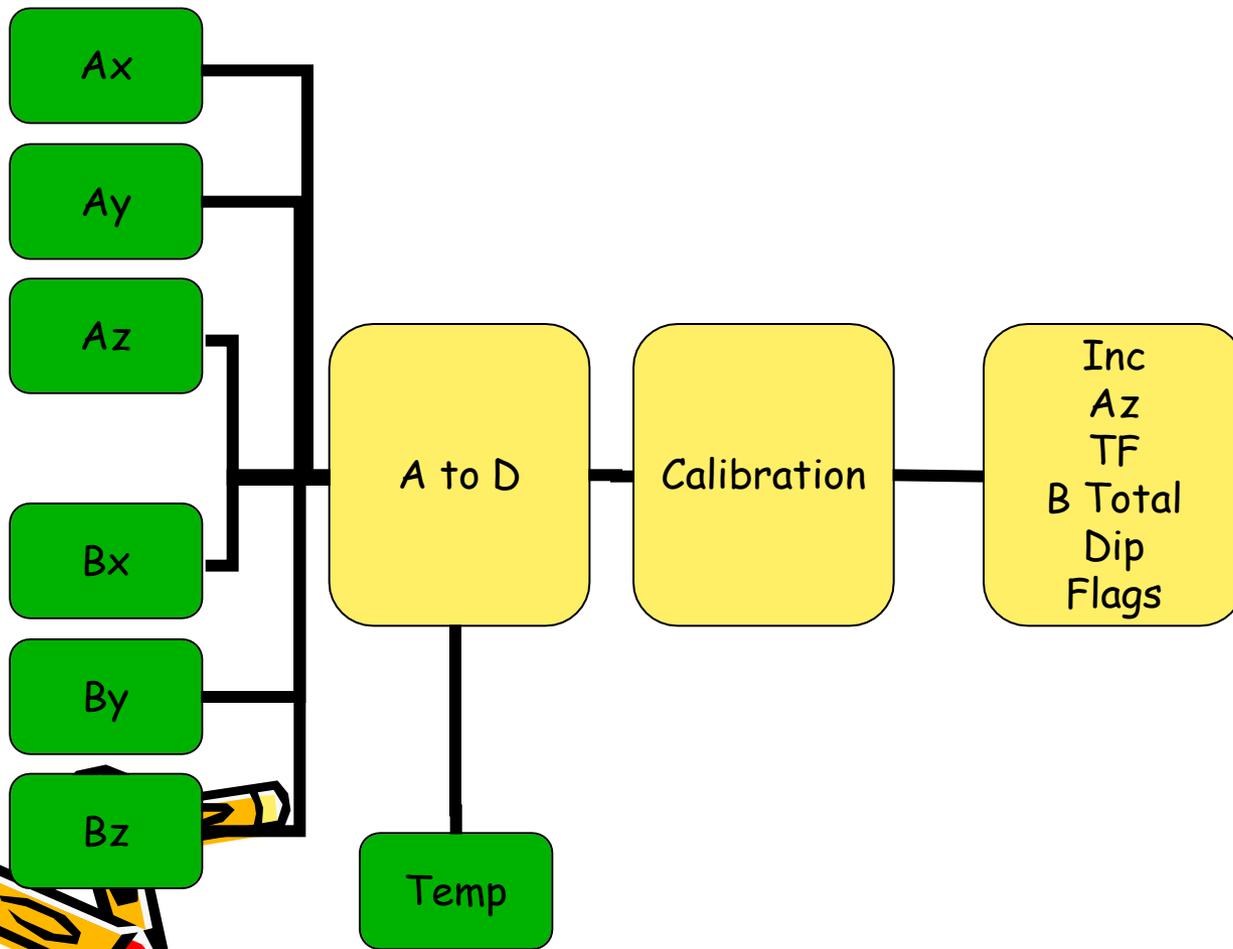
Real Raw Data



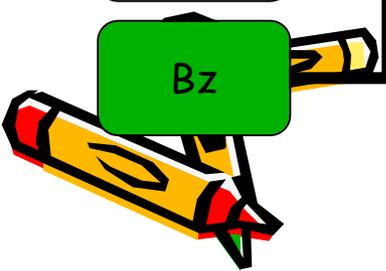
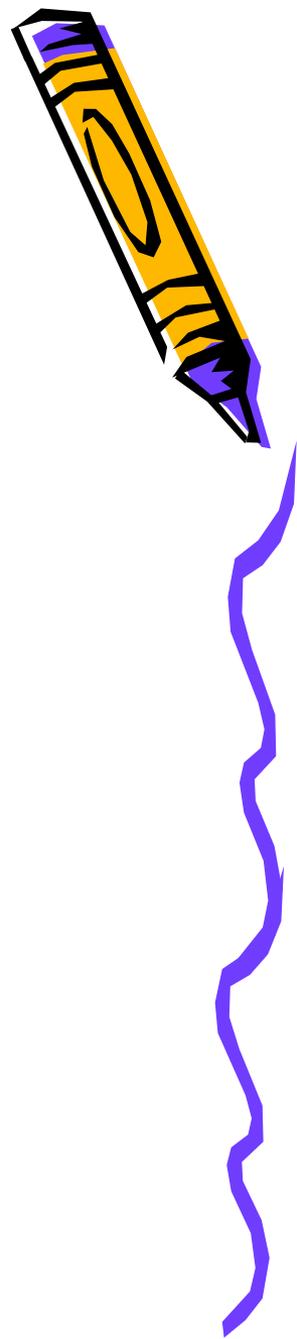
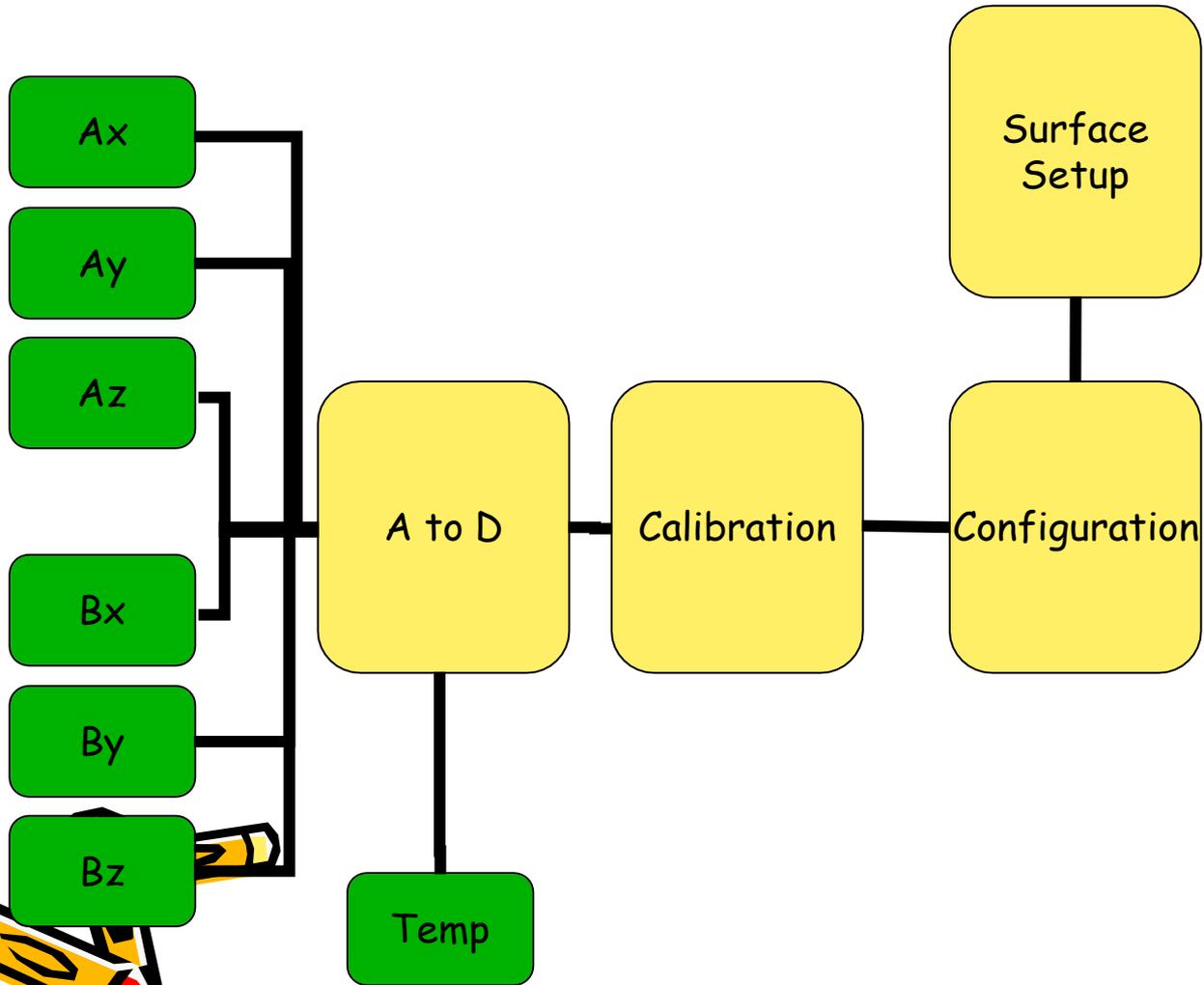
Raw Data



Calculations

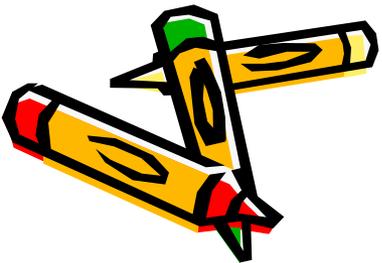
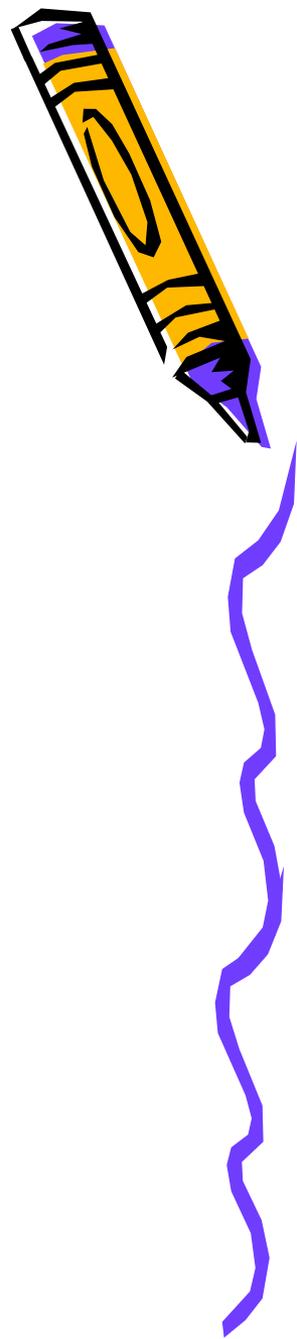


