UAV Magnetic Survey Planning, QAQC and Data Processing

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SUMMARY

UAVs have been deployed increasingly to collect magnetic data, however acquisition using these systems often lack QAQC checks that are typically expected from fixed-wing or helicopter-based acquisition. Furthermore, survey parameters such as line spacing or mean terrain clearance are often not given enough thought given the higher noise levels typically associated with this style of acquisition.

UAVs are not immune to system noise, instrument noise, GPS or navigation issues that also arise in their larger, fixed-wing and helicopter counterparts and these need to be addressed prior to acquisition. Due to the commercial infancy of these systems, delivered products are often suboptimal as they lack contractual agreements of data quality and noise levels. Factors such as deviation from planned survey height, deviation from planned lines, noise levels above a threshold etc. need to be pre-agreed on in a way that is fair and transparent to both the UAV operator, as well as the client.

Processing of UAV data can be thought of in two stages; the first being spatial data processing – checking and correcting for GPS positioning errors, including altitude, and separating the data into individual lines resulting in a correctly located neatly trimmed data set. The second stage is the assessment and correction of magnetic data – removal of spikes, dropouts, diurnal base station correction etc.

UAV data tends to be delivered as grids, images, and ASCII line data which oftentimes, has undergone minimum processing in this two-stage process. These data require additional processing to correct artifacts in the data related to line-directionality and height variations to allowing the gridding of a clean magnetic image without removing geological information.

Key words: UAV, drone, magnetics, DMAG

INTRODUCTION

Unmanned Aerial Vehicle (UAV) magnetic surveys, sometimes labelled a Drone magnetic survey (DMAG) are becoming more common. Compared to traditional fixed-wing and heliborne surveys, they benefit from lower mobilisation and transport costs making smaller size surveys more economical. Where terrain, logistics or access restrictions have previously prevented traditional airborne (AMAG) or ground (GMAG) magnetic surveys, drones have enabled data to be successfully collected. A comparative table of all three methods is given in TABLE 1.

The commercial infancy of DMAG has produced data sets ranging in quality from reasonable through to the quite poor. Some of these early surveys have been collected by operators with little to no experience of magnetic survey acquisition and processing resulting in data sets that have not been fully optimised.

Legal restrictions on UAV flying heights prohibit the use of high-altitude compensation calibrations used to correct heading errors that may be caused by the sensor itself and the survey platforms interaction with the magnetic field it is measuring.

Incorporating an independent third party into DMAG survey process not only ensures the survey design matches the intended target, but also that the DMAG platform is capable of delivering the data quality required to achieve the target definition. During data acquisition the ongoing QAQC process ensures the survey complies to predetermined specifications designed to ensure integrity of the raw magnetic data.

The raw magnetic data is (or should be) then taken into post processing where it becomes a neat, edited data set and is corrected for variations resulting from the survey process resulting in corrected Total Magnetic Intensity (TMI) data. When the post processing routine is done poorly, detail can be removed or altered from the data.

Benefits of UAVs

UAVs have quickly revealed their potential to collect AMAG data over areas conventional survey techniques were not easily, or not practically, able to acquire. Small areas are often difficult to warrant the mobilisation of a fixed-wing plane or helicopter as the mobilisation cost exceeds the survey cost. In isolated regions traditional surveys may not be available in a reasonable time frame or are prohibitively expensive due to their isolation resulting in high mobilisation costs. Regions of highly varied topography make it difficult for traditional survey platforms to drape the topography resulting in compromised data sets. UAVs are easily transported resulting in decreased mobilisation costs and can be a logistically simpler proposition compared to conventional fixed-wing and helicopter platforms.

Noise

The magnetic noise levels of any survey platform are one of the factors dictating the resolution of magnetic information that can be obtained from that survey. The noisier the system, the less resolution it will be capable of resolving.

Traditional airborne contractors will go to extreme measures to ensure aircraft are as magnetically quite as possible. Dedicated airborne magnetic survey aircraft are typically highly modified to minimise magnetic and electrical noise that compromise the data quality. UAVs operate with electrical circuits, servomotors and GPS navigation systems all producing magnetic noise which can hide geological magnetic signal. Traditional fixed-wing and helicopter platforms all suffer these same issues and are addressed prior to acquisition ensuring the data collected is within predetermined standards. Those standards are typically set by the contractors representing parameters they feel their system can attain thereby ensuring a minimum data quality. These parameters are set out in a contractual agreement covering data noise levels, deviations from planned flight paths and flying height. Uniform flying height is especially important in low level surveys as small height changes can result in large magnetic amplitude variations which must then be dealt with in post processing.

