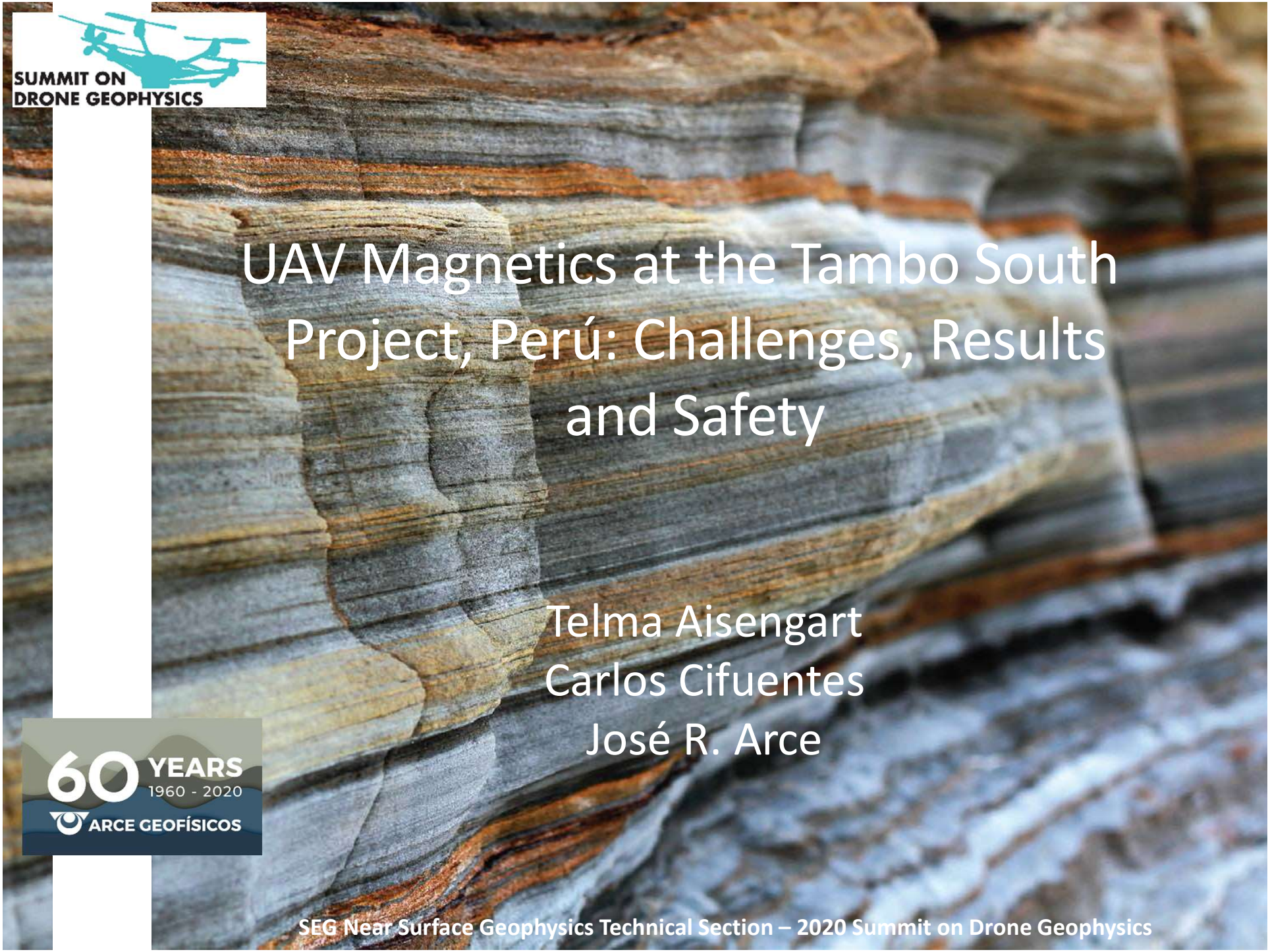

UAV Magnetics at the Tambo South Project, Perú: Challenges, Results and Safety

Telma Aisengart
Carlos Cifuentes
José R. Arce

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SEG Near Surface Geophysics Technical Section – 2020 Summit on Drone Geophysics

SUMMIT ON
DRONE GEOPHYSICS

Introduction

- Magnetic surveys have been used for decades in mining exploration. Large areas have been covered with airborne magnetometer suveys, while smaller areas by ground surveys.
- One problem found in the past was for areas ranging from 500 to 1500 line kilometers, where logistics could become very expensive for helicopter magnetometer surveys and the survey would take too long with ground surveys.
- Over the last years, multiple UAV capabilities have been developed for geophysical applications to attempt to supply surveys for medium sized áreas.
- UAVs provide a semi-automated platform with faster survey coverage than ground surveys.

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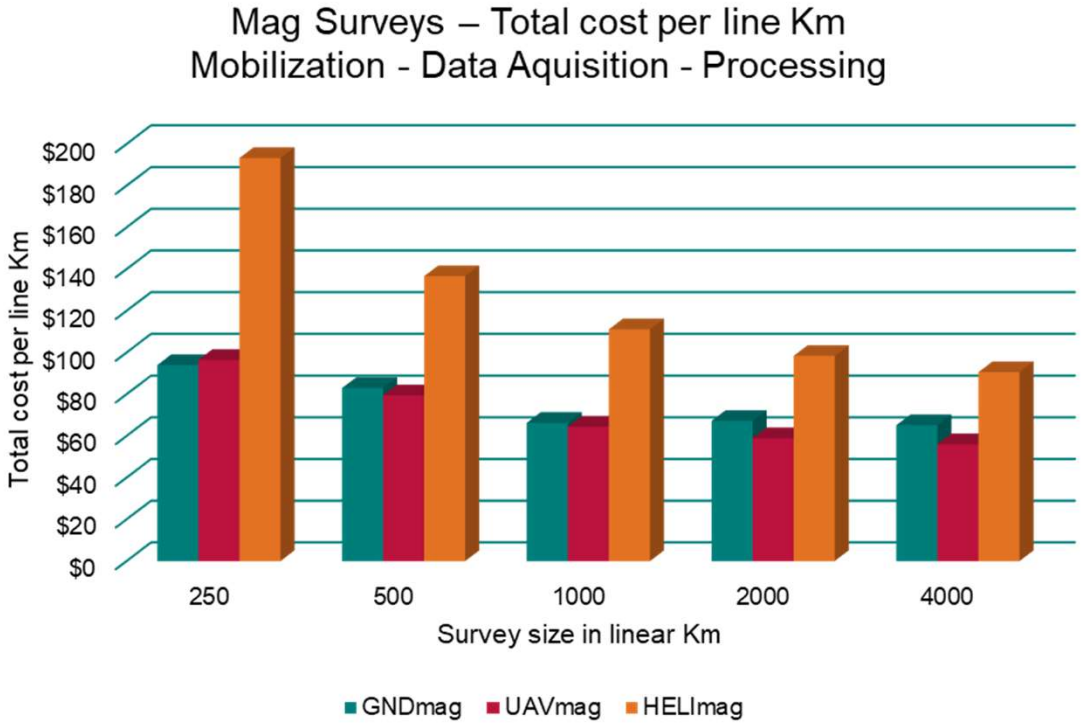
Magnetic Surveys

UAV Mag Advantages:

- Lower logistics and mobilization costs.
- Requires less maintenance and personnel than a conventional fixed wing or helicopter survey.



*Slide InformationPresented in Geophysics Virtual Conference, Chile, October 2020.

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The Tambo South Project

- Located 1147 kilometers SE from the city of Lima (A) and 10 kilometers NW from the city of Moquegua (B).
- Travel is by paved road from Lima to Moquegua, where the survey base is located, using the Panamerican highway. Daily Travel from Moquegua to the survey area partially paved on the Panamerican highway and partially cross country.

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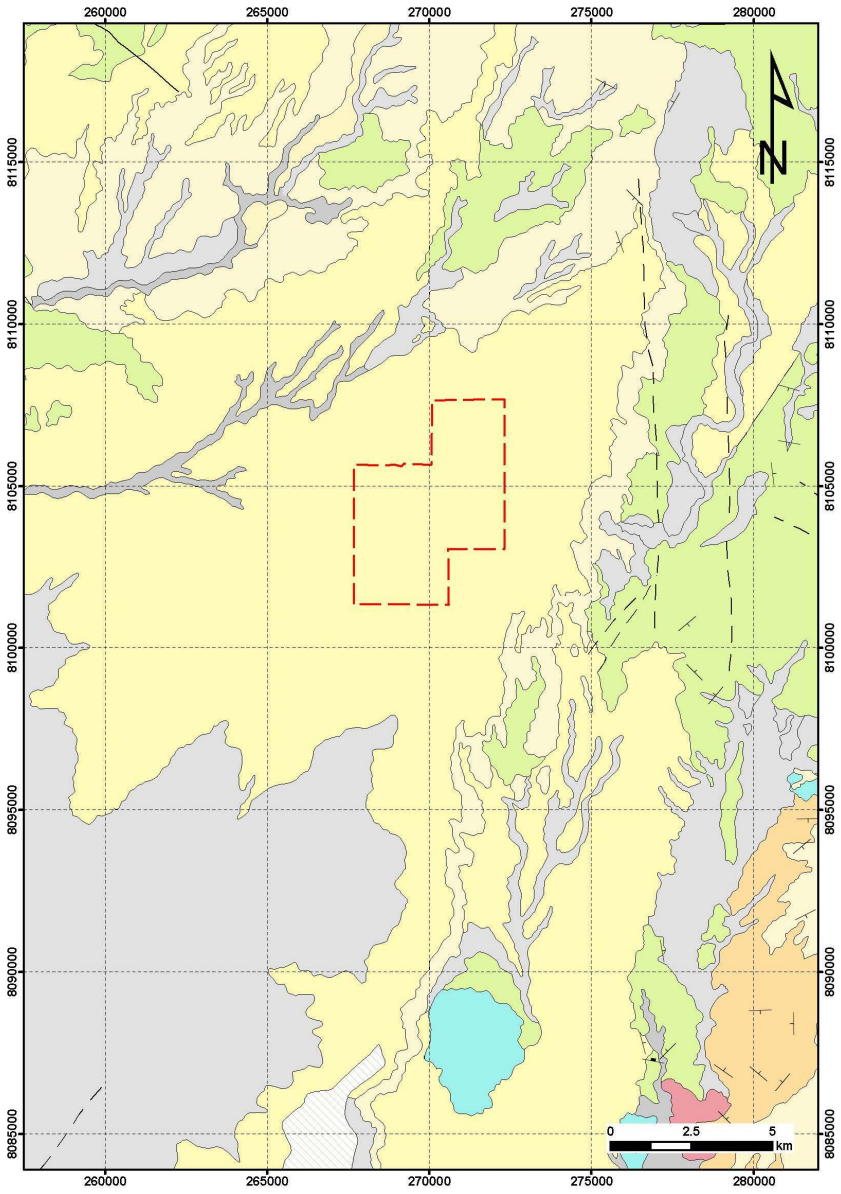
Geology