Surface Setup



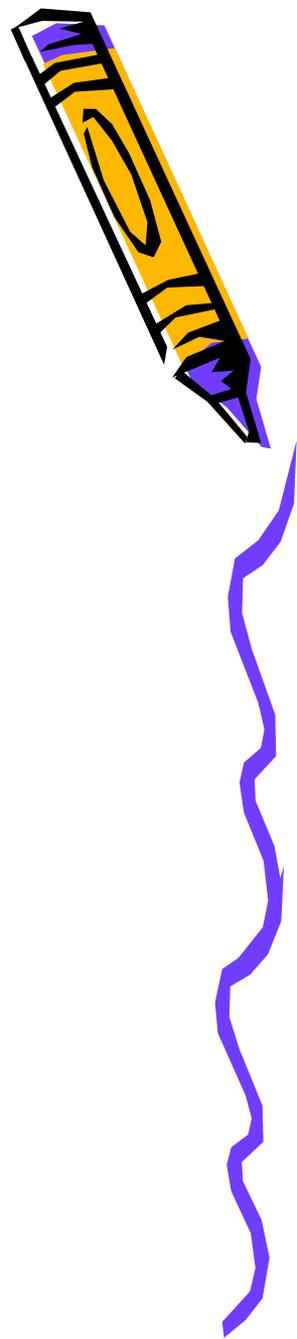
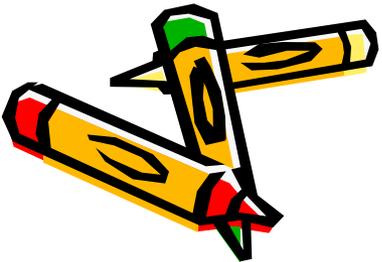
Minimum Survey

- Inclination
- Azimuth
- Toolface
- Data Quality Flag

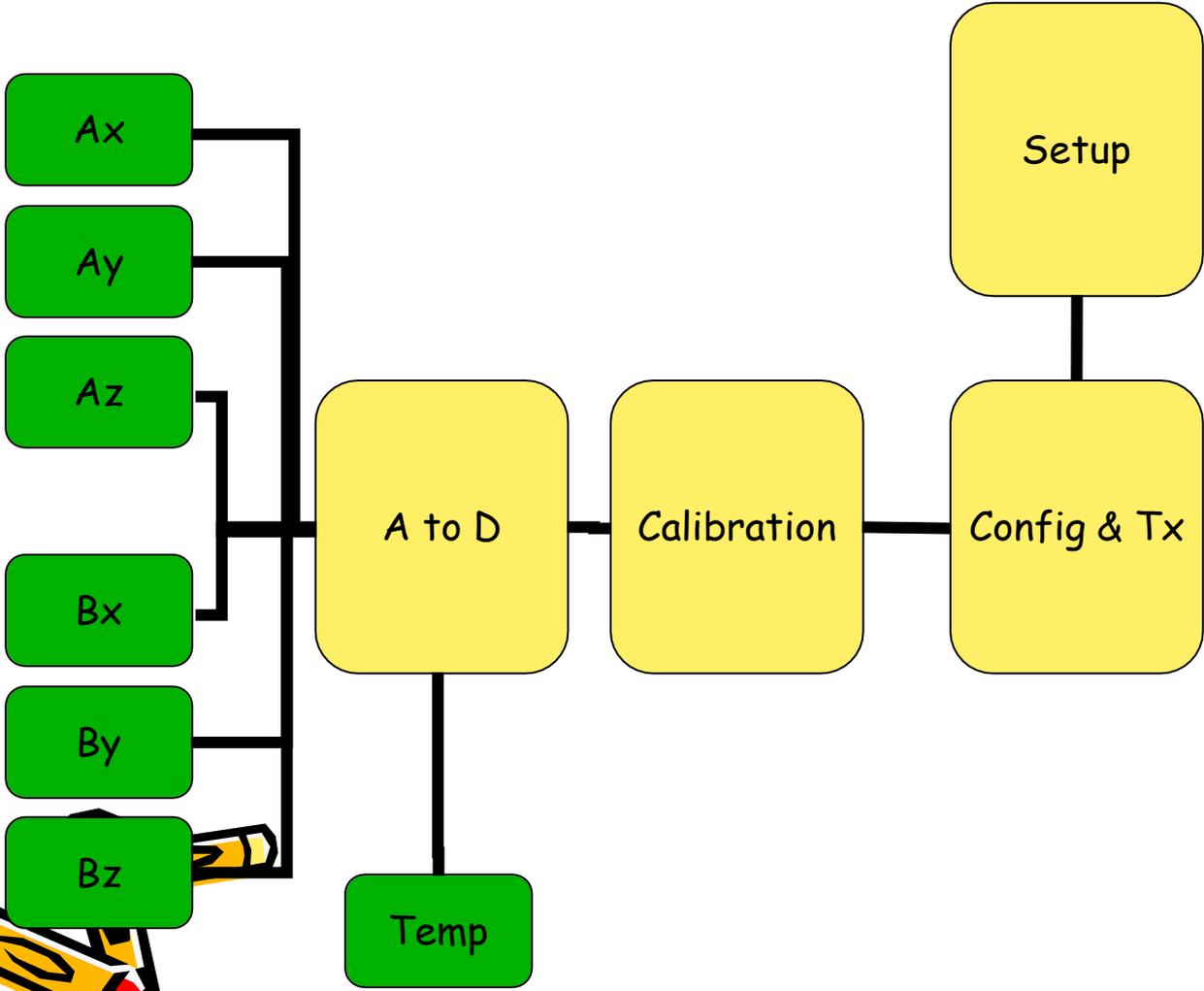


Long Survey

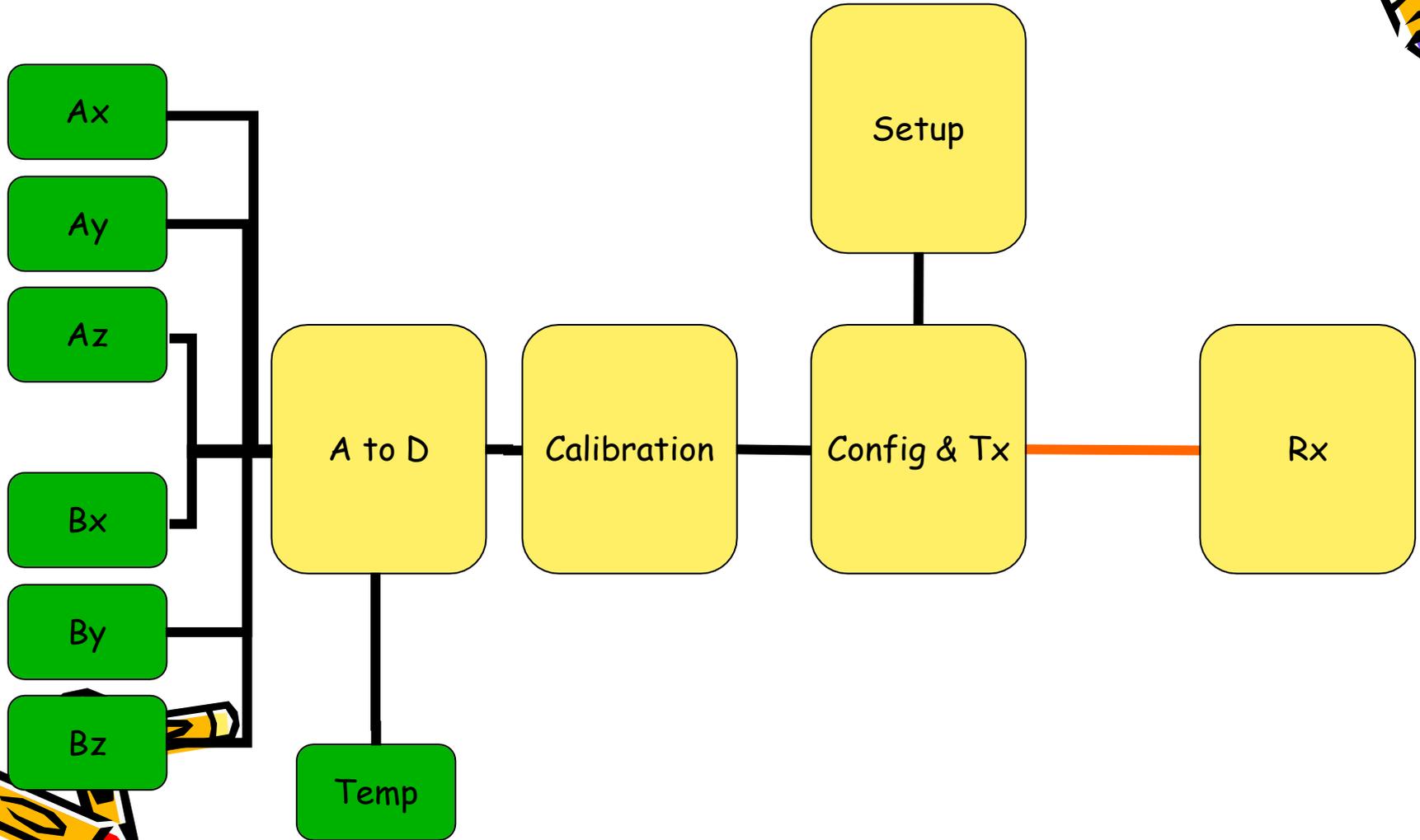
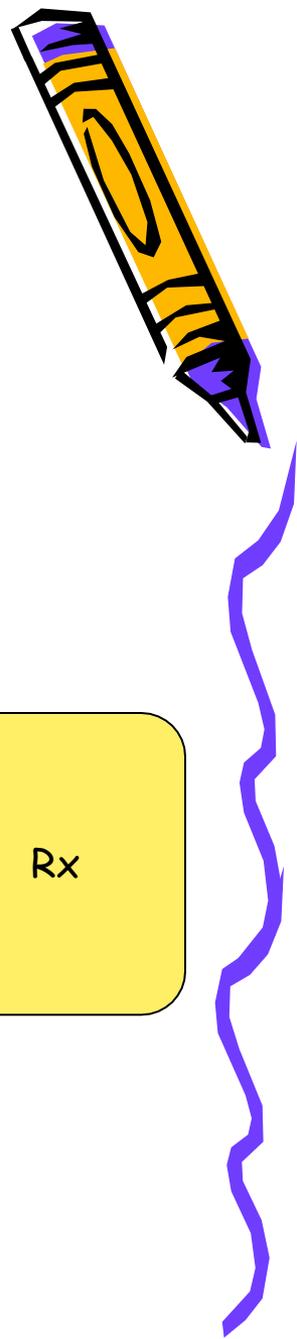
- Ax
- Ay
- Az
- Bx
- By
- Bz