All magnetic survey systems suffer from heading errors resulting in offset amplitudes recorded when flying in one direction compared to flying in another direction. This error can be caused by a combination of the sensor itself and the magnetic characteristics of the platform's interaction with the magnetic field. Slight variations in the roll, pitch and yaw of the magnetic sensor also introduce errors which again vary dependant upon flight line direction. Conventional AMAG surveys correct for this by flying a high altitude (10,000ft / 3km) compensation box. The high altitude positions the magnetic sensor away from the geological influence of the ground allowing the system to measure subtle magnetic field variations induced by aircraft manoeuvres.

Because UAVs are legally limited to a flying height of 400ft / 120m, they are not able to attain usable compensation data meaning these errors remain in the raw data and must be corrected with tie line levelling. The impact of these errors on the final data set is dependant upon the line spacing of the survey. The tighter line spacing, the more significant these errors become. At some point there is no benefit in tighter line spacing.

Early UAV AMAG surveys were typically flown by drone operators with little, or no, experience in airborne magnetic surveys. These data are often very noisy as a result of the magnetic sensor being located too close to the drone. Arguably in these data the lack of a directional compensation is very much a secondary problem as any high frequency information is lost into the system noise. While these systems may not be suitable for highly detailed surveys, they can still provide useful data in regions where the existing data is very coarse or non-existent.

Characteristics of the magnetic sensor should be considered when designing a survey platform. Traditional caesium vapor sensors have long been used in airborne magnetics however due to their size, weight and power consumption these are not ideal for DMAG. New generation sensors, smaller and lighter with lower power consumption, will ultimately be used in drone surveys however their successful application will be the secret to good quality data.

Data Processing

Data provided from UAV contractors is not always presented as a neat, edited data base as displayed in FIGURE 1. In these instances, it is likely the data processing is as crude as the data set. These data should still have value but will benefit greatly from a review by an independent expert.

The left image of FIGURE 1 shows the survey data as a single line, including ferry flights, turn arounds and reflights. Line spacing is irregular and many of the reflights cover only part of the line. The absence of tie lines suggests these have not been flown removing the possibility of tie line leveling. In the right image, the database is sorted by lines (split by line numbers and sorted by fiducials), ferry flights and turn around are removed, and tie-lines have been flown.

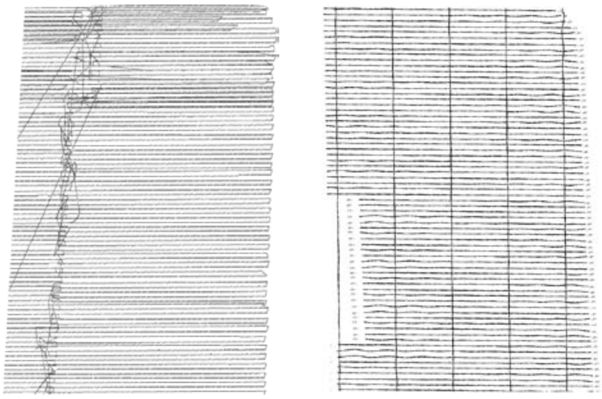

Figure 1. Examples of an unsorted UAV database (left) and sorted version (right)

Examples of poorly QAQC UAV data are shown in FIGURE 2. Highlighted issues with this data include:

1. Missing data
2. GPS errors
3. Unexplained line deviations
4. Duplicate and / or overlapping lines

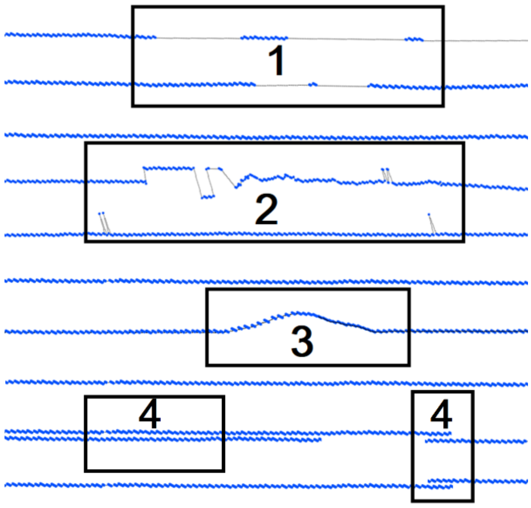

Figure 2. Example of line-data paths with various highlighted data and acquisition issues from a UAV survey.

Complete data lines may also contain the errors demonstrated in FIGURE 3; DC shifts within in the recorded signal mid-way through the lines or large spikes. Both examples represent system errors requiring the line to be reflown. There are a variety of causes to these errors however they remain the responsibility of the contractor to find the cause and implement the required mitigation strategies.

These issues can be time-consuming to edit, sort and lead to poor data grids, with potential loss of geologic response in the recorded signal.