- Tambo South is located in the Upper Moquegua formation of Tertiary age. This formation consists mostly of clay with interbedded sandstone.



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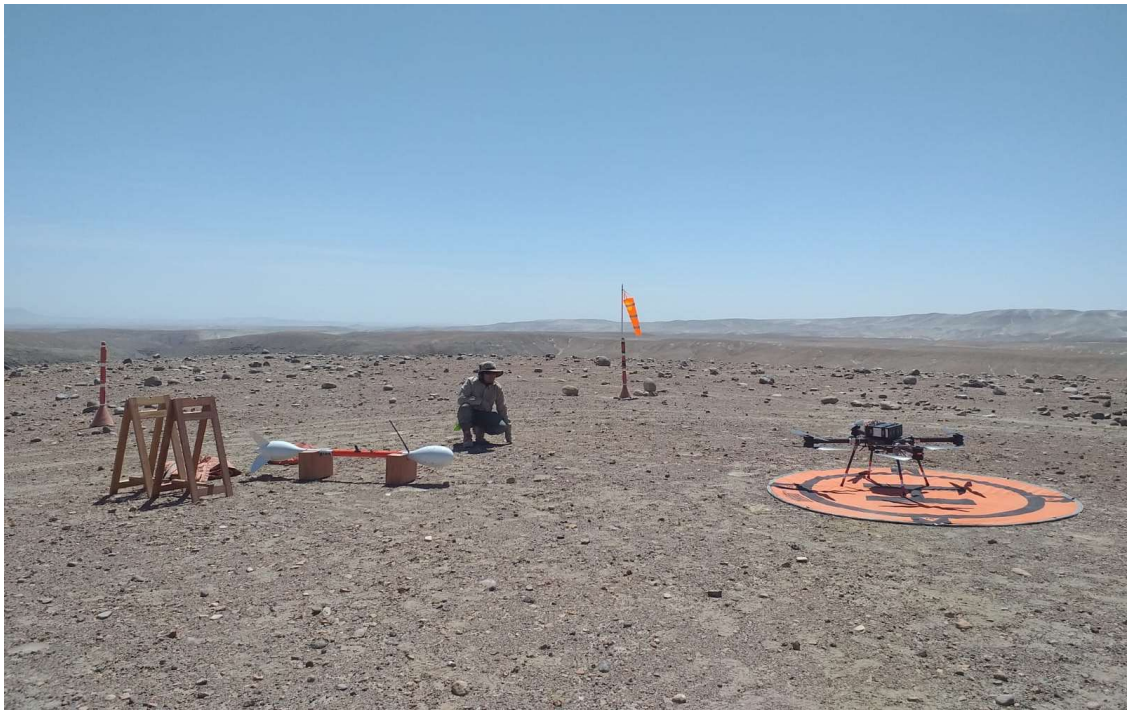
Tambo South:

Equipment



- BFD Systems HSE8 heavy duty drone.
  - 8 motors.
  - Four 22000 A/H batteries.
  - Payload: 17 kg max.
  - Autonomy: 15-45 minutes, depending on weather.
- GEM Airbird K-vapor sensor system. Features:
  - Potassium vapor sensor.
  - Laser altimeter, GPS.
  - Gyroscopes to measure pitch, raw and yaw.
  - Sensitivity: 0.0002nT@1Hz
  - Heading error: +/- 0.05 nT
  - 20Hz measurement frequency.
- GEM GSM 19T base station:
  - Proton Precession sensor.
  - 1Hz frequency.

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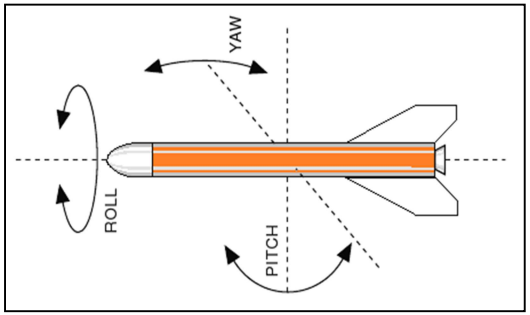
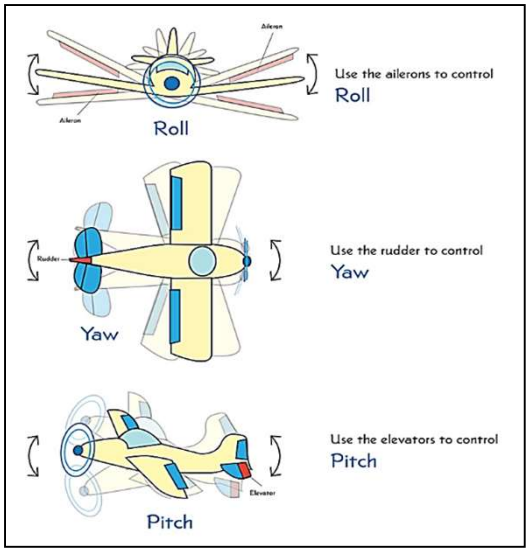
Tambo South:

Equipment





- To better understand noise and properly separate signal from noise, accurate measurement of pitch, roll and yaw is very important.
- In the Airbird system it is done through gyroscopes.

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Performance tests

Sea-level, Lima.
Airbird sensor.

San Mateo, Lima.
2500 m.a.s.l..
Dummy sensor

Ticlio, Lima.
5100 m.a.s.l.
Dummy sensor

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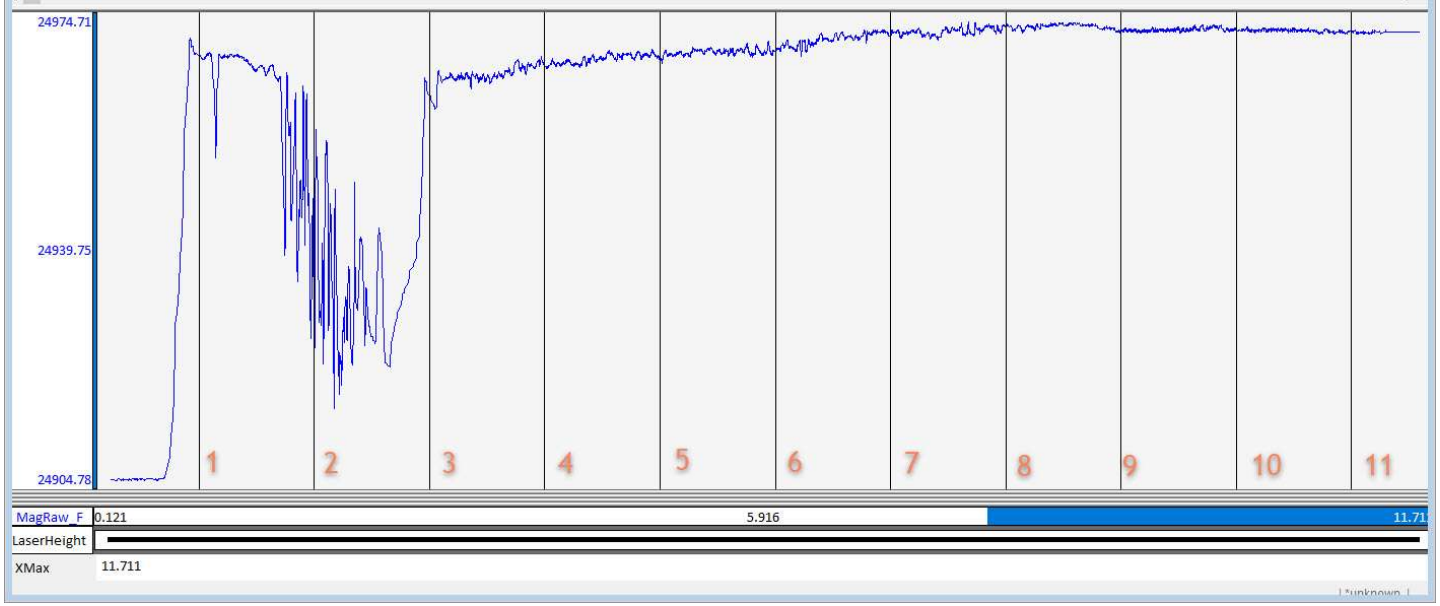
Sensor Interference Elevation Test