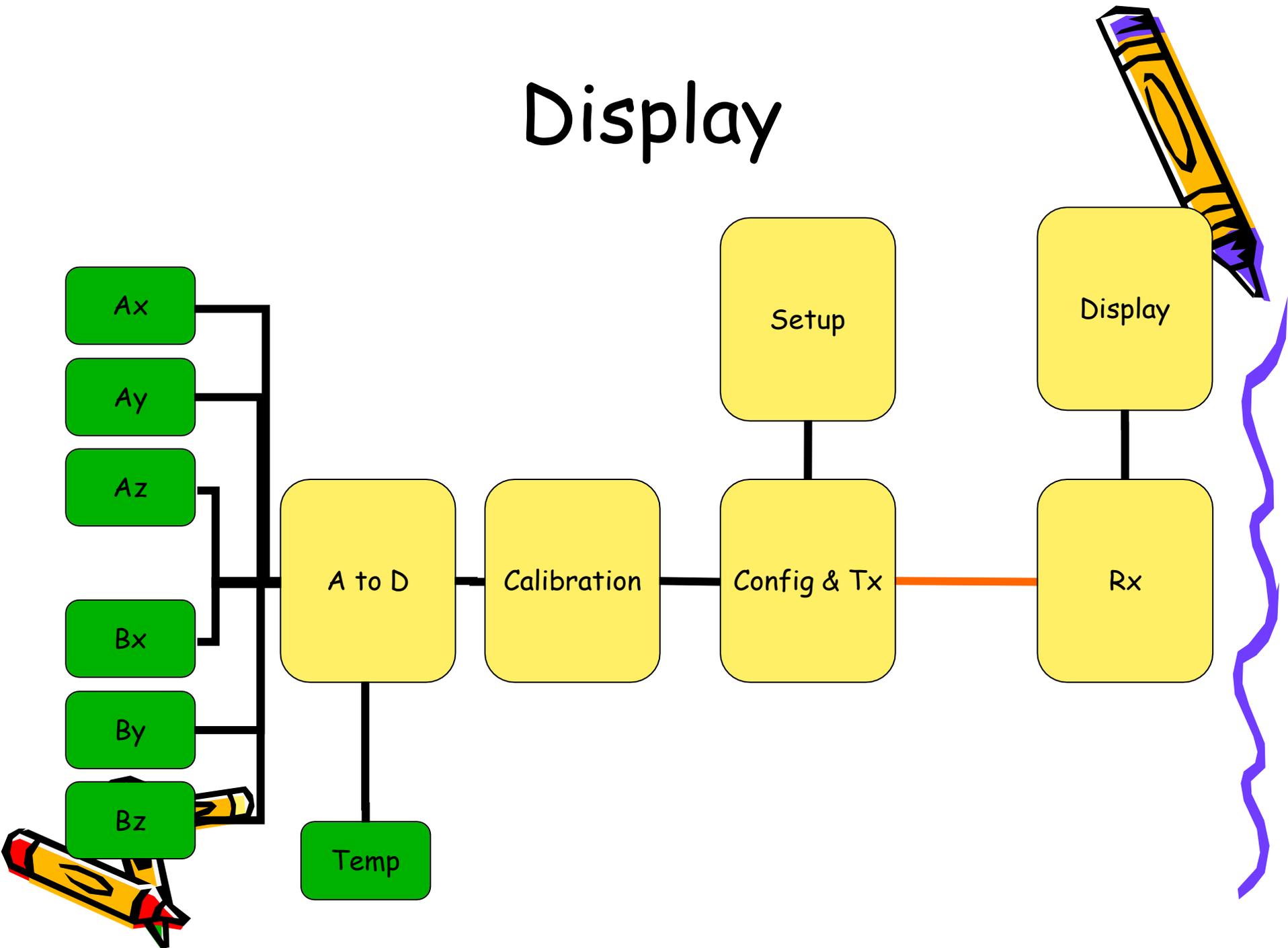
Encoding and Transmission



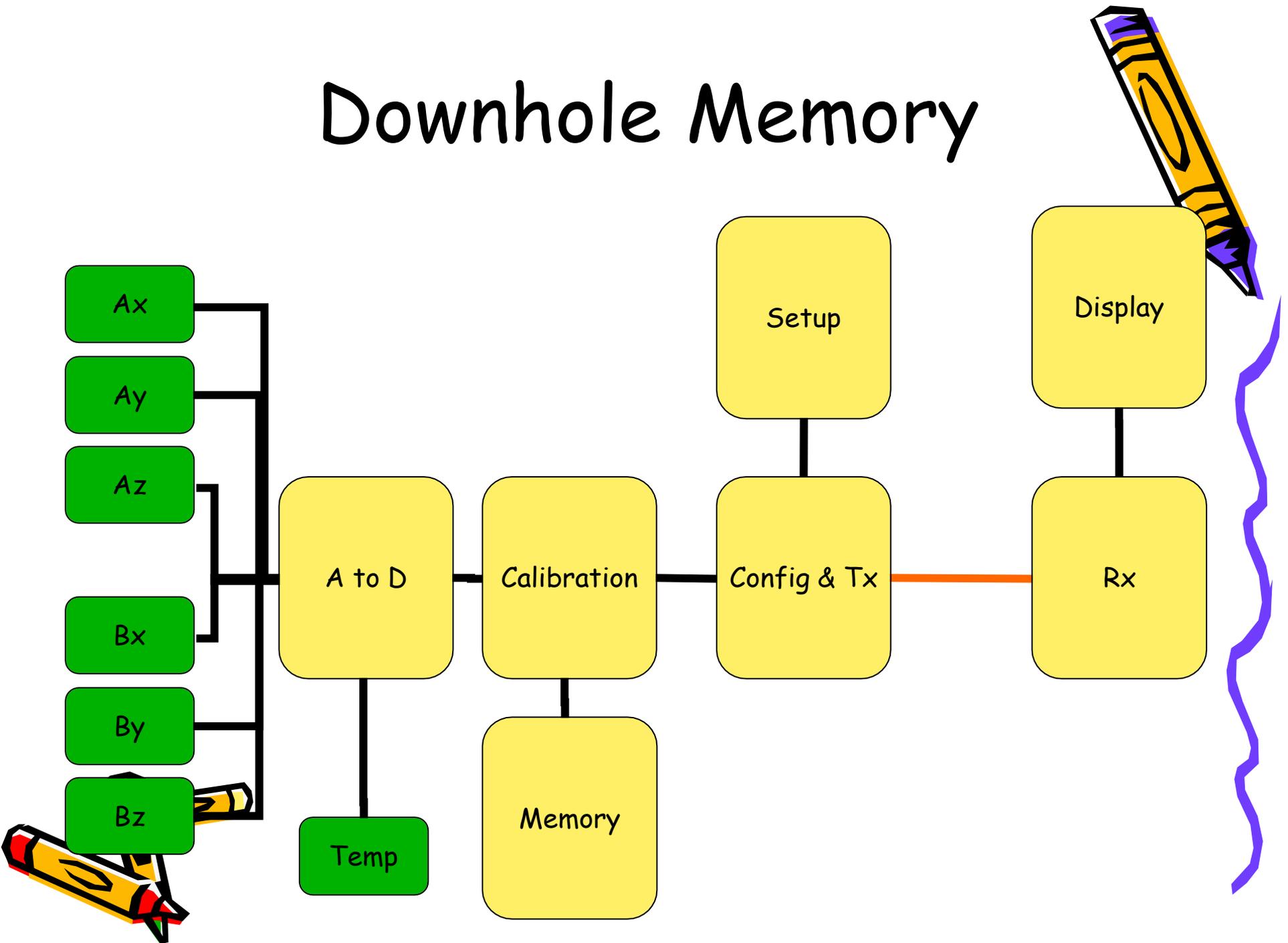
Receiving and Decoding



Display

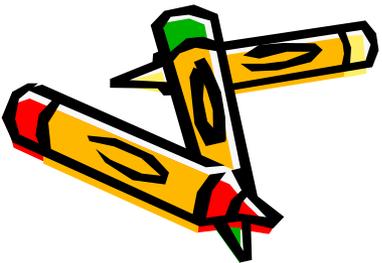
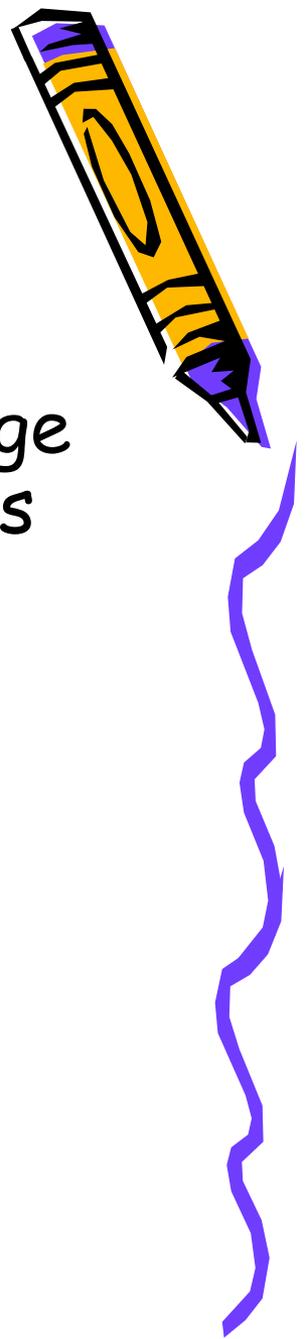