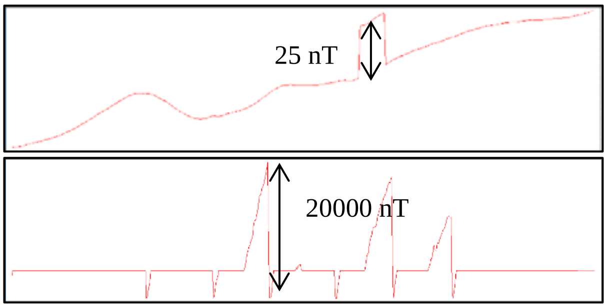

Figure 3. Example of two profile lines from a UAV survey showing unedited busts in the data.

When a dataset is noisy, or unusually low in noise, users should be aware of any previous processing done. Has the data been filtered? The data may be within noise limits however detailed geological information may have been filtered out or swamped by the noise. Checking the power spectrum for a full suite of frequencies is recommended. A low pass filter will remove the higher frequencies which contained the noise, but also geological information. What level of filtering are acceptable (to the target or purpose of the data)? A survey using 100 m spaced lines may permit some minor filtering. However, 25 m spaced lines will not tolerate filtering without the loss of geological signal.

Examples

An example of two separate UAV datasets over the same area is shown in FIGURE 4 (TMI and TMI-2VD). Contractor 1 had the UAV at a mean terrain clearance (MTC) of 45 m whilst Contractor 2 was at 25 m. Both surveys were at 20 m and 25 m, line spacing respectively.

It would be expected for the UAV at 45 m MTC to have a smoother and reduced higher frequency content in the grid compared to Contractor 2 (MTC of 20 m). This is not the case – as can be seen in the in the visibly higher frequency noise of the system from Contractor 1. Also note with higher-level filtering (TMI 2VD), the noise is more apparent and distinct anomalies as highlighted by the red circle and seen in the Contractors 2 data, can be drowned by the noise content, with the potential of otherwise missing a target.

The right image of FIGURE 4 – showing Contractor 2 grids, is not drowned out by the high-frequency noise and the high-lighted anomaly (red circle) is clearly seen. However, it should be asked if any pre-processing/filtering to Contractor's 2 data has occurred and what filtering has been applied; this is due to the apparent over smoothed grid of the TMI. Best have it appraised by an independent expert.

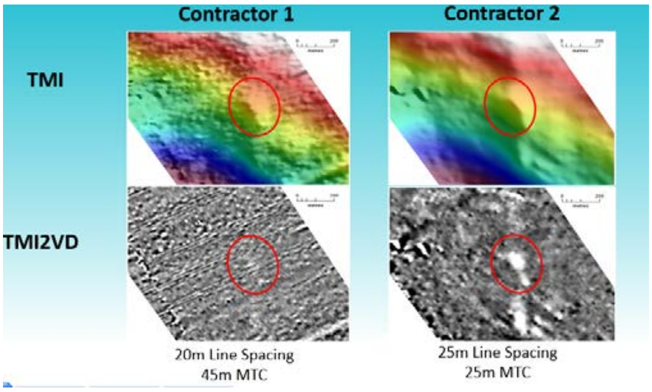

Figure 4. TMI and TMI2VD grids from two UAV contractors over the same area, showing differing noise levels.

CONCLUSIONS

UAVs have quickly revealed their potential to collect AMAG data over areas deemed with being too small, challenging terrain or safety risks, or complicated political and logistical settings which either restrict or prevent traditional AMAG or GMAG surveys.

However, a common lack of survey planning, QAQC during acquisition and processing quality checks, have resulted in UAV data that may not be appropriate or of poor quality to illuminating the geology or expected target.

Incorporating an independent third party into the project, including to review acquisition specifications, adherence or deviations from these, ongoing acquisition QAQC and processing; would allow for possible survey changes, re-flights and processing pre-delivery, which may otherwise possibly degrade the quality of data to illuminate the geology or expected target.

Not all systems will be suitable for highly detailed surveys, however they can still provide useful data in regions where the existing data is very coarse or non-existent.

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	AMAG	DMAG	GMAG
Cost per km	$8 to $12 USD*	$30 to 60 USD*	$70+ USD*
Optimal Survey Size	> 1000 line km	> 200 line k m	< 250 line km
Optimal line length	>5 km	0 - 2 km	N/A
Comments	• Cheapest option ($) • Includes radiometrics • As low as 25m MTC • High safety risk	• Best for difficult terrain • Best for complicated politics/logistics • Lowest safety risk	• Highest cost ($) • Highest resolution • Slow • Moderate risk

Table 1. Comparative table between the three stated methods of magnetic survey acquisition: AMAG, DMAG and GMAG. *Prices converted from AUD