SensorInfo_Sort.gdb

D0:0	TimeUTC	MagRaw_F	Magraw	LaserHeight	L	H	FR	uA	ampl	RFVDC	Vheater	Vsupply	sensortemp	boxtemp
1604.0	17:02:46.10	24966.26	24967.90	3.658	1	1	0	3.4	430.0	5.90	9.60	23.20	48	46
1605.0	17:02:44.20	24966.27	24967.85	3.658	1	1	0	3.4	430.0	5.90	9.60	23.20	48	46
1606.0	17:02:02.40	24966.16	24966.28	3.660	1	1	0	3.4	432.0	5.90	9.60	23.20	48	46
1607.0	17:01:50.60	24966.10	24965.64	3.664	1	1	0	3.4	432.0	5.90	9.70	23.20	49	46
1608.0	17:01:41.30	24966.15	24965.34	3.664	1	1	0	3.4	432.0	5.90	9.70	23.20	48	46
1609.0	17:02:01.20	24966.20	24966.23	3.668	1	1	0	3.4	431.0	5.90	9.70	23.20	48	46
1610.0	17:02:40.50	24966.08	24967.75	3.674	1	1	0	3.4	431.0	5.90	9.60	23.20	48	46
1611.0	16:59:28.40	24966.19	24906.31	3.675	1	1	0	3.4	450.0	6.00	9.90	23.30	49	45
1612.0	17:01:22.30	24966.00	24964.59	3.675	1	1	0	3.4	429.0	5.90	9.70	23.20	48	46
1613.0	16:59:28.30	24966.23	24906.31	3.676	1	1	0	3.4	451.0	6.00	9.90	23.30	49	45
1614.0	16:59:26.20	24965.91	24906.51	3.679	1	1	0	3.4	454.0	6.00	9.90	23.30	49	45
1615.0	17:01:23.70	24966.08	24964.64	3.684	1	1	0	3.4	431.0	5.90	9.70	23.20	48	46



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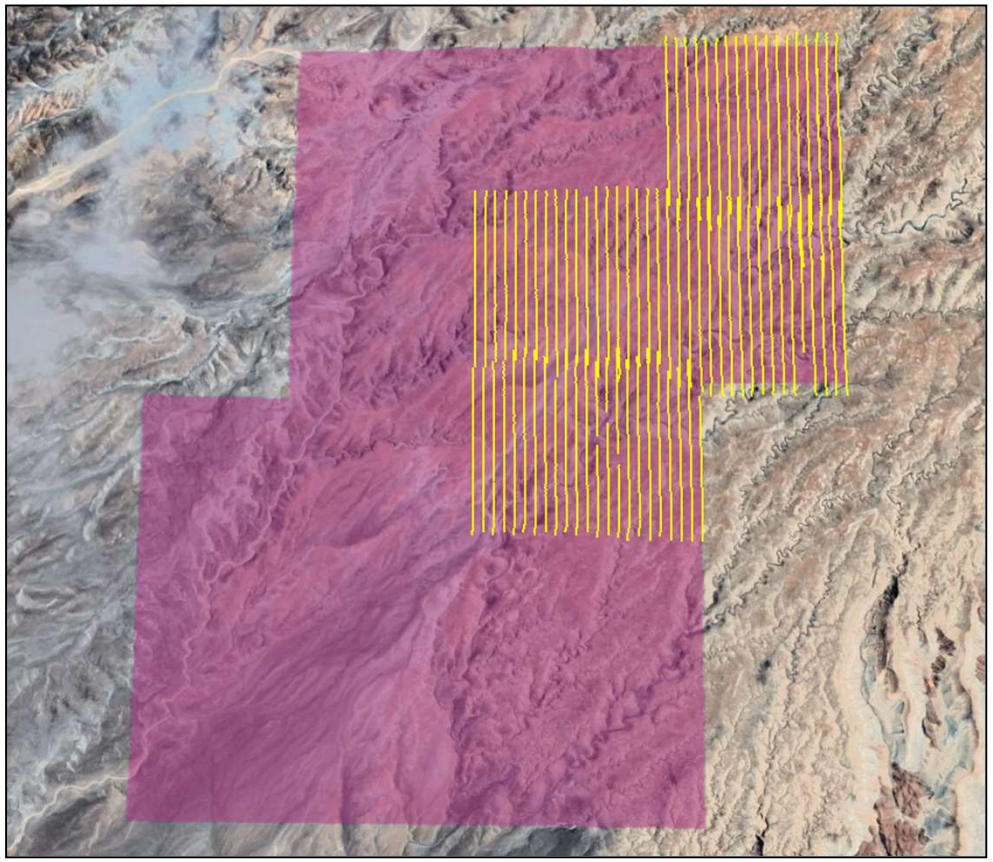
Tambo Sur Survey



- 181 line kilometers were completed over 7 days.
- Short working days complicated the survey as we had to repeat 17 kilometers due to noise and instability caused by wind.
- We only had 3-4 hours of good flying time.
- Overlaps of 250 meters were done in lines.
- Ground clearance varied between 35 and 50 meters.

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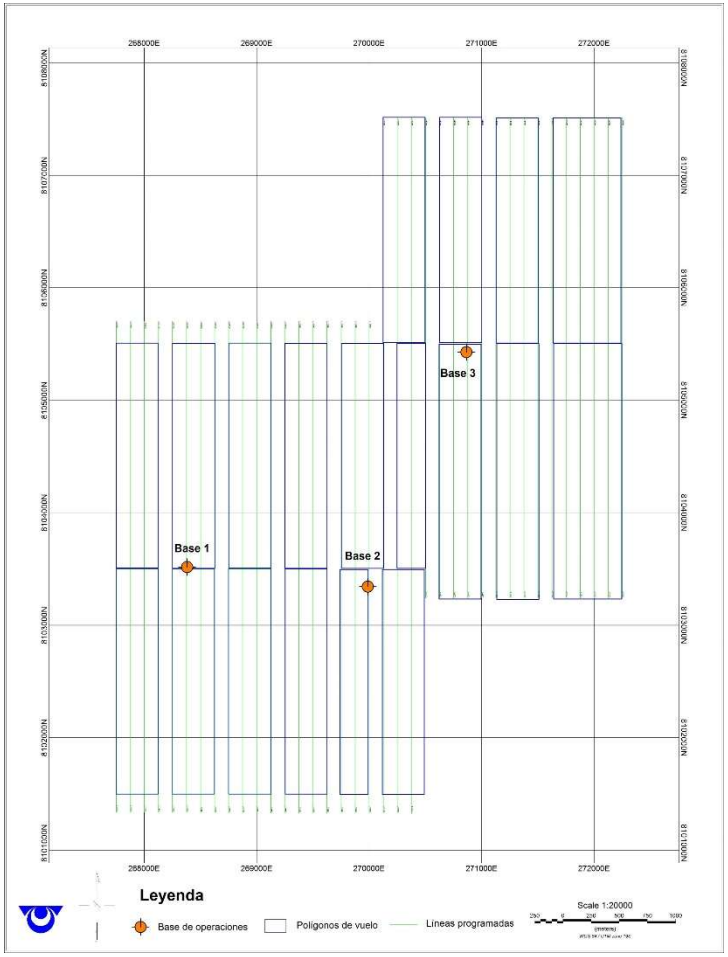
Tambo Sur Survey Design



- Design was done during the course of the survey.
- A total of 3 base stations were used due to accesibility issues and complex topography.
- Bases were located in areas where we could maintain line of sight with the drone, which is a legal requirement in Perú.
- Blocks had an approximate N-S length of 2 kilometers, based on the short battery life we had due to strong winds.

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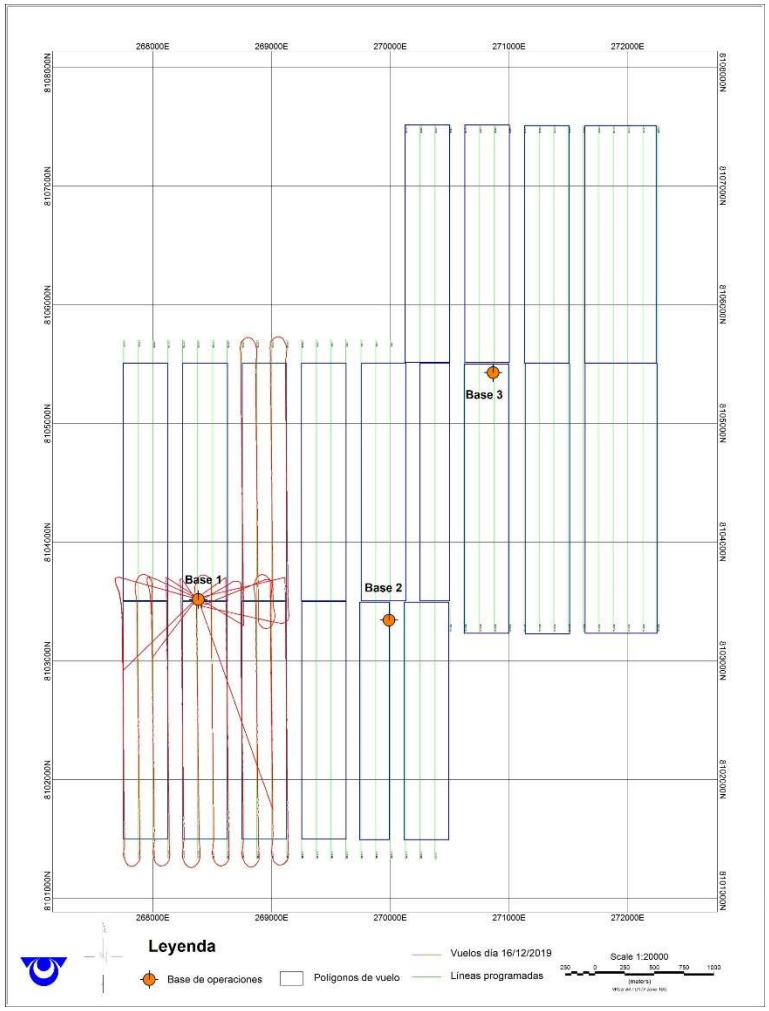
Tambo Sur Survey Design



- Base location and daily flight programming are fundamental to survey production.
- Flight line programming into drone was done with UgCS.
- The BFD Systems HSE8 drone permit us to have only up to 25 minutes of flight due to wind conditions and the many creeks in the area.
- In the survey design, ferry time betwen bases and lines has to be considered as well, for safe operation.

