Towards standard technical Deeds for (airborne) geophysical surveys in Australia

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SUMMARY

Geoscience Australia (GA) and its predecessors have been conducting geophysical surveys and processing geophysical data since the early 1950's. Over time, GA's role has changed from being a pioneer in the acquisition and processing of data to focusing on setting standards for the geophysical industry in Australia.

The experience gained from conducting geophysical surveys since the 1990's is now used to ensure that any government survey is conducted to a level of quality and consistency that ensures the collected data is world-class and fit for purpose.

Magnetic and radiometric technical Deeds were introduced in 2003. Suppliers on the Deed have been preapproved to provide geophysical data, processing and supply services to GA according to the requirements. The Deeds include requirements for calibration, acquisition, and processing of magnetic and radiometric data as well as data formats and reporting requirements.

The Deeds provide a means for consistent and reliable magnetic and radiometric data collection. These standards also enable us to create national compilations from surveys collected by different suppliers across Australia.

Key words: Deeds, technical specifications, calibration, magnetics, radiometrics.

INTRODUCTION

A brief history

In 1951, Geoscience Australia's (GA) predecessor, the Bureau of Mineral Resources (BMR), began acquiring airborne magnetic data over onshore Australia with a flying height of 150 m and a flight-line spacing of 1500 m or greater (Tarlowski *et al.* 1992). This marked the beginning of GA's involvement in the acquisition of pre-competitive geophysical data to support mineral exploration and undercover regional geological mapping.

In 1990, the National Geoscience Mapping Accord (NGMA) was established, marking the beginning of collaborations between GA and its state and territory partners to acquire higher resolution airborne magnetic, radiometric and elevation data across Australia using contractors (Denham, 1997). An emphasis was placed on higher resolution data acquisition with 400 m line spacing becoming standard for regional surveys and contract management and quality control undertaken by BMR.

Technical Deeds

In 2003, a Deed in relation to the Acquisition, Processing and Supply of Airborne Geophysical Data (Deed) was introduced to ensure consistent and high-quality airborne magnetic and radiometric data acquisition across different suppliers and acquisition instruments.

Suppliers on all of GA's Deeds agree to acquire, process and supply geophysical data according to the technical requirements within it. Through the Deeds, GA ensures that all geophysical data acquired on behalf of state or territory geological surveys comply with their requirements. This ensures that instruments are calibrated appropriately and data delivered by suppliers have been rigorously quality controlled according to guidelines set by GA.

PANEL SELECTION

In the initial stage of all of GA's geophysical Deeds, the Approach to Market (ATM) is open to any supplier who is able to acquire, process and deliver geophysical data that meets the specifications. Suppliers must only submit a response to an ATM if they have the expertise for that particular geophysical method (e.g. gravity, AEM, Magnetics, Radiometrics). A number of requirements are set to follow the Commonwealth procurement process and GA specifications for the acquisition and processing of geophysical data. These requirements include technical specifications, survey monitoring, calibration flights, format of the goods, quality control and deliverables.

Once evaluated, suppliers on the panel agree to acquire and supply data in accordance with the requirements of the Deed during each geophysical survey. In addition to the Deeds, each supplier signs a contract with GA, taking into consideration the specifications of the project.

TECHNICAL SPECIFICATIONS

This part of the Deed relates to aircraft specifications as well as quality control of the data. The parameters discussed in this paper are for airborne magnetic and radiometric data.

Some important parameters to consider are the speed of the aircraft, the quality of the equipment on board (magnetometer and gamma-ray spectrometer), and making sure that the aircraft is free of any radioactive contamination which may interfere with the measurements.

The designated aircraft must be able to fly within a reasonable nominal height even in areas of high relief or variable topography. Prior to signing the contract and before the commencement of the survey, the supplier must provide a drape analysis to ensure that the aircraft is capable of flying within the survey height limits. Table 1 shows the acceptable range of a set of parameters that need to be checked before and during the survey.

All equipment used must be calibrated prior to the commencement of the survey. For magnetometers, manoeuvrer noise tests and heading error tests should be performed. For the spectrometer, the calibration includes the thorium (Th) source test for sensitivity, cosmic and aircraft backgrounds, radon backgrounds removal, stripping ratios, height attenuation with the aircraft flying a calibration range approved by GA. The gamma-ray spectrometer calibration procedures are summarised in Grasty and Minty (1995) and IAEA (2003). These calibrations must be carried out within 12 months prior to the contract commencement date.

SURVEY MONITORING AND REPORTING

All surveys managed by GA must follow a monitoring and reporting process. This monitoring includes calibration, progress, quality control and data processing reports. It is essential for the supplier and GA to keep the communication going to monitor the survey and act as quickly as possible in case of any issues. The gamma-ray spectrometer needs to be monitored on a daily basis throughout the duration of the survey.

In addition to the monitoring, GA and the supplier must agree on the frequency of data delivery, so that the quality control can start and progress in line with data acquisition.

The delivery format is important to ensure it is easily accessible, transcribable and efficiently packaged upon release through state, territory and GA websites. The preferred format for point located and line data is ASEG-GDF2 (Pratt, 2003) defined by the Australian Society of Exploration Geophysicists (ASEG). It is an ASCII data exchange and archive standard that evolved from the earlier ASEG-GDF standard (Dampney *et al.*, 1985) and SEG draft standard (Dampney *et al.*, 1978). ERMapper (.ers) format is required for grids. However, GA is transitioning to Network Common Data Format (NetCDF) for gridded products.