Downhole Memory

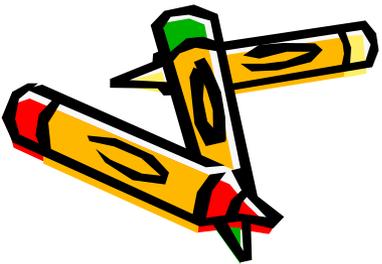
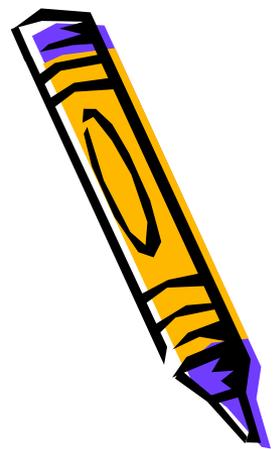
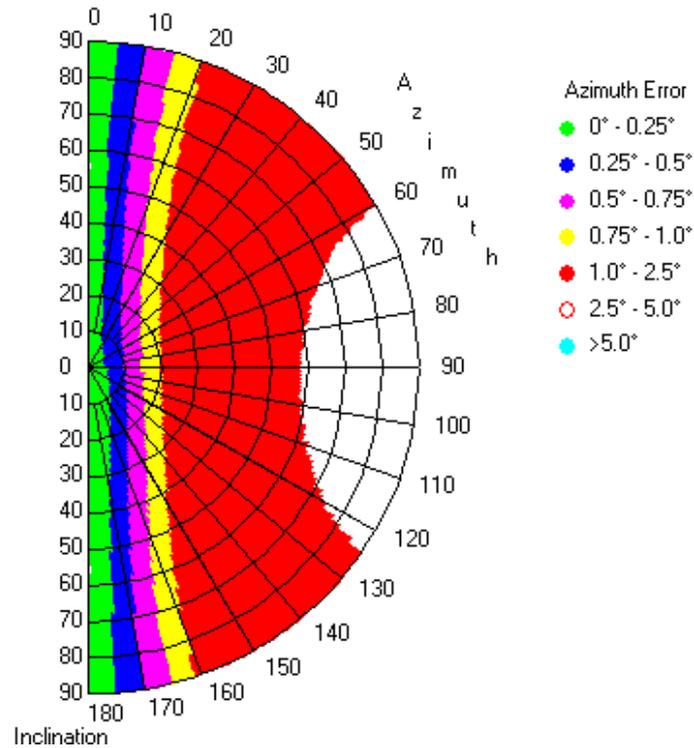


Basic Issues

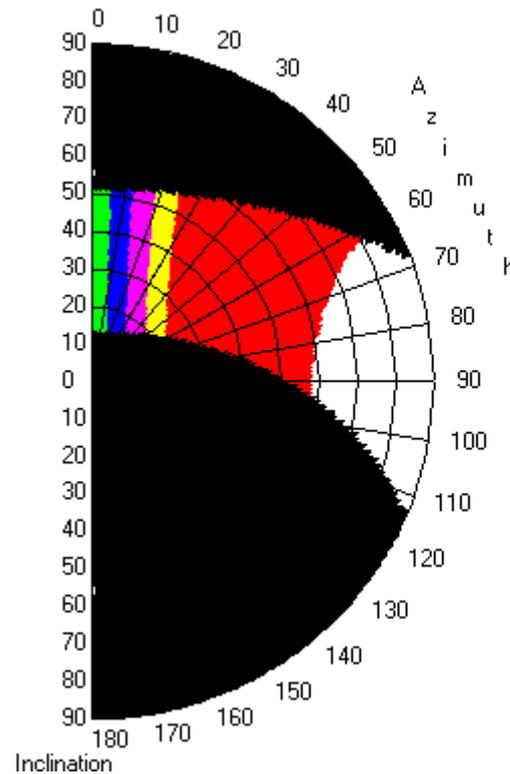
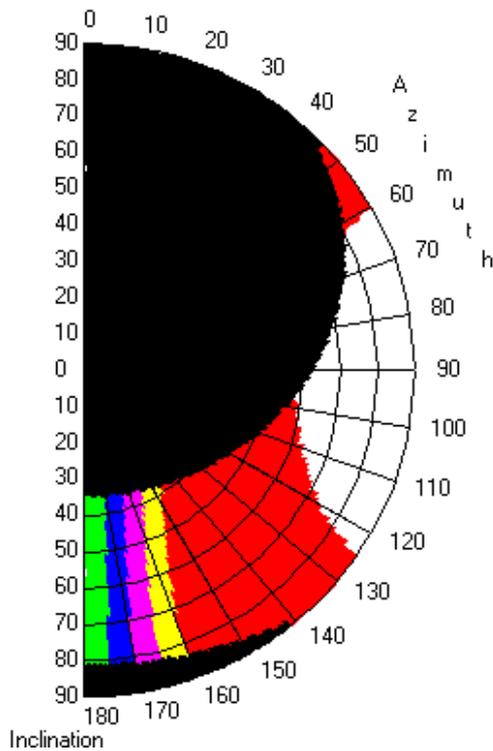
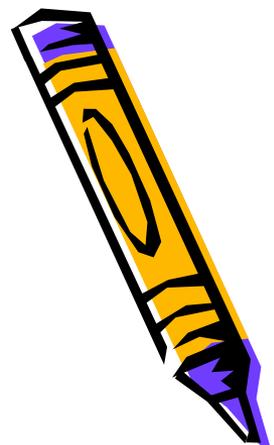
- Default Quality Limits - Often very large
+/-5000 nt on B Total and +/-5 degrees
on Dip
- Fail 'good' surveys
- Pass 'bad' surveys
- Hardware modified (Frankentools)
[Sensors, Electronics, Power Supply]
- Hardware and firmware limited



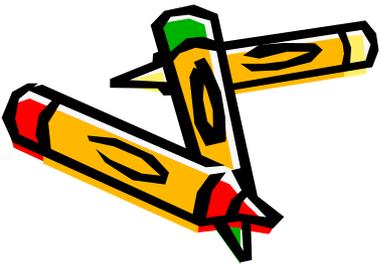
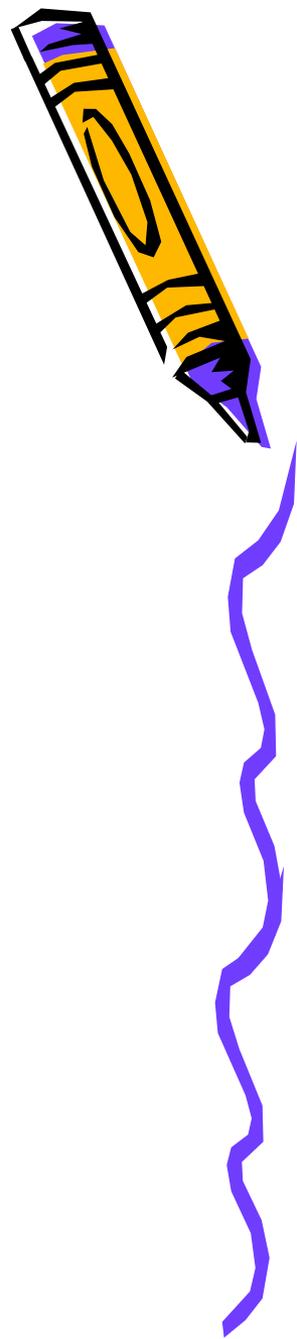
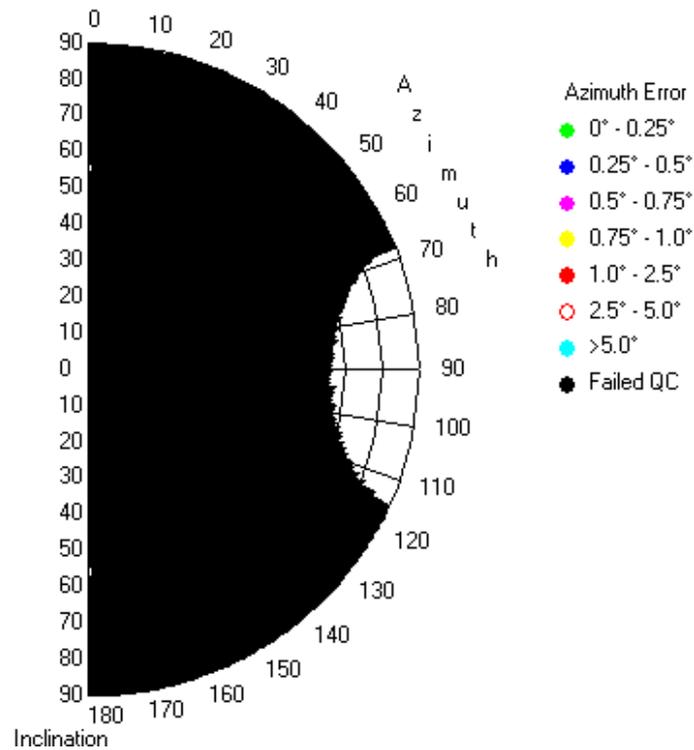
Expected Azimuth Error