*Slide Presented in Geophysics Virtual Conference, Chile, October 2020.

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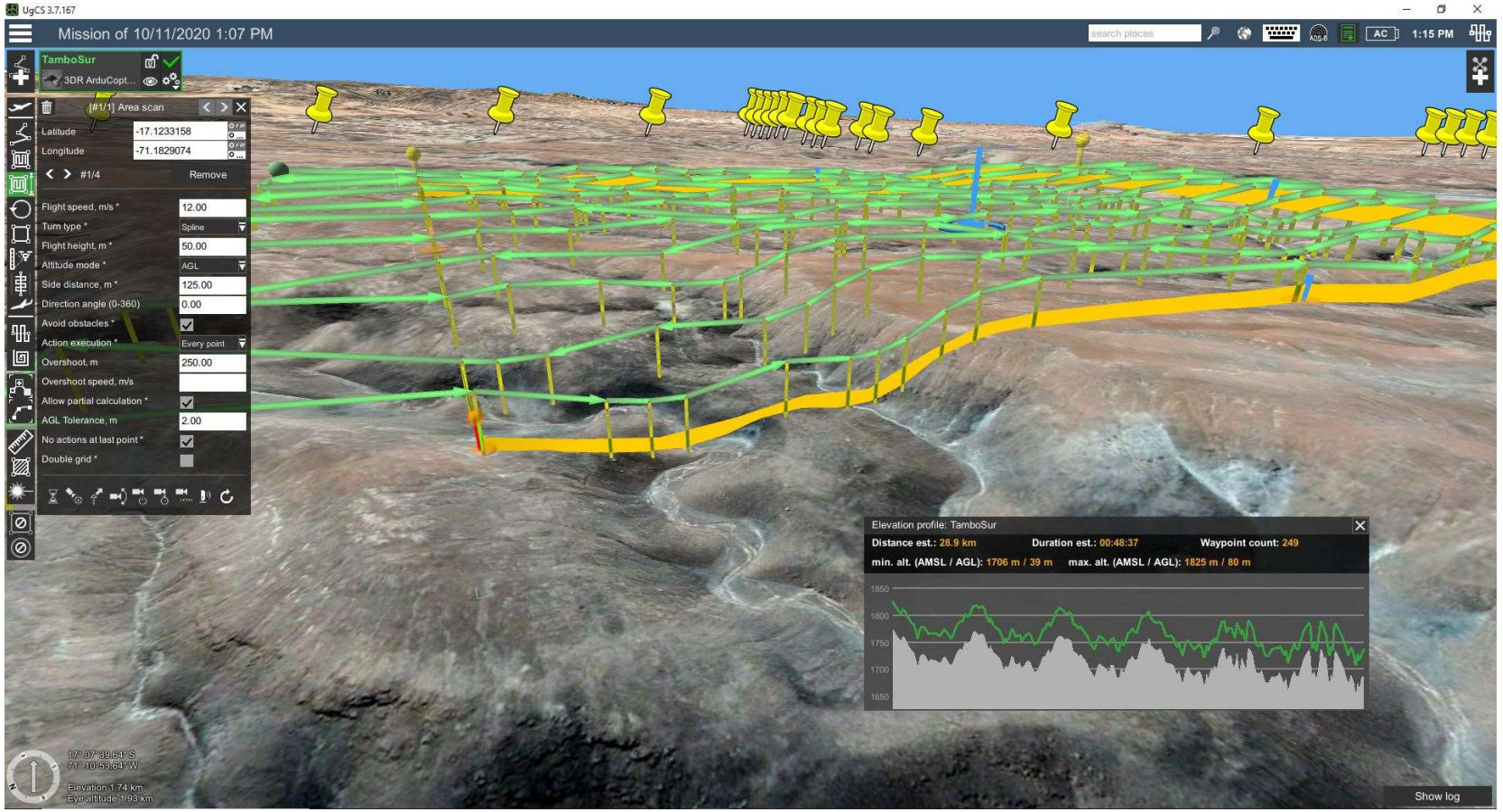
Tambo Sur Survey Design

UgCS Flight Plan design



*Slide Presented in Geophysics Virtual Conference, Chile, October 2020.

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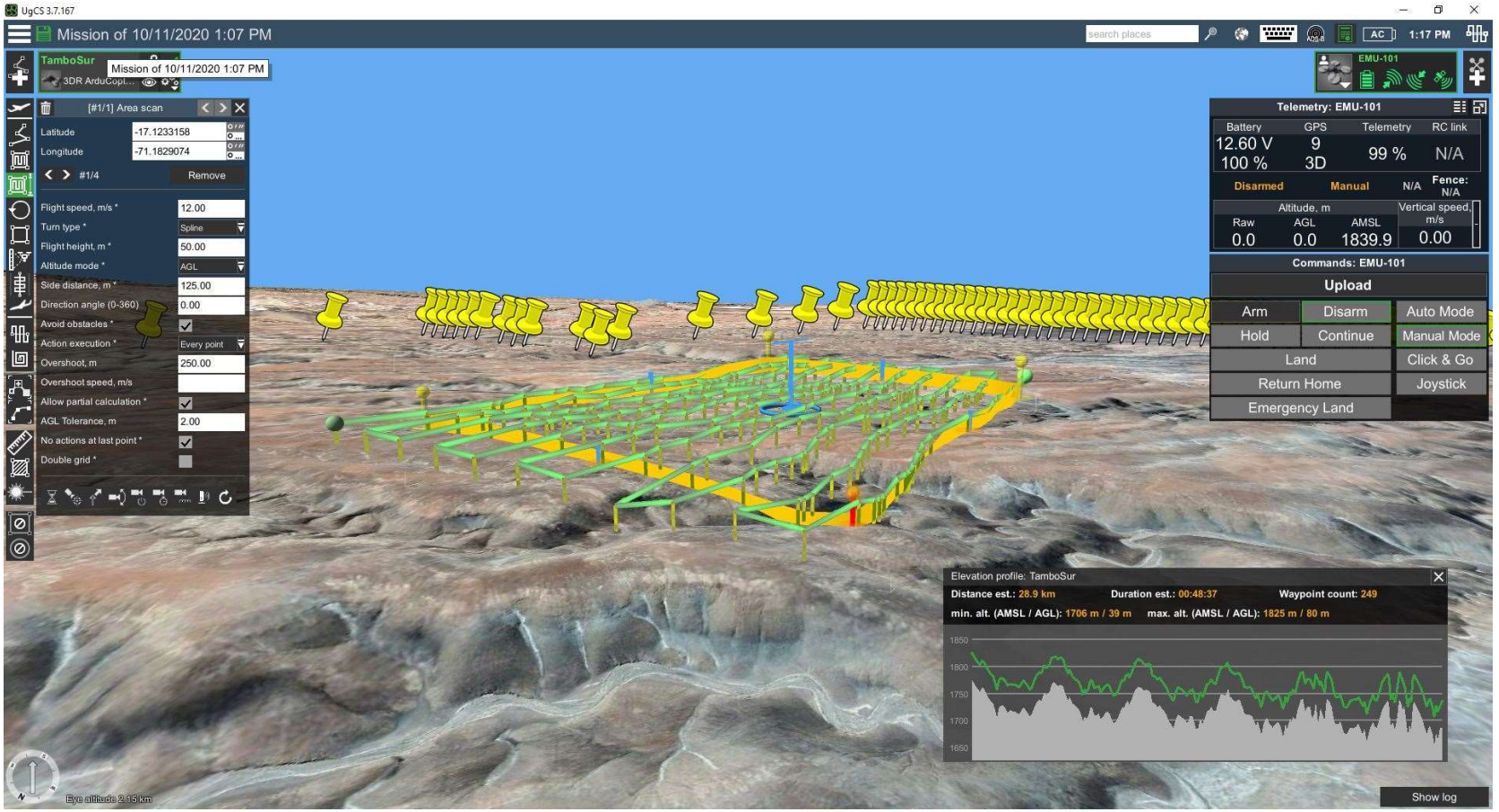
Tambo Sur Survey Design

UgCS Flight Plan design



*Slide Presented in Geophysics Virtual Conference, Chile, October 2020.