DATA QUALITY CONTROL AND DELIVERABLES

The contractor is required to demonstrate that the data have been corrected in accordance with the technical specifications. This is verified by asking the contractor to provide a series of benchmark plots and reports to show that all the survey parameters are within the range specified in the technical document.

The contractor must supply raw, edited and corrected data to GA. These data must be accompanied by a data processing report to show the quality control process that has been applied to the data. Attention is also drawn to the datum and projection as agreed by both parties for every given project area.

NEW ADDITIONS TO THE DEED

Network Common Data Format （NetCDF)

NetCDF 4 has become the dominant generic format for many forms of geoscientific data, leveraging (and constraining) the versatile Hierarchical Data Format (HDF5) container format (Ip *et al.*, 2007). The HDF5 open source file format supports large, complex and heterogeneous data and offers better file compression and faster load times due to ‘chunking. NetCDF builds on the HDF5 format while providing metadata conventions for interoperability. GA manages a large volume of diverse geoscientific data, much of which is being translated from proprietary formats to NetCDF at the National Computational Infrastructure (NCI) Australia.

Geoscience Australia is now transitioning to NetCDF format for all survey data because, unlike other data formats, the NetCDF files contain both scientific data variables (e.g. gravity, magnetic or radiometric values), and also domain-specific operational values (e.g. specific instrument parameters) best described fully in formal vocabularies. Such standard vocabularies have already been developed and maintained by the Climate and Forecasting (CF) Metadata Convention (NCAR, 2014).

Australian Vertical Working Surface (AVWS)

With the introduction of the new Geocentric Datum of Australia 2020 (GDA2020), all ellipsoidal heights are to be with respect to the AVWS (AGRS, 2020). The AVWS is a more accurate surface for corrections. GA requires that the supplier use this surface for the geoid-ellipsoid separation and replaces the previous standard, which was AusGeoid09.

New safety requirements

Other aspects of the Deed are implemented prior to signing a contract with a supplier. These aspects include a risk analysis of the survey area, stakeholder notification where landowners are informed about the upcoming survey, and finally a safety audit of the contractor (both the equipment and personnel) to ensure Work Health Safety (WHS) procedures are clearly followed.

GA has updated their safety policy requirements to include both a safety policy and a safety management system from the International Airborne Geophysics Safety Association (IAGSA). The safety management system includes the following components: (1) safety policy, (2) safety risk management, (3) safety assurance, and (4) safety promotion (IAGSA, 2020).

Future work

Quality controlled deliverables have been incorporated into GA’s Deeds to ensure that the standards are routinely followed and easily verified. To ensure reliable and consistent measurements, all supplier systems are required to acquire data across calibration ranges (e.g., Australian Fundamental Gravity Network for ground gravity, Carnamah, WA for radiometrics, Kauring, WA for airborne gravity, Menindee, NSW for airborne electromagnetics (AEM)) prior to the commencement of surveys and when significant adjustments or equipment replacements are made.

Well established now for the magnetic, radiometric and ground gravity surveys, the same approach has recently been applied to AEM systems and is being developed for airborne gravity and gradiometry.

CONCLUSIONS

GA has established a Deed for ground gravity, airborne magnetic and radiometric, as well as airborne electromagnetic surveys. The Deeds provide a means for consistent and reliable geophysical data collection. The standards enable us to create national compilations by combining multiple surveys acquired by different suppliers across Australia (Poudjom Djomani *et al.*, 2019; Poudjom Djomani, 2020). Ground gravity, airborne magnetic/radiometric and airborne electromagnetic Deeds will soon be published and made freely available to support consistent geophysical data collection and processing by both Government agencies and industry alike. Using the same approach, a Deed is in progress for airborne gravity and gravity gradiometry.

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	Parameter	**Description**	**Value and acceptable range**
Aircraft	Aircraft speed	Speed at which the aircraft is flying.	70 m/s, ± 10 % deviation
	Terrain clearance	Nominal height at which the aircraft is flying. Sets balance between safety and resolution considerations.	80 m, ± 10 m deviation
Magnetometer	Manoeuvre noise	Magnetometer manoeuvre noise.	< 0.2 nT peak to peak
	Heading error	Magnetometer heading error.	±1 nT or less
	Total noise	Noise on unfiltered magnetic profiles.	< 0.2 nT
	Diurnal variation	Geomagnetic diurnal activity.	< 5 nT within a 5 minute window
	Sampling rate	Rate at which the data is recorded	> 10 Hz
Navigation	Positional accuracy	Positional accuracy of the Global Navigation Satellite System (GNSS).	Better than 0.5 m horizontally, and 1.0 m in height
	Altimeter range	Altimeter used to measure the aircraft ground clearance.	Up to 760 m, with a precision of 30 cm or better
	Barometer	Air temperature and pressure recording.	Intervals of 1 s or less,

			Precision: temperature 1º C Celsius and pressure 0.1 %
Gamma-ray spectrometer	Th source test	As per the calibration methods described by Minty (1998) or (IAEA, 2003).	Pre and post calibration source must not differ by more than 3%
	Cosmic and aircraft backgrounds		Corrections applied to gamma-ray spectrometer data. Acceptable values defined in Minty (1998) or (IAEA, 2003).
	Radon background		
	Stripping ratios		
	Height attenuation coefficients		
	Window sensitivities		
	Live time	The system live-time.	Accuracy of 0.1 % or better. If the total dead-time is greater than 0.5 %, all window data must first be corrected for dead-time.
	Sample integration time.	Sum of all the counts	1 s
	Spectral resolution	The system resolution measured with a thorium source placed at least 40 cm from each detector package	< 7 %
	Sampling rate		1 Hz

Table 1. Summary of some technical parameters specified in the magnetic/radiometric Deed.