B Total and Dip QC Limits

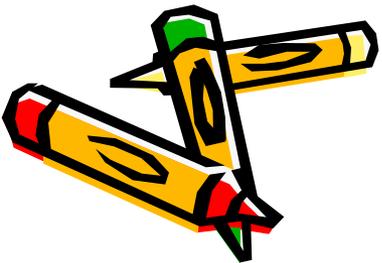
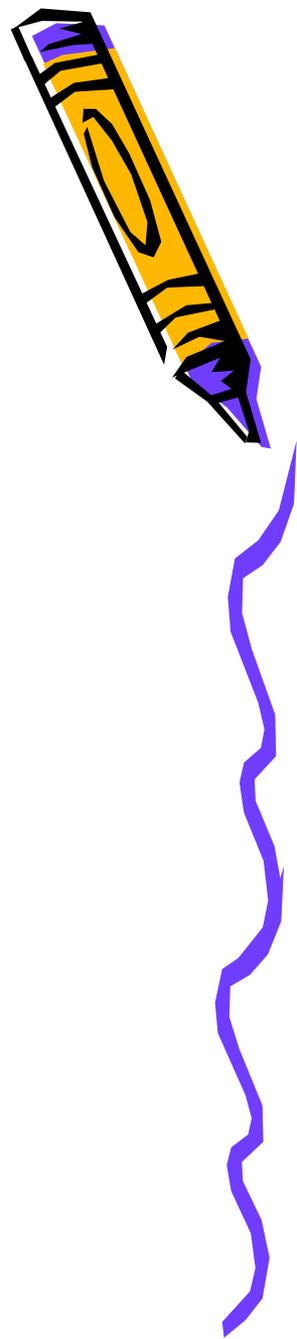


BTotal.Dip QC Limit

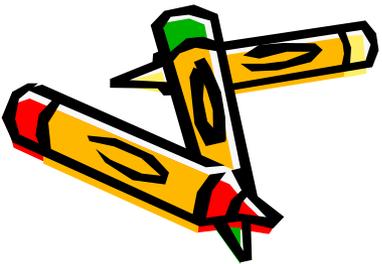
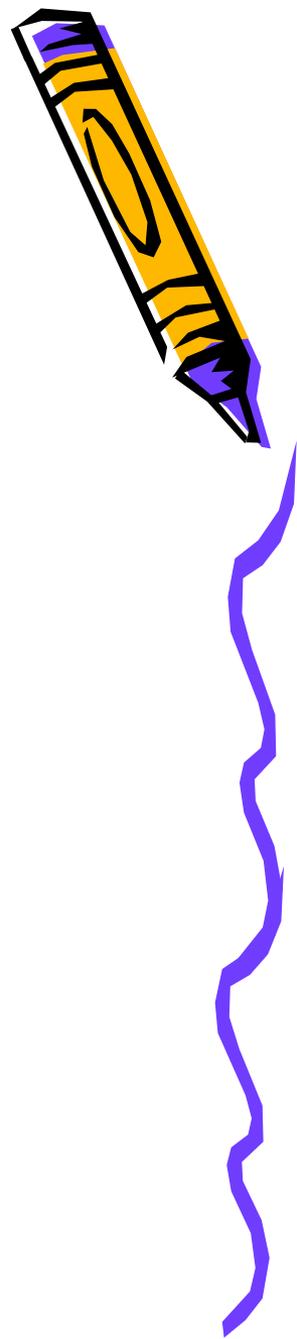


Advanced Issues

- Azimuth Correction
- Multi-Station Correction
- Magnetic Mud

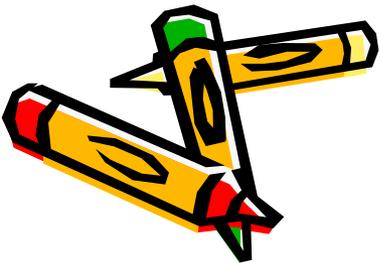
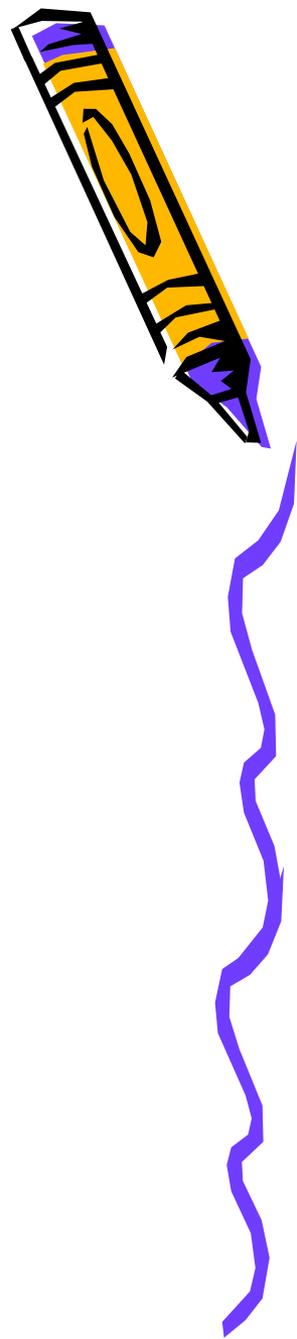


Any Questions



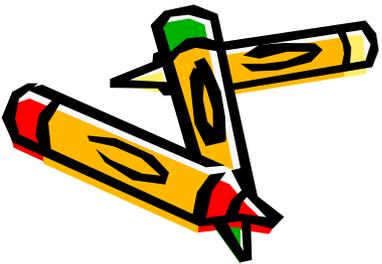
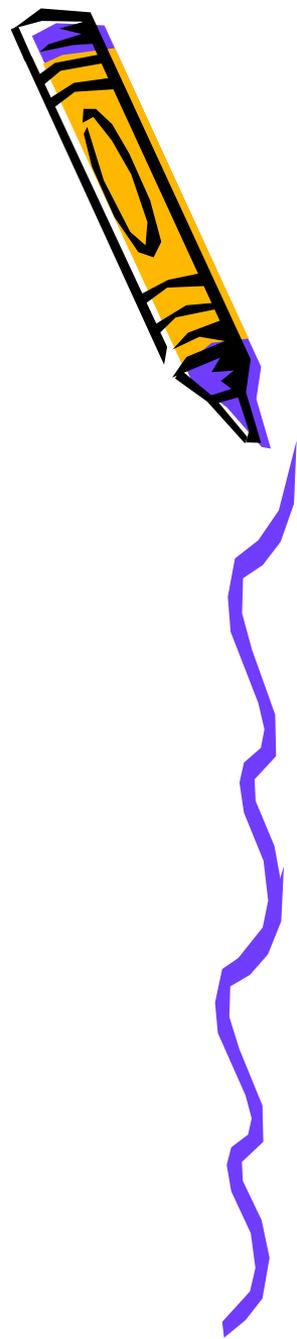
Magnetic Mud

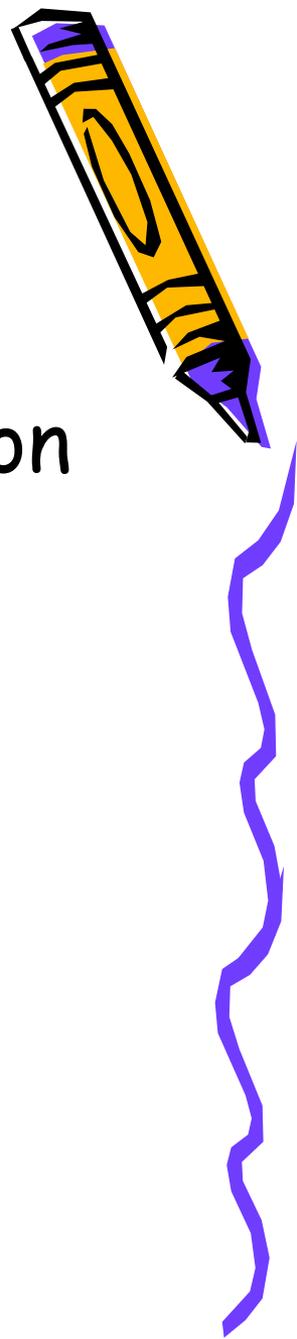
- Many good studies
- SPE 71400
- SPE 87169
- SPE 113206
- SPE 150548
- SPE 151039



Magnetic Mud

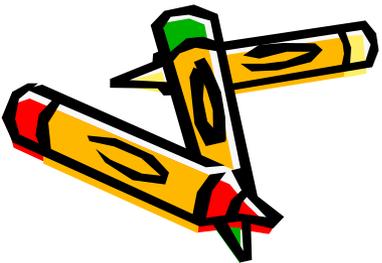
- Repeatable
- Not Repeatable
- Consistent
- Not Consistent
- Time dependent
- Complex





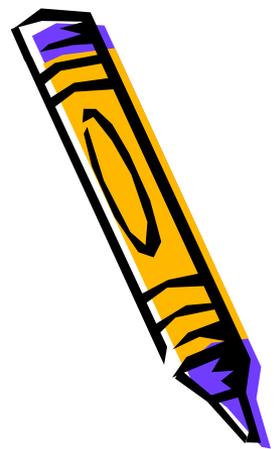
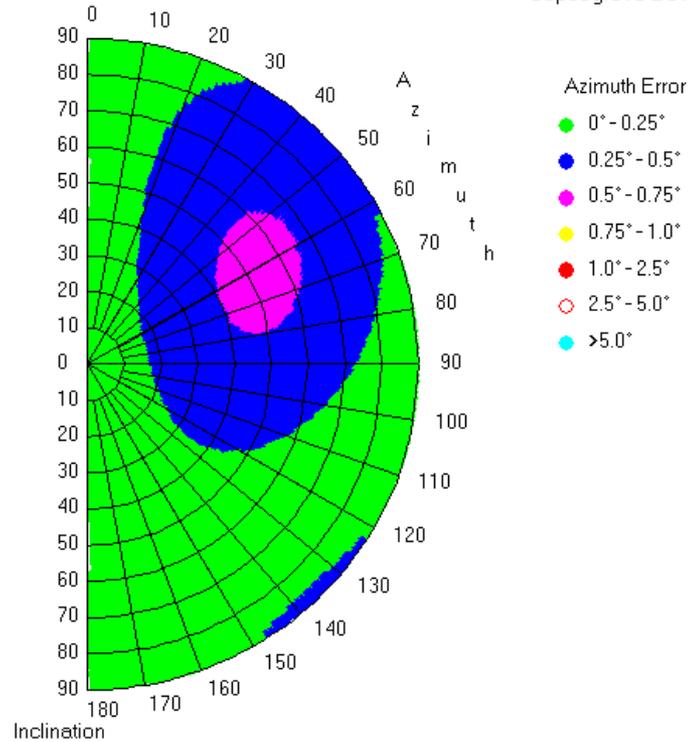
Effects of Magnetic Mud