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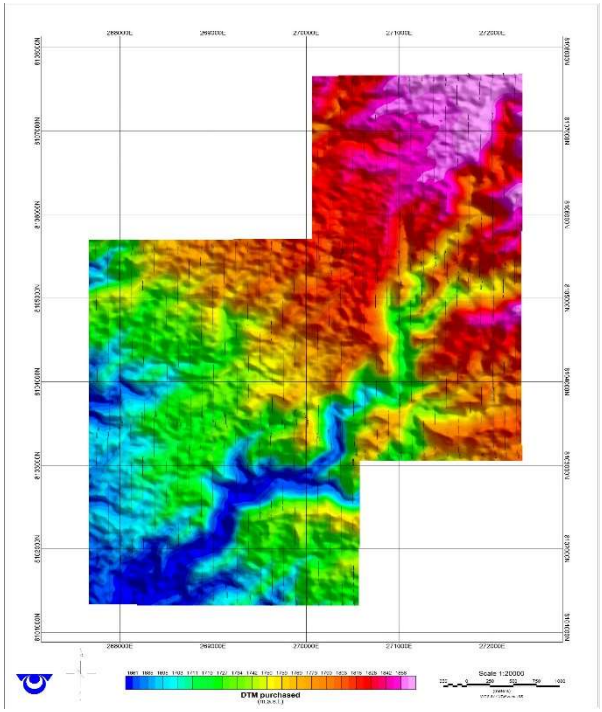
Tambo Sur Survey Design: DTM

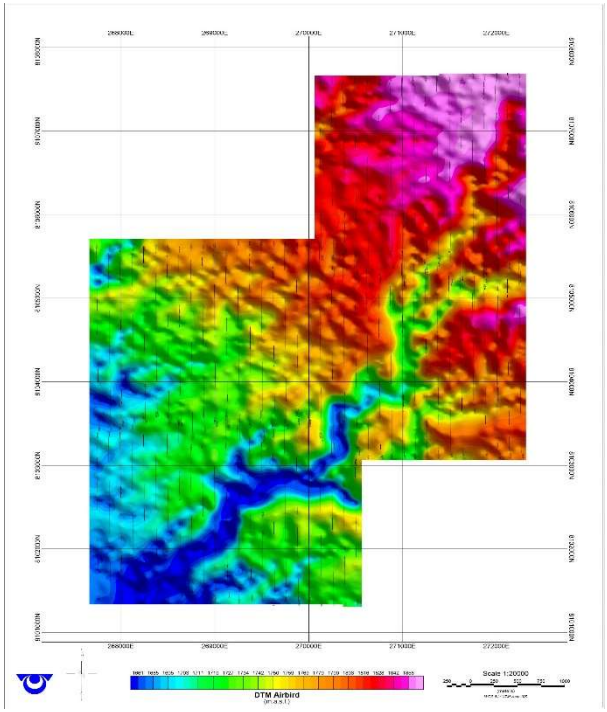
It is critical to have an adequate high resolution DTM to ensure flight safety

A



Intermap purchased DTM, 10m cell size.

B



DTM reconstructed with Airbird laser altimeter, 2m cell size.

Standard deviation between A and B is 5.9m approximately.

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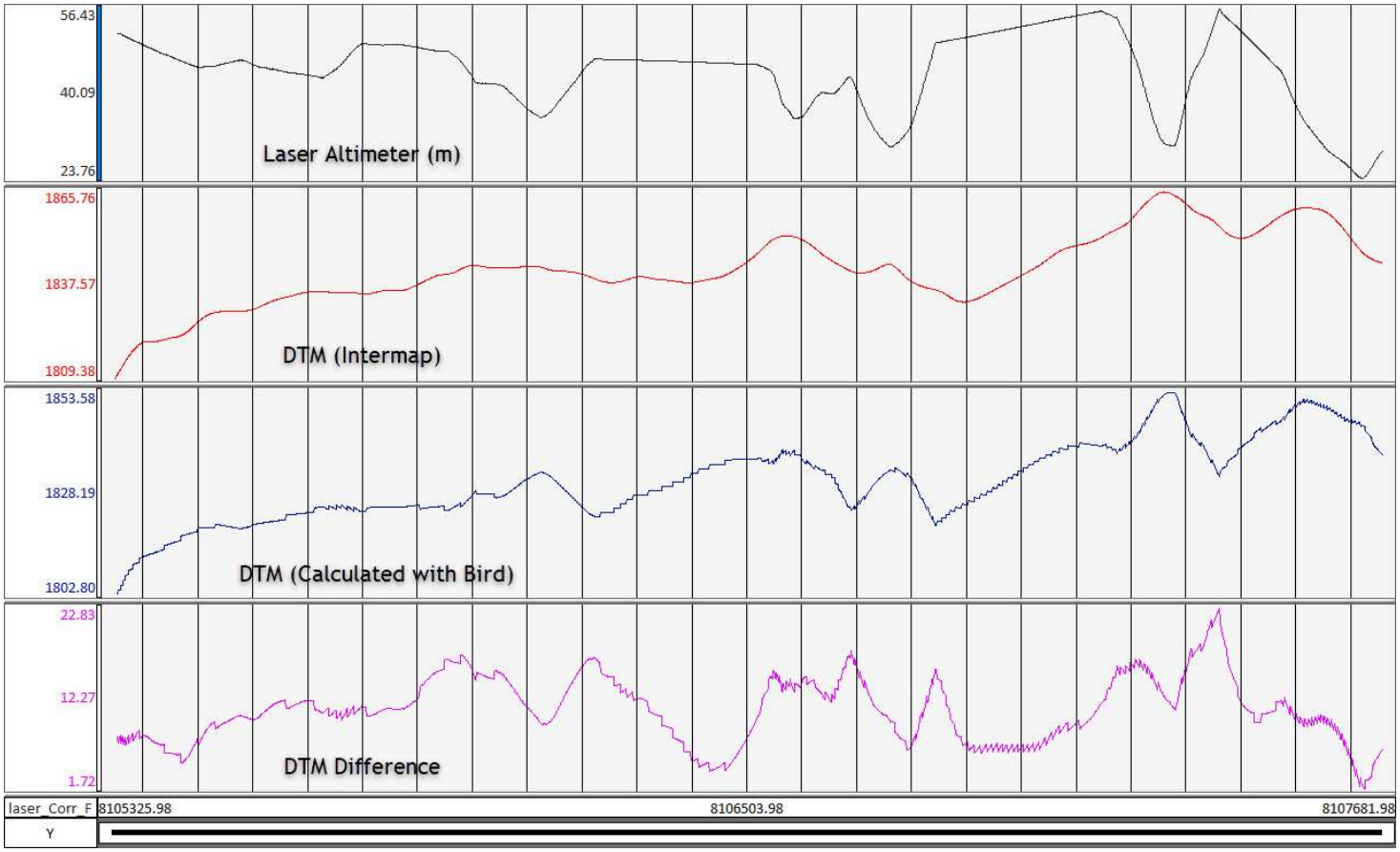
Tambo Sur Survey Design: Line 14300

The problem of correctly using DTM information to program flight.



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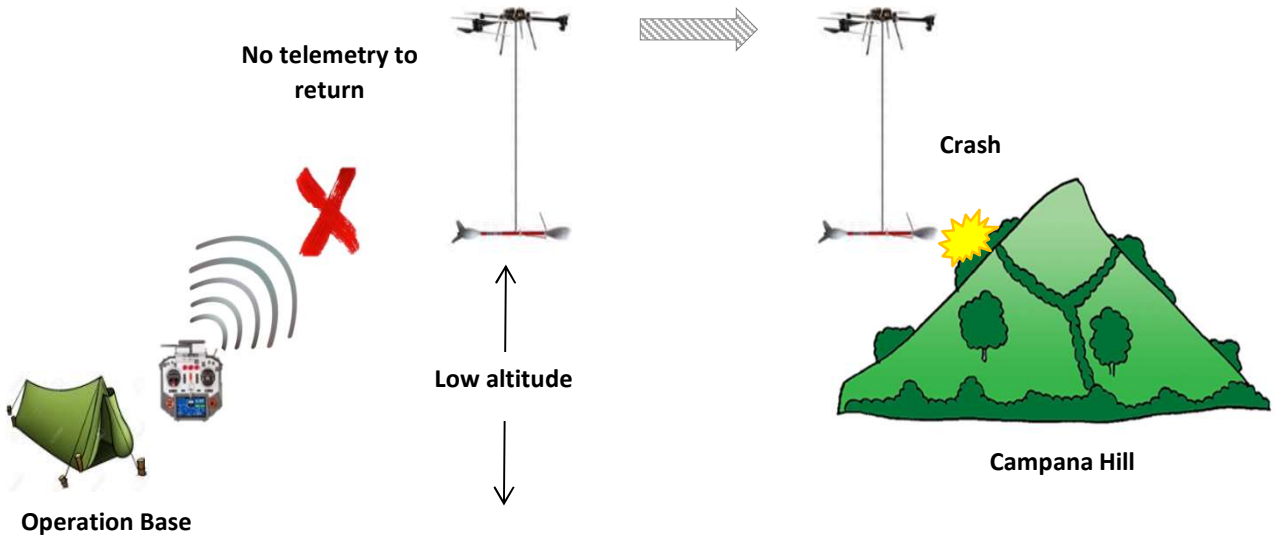
Flight Safety: Accident Example

We had an accident in another project. This was caused by poor DTM information and UgCS not considering ground clearance for the drone on the ferry flight between the base and the flight lines.



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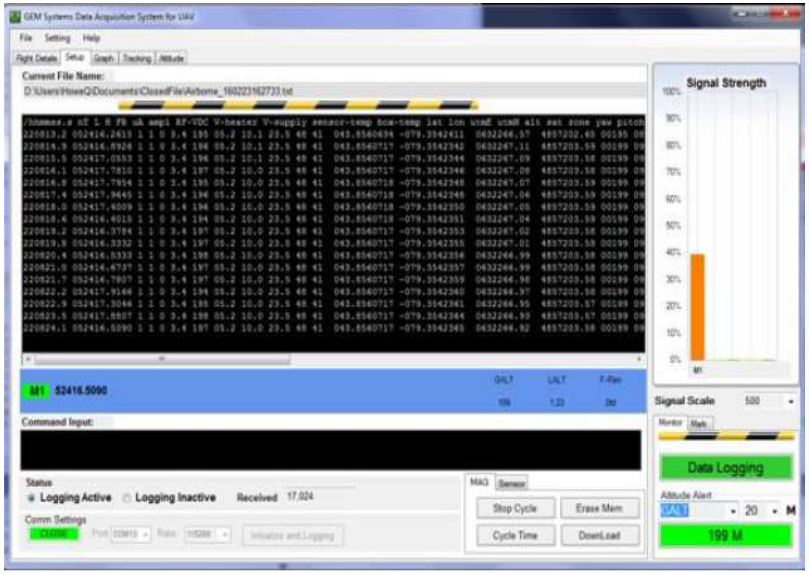
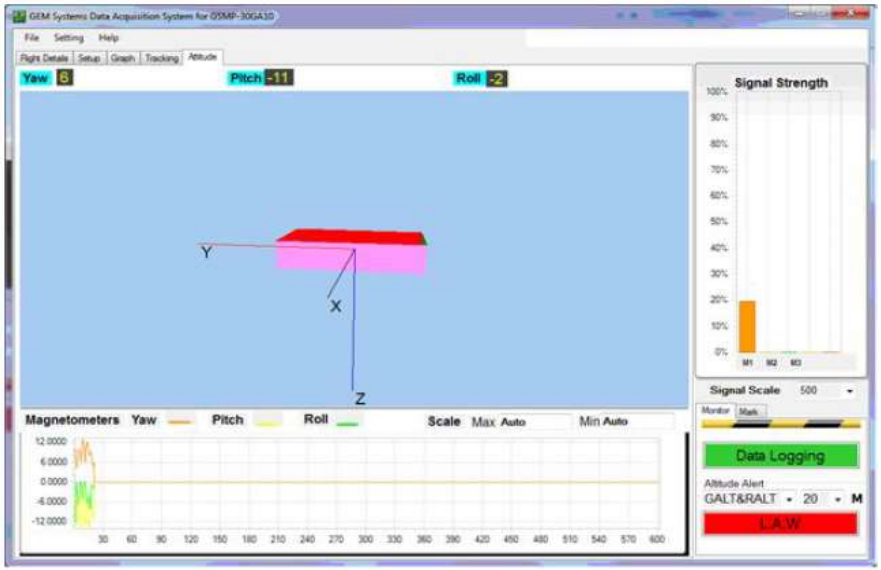
Data control: real-time monitoring

Survey was monitored in real time with the information the Airbird was sensing by radio to our base station.





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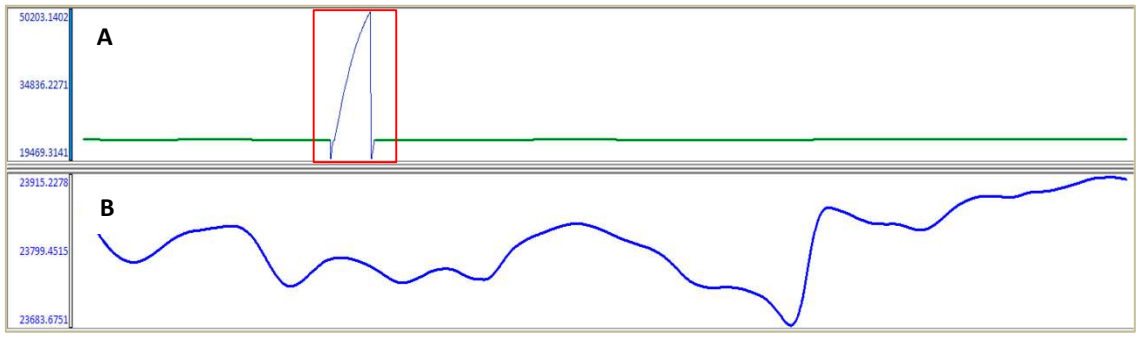
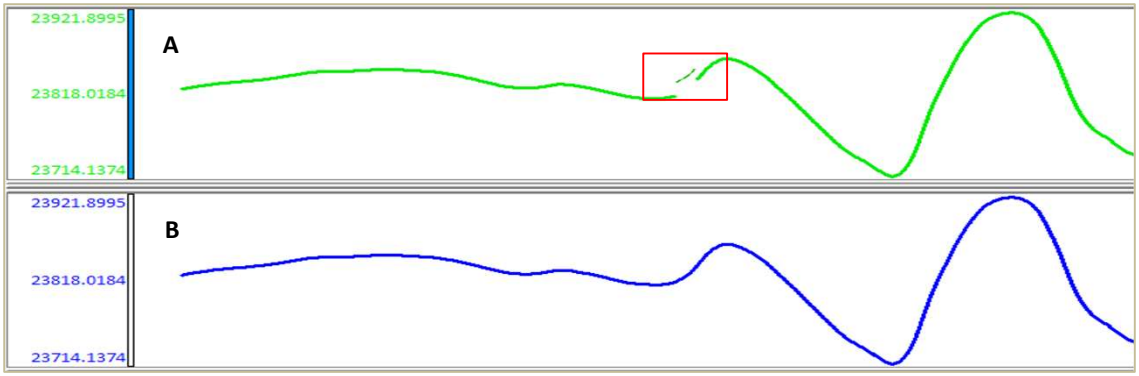
Data processing



Sensor dead zones



Data jumps in line overlaps.

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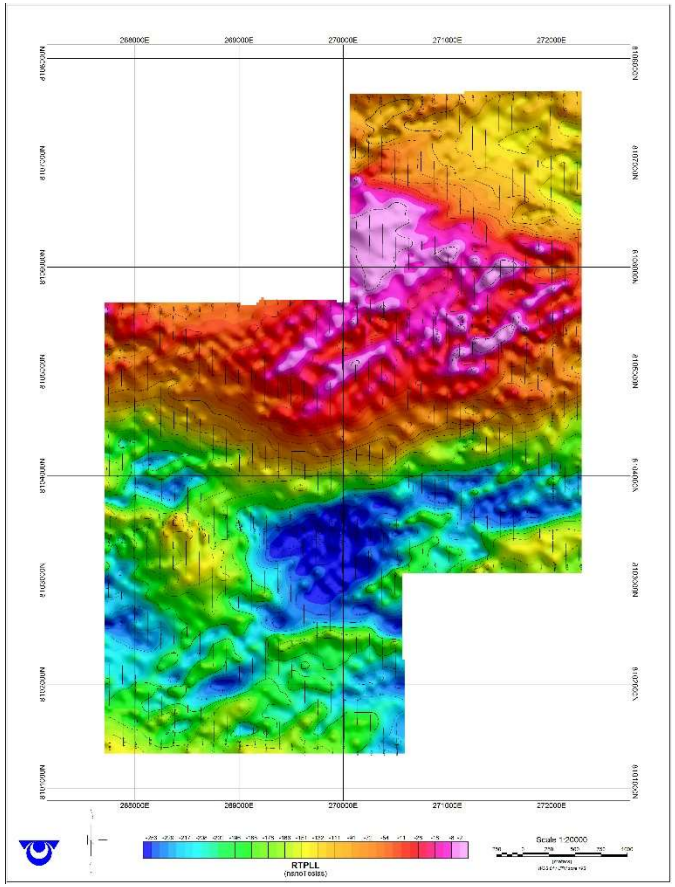
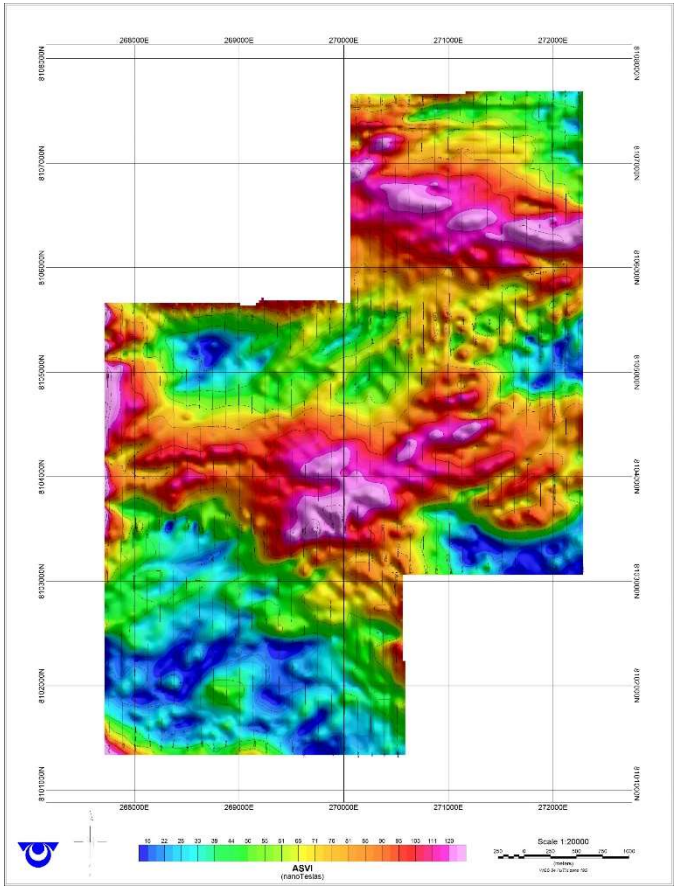
Processing