- Looks like Scale Factor reduction on cross-axis magnetometers
- Pumps-Off Surveys Fail QA/QC
- Pumps-On Surveys Pass QA/QC
- Effects increase with increase in mud weight



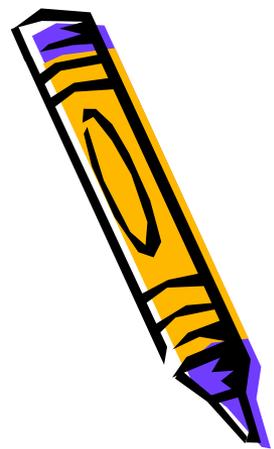
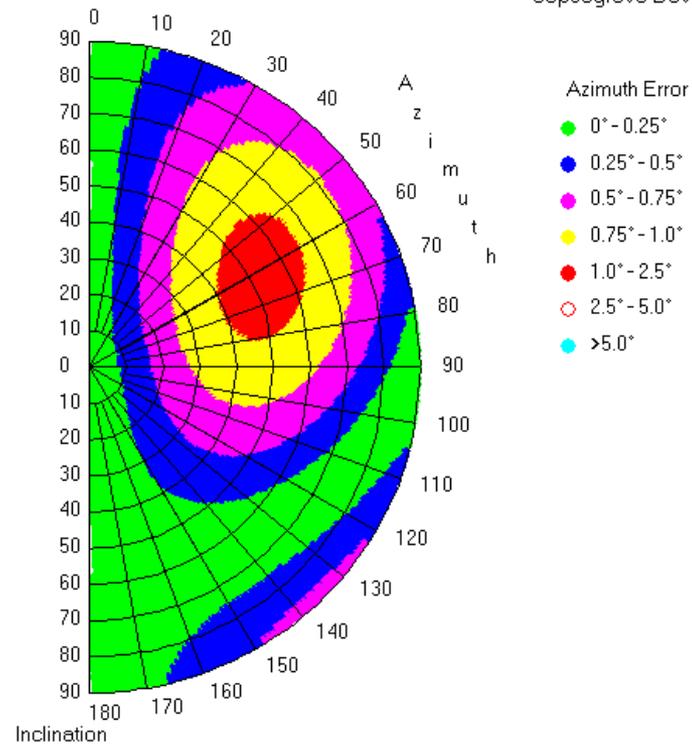
1% SF Reduction

Copsegrave Developments Ltd



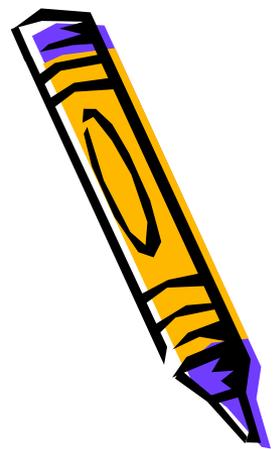
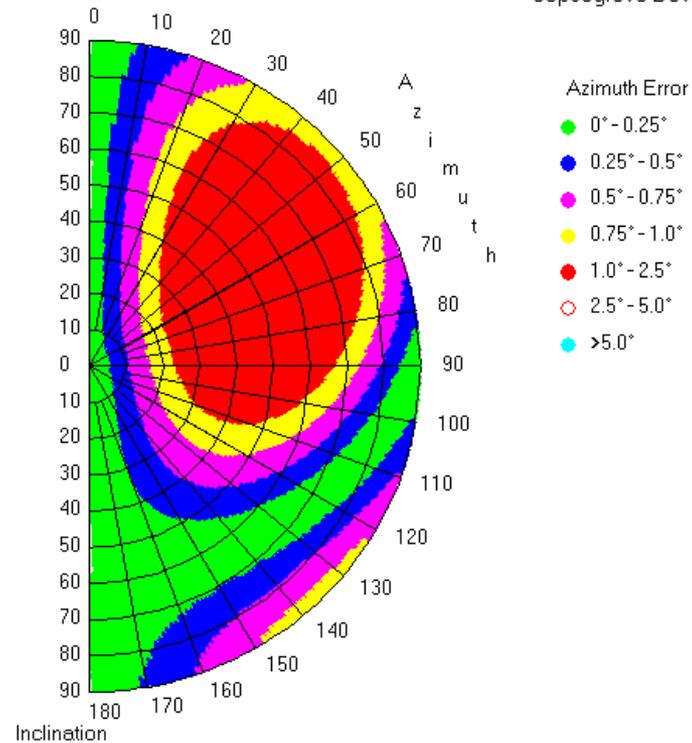
2% SF Reduction

Copsegrave Developments Ltd



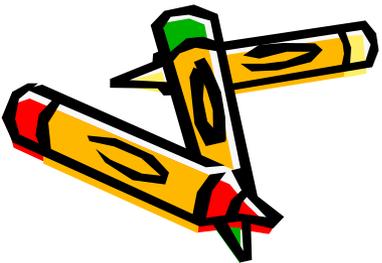
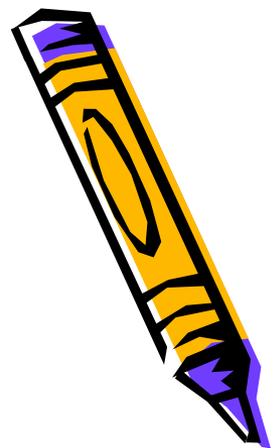
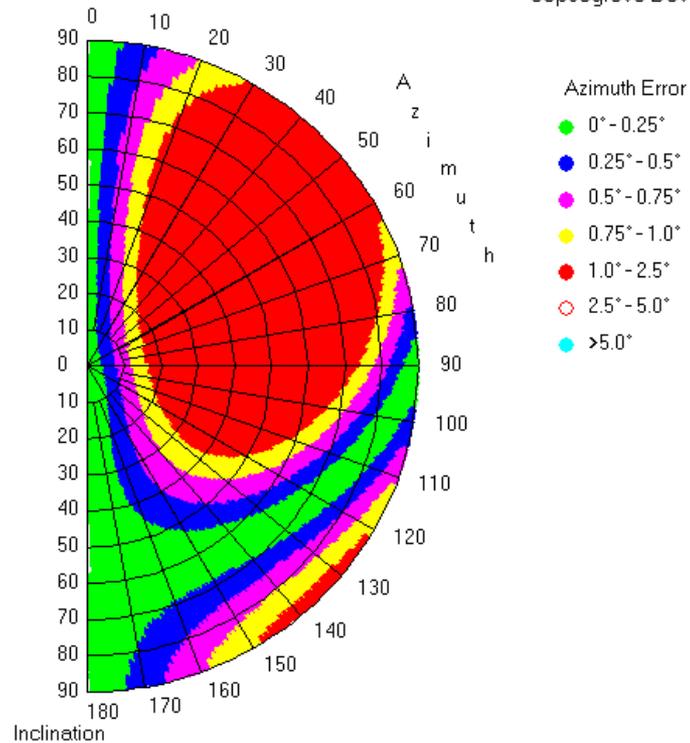
3% SF Reduction

Copsegrave Developments Ltd



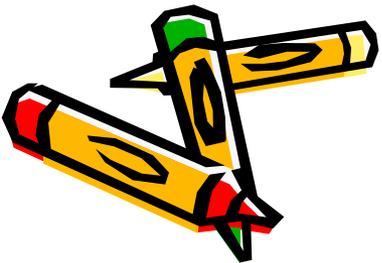
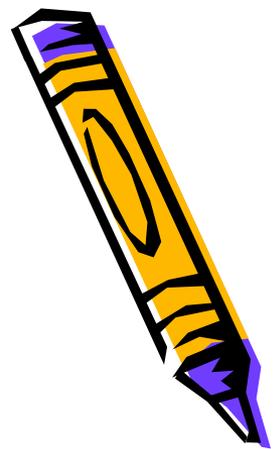
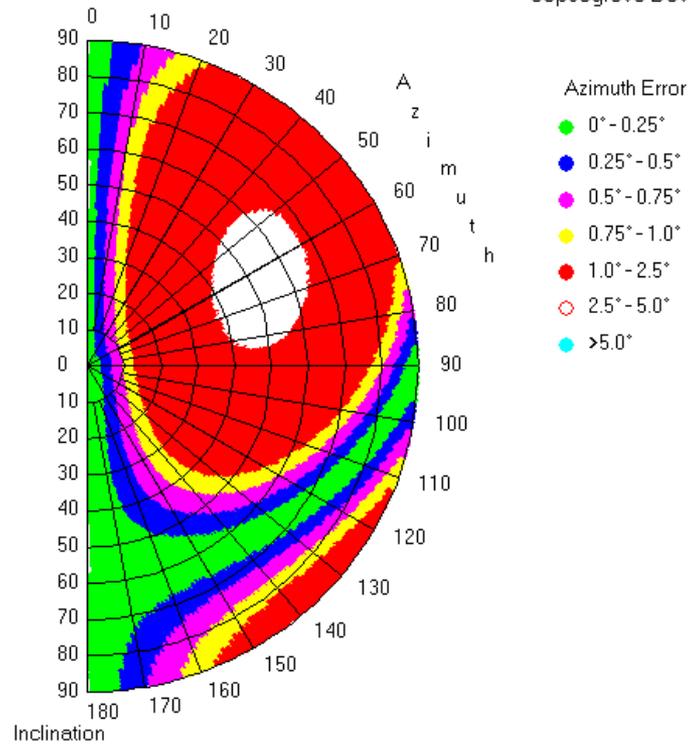
4% SF Reduction