RTPLL: Reduction to the Pole for Low Latitudes



ASVI

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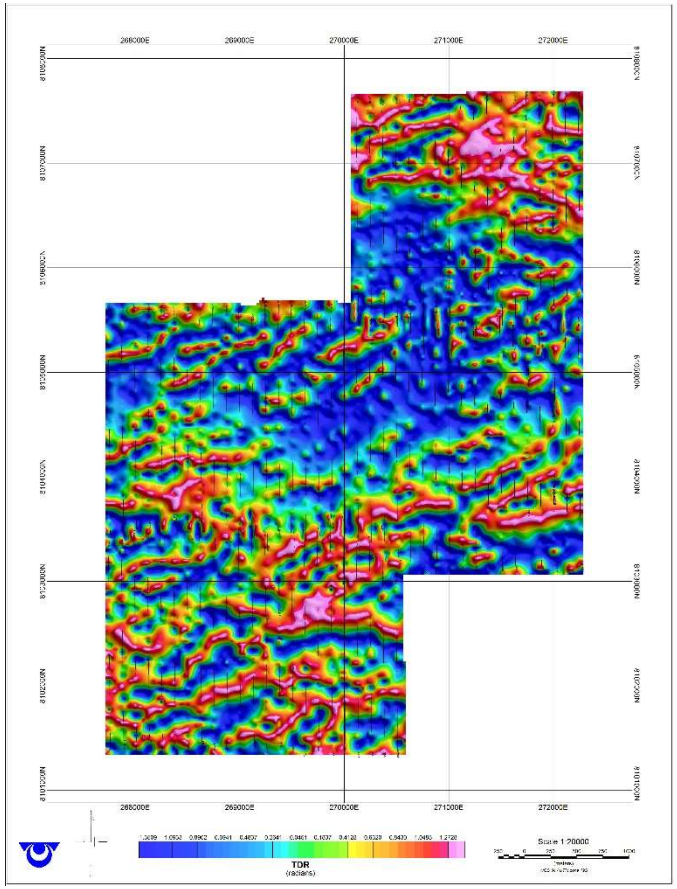
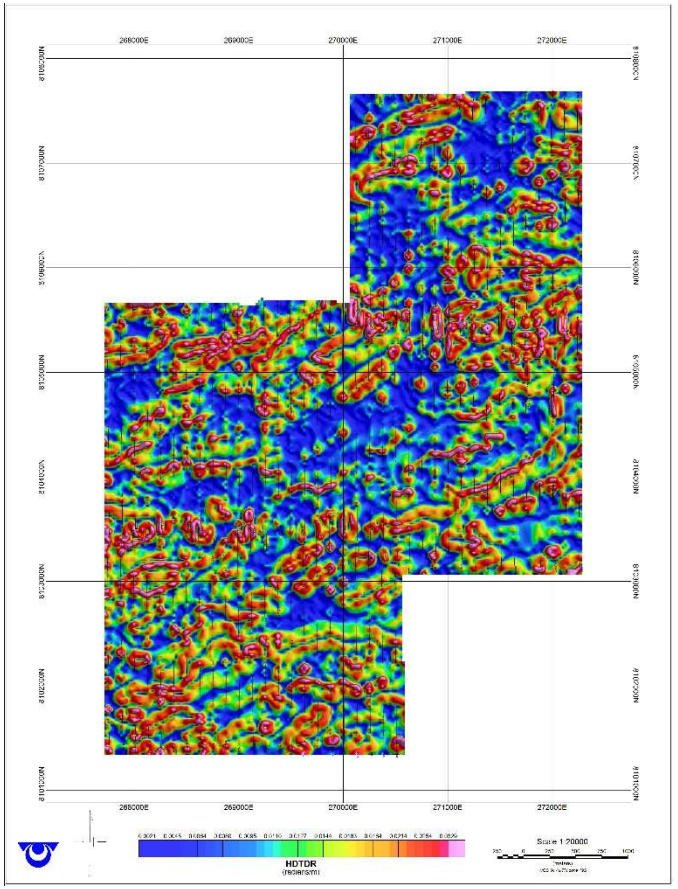
Processing



Tilt Derivative (TDR)



HDTDR

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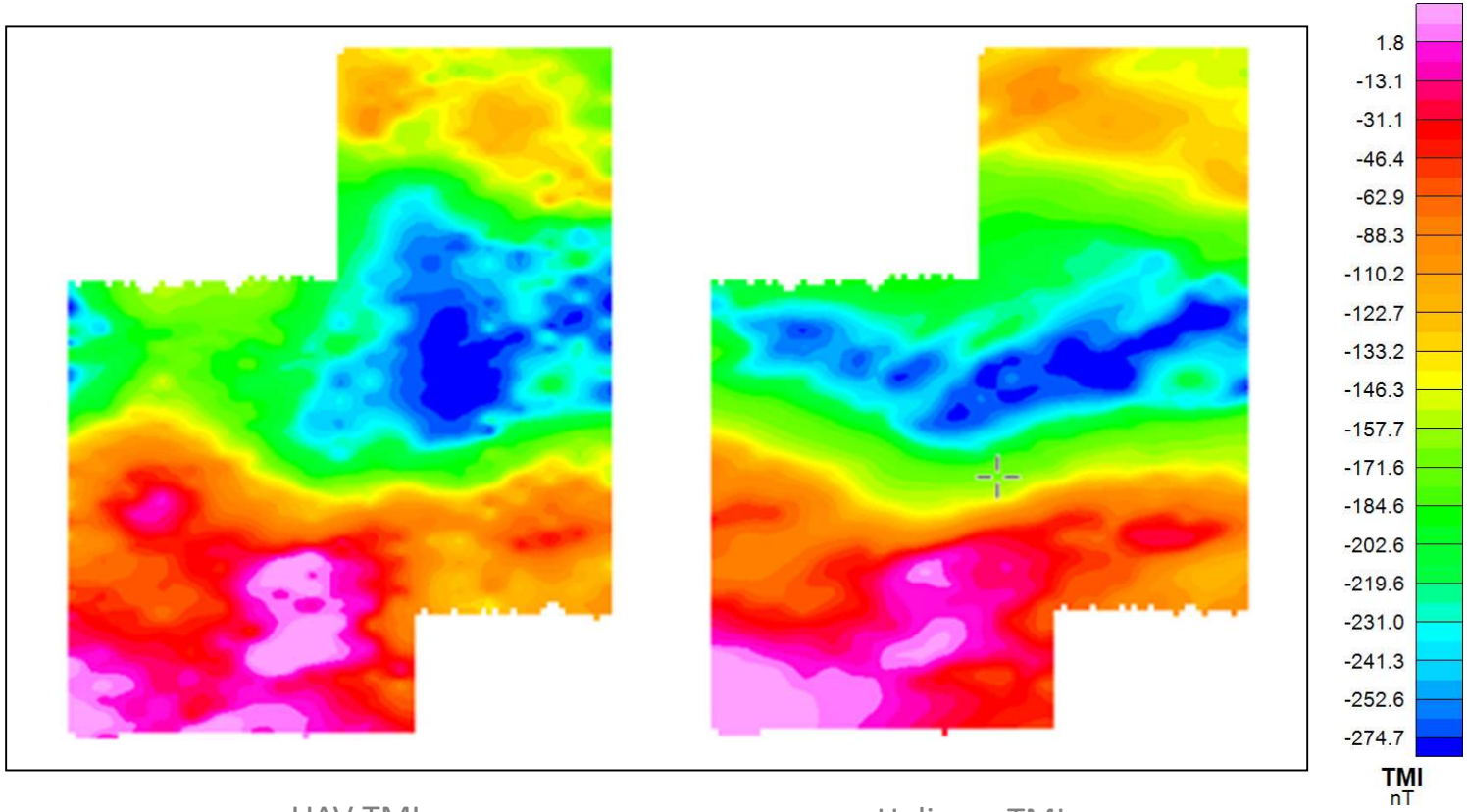
Comparison of UAV Mag and Helimag



UAV TMI
Flight lines @125m
Ground Clearance 35-50m

Helimag TMI
Flight lines every 250m
Ground clearance 100m

*Slide Presented in Geophysics Virtual Conference, Chile, October 2020.

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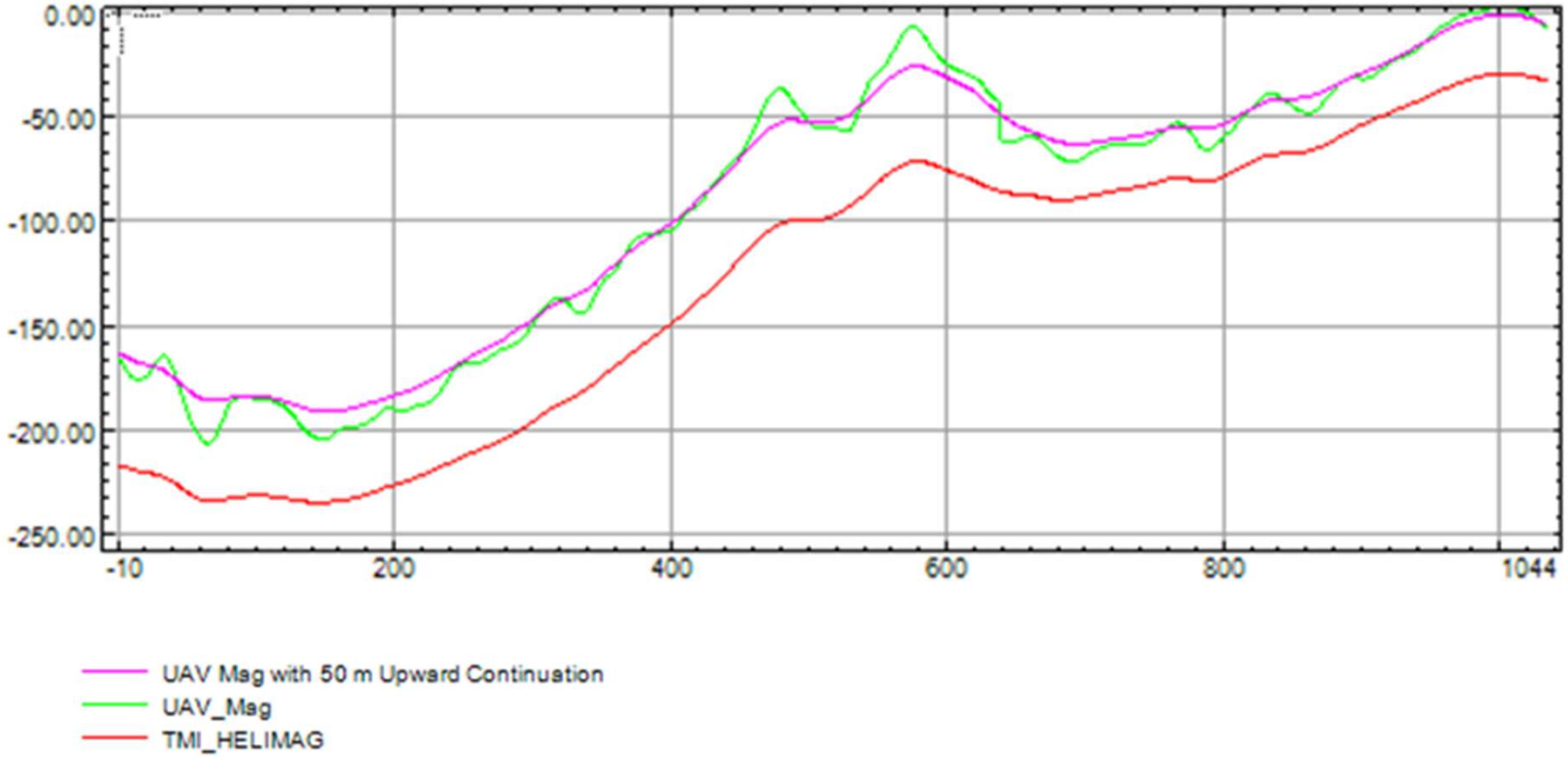
Comparison of UAV Mag and Helimag



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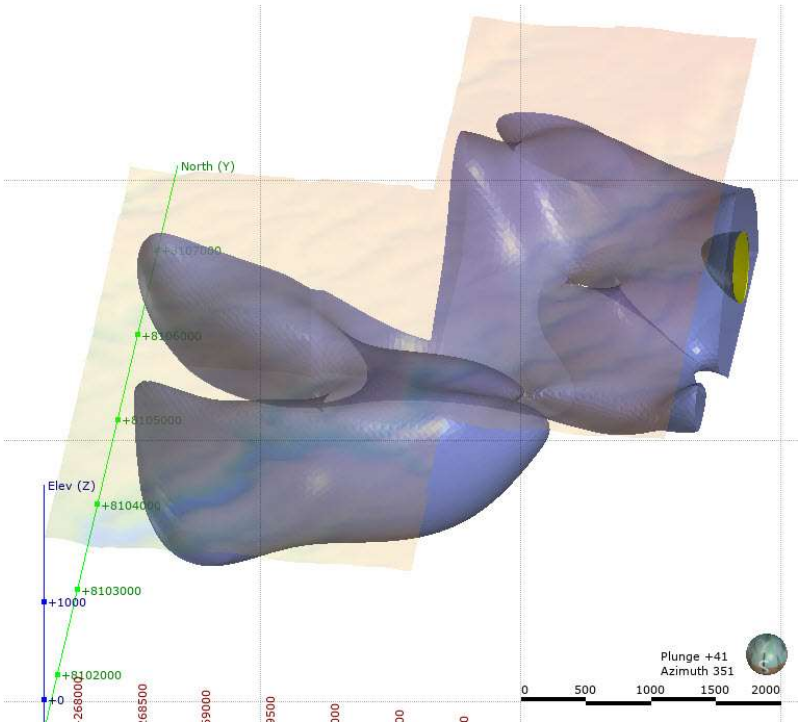
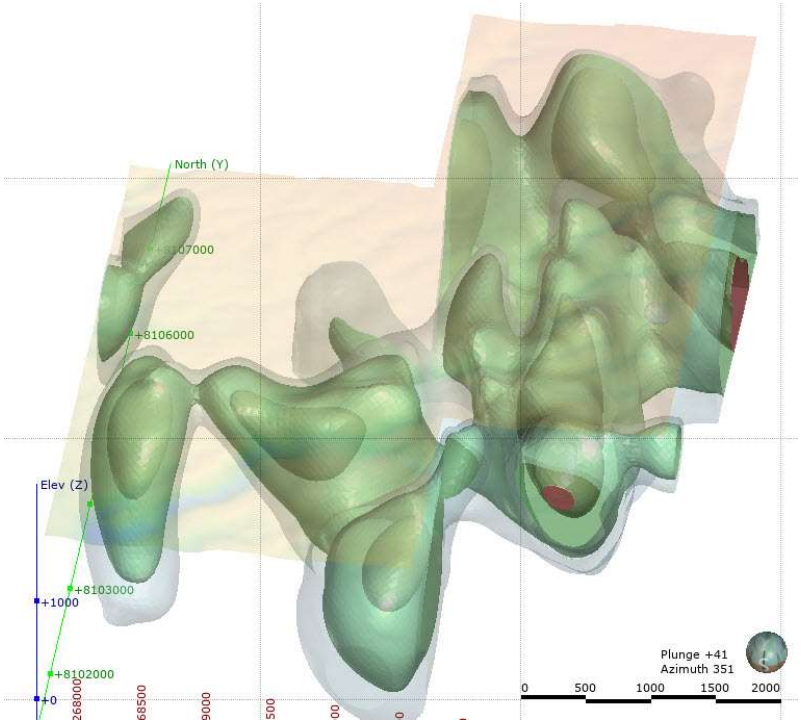
3D MVI Modelling



Helimag



UAV

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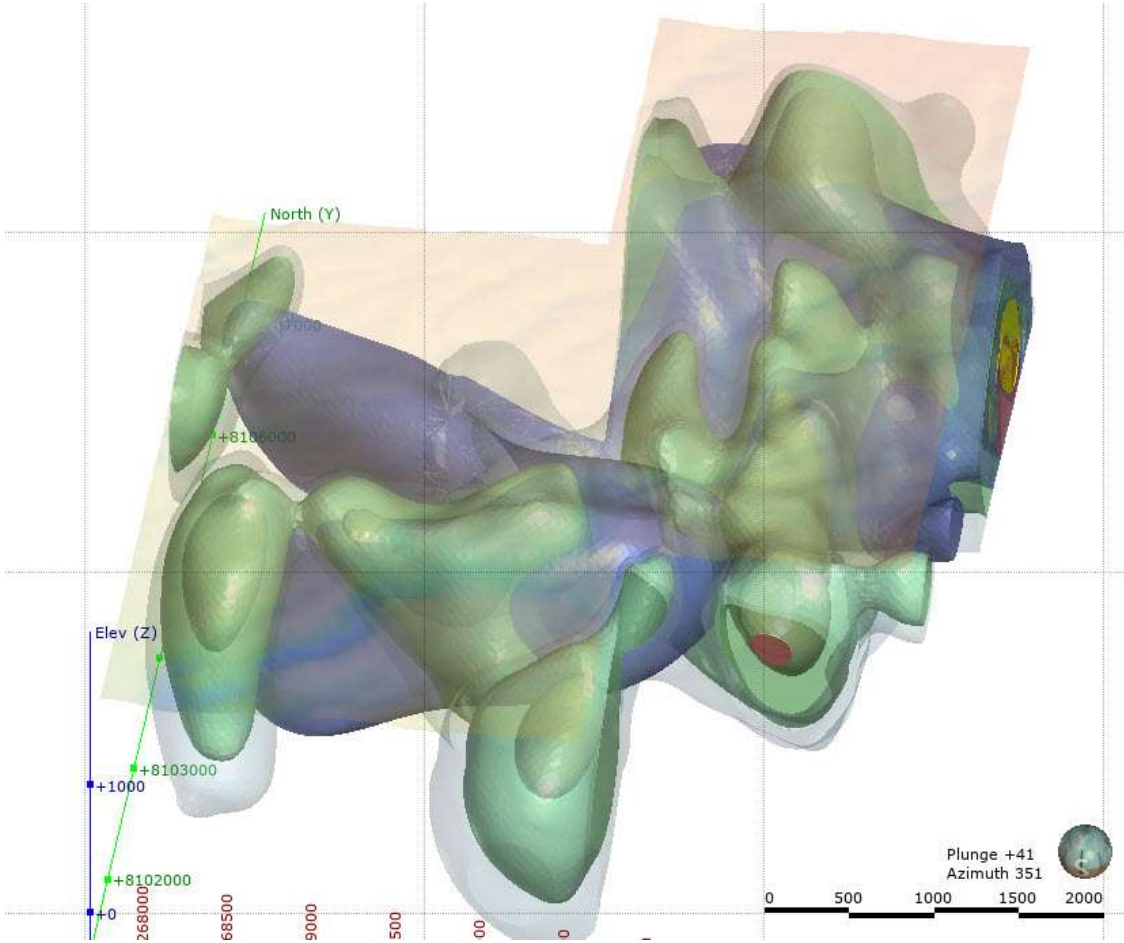
3D MVI Modelling



Helimag/UAV

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