Copsegrave Developments Ltd



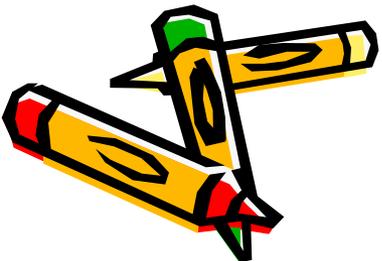
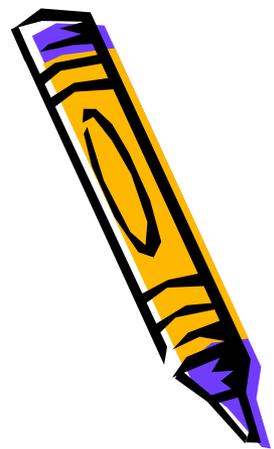
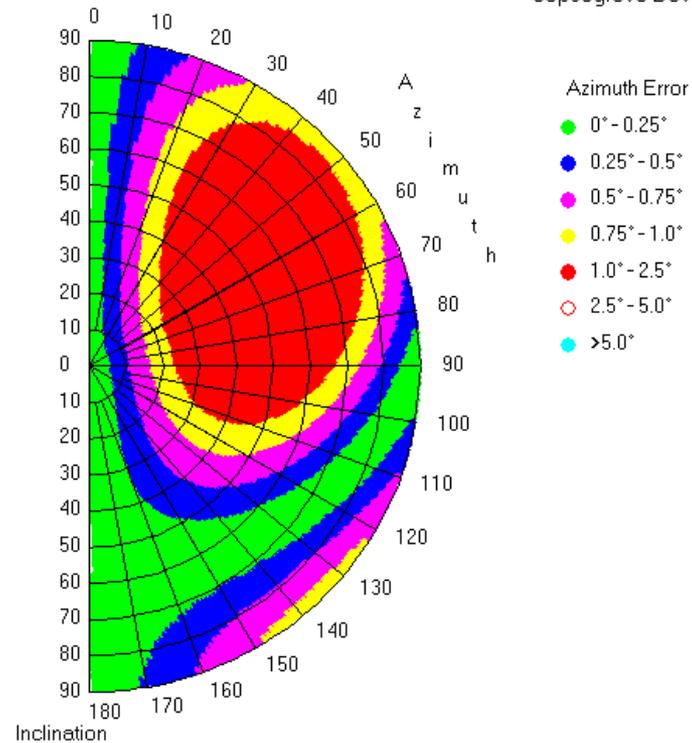
5% SF Reduction

Copsegrave Developments Ltd

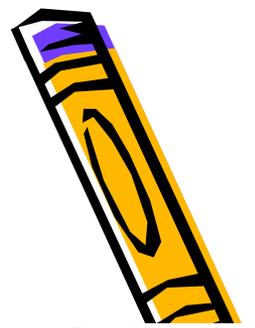


3% SF Reduction

Copsegrave Developments Ltd

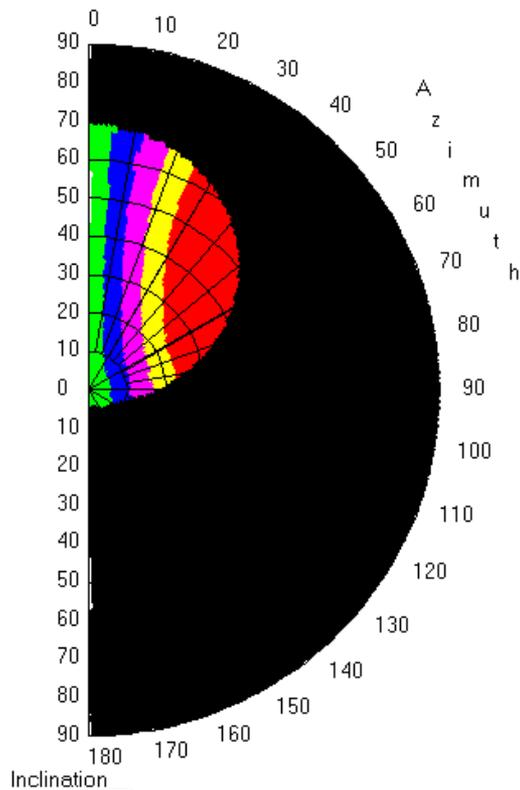


B Total and Dip QC Limits



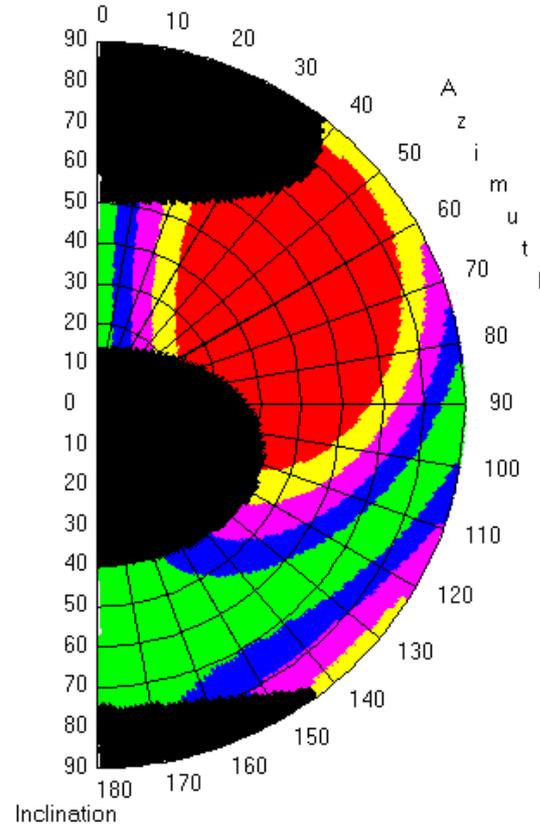
Copsegrove Developments Ltd

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Azimuth Error

- 0° - 0.25°
- 0.25° - 0.5°
- 0.5° - 0.75°
- 0.75° - 1.0°
- 1.0° - 2.5°
- 2.5° - 5.0°
- >5.0°
- Failed QC



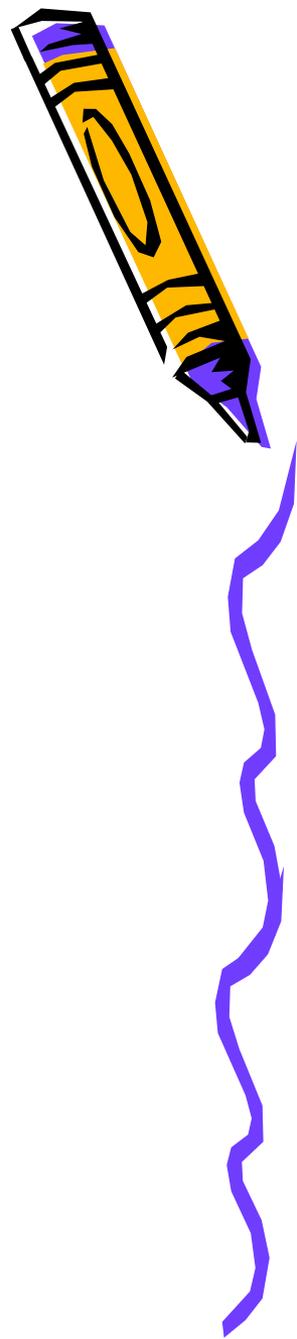
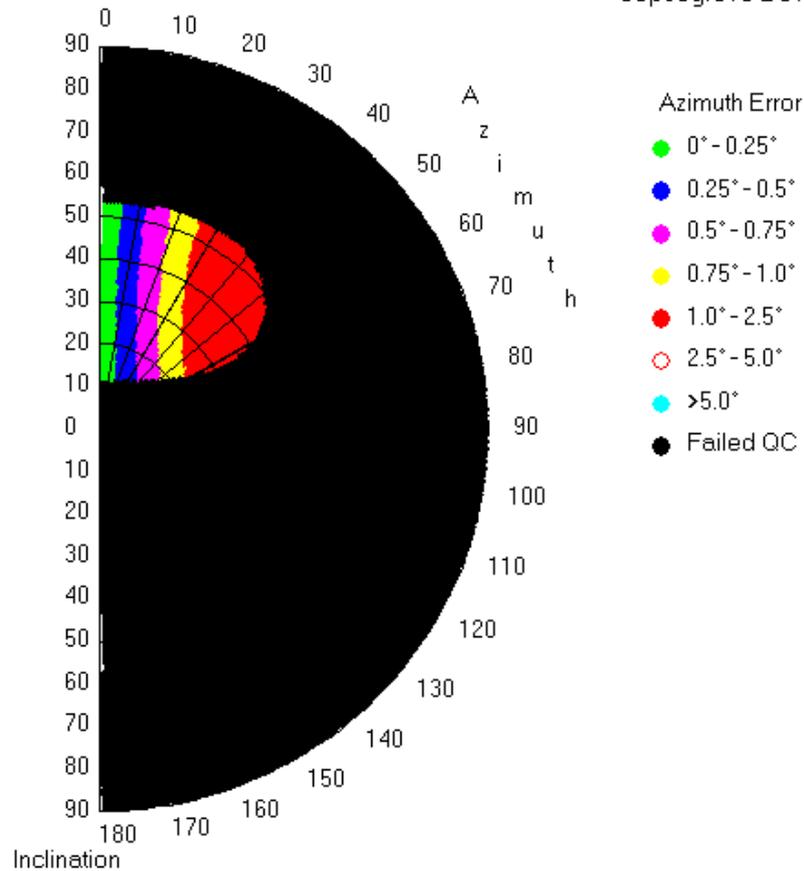
Azimuth Error

- 0° - 0.25°
- 0.25° - 0.5°
- 0.5° - 0.75°
- 0.75° - 1.0°
- 1.0° - 2.5°
- 2.5° - 5.0°
- >5.0°
- Failed QC

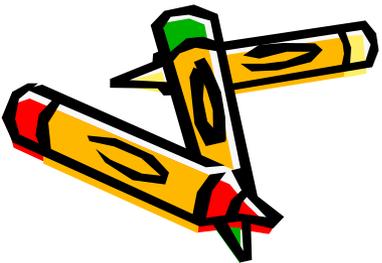
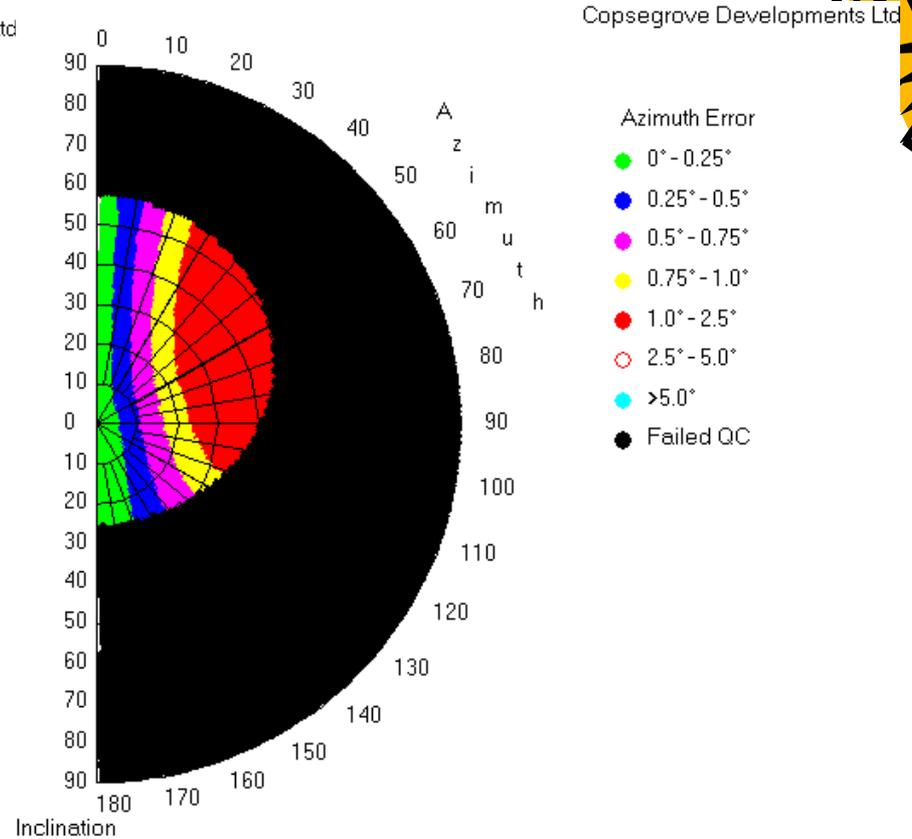
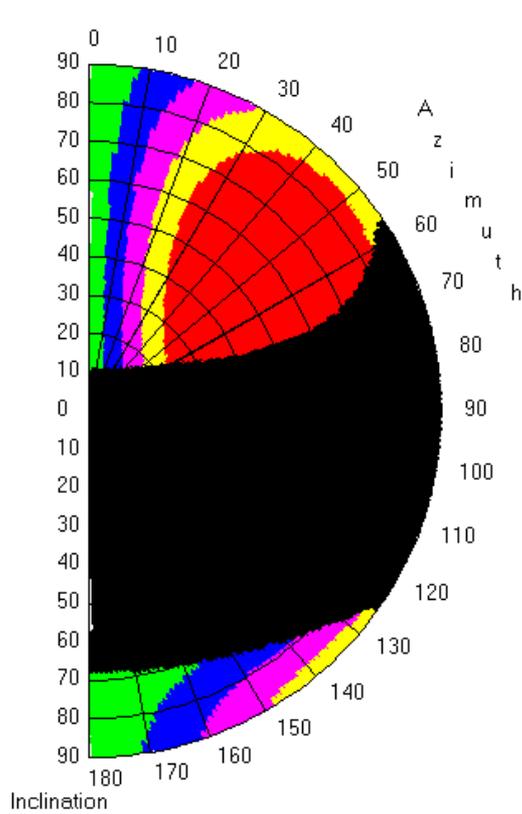


BTotal.Dip QC Limit

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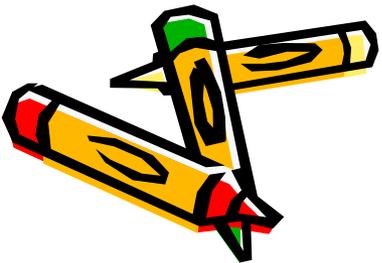
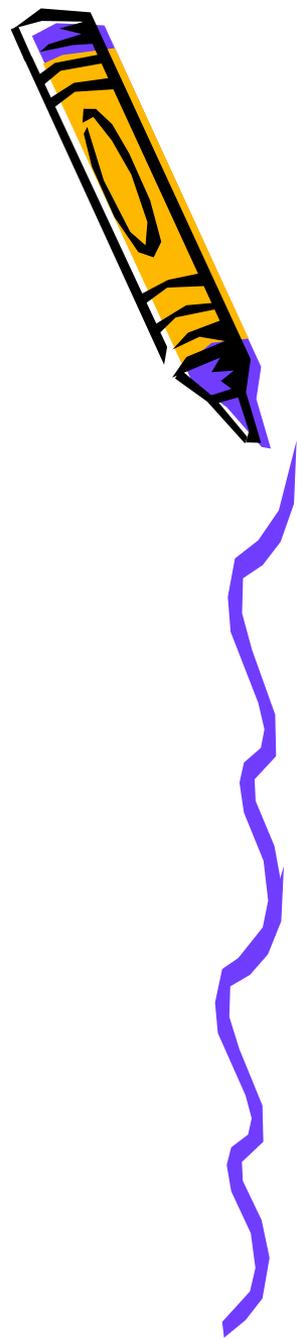
B Horizontal & Vertical QC Limits



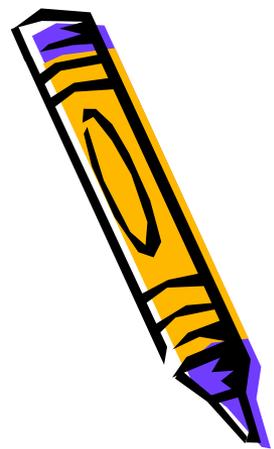
QA/QC Results at 60 Deg Azimuth

3% Magnetometer SF Reduction - 60° Azimuth

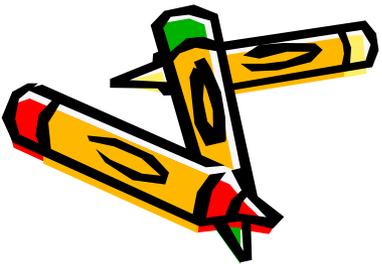
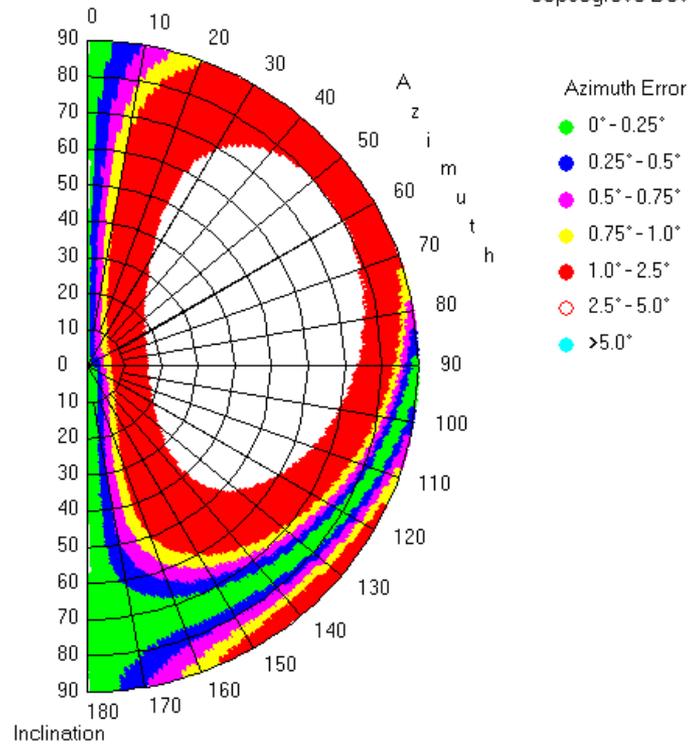
Inc	BTotal	Dip	BTotal.Dip	BHor	BVert
0	✓	x	x	x	✓
10	✓	x	x	x	✓
20	✓	x	x	x	✓
30	✓	✓	✓	✓	✓
40	✓	✓	✓	✓	✓
50	x	✓	x	✓	x
60	x	✓	x	✓	x
70	x	✓	x	✓	x
80	x	✓	x	✓	x
90	x	✓	x	x	x

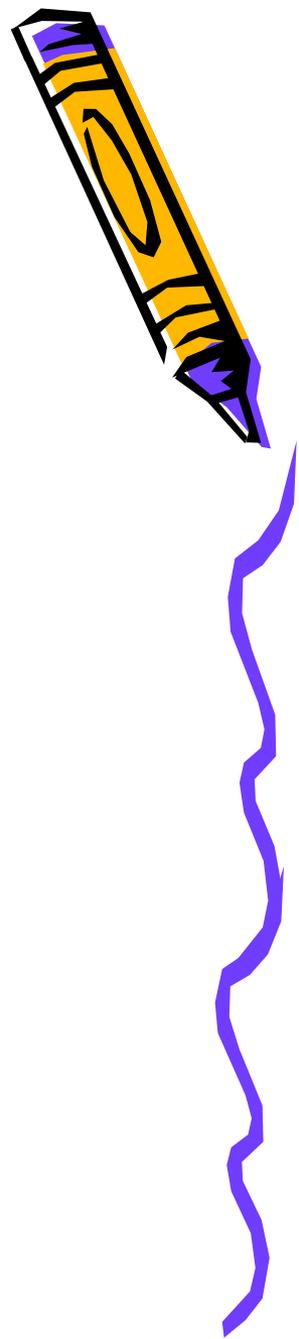
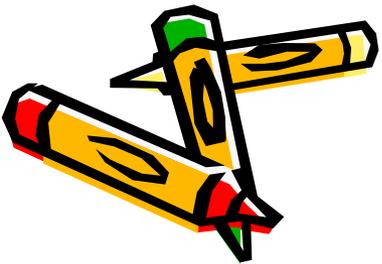


5% SF Reduction - North Sea



Copsegrave Developments Ltd





Master

